Introduction to the Idaho Master Naturalist Program

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Describe what a Master Naturalist is. Identify and communicate the mission and goals of the Master Naturalist program.
- Identify and communicate the requirements and responsibilities of an Idaho Master Naturalist.
- Discuss the purpose and requirements of the file box and bound curriculum.
- Identify partnering organizations' missions and philosophies.
- Understand how Idaho's Master Naturalists are organized.
- Identify how Master Naturalists find/choose projects to work on.
- Describe the resources available to Idaho Master Naturalists.
- Become familiar with administrative processes, such as keeping track of hours and volunteer recruitment.

What is the Idaho Master Naturalist Program?

If you are reading this section, you probably already know what an Idaho Master Naturalist is, and chances are you are working to become one. *The mission of the Idaho Master Naturalist Program is to develop a corps of well-informed volunteers to actively work toward stewardship of Idaho's natural environment.* To explain the program better, let's break down the name and mission.

The Idaho Master Naturalist Program-What is in the name?

You are probably familiar with the popular Master Gardener Program. Many states have developed Master Naturalist Programs (see history section below) and named them such due to the similarities to the Master Gardener Program. In Idaho, the name for this program was LONG debated.

The content included in the education sessions has been developed to give you a broad overview of important ecological topics. This is not a master's degree! We believe nobody can truly become a "master" of the knowledge about nature … it is endless. The term "naturalist" means different things to different people. Broadly defined a naturalist studies nature and is connected with nature through knowledge and interest.

As an Idaho Master Naturalist, you are encouraged to connect with both nature and your community by increasing your knowledge of nature and using that knowledge toward conservation efforts where you live.

Becoming a naturalist is a process, not an end in and of itself. At the end of your required education and service time, you will earn the title of Idaho Master Naturalist. But that won't mark the end of your learning and volunteering.

"…To develop a corps of well-informed volunteers…
To develop a corps of well-informed volunteers, program leaders strive to foster high-quality adult educational opportunities. We hope the content of the education is challenging and interesting. We believe that experience is the best teacher. That is why we value what experiences you bring to the program and we value providing great experiences for you. The education provided is designed to be diverse, ranging from classroom lectures to hands-on activities, reading, writing, discussing topics, and field experiences. We believe that we alone cannot develop a corps of well-informed volunteers. Rather, together with you, we can all create meaningful educational experiences that will prepare us to work together for conservation in Idaho.

…to actively work toward stewardship…
This part of the mission may seem vague. It was written that way on purpose. We have developed two Idaho Master Naturalist Tracks: Citizen Science and Conservation Education. However, in the future, we hope to have many tracks available to participants. We see a future of volunteers working in fields as diverse as data collection and educational programs to habitat restoration and public art! We have projects with which we need help, but stewardship is a job for all of us. No matter where you choose to spend your time volunteering, there is a net gain for everyone! Just as each plant and animal evolves to find its niche in an ecosystem, we encourage you to find your niche in conservation.

According to Merriam Webster's Dictionary, *stewardship* means *the careful and responsible management of something entrusted to one's care.* In this sense, the Idaho Master Naturalist Program advocates taking care of Idaho's environment not only for our own benefit, but for the benefit of the other species, plants and animals that share our state.

…of Idaho's natural environment."
Your volunteer work can manifest itself in many different ways. We want you to concentrate your volunteerism in your local community. There are many opportunities to do this directly; for example, collecting data about wildlife, working on habitat restoration, surveying for plants, and monitoring nests. Indirect work toward the environment comes in the form of teaching classes, working at nature centers, preparing brochures and written material for the public, and helping

educate people about conservation. Whatever work you choose, as long as it contributes directly or indirectly to stewardship and conservation of Idaho's natural environment, it will be beneficial! Your local chapter coordinating committee may have limitations on where you can volunteer, but undoubtedly, there will be something for everyone.

Why was the Idaho Master Naturalist program created?

- Over the last 40 years, Idaho's population has more than doubled (from 667,191 in 1960 to 1,466,465 in 2006) (U.S. Census Bureau, 2006). Today, 62% of Idaho's residents are classified as residents of urban areas, compared to 54% in 1980. Between 1990 and 2000, Idaho's population grew 28.5%. Idaho was ranked the third fastest growing state in 2004-2005 (U.S. Census Bureau, 2006). It is predicted that by 2050, 4.5 million acres of farm, ranch and open space in Idaho will be lost due to urban and suburban development (Federation for American Immigration Reform, 2006).

- Idaho has nearly 600 species of vertebrates (85 fish species, 15 amphibians, 24 reptiles, 361 birds and 113 mammals). Only 4% of these species can be hunted, fished or trapped, leaving the vast majority of them classified as nongame species. The management of nongame wildlife receives neither tax dollars nor hunting and fishing license sales revenues. Managing nongame species is under-funded yet crucial to the integrity of Idaho's ecosystems and all of Idaho's wildlife.

- Idaho has several local natural resource and conservation organizations with education, outreach, and service as part of their missions. Due to limited funding, nearly all of these organizations depend on well-trained adult volunteers to conduct programs, help researchers collect data, operate parks and visitor centers, and help with all types of natural resource and conservation work.

- Only 38% of Idaho land is privately owned. The rest is managed by public agencies with ever-decreasing budgets and personnel.

- Idaho Department of Fish and Game and other natural resource agencies and organizations want to involve citizens in conservation. It is explicitly stated in our agency's goals to seek out and welcome public input in decision making and tasks to carry out our mission. We believe that only with adequate involvement, input and partnerships with the citizens of Idaho, can we truly manage Idaho's resources for future generations.

We are clearly outnumbered with broadening and complex natural resource challenges that require an understanding of complex ecological dynamics at a local level. Taking care of Idaho is

everyone's business. Conservation and stewardship are not spectator sports. Idaho needs an involved and educated citizenry, willing to demonstrate their commitment toward conserving and managing the natural and cultural resources of Idaho. Humans—as in Master Naturalist Volunteers—are essential to the conservation and management of a better Idaho. We need more volunteers, like you, bringing together your diverse set of personal and professional skills in order to creatively tackle our natural resource challenges and accomplish more for Idaho's environment.

This cannot be done alone. The development of a culture of conservation with the help of you as volunteers has resulted and will continue to result in each Idahoan bearing personal responsibility for the management and conservation of the natural and cultural resources of the state. Through outreach, education, interpretation, recreation and science, you can help lead Idahoans to a better understanding of the responsibilities of stewardship, resource management and conservation.

History of the Master Naturalist Concept

The first Master Naturalist Program was formed in Fort Collins, CO in 1994 as a part of the city's Natural Space Program. The citizens of Fort Collins approved a sales tax to preserve natural space in and around the town. Part of the initiative mandated education and interpretation about these spaces to the public. As a result of this mandate, the first Master Naturalist program was created. This local program trained volunteers to give educational programs to the public regarding the value of natural spaces.

Statewide Master Naturalist Programs have typically been modeled after Master Gardener Programs. The first Master Gardener Program was developed in Washington State in 1973 and has trained over 4000 Master Gardener volunteers in that state alone (Chalker-Scott & Collman, 2006). The Master Gardener program is a function of state extension services and was created out of the need to "assist Washington State University Extension faculty in delivering applied plant and soil science information to individuals, communities and horticulture professionals" (Chalker-Scott & Collman, 2006). After required education, Master Gardeners are set out in the community to provide educational programs, identify plants, insects, diseases, and to provide information to their fellow community members regarding gardening and landscaping. A "rigorous, scientifically based curriculum" is used during the 50 hours of required training, followed by a mandatory 50 hours of service for certification.

In 1996, Texas became the first state to put the Master Gardener model into practice as a state-wide Master Naturalist Program. The Texas Master Naturalist Program (TMNP) has in turn, served as the model for most other state's Master Naturalist Programs, including Idaho's. This program requires 40 hours of training, 40 hours of service and 8 additional hours of training every year for certification. The goal of the Texas Master Naturalist Program is to "develop a corps of well-educated 'Master Volunteers' to provide education, outreach, and service dedicated toward the beneficial management of natural resources within their communities" (Texas A&M University, 2006). Visit http://masternaturalist.tamu.edu/ to learn more about the Texas program.

The Texas program is formed through a partnership between Texas Parks and Wildlife Department and Texas Cooperative Extension. This combination of resources has proven to be a successful partnership in Texas, as the program by 2007 consisted of 35 chapters and had trained 3,400 volunteers. In 2005 the Texas Master Naturalists volunteered 136,000 hours of time toward conservation projects and education (492,100 to date). The estimated value of this volunteer time was $2.38 million. Also in 2005, over 221,000 youth, adults, and private landowners were reached through TMN outreach activities (one million to date). Seventy-five thousand acres of habitat have been affected by volunteer projects.

The positive results from Texas and many other states, along with the success of the Master Gardener Program, suggest the general model of science-based training and volunteer service is a way to educate citizens about conservation issues and promote individual action toward improving and supporting natural resource management. Today there are 26 statewide Master Naturalist-type programs across the country.

Most other Master Naturalist programs have depended upon and are successful because of partnerships. Agencies partnering to create an Idaho Master Naturalist chapter may vary from region to region. The curriculum has been designed to accommodate different agencies, topics and regional concepts. Get to know your partnering agencies that are sponsoring your Master Naturalist Chapter! Consider volunteering for these agencies in their efforts to conserve nature in Idaho.

What is a Naturalist?

Naturalists are students of natural science or natural history. For most, becoming a naturalist is a life-long goal. Learning never stops, as the natural world presents an infinite number of things to investigate. Yet, many would agree that natural history is an almost obsolete term for the study of things in nature-plants, animals, minerals. In fact, the word "naturalist" brings to mind such

historic figures as Carl Linnaeus, John Muir, John Burroughs, and Aldo Leopold. So, are naturalists outdated, old fashioned types of investigators, students and teachers? Hardly! Although natural history may have begun as somewhat unsystematic approach to investigating the environment and its inhabitants, modern naturalist are scientist in the truest sense. They interact with the environment through careful observation, study, and analysis.

Before the current trend towards *specialization* in which scientists tend to know more and more about less and less, professional scientist were naturalist in a broad sense. In the past and today, naturalists are characterized by knowing something about the whole of nature-they are *generalists*. Although usually training in one discipline, they delve into a variety of subjects including botany, entomology, ornithology, mammalogy, herpetology and geology. Naturalists emphasize field investigations as opposed to laboratory work. A naturalist can be defined as someone who possesses extensive knowledge of the natural world. More importantly, modern naturalists understand that in nature rarely anything stands alone. The interconnectedness of all living things to each other and to their environment is the essence of the study of natural history. Therefore, naturalists also become ecologists, ethologists, and environmentalists. They study *relationships* in nature. They are people that understand that the natural world is not separate from human existence-we are surrounded by nature and we act upon it.

But naturalists aren't just trained scientists. They are people with a real appreciation and respect for nature. They are people equipped with the tools necessary to be a naturalist-and not just a quirky hat and binoculars. A desire to ask questions and seek answers, resources for naming and identifying things, a concern for the environment and an awareness of the threats to nature are a few of the naturalist's tools.

The term Master Naturalist, as used in this program, describes the scope of your training and the areas of your knowledge. The natural world comprises a variety of complicated, interrelated subjects and many questions still remain unanswered. None of us have or can truly *master* the natural world. But, we can master the skills of those that came before us, including careful observation, note-taking, asking questions and evaluation. So wear the title as a representation of this program, but understand that becoming a true Master Naturalist is a goal that can only be approached, never attained. Naturalists work to gain the wisdom of those that came before them, to build on that knowledge, and teach those who will come after them.

What is an Idaho Master Naturalist?

Idaho Master Naturalists are volunteers with the interest and desire to give back to their community and willingness to attend the education sessions. The Idaho Master Naturalist Program has three components: education, volunteer service, and advanced education.

Master Naturalist Certification

As set by state guidelines, completion of 40 hours of education, 40 hours of service certifies each participant as an Idaho Master Naturalist. These requirements are the state-wide minimum standards for certification. Local chapters may require more.

My Chapter Requires:

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Hours of core education the first year.

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Hours of advanced education the first year and each year after.

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During your first year of involvement in the Master Naturalist program you are expected to complete a combination of at least 40 hours of hands-on classroom and field experiences delivered by resource experts, professionals and specialists and designed to give you and understanding of natural history and ecological process influencing your local ecosystems. In return for this education, and prior to your certifications a Master Naturalist, you will complete 40 hours of volunteer service within the first year of starting the program. In your second year and each year after, another 40 hours of service and 8 hours of education are required to keep your certification.

A trained volunteer, no matter how little or how much volunteer service they are providing the chapter within a given year is always considered an Idaho Master Naturalist volunteer. Master Naturalist volunteers in any given year are either "Certified" or working toward certification for that year.

Master Naturalist Education

40 hours of service
+ 40 hours of education
IMNP CERTIFICATION

The overall goals of our curriculum are to provide non-biased natural resource information and materials in an interesting format to inspire you to become stewards of your natural resources and to share that information and enthusiasm with others. This curriculum was designed by resource professionals from state wildlife agencies, universities, and nongovernmental partners to provide you basic hands-on knowledge in the function, management and interpretation of the ecosystems and natural resources of your local area. This education can benefit everyone-from professionals wanting to increase the scope of their knowledge to the general public who has an interest in conserving our natural resources.

Because Idaho has such diversity in climate, population and land types, the natural resources (and their uses) in each area of the state are unique. Therefore, your local chapter has organized

and customized the following education categories to fit your local chapter's natural resource systems and needs. Your chapter's syllabus has been pre-approved by the Idaho Master Naturalist State Advisory Committee and State Program.

The core curriculum consists of 21 sections. Your chapter leaders have some flexibility in how they present these chapters, and some flexibility to delete and add chapters. In addition to the core curriculum, two specific tracks have been developed: Citizen Science Track and the Conservation Education Track. Check the sections your chapter will be covering in the education sessions. If you would like a copy of the sections not covered. They are available by request.

- ☐ Introduction to the Idaho Master Naturalist Program
- ☐ American Naturalists
- ☐ Nature Journaling
- ☐ Citizen Science - Learning About the World with Science
- ☐ Citizen Science - Practical Scientific Experience
- ☐ Conservation Education – Interpretation
- ☐ Land Use and Ownership in Idaho
- ☐ Ecological Concepts
- ☐ Ecological Regions of Idaho (large file, available in electronic version by request)
- ☐ Ecosystems: Concepts and Management
- ☐ Forest Ecology and Management
- ☐ Wetlands Ecology and Management
- ☐ Aquatic Ecology and Management
- ☐ Rangeland Ecology and Management

(Sagebrush Ecology was the predecessor to the Rangelands chapter and is not used by most IMN chapters.)

- ☐ Urban Systems
- ☐ Geology and Soils of Idaho (large file, available in electronic version by request)
- ☐ Nature of Naming
- ☐ Plants
- ☐ Ornithology
- ☐ Entomology (Insects)
- ☐ Ichthyology (Fishes)
- ☐ Herpetology
- ☐ Mammalogy

In addition to the core curriculum and the track curriculum, you have been given a binder to organize handouts and publications. Your chapter leaders may have you organize your binders in specific ways, but in general, the binder is to help you keep track of IMN education chapters, informative brochures, leaflets and publications.

Service Projects

Good quality natural resource service projects are never in short supply, nor is there a service project that doesn't fit your interests, skills or abilities. Service projects can be identified through your local chapter partners, by you the volunteer, by the statewide program and program coordinator, or through your local chapter. Volunteer service can be short; one-time projects such as an annual butterfly survey or the service can be long term projects such as regular program delivery at a nature center.

Service project involvement also ranges from a single master naturalist project developed and carried out by an individual to entire chapters developing and carrying out "signature projects" and working on them as a group. Whatever the project or number of people involved, all service is generally performed within the geographic area served by the Master Naturalist chapter in which you were trained. Additionally, all projects must be pre-approved through your local chapter.

Forty hours of volunteer service must be completed for certification one year from the date of your first education class. You may start volunteering before your education sessions are over, or after the education is complete.

The nature and structure of the Idaho Master Naturalist Program is such that volunteer hours can be donated to many different projects involving natural resource agencies, schools, local governments, private landowners, parks and nature centers to name a few. Many projects and volunteer opportunities already exist and are in need of people. Although opportunities already exist, please don't allow this to stifle your creativity. There are many new and exciting ideas for projects still out there to be discovered. Your chapter may have restrictions on where you can volunteer for your Master Naturalist service requirement.

Currently, a number of specific projects and areas of need exist in which volunteers may participate. The future, however, will undoubtedly bring many new and exciting projects. Some of the current and typical service projects that take place in your region include:

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The most important feature you should look for in a volunteer project is how interested you are in doing it. The project should be interesting and you should feel excited about doing it. If you don't, you may not enjoy your service as much as you could. You will have a better experience and perform better work if you are inspired and interested in the project you have chosen.

If you are not sure what you will like, commit to short volunteer projects and perform a variety of tasks until you find something that is suited for your interests and skills.

Another way to choose a project is to find a person or organization with which you like to work. Perhaps you frequent a state park or you like to fish. These factors might influence you to volunteer for the park or in aquatic ecology research. You may know a professional with whom you find it easy and enjoyable to work alongside. This could be a good way to guide you to a project that you will like. Volunteer service toward conservation is for the benefit of Idaho's environment, but don't forget about you! You must be happy and having fun in order to keep volunteering and participating in conservation.

Time spent performing administrative work for your Idaho Master Naturalist Chapter may be counted as volunteer time. Chapters are encouraged to set a limit on the number of administrative hours a member can perform and tally as volunteer time. Organization of chapter events, education, meetings, and service opportunities are needed in order for chapters to run smoothly. Likewise, time spent responding to formal feedback requests from program leaders will be considered valid volunteer time.

Advanced Education

Each year after your first year, 8 hours of advanced education is required. You may choose the education you want to attend. Education can include classes sponsored by the agency you are volunteering for, community education classes, on the "job" education with the biologist or conservation educator with whom you are working. Advanced education options are wide and flexible. Your advanced education must be approved by your agency representative ahead of time. Choose education options that will help you be a better volunteer, further you knowledge on a topic of interest, diversify your knowledge, or strengthen your skills.

- Television programs or educational movies will not be considered advanced training
- Travel time to and from education training will not be counted as education time.
- Idaho Master Naturalist chapters or participants may organize education for their chapter participants.

What are the benefits of being a Master Naturalist?

Master Naturalist volunteers receive many benefits from being involved in the program. Some of the most rewarding, as indicated by other state's volunteers include:

- Helping to make a difference for their State's natural resources both now and in the future.

- Having the opportunity to learn from experts in the field through Master Naturalist training and advanced training.
- Having the opportunity to provide important and valuable natural resource information to others.
- Gaining an appreciation for and understanding of natural environments.
- Having the opportunity to build new friendships and working relationships with people sharing the same interests.
- Individual awards and recognition offered by the state program.

What are the responsibilities of an Idaho Master Naturalist?

Upon beginning your natural resource education, you have one year to complete your volunteer service and advanced education hours to become certifies as an Idaho Master Naturalist. The title "Master Naturalist" and "Idaho Master Naturalist" shall only be used by individuals active in the Idaho Master Naturalist Program. When an individual is no longer actively participates in the program, their designation as a Master Naturalist and/or Certified Master Naturalist becomes void.

The Master Naturalist name, title, and certification should never be displayed as an endorsement; as an advertisement; as credentials; in place of business; or identified with a particular political viewpoint and/or political advocacy. The Master Naturalist program is a public service program established to provide unbiased and scientific based information and management practices. Therefore, the title shall only be used when conducting unpaid Master Naturalist and Master Naturalist Chapter work. Remember, as a Master Naturalist, you are a representative of the Idaho Department of Fish and Game and any other partnering agency sponsoring your chapter.

In addition, Master Naturalists should follow and respect the proper ethics, guidelines, laws and responsibilities as they relate to collecting specimens, species permits, landownership and landowner rights when conducting some volunteer projects. Unless specified in your volunteer project, you do not gain any special rights or exception to the laws by being an Idaho Master Naturalist.

Attaining and maintaining Master Naturalist Certification is your responsibility. An important part of that responsibility is record keeping. Documenting your observations, research, education, service, advanced education hours and the number of people or amount of the resource you were about to reach is your responsibility. The data from Master Naturalist volunteers are very valuable to the Idaho Department of Fish and Game and partners. Well-maintained, accurate records provide a written account of the ways the agency and partners are serving the public and making an impact on our natural resources. These records also ensure the strong support of the program and its volunteers. Record keeping may be submitted by paper or

on an internet site. Your chapter leaders will help you find the proper forms and tell you how to submit them.

Master Naturalist volunteers together natural resource partners can better and manage natural resources, collect data, and reach more people with education programs. In short, Master Naturalist volunteers make these agencies more effective and efficient! As equally important, Master Naturalists also need to strive to manage their own programs by taking on coordinating, committee and/or leadership opportunities with their local chapter. However you occupy your time and talents as a Master Naturalist volunteer have fun with it and know that the program sponsors and our resources are grateful for your time and dedication.

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American Naturalists

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Understand the history and current status of natural history as a discipline.
- Identify significant naturalists throughout American history and discuss their accomplishments.
- Describe the basic skills of a naturalist (e.g. observation, field journaling, species identification, sharing knowledge) and how to apply them in field studies.

Defining Natural History

As science and culture have changed, our understanding of the term "natural history" has also changed. In its earliest usage, natural history referred to the study of science in all its forms in order to differentiate it from ecclesiastical or political history. By the eighteenth century, natural history became a scientific subject. Today, natural history is a term that incorporates several scientific disciplines, mostly the study of living things, but sometimes including meteorology, paleontology, and geology. Defining natural history can be a problem. The word "history," as it applies in this use, has nothing to do with the past. Instead, it means "description." Therefore, natural history is a description of natural systems. In its earlier years, natural history was considered an analytical science. Marston Bates defines natural history as "the study of life at the level of the individual – of what plants and animals do, how they react to each other and their environment, how they are organized into larger groupings like populations and communities." It is the study of the whole organism, rather than the parts such as physiology, biochemistry, and genetics. It is the study of nature in its entirety.

Definition of a Naturalist

A person who studies and teaches natural history is called a naturalist. However, there are a number of variations on that definition. For example, a naturalist is also defined as: "an advocate of the doctrine that the world can be understood in scientific terms," "a biologist knowledgeable about natural history (especially botany and zoology); an expert in natural history;" "a person, often a scientist or writer, who studies and promotes nature;" or "someone who studies natural history, probably in the field rather than the lab." Green defines a "Scientific Naturalist" as someone with an understanding of a group of organisms or ecological communities that includes

knowledge of all the organism's or system's special traits. The scientific naturalist uses this knowledge to create and conduct research.

In its early academic usage "naturalist" was used to refer to a person committed to studying nature: mineral, vegetable and animal. Later, "naturalist" was split into geologist, botanist and zoologist. Even then, "naturalist" was used interchangeably with Greek titles to define a scientist. A person could be called a zoologist as his or her title but would be called a naturalist to define how they conducted their work (primarily field-based). Naturalist also referred to the many non-academics that studied nature. They may be explorers, writers, teachers, or dedicated amateurs, but are all drawn together by a passionate interest in nature and natural systems. A naturalist possesses a great knowledge of organismal ecology, behavior, systematics, distribution, and life history. He or she uses knowledge to create ideas and hypotheses and develops intelligently designed research. Naturalists have passion and fascination for biodiversity and for the organisms that create that diversity.

A Brief History of Natural History

Natural history is commonly considered the progenitor of all natural sciences. It is the oldest science in Western civilization, dating back to Aristotle's observations of animals. The term "Natural History" was first seen in Pliny the Elder's master work *Historia Naturalis*. Ever since this time, natural history has sought answers to the basic questions about the planet's inhabitants. The 18th and 19th centuries and the beginning of British expansion saw natural history study become a formal, regulated discipline. After getting a start in Great Britain, natural history societies flourished across Europe as the British Empire began its exploration and colonization in tropical areas and as England continued its interest in the American colonies. By 1750, Carl Linnaeus developed his *Systema Naturae*, a monumental step that strengthened the field of natural history by creating a common language and taxonomic system with which to communicate. Soon naturalists trained in the Linnaean taxonomy, such as the Bartrams, Nuttall, and Townsend began their famous and intellectually profitable explorations. The incredible natural history text, *The Travels of William Bartram*, is an astonishing trip through the early landscapes of southeastern North America. His detailed descriptions of plants, animals, weather, people, and landscape are as fresh and exciting today as they must have been in his day. Amazingly, although many species' names have changed, the faithful species accounts allow the reader to identify each by pure description.

Natural history in the 18th century was not left to the trained specialist. Many early leaders such as George Washington and Thomas Jefferson were avid naturalists. They enjoyed nature study as a commonplace part of the educated gentry's life. Often they saw natural history as an expression of God's great works and therefore not only worthy of study but requiring study. One only needs to read Thomas Jefferson's papers to understand the importance that natural history study and

experimentation had in his life. When Thomas Jefferson commissioned Meriwether Lewis and William Clark for their epic journey of discovery across the western United States, he gave them specific instructions for observing and recording the natural world.

Although neither was trained as botanists or zoologists, their observations and descriptions of hundreds of new and unknown plants and animals were devoured by a nation highly interested in natural history and fascinated by new information and ideas. Lewis and Clark's lack of formal training was mitigated by the fact that natural history was a regular part of early education and most people had a working knowledge of its concepts and descriptive methods.

The Nature Study Movement

During the late Victorian Era, Liberty Hyde Bailey crafted the nature study movement. Bailey, a zoologist, served as director of the Cornell College of Agriculture and started a nature study program to begin interesting country students in better farming practices. This event heralded the beginning of the nature study movement, a time of great interest and passion for natural history study throughout the United States. In 1903, Anna Botsford Comstock succeeded Liberty Hyde Bailey as director of this program and, over the course of thirty years, fully developed the nature study movement. The nature study movement emphasized a direct appreciation of nature and its beauty instead of a more analytical study of the natural world. Comstock, the first female professor at Cornell, recognized a need for natural history education for all students. She believed fully in the importance of nature study for children and that "the reason why nature study has not yet accomplished its mission, as though core for most of the required work in our public schools, is that the teachers are as a whole are untrained in the subject." To correct this shortcoming, Comstock published the *Handbook of Nature-Study* in 1911. This large volume is chocked-full of lessons, photography, and appropriate readings. The creation of this study guide made nature study accessible across the country, and Comstock's book became a common text in most American classrooms.

Decline of Natural History Study

During this same time period, giants in nature writing such as Joseph Wood Krutch and Edwin Way Teale were publishing works to the great delight of the nation. Nature study societies such as the Audubon Nature Clubs were developed and the public was captivated by nature. Natural history knowledge was considered an important part of primary, secondary, and university educations and naturalists were well-respected members of university faculty.

The nature study movement continued until the nexus of three events: the rise of "hard sciences," migration from country to city and suburbs, and World War II all led to its decline. Comstock

was aware of these changes and indicated as much in the 24th edition of the *Handbook* in 1939. Her forward read:

> *Some readers of the Handbook have suggested that the new edition be oriented away from the nature-study approach, and be made instead to serve as an introduction to the natural sciences… But the nature-study approach has been preserved. The kernel of that method of treatment is the study of the organism in its environment, its relation to the world about it, and the features which enable it to function in its surroundings… The promising science of ecology is merely formalized nature-study… The truth is that nature-study is a science, and is more than a science; it is not merely a study of life, but an experience of life.*

However, the march away from nature study and toward the modern scientific process had begun as scientists began to see the benefits of mathematical proofs, quantitative data, and statistical analysis in the natural sciences. Traditional natural history study focused on observation and description, both of which are subjective methods that depend greatly on the observation skills and descriptive writing of the observer. The experiential nature of natural history study made it impossible to duplicate observations. Observations of wildlife, weather events, even flowering of some plants are fleeting at best. As natural history has fallen out of favor in the academic community, so too has the title of naturalist. Because it has been used to refer not only to scientists and dedicated field naturalists, but also to people who study nature out of a love for its beauty and for no other purpose than to enjoy nature study, it has come to represent something weaker and softer than a "hard scientist" would like to claim. Soon, naturalists in many universities were thought of as old-fashioned, out of touch, and unnecessary lacking empirical though and scientific rigor.

In response to this trend, Marston Bates, in his book *The Nature of Natural History*, stated that although ecology is seen as "erudite and profound [sic] while natural history is popular and superficial … as far as I can see, both labels apply to just about the same package of goods." Bates believed that both experimental and observational methods were important. That all who studies life science should have a solid foundation in natural history upon which they build mathematical models and theoretical thought. Other natural historians rallied to create scientific rigor in natural history, one of the best examples being Joseph Grinnell, zoologist at the University of California at Berkley. Grinnell, in an effort to make field studies and field observation as meticulous and detailed as possible, developed a standard for field note-taking that is used to this day. Commonly called the Grinnell Method, it emphasizes a rigid form of note-taking that included categories for weather, location, habitat type, observations, species lists, and other required entries that would assist the naturalist in his or her field observations. It also benefits the naturalist who may read notes taken by another person to find the original field

location. These original field notes can be valuable in tracking the temporal distribution of species, determining climate change, or simply as a source of anecdotal information.

Despite these efforts, the hammer stroke finally fell on natural history during and after World War II. The race to produce atomic weapons and, after that, to be the first in space, stressed the importance of mathematics, physics, and other non-biological sciences. Biology moved from the field into the laboratory as new tools made cellular biology and microbiology more accessible. At the same time, the post WWII flight from the country to the city and suburbs cut a large percentage of the population's daily contact with nature.

Natural history: the study of species, their habits, niche, interrelationships and status has been formally conducted for hundreds of years. In the past 60 years we have seen a dramatic decrease in natural history education in the university system and society's knowledge of basic natural history. A few hardy academics still claim the title of "naturalist." Famed ecologist, E.O. Wilson, even named his autobiography *Naturalist*, but these people are few and far between. And, while natural history knowledge in our society has declined, there are still many amateur naturalists carrying on the tradition as best they can.

Knowing its beginnings, practice through the years, and why it has declined will help in the search for ways to bring it back to the classroom and our collective understanding. The Idaho Master Naturalist Program is doing its part to revive natural history study through sharing natural history knowledge and the practice of naturalist skills by its many trained naturalists.

Naturalist Skills and Tools

The ability to observe, to see keenly and then draw conclusions based on all elements noted is the most important skill a naturalist possesses. Honing this skill is a lifetime's work. Good observation is built upon a foundational knowledge of habitats, species, species behavior, and distribution. We see more because we understand more of what we are seeing. Therefore observational skill goes hand-in-hand with the ability to use a variety of tools available to the naturalist. These include the journal, field guides, identification keys, collection equipment, optics, etc. Understanding how we observe and the tools used in observation is the first part of a lifetime's journey as a naturalist.

Observation Skills

Naturalists learn everything they know through patient observation and study. Therefore, naturalists must hone their observation skills in order to collect as much information as possible. How we observe can be different, depending on the individual; however there are some methods that work for everyone:

- Increase your patience in order to slow down and watch.
- Pay close attention to your surroundings: who, what, when, where, & how.
- Be aware of animal reactions, plant locations, interactions between individuals, and any causal effects of note.
- Ask questions that can be answered through observation.
- Know yourself: what affects your concentration, what are your likely to overlook.
- Use available tools (journals, field guides, experts, etc.) to increase your knowledge and understanding.
- Be curious.
- Be ethical.

Field guides, dichotomous keys, and reference books

Identification of plants, animals, geologic formations, weather conditions, etc. is key to good natural history study. A naturalist is lost without this knowledge and, in turn, this knowledge is only as good as the resource the naturalist is using. Therefore, understanding how to use the variety of reference books available is critical to the naturalist's success. We are lucky to have hundreds of years of natural history information, gathered by early naturalist counterparts and present day observers, at our disposal. This information is organized in a variety of forms such as field guides, identification or dichotomous keys, reference books, professional journals, and nature writings. Each type serves a particular purpose.

Field guides

Field guides are books, usually written about particular taxa in a particular region. They typically contain short descriptions of each species in that taxa found in that region along with a drawing or photograph of the species and, perhaps a range map or range description. A classic example of a field guide is *Peterson's Field Guide to the Birds of Eastern and Central North America* by Roger Tory Peterson. Field guides can be organized in several ways such as by family, bloom time, flower color, range, etc. As their name implies, field guides are often used in the field and therefore must be small enough to fit into a backpack or back pocket.

Identification or Dichotomous Keys

An identification key, also known as a dichotomous key, is a tool used to identify a particular species. As the name implies, a dichotomous key works by giving two (or sometimes more) choices at each level. Choosing one alternative leads to the next level, narrowing the alternatives until the final choice leads to the species in question. Dichotomous keys can be fairly simple, such as those found in many field guides, and may only contain a few of the many species found in an area. Or they may be complex keys (often called taxonomic keys) that include all species for a group and that require

knowledge of specialized terminology or examination of characteristics not always available in the field.

Reference books

Books that are either too large to take into the field or that contain copious amounts of information on a particular subject are often called reference books. These books are important to the naturalist's library as they offer the background information on species or ecosystems that cannot be obtained in a field guide.

Keeping a Journal

The journal is the most important tool a naturalist has. It contains all the observations he or she makes and, therefore, serves not only as an observation record but also as a reference tool. Journals assist in the learning process, scientific study, and personal expression. A journal is a reflection of the author's interests and writing style. Therefore, it must suit the needs and goals of the author. Most journals include daily entries; in fact "journal" is a derivation, through French, from the Latin word *diurnalis* which means "of a day." Often, journals that are kept for personal pleasure or interest may contain more than just observations of the day. They could also include poetry, illustrations, and other creative elements. Some journals may contain more illustrations than written observation. These are a delight to look at and are a great way to describe the natural world. If kept for research purposes, i.e. to document observations about a particular area, habitat, species, etc. for the purpose of scientific study the journal is usually more formal; including particular standard elements.

Why Keep a Field Journal?

A field journal is a way to codify the observations and revelations that arise from an outdoor field experience. It serves as a memory of natural history events, aids in observation, records behaviors and habits of flora and fauna, and documents unusual sightings or rare species. It is a way of making field observations empirical through the careful recording of events or it can be a creative outlet, using creative writing and drawing to explore our connection and relationship with the natural world.

The human memory is a capricious thing. What we think will be permanently etched on our mind is often easily forgotten. Our memory of events can also change due to a variety of influences, including our own bias. Because of this we cannot trust ourselves to remember events, measurements, or field markings with faithful accuracy. We must record observations at the moment they occur in order to consider them legitimate. This type of record keeping provides the opportunity to compare observations to ones made earlier, to consult field guides and other references, and to share these first-hand observations with our colleagues. It also gives us the benefit of reflecting on them at a later time; perhaps even drawing new conclusions about them.

Natural history study is based on this type of observation and attention to detail. Only through hours of patient watchfulness and proper record keeping can we learn about and understand the behaviors of birds, pollination of plants, or any of the myriad other actions and interactions of species. The journal aids in field study by allowing the observer an immediate place in which to record their observations while they are fresh and true. Writing and/or sketching require the observer to slow down and record all the actions or physical elements of a species or community, thereby evoking the attention to detail necessary to their craft. The observer often finds that they see details that would have normally been missed, such as hairs on a plant stem or a particular wing movement, if they had not been required to look closely at the organism and record the information immediately.

Our current collective knowledge of animals and plants is derived from hundreds of years of careful observations and journal keeping by professional and amateur natural historians and their subsequent publications. Although we have a basic, and sometimes thorough, understanding of many organisms, there are still millions of new species to discover and more to be found out about even the most prosaic species. Good record keeping will give us further insight into the ecology of these species.

As we are discovering new species, the journal provides the important element of proof of sighting. Documenting sightings of new or rare species is critical to give veracity to the event. Being able to show a field record of a species' location, actions, and characteristics gives credibility to the sighting, particularly if the observer could not collect a voucher specimen. If a voucher specimen exists then information about the collection location, conditions, collection method, and related events must accompany the specimen.

Many people, however, are not as interested in maintaining a journal to record observations related to a scientific interest. Their purpose instead is to explore their relationship with the natural world, to derive pleasure from interactions with flora and fauna, and to develop knowledge of and a connection to nature through journaling. Their journals may not follow a regimented format but may include a variety of observations, poetry, drawings, and other creative methods of exploration. These journals, while not always relevant for scientific purposes, are useful to their creators and often inspirational to others. These nature journals are not less than the formalized field journal but are different, vital ways to learn about nature.

Elements of a Field Journal: Seven Essential Entries

Whether you follow the strict Grinnell methodology or simply keep a periodical record of forays into natural communities, there are certain elements that should be included with each journal entry. These seven elements ensure records that are useful seven days or seven years from the time of entry. They are:

Date and Time

The first element of each journal entry should include the date and time of day. This allows the recorder to track phenological events, can be consulted when planning trips to see the same events, and can even be used to track changes in weather patterns. Without a date the journal entry loses a great deal of its usefulness.

Location and Route

The location and route of any trip should be as specific as possible. It should include the state, county or parish, nearest town or area (park, national forest, etc.), and the particular trail or natural area in which you are. Be as specific as possible because you or someone else may want to return to this area for future study. Record landmarks and GPS coordinates if possible.

Weather

Record temperature, precipitation, wind speed and cloud cover. These meteorological elements can dramatically affect the day's observations. A cool, cloudy day will yield few dragonflies and butterflies; a rainy night will increase salamander sightings. Certainly weather can affect collection methods and capture numbers. It is important to know why you are seeing what you are seeing and weather certainly impacts that.

Habitats

Any information that can be recorded about the plant community, forest type, geology, soils, and water sources of the area in which you are studying is important.

Vegetation

Describe the dominant plant species in each forest layer as well as any vegetative phonological events (what's blooming, what's in fruit, etc.) Use this, along with the habitat description, to "paint a picture" of the location that immediately gives an impression of the site.

General Commentary

Include in this section all other observations, information about your trip, descriptions of unusual activity, collecting methods, etc. Describe the events of the trip in good, descriptive prose.

Species List

A list of species should end your journal entry. Separate the species by major taxonomic groups; plants, mammals, herps, insects, etc. and include scientific names if possible. Using scientific names in this manner is the best way to learn them.

Field Notebooks and Field Journals

There are two components to a field journal system, the field notebook and the field journal. Both are integral parts of good record keeping. The field notebook is the primary recording device. In it are written all the observations as they occur, in chronological order. This information will later be entered in the field journal. The field notebook is an important companion of most field scientists and many amateur nature enthusiasts. Many use them as all-purpose recording devices and include not only their field notes but telephone numbers, meeting notes, and schedules. The field notebook is typically a small, notebook that fits into a pocket for ease of carrying. It is best not to use a larger notebook that must either be carried by hand, which can be cumbersome when needing quick access to binoculars, or in the backpack. An inexpensive 3” x 5” flip-top notepad is quite adequate. A pencil is the only implement that should be used to write in the notebook. Pencil markings will not run when wet, unlike ink, and can be used to write on waterlogged paper. Pencil is also an excellent drawing tool and can be used to create renderings of specimens for identification later.

The field journal is the permanent record of all field observations, research, and collections. In it, all the notes from the field notebook, along with ideas derived from those observations, are organized. The field journal is traditionally kept in a loose-leaf notebook with sections for daily observations, species records, and collection inventories (if applicable), however some people keep their journal in bound blank books, composition notebooks, and even computer files. Whatever format that meets the needs of the user is appropriate.

The field journal is where the seven essential entries are recorded for each day or field excursion. Date, location and route, weather, and habitat are entered first, forming a header for the rest of the entry. Next, description of the vegetation and general commentary take up the majority of the entry. These should be entered as full sentences, using good descriptive language. At the end of the entry are the species lists. They won’t include all species in the study area (that would be difficult) however they do include all species of interest; species that are being studied, species that interact with the study subject, or species that are particularly noteworthy.

Field journals may also include species records. These are separate entries, kept in a separate section of the notebook, and are divided by species. Species records hold all the information known by the author about each species listed. They typically contain natural history and sighting dates for each species.

Field journals are traditionally kept on an annual basis with a fresh, new journal started at the beginning of each year. They are kept at home, or on longer field expeditions, back at camp or the hotel room. Because they are the permanent record of the field experience they should be

kept in good condition and never exposed to the rain, mud, and coffee stains that often mark the field notebook. Joseph Grinnell, former curator of the University of California Museum of Vertebrate Zoology, cautioned his students to write their field observations as soon as they day was done and before supper was taken. He believed that keeping a field journal required a certain level of discipline and that discipline would be beneficial in other parts of the naturalist's life.

Keeping a Journal for Science and Art

Now that we have discussed the usefulness of field journals, along with their basic components, let us explore more specific methods and applications. Let's take a closer look at the Grinnell Method (the style of choice for field biologists), the creative and expressive nature journal, and teaching nature journaling to children and adults.

The Grinnell Method

Joseph Grinnell (1877 – 1939) was the highly influential director of the University of California's Museum of Vertebrate Zoology. A great collector and naturalist, Grinnell's theory of ecological niche, published in 1924, became one of the organizing principles of ecology. Grinnell was highly influential in shaping the philosophy of the national park system and in the development of a system of field note taking that is still used today. Grinnell began his career during the time of increased scientific specialization and decreased interest in natural history study. In response to the need for scientific rigor in natural history Grinnell developed a disciplined, systematic approach to field note taking that he passed along to his students. This system, built around existing methods, consists of a tripartite record (Journal, Species Account, and Catalog) that Grinnell integrated into his field journal. Grinnell emphasized the value of the field journal as a tool of science, filled with first-hand observations, some of which may not be considered immediately useful but he felt may be useful in the future. He thought of the field journal as a tool of immediate use by the recorder and as a record for future study.

The following comments by Grinnell, regarding field notes, demonstrate his beliefs:

"The field collector is supplied with a separate-leaf notebook. He writes his records on the day of observation with carbon ink, on one side of the paper only. The floral surroundings are recorded, especially with respect to their bearing on the animal secured. The behavior of the animal is described and everything else which is thought by the collector to be of use in the study of the species is put on record at the time the observations are made in the field. The camera is as important a part of his outfit as the trap or gun. These field notes and photographs are filed so as to be as readily accessible to the student in the museum as are the specimens themselves.

At this point I wish to emphasize what I believe will ultimately prove to be the greatest value of our museum. This value will not, however, be realized until the lapse of many years, possibly a

century, assuming that our material is safely preserved. And this is that the student if the future will have access to the original record of faunal conditions in California and the west wherever we now work. He will know the proportional constituency of our faunae by species, the relative numbers of each species and the extent of the ranges of species as they exist today."

Recently, the University of California's Museum of Vertebrate Zoology made Grinnell's predictions a fact. They have begun a five-year undertaking called the Grinnell Resurvey Project. This wonderful validation of Joseph Grinnell's work involves resurveys of over two hundred of his original study locations, using Grinnell's meticulous notes as baseline data. They hope:

1. "To document changes in communities and the geographic range and relative abundance of species;

2. To relate observed dynamics to changes in habitat, climate and invasive species and, thereby, to understand what makes some species sensitive and others resilient to change;

3. To develop predictive models of how vertebrate diversity (at genetic, phenotypic, species & community levels) will respond to continuing change and efforts from the conservation community to protect diversity; and

4. To provide a new benchmark against which these predictions can be tested" (Museum of Vertebrate Zoology).

The three-part journal keeping method used by Joseph Grinnell offers a great deal to the modern student. It encourages the self-discipline necessary to good science, provides the all-important written record for field study, and increases the precision of the science being done. It also emphasizes structure and strict adherence to a standard method. The Grinnell Method, or a slightly modified version, is arguably the best method for all serious naturalists to use in their fieldwork.

The Nature Journal

The Nature Journal is in some ways similar and in others very different from the formal field journal we have just discussed. Often the nature journal is a personal creation that embodies the individual's interests in a creative and artistic way. The nature journal is creative, lacks the structure of the field journal, combines several methods and media such as drawing and sketching, painting, and creative writing. Certainly it can contain many of the elements of a field journal, but the main difference is the ability of the writer to explore nature through a variety of methods.

Because it is so tied to the interests and skill of the journal writer, the nature journal may often display a mix of creative and formal styles. It may include scientific and aesthetic observation. At times its writing may be creative and at others quite technical in nature. It may contain ideas developed through perception and others through analysis. The layout and presentation of ideas and observations is left up to the writer or artist and follows no set guidelines. The nature journal may offer opportunities for meditation and personal healing, for reflection and focus on a subject. Often it is a way for the observer to find their own voice and to find new ways to explore nature.

Glossary Terms and Definitions

- Field Journal - The permanent record of all field observations, research, and collections.
- Field Notebook - The primary recording device. In it are written all the observations as they occur, in chronological order. This information will later be entered in the field journal.
- Naturalist – One who studies natural history.
- Natural history - The study of nature, its components (living and non-living), and how they interact to each other, and their environment.
- Nature Journal - A creative journal, focusing on nature study that lacks the structure of the field journal. A nature journal combines several methods and media such as drawing and sketching, painting, and creative writing.

Study Questions

1. What is natural history?

   The study of nature, its components (living and non-living), and how they interact to each other, and their environment.

2. Anna Botsford Comstock was a key figure in what movement?

   The Nature Study Movement

3. What is a naturalist's most important skill?

   Careful observation

4. What are some of the causes to the decline of natural history study in universities and primary education?

   Urbanization of the population, emphasis on mathematics and "hard sciences," emphasis on laboratory based science

5. What kinds of resources are commonly used by naturalists?

   Field guides, dichotomous keys, reference books, journals

6. What are the seven essential entries in a field journal?

   Date, Location and Route, Weather, Habitats, Vegetation, General Commentary, and Species List.

7. Why is it important to keep a field journal?

   The journal is the most important tool a naturalist has. It contains all the observations he or she makes and, therefore, serves not only as an observation record but also as a reference tool. Journals assist in the learning process, scientific study, and personal expression.

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Forest Ecology and Management

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Describe forest ownership in Idaho.
- Explain the concept of shade tolerance and rank common Idaho conifers relative to shade tolerance.
- Understand and describe the process of succession in Idaho forests.
- Define silviculture and describe stand regeneration, thinning and at least one other silvicultural practice.

Idaho's Forests

Forest Ownership

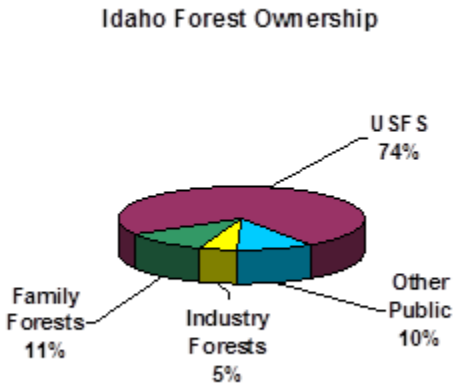
Over 41% of Idaho is forested. The largest piece is managed by the U.S. Forest Service (74%). The rest is managed by other public agencies such as the State of Idaho or the U.S. Bureau of Land Management (10%), family forest owners (11%) or forest product companies (5%).

"A nation that destroys its soils destroys itself. Forests are the lungs of our land, purifying the air and giving fresh strength to our people."

-President Franklin Roosevelt

The ownership mix may change considerably depending on where you are in the state. For example, 44% of all forested land in the panhandle counties is owned by family forest owners.

Forests embody many values, provide many different benefits, such as wood products, water, and valued places. Some of these benefits can be measured in dollars and cents (wood products, grazing). Other benefits are, not easily measured, more or equally important to many people. The primary management objectives vary by ownership. Most forests are managed for a simultaneous combination of values and benefits.



Forestry

Forestry is "the art, science, and practice of creating, managing, using, and conserving forest resources for human benefit and in a sustainable manner to meet desired goals, needs and values" *(Dictionary of Forestry)*. Forest management can vary considerably in intensity. It can be very intensive "fiber farming" of hybrid poplar. Whereas, some forests are managed with as little human input as possible by managing people's entry to a wilderness area. Most forest management falls somewhere between these two ends of the spectrum.

The expression "forest management" can be a confusing term to some people. In this chapter, the attempt will be to use it neutrally in application to the whole spectrum of uses. Humans have a role in managing forests, often unintentionally, through influences on climate or by introductions of invasive species.

Forest Ecology

To meet a wide variety of ownership objectives, most forests in the Rocky Mountain States are managed in ways that mimic natural processes of forest ecology and succession. To do this, foresters must have a solid understanding in forest ecology. Forest ecology is the study of the "forest as a biological community, with the interrelationships between the various trees and other organisms constituting the community, and with the interrelationships between these organisms and the physical environment in which they exist" *(Forest Ecology)*.

All Of The Parts

A famous quote of Aldo Leopold, famed ecologist and holder of 2 forestry degrees, was advice to practicing ecologists was to follow "the first precaution of intelligent tinkering…keep every cog & wheel". What are the "cogs and wheels" of a forest? The most obvious cog is the function of trees. Idaho has a wide variety of trees and forested habitats.

Most of Idaho's forests are coniferous, meaning they are dominantly composed of trees that bear seeds in cones. Idaho forests also have a number of non-conifer tree species, sometimes referred to as "hardwoods," including cottonwood, aspen, birch, willow, and alder.

Shade Tolerance

Tree species have evolved unique strategies to compete with other trees and vegetation, responding to many different environmental factors. One factor is shade from other trees. Each tree species differs in its ability to tolerate shade. The graphic to the right illustrates the relative shade tolerance of common Idaho tree species.

Shade-Intolerant Tree Species

As the name implies, shade intolerant species grow poorly in shade. They grow very rapidly in full sunlight to occupy a site, after some kind of disturbance, historically fire. Examples of

relatively shade intolerant species include larch, lodgepole pine, ponderosa pine, and white pine. All of our deciduous trees and shrubs are considered shade intolerant.

Shade-Tolerant Tree Species

Shade tolerant species survive under shade better than other species. Their strategy is to outlast the competition. Shade tolerant species tend to grow slower than shade-intolerant species. They can release, grow faster, after shade intolerant trees have died, eventually taking their place in a process called succession. The term is shade tolerant not shade loving. There are no shade-loving trees in Idaho but there are shade-tolerant trees. All trees struggle to capture as much sunlight as they can. There may be only cedar in a shaded understory, not because it loves shade but because it out competes other tree species in a shady environment. A shade tolerant tree will grow better in full sunlight than under a canopy. Heavily shaded cedars are stressed after an overstory is removed likely due to the abrupt change in conditions more than an affinity for shade.

Idaho Conifers Tree Species Shade Tolerance	
	Shade Intolerant Tree Species (tend to occur earlier in succession)
	western larch
	lodgepole pine
	ponderosa pine
	western white pine
	Douglas-fir
	Engelmann spruce
	subalpine fir
	grand fir
	western red cedar
	western hemlock
	Shade Tolerant Tree Species(tend to occur later in succession)

Big Trees

Big trees capture peoples' imagination. The University of Idaho coordinates the Big Tree Registry program in Idaho. The purpose of the program is: to locate and recognize the largest known species of its kind that grow in Idaho; to obtain the cooperation of the tree owners to protect and preserve these specimens as landmarks for future generations to enjoy; to stimulate interest in and a greater appreciation of trees - their worth as a natural resource and as individual specimens. To see the list or nominate a tree for the program, see:

http://www.uidaho.edu/extension/forestry/content/idahobigtree

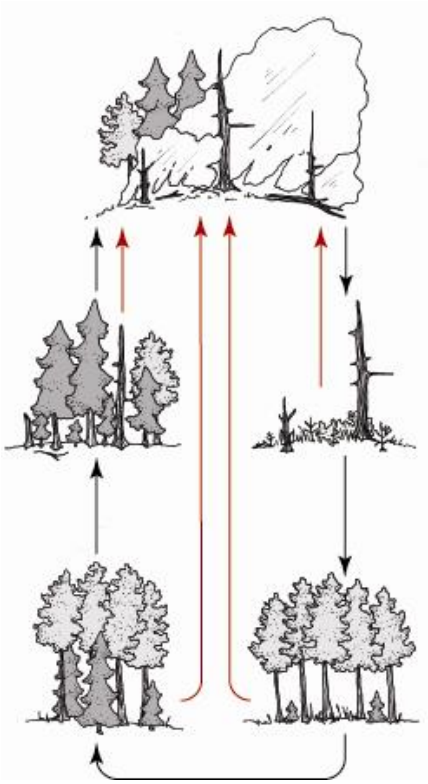
Forests Are More Than Trees

A forest is more than trees. It includes shrubs, forbs, and grasses; soil, microbes in the soil, other parts of the physical environment; wildlife and are popular recreational destinations.

Succession

Learning the "cogs and wheels" of a forest is only part of caring for it. It is just as important to understand how the various parts function in relation to one another. There are many levels of forest function. One of the most important to understand is succession. Succession is the gradual

replacement of one plant community by another. Trees are such a dominant presence in a forest ecosystem; described changes in forest succession are relative to trees**.**
In Idaho forests, succession commonly starts with some type of major disturbance, after which the site is quickly occupied by grasses, shrubs and other shade intolerant species like pine or larch trees. These trees compete by growing very fast, taking full advantage of space created by a disturbance, such as a windstorm, insects, disease or fire. Historically, the most common disturbance in the Inland Northwest has been fire. Over time, other species that are more shade tolerant become more prominent in the stand. This process continues barring more disturbances. The result is a climax forest, dominated by the most shade tolerant species the site can support.



Historically, many Inland Northwest forests never reached the climax stage. A stand replacement fire or other disturbance interrupted and started the process of succession all over again. Succession in western forests has been shaped by ground fires, which occurred every 5-60 years, depending on the site. Ground fires killed small trees coming up in the understory and left large trees with thick, fire-resistant bark. Historically, drier sites rarely had stand replacement fires because frequent ground fires reduced fuels and maintained open stands of ponderosa pine. In mid-elevation forests, many fires would have been mixed severity fires - a mosaic of both ground and stand-replacing fire with some of the pieces of the mosaic being quite large.

Trees are not the only plants that change with different successional stages. For example, many brush species and grasses are found in earlier stages of succession. Different animal, insect, and fungi species also increase or decrease in response to the successional vegetation changes. Some terms used in conjunction with forest succession are:

- **Seral Species:** Various plants which occur in succession before climax. These species will be replaced.
- **Seral Stages** or **Seres:** Plant communities occur in succession before climax.
- **Pioneer Species*:*** The very first species to seed into open areas following major disturbances.
- **Climax Species:** Survive/establish in shaded understory; persist for long periods.

Forest Habitat Types

One way to understand how succession takes place across the landscape is to understand habitat types. This term does not refer to wildlife habitat, though the system can be used to describe wildlife habitat. Habitat types are a land classification system based on patterns and trends of how trees and other plants grow on the landscape.

The Climax Plants & Trees Reveal the Site

Succession follows different paths, depending on a site's moisture, soil and other factors. Habitat types are based on the idea that, on a given site, the same successional patterns will repeat after disturbances and that the climax forest plants and trees are a meaningful index of soils, topography, precipitation, other factors affecting the growth of trees and other organisms. In some regions, similar site classification systems are also known as plant associations, though there are differences between systems (e.g., some integrate topography, soils, and other features more directly).

Habitat Type Organization

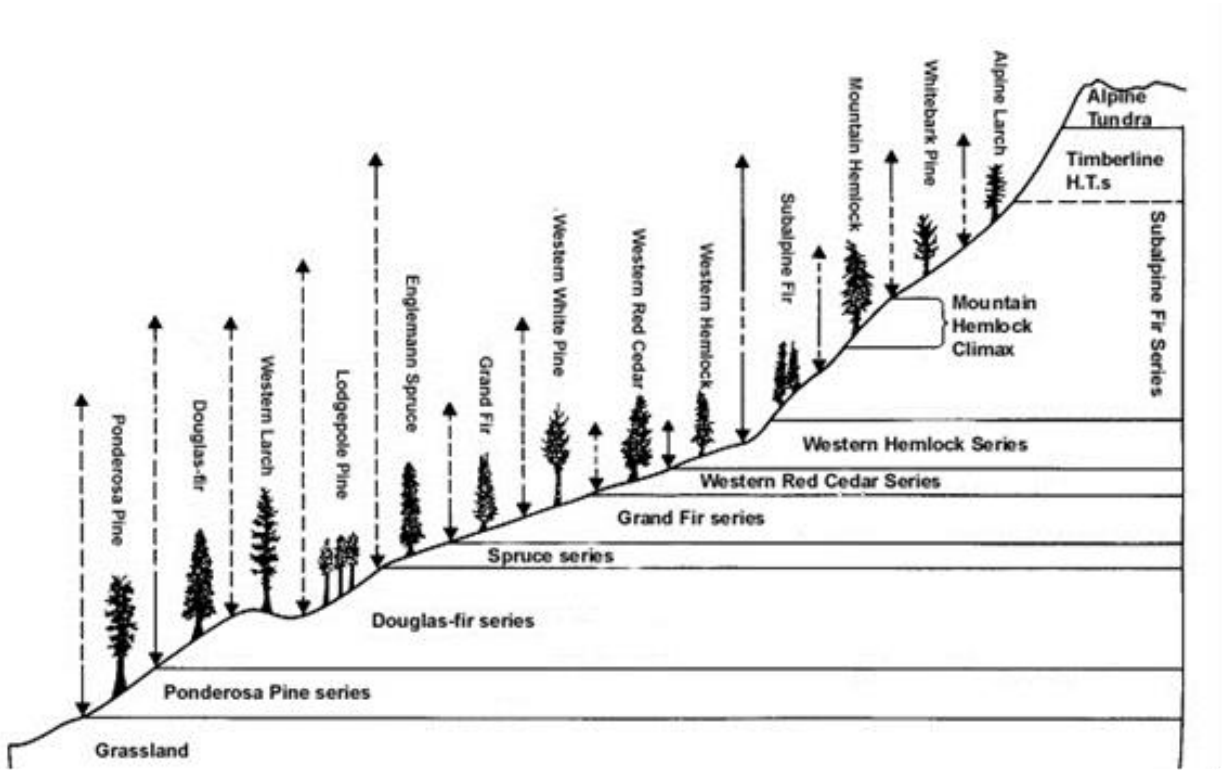
Habitat types have three basic levels: **series, habitat type** and **phase**. Series is identified by the climax tree species, usually the most shade tolerant tree capable of growing on the site. Series is not identified by trees growing on site now but in the future at climax. There are grand fir series of habitat types, a hemlock series of habitat types, etc. Each series is further subdivided into habitat types identified by an understory plant characteristic for the type. For example, the grand fir series has eight habitat types. The habitat type can further be broken into phases that name a second common understory plant.

Identifying Habitat Types

Climax species are progressively more shade tolerant on sites that are moist. Most habitat types change with available moisture. Since moisture tends to increase with elevation, habitat types tend to reflect that (e.g. hemlock habitat types higher up a mountain, ponderosa pine types lower down the mountain. See chart on page 6. Habitat types also reflect effective moisture available for plants. Wetter types found on northern versus southern aspects, different types of soils (e.g. a soil with a deep ash layer). Frost pockets and similar phenomena can also affect climax vegetation.

Identifying the series level of a habitat type can be comparatively simple. Find the most shade tolerant species in the understory. If there are 10 or more hemlock in the understory per acre, that is a hemlock habitat series. If Douglas fir is the most shade tolerant tree found it is likely a Douglas-fir series. In some cases, extensive repeated burns have eliminated seed sources for climax tree species. However, because of historical fire exclusion and partial harvesting of early

successional species (e.g. pines and larch), most Idaho forests usually have some of the most shade tolerant species capable of growing on that land.



Distribution of forest trees in the Rocky Mountains of northwestern Montana. Arrows show the relative elevational range of each species; solid portion of the arrow indicates where a species is the potential climax dominant (late-successional) and the dashed portion shows where it is seral (early successional). (After Pfister et al., 1977).

Determining the habitat type or phase level is more difficult because it requires identification of a variety of understory plants, essentially, an evaluation of the presence and abundance of key indicator plants. That appraisal is completed using a dichotomous key to determine the habitat type or phase. The genius of this system is that climax forest conditions do not have to be present to apply the key. Succession is often more rapid for understory plants than trees. The mix of key understory indicator plants found on the site can help predict the ultimate climax forest. The following is an example of one series Douglas fir and its nine associated habitat types. The scientific name is followed by the common name.

<u>Pseudotsuga menziesii</u> (PSME) Series **(Doulglas-fir)**

- Pseudotsuga menziesii/Physocarpus malvaceus h.t.
  (PSME/PHMA; **Douglas-fir/ninebark)**
- Pseudotsuga menziesii/Vaccinium caespitosum h.t.
  (PSME/VACA; **Douglas-fir/dwarf huckleberry)**

- Pseudotsuga menziesii/Vaccinium globulare h.t.
  (PSME/VAGL; **Douglas-fir/blue huckleberry)**
- Pseudotsuga menziesii/Symphoricarpos albus h.t.
  (PSME/SYAL; **Douglas-fir/common snowberry)**
- Pseudotsuga menziesii/Spiraea betulifolia h.t.
  (PSME/SPBE; **Douglas-fir/white spiraea)**
- Pseudotsuga menziesii/Calamagrostis rubescens h.t.
  (PSME/CARU; **Douglas-fir/pinegrass)**
- Pseudotsuga menziesii/Carex geyeri h.t.
  (PSME/CAGE**; Douglas-fir/elk sedge)**
- Pseudotsuga menziesii/Festuca idahoensis h.t.
  (PSME/FEID; **Douglas-fir/Idaho fescue)**
- Pseudotsuga menziesii/Agropyron spicatum h.t.
  (PSME/AGSP; **Douglas-fir/bluebunch wheatgrass)**

Accurately identifying habitat types can be challenging. A good plant identification booklet and field courses will help. Flowers help to identify understory plants. Identifying habitat types in the late spring or early summer may be easier or ask a forester for help.

How Can Habitat Types Be Used?

Habitat types can help in understanding successional pathways. Knowing a site's successional pathway helps foresters make forestry decisions. It can also better help in understanding the ecology of the forest. A habitat type is a name of a specific, predictable successional path. Knowing the habitat type gives some clues as to which species to manage to favor. For example, white pine probably occurred on a hemlock habitat type historically, even if there is no white pine on the site. By contrast, western red cedar probably never occurred on a site with a Douglas-fir habitat type in the last few thousand years.

Do Plant Communities Have Distinct Boundaries?

Plant ecologists have debated whether plant communities are distinct or continuous. Even advocates of the distinct school of thought acknowledge transitional areas, ecotones, which cannot be delineated as one type or another. There may also be small areas of different habitat types, inclusions, often closely related, within a given management unit. Generally, in Idaho's rugged terrain, habitat types are often distinct enough to be used for management decisions. The system works well.

Forest Cover Types Do Not Equal Habitat Types

Forest cover types are based on current tree cover. They change over time, depending on the type and extent of disturbance or forest management. Most non-foresters may refer to forests by cover type not habitat type. A weekend camping trip may be described as, "Our campsite was next to the creek, near the aspen forest, on the hill." Aspen forest, used this context, refers to the cover

type-that is there now. Habitat types refer to future tree cover or the dominant species at climax. For example, Idaho has much less ponderosa pine forest cover type now than it did historically. By contrast, there is nearly the same amount of land in the ponderosa pine habitat types as occurred 150 years ago. Habitat types are based on potential climax vegetation. That potential remains the same, barring major geological events or climatic trends. Some common forest cover types in Idaho include aspen forests, juniper forests, ponderosa pine forests, whitebark pine forests, mixed conifer forests and lodgepole pine forests.

Aspen is the predominate cover type in this photo, but without a closer look, the habitat type is difficult to determine.

Silviculture

Silviculture is "The art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet diverse needs and values of landowners and society on a sustainable basis."

Silviculture includes all practices used to manage a forest, regardless of whether primary management objectives are water quality, wildlife, wood products, huckleberries or other purposes. Timber harvests are probably the most commonly identified silvicultural practice because it is so visible, but silviculture also includes tree planting, fertilization, prescribed fire, thinning, pruning and other practices.

Stand Regeneration Harvests

Stand regeneration harvests are made to renew a forest, using methods prescribed by a *silvicultural system*, which is a specific system of practices designed to create favorable growing conditions for tree species we wish to perpetuate. There are four basic silvicultural systems: clearcut, shelterwood, seed tree, and selection.

A patchcut or clearcut (pictured below) removes all the trees in a given area. This may be done for several different reasons; to increase wildlife forage, to create a fire break, or to mimic natural mosaic forest patterns. Photo courtesy, Jim Rineholt, SNRA

The clear-cut system is when all of the trees in a unit are harvested in one operation. The area is reforested by planting trees or natural seeding. Clear-cuts do not have to be large. A 3-acre

opening is still technically a clear-cut. Sometimes, people may have negative views of clearcuts. Large clear-cuts can be harmful to an ecosystem. However, small clearcuts can produce many benefits.

The seed tree system is similar to a clear-cut except 5-10 trees per acre are left, evenly distributed, across the site to produce tree seed. The seed trees are usually removed after new seedlings are established.

The shelterwood system is similar to the seed tree system except more trees are left to shelter new seedlings. This system is commonly used on hot, severe sites. Shelterwood harvests may be made in two or three entries. Small trees are removed in one harvest. More trees are removed in a second seed cut. Finally, the seed trees are removed in a third harvest after the new seedlings have become well established.

The selection system attempts to maintain a range of desired tree sizes, species, and ages by harvesting individual trees or small groups of trees. Groups are usually 1/4 to 1/2 acre, or 10 to 50 trees, depending on tree size. Each harvest thins the stand. Because individual tree selection maintains a fairly shady environment, it is best suited to sites which can sustain shade tolerant trees over the long term.

The first three systems produce an even-aged stand, one in which all the trees in the forest canopy are within 20% of the same rotation age. Rotation is the length of time forest trees are grown before they are cut. Historically, many Inland Northwest forests were naturally even-aged because new trees seeded in after major fires. The selection system attempts to produce a multi-aged stand. The latter three systems tend to rely more on natural regeneration. Some site disturbance is often required to provide bare mineral soil for good conifer regeneration.

A shelterwood system leaves trees for a seed source and protection during the initial stages of regeneration. These large trees will be removed after new trees begin growing. This is a common silvicultural method for Douglas-fir trees which need some protection from the elements when first starting to grow.

Simply taking the largest trees or all the trees over a minimum diameter is not selection silvicultural system. Many forests have been degraded by, often well-intentioned but harmful, selective logging. The small trees left are not necessarily younger -- they are commonly the same age as the trees removed. They may be incapable of taking advantage of the new space, and often have undesirable characteristics.

The choice of silvicultural system depends on site characteristics, current stand conditions, management goals, wildlife needs, logging conditions, and desired species among other factors. The growing conditions needed by specific tree species, other plants and animals desired to be a part of the forest are of primary importance.

Thinning

Overstocking with too many trees for a site is a common ailment of Idaho forests, particularly in northern Idaho. Overstocking can reduce availability of light, water, nutrients, space, CO2, O2, etc. to individual trees and attract forest pests to stressed, competing trees.

A thinned Douglas-fir forest.

Thinning removes trees in a forest stand to reduce stand density. The primary purpose of a thinning is to improve species composition, reduce competition and enhance the growth of remaining trees. Thinning can also remove suppressed or undesirable trees, harvest trees that are likely to die, reduce insect and disease problems, improve wildlife habitat, reduce fire risk or help reach other environmental goals. Stand regeneration is not a primary goal of thinning.

A thinning may be either pre-commercial, when trees are too small to be sold for wood products, or commercial, when the trees are large enough to be sold. Stocking level, the space left between trees, can be varied according to site needs or management objectives. Many Idaho forests are thinned between 2-3 times between regeneration cycles.

Species Choices in Stand Regeneration Cuts & Thinning

Regardless of the type of harvest or thinning, seeing a tree in the forest does not mean it is a good species to favor. Foresters usually try to favor the tree species best adapted to the site over the long term.

On many forests have been altered by natural patterns of succession:

- excluding fire,
- preferentially harvesting shade intolerant species, such as pines and larch,
- introducing exotic plants, insects, and diseases, such as white pine blister rust.

These factors have created denser forests with more shade tolerant trees than in the past when fires resulted in higher proportions of wider-spaced, shade-intolerant species. Past grazing practices have also affected tree species.

Shade tolerant species tend to be less adapted to drought cycles and, consequently, less resistant to insects and disease. To compensate for the lack of fire, shade tolerant trees are preferentially cut to sustain healthier forests, especially on drier sites. Silvicultural systems that allow more light into stands also help shade intolerant trees grow better. Favoring a mix of species across the forest is also common, within the range of species well adapted to a specific site. It provides some insurance against insects, diseases or other agents that affect one species more than another does.

Planting

Many Idaho forests are regenerated naturally. However, even where natural seeding is anticipated, planting may be used to regenerate species for which seed may not be forthcoming, particularly on larch or blister rust-resistant white pine. Trees are also planted to restore forests to areas that were cleared generations ago for agriculture. Planting is more than simply getting the trees in the ground. Before seedlings are planted, the effort must be planned. Competing vegetation can kill tree seedlings. Reducing its effect is often done prior to planting with herbicides or other tools. Planted tree seedlings must be from the correct seed source, i.e., the correct altitude and latitude. They must be handled and planted correctly. Seedlings must be protected from damage by deer, elk, pocket gophers, porcupines or other animals and be monitored and replanted if seedling mortality is too high.

Pruning

Pruning, removing the lower limbs of a tree, may be done for a number of reasons: increasing the amount of clear wood on a log, improving aesthetics and reducing fire risk. Pruning is particularly effective in reducing mortality from white pine blister rust.

Fertility

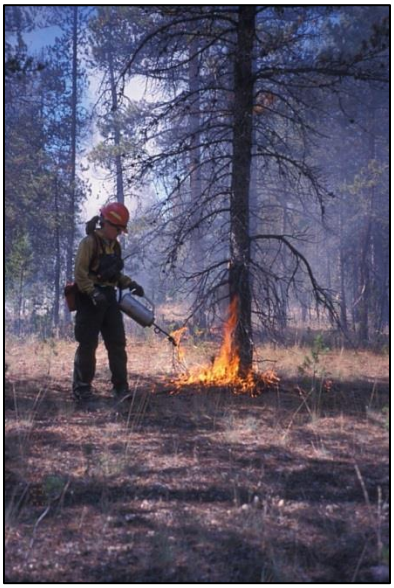
On better sites, fertilizers are applied to forests to increase volume growth, usually applied 10 years prior to a final harvest. Managing forest fertility is much more than fertilizer. Forest scientists are learning more about the importance of leaves, branches and large pieces of logs left scattered across the site for future forest health and productivity. There has been a much greater emphasis in recent years on retaining more green needles and branches, within fire safety limitations, as they are particularly high in nutrients. Approximately half of a conifer's aboveground nutrients (e.g., nitrogen and potassium) are stored in the needles and branches of the tree**.** Allowing nutrients to leach from fresh slash into the soil retains those nutrients for forest health and growth.

Larger diameter logs, often referred to as coarse woody debris or CWD, are also important, especially as they decay, for moisture reservoirs, improved soil structure, beneficial fungi habitat (e.g., mycorrhizal fungi) and wildlife habitat. Anywhere from 5-30 tons of CWD per acre is

recommended, more material on moist forests than dry forests. CWD is also important to a variety of forest organisms. Generally, larger logs, with bark attached, are preferred.

Prescribed Fire

Fire has played a very large role in the evolution of Idaho forests. Some tree, shrub, fungi and wildlife species thrive or not depending on how fire comes through the ecosystem. Forests were managed, to some degree, long before Europeans arrived in Idaho. Native Americans used fire to manage forests for berries, forage, game and other purposes. Early in western settlement by Europeans, there was some openness to having fire play a role in forest management. That changed during the 1910 fires, a huge fire event that burned through over 3 million acres of forest in Idaho and Montana and killed 86 people.



This firefighter uses a drip torch to set a tree on fire during a prescribed burn operation.

After 1910, there was a strong emphasis on putting out all fires as soon as possible before they became big ones. The strategy was very effective, particularly with an ever-growing repertoire of firefighting technology to help detect and put out fires. Forest fires have begun out stripping our ability to put them out recently. Forests that had been periodically burned by a variety of different type of fire had more fuels than ever and fires were becoming much harder to extinguish.

Smokey Bear is the US Forest Service mascot for fire prevention. It was one of the most successful behavior changing campaigns launched in the United State. Smoky taught Americans that fire in forests was bad, destructive and preventable. Some would argue Smokey's message went too far.

There has been a growing interest in bringing back fire to help manage western forests. This is often not as simple as lighting a match and letting nature take its course. As noted, many Inland Northwest forests have a historically unprecedented volume and configuration of fuels. Fires that burn through these forests may burn hotter than they ever did historically causing near permanent damage to forest soils.

Forest fires are still being extinguished. However, now forest managers are integrating more prescribed fire into the landscape. In some forests, this may mean allowing some fires to burn more naturally, particularly if there are no other values (e.g., homes are at low risk) and the fires were started by natural causes (e.g. lightning). Prescribed fires are being used more commonly.

Broadcast burns are used to prepare a site for planting. Under burns are used to reduce fuels or improve wildlife habitat.

In a prescribed fire, extra precautions are taken to ensure fires behave in ways that meet objectives. This may include thinning to reduce fuels, pruning to reduce the chances of a ground fire getting into crowns, burning in the spring or fall when the fire is less likely to escape and will burn cooler which reduces nutrient losses.

Treatments for Insects & Disease

Native insects and diseases are a natural part of the forest. Every tree species has insects and diseases that attack it, particularly when it is stressed by drought or other factors. By allowing forests to become too dense or heavily composed of less adapted tree species, sometimes these organisms damage more trees than wanted by unintentionally creating a favorable environment for them. Leaving the best species for the site, with adequate spacing, is the best insurance against forest insect and disease problems. The most common types of insects and disease that kill Idaho forest trees are root diseases, bark beetles, defoliators, stem decays, white pine blister rust and witches brooms.

Root Diseases

Root diseases are a problem in many Idaho forests, in part, because of the large percentage of Douglas-fir and grand fir on sites better suited to pines and other shade intolerant species. A sparse or dead crown may be one indication that a tree has root disease.

The main goal on root disease sites is to favor shade intolerant species, such as larch or pine, which are more resistant to root diseases. That may be done by thinning, or in some cases, open the forest up to more sunlight to regenerate these species

Bark Beetles

Bark beetles are a common problem in western conifers, especially in overstocked stands. Idaho has a half dozen major bark beetle species killing different tree species.

Bark beetle that infects lodgepole pine trees.

The first thing seen is individual trees or groups of trees with crowns turning red to brown. On pines, there may be thumbnail-sized globs of pitch and boring dust called "pitch tubes" on the trunk. On Douglas-fir, there may be long "pitch streaming" from high in the trunk of the tree, or

boring dust in the crevices at the base of the tree. In grand fir or subalpine fir, there are uplifted pieces of bark from previous attacks by fir engraver beetles. On many species, there may be small, white, popcorn-like “conks” from pouch fungus, a disease that is carried into the tree by bark beetles. Bark beetles bore into bark and feed in the cambium, the inner bark. They usually lay eggs there, which later hatch and feed. Eventually, the tree is girdled and dies.
Many times, beetle attacked trees are salvaged, or harvested, before they lose value. Additional infested trees are often removed and surrounding forests are thinned to increase vigor and enhance resistance to bark beetles.

Defoliators

Western spruce budworm, Douglas-fir tussock moth, and other defoliating insects eat conifer needles, which can decrease the tree’s ability to grow, kill the top, or even kill the whole tree. Many times, a tree survives some defoliation. However, frequently the tree or its top is killed. The primary strategy, in response to these defoliators, is to salvage defoliated trees and try to favor species that are not as subject to defoliation (e.g., pines and larch). In extreme cases, an insecticide, usually a natural biological control such as Bacillus thuringneisis, or a virus, may be sprayed on the insects.

Stem Decays

Conks are often the most visible evidence of stem decays, which decay the heartwood of a tree, making it weaker structurally and unusable for wood products. Usually, they are managed by maintaining younger stands, with the exception of when old growth forest conditions are an important management objective.

White Pine Blister Rust

The beauty and value of western white pine (*Pinus monticola*) inspired legislators to name it Idaho’s state tree. Unfortunately, white pine is now the primary species on less than 5% of its historic range, largely because of a non-native disease called white pine blister rust. White pine blister rust starts in the needles of white pine and travels down the branch to the trunk, where it kills the tree above that point. The first visible evidence of blister rust infection is "flagging" branches, individual branches that turn brown and die. You will also usually see pitch streaming around cankers.

Two main strategies are used to restore western white pine: 1) planting white pine seedlings bred, using traditional methods, to resist the disease and 2) pruning the bottom eight feet of white pine trees reducing mortality by half. Blister rust also infects two other Idaho five needle pines, whitebark pine and limber pine. Scientists are still studying methods to help these species resist disease.

Witches Brooms

Several diseases and conditions can cause "witches brooms." Witches brooms are most commonly caused by dwarf mistletoe. Dwarf mistletoe is a parasitic plant that reduces the health of many native conifers especially pines, larch and Douglas fir. The main strategy for managing mistletoe is to remove infected overstory trees so they will not infect smaller trees of the same species growing near them.

Witches broom or dwarf mistletoe infected this tree causing massive growths. Mistletoe can eventually kill the tree by using up all its resources in the brooms.

Different Management for Different Values

Forests are managed and management decisions are made based on the values and goals of each individual area. Some forests are managed to make money. Laws protect water, wildlife, and other values while managing for income. Other forests are managed primarily for recreation or wildlife habitat. Many forests are managed for multiple values. Decisions are constantly challenged and decisions weighed. Forest management is multifaceted and interdisciplinary.

Forest Water Quality

One of the most treasured benefits from Idaho forests is water. Water from forested watersheds is always our cleanest. As a result, many of our best fisheries rely on forested watersheds. Many Idaho communities have forests dedicated primarily to providing high quality water.

Forest activities, such as timber harvest, do not adversely affect water quality unless there is too much land harvested at one time from a given watershed or harvesting is poorly executed. Forest operations leave organic matter on the ground and often leave intact understory vegetation. The biggest potential source of water pollution in forest harvest practices is sediment from roads and skid trails. Idaho has the "Idaho Forest Practices Act" (FPA) that sets minimum standards to protect forest water quality. Idaho FPA rules require leaving buffer strips along streams, diversion structures to make sure water drains from roads and back into the forest quickly and many other practices to maintain good water quality in forests. FPA rules also set standards to reduce fire hazard from forest management activities and sets minimum reforestation standards.

Wildlife

Former Chief of the U.S. Forest Service, Jack Ward Thomas, a well-respected wildlife biologist said, "Timber management is wildlife management." Forest practices create a variety of patches of forest in different successional stages across a landscape, benefiting a wide range of wildlife

species. A given silvicultural treatment may benefit one species requiring more of that habitat type. However, it may have may have a negative benefit on the species that utilized the habitat in its original state. Foresters work with biologists to assure there is an adequate distribution of large and small habitat patches across the forest landscape to sustain all wildlife species.

The elusive woodland caribou lives in northern Idaho near the Canadian border. Photo courtesy IDFG.

Foresters try to integrate wildlife habitat within units treated by leaving snags of a variety of ages, sizes, and species distributed across the unit, by careful use of prescribed fire, and by maintaining adequate linkages between different types of habitat.

Some forest-dependent wildlife species depend on very specific types of forest for survival. For example, martin are located in thick, mixed-conifer, old growth forests. They are not in a ponderosa pine forest or an aspen forest. There are places to hide, food and nesting areas provided by unique, old growth conifer forests.

Recreation

Recreation uses of a forest can be compatible with other forest values. However, sometimes forest values can be at odds. Recreationists are sometimes disagree with the site of timber harvests or prescribed burns. They also dislike diseased forests. Some areas are managed primarily for recreation such as Hells Canyon National Recreation Area or the Sawtooth National Recreation Area. In these places, timber harvest, grazing and other forest uses are limited to enhance recreational values. In order for conflicts to be minimized, all forest users must educate themselves concerning the various uses of forests.

Evolving Forestry Practices

The science of forestry is always evolving. There are new sophisticated genetic tools for understanding forest species, better geospatial technologies (e.g., geographic information systems) that help manage forests at multiple scales from a stand level to landscape level. To learn more about Idaho forests and forestry, consult any of the agencies and organizations listed at the end of this chapter.

Selected References & Resources

Books

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Year of the Fires: The Story of the Great Fires of 1910. 2002. Penguin. 352pp.

Extension Publications & Videos*

Woodland Notes. Biannual newsletter for forest owners and others interested in Idaho forests and forestry (4pp)
After the Burn: Assessing and Managing Your Forestland after a Wildfire (UI SB 76) 78 pp.
Choosing Nursery Stock for Landscaping, Conservation, and Reforestation (UI CIS 923) 4 pp.
Enhancing reforestation success in the Inland Northwest (OSU PNW 520) 12 pp.
Evaluating Wildlife Habitat for Managing Private Forest Ecosystems in the Inland Northwest (UI SB 60) 78 pp.
Evaluating forest ecosystems for silvicultural prescriptions and ecosystem mgt. Planning (UI SB 59). 6 pp.
Forest Stewardship Planning Workbook - an Ecosystem Approach to Managing Your Forest. (WSU PNW 490). 60 pp.
Idaho Forestry BMP's: Forest Stewardship Guidelines for Water Quality. (UI EB 745). 33 pp.
Logging “Selectively”: A Practical Pocket Guide to Partial Timber Harvesting. (UI PNW 534). 96 pp.
Landscaping for Wildfire Prevention. (UI BULL 67) 20pp.
Plant your container-grown seedlings right (UI CIS 528). 5 pp.
Pruning Western White Pine: A Vital Tool for Species Restoration. (UI PNW 584). 62 pp.
Return of the Giants (White pine restoration) (UI SB 72) 21 pp.
Special forest products (UI CIS 952)3 pp.
Terminology for forest landowners (WSU EB 1353) 40 pp.

Thinning: an important timber management tool (OSU PNW 184) 8 pp.
Using scientific input in policy and decision making (OSU EC 1441) 20 pp.
Woodland Fish & Wildlife publications on managing forest habitats for everything from amphibians to bears. They are downloadable at http://www.woodlandfishandwildlife.org

*Extension publications are written primarily with family forest owners in mind. These publications are available from the publications offices of the University of Idaho (UI), Washington State University (WSU) and Oregon State University (OSU) many can be downloaded as PDF files:

- University of Idaho–Educational Communications, University of Idaho, P.O. Box 442240, Moscow, ID 83844-2240; tel. (208) 885-7982. http://info.ag.uidaho.edu/catalog/catalog.html
- Oregon State University—Publication Orders, Extension & Station Communications, Oregon State University, 422 Kerr Administration, Corvallis, OR 97331-2119; tel. (800) 561-6719 http://extension.oregonstate.edu/catalog
- Washington State University—Extension Publications, Cooper Publications Bldg., Washington State University, P.O. Box 645912, Pullman, WA 99164-5912; tel. (800) 723-1763; http://pubs.wsu.edu/cgi-bin/pubs/index.html

Many of these publications can also be downloaded as PDF files from these offices' web sites.

Videos

I Want to Log "Selectively" -- A Practical Guide to Partial Timber Harvesting for Inland Northwest Forest Owners and Logging Operators. University of Idaho Agricultural Communications Center, Moscow, ID. 40 minutes.
Forest Water Quality. University of Idaho Agricultural Communications Center, Moscow, ID. Two 20-minute videos.

Web Sites

American Forest & Paper Association	www.afandpa.org
University of Idaho Extension – Forestry	www.cnr.uidaho.edu/extforest
Idaho Department of Lands	www.idl.idaho.gov
Associated Logging Contractors of Idaho	www.idahologgers.com
The Idaho Forest Products Commission	www.idahoforests.org
Idaho Forest Owners Association	www.idahoforestowners.org/
American Forest Foundation	affoundation.org
American Forests	www.amfor.org
Association of Consulting Foresters	www.acf-foresters.com
Forest History Society	www.lib.duke.edu/forest
Forestry Images	www.forestryimages.org
National Arbor Day Foundation	www arborday.org
Official Smokey Bear Website	www.smokeybear.com
Society of American Foresters	www.safnet.org
USDA Forest Service	www.fs.fed.us

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Nature Journaling

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Describe what a naturalist journal is.
- Discuss the reasons for keeping a naturalist journal.
- Describe different types of entries that can be used in a nature journal.

What is a Nature Journal?

A nature journal is a place where you can record observations about nature. Thankfully, there is no one way or right way to keep a nature journal. A nature journal can be a place where you record interesting things you see in nature. You can keep a record of seasonal events in a nature journal. Using a journal to record your thoughts about what you see and how you feel is appropriate as well. Since nature is so diverse, there is always something new to see and discover. Recording it is a way to remember it and build to your ever-growing body of knowledge about the world.

Consider it like a diary about yourself and nature. "A nature journal may not be as private as a personal journal. Often, it is meant to be seen and reviewed by others (Walker Leslie, 2000 pg. 7)."

Why Keep a Nature Journal?

There are a variety of reasons for keeping a nature journal. Some find journaling about nature to be an interesting hobby, a way to express their passion for nature while using writing and drawing skills. Others like to record more scientific data and observations in a journal as they work or recreate in the outdoors. Using a nature journal as a way to remember an experience or a feeling is common. Recording what you learn about nature, what you observe with your senses, and what questions you have can also be a great reason for keeping a nature journal. Nature journaling, no matter the reason, helps people get connected to nature and encourages the practice of tuning your senses into the world around you. The use of nature journals is not new. Aristotle, Leonardo de Vinci, Queen Victoria, Charles Darwin, Louis Agassiz, John James Audubon, Lewis and Clark, and Thomas Jefferson are just a few famous journal keepers you might know (Leslie and Roth, p 208).

“Field journals make nature the subject, and use observation, reflection, drawing, and writing as the process for learning. As [you] observe and record nature through drawing and writing, [you] can get to know an area intimately and personally. They will use both intellectual and sensory "ways of knowing" that can be both more immediate and deeper than "left-brain" data collection skills alone.” (Matsumoto, 2005) If you don’t consider yourself to be a writer or an artist, a naturalist journal might seem like a challenging job. However, just like other skills, journaling takes practice and patience. There are endless ways you can create a journal entry, and you need to find what you enjoy and what works for you. Your journal does not have to be a work of art; it is a work in progress. It does not have to be beautiful or profound. Try a variety of techniques at first, challenge yourself to draw or write, to take a photo, or write a poem. Remember, this journal is for you, to help you learn, express yourself and record your experience.

Types of Nature Journals

- Grinnell-type journals are popular among biologists worldwide. They have two parts: they generally include daily accounts of observations at a location, combined with a running record of individual species of plants or animals (see appendix A).

- A phenology journal is an account of seasonal changes that affect plants and animals in a given location, and the biological effects of those changes. This can be an on-going journal, or it can be as simple as recording events on a calendar.

- A journal of a special location is intended to create a comprehensive account of the natural history of a limited area, such as a park or schoolyard, and might include observations of weather, plants, animals, species interactions, and human-caused changes.

- A chronological journal of a trip or camp experience can include many types of observations and feelings, and will provide a personal account of an experience from the point of view of a single observer (Matsumoto, 2005).

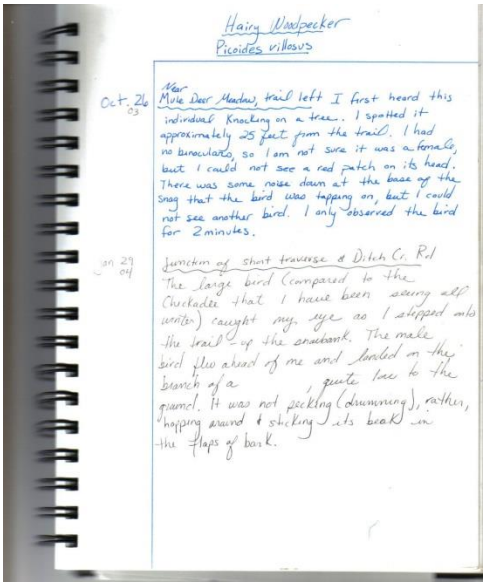
*Every entry, no matter what kind should include the **date, time** and **location**!*

You do not need to pick one of these types of journals. Use a mixture of these methods.

Entry Ideas for Your Nature Journal

Species Accounts	Poetry
Sound	Feelings
Sketches	Sensory Poem
Class notes	Sensory Information (what do you see, hear, taste, smell, feel)
Photos	Ideas you have
Questions	Volunteer Experience
Observations	Memories
Data Collection	Pressed plants
Weather data	Animal behavior

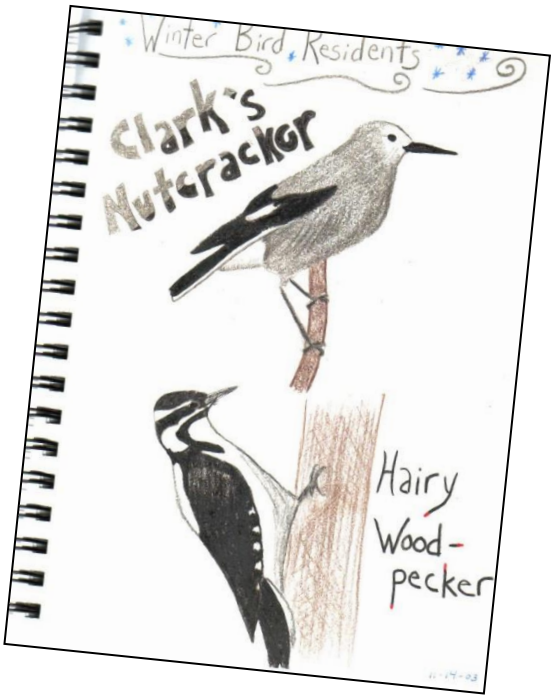
Following are a few journal entries from a nature journal. Note that there is a mix of scientific and artistic content.


Hairy Woodpecker
Picoides villosus

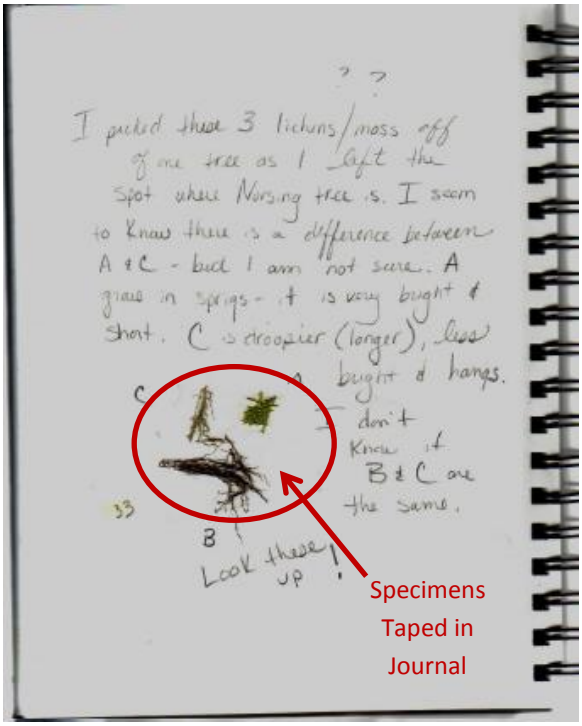
Oct. 26 03 Near Mule Deer Meadow trail left I first heard this individual knocking on a tree. I spotted it approximately 25 feet from the trail. I had no binoculars, so I am not sure it was a female, but I could not see a red patch on its head. There was some noise down at the base of the snag that the bird was tapping on, but I could not see another bird. I only observed the bird for 2 minutes.

Jan. 29 04 Junction of short traverse & Ditch Cr. Rd
The large bird (compared to the Chickadee that I have been seeing all winter) caught my eye as I stepped onto the trail up the embankment. The male bird flew ahead of me and landed on the branch of a , quite low to the ground. It was not pecking (drumming), rather, hopping around & sticking its beak in the flaps of bark.

The journal entry to the left is a classic species account. The name of the species is at the top and along the left margin are dates the naturalist saw the species and what it was doing. This species account goes on for several more pages (Focht 2003).

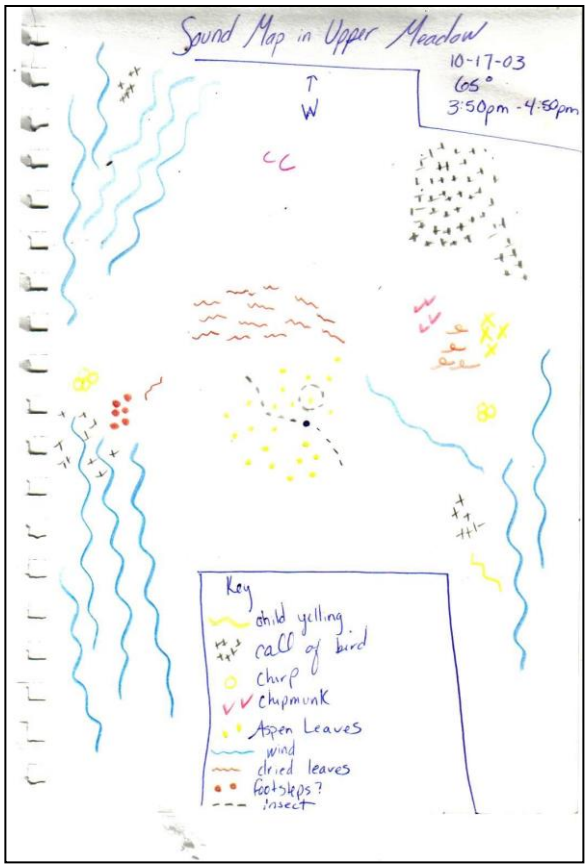


The journal entry to the right is an example of an artistic entry. This person set out to learn the major bird species that reside in her community during the winter. There were several pages of sketches. After completing the sketches, this person, who does not consider herself much of an artist, claimed she felt a sense of accomplishment from the drawings and never again had to look up these birds in a field guide. She could identify them all.



This journal entry may not be much to look at, but it is a very important type of entry. Notice the question marks near the top. The author did not know if what she collected was a lichen or moss. She collected small samples and taped them on the page, labeling them with A, B, and C. This is a great example of scientific inquiry. Later, in this same journal, the author has species accounts for each type of lichen and notes from a book about lichens along with several photos (Focht, 2003).

Journal activities that focus on sensory activities are excellent ways to get you to pay more attention to nature around you and practice using your senses to "observe" the world around you. This journal entry is a sound map. The dot in the middle of the page represents the person making the map. For 10-15 minutes, the person records sounds they hear in relation to themselves using different colors and symbols. You don't have to know what every sound is in order to record it. (Focht, 2003).

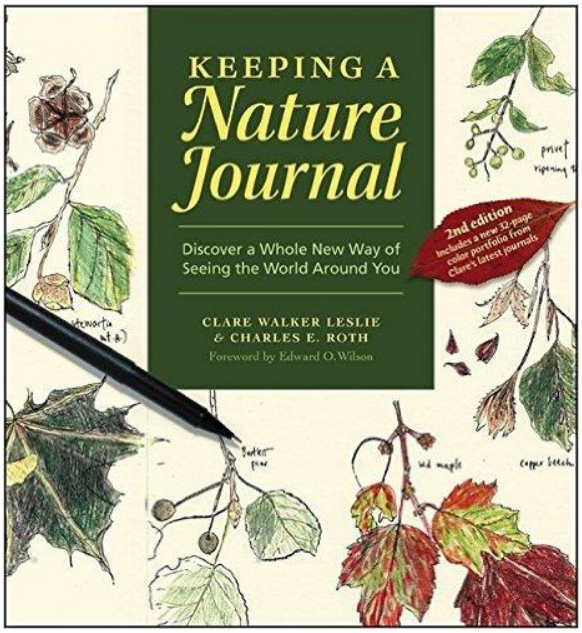


In their book, *Keeping a Nature Journal*, Clare Walker Leslie and Charles E. Roth give many ideas for daily journal entries. (Indicates the page number in the book)

Systematic record keeping. (44) Try recording the same thing every day, such as the temperature each morning, the birds at the feeder, sunrise time.

Hunt for connections. (45) Always be looking for connections between the objects you are observing and recording.

Set up a research project. (46) Go through the steps of the scientific process and do a simple experiment.



Reflect on one place or one thing over time. (49)

Keep a journal on a trip or outing. (50)

Keep a group journal with family or friends. (51)

Journal while hiking. (53)

Draw or take a photo. (54)

Write a family story in your journal. (55)

Write about holidays. (56)

Reflect on other's words. (58)

Record daily images…even the simple ones. (59)

Vary your layout; don't make every page the same. (60)

Draw a map-paste in a newspaper clipping. (61)

Record the phases of the moon. (67)

Visit a new place. (82)

The Idaho Master Naturalist Program has been designed and strives to be a science-based program. Many scientists and naturalists use nature journals and field notebooks for recording observations and events. Poets, artists, writers and amateur naturalists keep field notebooks and journals too. Feel free to make your journal your own. Your nature journal does not have to be purely scientific. Use it however you feel it will make you a better observer of nature. Whatever method of journaling you choose, consider sticking with the journal. You will undoubtedly be proud of your journal when you have the chance to look back on it.

Throughout the curriculum, you will find journal entry prompts. Your IMN chapter leader may assign or encourage journal use too. Feel free to do things on your own with your journal. There is no right way to do it!

Journaling ideas you have:

_____
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References and Credits

Focht, S. (2003). Phenology Journal: Teton Science School.

Leslie, C. W., & Roth, C. E. (2000). Keeping a Nature Journal: Discover a whole new way of seeing the world around you (2nd ed.). North Adams, MA: Storey Publishing.

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Appendix A

(Used with permission from the Virginia Master Naturalist Program).

Grinnell Field Journal Procedure

The Grinnell Method of the field journal writing process is simple but time consuming. First, notes are taken in the field notebook while in the field or laboratory. All notebook entries should begin with the date, time, specific location, and weather conditions (cloud cover, temperature, and wind speed). This information is placed in the upper right corner of the first page of the new notebook entry. Any change in location will require that that writer begin a new page with a new header. This ensures that the reader always knows the exact location and conditions in which observations were made. All notes to follow should be taken in chronological order of the observation and/or events being described. This is particularly important if the notes are taken while hiking a trail or anytime the observer moves from one location to another. The notes should be written into the field journal at the end of the day.

The field journal should be kept in a binder and on loose-leaf note paper. Before writing, vertical and horizontal margins must be drawn on the paper. The horizontal margin must be drawn over the first horizontal line of the page and the vertical margin should be drawn 3cm from the left side of the sheet. The name of the observer and the year are written in the upper left corner on each page, inside the square created by the two margin lines. All journal pages should be titled with the word "Journal" in the upper center of the page. Writing is only done on the front of each page, reserving the back for drawings, maps, etc.

The Species Account Page is titled with the common name of the species of record with the scientific name written below and includes all the information learned about the particular species along with dates and locality of sightings. Attention should be paid to including the species' ecology, morphology, distribution, phenology, and data from other observers. Entries in the Species Account are made by date with a horizontal line drawn between each date. Species Accounts will understandably grow over the years as the observer finds new opportunities to observe the species and learns more through research.

If the observer is also taking specimens of particular plants or animals then they will also include a Catalog Page that details the specimens taken, the date taken, and the location of the specimen. The Catalog Page is titled "Catalog" in the upper center of the page. Catalog entries are not as common today as they were in Grinnell's time. Emphasis is no longer placed on the collection of specimens. However, there are times when collection is required, particularly when a voucher specimen is needed, and good records of those collections will never go amiss.

The Grinnell Method is rigid, time consuming, and requires a great deal of dedication and discipline in order to maintain its format. This is not a format for the faint-hearted; however, if kept faithfully, there is no better way to document field observations, particularly if those field observations are to be used for the purpose of research. The scientist will be rewarded with an easy to read, highly organized record of their work.

Ecological Concepts

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Explain the ecological principles that apply to individual organisms, populations, communities, and ecosystems
- Explain the balances that exist between ecosystems and what factors are necessary to keeping ecosystems in balance
- Explain how different ecosystems are determined largely by different environmental factors
- Describe the hydrologic cycle, the nitrogen cycle, and the carbon cycle
- Explain what is meant by succession and climax and list the factors responsible for each
- Illustrate a food web and explain the importance of trophic relationships
- Define biodiversity and understand the importance of managing for biodiversity
- Identify ecological factors that are relevant to a threatened species
- Understand the laws and procedures necessary for protecting species

Defining Ecology

> *"The Laws of Ecology:*
> 1. *Everything is connected.*
> 2. *Everything must go somewhere.*
> 3. *Nature knows best.*
> 4. *There is no such thing as a free lunch."*
>
> *-Barry Commoner, 1971*

The term "ecology" is derived from the Greek words, oikos, for house or household, and *logos*, which refers to "the study of" some particular topic. Literally translated then, ecology means the study of households, in this case, the households of nature. German zoologist Ernst Haeckel, who is credited with coining the word in 1870, defined it as follows: "By ecology we mean the body of knowledge concerning the economy of nature – the investigation of the total relations of the animal both to its inorganic and its organic environment." If you peruse modern texts for a more current definition, you will find that they still focus on the key importance of *relationships* and *interaction*s. "Ecology is the study of the relationships of organisms to their environment and to one another" (Brewer, 1994). "Ecology is the scientific study of the interactions that determine the distribution and abundance of organisms" (Krebs,

1972). A somewhat different definition, offered by Odum in 1963, stressed the then emerging systems approach; "Ecology is the study of the structure and function of ecosystems."

Given the fact that you are embarking on a lifelong journey to becoming a Master Naturalist, you might find the definition offered by the early English ecologist, Charles Elton (1927), an especially appealing one. He defined ecology as "scientific natural history." Natural history – the observations and descriptions of the behavior and adaptations of organisms – especially as collected by naturalists of the 17th, 18th, and 19th centuries, provided a good background for the emerging field of ecology in the 20th century. What allowed for the transition to "scientific" natural history was Darwin's theory of evolution. Specifically, his concept of natural selection provided a mechanism to explain how populations of organisms change, adapt, evolve, to an ever-changing environment. Within the unifying framework of natural selection, ecologists can now go beyond just describing the many varied and amazing behaviors and adaptations of organisms to provide us with logical explanations of their evolutionary origin and purpose.

Levels of Biotic Organization

While early naturalists were primarily interested in describing individual organisms, ecologists frequently investigate higher levels of biotic organization (Note that these terms have very specific ecological meanings that differ from their common usage):

- *Population* – A group of organisms belonging to the same species occupying a particular area at the same time.

- *Community* – An association of interacting populations usually associated with a given place in which they live.

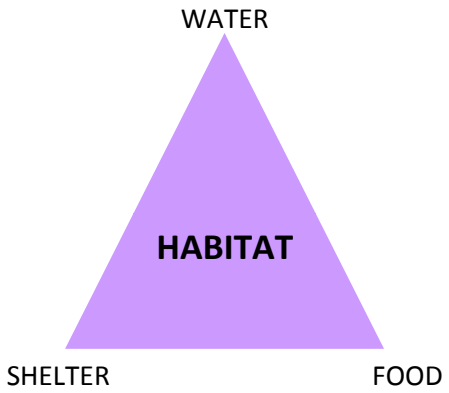
- *Ecosystem* – An ecological system. The biological community of a given area and the physical environment with which it interacts.

- *Landscape* – Interacting ecosystems on a relatively small geographic scale.

- *Biosphere* –That portion of the earth and its atmosphere in which life occurs and the physical-chemical environment in which it is embedded.

A cautionary note: The above levels of biotic interaction are often so ordered and imply a sense of increasing scale. Excluding the "biosphere," which clearly does encompass the entire planet, any of the other terms may apply equally well to a variety of physical scales. You are perhaps familiar with the concept of an "ecosystem" within a **drop of pond water.** While it would be erroneous to think that the numerous organisms you might find in such a drop would be self-sustaining over any length of time, it is nevertheless true that functioning communities, ecosystems and landscapes can be found within small confines, including individual organisms!

Two other commonly used terms with which you will become familiar are *niche* and *habitat*. An organism's niche is best thought of as its "occupation" or ecological role in the community.
Important aspects of a species' niche would include its position in the food web, which species it relies on for food and which species prey on it, as well as its relative importance in the flow of energy and the cycling of nutrients. Ecologists more broadly define the niche of a species as the sum total of all its interactions within a given community, or the ranges of conditions and resource qualities within which the organism or species can persist.



If niche defines an organism's occupation, *habitat* describes its address. It is the place where a plant or animal normally lives, and is often characterized by a dominant plant form or physical characteristic. For example, boreal forest is the habitat for the woodland caribou while cold mountain streams are the habitat for cutthroat trout. For any organism to survive in a particular area, the habitat must provide it with three important resources – food, water and shelter. In order for a habitat to be suitable, however, these three resources must be easily accessible. If water was located at too great a distance from food and shelter, for instance, a particular species might not find that habitat acceptable. Space is yet another important component of habitat. Beyond the fact that most species have minimal home range requirements, that amount of area necessary to provide all necessary resources for survival, many are also territorial, defending their space from being utilized by others of their own species. Thus habitat must provide each species with easily accessible food, shelter and water within a space large enough to secure those resources for the individual or social group.

Ecosystem Characteristics

During your Master Naturalist training, you will be introduced to a number of ecosystems distinct to your region of Idaho. We want you to become better acquainted with both the structure and functioning of those systems, and the ways in which each major component of the system interacts and depends on the rest to maintain the overall health of that system.

Early ecologists soon became aware of the fact that regardless of where they were, be it arctic tundra, prairie grassland, tropical rain forest, or coral reef, there were a number of underlying

principles and relationships which seemed to provide a foundation for the understanding of all ecological systems.

Climate and Weather

When any ecosystem is examined, it is clear that we can first organize it on the basis of its *biotic* (living) vs. *abiotic* (non-living) components. Two important abiotic features are climate and nutrients. We'll examine the role of nutrients in more detail a little later on, but first, let's look at climate. *Climate* is defined as the long-term patterns of temperature, precipitation, wind and humidity that exist for a given area. Short-term changes in these atmospheric conditions are referred to as *weather*. On a large geographic scale, it is interesting to note that the world's major terrestrial ecosystems, often referred to as *biomes*, can be delineated almost entirely on the basis of mean annual temperature and precipitation. Not unexpectedly, tropical rain forests are found where both average annual precipitation and average annual temperature are high. Perhaps less expected is the fact that both deserts and tundra are characterized by very low average precipitation. What role do you think temperature and precipitation play in determining the eco-regions of Idaho?

Five Eco-regions of Idaho

1.

2.

3.

4.

5.

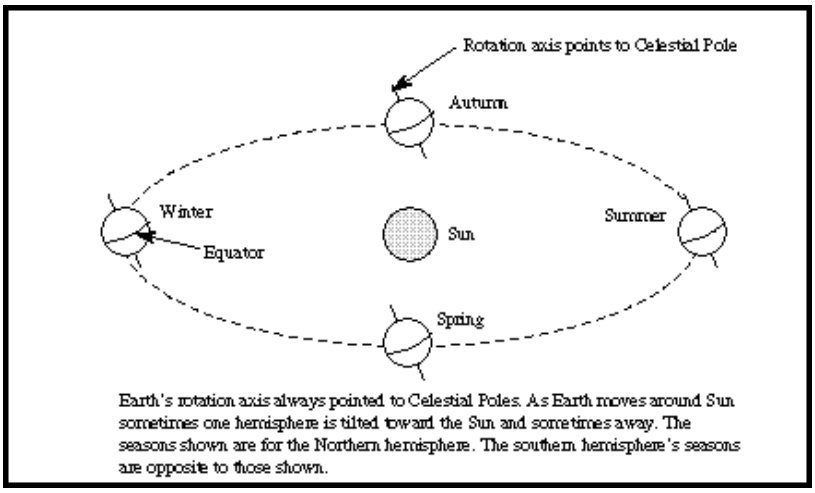
The plants and animals that comprise the biotic component of a given biome often exhibit unique adaptations that are reflective of their abiotic environment. For example, can you think of at least three features of high desert plants (such as sagebrush) that have evolved in response to arid conditions? What adaptations do high desert animals exhibit? Plants and animals that are not closely related often exhibit similar adaptations to similar environmental conditions. This is known as *convergent evolution*.

Sunlight and Heat

Heat and light received from the sun, collectively known as *solar radiation*, does not reach all parts of the Earth in equal amounts or for equal lengths of time. Heat and light vary in intensity during the course of a day as the Earth rotates on its axis, and throughout the year as it revolves in an orbit around the sun.

Polar Regions receive much less solar radiation than do tropical regions because the sun is farther from the poles than from the equator, and because of the Earth's tilt on its axis. This tilt prevents direct sunlight from reaching the poles for long periods each year. As a result of the daily, seasonal, and annual distributions of solar radiation, we assign the Earth specific *climatic zones*—ranging from polar to temperate to tropic—which relate primarily to temperature differences.

We measure solar heat, as a form of energy, in degrees of relative warmth called *temperature*. Plants and animals tolerate certain high and low limits of temperature. Beyond those limits, each organism cannot survive.



The sun's rays do not strike the Earth evenly, as seen in this diagram of the sun and the earth's axis. This uneven radiation creates different climates on Earth. Permission for diagram usage pending Nick Strobel.

Temperature also influences rate of reproduction, growth, and survival of living things. For example, in a temperate climate, persistent cold weather late into the spring prevents most plants from developing properly, as well as the insects and rodents that feed upon them. A poor supply of insects and rodents then decreases the well-being of hawks, foxes, and other animals. Therefore, temperature—as a component of weather— influences the strength or weaknesses of food chains and webs.

A warm blooded fisher. Photo courtesy, IDFG.

Warm-blooded animals, such as birds and mammals, have insulated bodies that regulate internal temperatures regardless of the amount of heat in their environments. *Cold-blooded* animals, such as reptiles, fishes, amphibians, and insects, have no way to regulate their own body temperatures. So, their bodies usually assume the same temperature as their environments.

A cold blooded wood frog. Photo courtesy, Steve Kozlowski, USFS.

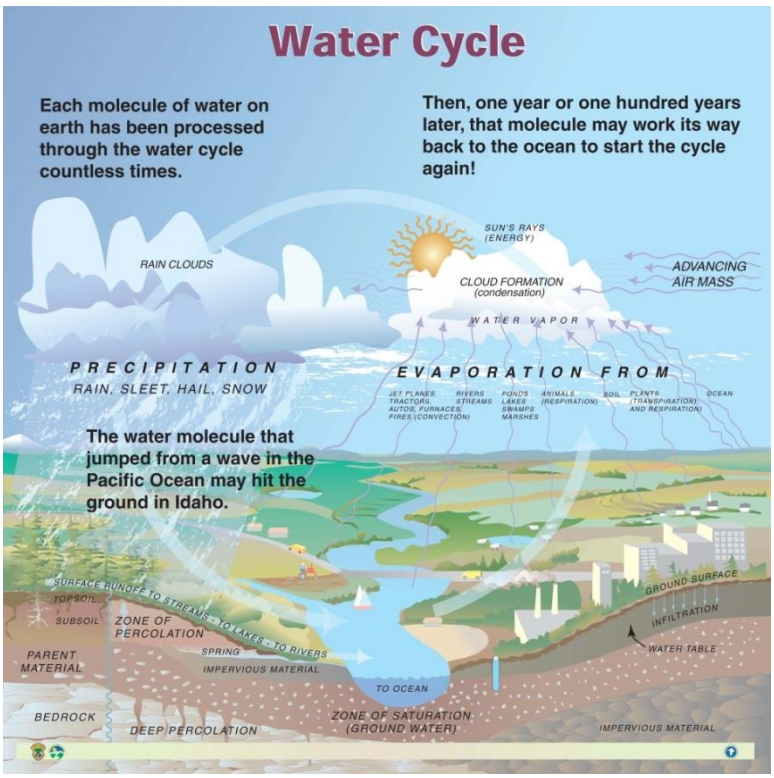
The amount of moisture in the air, known as *humidity*, influences the tolerance of most warm- and cold blooded animals to external temperature extremes. Hot or cold temperatures in dry climates generally are easier for most animals to cope with than similar extremes in wet climates.

Soil

Soil is the Earth's loose surface material in which most plants are rooted. In large measure, the quality and abundance of life in any region is a reflection of its soil's characteristics. More than just "dirt," soil is itself a complex ecosystem. It is composed of fragments of inorganic material (minerals), organic matter derived from living organisms in various stages of decomposition, soil water and the minerals and organic compounds dissolved in it, soil gases and living organisms. The development of a mature soil may take hundreds of years to complete through the complex interactions of climate, parent material (bedrock), topography and organisms. The abundance of life in any environment depends, to a great extent, on the characteristics of its soil. Soils classified as loams are a mixture of fine, medium, and coarse (clay, silt, sand) particles and often contain significant amounts of organic matter (humus). These soils are often more fertile than either heavy clay or very sandy soils and generally support a greater number and diversity of plants and hence, a greater diversity of animals. More information on soils can be found in section 11 of the Geology chapter.

Water and Air

The sun drives movements of water and air over the surface of our planet. Differential heating of the atmosphere, based on latitude and season, sets in motion generally recognized global wind patterns which circulate both heat and water. Together with topography, these atmospheric movements play a dominant role in determining the location of the Earth's major biomes, as well as the regional availability of water.



This diagram of the hydrological cycle shows how water is circulated around the globe. Graphic by Renai Brogdon, IDFG.

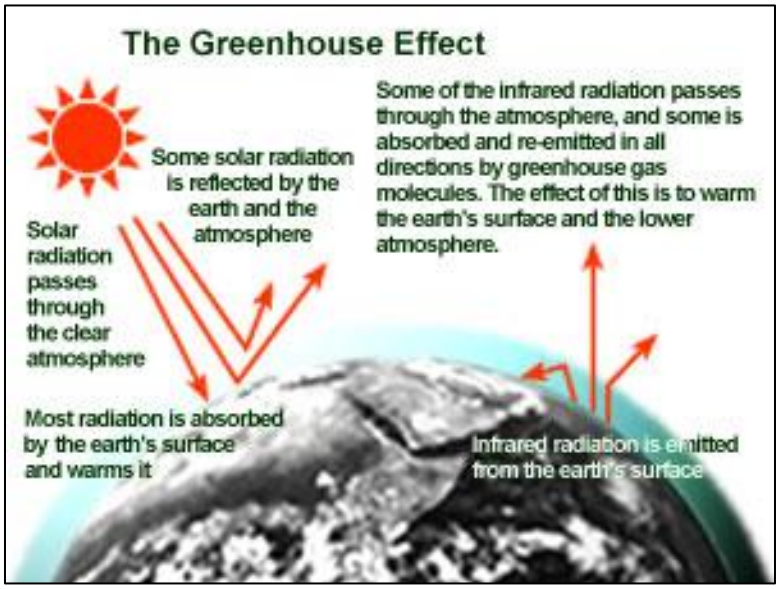
Water

Water takes many forms in the environment: water vapor is a gas; standing water is liquid; and frozen water or ice is a solid. In the atmosphere, water is humidity. We call water *precipitation* when it

falls to the ground as snow, sleet, rain, or hail. In oceans, lakes, and streams, we call it surface water; and it is part of every cell making up the bodies of plants and animals. No matter where or in what form it occurs, water eventually recycles through processes of evaporation from streams, lakes, and oceans; transpiration from plants; and respiration from animals.

Similar to solar radiation, water differs in amount and availability from place to place throughout the world. For example, deserts are almost always dry. Tropical forests tend to be very wet. Determined by annual precipitation, many other climatic zones include humid, sub humid, semiarid, and others

Air



While we sometimes use the words "air" and "oxygen" interchangeably, our atmosphere is actually 78% nitrogen and only 21% oxygen. The remaining one percent is comprised primarily of carbon dioxide, CO2, and water vapor. These two gases are very important in creating the "greenhouse effect." By absorbing much of the sun's infrared radiation, these gases trap the sun's heat and act as the Earth's warming blanket. Without them, our planet would be uninhabitable, much like our moon or the planet Mars. Scientists are concerned that our present rate of fossil fuel consumption will raise atmospheric levels of carbon dioxide enough to significantly increase global temperatures over the next 50-100 years. If this were to occur, it would have profound effects on both the distribution and survival of many species, including our own!

Oxygen, given off by plants and other sources, is taken in by animals through lungs, gills, and other specialized breathing mechanisms. Animals transport oxygen in their blood to many cells of the body, to be used for every life-support process.

At high elevations, air contains less oxygen, so animals' hearts must pump harder to get blood and, therefore, oxygen to all parts of their bodies. Animals must adapt to different conditions of the air, move to a different environment, or perish. For example, animals living at high altitudes have larger hearts than do their relatives at lower elevations. Air also supplies plants with nitrogen and carbon dioxide as well as oxygen. When traveling through the mountains or in an

elevator you may notice an increasing or decreasing pressure in your head as you go up or down. Your ears probably pop. This occurs as the result of rapid changes in atmospheric pressure.

The atmosphere is denser close to the Earth; at sea level, than higher in the sky. Unlike water in oceans, that is nearly incompressible and weighs the same at the ocean floor as it does at the surface, air at sea level weighs more than air at the top of mountains. Although there is air in our atmosphere hundreds of mile above the Earth, more than one-half of our breathable air stays within 3 ½ miles (5 3/5 kilometers) of Earth's surface. Because air is highly compressible, air at or near the Earth's surface is much heavier, and less stable than air higher up. This condition determines weather changes. Therefore, air pressure refers to the density of air at a given time in a given place.

The Hydrological Cycle

The continuous process involving the circulation of water between the atmosphere, the ocean, and the land is called the hydrologic cycle. Solar radiation and gravity are the driving forces that "run" the cycle. It has been calculated that there is a mass of around 13,967 X 10^{20} grams of water on the accessible areas of the earth's surface. This water may be found on the surface as liquid or ice, and in the atmosphere as vapor. Approximately 99% of the total is in the oceans and seas, and most of the remainder is locked in glaciers, snow and ice. Water vapor in the atmosphere amounts to only a minor fraction of 1 percent of the total. The remainder, the inland waters of lakes, rivers, and wetlands, constitutes only about 0.25 X 10^{20} g, or 0.000018% of the total. Not only is water a key constituent of life in its own right, but it also serves as the medium through which many other nutrients are carried.

When all the water on Earth is represented in a 5-gallon bucket …

1,244.16 Tablespoons = Ocean water

25.6 Tablespoons = icecaps and glaciers

7.93 Tablespoons = groundwater

.11 Tablespoons = Freshwater lakes

.1 Tablespoons = Inland seas and salt lakes

.0128 Tablespoons = Atomospheric water

.0012 Tablespoons = Rivers

The hydrological cycle details the circulation of water between ocean, earth, and atmosphere. Atmospheric water falls on the earth as ***precipitation*** in the form of rain, snow or fog. About five-sixths of the water ***evaporated*** in the cycle comes from the oceans, but only three-fourths of global precipitation falls on them. The difference is that which is exported to the land. In heavily vegetated areas, much of the precipitation is intercepted by plants and released back to the atmosphere as evapotranspiration. That which does not, soaks into the ground or becomes surface ***runoff***, creating our streams and rivers. Water that percolates through the soil may eventually reach an impermeable layer and reside there as ***groundwater***. Its upper surface

is referred to as the water table. Geological formations that yield water in usable (in human terms) quantities are referred to as ***aquifer***s. If not used somewhere along the way, all ground and surface water eventually returns to the sea, completing the cycle. Carried in solution will be many nutrients either leached from the soil or derived from the weathering of parental rock. These nutrients will eventually be deposited as ocean sediments and their biogeochemical cycle will not be completed unless, and until, these deposits are again raised above sea level in a geological uplift.

Implications for Management

"Everybody talks about the weather, but nobody ever does anything about it" is a popular saying. Despite our best efforts to bring needed rains through chanting, dancing, or seeding clouds, we have had limited success in changing, or even predicting, short-term weather. Our discussion of the implications for management of the hydrological cycle is therefore going to focus on the management of water (aquatic systems) once it's on the ground. How we manage aquatic systems is based on the values we assign to them. Some of those values might include flood storage and conveyance, water supply, pollution and sediment control, recreation, aquifer recharge and fish and wildlife habitat. Managing aquatic systems for recreation (swimming, boating, and water skiing) may involve methods different from those employed if managing for fish and wildlife habitat. As is true for any system, management objectives will determine management guidelines.

All aquatic systems are affected by the status of the terrestrial (land) systems that surround them. Controlling erosion throughout the watershed is of primary importance to maintaining the health of aquatic systems. Excessive run-off following storm events is a primary cause of both stream bank erosion and stream sedimentation. Improving groundwater infiltration by reducing the amount of impervious surfaces and increasing the use of deep-rooted native species of grasses and wildflowers can greatly reduce damaging run-off. Surrounding urban or agricultural lands also contribute significant levels of point source and nonpoint source pollution to aquatic systems. Reduction of these pollutants should be an important management objective in terms of increasing water quality of the affected aquatic systems.

Appropriate management of aquatic vegetation can enhance many of the benefits provided by aquatic systems. Restoration of native aquatic plants (including submerged, emergent and shoreline species) can improve infiltration, reduce erosion, and filter out many harmful pollutants, while increasing habitat for fish and wildlife. In some cases, aquatic systems may benefit by the removal of aquatic plants, especially invasive non-natives such as Eurasian watermilfoil (*Myriophyllum spicatum*).

Controlling water levels is another management tool that can improve the value of aquatic systems, particularly those involving constructed wetlands. Reducing water levels creates mudflats that are attractive to a variety of birds, allows for improved soil aeration and growth of

new food-producing plants. Such “drawdowns” are frequently performed in the fall to provide migratory birds with critical food resources along their routes. Conversely, increasing water levels simulates flood conditions, bringing in additional nutrients and stimulating aquatic plant growth.

Mineral and Nutrient Cycling

The never-ceasing quest for energy among all living organisms is an important determinant of many of the unique and peculiar traits of organisms. Entire books have been written about the adaptations related to either acquiring food or avoiding becoming food. But energy needs aren’t the only consideration for organisms. In addition to the basic building blocks of organic matter (carbon, hydrogen, oxygen, nitrogen, phosphorus and sulfur), at least 20 other elements are considered essential to life. These elements move freely between the abiotic (non-living) and biotic (living) portions of an ecosystem as plants take in carbon dioxide from the air, and water and minerals from the soil to produce carbohydrates, fats, and proteins. They are then passed along the food chain to both herbivores and carnivores. Nutrients are eventually returned to their elemental form and again take up residency in the abiotic environment upon decomposition of both excretory waste and dead plant and animal tissue.

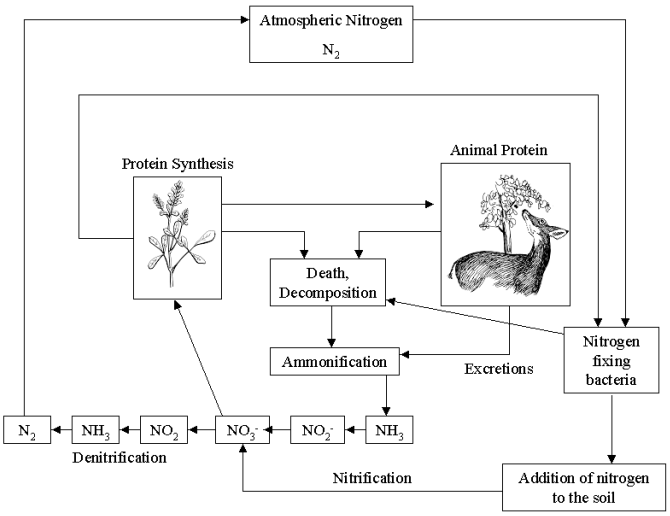
This circulation of elemental materials is thus another important aspect of ecosystem function. Note that unlike energy, which *flows through* an ecosystem, matter is continually recycled. Some elements that currently (and temporarily) make up your body may well have resided in a dinosaur a hundred million years ago, or in the primordial bacteria that first colonized the planet almost 4 billion years ago!

Nutrient cycles are more formally referred to as *biogeochemical cycles*. It emphasizes the fact that the biological (bio) realm and the rest of the earth (geo) are inextricably interconnected through the movement of essential chemical elements. Biogeochemical cycles have no starting point. They are not for the ultimate benefit of plants or consumers any more than they are for detritivores or bacteria.

Of the many existing biochemical cycles, those most frequently detailed include the cycling of carbon, nitrogen, phosphorus and sulfur. Common to all are the presence of either a gaseous or sedimentary reservoir, and a change in the chemical nature of the element as it passes from one step to the next. We will examine the nitrogen cycle in more detail. Those wishing to learn more about the cycling of other nutrients are encouraged to do so by consulting any ecology text.

The Nitrogen Cycle

Nitrogen, in the form of NH_2 (one nitrogen atom and two hydrogen atoms), is the building block of all plant and animal proteins. However, it does not exist in this form in nature, and outside of biological processes, it exists almost entirely in its non-reactive molecular form, N2 gas. The earth's atmosphere, which is 79% nitrogen, is the vast reservoir for this important nutrient. Plants need nitrogen, but they cannot absorb it in its gaseous form (N2). They only take up nitrogen as either ammonia (NH3) or nitrate (NO3), so even though life is bathed in nitrogen, it can't use any of it unless it is first transformed or "fixed."



The Nitrogen Cycle, Courtesy of G.T. Miller.

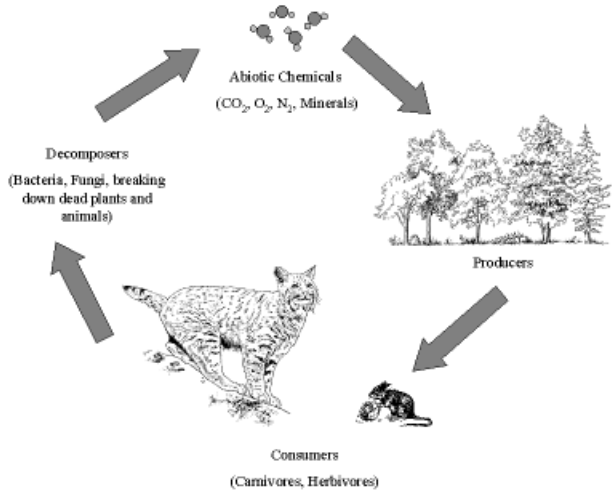
Nitrogen Fixation

Nitrogen fixation, the process of converting atmospheric N2 to ammonia (NH3), although energetically expensive, is accomplished by a wide variety of terrestrial and aquatic microorganisms, especially by both free-living and symbiotic bacteria. In many terrestrial environments, leguminous plants (members of the pea and bean family) often harbor the bacterium, *Rhizobium*, in root nodules. This is a *symbiotic* arrangement; that is, both organisms benefit from the relationship. The bacteria tap into the plant's stored food, acquiring the energy necessary to carry out fixation, while the legume benefits by having access to the excess of ammonia produced beyond the needs of the bacteria. This is why legumes are often high in protein. It is also why legumes like vetch, clover and alfalfa are often planted as cover crops. *Rhizobium* not only provides for the needs of itself and its symbiont, it may actually result in as much as 250 pounds of nitrogen compounds being added annually to each acre planted.

This wildflower, growing in the Boise Foothills, is a type of vetch. As a member of the pea family, these plants are nitrogen fixators.

Ammonification

Animals and decomposers produce their proteins from the plant or animal proteins in their diet. When these proteins are broken down in respiration, a waste product, ammonia, is produced. This may be excreted directly (fish) or it may first be converted to a less toxic form. Most mammals, us included, convert it to urea, while most birds, reptiles, and invertebrates convert it to a more solid form, uric acid. These compounds are the source of energy for another group of bacteria, which convert the nitrogen compounds to ammonia in a process known as *ammonification*. Upon death, this same process will break down an organism's body proteins.



The nitrogen cycle, courtesy TX Master Naturalist Program.

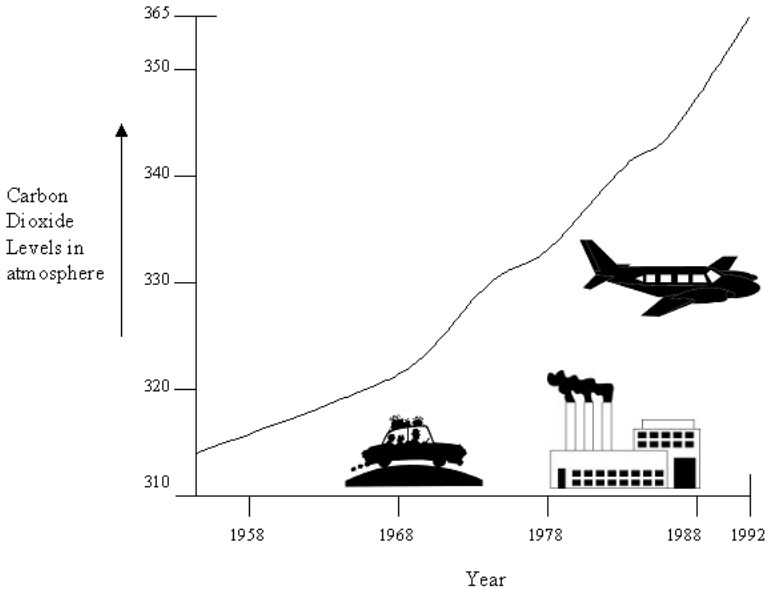
Nitrification

While ammonification returns nitrogen once again into a form immediately utilizable by plants, ammonia is often further acted upon by two separate groups of bacteria (again as a means of obtaining energy) in a two-step process known as nitrification. The first group of bacteria converts ammonia to nitrite (NO2) and the second group converts nitrite to nitrate (NO3). Both of these compounds are negatively charged (anions) and often precipitate out as various salts when bonded to positively charged cations, such as potassium or magnesium. As such they can be retained in soils for a much longer time than ammonia, and are therefore important components of a soil's fertility. Like table salt, these nitrogenous salts readily dissociate in water, thus making nitrate available for uptake by plants after a rain.

Denitrification

The above reactions will only take place under aerobic conditions, that is, where oxygen is present. Soils that have been compacted, waterlogged, or are otherwise anaerobic, will often set the stage for a loss of utilizable nitrogen in soils. Yet another group of bacteria, all anaerobes, will obtain significant energy by converting nitrate or nitrite back to elemental nitrogen, N2. Although this may be looked at by some as a "negative" or harmful process (well-aerated soils are more productive), denitrification does bring the nitrogen cycle full circle, insuring that atmospheric concentrations of nitrogen are maintained and that the system as a whole remains in balance.

The Carbon Cycle



As all good Trekkies know, we here on Earth are carbon-based life forms. Carbon is not only one of the major building blocks of all life (known to date), but it is inextricably bound to the way most all organisms obtain their energy. For that reason the carbon cycle is sometimes referred to as the energy cycle. Plants take in carbon dioxide (CO_2) and water, and through the process of photosynthesis, create glucose, a simple carbohydrate or sugar. Simple sugars, the most basic form of food energy, can be further modified to form complex carbohydrates (starches), various fats and oils and proteins. Plants use some of these organic compounds for their own metabolic needs, thereby returning some carbon back to the environment as CO_2, but most is retained in the plant body. Herbivores (plant eaters) obtain their carbon (energy) from the plants they eat and higher level consumers (carnivores) from the animals they eat. Decomposers obtain their carbon from the dead plants and animals they consume. Ultimately, all consumers and decomposers return most of the carbon back to the atmosphere (or water) as CO_2 in the process of respiration, thus making it available once again to plants.

That's the simple part of the cycle. The more interesting part has to do with the amount of carbon that *isn't* returned to the system as gaseous CO_2. Organic matter that escapes immediate decomposition may enter long-term storage as fossil carbon. This doesn't happen to any appreciable degree today, but vast quantities of carbon entered such long-term storage 285-350 million years ago during the Carboniferous Period. This carbon is now being returned to the environment as CO_2 at the rate of about 7 billion tons per year in the process of burning our fossil fuels of coal, oil and gas. About half that amount seems to be accumulating in the atmosphere. An estimated one to two billion tons is being absorbed by oceans and the remaining amount has most likely gone into increased plant biomass. The great majority of un-oxidized carbon is not found in fossil fuels, but in various carbonate rocks deposited as sediments on the bottom of lakes and oceans. Oceans are actually the single largest reservoir for CO_2, storing 60% more than the atmosphere. When CO_2 dissolves in water, some of it forms carbonic acid that, in turn, may form various carbonates and bicarbonates. Because they are not very soluble,

carbonates usually precipitate out and form sediments. One of the most common examples that everyone is familiar with is calcium carbonate or limestone.

Implications for Management

Most everyone has heard of the greenhouse effect and global warming. The greenhouse effect refers to the fact that gases (most prominently CO2) in our upper atmosphere (troposphere) trap and hold radiant heat, much like the glass in a greenhouse. Increasing the concentration of greenhouse gases increases this heat retention. The vast majority of climatologists are now convinced that human activity, primarily the burning of fossil fuels, is directly responsible for the significant increases in greenhouse gas concentrations measured over the last 50 years. If this trend continues, CO2 levels could double by 2050, leading to a possible increase in global average temperature between 3.5-9o F. The implications of such a temperature increase, at a rate 10-100 times faster than has occurred during the past 10,000 years, are profound. Hotter, drier conditions will negatively impact food production and water resources, increase the frequency and severity of storms and hurricanes, raise sea levels 2-3 feet (flooding coastal communities) and have a severe impact on most plant and animal communities. If, for example, CO2 levels do double by 2050, hardwood trees (and the entire assemblage of hardwood forest species) east of the Mississippi would have to shift 300 miles northward to find suitable climatological conditions. Plants and animals can, of course, shift their distributions in response to climate change, but following the retreat of the last ice age, northward movement of hardwood trees was only 12 miles per 100 years. The implication is that many members of those forest communities will simply not survive.

As severe as these outcomes are, there is concern that rising temperatures may set in motion a dangerous

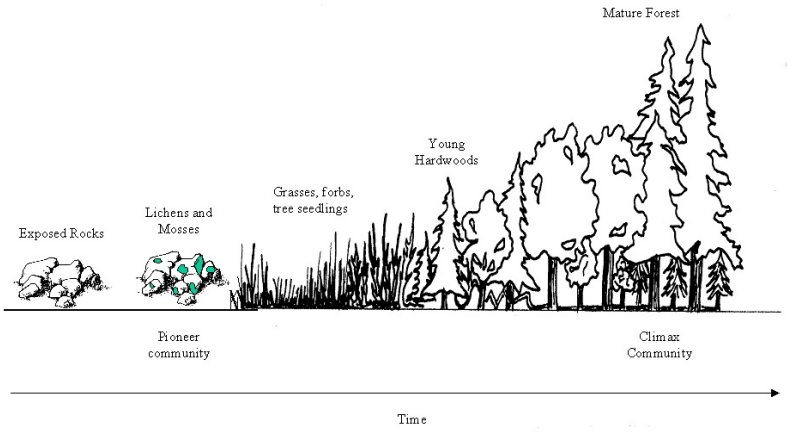
10 things you can do to reduce your carbon footprint

1. Drive less (combine trips, ride your bike, carpool, use public transportation, and walk)!
2. Replace your incandescent light bulbs with compact fluorescent lights (CFLs).
3. Put one-sided faxes and printed reports back into the printer for re-use on the other side.
4. Unplug phone, radio, and cell phone chargers when not in use. These use energy regardless of if they are charging.
5. Buy local. Reduce trucking and shipping pollution.
6. Replace single-pane windows with double-pane windows.
7. Buy “green” energy from your power company.
8. Rid yourself of junk mail. Take the time to call, email or write to the companies that send you junk mail and get your name off their list!
9. Hang your clothes on the line to dry.
10. BYOCSB-bring your own cloth shopping bags. Put empty shopping bags in your car, so you have them for when you go to the grocery store.

positive feedback or "runaway greenhouse" effect. We mentioned that the oceans serve as an important reservoir or sink for carbon dioxide. However, as global temperatures rise, the ocean's ability to dissolve and hold CO2 falls. Release of this oceanic CO2 into the atmosphere will further accelerate the rate of change. Likewise, increasing temperatures on land will melt continental ice sheets, adding to rising ocean levels and exposing more dark, heat-absorbing landmass. It will also speed up decomposition rates, resulting in the release of even more CO2. Lastly, the continued destruction and burning of tropical forests exacerbates the problem two-fold. Deforestation directly contributes about one-fourth of the annual release of carbon dioxide. In addition, loss of these trees removes their ability to absorb excess CO2. To at least partially offset rising CO2 production, many countries have embarked on significant reforestation programs. Most experts agree, however, that significant reduction in the threat of global warming will not come without significant reduction in our use of fossil fuels. We need to greatly increase the efficiency with which we continue to use coal, oil and gas and switch as soon as possible to alternative, renewable energy sources.

Ecological Succession

One of the overarching themes to your Master Naturalist training should be the fact that nature is dynamic. The natural world is constantly undergoing change. Everyone living in Idaho is familiar with the phrase, "If you don't like the weather, stick around a few minutes, it's bound to change." We can all relate to the fact that not only is our weather unpredictable on a day to day basis, but that even seasonal patterns vary from year to year. Last winter may have brought record snowfall, while this year hardly any fell. Weather is just one of many factors that are subject to change within any organism's environment. Changes in the distribution and abundance of species may be in response to changes in either short or long-term weather patterns, other species, random events, human disturbance, or ecological succession.



Succession can be defined as the replacement of populations on a site through a regular progression until a relatively permanent or *climax* community is established. Succession occurs

both on land and in the water. The former is usually referred to as *xerarch* (dry) succession and the latter as *hydrarch* succession. When this process occurs on a site previously devoid of life, such as on bare rock or in a sterile body of water, it is called *primary succession*. *Secondary succession* occurs on areas that have recently supported an ecological community, but have been disturbed. Secondary succession would be observed on a forested area following a fire, on an area inundated by floodwaters, or on abandoned cropland.

Primary Succession

Primary succession may take hundreds, or thousands, of years before a stable climax community is attained. Much of that time may be involved in the creation of a soil substrate substantial enough to support the climax plant species. *Pioneer* species are the first to occupy a barren site. They typically share the following characteristics: strong powers of dispersal, high reproductive rates and the ability to persist under the extreme environmental conditions often encountered at such sites. They are usually short-lived "fugitives" which can quickly establish a foothold, but are competitively inferior to species that may take longer to establish their presence. Many well-known "weed" species are good examples of such fugitive pioneers. Over time, increasing deposition of organic matter provides resources for a greater diversity of plants. Succeeding communities, known as *seres*, frequently exhibit an increase in the both the number and size of species.

Whereas succession was once viewed as a very orderly process whereby each sere "paved the way" for the one that followed, we now know that succession is neither so altruistic nor so predictable. While earlier plant species *may* make the environment more suitable for later successional species, it is equally possible that they may inhibit later species from invading or have little or no effect either way. In forest habitats, plant species replacement may be based, in part, on individual germination tolerances for light or shade or levels of soil moisture. Ultimately, succession for any geographic region may vary considerably from site to site. Not only may it proceed along a variety of pathways, it may not always end up at the same end-point. Local conditions and chance events may produce any number of "climax" communities. Changes in the composition of animal species also occur over time, with animal species usually reflecting changes in the plant community. An example of the plants that might dominate the seral stages of primary succession is shown (pg. 19). The climax community is one that is capable of self-replacement, achieving some level of steady-state stability as long as climatic patterns remain unchanged.

Secondary Succession

Disturbances that remove all or most of the members of a community often do not remove the soil substrate necessary for their existence. This soil also serves as a seed bank and will often contain viable seeds from previous communities. Thus, secondary succession may progress much more rapidly than primary succession and may skip entirely many of the earlier seral

stages. While second-growth forests may not immediately share all of the characteristics of the forest it replaced, it may be possible to re-establish most members of a forest community within 80-100 years following a fire or other such disturbance.

Disturbance and Recovery

An ecological disturbance can best be thought of as an interruption of a settled state. The magnitude and frequency of disturbances, be they natural or otherwise, will determine the rate and degree to which a community will return to its pre-disturbed state. Small-scale disturbances, such as the loss of several trees in a forest due to high winds, may not alter the community composition at all; those individuals lost being replaced by saplings of the same species "waiting their turn" in the understory. On the other hand, a mature, climax forest, unaltered for many years, may be completely devastated by an intense fire. Recruitment may have to come from seeds arriving from a distant source, perhaps from a forest of different species composition. In this case, secondary succession may proceed along any number of pathways and recovery of the original forest may take many decades if it happens at all. Communities subjected to frequent disturbance, such as in a floodplain, are more likely to contain species with adaptations favoring their rapid recovery.

If undisturbed, what plants dominate your ecosystem?

Implications for Management

As you might surmise from the above, disturbance regimes can have profound effects on the level of species diversity present at a given site. At low levels of disturbance, climax communities may exhibit relatively low levels of diversity, since competition will be high and the community will be primarily composed of a few dominant species. At high levels of disturbance, diversity will also be low, since relatively few species will be adapted to survive under those conditions. It follows that species diversity is actually highest at both intermediate stages of succession as well as under moderate levels of disturbance. If one wishes to manage an area for maximum species diversity, it will be necessary to create or maintain these conditions. Middle successional stages, where habitat is varied, will foster species diversity.

On the other hand, certain animals may be on the threatened or endangered species list because they are tied to a particular successional stage that is no longer abundant due to human interference. For example, flammulated owls and white-headed woodpeckers need large tracks of mature and old growth ponderosa pine trees. According to a Forest Service and Bureau of Land Management study, 75% of ponderosa pine ecosystems have been lost in the interior Columbia River landscape due to fire exclusion, logging, and grazing of livestock. (Idaho Department of Fish and Game, 2000)

Current estimates indicate that greater than 75% of the historical old growth ponderosa pine ecosystems have been lost across the Interior Columbia River Basin landscape (USFS and USBLM 1997). The primary effect of past forest management activities on overall acres of ponderosa pine has been the significant change in the historical fire regime. Three types of management activities have had the most influence on changing the historical fire regime: 1) fire exclusion policies; 2) grazing of livestock; and 3) harvesting of trees. (Covington and Moore 1994, Agee 1996)

Trophic Relationships

To early ecologists, it became apparent that the most obvious *functional* relationship linking plants and animals together in any ecosystem was food based. Feeding or *trophic* relationships delineated who ate whom in order to obtain the energy and nutrients necessary for survival. Hence, any community of organisms could be organized on the basis of the following *trophic levels*:

- Producers – Those organisms capable of producing their own food, primarily by fixing energy from the sun via photosynthesis. These *autotrophs* (self-feeders), most of which are plants, then serve as the primary energy source for the rest of the biosphere!

- Herbivores (primary consumers) – Those organisms obtaining their energy directly from plants, also referred to as primary consumers.

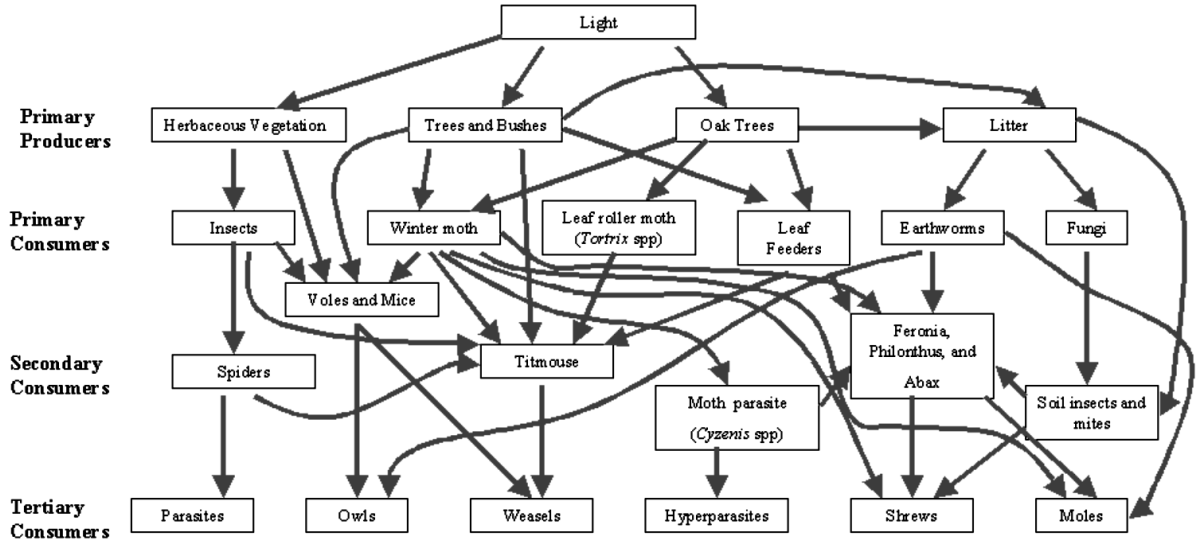
- Primary Carnivores (secondary consumers) – Those organisms obtaining their energy from herbivores.

- Secondary Carnivores (tertiary consumers) – Those organisms obtaining their energy from other carnivores. While one could conceivably continue "stacking up" carnivores in this fashion indefinitely, most ecosystems rarely exceed 4 or 5 trophic levels.

- Detritivores – Also known as decomposers, these organisms obtain their food from dead plants and animals. Through their actions, the building blocks of life are returned to the environment in elemental form to be used yet again. While often not considered a distinct trophic level, they are indispensable members of the biotic community.

Food Webs

A sequence of organisms, each of which feeds on the one preceding it, form a *food chain*. An Idaho example would be grass-insects-songbirds-raptor.

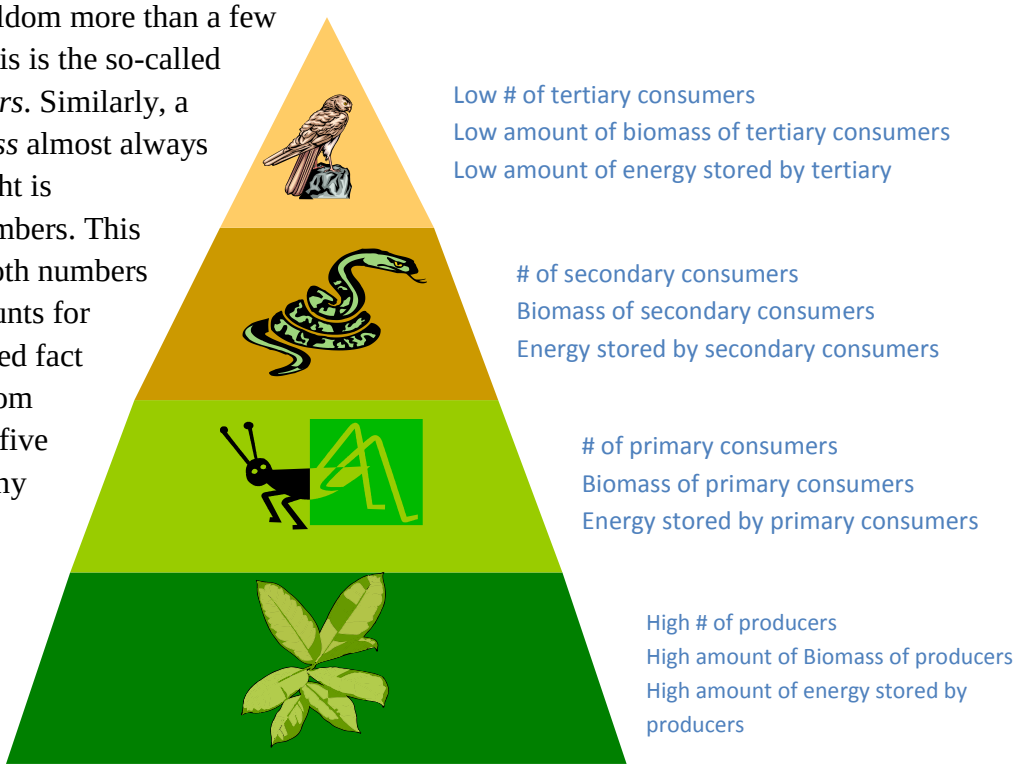


This is an attempt to draw a food web using broad categories of animals and plants.
Graphic courtesy of Texas Master Naturalist Program and Varley, Gradwell, and Hassel.

In most communities, several to hundreds of such food chains exist, and are interconnected in such a way as to form *food webs*. Were all organisms to be included, such food webs would be too complex to actually draw. Thinking of examples of food chains and webs reveals the "complexities" about trophic organization. First, not all organisms fit neatly into a single trophic level. Voles and mice, for example eat both herbs and insects, and like many other animals, including us, are considered *omnivores*. Second, while detritivore food webs are often considered separately, in reality the so-called herbivore food web and detrivore food webs usually interdigitate in a complex fashion. Finally, such food webs do not tell us much about which species are the most "important" to the stability of that particular community.

Pyramids of Numbers and Biomass

A general pattern emerges from observing community structure based on trophic relationships. There are usually many more plants than herbivores, greater numbers of herbivores than carnivores, and seldom more than a few top carnivores. This is the so-called *pyramid of numbers*. Similarly, a *pyramid of biomass* almost always results if dry weight is substituted for numbers. This rapid decline in both numbers and biomass accounts for the previously noted fact that there are seldom more than four or five trophic levels in any community.



Energy Flow

In order to understand the patterns in the graphic (right), we need to examine *energy* and *energy flow* within an ecosystem. Without getting sidetracked by a physics lesson, we're going to define energy as the capacity to do work. When you are "out of energy," your capacity to do work certainly feels limited. Work, however, isn't confined to just physical labor. It also includes maintaining basic metabolic functions, such as biochemical transformations, biosynthesis, secretion, and cell maintenance. Thus, as long as they're alive, all organisms continually lose energy in the form of heat. Lying in bed in a coma still requires energy! Unless an organism can replenish that energy which is constantly being lost, it will die.

The original source of all energy utilized by organisms is the sun. Unfortunately, the sun's energy or *solar radiation* cannot be used directly by most organisms to meet their constant energy needs (sun bathing would otherwise be looked at in a whole different light, so to speak). Only those organisms capable of photosynthesis can accomplish this. Interestingly, less than 1% of the solar radiation reaching the Earth's atmosphere is fixed in the form of chemical bonds in photosynthesis, yet this is sufficient to produce all of the plant and animal biomass on the planet! Unless this chemical form of energy in plant and animal tissue enters long-term storage (as was the case in the formation of oil, gas and coal), all of it is eventually degraded to heat, a form of energy no longer capable of performing biological work. That is why we say that energy *flows* through an ecosystem. The daily influx of energy from the sun that is fixed by the producers is

roughly balanced by the daily outflow of heat produced by the myriad of living, metabolizing organisms, ultimately radiating back into outer space.

Ecological Efficiencies

Let's now go back and more closely examine the basic pattern we find in nature with regard to the pyramid of numbers and biomass. Why is it that most ecosystems support only three to five trophic levels? Why not 10 or 20 or 100? Is that picture we've all seen of a tiny minnow being swallowed by a larger fish and that by a still larger fish, and it in turn by a yet larger fish, and on and on until the last is swallowed by the giant whale false? In a word, yes! In order to see why, we need to understand what happens to a "packet" of energy as it makes its way from one trophic level to the next. Let's imagine 1,000 square meters of grassland and assume, for purposes of illustration, that our initial packet of solar energy fixed by all of the plants in that ecosystem has a value of 10,000 units. As we shall see, only a small percentage of this energy is going to end up in the next trophic level, the herbivores. First, some of that energy will be needed by the plants to meet their own metabolic needs. For plants, that figure lies between 20 and 75%, thus leaving between 25-80% of the energy plants fix in photosynthesis for growth or *net production*. Put another way, we can say that the *net production efficiency* of plants is between 25-80%. This is the new plant biomass (energy) available for consumption by the herbivores.

If we take an average *net production efficiency* of 50% (actually typical for grassland plants) we now have 5,000 units of energy available to the herbivores. But herbivores are not going to consume every last shred of plant material available. The *harvesting efficiency* of grassland herbivores varies between 5-30%. Let's assign a value of 20% to our herbivores. That means they will eat (ingest) only 1,000 units of energy (5,000 x 20% = 1,000). As you can see, we have already "lost" 90% of the energy we started with!

Let's continue to follow our packet of energy, now 1,000 units, as it proceeds through the herbivores. First, we have to be aware that most consumers don't digest, or *assimilate* everything they eat. Because plant material contains a lot of indigestible parts, *assimilation efficiencies* for herbivores are typically low, ranging between 30-60%. Thus, we are now left with between 300-600 units of energy that are actually digested (assimilated) by the herbivores, the remainder leaves the animal as fecal material, or *egestion*. Can all of the energy assimilated by an herbivore be applied towards growth? No. A significant amount of this energy must also be used to take care of an animal's basic metabolic needs.

Here is where we see a large difference between *ectotherms* and *endotherms*. You may know the former as "cold-blooded" and the latter as "warm-blooded" animals. Whereas ectotherms can put 20-50% of their assimilated energy towards growth, endotherms (birds and mammals) can only muster 1-3%. Why is this *tissue growth efficiency* so low for birds and mammals? Because most of their assimilated energy must be used to maintain an elevated body temperature (high

metabolic rate). Since ectotherms simply assume the temperature of their surroundings, their metabolic needs are substantially less and they can put more of their available energy directly into growth.

Let's apply the above tissue growth efficiencies to an average value of 500 units of energy assimilated by the grassland herbivores. Ectotherms, such as grasshoppers, will produce between 100-250 units of new tissue (500 x 20-50%), while endotherms, such as mice or rabbits) will produce only 5-15 units (500 x 1-3%). Out of our original 10,000 units of energy, we have managed to produce only 100-250 units of herbivore tissue if we're talking grasshoppers and the like, and very scant 5-15 units of herbivore "meat" if we're considering birds and mammals. This is all that will be available to the next trophic level, the primary carnivores. We have lost somewhere between 97.5 to 99.95% of the energy originally fixed by plants in photosynthesis!

Having "crunched the numbers," you can begin to appreciate the rather drastic reduction in numbers and biomass usually portrayed in the third and fourth levels (carnivores) of the respective pyramids (refer again to pg.19). This is why the fourth trophic level only represents a few individual carnivores for the size of our illustration.

As a simplification, ecologists often employ the "10% rule" to illustrate the decline in available energy from one trophic level to the next. Thus, only .01% of the original amount of energy fixed by the plants in photosynthesis would be available to tertiary carnivores in any given area! It is this low trophic-level efficiency that accounts for the small number of trophic levels observed in any ecosystem.

Implications for Management

The exceedingly small amount of energy available to the highest trophic level accounts for the fact that "big, fierce animals," those top carnivores, are exceedingly rare. In fact, most top carnivores need to be highly mobile to cover the vast amount of ground needed to supply their energy needs. Home ranges of wolves and mountain lions, for example, are on the order of hundreds of square miles! Their predatory activities often form crucial energy links between neighboring ecosystems or landscapes. It also explains why many of these top carnivores are often on endangered species lists. Never existing in large numbers, encroaching development and increasing levels of habitat fragmentation are compromising their need for large expanses of suitable habitat. It is also putting them in more frequent contact with human activities, often with negative consequences.

The territorial needs of these predators are also posing a dilemma to conservation biologists. As wildlife habitat continues to shrink, biologists are recognizing that the long-term survival of many species may ultimately depend on our willingness and ability to set aside sufficiently large tracts of land as biological reserves. The important question is – "How large of an area is needed to maintain a viable population of that region's largest carnivore?" Is there the financial and political wherewithal to create at least one park or preserve on the magnitude of thousands of square miles? If not, we might not only lose those magnificent large predators but also the long-term stability of entire biological community of which they are important, perhaps critical, members.

Ecological Relationships

Species Interactions

So far, we have learned that the structure and function of all ecosystems is based on the concepts of energy flow and nutrient cycling. An organism's trophic relationships, and its relative importance in the flow of energy and the cycling of nutrients, are important aspects of its role, or niche in the community.

Another key element in describing an organism's niche is the way it interacts with other species within its community. What kinds of interactions exist among species? One way of answering this question is to determine the effect that one species has on another's ability to survive and reproduce. In the table to the right, types of interactions are listed along with their effects on the two species involved. In a predator-prey interaction, for instance a plus indicates that species one (the predator) benefits from the interaction. For species two (the prey), the negative sign signifies a negative impact on its population. Note that this particular type of interaction would also include herbivores eating plants and host/parasite interactions.

INTERACTION SPECIES

	1	2
Neutralism	0	0
Competition	-	-
Amensalism	0	-
Predation	+	-
Commensalism	+	0
Protocooperation	+	+
Mutualism (obligatory)	+	+

Types of Interactions their effects on the species involved:

- *+ is a positive effect*
- *- is a negative effect*
- *0 is no effect*

Neutralism - the state of being neutral.

Competition - The simultaneous demand by two or more organisms for limited environmental resources, such as nutrients, living space, or light.

Amensalism - A symbiotic relationship between organisms in which one species is harmed or inhibited and the other species is unaffected.

Predation - The capturing of prey as a means of maintaining life.

Commensalism - A symbiotic relationship between two organisms of different species in which one derives some benefit while the other is unaffected.

Protocooperation - the first in time association of organisms working together for common benefit

Mutualism -An association between organisms of two different species in which each member benefits.

Competition is defined as the use of a limited resource by two or more individuals, either of the same species (intraspecific competition) or different species (interspecific competition). Competition is negative for both because use or defense of a resource by one (individual or species) always reduces availability of that resource for any other.

For much of the past 130 years, most ecologists believed that the old dictum "nature, red in tooth and claw" succinctly described the dominant forces shaping and controlling the natural world. We discovered that the concepts of trophic interaction and energy flow were pivotal in developing an ecological framework. They also influenced thinking about the way in which biological communities were structured. Predation and competition, (killing and fighting for resources) were seen as the key to understanding how communities were organized. They were also viewed as important determinants of population size and stability of natural systems. As one famous study put it, "Are populations limited primarily by what they eat or by what eats them?" (Hairston, Smith and Slobodkin, 1960) As a result, the ecological literature is especially rich in articles detailing predator-prey interactions and competition. Over the years, observation, theory and experiments have clearly demonstrated that both do play important roles in structuring biological communities. More recently, ecologists have turned their attention to other types of interactions. Within the last several decades, they have begun to elucidate the importance of win-win interactions, such as symbiotic relationships among plants and their pollinators and the mycorrhizal association of fungi with plant roots, to similarly shape community structure.

Species-Community Relationships

Interspecific (between species) interactions often have a significant effect on the number of species present in a community and their relative abundance. Evolutionary ecologists believe, for example, that much of the great diversity in life we see has come about through *competitive exclusion*. The *Competitive Exclusion Principle* states that two or more species cannot coexist on a single limited resource. Competition thus leads to one of two scenarios. Either one species will "out compete" the other(s) and gain sole possession of that resource *or* natural selection will, over time, select for those individuals that exploit different resources, thereby avoiding competition. Ultimately, characteristics of species diverge sufficiently to allow for coexistence with each species occupying a unique niche in the community.

In some habitats, ecologists have identified *keystone species*, species whose addition or removal may lead to major changes in community structure.

Think of examples in Idaho of effects of removing a keystone species. What happened?

Population Dynamics

As illustrated in the preceding section, species interactions can have profound effects on the numbers of individuals in a given population. Obviously, many other environmental factors, both abiotic and biotic, affect population size. Ultimately, though, we can track changes in *population density*, the number of individuals per unit area, as a resultant of four factors:

- **Natality** – the production of new individuals through either sexual or asexual reproduction
- **Mortality** – loss of individuals through death
- **Immigration** – new individuals moving into a population
- **Emigration** – residents moving out of a population.

All the fancier models of population growth (which we happily won't go into) are based on this simple equation:

$$N_{(t+1)} = N_t + B + I - D - E$$

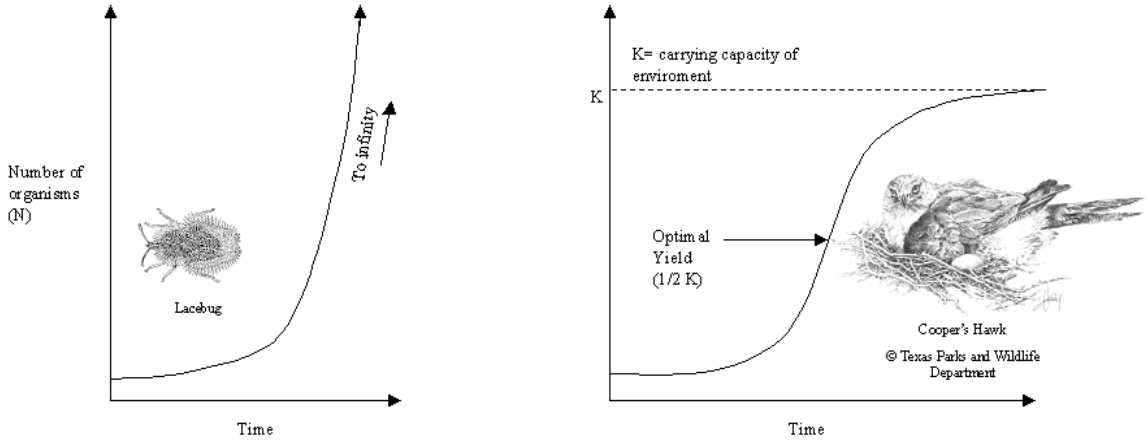
Verbally this reads: The number (N) of individuals in a population at some unit of time in the future (Nt+1) is equal to the current number of individuals (Nt) plus the number of new individuals recruited via reproduction (B) and immigration (I), minus the number lost to death (D) and emigration (E) over that unit of time. If recruitment exceeds losses, the population grows; if not, the population declines.

In part, the job of population biologists and wildlife managers involves assigning values to each of these four variables to better predict future population trends. *Intrinsic* (internal) factors affecting population growth include its sex and age distribution, age-specific fecundity (rate at which an individual produces offspring), and social structure. A population comprised mostly of young, pre-reproductive individuals is going to have a different growth pattern than one that has a high percentage of older, post-reproductive individuals. Certain populations, such as some species of salamanders, need a critical minimal number of individuals in order for successful breeding to occur. Territorial species, such as many of our songbirds, will behaviorally limit the number of breeding pairs allowed in a given habitat.

There are also many *extrinsic* (external) factors affecting population growth, including competition, predation, disease, pollution, hunting, and *carrying capacity* of the environment.

Carrying Capacity

Carrying capacity is a very important ecological concept. It is defined as the maximum number of individuals of a given species that a habitat can sustain indefinitely. When habitat quality improves, its carrying capacity increases. If habitat declines so does the carrying capacity. This is why both the *quantity* and *quality* of wildlife habitat is so critical to maintaining wildlife populations and why wildlife managers "manage" habitat, not wildlife.



Two growth forms - exponential (first graph) and logistic (second graph). Courtesy of E.O. Wilson and W.H. Bossert, 1971.

Population Growth Models

For many species (most invertebrates), populations may exhibit *exponential growth* **(**first graph) After starting slowly, numbers begin to accelerate rapidly, increasing at an ever-increasing rate, mimicking the way money grows in an account earning compound interest. Populations often continue to grow exponentially until a sudden change in environmental conditions causes them to "crash." An insect population growing exponentially throughout the spring and summer may be brought to a sudden halt by the first cold snap. This is *density-independent* growth, the growth rate of the population is independent of the population density. Other species, especially long-lived vertebrates, may exhibit a *logistic growth* pattern, as idealized in the second graph. Their populations show the effects of increasing *environmental resistance*. The greater the population size, the more the environment "pushes" against further growth. As numbers of individuals approach the habitat's carrying capacity (K), the population growth rate gradually slows until, at K, it becomes zero, thus stabilizing the population at carrying capacity. This *density-dependent* growth is the result of both intrinsic factors (greater social stress leads to lower natality rates, lower survivorship rates, higher emigration rates, etc.) and extrinsic factors (increased predation, disease).

No species in nature follows either pattern exactly or indefinitely. The logistic growth model, for example, assumes that populations are capable of immediately changing their growth rates in

response to environmental resistance. The reality is that there is usually a lag effect, or time delay. A population at carrying capacity may continue to grow for some time before environmental factors leading to zero population growth take effect. Thus, rather than leveling out at K, a population may overshoot it, leading to over-exploitation of resources and an eventual decline below the original carrying capacity. The long-term result may either be a population that oscillates around K in an increasing tighter pattern (damped oscillation) or one that exhibits more or less regular periodic cycles of abundance. Periodic fluctuations in numbers have often been documented in northern habitats such as the classic 10-year cycle exhibited by snowshoe hare, lynx, ptarmigan and ruffed grouse and the 4-year cycles exhibited by various species of voles and lemmings.

Implications for Management

Despite their apparent limitations, these basic models have served as the foundation for more sophisticated attempts to understand population dynamics. Population models are the primary tools of today's resource managers. The objective of all natural resource management is to produce the greatest *yield* without endangering the resource being harvested. Whether we are discussing forestry, fisheries, or wildlife, the resource manager must know enough about the population dynamics of the species in question to accurately set appropriate harvest rates on a year to year basis. Sadly, much of human history is strewn with examples of how poor management has led to the destruction of a once abundant resource. An application of the logistic population growth model has been the basis of scientific resource management since the 1930s. The model predicts that the *maximum sustained yield* for any population is obtained not at the highest population size, but rather at a point much below K. In its simplest form, the logistic model reveals that the highest rate of population increase occurs at the mid-point of the growth curve, or when N = ½ K. Thus the maximum sustained yield for a game species would be obtained by cropping that population back to one half the carrying capacity, prior to the next breeding season. To determine actual hunting or "bag" limits, wildlife managers must collect and analyze both population and habitat data to determine the relationship between a population's current size and its potential for future growth set by the carrying capacity of the habitat.

Species Diversity

Species diversity refers to the number of different species found in a community. One of the most striking global patterns is the marked increase in biological diversity (commonly referred to as *biodiversity*) as one proceeds towards the equator. Greenland, for example, is home to 56 species of breeding birds, New York has 105, Guatemala 469, while Colombia boasts 1,395!

Turf grass (far above) can be replaced with native flowers and plants (above) to increase diversity and attract wildlife.

There have been many hypotheses proposed to explain this phenomenon. Tropical habitats are older, more productive, are structurally more complex (hence have a greater number of ecological niches), and have greater numbers of predators, thereby decreasing competition among prey species. Ecologists are currently examining each of these factors to see which best explains the observed latitudinal gradient.

As noted previously, we often see species diversity increase as we proceed through succession (recall that the greatest number of species often occurs prior to the climax community). In general, ecologists have observed that disturbed sites exhibit low species diversity, usually comprised of a few broadly adapted generalists, while undisturbed sites are comprised of a richer diversity of species, many of whom may specialize on a rather narrow group of resources. *Monocultures*, communities dominated by a single plant species, such as we frequently establish in growing our crops and landscaping our urban environment, are often unstable with regard to community structure, and often exhibit wide fluctuations in the population densities of the few species they support. Outbreaks of "pest" species and diseases are much more frequently encountered in these habitats than in more diverse communities. The "balance of nature" is more likely to be a reality within communities featuring complex food webs and numerous interspecific interactions. It is one reason we support homeowners replacing the typical "turf and trimmed trees" look with native landscaping, or wildscaping.

Fragmentation and Edge Effects

As the human population continues to increase both locally and globally, we continue to reduce remaining "undisturbed" habitat. As these natural habitats become smaller and increasingly fragmented, the ratio of an area's border to its interior rises. Smaller plots are subject to greater light intensities, higher wind velocities, and a variety of biotic factors associated with the relatively greater amount of perimeter or *edge*.

Cutting holes in a forest to create more edge was once looked upon by game managers as the premier technique for increasing the density of almost any game species. Stature of this "edge effect" was further increased by some ecologists who touted its ability to also increase overall species diversity. This was true, but only up to a point, the point at which interior species began to be lost. In the case of forest habitats, the species added by increasing edge are the generalist species common everywhere – such as the white-tailed deer, raccoon, grackles and song sparrow. When used now, "edge effect" usually carries a strong negative connotation. Many forest species, such as our songbirds, are harmed by edge in one or both of two ways.

- Many interior species not only avoid the edge, but the space from a few to many meters interior to an edge. A 4-acre cut from a forest tract actually removes a considerably larger area from use of these species.

- Reproductive success of interior species is often adversely affected by increasing edge because nest-parasitizing cowbirds and many native and domestic predators enter forests via edges. For particularly vulnerable species, such as ground nesters, forests with large amounts of edge may be "ecological traps" – attractive habitat, but deadly to them or their eggs and young.

A dramatic decline in the populations of many Neotropical songbirds has been documented over the past three decades. Members of this group of birds typically breed in the United States and Canada, but winter in Central and South America. While the initial focus of attention was on the continuing loss of breeding habitat in the north, destruction of tropical forests and other key habitats in their wintering grounds have also been implicated, especially since many of these birds actually spend two-thirds or more of their time in the tropics. Recognizing the seriousness of this issue, new initiatives on the national and international level, backed by significant funding, are underway to reverse this trend. The emphasis is on the identification, preservation and restoration of both breeding and wintering habitats, as well as those critical stop-over habitats used during migration.

Endangered Species

Why do some species become rare and go extinct while others thrive? First, we must remember that extinction is a natural process. The species that exist today represent only a tiny fraction of all the species that have ever existed. Aside from geologically rare instances of mass extinction (such as the apparent asteroid impact that brought an end to the 140 million year reign of the dinosaurs), extinction rates for any given group are usually low. For mammals, the fossil record indicates this rate was between .002 and .02 species per year. In the 20th century, 25 mammals are known to have gone extinct, or .25 per year, or 12.5 to 125 times the "background" rate. In fact, given the current rate of loss of all species worldwide, we may be in the midst of one of the

fastest extinction rates of all time. The primary cause of this sharp rise in extinction rates is, first and foremost, habitat loss. As already mentioned, our burgeoning human population continues to occupy, clear and degrade more and more previously undisturbed land. Other factors, all related to human activity, include commercial hunting and fishing, predator and pest control, the exotic pet and plant trade, the introduction of alien species and pollution.

Which species are we losing? Primarily those species whose habitat is being fragmented or destroyed. These species tend to be habitat specialists rather than generalists. In Idaho, these species include the Woodland Caribou, Grizzly Bear, Lynx and Northern Idaho Ground Squirrel.

In contrast, generalists, those species with broad diets capable of surviving in a wide variety of habitats (especially those created by human activity), are common and often increase under conditions of disturbance.

So why should we care? What difference could it possibly make if we lose the woodland caribou or the lynx? There are three broad categories of arguments that are usually made to address such questions – aesthetic, practical and moral or ethical (Brewer, 1994).

The aesthetic argument is simply that the natural world has much to offer in terms of beauty, inspiration and wonder. John Burroughs said, "I go to nature to be soothed and healed, and to have my senses put in tune once again." Destroying the natural world impoverishes us all. A 2006 survey by the U.S. Fish and Wildlife service found that over 71 million Americans identify themselves as "wildlife watchers" and spent over $45 billion in pursuit of their hobbies. There are more active birders than golfers and birding has become one of the country's fastest growing outdoor activities.

Birding at Heyburn Marsh, Idaho.
Photo courtesy, Jennifer Miller, WREN Foundation.

On the practical side, all species are part of the web of life that sustains human life. There is no such thing as an "unnatural resource." Nature is the ultimate provider of all the goods and services that make our highly technological lives possible. Despite our ability to manufacture synthetic compounds, over 25% of all prescription drugs still rely on compounds derived directly from plants. A much higher percentage of drugs we have developed to treat everything from various types of cancer to HIV to malaria are modified derivatives of naturally occurring substances. An antiviral drug proven effective against a previously lethal form of herpes encephalitis was derived from a previously obscure Caribbean sponge and is now saving thousands of lives annually. When we lose any species, we lose forever the genetic information

that is uniquely theirs and the opportunities to even test them for potentially useful compounds. As far as services are concerned, there is simply no replacing the roles countless organisms and communities play in maintenance of the atmosphere, biogeochemical cycling, soil formation, watershed management pest control and pollination.

Finally, there is a moral or ethical argument that can be made. Whether or not it is deemed "beautiful" or "economically beneficial" the decision to destroy another species can be thought of as simply "not the right thing to do" in the same way that murdering another human is morally and/or ethically wrong. If we come to the understanding that humans are a part of nature, not apart from nature, we will appreciate the fact that all living things are members of one biotic community. In Aldo Leopold's words, "We are all kin."

Threatened and Endangered Species Lists

The federal Endangered Species Act of 1973 committed the United States to preventing the extinction of plant and animal species. Most states, including Idaho, have enacted their own legislation with similar provisions. *Endangered species* are those in imminent danger of extinction throughout their range. *Threatened species* are those likely to become endangered within the foreseeable future. Many states also include a third category, *rare species*, which recognizes species that, because of their low or declining numbers and other special features, such as shrinkage of critical habitat, need special attention. At the federal level, the primary authority to list, delist or change the status of any species resides with the Secretary of the Interior.

Endangered species in Idaho as of 4/3/2008	Threatened species in Idaho as of 4/3/2008
Mammals Woodland Caribou	**Mammals** Grizzly Bear (sans the Yellowstone distinct population) Lynx Northern Idaho Ground Squirrel
Fish Sockeye Salmon White Sturgeon	**Fish** Bull Trout Chinook Salmon Steelhead
Invertebrates Banbury Springs Limpet Bruneau Hot Springsnail Desert Valvata Idaho Springsnail Snake River Physa	**Invertebrates** Bliss Rapids Snail

Endangered species in Idaho as of 4/3/2008	Threatened species in Idaho as of 4/3/2008
	Plants MacFarlane's Four-o'clock Spalding's Silene Ute Ladies' Tresses Water Howellia

(for an updated list, visit the Idaho Conservation Data Center website at http://fishandgame.idaho.gov/cdc/t&e.cfm)

Protection

Under both state and federal law, it is illegal to take, possess, transport or sell any animal species designated as endangered or threatened without the issuance of a permit. State laws and regulations also prohibit commerce in threatened and endangered plants and the collection of listed plant species from public land without a permit. Endangered species receive additional federal attention. Their essential habitats are also protected and a recovery plan is supposed to be devised, based on knowledge of the ecology of the species. It outlines procedures designed to build up populations to a level where the chance of extinction is minimal, allowing the species to be delisted. Well known success stories include the Bald Eagle, American Alligator and Peregrine Falcon.

Species of Greatest Conservation Need

In early 2006, the U.S. Fish and Wildlife Service (USFWS) approved Idaho's Comprehensive Wildlife Conservation Strategy (CWCS). This strategy was mandated by USFWS for each state. The strategy identifies Species of Greatest Conservation Need and what actions need to be taken to keep these species from becoming eligible for listing on the Endangered and Threatened Species list. A list of Species of Greatest Conservation Need in Idaho is located on page six of the following document.

http://fishandgame.idaho.gov/cms/tech/CDC/cwcs_pdf/appendix%20b.pdf

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Ecosystems: Concepts and Management

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Understand and discuss the seven principles of ecology
- Describe management, ecosystems, and ecosystem management
- Identify the five ecological principles that can help assure the Earth's ecosystems

Defining Ecology

Today it is acknowledged that importance exists and a relationship is seen between the management at a site specific level (backyard, park, pasture, community, vegetation region, watershed, etc.) and the whole earth system. What happens with management on a smaller scale can have impact at a larger scale. At a landscape level, it is recognized that things are interconnected. A term used today in the United States to describe this view is "Ecosystem Management." This phrase has become a popular buzz-word in political arenas as well as with government agencies and private organizations. However, the term "ecosystem management" has numerous definitions and has resulted in some confusion on how ecosystem management should be conducted and accomplishments achieved. To understand current thinking and philosophy, we begin our study with the principles of ecology, definition of an ecosystem and what management implies.

The confusion with the use of the term "ecosystem management" can be seen in the following illustration. The Bureau of Land Management (BLM) defines ecosystem management as "a process that considers the total environment. It requires the skillful use of ecological, economic, social and managerial principles to produce, restore or sustain ecosystem integrity and desired conditions, uses products, values, and services over the long term….." This definition of ecosystem management recognizes that people and their social and economic needs are an integral part of ecological systems (Federal Register 1993 pp. 43208- 43209). Despite this official definition, a report in the High Country News (Giller 1994, page 2), referenced a Wyoming BLM public officer who stated that an offer was made to transfer an individual to a

position responsible for ecosystem management in the state of Utah where his technical skill will be of value, but he would not be in contact with the public. We will now ask, are people to be included in the definition or not? This illustrates the first major problem resource managers will have trying to implement ecosystem management. If ecosystem management is going to work, at the lowest but meaningful level, people must be able to tell each other what this kind of management means.

"Single species management" is the opposite of ecosystem management. As the name implies, single species management is when all actions with only one species in mind.

The movement to use ecosystem style management has come about because of the need to recognize and deal with the "big picture". This includes dealing with larger scales in time, space, and social dimensions associated with natural resources. A second reason is the typical government approach to solving or improving resource problems. The ecosystem management approach now implies that something else is needed. We are currently struggling to determine what is the most appropriate basis for action and then how do we blend the technical and human aspects with management? "As humans, we have, like all other animals, an inherent bias toward our own interests. Our vision (management goal) must shift to an ecosystem perspective rather than a short term personal view of what's good for me is good for everyone and I can do with my land what I want because I own it!" (White, 2001)

Principles of Ecology

Common Wood Nymph, a smaller member of many Idaho ecosystems, Photo courtesy of Kent Fothergill

How many times have we stopped to think about our land management practices and the effects these practices have on naturally occurring processes? This could be a monarch butterfly emerging from a chrysalis, clean water falling from the sky and flowing clear in a nearby creek or a green grass covered pasture turning to the yellow hue of broomweed by fall. Changes are occurring each day from natural processes, many of which we never notice or take the time to evaluate. For many, our minds are lost in the narrow-sighted world of cause and effect related to outdoor recreation, lawn maintenance, protection of our property and even agricultural processes; i.e. livestock weight gain, noxious plant kill or damage, and the amount of harvestable wildlife for the next hunting season. We too often forget that we are not in control of many things that happen around us to the land, plant communities, and animal resources. Many of these happenings and changes are described in the principles of

ecology -- principles or laws, that as land and resource managers, we should not forget and should be working *with* and not *against*. An understanding of how our ecosystem functions may allow land managers to explain things that are observed and even allow us to predict some results of decisions and actions we make on the land. Knowledge of the ecosystem can help us understand the relationships among soil, water, plants, animals and their environments. With knowledge of ecological principles, we can better accomplish our objectives.

Ecology is the field of study that is concerned with the mutual relationship of plants, animals, and microorganisms with their environment. Since range plants and animals are biological organisms, their interrelationships are ecological in nature. Range, forestry and wildlife management is often looked at as applied ecology, since they consist of manipulating the environment in which both plants and animals live. Plants and animals often live together where the welfare or future of each is dependent on the other. This is a fundamental concept of natural resource management. **The plant or producer, the grazing animal or consumer and the intrinsic value of a healthy ecosystem needs to be looked at together, not separately.** (*Principle Number 1*)

The ecosystem is made up of living and non-living things which are interconnected. An "ecosystem" includes all the organisms that live in an area and the physical environment with which those organisms interact. A change in any one of the components can invariably influence or cause a change in the relationship of all the other factors of the system. However, change is normal. **The natural resource manager should understand the change and know it has an influence on all of his management decisions.** (*Principle Number 2*)

For every action on the land, there are multiple reactions which can occur. (*Principle Number 3*) Humans often only see the target response to an action. For example, a property owner or natural resource manager might plant crested wheat grass on a hillside after a burn to prevent erosion and maintain good water quality in the stream below. Crested wheatgrass is an excellent soil stabilizer, but out-competes native vegetation. The biodiversity of the hillside would change. Wildlife species that used to forage there would go somewhere else. The simple action of trying to prevent erosion with a non-native species could have many negative effects that are difficult to reverse.

Management of lands has occurred through the introduction and manipulation of domestic livestock, high fencing for wildlife and the planting of food plots for man-made objectives. Currently many areas do not have the carrying capacity of wildlife or domestic livestock once noted by our earlier managers or naturalists. Change occurred. As plant communities changed and responded to new uses or even excessive use, less forage was often available for consumption by domestic livestock and wildlife species. Less plant cover provided open,

uncovered soils and an excellent opportunity for natural processes to respond. Lost beneficial plants were replaced with those noted by man to be less valuable to livestock or wildlife. From these actions and changes, humans have found that **Nature abhors a void and provides plants through the processes of primary and secondary succession to fill the openness.** (*Principle Number 4*)

Land managers must observe and evaluate the responses to their actions or new plants and plant communities may not meet their goals, needs or desired financial returns. A new plant community could lead to changing land uses, land value, livestock enterprises and new land ownership goals. Key measures for the manager to use in evaluating effectiveness of management are to recognize and understand the stages of soil, plant and animal succession.

With the loss of desirable, perennial plants, a decreased plant cover on the soil allowed an increased loss of rainfall through increased evaporation from the soil surface, increased runoff and increased use by newly established and often less efficient plants. Less water available in quantity or for a shorter period of time, promoted plants which could live in a dryer, more open soil environment. The new regime of plants did not provide the amount or same kind of biomass produced by previous occupants, and less litter or dead standing plant material was available for soil cover and for contribution to soil organic matter. Soil temperatures also rose. This new environment was conducive to many weeds and brush species. **Humans have found that Nature knows best. Organisms which are suited and adapted to the change, occupy the site.** (*Principle Number 5*)

Change does not always satisfy humans. They seek to find the best plants, the miracle plants, and animals that eat brush and weeds to solve these problems. As an alternative, we plant foreign plant species which can survive on our changed, depleted and otherwise mismanaged soils, only to find that Nature is still in control. When native plants emerge in non-native crops, we look to new technology to keep these plants and natural processes out of our planted monocultures. We fertilize to give these plants a competitive edge, only to find out that excessive nutrients can accumulate or flow out of the system and cause damage on adjacent land and water resources. In ecological terms, "**Everything must go somewhere.**" (*Principle Number 6*) and man often not knowingly creates the next problem. The ecosystem manager's job is to minimize the energy and nutrient drain on the ecosystem while ensuring ecosystem health.

The reduction of fire by Europeans, as they worked to protect their environment, also created an environment which helped to sustain many of the pest woody plants and their densities we see today. To push the ecosystem back to the earlier excellent or a natural state takes a lot of energy, human resources and dollars. Every gain is won at some cost. We find through principles of ecology that "**There is no such thing as a free lunch.**" (*Principle Number 7*)

What is Management?

What is "management?" Management is defined in the Webster Dictionary as the act, manner, or practice of managing, handling or controlling of something. Management is the use of certain means to achieve desired results. Management clearly implies the influence and application of human manipulation. To some the term "management" holds as a premise the concept of conquering nature and suggests that attempts at dominating nature contradicts the ethic of sound natural resource management. Traditional natural resource management has approached goal setting, problem-solving and planning from a technical basis alone, using assumptions about community values and objectives that may not be accurate. Today, management is planning, establishing goals, evaluating alternatives, making decisions, then implementing those decisions, controlling resource flow and allocation to most effectively accomplish goals, monitoring, adjusting and re-planning. Resource limitations and environmental constraints always affect management choices. The choice between short and long term goals (balance) requires foregoing some immediate benefits for long term sustainability of natural resources. You cannot have it all now if you want the resource to be renewable and sustainable.

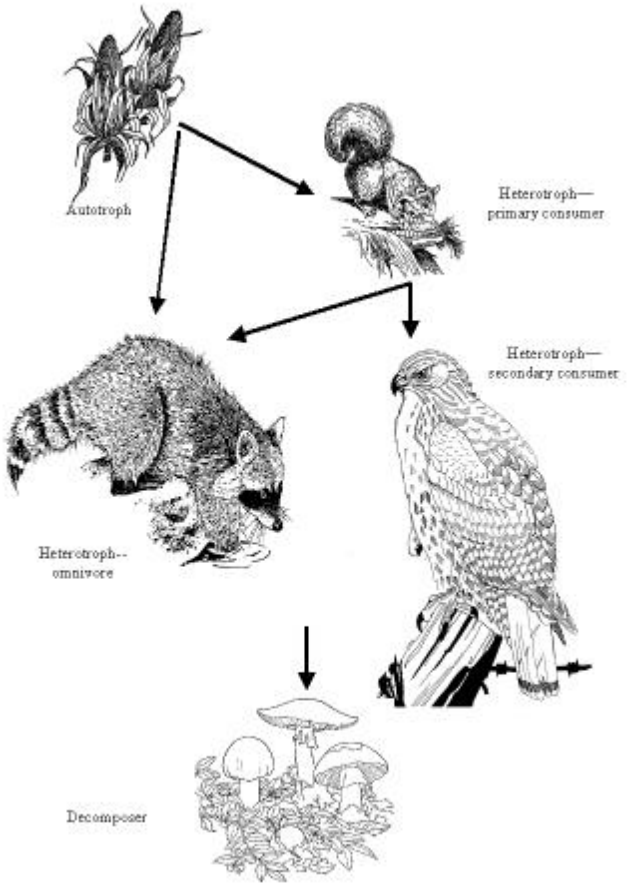
Drucker (1974) states that "Management always has to consider both the present and future--both the short run and the long run. A management problem is not solved if immediate profits are purchased by endangering the long-range health, perhaps even the survival, of the company. A management decision is irresponsible if it risks disaster this year for the sake of a grandiose future… A decision is a judgment. It is a choice between alternatives. It is rarely a choice between right and wrong. One has to make a decision when a condition is likely to degenerate if nothing is done. The effective decision maker compares effort and risk of action to risk of inaction."

A management plan basically identifies where you are, where you want to go and how you are going to get there. How many people do we know that planned to destroy their rangeland, bays, waterways or forests? I have not met one yet! But if they did not plan to do this, then why does it happen? Management decisions resulted in this situation. Management or failure to manage for the right things and understand how daily decisions affect long term sustainability of natural resources has been neglected. The decisions that we make have implications for the future, and

the future inherently will involve the unknown. To reduce risk, calls upon us to understand our needs, the environment around us and we need to learn from our mistakes.

What Are Ecosystems?

Living organisms that interact with one another and with the non-living or abiotic environment constitute an "ecosystem." The non-living or abiotic factors of the environment include light, temperature, oxygen level, air circulation, precipitation, and soil type. The population of living organisms in a given area composes a unit known as a biotic community. The interrelationship of organisms can be viewed as a hierarchy. The most basic level is a **population**, which is an interacting group of individuals of a single species. Populations of different species make up a **community**, and communities and their physical environments compose an **ecosystem.**



Organisms in ecosystems may be grouped into trophic levels as determined by their mode of nutrition. Ideally, ecosystems can sustain themselves entirely by photosynthesis or chemosynthesis and the recycling of nutrients. Autotrophic organisms (plants) either capture light energy and convert it, along with carbon dioxide and water, to energy-rich sugars, or they oxidize chemicals as a source of energy. These autotrophic organisms are named producers. Heterotrophic organisms such as herbivores (i.e. deer, antelope, and elk), which eat only producers, are called primary consumers. Secondary consumers, such as carnivores (i.e. eagles, wolves and owls), eat primary consumers. Omnivores such as bears may consume both plants and animals. Decomposers break down organic materials to forms that can be re-assimilated as mineral components by the producers. The foremost decomposers in most ecosystems are bacteria and fungi.

In any ecosystem, the producers and consumers form food chains or connecting food webs that determine the flow of energy through the different trophic levels. Energy enters a food chain at the producer level and flows to subsequent levels of consumers and decomposers in an ecosystem. Only about 1% of the light-energy striking a temperate-zone community is converted to organic material. This organic material and its energy pass to subsequent trophic levels, and as the organisms at each level respire, energy gradually dissipates as heat into the atmosphere. Some energy is stored in organisms that are not consumed and is released when they decompose.

Only a small portion of energy stored in one trophic level will flow to the next level. Most energy is lost as heat during growth, maintenance and decomposition. About 10% of the energy stored in green plants that are eaten by cattle is converted to animal tissue; most of the remaining energy dissipates as heat. If 90% of the energy is lost as heat at each level of a food chain, then only about 0.1% of the original energy captured by the producers will be used in a typical food chain with three levels of consumers. Therefore, the longer the food chain, the greater the number of producers necessary to provide energy for the final consumer. In terms of the numbers of individuals and the total mass, there is a sharp reduction of usable energy at each level of the food chain. In a given part of the ocean, for example, billions of microscopic algal producers may support millions of tiny crustacean consumers, which, in turn, support thousands of small fish, which are finally eaten by one or two large fish. In other words, one large fish requires and depends on a billion tiny algae to meet its energy needs every day.

The interrelationships and interactions among the components of an ecosystem can be complex, but over the long term there is balance between producers and consumers. An increase in food made available by producers can increase the number of consumers. This increased number of consumers reduces the available food, which then inevitably reduces the number of consumers. The result is sustained self-maintenance of the ecosystem.

Ecosystems exhibit considerable variation in net productivity. Net productivity is defined as the energy produced by photosynthesis minus that lost in respiration. Productivity (in terms of biomass produced) is usually measured as grams per square meter of land per day, whereas grasslands produce 0.5-3.0 grams and deserts produce less than 0.5 grams.

Ecosystems are dynamic and under constant change. They undergo daily changes, seasonal changes, and changes that may take from ten to hundreds of years. In the world of daily changes, photosynthesis occurs only during the daylight hours. Many animals in ecosystems are active during only daylight or night-time hours, but not both. Plants can lose their leaves for part of the year. Seasonal period of dormancy and rejuvenation are common in woody plants.

Each ecosystem includes a diversity of organisms. These organisms are distributed in specific patterns determined by the physical environment and by relationships with other organisms. A diverse growth form will exist in the organisms of an ecosystem. Species diversity depends on the number of species and number of individuals per species in an ecosystem. Species diversity is important in an ecosystem as this increases the ecosystem's resilience. Diverse ecosystems recover from stress such as drought or too much rain faster than do ecosystems with less diversity. Ecosystems can become saturated after a certain level of diversity is reached. Although diversity is valuable to a certain point, most ecosystems contain more diversity than is needed to reach peak productivity. The random loss of species does not impair the productivity of an ecosystem, for such extinctions leave behind a few species in each growth form category such as vines, canopy trees and understory ferns. This raises the question, should we be concerned about the loss of biodiversity and extinctions that human activities are causing? Yes, we should be concerned as these extinctions are not random. Human driven extinctions probably have a greater impact on an ecosystem than do random extinctions.

What Is Ecosystem Management?

The word "ecosystem" comes from "eco" which means house, "system" means that things are connected to form a whole and "manage" means to conduct or direct or make decisions. Salwasser (1995) states "Ecosystem management can be defined as the process of seeking to produce (i.e., restore, sustain or enhance) desired conditions, uses and values of complex communities or organisms that work together with their environment as integrated units. It seeks a broad focus on sustaining desired ecosystem conditions of diversity, long-term productivity and resilience, with yields of desired resources and uses being commensurate with the larger goal of sustaining these conditions." Since we are managing our house, whatever we do affects the place we live and the future conditions we will live under. We cannot do just one thing. Everything is connected and there are multiple responses to each action. Some responses are "beneficial", while some are "detrimental."

Are the natural resource agencies in your community practicing ecosystem management?

Ecosystem management requires communities and agencies working together, using different means to achieve ends that are not defined by an agency in isolation from the community. This type of management requires both the community and agencies to develop "people skills" for effective implementation. Further, resource managers and agencies need to be clear about their role(s) in the process. Are they facilitators, leaders, providers of scientific knowledge and expertise, or the ground managers? The traditional approach has emphasized social and economic criteria with limited consideration

of ecosystem processes. The ecosystem approach emphasizes ecosystem processes and long-term conditions in lieu of social and economic criteria. As land ecosystem managers, we are managing the flow of energy and the cycling of nutrients in the ecosystem. We can make changes to our advantage and benefit to the ecosystem. We successfully do this through an understanding and expectation of our actions. Natural processes do most of the work for free. A successful ecosystem manager utilizes a small fraction of the total energy budget and in return provides a service which aids the system in its function and continued survival. *In short, a successful ecosystem manager times their interactions to the right moment and the right place, often becoming somewhat inconspicuous and seemingly unimportant.*

Planning and acting at larger than usual scales is implicit and a must in ecosystem management. There is importance of spatial scale when it is recognized that differences exist between individual land enterprises and regional land use objectives. Ecosystem management has often been interpreted to imply bio-physical boundaries for the process. This may not always be appropriate or workable. In some instances the process may work better if boundaries are identified in social terms, as in naturally forming communities and groups. Recently, the Ecological Society of America Committee on Land Use (1999) identified five ecological principles that "can assure that fundamental processes of the Earth's ecosystems are sustained." From their report these include: 1) ecological processes occur within a temporal setting and change over time; 2) individual species and networks of interacting species have strong and far-reaching effects on ecological processes; 3) each site or region has a unique set of organisms and abiotic conditions influencing and constraining ecological processes; 4) disturbances are important and ubiquitous ecological events whose effects may strongly influence population, community, and ecosystem dynamics; and 5) finally the size, shape and spatial relationships of habitat patches on the landscape affect the structure and function of ecosystems.

White (2001) states that "these principles dictate several guidelines for land use and include:

1. Examine impacts of local decisions in a regional context.
2. Plan for long-term change and unexpected events.
3. Preserve rare landscape elements and associated species.
4. Avoid land uses that deplete natural resources.
5. Minimize introduction and spread of non-native species.
6. Avoid or compensate for the effects of development on ecological processes.
7. Implement land-use and management practices that are compatible with natural potential of the area."

All ecosystems should be managed in an ecologically sustainable manner for current and future benefits. If this cannot be done with the proposed land-use or management practices, then management should select different goals/or practices.

To meet the challenges of sustaining ecological systems and understand our role as managers, we must first consider - "Who was managing the lands of Idaho before the European settlers began arriving in the early 1800's? Even with the Native Americans present in Idaho, much of this system was functioning through natural processes and yes, the Native Americans were living, gathering, hunting, and setting fires to the land. But the reason for management lies more in the facts of not managing the "natural" but what was "not natural." The Spaniards introduced cattle to the western hemisphere in 1542. Cattle, domestic sheep and goats, horses, donkeys, emus, camels, etc., are not native to this hemisphere. They are not native to Idaho! Then we have introduced foods, grains, pasture grasses and other plants which are not native to Idaho. With all of the introduced, foreign plants and animals humans must manage the land, soil, plants and animals in order to keep what was natural healthy. Without management, the non-native species could overtake our landscape and the ensuing change creates an environment that is not healthy or sustainable. We must consider what humans are doing in the system. Consider the following actions and potential results:

1. Planting of potato or wheat crops,
2. Building homes in the flood plains of large rivers and small creeks,
3. Over-grazing by cattle, sheep and goats,
4. Stopping all wildfires,
5. Promotion of planting monocultures; result - suppression and loss of biodiversity.

The "ecosystem" approach encompasses biological, environmental, and human factors; interactions; impacts and responses. Ecosystem management is simply an ecological based planning approach to integrate social, economic and ecosystem level considerations to improve sustainable benefits and integrity of the ecosystems we utilize. It involves all major stakeholders for common problem solving of issues that transcend current "management" boundaries. This requires development of a better understanding of relationships among land management activities, resource capabilities, social and economic demands, ecological health and sustainability so that responsible management can be implemented by respective landowners (private, county, perish, state, federal, and even lessees).

To the U.S. Fish and Wildlife Service, "ecosystem management is an attitude, an approach and a philosophy that considers the whole environment within a geographic area." This means "protecting the function, structure and species composition of an ecosystem while providing for its sustainable socioeconomic use." The Bureau of Land Management considers "the primary

goal of ecosystem management is to develop management that conserves, restores and maintains the ecological integrity, productivity and biological diversity of public lands." Ranchers have become more environmentally pro-active in their management, e.g. proper use of animal health care products, lean meat, managing habitat for wildlife, and proper use of herbicides, proper stocking rates and conservation ethics. Planning for the future must include on and off ranch impacts and values. Ranchers will need to be active stakeholders in ecosystem planning with all the various agencies, organizations, ranch employees, neighboring ranches, close-by urban and suburban communities and other stakeholders. Tools such as geographic information systems, remote sensing, aerial photography and computer record keeping and analysis, are invaluable to local ranchers, citizens, communities and agencies for better planning, implementing, monitoring and resource allocation to achieve solutions that sustain natural resource productivity for the future.

Summary

Ecosystem management is a "state of mind." It is a way to view things so that you consider what effects your actions may have on other organisms and parts of the natural ecosystem you are associated with and managing. The landowner, manager, "steward," will have to make the "right decisions," and then seek the best methods to do the job right. Having an expectation for the actions we place on the environment is a must. Without understanding the principles of ecology and the natural landscape processes that are on-going, we could make the wrong decisions.

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Nature of Naming

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Demonstrate an understanding of the classification system.
- Discuss the uses and importance of the classification system.
- Identify the main parts of a scientific name.
- Understand the importance of the binomial classification system.
- Discuss the pitfalls of using common names.
- Discuss changes that genetics research has had on plant and animal classification (lumping and splitting species).
- Demonstrate the ability to use a dichotomous key to identify a species.

Knowledge of the earth and the living things on it is of great importance to us. We are not the independent, free-living humans we often regard ourselves to be. Our life and existence on earth is controlled by many factors such as the earth on which we live, the air we breathe, the plants and animals we depend on as our constant associates. It is true that, through the process of becoming civilized, we have acquired a wide variety of skills enabling us to modify and use our environment, in a limited number of ways, to meet our needs and ambitions. Regardless, we have found that new skills and technology have not reduced our dependence on the earth and the living things around us. Actually, technology, progress, and change have made us more dependent. The very technologies that appear to give us greater freedom tie us more and more closely to the environment. As technologies improve, and demands on natural resources increase, the trend toward more intensive and extensive processing of "natural" materials is progressively increasing.

Early humans satisfied their needs by taking nature's offerings as they found them. Their food requirements met by the animals they hunted and by the edible fruits, seeds, roots, and other plant parts gathered in the forest and grassland prairies. Early humans lived a wandering existence, constantly in search of food. Eventually, humans learned to domesticate certain useful food animals. In doing so, humans probably came to realize even more fully the importance of the natural vegetation. Seasonal changes in the vegetation make it necessary to move flocks from place to place in search of abundant forage. Later, humans discovered, by planting seeds of useful plants in prepared soils, that they could produce foods for both animals and themselves. This technology relieved humans of the uncertainty of their daily food supply. It allowed them

to live in one place. With this change, humans could indulge in other pleasures and activities. With more and more discoveries, this led to our present day mode of existence, a result of continued exploration and exploitation of our environment.

Our earth environment is rich with living things. There are about 2 million different, known types of living things. Just as humans have found it necessary to place various screws, nails, bolts, nuts and washers into different groups, it is also necessary to classify organisms into groups. To classify something means to arrange it into groups.

Arrowleaf Balsomroot,
Balsomorhiza sagittata (Pursh) Nutt

A good classification system helps in at least two ways. First, it provides an easier means of dealing with living things by dividing them into groups of similar organisms. Second, it makes information about specific organisms easier to organize and find. It is often convenient to talk about large groups, such as birds, or about smaller groups, such as ducks, songbirds, or owls. Information about specific organisms, such as where screech owls live, what mallard ducks eat or how long it takes robin eggs to hatch, can be found more easily if a good classification system is used.

Just as there are many different ways to group screws, nails, bolts, nuts, and washers, there are many ways to classify living things. One method would be to classify living things according to where they normally live. If this were done, we would have groups of saltwater organisms, pond organisms, wetland organisms, stream organisms, meadow, prairie, high desert, desert, tropical, pine forest, and under-a-rock organisms. Although this method might be useful for some applications, it would present many problems when naming organisms, since many organisms live in several different places. Some move from place to place as they pass through various life stages of their life cycles. We do not use where an organism lives as our means to classify life for naming purposes. The classification system we use today places organisms into groups based on the physical characteristics of the organisms classified. If it were not for a good classification system, most information about the organism would be lost in a hodgepodge of facts.

Who developed the classification system?

Carolus Linnaeus (1707-1778) developed the classification system we still use today, called binomial nomenclature. Binomial means “two-name” and nomenclature means, “naming.” Our system for naming people is binomial. You have a first name and a last name.

Before Linnaeus, many others had attempted to classify plants, primarily based on their medicinal value. These early classification systems, as well as Linnaeus' system, are all examples of "artificial classification" systems. Plants were placed into categories based on features that had been pre-determined. Linnaeus' system was comprised of 24 classes of vascular plants, distinguished from one another, based on the number and nature of stamens in the flower of each plant. This classification system was developed primarily for the aid of identification. It met that objective well.

The disadvantage of all artificial classification systems, including binomial nomenclature, is it often does not reflect "natural relationships" (genetic relationships). Plants within the same class may not be more related to each other than they are to plants from a different class. With the technology of DNA testing that Carl Linnaeus did not have, we could actually re-classify living organisms into new classification systems that reflect genetic relationships. However, this system would not help the average person who does not have a DNA lab in their kitchen identify plants in the field.

Linnaeus picked Latin to use in binomial nomenclature because no one spoke Latin as his/her native tongue. Most worldly scholars of the time knew Latin. They would be able to understand the scientific name of the organism. Latin is also a descriptive language. It suited the purposes of Linnaeus well. If he had picked his native language to name organisms, his life's work would have become out of date as the meanings of the descriptive words he chose to describe an organism changed. For example, we know the word "charity" to mean the giving of money or service, but in the 1600's, charity meant simply "love." If all languages had been acceptable for naming organisms, scientists or taxonomists would have to become linguists to assure they were talking about the same organism others were discussing.

Taxonomy is the study of naming organisms. It is the science of discovering, describing, naming, and classifying organisms. Taxonomists use a classification hierarchy or an arrangement of grade levels. The organisms placed together into lower and lower levels of the classification system have more and more characteristics in common. The system has seven basic levels that include:

Kingdom
Phylum (or Division for plants)
Class
Order
Family
Genus
Species

Examples of the classification hierarchy for two types of organisms follow—one for an animal and one for a plant:

Common name: Mountain Bluebird

Kingdom: Animalia (animals)
Phylum: Chordata (animals with notochords)
Class: Aves (birds)
Order: Passeriformes (perching birds)
Family: Turdidae (thrushes, sparrows, robins)
Genus: *Sialia* (bluebirds)
Species: *Sialia currucoides* (mountain bluebirds)

Sialia currucoides.
Photo courtesy, IDFG.

Common name: Lewis's Mock Orange

Kingdom: Plantae (plants)
Division: Magnoliophyta (flowering plants)
Class: Magnoliopsida (dicotyledons)
Order: Rosales (rose-like plants)
Family: Hydrangeaceae (hydrangea-like plants)
Genus: *Philadelpus* (mock oranges)
Species: *Philadelphus lewisii* (Lewis' mock orange)

Philidelphus lewissi.
Photo courtesy, Gary A. Monroe, USDA Plants Database.

The scientific name of an organism includes its genus and species name (the final two categories of the classification hierarchy highlighted above). The complete scientific name of plants also includes the initials or name of the person or persons who first described the species. The scientific names of plants described by Linnaeus still bear an L. after the binomial. For example, the scientific name of cheat grass is *Bromus tectorum* L.

Using plants as an example, the scientific name of a plant is written in three parts: The plant genus, the specific epithet (species name) and the author's name. The genus is always capitalized. Both the genus and species are *italicized* or <u>underlined,</u> as shown in the example of cheat grass. The genus name is abbreviated to an initial after the first use within a document. *Bromus tectorum* would be written in full the first use and abbreviated as *B. tectorum* in subsequent uses, as long as confusion with other genuses does not occur.

Why learn scientific names?

The scientific name, made up of the genus and the specific epithet, points to a unique species. One, and only one, species will have that scientific name. Common names can often be ambiguous. The common name used to refer to a species in one region may refer to a different species in another region.

Scientists around the world understand scientific names. *Taraxacum officinale* is the common dandelion. *Taraxacum officinale* refers to the same species, no matter where you are in the world. Scientists in Russia, Germany, Korea, and the United States all know to what species reference is being made. You can look at scientific article written in Russian and the only words you will be able to pick out and understand will be the scientific names.

SUBSPECIES

Artemisia tridentate is the scientific name for a common species of sagebrush in Idaho. This species happens to also be divided into sub-species.

In the case of sub-species, an additional name is added after the genus, species and name and author's name.

Big Sagebrush
Artemisia tridentata Nutt. ssp. *vaseyana* (Rydb.) Beetle

Mountain Big Sagebrush
Artemisia tridentata Nutt. ssp. *wyomingensis* Beetle & Young

Wyoming Big Sagebrush
Artemisia tridentata Nutt. ssp. *xericensis* Winward ex R. Rosentreter & R. Kelsey

The Use of Common Names

The name used to identify plants in everyday conversation is a plant's "common name." You and I use this name most of the time. Common names have originated from various sources. People just like you and I, including early European settlers, Native Americans, traveling naturalists and others, have named all 3,175 species of plants known to occur in Idaho. Plants were named for characteristics: smell, color, beauty, if they hurt, bite, scratch, general appearance reminding the observer of something already known. Early naturalists or travelers named many plants after similar or look-alike plants they were familiar with in Europe. Often, when you see a plant at the same stage of growth as the person who named the plant saw, you can see why the name was given. Likewise, when you hear a plant name, the mind may produce a visual picture from the spoken name. Sometimes this does not work when the plant is a seedling or in winter growth, for example, "snowberry." Some plants have been named after people as a way of formally recognizing them for their work or contribution. Plant naming has usually been based on some physical-visual character of the plant, i.e., the plant is spiny, thorny,

Artemisia frigida, Rocky Mountain Sage. Photo courtesy, Idaho Department of Transportation.

Russian Thistle, Salsola *tragus* L. Photo courtesy, Forrest and Kim Star, U. S. Geological Survey,

hairy, colorful, large flowered, odiferous; or grows in a particular season or a discrete area.

There are two major problems when using common names. First, the common name may actually include more than one particular plant species in a genus. We refer to a pine tree; the name "pine" is the common name for all trees in the genus *Pinus.* Some common pine trees in Idaho include the ponderosa pine (*Pinus ponderosa*), the lodgepole pine (*Pinus contorta*), and the western white pine (*Pinus monticola*). Although these plants are all related, they are independent plant species, which grow in different situations, respond to management differently and are encouraged or suppressed under natural fire regimes differently.

Second, one plant species often has more than one common name. Depending on where you born, raised, or went to college, you many refer to the tree *P. ponderosa* as ponderosa pine, yellow pine, blackjack pine, or bull pine. Common names for plants will change from community to community and region to region. This fact may make identification confusing and illustrates why we use scientific names in training, science, government documents, and industry literature. Several authors, societies and agencies have accepted specific common names, but there is still much confusion out in the field and in publications referring to plants by their common name.

Another example of a problem with common name usage is the plant name, "thistle." Because thistles usually have thorns and are harmful to the touch of skin, many people will call a bristly, thorny, upright plant a thistle. After examining the use of this common name in Idaho, many species of plants have the name thistle as part of their common name. Most of these plants are in the Sunflower Family or Asteraceae. They include plants like bull thistle, yellow starthistle, and spiny sowthistle. These thistles occur in the genera *Cirsium*, *Centaurea*, and *Sonchus*, respectively. Consider "Russian thistle." It is not a member of the Asteraceae or Sunflower Family but is in the Chenopodiaceae or Goosefoot Family. This plant is also named "tumbleweed." Also, consider the confusion that exists with names like "blue-eye grass." Plants with this name are in the genus *Sisyrinchium* in the Iridaceae or Iris Family. These plants are not grasses at all. Their leaves, or early growth, resemble a grass leaf or leaves. Quite often in the animal kingdom, a common name may apply to several different organisms. The name "gopher" has been used to refer to a salamander, a turtle, a frog, one of several snakes or any of about fifty different types of rodents.

Impact of Advances in Genetics on Classification

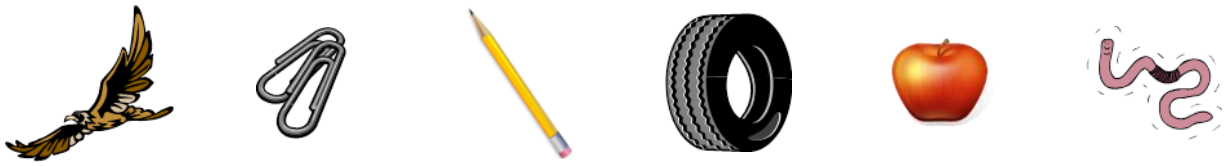
Linnaeus developed his system of classification long before Charles Darwin advanced the concept of biological evolution. The idea that species were related was not at the forefront of scientific thought. Linnaeus based the classification system on similar characteristics among organisms. If two organisms had many characteristics in common, they were placed together at a low level (such as family or genus) in the classification system. If they had few characteristics in common they were only placed a high level (such as kingdom or phylum/division) in the classification system. Since the classification system was based on arbitrary characteristics rather than actual relationships, it is considered an artificial rather than natural system. Generally, organisms that have many characteristics in common are also closely related. There are many flaws in the system.

Modern genetic techniques allow scientists to better estimate the closeness of the relationships between species. Sometimes this knowledge leads the scientists to propose splitting one classification taxon apart into two and other times lumping two or more taxon into a single taxon. A taxon is any specific element of the classification system (such as a specific family or genus). For example, scientists may look at the genetics of all ten species in a single genus. They may discover that three of the species are only distantly related to the other seven species in the genus. These scientists may propose splitting the genus into two separate genera and providing a new name for one of the genera. This would change the scientific name of the species in the new genus, but the scientific name would still uniquely identify the species. The old (now superseded) scientific name can be traced to the new name and thus the species. In another example, scientist may look at the genetics of various genera in two different families. They may conclude that the genera are all closely related. They may propose lumping the two families into a single family.

Dichotomous Keys are used to identify a living organism. As the name implies, dichotomous keys give a series of two (di) characteristics. The reader of the key must choose a characteristic to move onto the next set of two characteristics. Eventually, if the reader made all the right characteristic choices, the name of the species can be identified. In theory, dichotomous keys are easy! You simply look at the organism you are trying to identify and answer questions about it. However, in reality, some dichotomous keys can be difficult if you are unfamiliar with the terminology of the life form. Vocabulary can limit a person's ability to successfully identify an organism using a dichotomous key. The best way to learn to use these keys is to brush up on your vocabulary and then just practice. Below is an exercise to demonstrate how dichotomous keys work.

Suppose you were an alien from outer space visiting earth. You found the items pictured below and you were interested in learning their names and if you should present one of them to an

earthling as a token of peace. You happen to have a copy of Earthly Treasures; A Field Guide and Key with you. Therefore, you begin to "key out" the objects. You first choose the object on the far left on which to work.



A.

1. The earthly object is made of metal or has metal on it……..……...Go to B
2. The earthly object is comprised of a material other than metal……Go to C

B.

1. The earthly object is made entirely of metal……...Paperclip
Pulpilious grasponii
2. The earthly object is made mostly of wood with traces of metal on one end……..Pencil
Writonae scriptus

C.

1. The earthly object can move freely on its own……Go to D
2. The earthly object cannot move freely on its own……Go to E

D.

1. The earthly object moves freely on the ground or in the sky……..……Eagle
Unitedae Statesii
2. The earthly object moves freely on the ground only…….Earth Worm
Sidewalkidae squishineus

E.

1. The earthly object has a large hole in the middle……Tire
Petroliuminus circularii
2. The earthly object has a core, or solid center……...Apple

This simple illustration of a dichotomous key also can serve as an example about how vocabulary becomes important. Words like ground, sky, metal, and wood would have to be known in order to use the key. In order to use dichotomous keys to identify plants or animals, learning biological vocabulary may be necessary.

A Final Note

Naming and being able to identify plants and animals is an important component of being a naturalist. Some people enjoy the knowledge of scientific names more than others do. Build your skills so you can use keys and communicate with other naturalists. However, do not let the task of identifying plants and animals intimidate you. Do not worry if the task of keying out organisms or remembering Latin names is not your favorite naturalist activity. There are other naturalists willing to help.

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This chapter was modified from the Texas Master Naturalist Program “Nature of Naming” chapter. We appreciate TMNP generous sharing of their curriculum.

Forest Ecology and Management

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Describe forest ownership in Idaho.
- Explain the concept of shade tolerance and rank common Idaho conifers relative to shade tolerance.
- Understand and describe the process of succession in Idaho forests.
- Define silviculture and describe stand regeneration, thinning and at least one other silvicultural practice.

Idaho's Forests

Forest Ownership

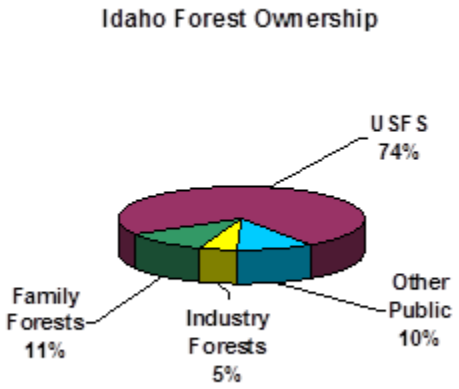
Over 41% of Idaho is forested. The largest piece is managed by the U.S. Forest Service (74%). The rest is managed by other public agencies such as the State of Idaho or the U.S. Bureau of Land Management (10%), family forest owners (11%) or forest product companies (5%).

"A nation that destroys its soils destroys itself. Forests are the lungs of our land, purifying the air and giving fresh strength to our people."

-President Franklin Roosevelt

The ownership mix may change considerably depending on where you are in the state. For example, 44% of all forested land in the panhandle counties is owned by family forest owners.

Forests embody many values, provide many different benefits, such as wood products, water, and valued places. Some of these benefits can be measured in dollars and cents (wood products, grazing). Other benefits are, not easily measured, more or equally important to many people. The primary management objectives vary by ownership. Most forests are managed for a simultaneous combination of values and benefits.



Forestry

Forestry is "the art, science, and practice of creating, managing, using, and conserving forest resources for human benefit and in a sustainable manner to meet desired goals, needs and values" *(Dictionary of Forestry)*. Forest management can vary considerably in intensity. It can be very intensive "fiber farming" of hybrid poplar. Whereas, some forests are managed with as little human input as possible by managing people's entry to a wilderness area. Most forest management falls somewhere between these two ends of the spectrum.

The expression "forest management" can be a confusing term to some people. In this chapter, the attempt will be to use it neutrally in application to the whole spectrum of uses. Humans have a role in managing forests, often unintentionally, through influences on climate or by introductions of invasive species.

Forest Ecology

To meet a wide variety of ownership objectives, most forests in the Rocky Mountain States are managed in ways that mimic natural processes of forest ecology and succession. To do this, foresters must have a solid understanding in forest ecology. Forest ecology is the study of the "forest as a biological community, with the interrelationships between the various trees and other organisms constituting the community, and with the interrelationships between these organisms and the physical environment in which they exist" *(Forest Ecology)*.

All Of The Parts

A famous quote of Aldo Leopold, famed ecologist and holder of 2 forestry degrees, was advice to practicing ecologists was to follow "the first precaution of intelligent tinkering…keep every cog & wheel". What are the "cogs and wheels" of a forest? The most obvious cog is the function of trees. Idaho has a wide variety of trees and forested habitats.

Most of Idaho's forests are coniferous, meaning they are dominantly composed of trees that bear seeds in cones. Idaho forests also have a number of non-conifer tree species, sometimes referred to as "hardwoods," including cottonwood, aspen, birch, willow, and alder.

Shade Tolerance

Tree species have evolved unique strategies to compete with other trees and vegetation, responding to many different environmental factors. One factor is shade from other trees. Each tree species differs in its ability to tolerate shade. The graphic to the right illustrates the relative shade tolerance of common Idaho tree species.

Shade-Intolerant Tree Species

As the name implies, shade intolerant species grow poorly in shade. They grow very rapidly in full sunlight to occupy a site, after some kind of disturbance, historically fire. Examples of

relatively shade intolerant species include larch, lodgepole pine, ponderosa pine, and white pine. All of our deciduous trees and shrubs are considered shade intolerant.

Shade-Tolerant Tree Species

Shade tolerant species survive under shade better than other species. Their strategy is to outlast the competition. Shade tolerant species tend to grow slower than shade-intolerant species. They can release, grow faster, after shade intolerant trees have died, eventually taking their place in a process called succession. The term is shade tolerant not shade loving. There are no shade-loving trees in Idaho but there are shade-tolerant trees. All trees struggle to capture as much sunlight as they can. There may be only cedar in a shaded understory, not because it loves shade but because it out competes other tree species in a shady environment. A shade tolerant tree will grow better in full sunlight than under a canopy. Heavily shaded cedars are stressed after an overstory is removed likely due to the abrupt change in conditions more than an affinity for shade.

Idaho Conifers Tree Species Shade Tolerance	
	Shade Intolerant Tree Species (tend to occur earlier in succession)
	western larch
	lodgepole pine
	ponderosa pine
	western white pine
	Douglas-fir
	Engelmann spruce
	subalpine fir
	grand fir
	western red cedar
	western hemlock
	Shade Tolerant Tree Species(tend to occur later in succession)

Big Trees

Big trees capture peoples' imagination. The University of Idaho coordinates the Big Tree Registry program in Idaho. The purpose of the program is: to locate and recognize the largest known species of its kind that grow in Idaho; to obtain the cooperation of the tree owners to protect and preserve these specimens as landmarks for future generations to enjoy; to stimulate interest in and a greater appreciation of trees - their worth as a natural resource and as individual specimens. To see the list or nominate a tree for the program, see:

http://www.uidaho.edu/extension/forestry/content/idahobigtree

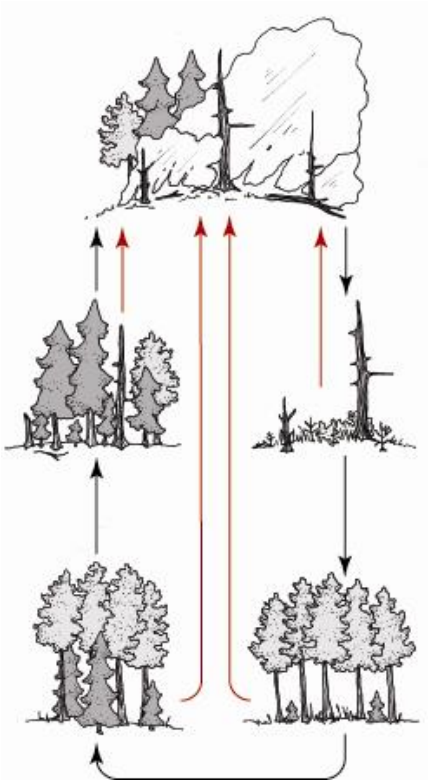
Forests Are More Than Trees

A forest is more than trees. It includes shrubs, forbs, and grasses; soil, microbes in the soil, other parts of the physical environment; wildlife and are popular recreational destinations.

Succession

Learning the "cogs and wheels" of a forest is only part of caring for it. It is just as important to understand how the various parts function in relation to one another. There are many levels of forest function. One of the most important to understand is succession. Succession is the gradual

replacement of one plant community by another. Trees are such a dominant presence in a forest ecosystem; described changes in forest succession are relative to trees**.**
In Idaho forests, succession commonly starts with some type of major disturbance, after which the site is quickly occupied by grasses, shrubs and other shade intolerant species like pine or larch trees. These trees compete by growing very fast, taking full advantage of space created by a disturbance, such as a windstorm, insects, disease or fire. Historically, the most common disturbance in the Inland Northwest has been fire. Over time, other species that are more shade tolerant become more prominent in the stand. This process continues barring more disturbances. The result is a climax forest, dominated by the most shade tolerant species the site can support.



Historically, many Inland Northwest forests never reached the climax stage. A stand replacement fire or other disturbance interrupted and started the process of succession all over again. Succession in western forests has been shaped by ground fires, which occurred every 5-60 years, depending on the site. Ground fires killed small trees coming up in the understory and left large trees with thick, fire-resistant bark. Historically, drier sites rarely had stand replacement fires because frequent ground fires reduced fuels and maintained open stands of ponderosa pine. In mid-elevation forests, many fires would have been mixed severity fires - a mosaic of both ground and stand-replacing fire with some of the pieces of the mosaic being quite large.

Trees are not the only plants that change with different successional stages. For example, many brush species and grasses are found in earlier stages of succession. Different animal, insect, and fungi species also increase or decrease in response to the successional vegetation changes. Some terms used in conjunction with forest succession are:

- **Seral Species:** Various plants which occur in succession before climax. These species will be replaced.
- **Seral Stages** or **Seres:** Plant communities occur in succession before climax.
- **Pioneer Species*:*** The very first species to seed into open areas following major disturbances.
- **Climax Species:** Survive/establish in shaded understory; persist for long periods.

Forest Habitat Types

One way to understand how succession takes place across the landscape is to understand habitat types. This term does not refer to wildlife habitat, though the system can be used to describe wildlife habitat. Habitat types are a land classification system based on patterns and trends of how trees and other plants grow on the landscape.

The Climax Plants & Trees Reveal the Site

Succession follows different paths, depending on a site's moisture, soil and other factors. Habitat types are based on the idea that, on a given site, the same successional patterns will repeat after disturbances and that the climax forest plants and trees are a meaningful index of soils, topography, precipitation, other factors affecting the growth of trees and other organisms. In some regions, similar site classification systems are also known as plant associations, though there are differences between systems (e.g., some integrate topography, soils, and other features more directly).

Habitat Type Organization

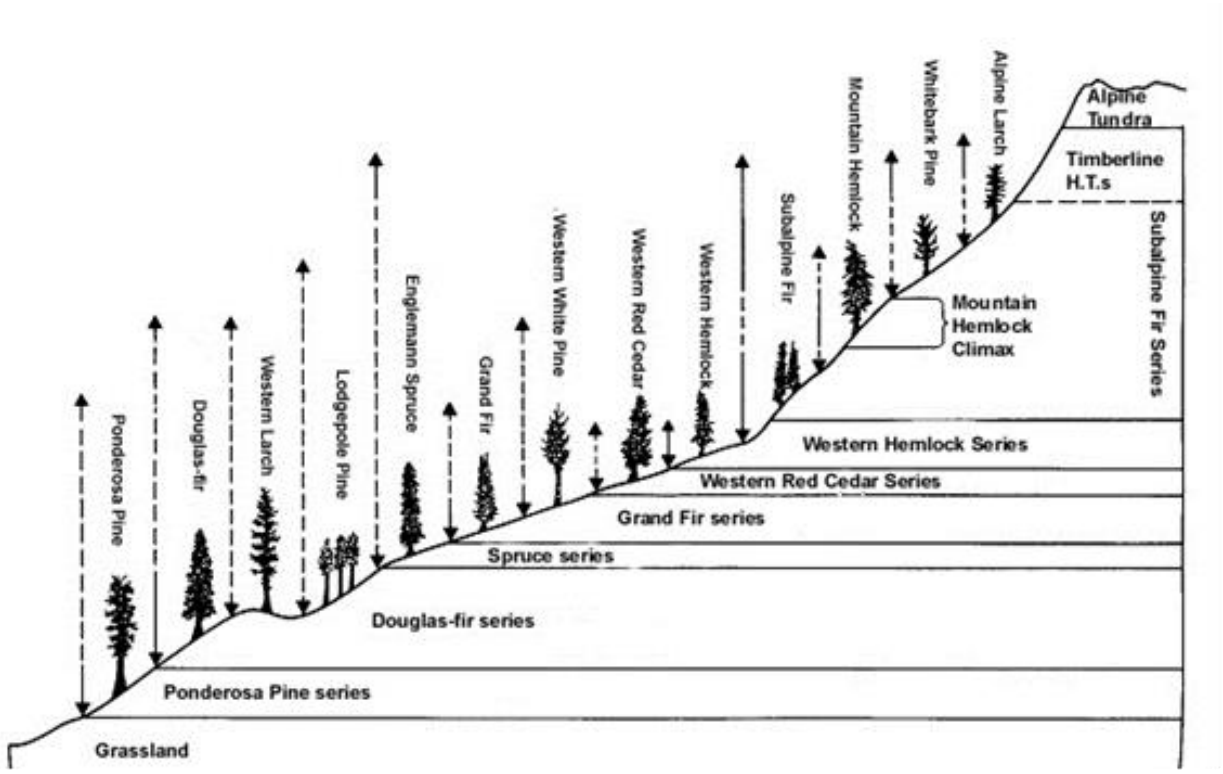
Habitat types have three basic levels: **series, habitat type** and **phase**. Series is identified by the climax tree species, usually the most shade tolerant tree capable of growing on the site. Series is not identified by trees growing on site now but in the future at climax. There are grand fir series of habitat types, a hemlock series of habitat types, etc. Each series is further subdivided into habitat types identified by an understory plant characteristic for the type. For example, the grand fir series has eight habitat types. The habitat type can further be broken into phases that name a second common understory plant.

Identifying Habitat Types

Climax species are progressively more shade tolerant on sites that are moist. Most habitat types change with available moisture. Since moisture tends to increase with elevation, habitat types tend to reflect that (e.g. hemlock habitat types higher up a mountain, ponderosa pine types lower down the mountain. See chart on page 6. Habitat types also reflect effective moisture available for plants. Wetter types found on northern versus southern aspects, different types of soils (e.g. a soil with a deep ash layer). Frost pockets and similar phenomena can also affect climax vegetation.

Identifying the series level of a habitat type can be comparatively simple. Find the most shade tolerant species in the understory. If there are 10 or more hemlock in the understory per acre, that is a hemlock habitat series. If Douglas fir is the most shade tolerant tree found it is likely a Douglas-fir series. In some cases, extensive repeated burns have eliminated seed sources for climax tree species. However, because of historical fire exclusion and partial harvesting of early

successional species (e.g. pines and larch), most Idaho forests usually have some of the most shade tolerant species capable of growing on that land.



Distribution of forest trees in the Rocky Mountains of northwestern Montana. Arrows show the relative elevational range of each species; solid portion of the arrow indicates where a species is the potential climax dominant (late-successional) and the dashed portion shows where it is seral (early successional). (After Pfister et al., 1977).

Determining the habitat type or phase level is more difficult because it requires identification of a variety of understory plants, essentially, an evaluation of the presence and abundance of key indicator plants. That appraisal is completed using a dichotomous key to determine the habitat type or phase. The genius of this system is that climax forest conditions do not have to be present to apply the key. Succession is often more rapid for understory plants than trees. The mix of key understory indicator plants found on the site can help predict the ultimate climax forest. The following is an example of one series Douglas fir and its nine associated habitat types. The scientific name is followed by the common name.

<u>Pseudotsuga menziesii</u> (PSME) Series **(Doulglas-fir)**

- Pseudotsuga menziesii/Physocarpus malvaceus h.t.
  (PSME/PHMA; **Douglas-fir/ninebark)**
- Pseudotsuga menziesii/Vaccinium caespitosum h.t.
  (PSME/VACA; **Douglas-fir/dwarf huckleberry)**

- Pseudotsuga menziesii/Vaccinium globulare h.t.
  (PSME/VAGL; **Douglas-fir/blue huckleberry)**
- Pseudotsuga menziesii/Symphoricarpos albus h.t.
  (PSME/SYAL; **Douglas-fir/common snowberry)**
- Pseudotsuga menziesii/Spiraea betulifolia h.t.
  (PSME/SPBE; **Douglas-fir/white spiraea)**
- Pseudotsuga menziesii/Calamagrostis rubescens h.t.
  (PSME/CARU; **Douglas-fir/pinegrass)**
- Pseudotsuga menziesii/Carex geyeri h.t.
  (PSME/CAGE**; Douglas-fir/elk sedge)**
- Pseudotsuga menziesii/Festuca idahoensis h.t.
  (PSME/FEID; **Douglas-fir/Idaho fescue)**
- Pseudotsuga menziesii/Agropyron spicatum h.t.
  (PSME/AGSP; **Douglas-fir/bluebunch wheatgrass)**

Accurately identifying habitat types can be challenging. A good plant identification booklet and field courses will help. Flowers help to identify understory plants. Identifying habitat types in the late spring or early summer may be easier or ask a forester for help.

How Can Habitat Types Be Used?

Habitat types can help in understanding successional pathways. Knowing a site's successional pathway helps foresters make forestry decisions. It can also better help in understanding the ecology of the forest. A habitat type is a name of a specific, predictable successional path. Knowing the habitat type gives some clues as to which species to manage to favor. For example, white pine probably occurred on a hemlock habitat type historically, even if there is no white pine on the site. By contrast, western red cedar probably never occurred on a site with a Douglas-fir habitat type in the last few thousand years.

Do Plant Communities Have Distinct Boundaries?

Plant ecologists have debated whether plant communities are distinct or continuous. Even advocates of the distinct school of thought acknowledge transitional areas, ecotones, which cannot be delineated as one type or another. There may also be small areas of different habitat types, inclusions, often closely related, within a given management unit. Generally, in Idaho's rugged terrain, habitat types are often distinct enough to be used for management decisions. The system works well.

Forest Cover Types Do Not Equal Habitat Types

Forest cover types are based on current tree cover. They change over time, depending on the type and extent of disturbance or forest management. Most non-foresters may refer to forests by cover type not habitat type. A weekend camping trip may be described as, "Our campsite was next to the creek, near the aspen forest, on the hill." Aspen forest, used this context, refers to the cover

type-that is there now. Habitat types refer to future tree cover or the dominant species at climax. For example, Idaho has much less ponderosa pine forest cover type now than it did historically. By contrast, there is nearly the same amount of land in the ponderosa pine habitat types as occurred 150 years ago. Habitat types are based on potential climax vegetation. That potential remains the same, barring major geological events or climatic trends. Some common forest cover types in Idaho include aspen forests, juniper forests, ponderosa pine forests, whitebark pine forests, mixed conifer forests and lodgepole pine forests.

Aspen is the predominate cover type in this photo, but without a closer look, the habitat type is difficult to determine.

Silviculture

Silviculture is "The art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet diverse needs and values of landowners and society on a sustainable basis."

Silviculture includes all practices used to manage a forest, regardless of whether primary management objectives are water quality, wildlife, wood products, huckleberries or other purposes. Timber harvests are probably the most commonly identified silvicultural practice because it is so visible, but silviculture also includes tree planting, fertilization, prescribed fire, thinning, pruning and other practices.

Stand Regeneration Harvests

Stand regeneration harvests are made to renew a forest, using methods prescribed by a *silvicultural system*, which is a specific system of practices designed to create favorable growing conditions for tree species we wish to perpetuate. There are four basic silvicultural systems: clearcut, shelterwood, seed tree, and selection.

A patchcut or clearcut (pictured below) removes all the trees in a given area. This may be done for several different reasons; to increase wildlife forage, to create a fire break, or to mimic natural mosaic forest patterns. Photo courtesy, Jim Rineholt, SNRA

The clear-cut system is when all of the trees in a unit are harvested in one operation. The area is reforested by planting trees or natural seeding. Clear-cuts do not have to be large. A 3-acre

opening is still technically a clear-cut. Sometimes, people may have negative views of clearcuts. Large clear-cuts can be harmful to an ecosystem. However, small clearcuts can produce many benefits.

The seed tree system is similar to a clear-cut except 5-10 trees per acre are left, evenly distributed, across the site to produce tree seed. The seed trees are usually removed after new seedlings are established.

The shelterwood system is similar to the seed tree system except more trees are left to shelter new seedlings. This system is commonly used on hot, severe sites. Shelterwood harvests may be made in two or three entries. Small trees are removed in one harvest. More trees are removed in a second seed cut. Finally, the seed trees are removed in a third harvest after the new seedlings have become well established.

The selection system attempts to maintain a range of desired tree sizes, species, and ages by harvesting individual trees or small groups of trees. Groups are usually 1/4 to 1/2 acre, or 10 to 50 trees, depending on tree size. Each harvest thins the stand. Because individual tree selection maintains a fairly shady environment, it is best suited to sites which can sustain shade tolerant trees over the long term.

The first three systems produce an even-aged stand, one in which all the trees in the forest canopy are within 20% of the same rotation age. Rotation is the length of time forest trees are grown before they are cut. Historically, many Inland Northwest forests were naturally even-aged because new trees seeded in after major fires. The selection system attempts to produce a multi-aged stand. The latter three systems tend to rely more on natural regeneration. Some site disturbance is often required to provide bare mineral soil for good conifer regeneration.

A shelterwood system leaves trees for a seed source and protection during the initial stages of regeneration. These large trees will be removed after new trees begin growing. This is a common silvicultural method for Douglas-fir trees which need some protection from the elements when first starting to grow.

Simply taking the largest trees or all the trees over a minimum diameter is not selection silvicultural system. Many forests have been degraded by, often well-intentioned but harmful, selective logging. The small trees left are not necessarily younger -- they are commonly the same age as the trees removed. They may be incapable of taking advantage of the new space, and often have undesirable characteristics.

The choice of silvicultural system depends on site characteristics, current stand conditions, management goals, wildlife needs, logging conditions, and desired species among other factors. The growing conditions needed by specific tree species, other plants and animals desired to be a part of the forest are of primary importance.

Thinning

Overstocking with too many trees for a site is a common ailment of Idaho forests, particularly in northern Idaho. Overstocking can reduce availability of light, water, nutrients, space, CO2, O2, etc. to individual trees and attract forest pests to stressed, competing trees.

A thinned Douglas-fir forest.

Thinning removes trees in a forest stand to reduce stand density. The primary purpose of a thinning is to improve species composition, reduce competition and enhance the growth of remaining trees. Thinning can also remove suppressed or undesirable trees, harvest trees that are likely to die, reduce insect and disease problems, improve wildlife habitat, reduce fire risk or help reach other environmental goals. Stand regeneration is not a primary goal of thinning.

A thinning may be either pre-commercial, when trees are too small to be sold for wood products, or commercial, when the trees are large enough to be sold. Stocking level, the space left between trees, can be varied according to site needs or management objectives. Many Idaho forests are thinned between 2-3 times between regeneration cycles.

Species Choices in Stand Regeneration Cuts & Thinning

Regardless of the type of harvest or thinning, seeing a tree in the forest does not mean it is a good species to favor. Foresters usually try to favor the tree species best adapted to the site over the long term.

On many forests have been altered by natural patterns of succession:

- excluding fire,
- preferentially harvesting shade intolerant species, such as pines and larch,
- introducing exotic plants, insects, and diseases, such as white pine blister rust.

These factors have created denser forests with more shade tolerant trees than in the past when fires resulted in higher proportions of wider-spaced, shade-intolerant species. Past grazing practices have also affected tree species.

Shade tolerant species tend to be less adapted to drought cycles and, consequently, less resistant to insects and disease. To compensate for the lack of fire, shade tolerant trees are preferentially cut to sustain healthier forests, especially on drier sites. Silvicultural systems that allow more light into stands also help shade intolerant trees grow better. Favoring a mix of species across the forest is also common, within the range of species well adapted to a specific site. It provides some insurance against insects, diseases or other agents that affect one species more than another does.

Planting

Many Idaho forests are regenerated naturally. However, even where natural seeding is anticipated, planting may be used to regenerate species for which seed may not be forthcoming, particularly on larch or blister rust-resistant white pine. Trees are also planted to restore forests to areas that were cleared generations ago for agriculture. Planting is more than simply getting the trees in the ground. Before seedlings are planted, the effort must be planned. Competing vegetation can kill tree seedlings. Reducing its effect is often done prior to planting with herbicides or other tools. Planted tree seedlings must be from the correct seed source, i.e., the correct altitude and latitude. They must be handled and planted correctly. Seedlings must be protected from damage by deer, elk, pocket gophers, porcupines or other animals and be monitored and replanted if seedling mortality is too high.

Pruning

Pruning, removing the lower limbs of a tree, may be done for a number of reasons: increasing the amount of clear wood on a log, improving aesthetics and reducing fire risk. Pruning is particularly effective in reducing mortality from white pine blister rust.

Fertility

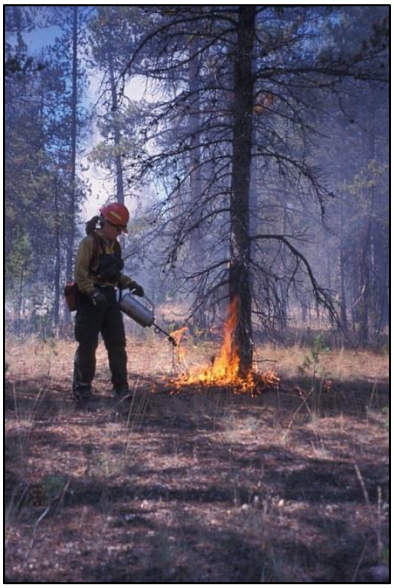
On better sites, fertilizers are applied to forests to increase volume growth, usually applied 10 years prior to a final harvest. Managing forest fertility is much more than fertilizer. Forest scientists are learning more about the importance of leaves, branches and large pieces of logs left scattered across the site for future forest health and productivity. There has been a much greater emphasis in recent years on retaining more green needles and branches, within fire safety limitations, as they are particularly high in nutrients. Approximately half of a conifer's aboveground nutrients (e.g., nitrogen and potassium) are stored in the needles and branches of the tree**.** Allowing nutrients to leach from fresh slash into the soil retains those nutrients for forest health and growth.

Larger diameter logs, often referred to as coarse woody debris or CWD, are also important, especially as they decay, for moisture reservoirs, improved soil structure, beneficial fungi habitat (e.g., mycorrhizal fungi) and wildlife habitat. Anywhere from 5-30 tons of CWD per acre is

recommended, more material on moist forests than dry forests. CWD is also important to a variety of forest organisms. Generally, larger logs, with bark attached, are preferred.

Prescribed Fire

Fire has played a very large role in the evolution of Idaho forests. Some tree, shrub, fungi and wildlife species thrive or not depending on how fire comes through the ecosystem. Forests were managed, to some degree, long before Europeans arrived in Idaho. Native Americans used fire to manage forests for berries, forage, game and other purposes. Early in western settlement by Europeans, there was some openness to having fire play a role in forest management. That changed during the 1910 fires, a huge fire event that burned through over 3 million acres of forest in Idaho and Montana and killed 86 people.



This firefighter uses a drip torch to set a tree on fire during a prescribed burn operation.

After 1910, there was a strong emphasis on putting out all fires as soon as possible before they became big ones. The strategy was very effective, particularly with an ever-growing repertoire of firefighting technology to help detect and put out fires. Forest fires have begun out stripping our ability to put them out recently. Forests that had been periodically burned by a variety of different type of fire had more fuels than ever and fires were becoming much harder to extinguish.

Smokey Bear is the US Forest Service mascot for fire prevention. It was one of the most successful behavior changing campaigns launched in the United State. Smoky taught Americans that fire in forests was bad, destructive and preventable. Some would argue Smokey's message went too far.

There has been a growing interest in bringing back fire to help manage western forests. This is often not as simple as lighting a match and letting nature take its course. As noted, many Inland Northwest forests have a historically unprecedented volume and configuration of fuels. Fires that burn through these forests may burn hotter than they ever did historically causing near permanent damage to forest soils.

Forest fires are still being extinguished. However, now forest managers are integrating more prescribed fire into the landscape. In some forests, this may mean allowing some fires to burn more naturally, particularly if there are no other values (e.g., homes are at low risk) and the fires were started by natural causes (e.g. lightning). Prescribed fires are being used more commonly.

Broadcast burns are used to prepare a site for planting. Under burns are used to reduce fuels or improve wildlife habitat.

In a prescribed fire, extra precautions are taken to ensure fires behave in ways that meet objectives. This may include thinning to reduce fuels, pruning to reduce the chances of a ground fire getting into crowns, burning in the spring or fall when the fire is less likely to escape and will burn cooler which reduces nutrient losses.

Treatments for Insects & Disease

Native insects and diseases are a natural part of the forest. Every tree species has insects and diseases that attack it, particularly when it is stressed by drought or other factors. By allowing forests to become too dense or heavily composed of less adapted tree species, sometimes these organisms damage more trees than wanted by unintentionally creating a favorable environment for them. Leaving the best species for the site, with adequate spacing, is the best insurance against forest insect and disease problems. The most common types of insects and disease that kill Idaho forest trees are root diseases, bark beetles, defoliators, stem decays, white pine blister rust and witches brooms.

Root Diseases

Root diseases are a problem in many Idaho forests, in part, because of the large percentage of Douglas-fir and grand fir on sites better suited to pines and other shade intolerant species. A sparse or dead crown may be one indication that a tree has root disease.

The main goal on root disease sites is to favor shade intolerant species, such as larch or pine, which are more resistant to root diseases. That may be done by thinning, or in some cases, open the forest up to more sunlight to regenerate these species

Bark Beetles

Bark beetles are a common problem in western conifers, especially in overstocked stands. Idaho has a half dozen major bark beetle species killing different tree species.

Bark beetle that infects lodgepole pine trees.

The first thing seen is individual trees or groups of trees with crowns turning red to brown. On pines, there may be thumbnail-sized globs of pitch and boring dust called "pitch tubes" on the trunk. On Douglas-fir, there may be long "pitch streaming" from high in the trunk of the tree, or

boring dust in the crevices at the base of the tree. In grand fir or subalpine fir, there are uplifted pieces of bark from previous attacks by fir engraver beetles. On many species, there may be small, white, popcorn-like “conks” from pouch fungus, a disease that is carried into the tree by bark beetles. Bark beetles bore into bark and feed in the cambium, the inner bark. They usually lay eggs there, which later hatch and feed. Eventually, the tree is girdled and dies.
Many times, beetle attacked trees are salvaged, or harvested, before they lose value. Additional infested trees are often removed and surrounding forests are thinned to increase vigor and enhance resistance to bark beetles.

Defoliators

Western spruce budworm, Douglas-fir tussock moth, and other defoliating insects eat conifer needles, which can decrease the tree’s ability to grow, kill the top, or even kill the whole tree. Many times, a tree survives some defoliation. However, frequently the tree or its top is killed. The primary strategy, in response to these defoliators, is to salvage defoliated trees and try to favor species that are not as subject to defoliation (e.g., pines and larch). In extreme cases, an insecticide, usually a natural biological control such as Bacillus thuringneisis, or a virus, may be sprayed on the insects.

Stem Decays

Conks are often the most visible evidence of stem decays, which decay the heartwood of a tree, making it weaker structurally and unusable for wood products. Usually, they are managed by maintaining younger stands, with the exception of when old growth forest conditions are an important management objective.

White Pine Blister Rust

The beauty and value of western white pine (*Pinus monticola*) inspired legislators to name it Idaho’s state tree. Unfortunately, white pine is now the primary species on less than 5% of its historic range, largely because of a non-native disease called white pine blister rust. White pine blister rust starts in the needles of white pine and travels down the branch to the trunk, where it kills the tree above that point. The first visible evidence of blister rust infection is "flagging" branches, individual branches that turn brown and die. You will also usually see pitch streaming around cankers.

Two main strategies are used to restore western white pine: 1) planting white pine seedlings bred, using traditional methods, to resist the disease and 2) pruning the bottom eight feet of white pine trees reducing mortality by half. Blister rust also infects two other Idaho five needle pines, whitebark pine and limber pine. Scientists are still studying methods to help these species resist disease.

Witches Brooms

Several diseases and conditions can cause "witches brooms." Witches brooms are most commonly caused by dwarf mistletoe. Dwarf mistletoe is a parasitic plant that reduces the health of many native conifers especially pines, larch and Douglas fir. The main strategy for managing mistletoe is to remove infected overstory trees so they will not infect smaller trees of the same species growing near them.

Witches broom or dwarf mistletoe infected this tree causing massive growths. Mistletoe can eventually kill the tree by using up all its resources in the brooms.

Different Management for Different Values

Forests are managed and management decisions are made based on the values and goals of each individual area. Some forests are managed to make money. Laws protect water, wildlife, and other values while managing for income. Other forests are managed primarily for recreation or wildlife habitat. Many forests are managed for multiple values. Decisions are constantly challenged and decisions weighed. Forest management is multifaceted and interdisciplinary.

Forest Water Quality

One of the most treasured benefits from Idaho forests is water. Water from forested watersheds is always our cleanest. As a result, many of our best fisheries rely on forested watersheds. Many Idaho communities have forests dedicated primarily to providing high quality water.

Forest activities, such as timber harvest, do not adversely affect water quality unless there is too much land harvested at one time from a given watershed or harvesting is poorly executed. Forest operations leave organic matter on the ground and often leave intact understory vegetation. The biggest potential source of water pollution in forest harvest practices is sediment from roads and skid trails. Idaho has the "Idaho Forest Practices Act" (FPA) that sets minimum standards to protect forest water quality. Idaho FPA rules require leaving buffer strips along streams, diversion structures to make sure water drains from roads and back into the forest quickly and many other practices to maintain good water quality in forests. FPA rules also set standards to reduce fire hazard from forest management activities and sets minimum reforestation standards.

Wildlife

Former Chief of the U.S. Forest Service, Jack Ward Thomas, a well-respected wildlife biologist said, "Timber management is wildlife management." Forest practices create a variety of patches of forest in different successional stages across a landscape, benefiting a wide range of wildlife

species. A given silvicultural treatment may benefit one species requiring more of that habitat type. However, it may have may have a negative benefit on the species that utilized the habitat in its original state. Foresters work with biologists to assure there is an adequate distribution of large and small habitat patches across the forest landscape to sustain all wildlife species.

The elusive woodland caribou lives in northern Idaho near the Canadian border. Photo courtesy IDFG.

Foresters try to integrate wildlife habitat within units treated by leaving snags of a variety of ages, sizes, and species distributed across the unit, by careful use of prescribed fire, and by maintaining adequate linkages between different types of habitat.

Some forest-dependent wildlife species depend on very specific types of forest for survival. For example, martin are located in thick, mixed-conifer, old growth forests. They are not in a ponderosa pine forest or an aspen forest. There are places to hide, food and nesting areas provided by unique, old growth conifer forests.

Recreation

Recreation uses of a forest can be compatible with other forest values. However, sometimes forest values can be at odds. Recreationists are sometimes disagree with the site of timber harvests or prescribed burns. They also dislike diseased forests. Some areas are managed primarily for recreation such as Hells Canyon National Recreation Area or the Sawtooth National Recreation Area. In these places, timber harvest, grazing and other forest uses are limited to enhance recreational values. In order for conflicts to be minimized, all forest users must educate themselves concerning the various uses of forests.

Evolving Forestry Practices

The science of forestry is always evolving. There are new sophisticated genetic tools for understanding forest species, better geospatial technologies (e.g., geographic information systems) that help manage forests at multiple scales from a stand level to landscape level. To learn more about Idaho forests and forestry, consult any of the agencies and organizations listed at the end of this chapter.

Selected References & Resources

Books

Breaking New Ground (Gifford Pinchot). 1947. Island Press. 542 pp.
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Year of the Fires: The Story of the Great Fires of 1910. 2002. Penguin. 352pp.

Extension Publications & Videos*

Woodland Notes. Biannual newsletter for forest owners and others interested in Idaho forests and forestry (4pp)
After the Burn: Assessing and Managing Your Forestland after a Wildfire (UI SB 76) 78 pp.
Choosing Nursery Stock for Landscaping, Conservation, and Reforestation (UI CIS 923) 4 pp.
Enhancing reforestation success in the Inland Northwest (OSU PNW 520) 12 pp.
Evaluating Wildlife Habitat for Managing Private Forest Ecosystems in the Inland Northwest (UI SB 60) 78 pp.
Evaluating forest ecosystems for silvicultural prescriptions and ecosystem mgt. Planning (UI SB 59). 6 pp.
Forest Stewardship Planning Workbook - an Ecosystem Approach to Managing Your Forest. (WSU PNW 490). 60 pp.
Idaho Forestry BMP's: Forest Stewardship Guidelines for Water Quality. (UI EB 745). 33 pp.
Logging “Selectively”: A Practical Pocket Guide to Partial Timber Harvesting. (UI PNW 534). 96 pp.
Landscaping for Wildfire Prevention. (UI BULL 67) 20pp.
Plant your container-grown seedlings right (UI CIS 528). 5 pp.
Pruning Western White Pine: A Vital Tool for Species Restoration. (UI PNW 584). 62 pp.
Return of the Giants (White pine restoration) (UI SB 72) 21 pp.
Special forest products (UI CIS 952)3 pp.
Terminology for forest landowners (WSU EB 1353) 40 pp.

Thinning: an important timber management tool (OSU PNW 184) 8 pp.
Using scientific input in policy and decision making (OSU EC 1441) 20 pp.
Woodland Fish & Wildlife publications on managing forest habitats for everything from amphibians to bears. They are downloadable at http://www.woodlandfishandwildlife.org

*Extension publications are written primarily with family forest owners in mind. These publications are available from the publications offices of the University of Idaho (UI), Washington State University (WSU) and Oregon State University (OSU) many can be downloaded as PDF files:

- University of Idaho–Educational Communications, University of Idaho, P.O. Box 442240, Moscow, ID 83844-2240; tel. (208) 885-7982. http://info.ag.uidaho.edu/catalog/catalog.html
- Oregon State University—Publication Orders, Extension & Station Communications, Oregon State University, 422 Kerr Administration, Corvallis, OR 97331-2119; tel. (800) 561-6719 http://extension.oregonstate.edu/catalog
- Washington State University—Extension Publications, Cooper Publications Bldg., Washington State University, P.O. Box 645912, Pullman, WA 99164-5912; tel. (800) 723-1763; http://pubs.wsu.edu/cgi-bin/pubs/index.html

Many of these publications can also be downloaded as PDF files from these offices' web sites.

Videos

I Want to Log "Selectively" -- A Practical Guide to Partial Timber Harvesting for Inland Northwest Forest Owners and Logging Operators. University of Idaho Agricultural Communications Center, Moscow, ID. 40 minutes.
Forest Water Quality. University of Idaho Agricultural Communications Center, Moscow, ID. Two 20-minute videos.

Web Sites

American Forest & Paper Association	www.afandpa.org
University of Idaho Extension – Forestry	www.cnr.uidaho.edu/extforest
Idaho Department of Lands	www.idl.idaho.gov
Associated Logging Contractors of Idaho	www.idahologgers.com
The Idaho Forest Products Commission	www.idahoforests.org
Idaho Forest Owners Association	www.idahoforestowners.org/
American Forest Foundation	affoundation.org
American Forests	www.amfor.org
Association of Consulting Foresters	www.acf-foresters.com
Forest History Society	www.lib.duke.edu/forest
Forestry Images	www.forestryimages.org
National Arbor Day Foundation	www arborday.org
Official Smokey Bear Website	www.smokeybear.com
Society of American Foresters	www.safnet.org
USDA Forest Service	www.fs.fed.us

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Wetlands

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Describe the identifying characteristics of a wetland.
- List some ways wetlands benefit people.
- Describe wildlife and plants in wetlands.
- Understand how wetlands can be damaged and the effects of damaged wetlands.

What are Wetlands?

Wetlands exist all over the United States. They are literally "wet lands," at least for part of each year. Some marshes, bogs, swamps, pond and lake margins are wet all year. Other wetlands, such as prairie potholes and desert seeps, are wet only part of the year. Wetlands can be fresh water, salt water, or a mix (called brackish). Most of the wetlands in the Rocky Mountain region are fresh water. Many of them dry up each year.

Whether permanent or seasonal, wetlands provide valuable habitat for insects, amphibians, reptiles, birds, some fish and mammals. Because of their abundant animal life, wetlands also attract scientists, hunters, birders, artists, and people who appreciate natural places.

Identifying Wetlands

Your senses can help identify wetlands. Check the soil: Is it damp to the touch? Does it glisten with liquid? Does the water soak through your shoe? Can you literally squeeze the water out? Do you see plants, such as sedges or cattails that are adapted for living in wet soil? Do you hear frogs or see salamanders?

Dragonfly on Cattail
Photo: © Jenifer Whipple 2003

What if that pothole or pond has already dried up for the season? How might you identify it as a wetland? Observe the area carefully. When mud dries is the surface cracked? Or is it damp beneath the surface? Look for signs of higher water such as marks on the shrubs, trees or rocks; grasses and twigs collected at the base of other plants; leaves coated with a thin layer of

sediment.

Similar protocols help environmental scientists and biologists determine the presence and extent of wetlands in a process called wetland delineation.

Hydric Soils

If you can squeeze a fist full of soil into a ball, you have soil with not much room for oxygen. That is bad for most plants. Oxygen is an essential part of their respiration. They absorb the oxygen from the soil through their roots.

Cracked soil often indicates that it was once wet soil.
Photo: © Carolyn Duckworth, 2014

These oxygen-starved (anaerobic) soils often smell like sulfur or rotten eggs due to the bacteria that thrive under anaerobic conditions. The dampness also causes chemical reactions in the elements of the soil. For example, iron will oxidize and mottle the soil with orange.

Scientists recognize two major types of wetland soils: organic and mineral. Organic soil has an obvious amount of decomposing plants. This kind of soil is often black or dark brown. Mineral soil contains few decomposing plants. Instead, it is comprised of materials such as clay, sand, or silt. Wetland mineral soils may be gray, greenish, or bluish-gray. They might also be mottled with orange or red streaks.

Scientists use color charts that key soil color with the amount of water in the soil (such as the Munsell Soil Color Charts). The U.S. Natural Resource Conservation Service (NRCS, formerly the Soil Conservation Service) also publishes a list of hydric soils http://soils.usda.gov/.

Soil content also determines the speed of draining. For example, water seeps through sandy soils faster than clay soils. Sand particles are large and irregularly shaped. They have more air pockets through which water can move. Clay particles are smaller. They can compress when wet. Their smaller air pockets fill more quickly and completely.

Wet Roots

Plants that live in wet soil must adapt to the lack of oxygen. Reeds and some sedges, such as those found in freshwater wetlands, have hollow structures that enable the little oxygen they obtain to travel quickly through the plant. Mangrove trees, found in saltwater (marine) wetlands, have a tangle of roots that are exposed periodically to the atmosphere as the tides ebb and flow. Cypress trees, which grow in freshwater swamps, have knobs or "knees" of root material that

emerge from the water. Scientists speculate that these knees absorb oxygen. The roots of floating plants, such as duckweed or lilies, dangle into water and absorb oxygen.

This small wetland plant can thrive even with wet roots.
Photo: © Carolyn Duckworth, 2004

Wetlands plants must also be efficient at absorbing other nutrients such as nitrogen and phosphorus. For example, in wetlands, nitrogen is most often available as ammonia. Thus, many wetlands plants have become super-efficient absorbers of ammonia.

Wetland Delineation

If a wetland exists on property slated for development, the developer will need to mark, or delineate, the boundaries of the wetland. To find out if a wetland has already been surveyed and designated as wetlands, a developer would contact the district office of the U.S. Army Corps of Engineers. If the area is not yet surveyed, the developer must hire wetlands experts (Society of Wetland Scientists; www.sws.org). They might begin by looking at aerial photographs or soil maps of the area (soil surveys available from the US Department of Agriculture; http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm). Then, they visit the site to evaluate the soils, plants, and hydrology.

The timing of those inspections can be critical. Many evaluators visit wetlands during the summer and fall because that's when wetland plants are most easily identified.

The delineation process should produce:

- Maps showing the size, location, shape and names of features.
- Data sheets listing soil, vegetation, and hydrological indicators.
- Vicinity map that identifies the study area.

Defining Wetlands

You would think the answer to "What is a wetland?" would be easy. Scientists, politicians, environmentalists, ranchers, farmers and developers have all been debating the definition of a wetland for over fifty years. Although many definitions of wetlands exist, the two definitions used by the U.S. Government agree that a wetland contains specific:

- Hydrology (amount and period of time that water is present)
- Hydrophytic vegetation (wetland plants adapted to wet soils)
- Hydric soils (soils low or absent in oxygen due to their saturation in water).

The U.S. Fish and Wildlife Service (FWS) say an area need only have one of these conditions to be considered a wetland. The U.S. Army Corps of Engineers (Corps) says an area must have all three conditions before it is considered a wetland. The Corps administers the wetlands provisions of the federal Clean Water Act. Therefore, its definition is the one most used by the federal, state, and local governments. The definition, as published in the 1987 Corps of Engineers *Wetlands Delineation Manual*, says:

> *"Wetlands are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."*

Within this definition there are many different types of wetlands, and many common names to describe these different wetlands.

Changing Attitudes

Our positive attitude about wetlands has developed mostly in the last half of the twentieth century. Prior to that time, many people in the United States considered wetlands to be dangerous, dark, damp, horrible places full of snakes that can kill you and mosquitoes that will spread diseases. Think of the name of a big wetland in southern Virginia: The Great Dismal Swamp. Today this is a National Wildlife Refuge revered by birders and botanists as a haven for wildlife and wild flora. But in the 1700s, it was described as "a horrible desert, the foul damps ascend without ceasing, corrupt the air and render it unfit for respiration."

With attitudes like this, it is no wonder that Americans, like many people around the world, dredged, drained, and filled in as many wetlands as possible, making these lands into farms, pastures, towns, and cities. Today, when you walk many of the streets of major cities such as Chicago, Boston, San Francisco, and Washington, D.C., you are walking upon filled-in wetlands.

Another Attitude

Native people of the Americas did not share this view of wetlands. Archeological evidence indicates that Mayans built raised fields in wetlands of Central America. The water would sweep up into the raised beds to moisten the crops. The Anishinabe (the tribe's preferred name, instead of Chippewa or Ojibway) live in a land of water, in and around Lake Superior and the other Great Lakes. They gather food of the wetlands, such as cranberries, and every fall they harvest wild rice, which can grow only in healthy, clean wetlands.

Chicago, IL is built on a wetland
Photo © Carolyn Duckworth

Scientists think that people began occupying the Columbia River Basin of Idaho and Washington more than 12,000 years ago. Ancestors of the

Nez Perce traveled to the Palouse region where they harvested camas bulbs that grow in seasonal wetlands of this fertile grassland. The Nez Perce, and many other tribes, continued this migration. Even today, they will travel to the camas meadows of the Columbia Basin for this staple. The Coeur d'Alene tribe considers the water potato so important that they celebrate it in a tribal holiday. Native people harvested other wetland plants such as alder, lovage, and horsetail. They also hunted animals of the wetlands, such as ducks and beaver.

(See appendix A for a list of wetland laws.)

Why Are Wetlands Important?

You can think of wetlands as acting like sponges, kidneys, and supermarkets, all at the same time.

Wetlands act like giant sponges, absorbing water during floods and storms. Instead of washing downstream and transporting sediment, water in wetlands slowly soaks into the ground to recharge aquifers and other ground water sources.

As water collects in wetlands, this ecosystem cleans the water. Sediments settle out as the water slows. The soil particles bind with pollutants. Some plants absorb the nutrients and toxins that would otherwise wash into our lakes, rivers, and coastal waters.

Some communities use this natural cleansing ability of wetlands to treat the wastewater and sewage. Such treatment occurs in urban areas of Pennsylvania and Wisconsin, plus smaller communities such as Moscow, Idaho. Wastewater treatment wetlands in Moscow, Idaho not only provide habitat for birds, but also polish the water before it flows down Paradise Creek.

Wetlands not only provide food and other functions. They are peaceful places where many people choose to recreate. In wetlands, people enjoy hunting, trapping, wildlife viewing, and many other activities.

Wetlands also serve as nurseries, cafeterias, and homes for fish and other aquatic species that we humans love to eat. Studies estimate that wetlands provide habitat, at some point, for at least two-thirds of the fish caught and sold in the United States.

In some wetlands, dense layers of rich organic material form as vegetation dies and is compressed. This resource, called “peat,” is mined to provide a soil conditioner for gardens and to provide fuel.

Economists consider all of these uses when they estimate the value of wetlands. One small Massachusetts wetland has been valued at $200,000. One acre of Louisiana coastal wetland might generate $80,000 in fish and other resources.

A wetland provides important services to our environment. When it disappears, so do those services. We lose vital flood protection, water cleansing, and food. All of the animals and plants that live in that habitat, for all or part of their lives, often have nowhere else to go. Frogs have no place to mate and lay eggs. Pintail ducks lose a watering and feeding stop on their long migrations. Aquatic insects die. All the animals that eat them must find food elsewhere.

Wetlands and People

Wetlands provide another important service for people. These bountiful habitats are popular places for recreation. Birders are the fastest growing group of outdoor enthusiasts in Idaho. They can often be found around wetlands watching waterfowl, songbirds, raptors, and shorebirds. Idaho's outdoor enthusiasts have good company. According to the U.S. Fish and Wildlife Service (USFWS), people who hunt, fish, canoe, and photograph wildlife rely on wetlands and contribute almost $60 billion to our national economy in a year.

Peace in the wetland
Photo: © USFWS 2004

Wetlands and the Environment

Wetlands cover less than ten percent of the earth's surface but are the source of almost one-quarter of the world's productivity. Saltwater wetlands provide nursery habitat for most of the fish and shellfish that we eat. As these habitats are destroyed, the ability of fish populations to replenish themselves is also destroyed. What effect will this have on our food supply in the future?

Wetlands are so productive because of the amount of vegetation they contain. Abundant plants constantly photosynthesize, converting carbon dioxide to oxygen and producing energy and food. Nutrients produced by the plants are distributed widely through floods, storms, and tides. The dead and dying plants (detritus) form the base of food webs. Protozoa, bacteria, fungi, and larvae consume the detritus; fish, worms, birds, and insects consume the detritus-consumers; etc. The dense vegetation of wetlands creates a natural water-treatment system that surpasses anything humans have created. As water enters a wetland, it slows. Sediment settles out and is

Emergent palustrine wetland on the Palouse, Idaho
Photo: © Penelope Morgan 2004

trapped by the wetland plants and their roots. The plants also absorb almost two-thirds of the nitrate and phosphorus commonly carried in storm water runoff and floods, especially from agricultural areas with their heavy loads of fertilizer. Bacteria in the water and soil also can neutralize wastes, including the body wastes of animals and humans.

The slowed, cleansed water of a wetland may pass into another waterway. Much of it percolates into the ground and recharges groundwater supplies. Such supplies provide a majority of the drinking water in many areas in the U.S. For example, one wetland in Massachusetts was found to recharge a shallow aquifer with more than 240 million gallons per month. In addition to slowing and cleansing water, in coastal areas the wetland's dense vegetation creates a tough buffer zone that can deflect waves and other heavy water action.

Wetland Plants and Animals

When you enter a wetlands habitat, you are entering an environment that supports thousands of plants, hundreds of birds, and almost all of the fish and shellfish that we consume. Permanent residents of wetlands in the Intermountain West include algae, bacteria, and other micro-organisms; animals such as the mosquito, dragonfly, and numerous aquatic insects, plus toads, the leopard frog, tiger salamander, pupfish, crayfish, beaver, muskrat; plants such as sedges and bulrushes, berry bushes, shrub willows, and cottonwoods. Seasonal residents include the American peregrine falcon, the whooping crane, ducks, geese, swans, numerous elk, bats, black bear, grizzly bear, bald eagle, osprey, trout, and salmon.

Rare Species and Wetlands

Nearly half of the threatened and endangered species in the United States rely directly or indirectly on wetlands for their survival. In Idaho, 49 species of rare plants and 29 species of rare animals depend on wetlands.

A Few of Idaho's Rare Wetland Species

- Bog-rosemary
- Bristly sedge
- Giant helleborine
- Bog willow
- Purple meadow rue
- Bull trout
- Northern leopard frog
- Coeur d'Alene salamander
- Northern bog lemming
- Brown bear
- Whooping crane

What does a riverside shrub have to do with a trout?
Plenty! For one thing, the overhanging limbs create shade beside the banks, a perfect place for a trout to rest during the heat of the day. Leaves also fall into the water and begin to decompose, providing food for the aquatic insects that trout eat.

Wetland Plants

Some wetland plants include alder, willow, cottonwood, cattails, sedges, rushes, and bulrushes. Others include beautiful purple camas, wild iris, and chokecherry. Many of these wetland plants provide food, shelter, perch sites, and nesting areas for wildlife. Have you ever walked under a willow and felt a cool mist in the air? Wetland plants keep the area cool with their shade. The water is transpired through their leaves.

Salmon and Wetlands

Spawning Chinook
Photo: © IDFG 2004

Riverine wetlands benefit young salmon directly, by providing them with shelter during the start of their lives. Riparian areas, or areas along streams or rivers, continue to benefit salmon indirectly throughout their lives, by helping to keep streams and rivers cool and free of sediment. The wetland vegetation shades the pools along the bank. It traps sediments during floods and binds the banks to prevent erosion. Sediment-free water is essential to salmon. For example, salmon eggs and alevin (hatchlings) depend on ample flows of clean water through gravel to bring them air and food. Sediment can smother the eggs and young salmon, and rob them of food. Sediment can also trap young salmon upstream preventing their migration to the ocean. Likewise, sediment can block adult salmon downstream preventing their return to spawning sites.

The wetlands of estuaries, such as at the mouth of the Columbia River, provide essential resting and feeding places for salmon. Young salmon spend at least a short time in these quiet waters before moving into the ocean. Fall Chinook salmon spend months there before beginning their adult journeys. Returning salmon also may rest briefly in the nutrient-rich waters of the estuaries, consuming one last massive meal before they journey to their spawning grounds.

Beaver and Their Dams

Beaver dams back up water on a stream, diversifying the habitat for other animals and plants. Beaver Lake, in Yellowstone National Park, is testimony to the industry of beavers and the ultimate result. This lake is now more meadow and mud than a body of water. However, you still can see the long dam built by beavers at least a century ago. Their dam slowed the flow of stream water and created a wetland.

The Intermountain West had thousands of beaver-created wetlands until trappers, supplying the fashion industry in the early 19th century, wiped out beaver. In Idaho, beaver were gone in less than ten years.

Beaver Dam
Photo © Carolyn Duckworth 2004

Today, beaver populations are steadily increasing. They are welcome residents in many natural areas. Some places in Idaho, beaver are doing so well that trapping is allowed again. The Idaho Department of Fish and Game plans these trapping seasons in order to manage beaver populations.

Because beaver have played such a large part in shaping, and even creating, wetlands in the past, biologists throughout the U.S. are using beaver to restore wetland habitats. The beaver are trapped and transplanted from healthy wetlands or urban areas to the damaged wetland. After some time, the beaver dams can re-create the natural hydrology of the area by slowing water and causing streams to overflow their banks. This is important for many species of wetland plants and animals that depend on flooding to deposit fresh soil and nutrients on the floodplain and to create many small pools of water where insects and amphibians may lay their eggs. Beaver may also have a revitalizing effect on some willows and red-osier dogwood. Maintaining beaver populations is a critical element in sustaining natural wetland complexes.

Types of Wetlands

One of the first questions to ask when you are trying to determine the type of wetland is “Is it fresh or salt water? Is it on the coast or inland? These answers will guide you to the five categories of wetlands recognized by most scientists and wetlands regulators: Marine (coastal, salt water), Estuarine (coastal, salt/freshwater mix), Riverine (associated with rivers and streams), Lacustrine (associated with lakes), and Palustrine (miscellaneous freshwater wetlands, generally shallow).

Scientists or regulators use these terms when discussing wetlands. These terms have specific definitions. Common names vary by region and country. The words “fen, bog, mire, peatland, and moor” all refer to freshwater wetlands that produce peat. Peat is the compressed layer of dead plants that resist decay in acidic wetland environments. These terms are also used

colloquially: "...especially that boggy part on the curve." Is this a real bog or just a wet place? However, if you said, "I have a wet area on my property. Is it some kind of palustrine wetland?" This question eliminates saltwater marshes, estuaries, and lakeside wetlands. It will help the expert determine what kind of plants, soils, and hydrology may be in the area.

Marine Wetlands

Saltwater wetlands along coasts. Water levels rise and fall with the daily tides. They can be subject to the force of waves, storms and ocean currents. Characteristics of marine wetlands vary with the level of tidal, wave, and current effects. Salt-tolerant plants, called halophytes, are dominant. Common halophytes include grasses such as Spartina species. Sub-tidal marine wetlands are submerged continuously. Intertidal marine wetlands are periodically exposed.

Estuarine Wetlands

Coastal wetlands within estuaries (zones where fresh and salt water mix). Estuarine wetlands usually have some access to oceans, with significant inflows of freshwater. Water levels rise and fall with the daily tides and can be subject to the force of waves and storms. Characteristics vary with the level of tides, waves and amount of salinity, which can vary with location and interactions with oceans and freshwater sources. Halophytes are dominant. Sub-tidal estuarine wetlands are submerged continuously. Intertidal estuarine wetlands are only periodically exposed. The wetlands of estuaries, such as at the mouth of the Columbia River, also provide essential resting and feeding places for salmon.

Estuarine Wetland
Photo © U.S. Army Corps of Engineers.

Riverine Wetlands

Wetlands in the channels of rivers and streams. Riverine wetlands occur along streams, rivers, and irrigation canals throughout the United States. They are particularly noticeable in western states, such as Idaho, because they form ribbons of trees and shrubs in an otherwise arid landscape. You may have heard of these inland wetlands by their other name: “riparian” areas.

Riverine Wetland
Photo: © USFWS

Riverine wetlands play an essential role in maintaining healthy streams and rivers. They

typically support dense stands of trees such as cottonwood and quaking aspen, shrubs such as mountain maple and red alder, and grasses. These plants help bind the soil of banks, protect the banks from erosion during floods, and trap additional sediment from floodwaters.

The plants also provide habitat for wildlife. Birds, from tiny warblers to majestic bald eagles, use riparian areas for cover from the weather, for breeding, resting, and foraging sites. Many species of salmon are dependent on healthy riverine wetlands and riparian areas for survival.

Riverine wetlands represent only about one percent of land in the Intermountain West. Scientists estimate that as much as eighty percent of the birds and other animals of the West depend on riparian habitats during all, or part, of their lives. Like other kinds of wetlands, riverine wetlands have been affected by human disturbance.

Lacustrine Wetlands

Wetlands around lakes and reservoirs. These freshwater wetlands form around the perimeter of lakes and reservoirs. They are larger than twenty acres or contain water depths of six feet. Like marine and estuarine wetlands, lacustrine wetlands are exposed to wave action.

Lacustrine Wetland
Photo: © Jennifer Whipple

Palustrine Wetlands

Isolated, inland wetlands not associated with lakes or reservoirs. Smaller and shallower than lacustrine wetlands, palustrine wetlands include marshes, wet meadows, bogs, potholes, and playas. Palustrine wetlands may be connected by surface or groundwater to rivers or lakes, or they may be isolated.

Palustrine Wetland
Photo: © U.S. Corps of Engineers

Forested palustrine wetlands occur in areas with abundant moisture, such as in the mountains. In the Rockies, look for them on the west side of watershed divides. Forest wetlands occur more frequently on the Idaho side of the Bitterroot Mountains receiving more precipitation than the Montana side.

Forested wetlands are easily missed. If you walk into a forest wetland, your senses will detect the difference. The air is often cooler, the ground

damp, if not soggy. Ferns and mosses may be abundant and other understory plants thicker. Look for tamarack, western red cedar, and western hemlock.

In Idaho, forest wetlands provide habitat for several species of salamanders, toads, and frogs. The Coeur d'Alene salamander only exists in moist forest areas of northern Idaho where rocky areas meet the wetlands. Open areas, such as sloughs, feature many kinds of grass-like plants such as sedges, bulrushes, cattails, and reeds. Other special types of isolated, palustrine wetlands include hot springs and vernal pools.

Hot springs, which are numerous in Idaho, provide warm wetland habitat that supports a variety of rare life. In no other wetlands will you find “thermophiles” (heat-loving microorganisms). These warm wetlands also harbor rare plants such as giant helleborine and Jones' primrose. In the winter, hot springs provide food and water for many animals.

Idaho's Animals and Wetlands

Fish: According to Gregg Servheen, a biologist with the Idaho Department of Fish and Game, "I guess you can say that all Idaho's fish species depend on wetlands. This includes bull trout, salmon, and steelhead, which are all threatened."

Birds: In Idaho's wetlands these include geese, yellow warblers, sandpipers, avocets, willets, plovers, herons, rails, ducks, red-winged blackbirds, owls, ducks, black terns, and boreal chickadees.

Vernal pools, also called ephemeral ponds, typically are wet in the spring after snowmelt or seasonally heavy rains. Their shallow, quickly disappearing waters cannot support fish. They provide essentially predator-free breeding areas for amphibians. Some scientists estimate that half of the amphibians in the U.S. breed only in these and other seasonal wetlands.

(See appendix B for common names of wetlands)

Wetlands in Idaho

"Race you to the river!" shouts a young girl as her horse trots across the hayfield. Her friend holds onto her hat with one hand and the reins with the other galloping fast to catch up. They plunge down the steep bench and slow their horses to a walk as they enter the cool shade of cottonwoods. Reining their horses to a stop, the two girls listen: A symphony of insects and birds call and sing throughout the leaves of the trees and shrubs. They dismount to examine two sets of tracks, deer and bobcat, crossing the soft, moist soil. Then, they quietly approach another friend, who is fly-casting out into the river. It is just another summer afternoon in central Idaho, brought to you by wetlands.

Idaho wetlands may be obvious habitats. There are freshwater marshes or lake edges. More subtle habitats such as winding miles of riverside wetlands can be found. Sometimes, there are

hard-to-find habitats, such as ephemeral ponds of forests, prairies, and glaciated valleys. They are not always freshwater habitats. You will find saline wetlands in undrained depressions and areas receiving irrigation runoff. This vast region, with its varied terrain-rivers, valleys, mountains, and grassland-provides a living laboratory of inland wetlands. We will focus on the two types of inland wetland habitats common in this region: riverine and palustrine.

Inland freshwater wetlands differ from coastal/marine wetlands in water chemistry and dynamics. They are not subject to tidal fluctuations or to extreme wave action of ocean storms. Thus, their vegetation can be more stable, such as shrubs, or less anchored, such as floating plants that have no roots in the sediment. You will often find mats of duckweed on freshwater wetlands. These plants float on the surface. Their roots extend into the water but not down to the sediment.

Freshwater wetlands play an essential role in the availability of water in the arid Intermountain West. By slowing floodwaters or capturing snowmelt each season; inland wetlands retain the water, which then can seep into the ground to recharge aquifers and other sources of groundwater. In addition, the wetlands vegetation and sediment filter out many pollutants from the water.

Some inland wetlands, such as sloughs associated with rivers, may appear the same each year. The relatively stable climate of mountain valleys allows vegetation in these wetlands to stabilize and reappear year after year.

Other inland wetlands, such as prairie potholes, may seem to disappear for most of a decade, only to reappear during wet years. Look for more subtle clues to identify these types of wetlands. The dryness of the soil or the present vegetation can be deceptive. This type of wetland is found throughout the Palouse in North Idaho.

Losing our Wetlands

A harried homeowner stands on her deck, her shoes damp and anger on her face. She is yelling at her companion. She has to shout to be heard above the rush of the river in spring flood. "The second cottonwood went down last night. Now, the river is eating away at the third. If that one goes, I think we may lose the entire backyard. The real estate agent swore our land would be safe, but a fourth of it is gone!"

Photo: © US Corps of Engineers

If you understand how riverine wetlands protect us from flooding. You know that we have lost so much of this vital habitat. You would think that no one would buy a house next to a big river. People do it every day, in every state, in the country. We cannot seem to help ourselves. We love water. We love vegetation. We love birds, mammals, and fish. As the woman above is discovering, our love of this riverside land could be our undoing.
Such a revelation is ironic when you consider that wetland destruction historically has been caused by our hatred of these same habitats. After all, they bred mosquitoes, were impossible to build upon or plow. So why not get rid of them? We have destroyed millions upon millions of acres of wetlands everywhere from Maine to Florida to the west coast.

How Much Have We Lost?

In a few hundred years of settlement, the United States has lost more than half of its original wetlands, from an estimated 220 million acres to less than 110 million acres, in the contiguous states. More than half of Idaho's wetlands disappeared by 1980. Ninety percent of the state's low-elevation wetlands are gone, converted to agriculture or urban areas, destroyed by channelizing of streams, polluted by humans, and invaded by exotic plants. These changes have decreased fish reproduction and reduced populations of the spotted frog and western toad.

Photo: © US Corps of Engineers

Currently, the United States loses more than 70,000 acres of wetlands every year. This pace probably will not slow. Within the next few decades, more than half the population of this country will live within fifty miles of our coasts. Urban development in this region has already accounted for almost half of the coastal wetlands destruction in the last decade of the twentieth century. If we keep moving to and building in this region, how much longer will the remaining wetlands survive? The same conundrum faces homeowners of the Intermountain West. Can we keep from loving our favorite places to death?

How Are Wetlands Damaged?

Draining, dredging, building dikes, dumping pollutants, mining for sand and gravel, ditching, and building roads are just a few of the many direct ways we damage or destroy wetlands. The indirect methods, wakes of motorboats, urban runoff, and global climate change. It is a wonder there are any wetlands left.

For hundreds of years, agriculture has been the chief destroyer of wetlands. If a field were too wet in the spring, farmers would dig a ditch to drain off the water. When the country and the world demanded more grain, the federal government paid people to drain more wetlands. When family farmers struggle to make their mortgage each month, it is hard to ask them not to plow every square inch of ground.

Urban expansion gobbles up more large chunks of wetlands. Vast acres of marshes in the San Francisco Bay, Chesapeake Bay, New York Harbor and other coastal areas were dredged or filled in the twentieth century to make way for freeways, airports, industrial sites, business parks, and thousands of homes. Those are the obvious losses. Most people barely notice the millions of small wetlands lost to bulldozers. These small wetlands, which often last only a few months each year, are vital purifiers of surface water, rechargers of groundwater, and providers of habitat for wildlife.

In the western United States, riparian areas along riverine wetlands face continued destruction from several sources. According to some researchers, livestock grazing has damaged hundreds of thousands of acres of riverine wetlands. Livestock not only consume the vegetation. They tend to remain in the same area for an extended period. Their movements to and from riversides create gullies and undermine the banks. Our construction efforts, whether building roads and bridges or homes and businesses, can also affect streamside habitats by compacting soil, ripping up vegetation, and accidentally carrying in seeds of non-native or noxious plants, such as knapweed.

Threats to Idaho's Wetlands

Idaho has lost more than half of its wetlands. They continue to be lost today. How does this happen?

- Road and highway fill and construction.
- Development, Irrigation and other water use.
- Converting grasslands to agriculture in the Palouse region.
- Hardrock mining, which can lower water tables, drying up wetlands that are fed by groundwater.
- Sand and gravel mining, placer and dredge mining can destroy habitat along the bottoms and banks of rivers.
- Channelizing streams and rivers, such as the Portneuf River near Pocatello, increases water velocity, erosion, and flooding.
- Industrial-scale timber harvesting can damage riversides when road construction and tree removal of from streamside areas and steep hillsides above streams cause runoff and sediment loads to increase.

What Happens When Wetlands Disappear?

There are flooded basements in the spring. Entire downtowns are inundated. Millions of pounds of soil are washed downstream, destroying

farmland, fisheries, and food for wildlife. Whether it is localized flooding or catastrophes, such as the Midwestern floods of 1993, the entire United States is at risk from increased flooding due to our destruction of wetlands.

Photo: © US Army Corp of Engineers

The U.S. Army Corps of Engineers has studied the causes of flooding and advocates wetlands protection as the most cost effective way to prevent flooding. Florida and Louisiana were both hit directly by Hurricane Andrew in 1992. Florida suffered ten times the destruction. What was the difference? Louisiana had retained more of its coastal wetlands.

Small-scale wetlands destruction can also have far-reaching effects. As they disappear, so too do their abilities to recharge groundwater, collect sediment, and trap pollutants. Isolated wetlands often serve as crucial habitat for small populations of rare birds, insects, and amphibians. Only a few whooping cranes nest at Gray's Lake National Wildlife Refuge in eastern Idaho. If irrigation drew down the water table enough to dry up even small portions of this wetland, the crane's nesting success could be threatened by increased predator access or other problems associated with diminished wetland.

Agriculture and urbanization have devastated the wetlands of California's Central Valley. In previous centuries, this huge valley's wetlands supported 40 million waterfowl. Today, it supports only 8 million waterfowl, with simultaneous reductions in recreation, hunting, and fishing associated with this habitat.

The Caddis fly is an aquatic invertebrate.

The impact of wetland destruction occurs far beyond what we can see. Aquatic invertebrates (picture to right is a Caddis fly) are primary consumers in many aquatic ecosystems. They consume algae and other organic matter, and subsequently become food for other types of invertebrates and vertebrates throughout the food web. Some species are only found in a few springs or streams. Their loss could ripple far beyond their isolated wetlands.

The loss of small, seemingly insignificant, wetlands causes problems no matter where they

are. In urban areas, many construction crews ignore or are unaware of seasonal stream channels and ponds. They fill the depression in the ground without considering the cumulative impact of this landscape alteration. Subsequent home or business owners will have to deal with the flash floods, wet basements, and inundated parking lots.

Downstream, water quality begins to suffer and affects life from the microorganism to the megafauna. What are we to do? Should we learn to live with more floods, less water, or fewer fish? Maybe we should not. Next, find out about people trying to protect and restore wetlands.

Protecting Wetlands

Suppose you live near a wetland surrounded by land slated for development. What should be done to protect this wetland? Bring in wetlands experts to delineate and define the wetland. Identify adjacent landowners and other interested people. Invite them to tour the site and meet to discuss a plan. Establish goals, which should include:

- Establishing protection for the wetland.
- Preventing any further damage.
- Repairing as much damage as possible.
- Educating the public about the presence of the wetland and how they can help.

Work with private landowners, local governments, and area conservation groups to evaluate and choose from a number of protection options, including:

- **Conservation easement:** This voluntary, legal agreement, usually between a private landowner and an agency or nonprofit organization, such as a land trust, restricts the amount and type of development and protects natural features, such as wetlands. The landowner can sell or give the property to heirs. All future owners must comply with the easement. Easements vary from site to site.
- **Lease:** You can agree to rent the wetland to a government agency or nonprofit organization for a specific period of time.
- **Donation:** The landowner gives the property to a nonprofit organization and receives a generous tax deduction and the assurance that the land will be maintained as a wetland.
- **Sale:** You can sell the land to a nonprofit organization that will either maintain the land or turn it over to an appropriate government agency.

The Natural Resources Conservation Service (NRCS) administers the following programs:

- **Conservation Reserve Program:** Through rental payments and cost sharing, the federal government helps landowners develop conservation plantings and other habitat enhancements on and around agricultural land.
- **Wetlands Reserve Program:** The federal government purchases a conservation easement, which limits future use of the land and allows continued agricultural practices while setting aside and restoring valuable wildlife habitat.
- **Wildlife Habitat Incentives Program:** This cost-sharing program enables landowners to create and improve wildlife habitat in collaboration with the NRCS. For more information: www.nrcs.usda.gov.

Protection Success

Rancher: On Flat Ranch, on the Henry's Fork of the Snake River in eastern Idaho, you are as likely to see sandhill cranes as you are cows, birders and anglers as you are to see cowboys. This 1600-acre ranch keeps cows moving in a grazing rotation that protects the land. The riparian areas are being re-vegetated with willows and other wetlands plants. Each year more visitors come to enjoy the recreation provided on this ranch, owned by the Nature Conservancy.

Sandhill Cranes
Photo: © William H. Mullins

Partnership: Nonprofit groups and government agencies formed a partnership to protect one of Idaho's last high desert, spring-fed wetlands. Chilly Slough, in the Big Lost River Valley, provides habitat for rare plants and more than 134 bird species. Its 1,000 acres are maintained by The Nature Conservancy, Ducks Unlimited, the Rocky Mountain Elk Foundation, Idaho Department of Fish and Game, U.S. Fish and Wildlife Service, and the U.S. Bureau of Land Management.

School group: Fifth graders from Wendell Elementary, in Wendell, Idaho, have planted marsh grasses to restore an eroded wetland and help a larger wetland mitigation project that will use wetlands to clean irrigation water.

Wetland Restoration

Can we put back what we have taken away? Some people say yes. We can restore wetlands. Other people say no. Sometimes, simply stopping or changing the damaging disturbance will allow the stream or wetland to restore itself. When livestock grazing is removed, wetland vegetation often returns, as is seen with this project that fenced out sheep from Big Mud Creek. When the disturbance has been long-term or certain functions such as flood control or clean water are desired, we speed up the rehabilitation process by doing restoration projects.

It is certainly possible to restore an area so that it looks like a wetland. Plants will grow again. Ducks will stop by, fish and frogs may return. What looks like a wetland may not act like a wetland, at least not for many decades. These ecosystems are so complex and provide such a variety of essential functions to the rest of the environment that they cannot possibly be recreated completely. Even so, restored wetlands provide valuable habitat functions for many plant and animal species. As long as we do not fool ourselves into thinking we have rebuilt the entire function of a wetland overnight, restoration has a role to play in wetlands preservation.

"Restoration" is a general term used for projects that have many different goals. Some goals of restoration projects may include:

Restored Wetland at the University of Idaho
Photo: © Penelope Morgan

- Stabilizing stream banks to stop erosion.
- Creating habitat for fish, birds, amphibians, or other wildlife.
- Reconnecting incised streams with their floodplains.
- Bringing back native vegetation.
- Controlling floods.
- Improving water quality by trapping sediment and filtering runoff with riparian buffer strips.
- Increasing infiltration or surface water to ground water through wetlands and riparian areas.
- Preserving rare species.
- Mimicking formal natural conditions.
- Cleaning water with wetlands.
- Educating and bring communities together.
- Beautifying streams and wetlands.
- Providing sites for ecological research.

Appendix A: Wetland Laws

Clean Water Act (CWA) of 1972, Section 404
Requires permits before disposing dredge or fill materials into waters of the United States; protects adjacent wetlands.

National Environmental Policy Act (NEPA)
Requires federal assessment of impacts to the environment, including wetlands, of any projects proposed by federal agencies. It requires annual report to Congress on the status of the environment.

Executive Order 11990 (Protection of Wetlands)
Issued by President Carter, in 1977; forbids federal government construction in wetlands unless no other alternative exists; if construction must occur, it must limit harm to the wetland. Also requires agencies to have the public review its plans for any new construction in wetlands.

Executive Order 11988 (Protection of Floodplains)
Issued by President Carter requires federal agencies to avoid activities in floodplains. Also provides incentives to communities that conserve floodplains.

Food Securities Act of 1985 (Swampbuster)
Removes incentives to convert wetlands to cropland.

Coastal Zone Management Act
Establishes importance of preservation, protection, and restoration of coastal lands, including those of the Great Lakes.

Fish and Wildlife Coordination Act
Requires all federal agencies to consult with the U.S. Fish and Wildlife Service on wildlife impacts of any projects that involve water.

North American Wetlands Conservation Act
Helps fund wetland conservation projects in the U.S., Canada, and Mexico with the North American Wetlands Conservation Fund.

Jimmy Carter Saved Wetlands

On May 24, 1977, President Jimmy Carter issued one of the most environmentally important executive orders, Number 11990, "Protection of Wetlands." This executive order forbids federal government construction in wetlands unless no alternative exists; if construction must occur, it must limit harm to the wetland. The order also required agencies to have the public review its plans for any new construction in wetlands. Number 11990 spawned numerous new laws and policies, and its influence continues today.

Coastal Wetlands Planning, Protection, and Restoration Act
Funds grants to states to purchase and protect coastal wetlands.

Water Resources Development Act of 1999
Authorizes $200 million for wetlands restoration for flood control.

1990 Food, Agriculture, Conservation, and Trade Act
Establishes Wetland Reserve Program (WRP) to restore wetlands that were converted to cropland before 1985.

Appendix B: Common Names for Wetlands

Bog
Acidic wetland with no appreciable inflow or outflow of water. Supports acid-loving mosses such as sphagnum, plus some shrubs and trees. Dead plants accumulate and are compressed, forming peat.

Bottomland
Usually forested lowland in the floodplains of streams and rivers. Also called bottomland hardwood forests.

Fen
Similar to bog (some scientists say that bog and fen are the same). Receives some water from surrounding mineral soils and supports marsh like plants, which form peat as they die and are compressed. In northern Europe, they call fens and bogs "mires."

Marsh
Fresh, brackish, or saltwater lands along rivers, creeks, ponds, lakes, and coasts; often or always flooded. Supports plants that grow up out of the water (emergent vegetation).

Muskeg
Common in northern regions such as Alaska and Canada. An expanse of very wet peatland or bog. Also called subarctic peatland.

Peatland
Any wetland that forms peat, including bog, fen, mire, and muskeg.

Playa Lake
Desert or Great Basin seasonal wetlands formed in depressions; usually dry by summer. Plants are marsh like.

Pothole
Depressions created by the scraping action of glacier. Provides essential nesting and migratory rest stops for birds. Found in the grasslands of the mid-west, as well as in other glaciated landscapes.

Riparian
Wetlands along rivers or streams.

Slough
Freshwater wetlands including swamps and shallow lakes.

Swamp
Any freshwater wetland supporting trees and shrubs. Often found along rivers, slow streams, or in depressions.

Wet Meadow
Grassy area with saturated soils but not standing water.

For other definitions of wetlands, go to:
http://water.epa.gov/lawsregs/guidance/wetlands/definitions.cfm

To explore different types of wetlands, go to:
http://water.epa.gov/type/wetlands/types_index.cfm

This chapter was created from the wetlands information pages on the Idaho Department of Fish and Game website, with permission.

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Aquatic Ecosystems & Management

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Describe the characteristics of water
- Communicate the characteristics and properties of aquatic systems
- Understand and communicate how aquatic systems function
- Become familiar with management techniques for aquatic systems
- Understand and communicate threats to aquatic systems

Introduction

Idaho's aquatic ecosystems are as diverse, interesting, and unique as any in the world. Idaho's lakes, rivers, streams and wetlands reflect the diversity of climate and landscapes found in the state. These ecosystems include huge, deep cold-water lakes, small high mountain lakes, large alkaline lakes, streams and rivers of with diverse size, gradient and temperature regimes and wetlands that include vast marshes and diminutive beaver ponds.

Redfish Lake in the central Idaho Sawtooth Range.
Photo courtesy, Rex Sallabanks, IDFG

Notably, no "aquatic" ecosystem operates independent of the surrounding landscape. Aquatic and terrestrial ecosystems operate as one system that can best be defined, described and studied as a watershed. Land and water exchange energy (nutrients). As in all systems the sun is the primary source of energy as it is captured by plants to create the foundation for food webs and energy (nutrient) cycles.

Life on earth evolved in an aquatic system. Aquatic systems are extremely diverse ranging from marine (though not in Idaho) to freshwater, static to flowing. While all aquatic systems are dependent on water, not all have a constant water level or continuous water supply. Water, probably more than any other element or compound, makes life possible on Earth. In this chapter we will explore the properties of water, aquatic ecology and management of aquatic systems.

Characteristics of Water

Water's unique properties "explain" why water is the basis of life and why aquatic systems function as they do. Water's simple structure of 2 hydrogen atoms and 1 oxygen atom is the basis for water's unique properties. These properties include surface tension, specific heat, and ability to dissolve other substances. Also important is that water at moderate earth temperatures is in a liquid state, and so it forms our oceans, rivers, wetlands, and lakes.

Water is an extremely stable compound, meaning it does not breakdown or interact in chemical reactions readily. The H2O formula for water indicates that each water molecule consists of two atoms of hydrogen and one atom of oxygen. However, water has a most interesting and unique structure, in that the hydrogen atoms do not oppose each other at a 180◦ angle to the oxygen but instead cluster to one side, at 104.5◦ angle to the oxygen atom. This angle gives the water molecule a "bipolar" structure with the hydrogen side being positively charged and the oxygen side being negatively charged. These unequal charges make the water molecules attract each other, forming clusters with each water molecule bonding to three others (forming what is called a "tetrahedral" structure of 4 water molecules). This structure gives water the unique abilities to:

- develop surface tension,
- be a solid, liquid, or gas over a relatively small temperature range,
- become less dense in its solid state (ice floats),
- have a high specific heat, and
- dissolve other substances.

The surface tension of water gives its strong, elastic exterior. It is because of surface tension that water forms droplets, moves through minute openings in soils and living tissues, and allows some creatures to inhabit its surface.

The bonds water forms with surrounding water molecules and other molecules are called "hydrogen bonds." These weak hydrogen bonds between water molecules are constantly breaking and reforming depending on temperature and pressure. As temperature increases (and pressure decreases) this molecular activity increases and some water molecules are lost from the surface of the water to become "water vapor" (water vapor are single molecules of water).

As water vapor cools, it re-forms or condenses to liquid water (i.e. forms clouds). *A unique property of water is that its solid state is less dense than its liquid state.* As liquid water cools, its structure becomes most dense at 4 degrees C or 39 degrees F. Because of its tetrahedral structure, water cooled below this temperature becomes less dense, traps more gasses, and therefore freezes or becomes a solid at the surface, not as a block. This is biologically important because it causes the mixing and turnover in lakes. The surface ice traps warmer water (usually 39 degrees

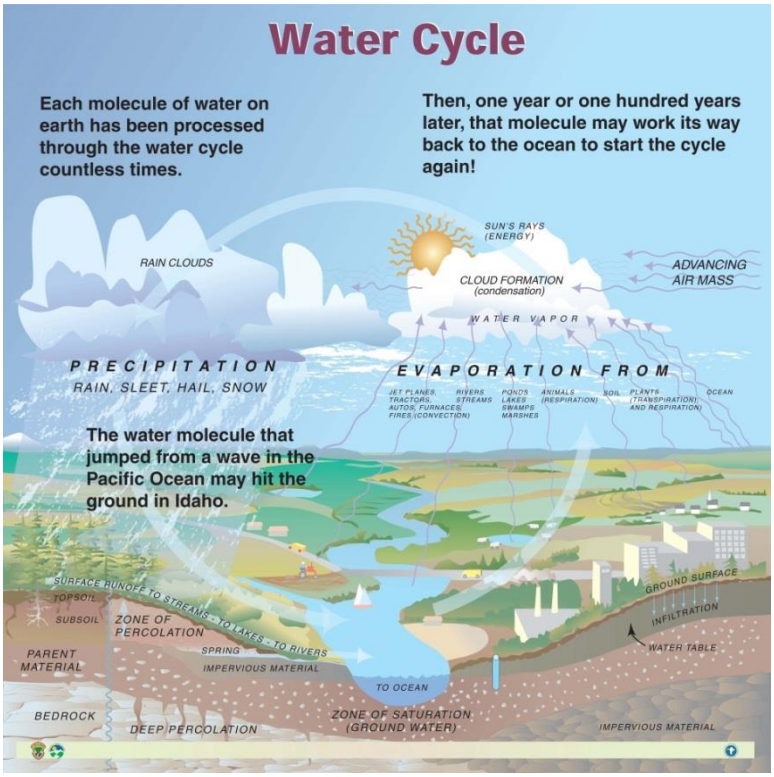
F) below and makes it difficult for large bodies of water to freeze solid. The fact that water freezes at the surface but not uniformly (as a solid block) makes life possible under the water during cold times.

A substance's specific heat is its capacity to absorb heat or thermal energy in relation to temperature at a constant volume. Water has an extremely high specific heat, which means it absorbs or releases heat slowly and therefore stores large quantities of thermal energy. This allows all bodies of water (particularly oceans) to store enormous amounts of energy in the form of heat. This stored energy is then transferred to the atmosphere and drives global weather patterns. This specific heat of means even small water bodies warm and cool slowly compared to the atmosphere, making aquatic systems very stable environments for aquatic organisms.

Finally, water is considered the "universal solvent" because of its ability to dissolve so many other elements and compounds. Substances dissolved in water (minerals, nutrients, gasses, etc.) then move freely, or diffuse, within the water body, making them available to aquatic organisms. These physical characteristics of water make it the medium of life on Earth and life as we know it cannot exist without water. Most plants and animals are comprised primarily of water. The human body is 75% water!

The Water Cycle

The water or "hydrologic" cycle is basic to life on the earth. It is a continuous process involving the exchange or circulation of water between the oceans, the atmosphere, and the land. The energy forces that drive the hydrologic cycle are solar radiation and gravity. It is estimated that 1.1 X 1015 acre-ft. or 325,550,833 cubic miles of water exist on the earth. Over 97% of this water is in the oceans with the remainder in ice (glaciers, snow, etc.) 2%, groundwater 0.58%, lakes and rivers 0.02%, or the atmosphere 0.001%. The amount of fresh water is only 2.29 X 1013 acre-ft. Living organisms utilize only 0.000078% of the total water on the earth.



To put this into perspective, if a five gallon bucket of water represented all the water on the earth, only 1 tablespoon of that water would represent the amount living organisms utilize. Evaporation (mostly from the oceans) and transpiration (from plants) releases water vapor to the atmosphere. Atmospheric water falls back to the earth as rain or snow precipitation. Water falling as precipitation can:

- evaporate back into the atmosphere,
- collect to form fresh surface waters (rivers, lakes, etc.),
- percolate into the ground, or
- be incorporated into living organisms.

Fresh surface waters can evaporate into the atmosphere, percolate into the ground, be absorbed by organisms, or flow back to the oceans. Ground water can flow back to surface water, be absorbed by plants, be stored in “aquifers,” or flow back to the ocean. It is estimated that the recycling or renewal times for water are:

- 37,000 years for oceans,
- 16,000 years for ice,
- 300 years for groundwater,
- 1-100 years for lakes,
- 280 days for soil moisture,
- 12-20 days for rivers, and
- 9 days for atmospheric moisture.

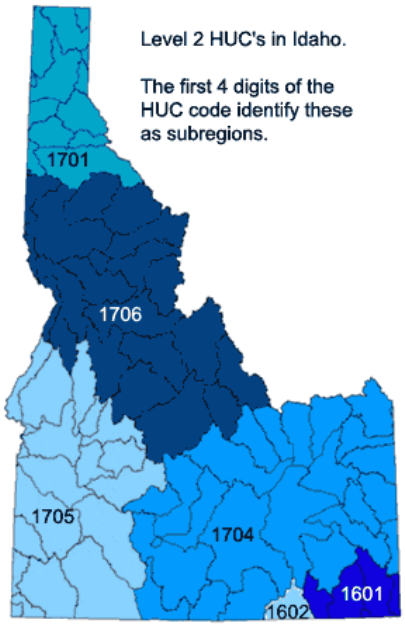
Thus, freshwater is very transient and rapidly recycles.

Characterizing Aquatic Systems

Aquatic systems can be divided into “lentic” or "lotic” systems. Lentic systems are standing or non-flowing waters while lotic systems are flowing water systems. Obviously, this classification is overly simplistic and both systems have many common characteristics as well as some distinct differences. Wetlands, reservoirs, and aquifers are examples of aquatic systems that have both lentic and lotic characteristics.

Watersheds

A watershed is the land area from which water drains into a common watercourse. All land is part of a watershed and we all live within a watershed. As water moves along the surface, through the soil, or through rock layers it dissolves and transports sediment and minerals.



H.U.C. is an acronym for Hydrologic Unit Codes. Hydrologic unit codes are a way of identifying all of the drainage basins in the United States in a nested arrangement from largest (Regions) to smallest (Cataloging Units). A drainage basin is an area or region of land that catches precipitation that falls within that area, and funnels it to a particular creek, stream, and river and so on, until the water drains into an ocean. A drainage divide is the division between adjacent drainage basins. Just as a creek or stream drains into a larger river, a drainage basin is nearly always part of a larger drainage basin. Drainage basins come in all shapes and sizes, with some only covering an area of a few acres while others are thousands of square miles across. Drainage basins cross artificial boundaries such as county, state, and international borders. The term watershed is often used in place of drainage basin.

Digital Atlas of Idaho http://imnh.isu.edu/digitalatlas/hydr/huc/huc.htm

Lotic systems

Streams, creeks, and rivers are lotic systems (moving water environments). Streams in a watershed are classified based on size and hierarchy in the watershed. The smallest streams in a watershed have not tributaries or feeder streams and are classified as "first order streams." First order streams run together forming "second order streams," and second order streams run together to form a "third order stream" and so forth up to "tenth order streams." First, second, and third order streams are called "head-water" streams. Fourth, fifth and sixth order streams are called mid-sized streams and seventh through tenth order streams are large streams or rivers.

A river is an example of a lotic system. Photo courtesy, IDFG.

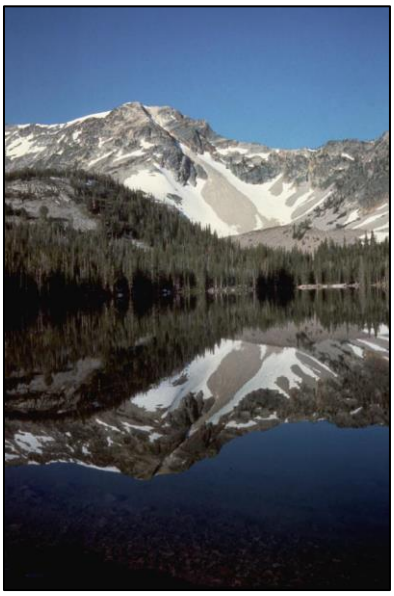
Streams in upland areas generally have higher gradients/slopes and are cooler and faster-flowing than streams in lowland areas. Rainfall, stream gradient, vegetation, and soil/substrate generally determine stream flow characteristics. Streams that flow constantly are called "perennial streams" while those that flow only occasionally are called "intermittent streams." Many first and second order streams are intermittent.

Flow rate or velocity varies widely within a stream or lotic system. Streams are usually characterized by pools, riffles, and meanders (bends). Pools are deeper, slower moving water sections while riffles are shallow, faster moving water sections of a stream. Meanders change the flow patterns of streams by focusing currents into specific areas and thus creating pools or rifles. Rainfall in the watershed increased flow in the streams. High flow velocities scour streambeds, moving stones, gravel, and silt, and cutting new channels and banks. Flowing waters transport nutrients, sediments, and aquatic organisms. Aquatic organisms that live in these lotic environments must adapt to withstand these flow changes, find sheltered areas, or be transported downstream.

The primary energy source in lotic environments is exogenous (from the outside). Organic material and nutrients from the surrounding environment or watershed supply energy for bacteria and other micro-organisms, macro-invertebrates, and fish. Some photosynthetic production does occur from algae and rooted vegetation, but is minor compared to the influx of organic matter from the outside.

Lentic systems

Lakes, ponds, and ephemeral pools are lentic systems (still water). However, all are part of a watershed and receive water from rainfall events. Most lakes and ponds overflow during heavy rainfall and thus have some characteristics similar to lotic systems. Ponds and lakes accumulate exogenous nutrients and sediment over time, becoming nutrient rich and shallower with less volume. This accumulation and its associated changes are part of the natural successional cycle. Lakes tend to accumulate sediments near the shoreline and thus slowly become shallower and smaller in volume from the edges inward. The expected life of a pond is only from 25-100 years before it is filled in to the point it becomes a swamp or wetland. Watershed characteristics above the pond or lake will determine the life of the water body. These characteristics include soil type, slope, vegetation type, and land use patterns. Agriculture practices like row-cropping and excessive livestock grazing, mining and certain industrial practices in the immediate watershed increase nutrients and sediment accumulation in ponds and streams.



The high mountain lake is an example of a lentic system. Photo courtesy, IDFG.

Light penetration drives lentic systems probably more than any other single factor. The littoral zone and limnetic zones of a lentic system are where light penetrates. Only in these areas can plant grow or photosynthesize. Turbidity in the water also affects the depth of these zones. In the littoral zone light penetrates to the bottom and this region tends to be highly diverse and

productive in plant and animal life. While exogenous materials dominate the food chain of lotic systems, lentic systems produce most of their own food (endogenous) through photosynthesis of plants within the system.

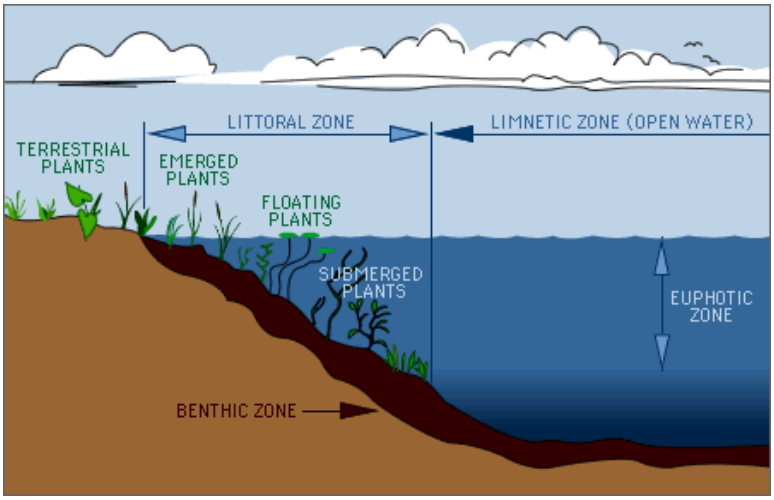


Diagram of lake zones courtesy of Water on the Web, University of Minnesota.

The limnetic zone is open water where light penetrates. Free-floating and microscopic plants (phytoplankton), microscopic animals (zooplankton), and pelagic (open water, away from the shore) animals inhabit this zone.

Light does not penetrate into the profundal zone below the limnetic zone. This zone can be inhabited by animal life, but is dependent on temperature, dissolved oxygen, and other water quality factors. This zone can become anaerobic (depleted of oxygen) at times and may be inhabitable by life forms other than anaerobic microorganisms (e.g. bacteria).

The benthic zone is the bottom and consists of organic and mineral sediments. Much of the benthic zone can be anaerobic, particularly below the profundal zone. However, where oxygen is present, this zone is highly productive and inhabited by invertebrates that consume detritus (decaying material).

Water and Temperature Quality Parameters

Temperature, driven by solar energy, is the primary physical parameter in aquatic environments. Most aquatic organisms are poikilothermic or "cold-blooded" meaning that they assume the temperature of their environment. This means environmental temperature affects their metabolism and controls feeding, reproduction, and behavior. Many microorganisms survive and thrive only over specific temperature ranges and are dormant outside that temperature range. Even fish are often

This cutthroat trout needs cold water to survive. Photo courtesy, Chris Schnepf, University of Idaho, Bugwood.org

classified as cold, cool, or warm water species. Trout for example are cold-water fish and cannot survive at temperatures above 20◦ C or 68◦ F, while many warm-water species cannot survive temperatures below 13◦ C or 55◦ F. Temperature differences are ecologically very important and determine species composition, food chain diversity, and nutrient recycling. Shallow water changes temperature more rapidly than deep water and water surfaces exposed to sunlight warm faster and stay warmer than shaded waters (i.e. streams with tree canopies). In general, water changes temperature slowly (see specific heat section above) enough that it never gets as cold or as warm as the air. As water warms, evaporation tends to release heat and slow the warming effect of solar energy. As water cools, the warmer water sinks and the cooler water rises (at 39 degrees F) and eventually freezes at the surface.

Turbidity

Turbidity is the degree to which water is transparent (its natural color). Suspended sediments, dissolved substances, and micro-organisms decrease water's transparency and thus increase turbidity. Turbidity caused by suspended solids (muddy water) can be an indication of erosion problems within the watershed or a clay layer within the water body's substrate. Lowland streams tend to have turbid water because of the constant influx of sediments after rainfall, especially in disturbed watersheds (logging, fire, grazing), and the redistribution of sediments in the stream itself.

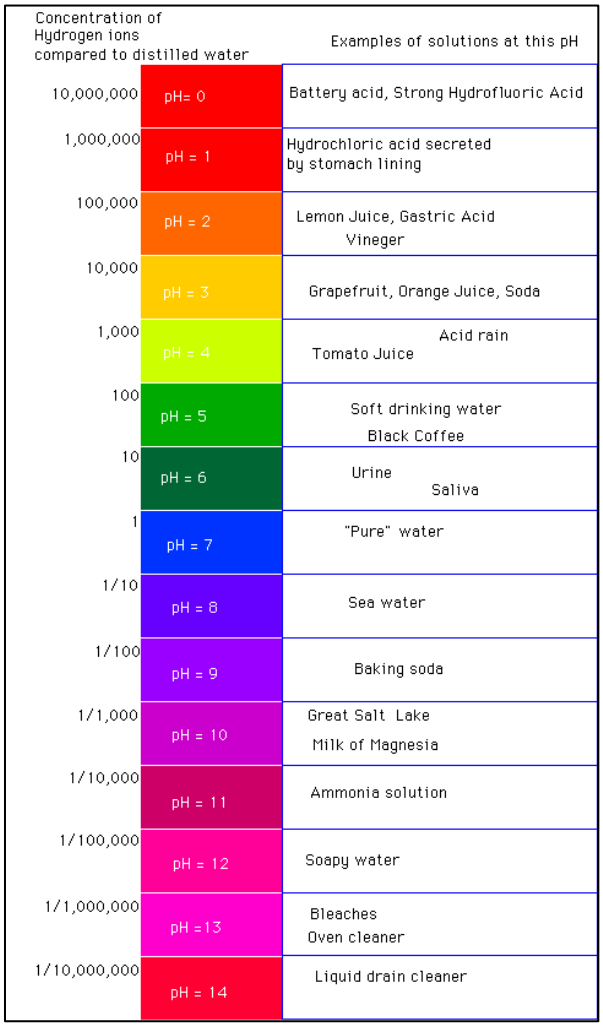
Turbidity can influence temperature of water. Turbid water is darker in color than clear water and thus absorbs more sunlight and heat.

Highland streams tend to be less turbid. Turbidity caused by microorganisms, usually algae, indicates the presence of nutrients. Algal turbidity is an indication of primary productivity, but can also be too dense, indicating high nutrient inflows. Clear water is not necessarily good, as it may indicate low primary productivity or that nutrients are tied up in rooted vegetation and not cycling efficiently through the food chain.

pH

The pH is a scale on which acidity (hydrogen ions) and alkalinity (hydroxide ions) of water is measured. A pH of 7 is neutral (balanced in H and OH ions), above 7 is alkaline (basic) and below 7 is acidic. The pH scale is logarithmic which means that a pH change of 1 point (from a 7 to a 6, for example) is a 10 fold increase or decrease in acidity or alkalinity. Fresh waters generally have pHs between 6-10 (basic). The pH of water is not static and changes or cycles daily. Changes in the pH of a body of water occur during a 24 hour cycle because of respiration and photosynthesis during that period.

Carbon dioxide from respiration (particularly at night) reacts with water to form carbonic acid (releases H+). Carbonic acid drives pH downward, making the water slightly more acidic. During the day, pH tends to move upward (the water becomes more basic and alkaline) because the carbon dioxide is removed from the water by plants for photosynthesis.



The range of pH for most bodies of water is between 6.5 and 9.5. The pH of water is strongly influenced by the pH of the rocks and soils in the watershed and the accumulation of organic matter in the mud. Water bodies in areas with certain mining activities (e.g. coal) can receive acid drainage causing very low pHs. Often, pH influenced by mine drainage can be in the range of pH 4-6. In areas with thin and acidic soils, acid rain can lower pH in water bodies similar to mine drainage.

The pH of a body of water (i.e. a small pond) can be modified by adding lime, gypsum, alum, bicarbonate, and certain other chemicals as discussed later in this chapter. One might do this if trying to maintain a fishery or other management objective, but would only be effective on a small body of water.

Alkalinity and Hardness

Alkalinity is a measure of bases in water. These bases include hydroxides (OH-), carbonates (CO3 -2), and bicarbonates (HCO3-). Alkalinity is related to, but not the same as pH. Alkaline bases act as buffers to absorb hydrogen ions and resist or stabilize pH changes.

Hardness is a measure of divalent (+2) ions, mostly calcium and magnesium. In chemical tests, both alkalinity and hardness are measured in parts per million (ppm) of calcium carbonate equivalence, which leads many people to believe they are the same. If alkalinity and hardness are both derived from limestone soils, then they usually have similar values. It is possible, however, to have water that is high in alkalinity and low in hardness and vice versa.

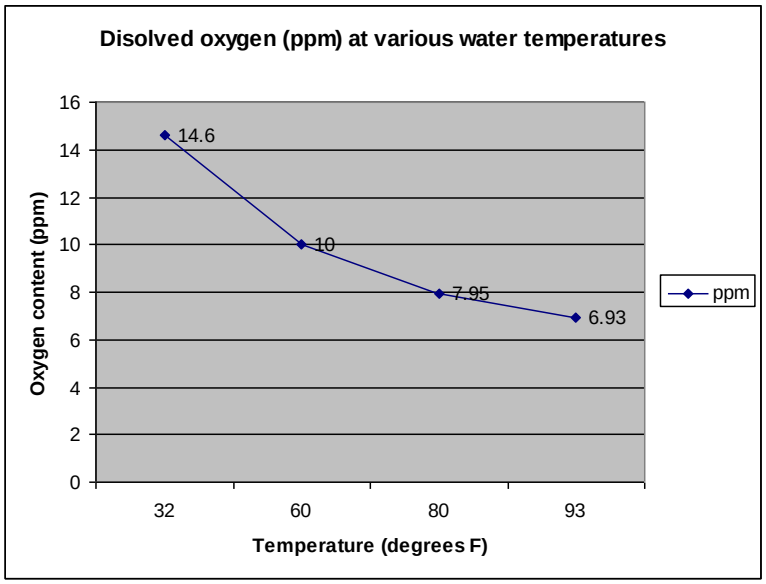
Dissolved Oxygen

Dissolved Oxygen is probably the single most important water quality factor. Low dissolved oxygen is by far the most common cause of fish kills. Water obtains oxygen from two sources: the air and photosynthesis. Atmospheric oxygen diffuses into water from the air. Diffusion is a slow process but can be aided by the action of wind or some type of agitation that mixes air and water together (e.g. waterfalls, riffles, and aerators).

Oxygen dissolves in water at very low concentrations. Our atmosphere is 20% oxygen or 200,000 ppm. However, seldom will a body of water have more than 10 ppm dissolved oxygen. Oxygen simply does not dissolve well in water. Dissolved oxygen concentrations below 3 ppm stress most warm water species of fish (5 ppm for cold-water species) and concentrations below 2 ppm for prolonged periods will kill many species and large fish. Also many fish that have been stressed by low dissolved oxygen concentrations will become susceptible to diseases.

The primary source of oxygen for lentic (still water) water bodies is from microscopic algae or phytoplankton. Submerged plants also produce oxygen but not in the quantities phytoplankton produce. In the presence of sunlight, algae and submerged plants produce oxygen through photosynthesis and release this oxygen into the water. At night and on very cloudy days, algae remove oxygen from the water for respiration. In lotic or stream environments, oxygen concentrations are more stable because the moving water is constantly dissolving oxygen from the atmosphere.

At night, no oxygen is produced and the respiration of the algae, higher plants, fish, and decomposers (bacteria and other microorganisms) remove oxygen from the water. Thus, dissolved oxygen cycles up and down daily, with photosynthesis and respiration. Under normal conditions, more oxygen is produced by photosynthesis than is removed by respiration.



There is a negative relationship between water temperature and dissolved oxygen. As water temperature decreases, the amount of dissolved oxygen increases. Cold water holds more oxygen.

Cold water holds, or will dissolve more oxygen than warm water. Therefore, as temperature increases, less oxygen will

dissolve. The amount of oxygen that water will dissolve at different temperatures (saturation) and sea level atmospheric pressure varies as is illustrated on the chart on page 10.

Water bodies can supersaturate with oxygen on sunny days when algal populations are dense (heavy bloom). Very high concentrations of oxygen (twice saturation) during the day indicate that oxygen depletion might occur that night.

Critically low dissolved oxygen concentrations can usually be predicted. Low dissolved oxygen levels occur because of one of the following:

- Too many pounds of fish present.
- Extremely high oxygen demands, due to high nighttime respiration caused by dense algal blooms or dense stands of submerged vegetation plus fish waste decomposition.
- Excessive decomposition from algae bloom or aquatic macrophyte die-offs.
- Turn-overs related to weather changes such as rain, wind, and cold air (lotic systems only).
- Reduced oxygen production from photosynthesis due to reduced sunlight from cloud cover, fog or haze.
- Lack of agitation from wind/waves.

Most low-oxygen problems occur during the summer when temperatures are warm, algae blooms or submerged macrophytes are dense and aquatic organisms metabolic rates are high. All of these conditions can cause more oxygen to be removed from the water body at night than is produced during the day. Also, still and overcast days may reduce the amount of dissolved oxygen absorbed by wave action or produced by photosynthesis. This condition may promote oxygen depletion.

Snow accumulation on iced over lakes can prevent the sunlight from reaching aquatic plants. This condition can also cause oxygen depletion and fish kills. This has happened at Henrys Lake in eastern Idaho.

Fish kills from oxygen depletion can range from “partial” to “total.” In a partial kill, the dissolved oxygen concentration gets low enough to suffocate sensitive species and larger fish, but many small fish and hardy species survive. Most oxygen depletions cause partial fish kills. Total fish kills are relatively rare.

Nitrogen Wastes

All animals produce nitrogenous wastes from the digestion and metabolism of proteins in their diet. Ammonia is the principal nitrogen waste product of aquatic animals. It is excreted directly

into the water from the gills and kidneys of fish or other aquatic organisms. Ammonia is toxic at high concentrations to most aquatic organisms.

Ammonia is also produced from bacterial decomposition of the proteins from dead animal or plant matter, including algae. Algae, macrophytes, or bacteria quickly absorb ammonia, once it is released into water. Algae and certain bacteria use ammonia as a nutrient for growth and reproduction. Certain aerobic (oxygen-requiring) bacteria use ammonia as a food source in a process called "nitrification."

Nitrification is an important process by which toxic nitrogenous wastes are decomposed. In the process of nitrification, bacteria of the genus Nitrosomonas convert (oxidize) ammonia to nitrite, and bacteria of the genus Nitrobacter convert nitrite to nitrate. Ammonia and nitrite are both toxic to some species of fish; nitrate is not. Ammonia in water dissolves into two compounds: ionized (NH_4^+) ammonia and un-ionized (NH_3) ammonia. Un-ionized ammonia is extremely toxic to fish and most other aquatic organisms, while ionized ammonia is relatively nontoxic. Un-ionized ammonia levels as low as 0.4 ppm can cause death of small fish. Reduced growth and tissue damage can occur at levels as little as 0.06 ppm.

$$\underset{\text{Ammonia}}{NH_4^+} \xrightarrow[\text{bacteria oxidize}]{\textit{Nitrosomanas}} \underset{\text{Nitrite}}{NO_2} \xrightarrow[\text{bacteria}]{\textit{Nitrobar}} \underset{\text{Nitrate}}{NO_3^-}$$

The ratio of the total ammonia nitrogen (TAN) in the un-ionized form depends on temperature and pH. The amount of toxic un-ionized ammonia increases as temperature and pH increases. Under good water quality conditions, ammonia is seldom a problem. Ammonia can become a serious problem if:

- Overfeeding or over fertilizing is common.
- A sudden algal/phytoplankton or macrophyte die off occurs.
- Excessive amounts of manure from livestock wash in to the water body.
- A high afternoon pH drives the un-ionized ammonia concentration to a toxic level.

High ammonia levels can occur at any time of the year, but they are most likely during the summer because of higher metabolic rates. Managing high ammonia levels is difficult to impossible.

Nitrite is also toxic to some species of fish and other aquatic organisms. Under normal conditions, nitrite does not accumulate to toxic levels because it is rapidly absorbed by algae

bacteria, or macrophytes. Nitrite can reach toxic levels if bacterial decomposition (nitrification) is disrupted in small impoundments, especially those with high feeding or manure inputs. Most nitrite problems occur during fall and winter, when sudden changes in water temperatures disrupt normal bacterial decomposition.

Temperature, dissolved oxygen, and chloride ions affect nitrite toxicity. A nitrite concentration as low as 0.5 ppm can cause stress in some species of fish. Nitrite toxicity is reduced in waters with chloride ions in the range of > 30 ppm.

Phosphorous

Phosphorous is an essential element for plant growth. The amount of phosphorous often regulates primary productivity in a body of water. Some phosphorous enters bodies of water in run-off from the watershed and in groundwater from the dissolution of phosphorous in rocks. Phosphorous can exist in several chemical forms, but the soluble orthophosphate is most available to aquatic plants. Concentrations of total phosphorous are usually very low in water bodies and seldom exceed 0.1 ppm. The fate of most phosphorous is to end up in the mud. Phosphorous precipitates or is absorbed by aerobic muds. The rate of this absorption depends on acidity and/or calcium carbonate content. As pH and calcium carbonate concentrations go up, so does the rate of absorption. Some phosphorous re-dissolves into the water but usually is insufficient to maintain algal blooms. Rooted aquatic macrophytes can absorb phosphorous directly from the water or from the mud.

Research has shown that primary productivity can be increased through the addition of phosphate fertilizers. Many private impoundment managers use high phosphorous fertilizers to increase primary productivity and thus fish biomass.

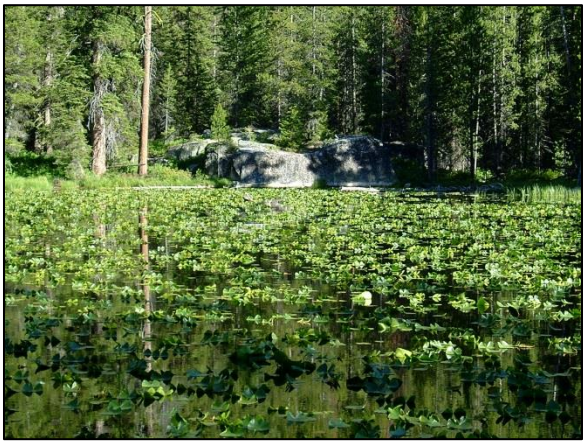
Ecology: How do Aquatic Ecosystems Work?

Aquatic ecosystems work like all other ecosystems-solar energy serves as the ultimate source of energy which is captured and moved through various life forms.

Lentic systems are often classified based on nutrient inputs and cycling. The process of change from nutrient poor to nutrient rich is called eutrophication." Nutrient poor lakes are classified as "oligotrophic." Typically these lakes have low input of nutrients from their watersheds (particularly phosphorous), inorganic sediments, a small surface to volume ratio (i.e. deep), and low productivity. Oligotrophic lakes are generally clear, blue-water lakes with low dissolved oxygen demands, low rates of decomposition, and low total biomass or numbers of organisms. Typically oligotrophic lakes are found in areas dominated by igneous rocks.

As nutrients increase, particularly phosphorous, lakes are classified as mesotrophic. Mesotrophic lakes tend to have moderate inputs of nutrients from their watersheds, some organic buildup in the sediments, and moderate productivity.

As nutrients increase further, lakes become eutrophic. Eutrophic lakes tend to be shallow, have high nutrients, high organic sediments, and green-water lakes. Eutrophic lakes have high dissolved oxygen demands, high rates of decomposition, and high total biomass of aquatic organisms.



An example of a eutrophic lake.
This lake is shallow, with abundant plant life.
Photo courtesy, Mark Moultan,
Sawtooth National Recreation Area

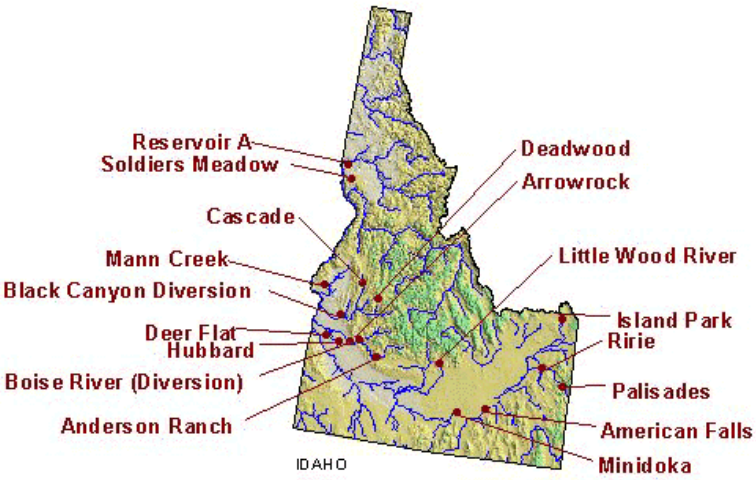
Typically, all lentic systems undergo eutrophication as part of natural succession. Eventually, all reservoirs and ponds fill with sediment becoming wetlands and eventually dry land. The natural process of eutrophication can be accelerated by human activities like mining, farming, urban development, etc.

The moving water of lotic systems strongly influences the characteristic of its ecology. Lotic systems fluctuate widely and rapidly in volume of stream flow and input of nutrients because of substrate and inflow differences. Flooding and drought strongly influence stream flow rates and nutrient inputs as does cultural uses of the watershed. The slope or grade of a stream influences its erosion and siltation characteristics. Streams with steep slopes have high flow rates, are relatively straight with rapids and waterfalls and tend to erode banks and cut deeper channels. As stream slope moderates flow rates are reduced, heavier sediments dropout or are deposited, and the stream forms bends or meanders. Often, these meanders double back on themselves and then get cut-off from the main stream because of flooding and deposition to form “oxbow” lakes. When the stream/river reaches relatively flat slopes, its velocity is greatly reduced, it spreads out and deposits much of its sediment.

Flood events cause the stream to overflow its banks and deposit sediment in the “flood plain.” Because of their deep and nutrient rich soils, people have extensively utilized flood plains for agriculture and settlement. When a stream flows into a lake or the ocean, the remaining sediment drops out forming a fan-shaped “delta.” Most of Idaho’s reservoirs are constructed on stream or river course and therefore trap large amounts of sediments from the upstream watershed. This sediment not only reduces the volume of the reservoir, but also introduces nutrients, which accelerate eutrophication.

The Minidoka Dam near Rupert, ID creates Lake Walcott by damming the Snake River.
Photo courtesy, Bureau of Reclamation

Streams with their constant input of nutrients from the watershed and transportation downstream of these nutrients along with some organisms, particularly during floods, are highly dynamic systems. Stream temperatures tend to be moderate and dissolved oxygen and carbon dioxide concentrations tend to be relatively stable and high, except in very deep pools during low flow or because of pollution. These conditions increase productivity to the point that most streams are 6-30 times more productive than lentic waters.



In Idaho, there are many reservoirs. Most were dammed for water supply, electrical generation, irrigation, or flood control. Dams dramatically alter a river's ecology and hydrology. Reservoirs trap nutrients and sediments that were previously transported downstream and alter flow patterns. Basically, dams replace a lotic system with one more lentic in nature. Most aquatic organisms adapted to lotic environments cannot tolerate static water conditions and are eliminated or severely reduced in reservoirs. Downstream of reservoirs water flows can fluctuate radically from high flows during peak hydroelectric generation, or high releases during flood events, to little or no flow during off-peak hours or drought conditions. These abnormal flow patterns adversely impact many lotic fish and invertebrate species. For this reason, today most reservoirs are operated to provide a minimum stream flow at all times in an effort to provide critical habitat conditions for lotic organisms.

Aquatic Flora

Aquatic flora includes a wide variety of plants from microscopic algae to large trees. Generally aquatic plants are divided into four groups: 1) algae, 2) floating, 3) submerged, and 4) emergent. Algae are primitive plants that do not flower or produce seeds but reproduce asexually or

through spore production. All other aquatic plants are angiosperms (flowering plants). Floating aquatic plants are only those that completely float (roots and all) and not those with just floating leaves. Submerged plants have flaccid stems and are usually rooted to the bottom. Emergent or shoreline plants have relatively rigid stems. Most submerged and all emergent plants inhabit only littoral zone (area between high and low water) while planktonic algae and true floating plants and some submerged plants such as hydrilla and milfoil can inhabit the limnetic (lighted surface water) zone.

Some aquatic plants have mechanisms that allow them to transport oxygen from the atmosphere throughout the plant and thus survive in anaerobic water or soil conditions. Many aquatic plants have no cuticle like terrestrial plants and thus can easily absorb gasses and nutrients directly from the water. Many rooted aquatic macrophytes are perennials and have rhizomes, tubers, or stolons, which store food reserves and resprout or root to form new plants. Most floating aquatic plants have waxy surfaces to shed water and keep their stomata open. Often floating and emergent aquatic plants transpire large amounts of water into the atmosphere and can contribute to increased water loss from rivers and reservoirs.

Eurasian water milfoil grown in a fish tank to show people what the plants look like underwater.
Photo courtesy, Robert L. Johnson, Cornell University, Bugwood.org

In small reservoirs and lakes, with their relatively shallow depths and usually high nutrient inputs, native aquatic plants can take over large areas reducing access, and impacting fishing and other activities. However, in large public water bodies it is usually non-native aquatic plants that are problematic. These non-native species were introduced into the environment without any of their native diseases, herbivores, or other controlling factors. Without any natural checks-and-balances, these plants can invade and infest large areas, restricting navigation, recreation, irrigation, and other societal uses. Eurasian water milfoil is a noxious aquatic plant spreading rapidly in Idaho waters.

Aquatic Fauna

Aquatic ecosystems also support a large and diverse group of animals (fauna) ranging from microscopic zooplankton, worms, and fish to reptiles, birds, and mammals. Like aquatic flora, aquatic fauna have special mechanisms to survive in aquatic environments, including mechanisms for reproduction, respiration, movement, food gathering, and many other vital functions. In particular, aquatic animals use more energy to move through the water because of its density than land animals use to move through the atmosphere. Therefore, most aquatic animals are streamlined and have surfaces with reduce friction or repel water (e.g. ducks). Also

because of the aquatic environment internal fertilization is unnecessary and most aquatic animals simply release sperm and eggs into the water, where fertilization and incubation occur.

Stream invertebrates often have adaptations for clinging to surface of rocks or vegetation or for burrowing into the sediment. Fish that must swim fast to chase prey or fight strong currents must be more streamlined than fish that inhabit slow-moving or stagnate waters. Mammals and birds inhabit aquatic environments often have webbed feet and specialized organs for capturing prey.

Again, not all aquatic fauna are native. Non-native species problematic in Idaho's waters include brook trout, introduced hatchery rainbow trout, lake trout, walleye, northern pike, and carp. These species often out-compete, replace, or alter the environment of native species.

Aquatic Food Chains and Webs

All food chains, whether aquatic or terrestrial begin with plants. Plants, and a few chemosynthetic bacteria, capture energy for sunlight and manufacture food. A "food chain" is then the transfer of this food energy, starting with plants, through a series of organisms, eating one another. In ecological terms, green plants and chemosynthetic bacteria are called "primary producers." All other life forms are consumers. Consumers are subdivided into groups such as "primary consumers," or "herbivores" meaning they consume only plants directly. "Secondary consumers" or "carnivores" consume animals that consume plants. "Omnivores" consume both plant and animal matter. Parasites consume the tissue of another living creature, usually without killing it. "Detritivores" consume dead or decaying organic matter. Some food webs have a secondary carnivore which consumes other carnivores.

Generally, food chains are no more than four or five sequential steps or links long. The shorter the food chain, or nearer the organism is to the start of it, the greater the amount of energy available. Available energy is converted into biomass or living tissue. Herbivores are closer to the start of the food chain, and therefore, have more available energy and greater biomass as a group than carnivores (the biomass of all the plants is greater than the biomass of all the trout). Animals near the start of the food chain (aquatic examples here) are said to feed "low on the food chain." In general, as one animal consumes another, about 10% of the energy obtained is converted into biomass (tissue) and 90% is lost in metabolism. Food chains are not independent from each other but form an interconnected "food web." Food webs are usually extremely complex involving a multitude of organisms.

In freshwater, all food chains start with algae, chemosynthetic bacteria, or high vascular plants. Algae are by far the most important primary producers in aquatic food chains. Herbivores are generally either free-floating, near microscopic, animals (i.e. zooplankton), insects, crustaceans, mollusks, or worms. Zooplankton, insects and crustaceans are by far the most important primary consumers in aquatic food chains. A few native North American fish are omnivorous but none

are strictly herbivorous. In freshwater, the major food chain is detrital based. Little direct herbivory takes place, the major energy pathway is from detritus. The primary consumers of detritus are bacteria and fungi, protozoans, worms (annelids and nematodes), mollusks, insects, crustaceans, and some species of fish.

How do we mimic Natural processes in Aquatic Systems?

First, it is important to remember that most Idaho's rivers and streams have been modified (dammed) for cultural purposes. Cultural purposes can include water supply (human, animal, and irrigation), navigation, hydroelectric power, flood control, pollution abatement, recreation, or fish and wildlife habitat. Most dams, whether public or private, have more than one purpose and management must reflect the desired uses. Therefore, possibly the most important question is what are we managing for?

Watershed Management

First, it should be obvious from the previous discussions that siltation, water quality, and other critical factors are influenced by the watershed, whether a lentic or lotic system. Therefore, any aquatic management strategy must include watershed management. Critical watershed management strategies could include:

- establishing better vegetation cover,
- reducing nutrient inputs,
- reducing livestock and agricultural impacts, or
- creating a riparian buffer.

Often clay turbidity or muddiness is cause by exposed soils in the watershed. Establishing vegetation in the watershed to cover exposed soils can reduce or eliminate clay turbidity and reduce erosion and siltation. Usually native turf grass or other vegetation establishment is the simplest way to reduce erosion in areas with full sun conditions. The size or width of vegetation needed to stop turbidity depends on conditions of watershed size, slope, and rainfall events.

Vegetation buffers around water can help decrease the amount of erosion and water turbidity. Also vegetation around water will reduce the nutrients entering ponds or streams from the watershed.

Again, larger vegetative buffers are needed for greater slopes and larger runoff areas. In general, the larger buffer, the greater nutrient absorption. Nutrients can also be reduced by not applying fertilizers or manures close to ponds or streams. Fertilizers and manures should not be applied within a minimum of 30 feet of ponds and streams.

Livestock trample vegetation around ponds and streams, leading to de-vegetation and erosion. The erosion caused by livestock tends to produce shallow areas and turbidity. Shallow shorelines can encourage the invasion of unwanted aquatic vegetation. Livestock should be fenced from ponds and streams and provided with water troughs that are away from ponds or sensitive riparian areas. Where water troughs are no possible, livestock should be fenced from all but a small section of the pond or stream. The area selected for livestock access should have a gentle slope and be where runoff is limited. Access should not be on a pond dam. Often adding gravel to the access area will reduce livestock impacts.

Riparian buffers are usually associated with rivers or streams. They are simply zones along the borders of streams. They are simply zones along the borders of streams that are left intact with native vegetation adapted to riparian conditions. Again, these act as filters for nutrients, reduce erosion and siltation, and serve as wildlife habitat and migration corridors. A minimum width for a riparian buffer is 50 feet and wider ones are needed in areas of steep slopes or highly erodible soil. Where riparian buffers have been destroyed, native grasses and shrubs can be established to stop erosion and siltation. Over time native woody and herbaceous riparian species may re-establish within the zone.

Management of Rivers and Streams

Most streams, unless intermittent, are considered public waters and therefore cannot be altered without permission of state or national regulatory agencies. However, riparian areas around streams can be managed to entrain nutrients, reduce erosion, and stabilize banks, and encourage wildlife. As previously discussed, maintaining a riparian buffer of at least 50 feet wide and encouraging native riparian vegetation are good management practices along stream corridors.

There are methods to assess stream quality by analyzing water quality and macro-invertebrates (insects, mollusks, crustaceans, and worms) can be barometers of stream health. Macro-invertebrates like stonefly larvae, mayfly larvae, caddis fly larvae, and certain snail species are indicators of unpolluted streams. Crayfish, dragonfly larvae, black fly larvae, crane fly larvae, and hellgrammites are organisms that tolerate a wide variety of conditions and endure some pollution. Macro-invertebrates like midge larvae and tubiflex worms, generally tolerate polluted conditions. So by collecting classifying, and establishing relative abundance of various species of macro-invertebrates, stream quality can be determined.

Threats to aquatic systems

Human activities are the main threats to aquatic systems. As the human population continues to increase, the increased demand for natural resources (particularly water) will affect aquatic systems. As previously discussed, human impacts include removal and transfer, pollution (point and non-point), erosion, siltation, and introduction of non-native species.

WOW. 2004. Water on the Web

Monitoring Minnesota Lakes on the Internet and Training Water Science Technicians for the Future - A National On-line Curriculum using Advanced Technologies and Real-Time Data. (http://WaterOntheWeb.org). University of Minnesota-Duluth, Duluth, MN 55812.

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Ichthyology & Fisheries Management

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Demonstrate an appreciation for fishes and an interest in ichthyology.
- Discuss the diversity of fishes in Idaho and demonstrate familiarity with the different groups of fishes.
- Identify the relationship among various groups of fishes.
- Recall the general characteristics of the major groups of fishes.
- Discuss basic principles of fish behavior, physiology, and ecology and relate these principles to environmental adaptations.
- Discuss the habitat needs of various groups of fishes.
- Explain key threats to fisheries in Idaho.
- Tell the distribution of native fishes and their value as indicators of environmental and watershed health.
- Summarize the role that fish play in Idaho ecosystems.
- Recognize threatened, endangered, and at risk fish species.

Why Study Fishes?

There are many reasons for studying fishes ranging from the quest for knowledge to the practical. Throughout history, humans have had an insatiable appetite for knowledge about life on Earth. Much of our education is based on understanding the foundations that underlie the functioning of life on our very diverse planet. We humans are fascinated by our natural world. As a group of organisms, fishes represent a large, diverse, and incredibly interesting variety of species. Humans are interested in fishes for a host of reasons. They provide sport, provide food for millions across the globe, and have other commercial uses as animal food and raw materials. Many species are kept as pets in aquaria by hobbyists, while students concentrate on the structure of fishes, their systematic arrangement, and great evolutionary significance. In considering the relationship between humans and fishes, one automatically considers the use of fishes as food, for this is the greatest and most obvious relationship. Organisms that we classify as fishes are more numerous in number of species (over 25,000). They have a greater variety of body shapes and sizes, occupy a greater number of habitats, feed on a greater range of prey with a wider variety of feeding mechanisms, and reproduce in a larger number of modes than the other groups of vertebrates (amphibians, reptiles, birds, and mammals). Bony fishes represent about 40% of

the living vertebrate species. In summary, fishes represent an incredible evolutionary history, diversity, and adaptability.

The first known fish-like vertebrates appeared in the fossil record of the early Cambrian Period, over 500 million years ago. Fishes gave rise to other vertebrate groups, including humans. Thus, the study of fishes can reveal much about other groups of vertebrates. As a group, fishes have evolved and survived through the eons while the Earth was undergoing enormous cataclysmic changes. They have largely maintained their existence during the comparatively short, but significant, realm of humankind. People often mention how many generations their family has lived in an area or owned a business. Compared to the evolutionary and generational histories of fish, we are but a mere blip on the screen. Fish are the ultimate survivors.

Historically, why were fishes studied and why does it remain important?

From the mid eighteenth to the early twentieth century, natural history was a major scientific field that was investigated to further our knowledge beyond the eastern United States. However, some of the major expeditions were led by military or other representatives of the Federal Government and had geopolitical, economic, and expansionist goals. Examples of the government-sponsored expeditions include the Lewis and Clark Expedition to the West Coast (1803-1806), the Long Expedition to the Rocky Mountains (1819-1820, 1823), and the Powell Geographic Expedition (1869). By the late 19th and early 20th century, the government was conducting fisheries surveys both in fresh and marine waters. These surveys were conducted to collect baseline information on fisheries resources. At about the same time, government fishery labs and hatcheries were raising fish to stock streams and lakes across the United States. State fish and wildlife agencies assumed the primary responsibility for conserving and managing fishery resources. This is still one of the primary duties of fish and wildlife agencies to raise fish for stocking, survey fish populations, and protect fish habitat.

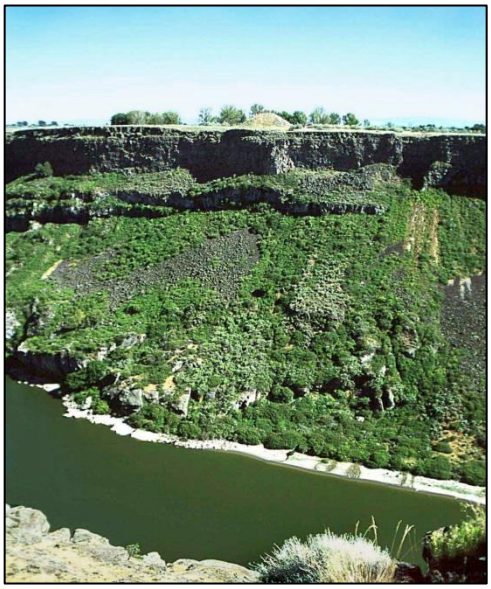
While the importance of fishes to humans is primarily as a food source, their value for recreation is enormously popular, particularly in the United States. In Idaho, trout are the most popular of our game fishes. Many millions of dollars are directed at recreational fisheries statewide. These monies filter through local economies providing revenues and jobs. According to the 2001 Hunting, Fishing and Wildlife-Associated Recreation Report, 416,000 Idahoans and visitors fished in Idaho that year. Cumulatively, they spent over 310 million dollars while fishing in Idaho, buying gas, paying for lodging, eating and buying equipment (USFWS, 2001).

Diversity of Fishes

Fishes as a group and their habitats appear to be of endless variety. They seem to occupy every available niche in the many aquatic environments of the world, ranging from small thermal pools to the deepest abysses of the oceans, in both fresh and salt-water. Fishes occupy freshwater in environments that range from:

- running headwater streams at high elevations characterized by swift current, rocky substrate, high dissolved oxygen, and cold water temperatures, to
- large rivers at lower elevations characterized by sluggish currents, silt-sand substrates, greater water depth, and warmer water temperatures.

Diversity represented by the number of different fish species in these flowing freshwater environments generally ranges from low diversity in small headwater streams to moderate to high diversity in larger river systems.



Petit Lake Creek (far above) is fast moving, shallow, and cold. The Snake River (above) is slower, warmer, and deeper.
Photos courtesy, Idaho Travel Council.

In still water environments, such as ponds and lakes, the diversity of fishes varies greatly depending on the age and productivity of the body of water.

Youthful lakes, in temperate regions, are characterized by low nutrient and organic loads. They have abundant oxygen supplies, colder water temperatures, and thermal stratification. Whitefishes, chars, and trout are the usual inhabitants in such lakes in the northern hemisphere. These lower productivity lakes support a relatively low biomass per unit area of water.

As lakes age and become more productive, the capacity to support a fish fauna changes and they can sustain a large biomass per unit area. However, this increased productivity comes with a tradeoff because the decomposition of the increased organic material requires much oxygen and the deeper waters of an enriched lake can be low or lacking in dissolved oxygen. In northern areas pike, perch, and pike-perches can coexist with or

succeed the salmonids, such as trout. In warmer North American waters, fishes can include black basses, crappie, sunfishes, and rock basses.

Groups of Fishes

Fishes are comprised of four natural groups: the hagfishes, lampreys, cartilaginous fishes, and ray-finned fishes.

- **Hagfishes** are blind, eel-shaped, marine predators and scavengers. There are about 43 species worldwide. They are the most primitive vertebrates characterized by lacking mandibular jaws, paired fins, clearly defined vertebrae, and functional eyes. Hagfishes are marine animals and live largely buried in sediments where they feed on soft-bodied vertebrates and carrion. Obviously, since they are marine animals, we have no species of hagfishes in Idaho.

- **Lampreys** also lack mandibular jaws and paired fins but they have true vertebrae and eyes. There are 41 species of lamprey and one species, the Pacific lamprey, occurs in Idaho. Lampreys are eel-like and secretive. They are mainly seen when they are on their spawning migrations. Larger species are parasitic, feeding upon fishes and marine mammals. Smaller species are usually non-parasitic and feed only in the larval stage. Although all lampreys spawn in freshwater, some of the parasitic forms grow to maturity in marine waters, including the Pacific lamprey.

The Pacific Lamprey is a little known and underappreciated native fish of Idaho. Photo courtesy, IDFG

- **Cartilaginous** fishes have mandibular jaws, true vertebrae. They are distinguished from the ray-finned fishes (see next category) in possessing cartilaginous skeletons, teeth-like scales with an enamel-like covering, and horny, un-segmented fin rays that are unpaired. This group includes chimaeroids, sharks, rays, and skates. They are largely marine creatures. There are about 1,000 living representatives of the cartilaginous fishes worldwide. No species of cartilaginous fishes are found in Idaho.

- **The ray-finned or bony fishes** represent about 40% of the living vertebrate species. They possess mandibular jaws, bony skeletons, thin scales lacking an enamel-like covering, segmented paired fin rays. Ray-finned fishes occur in all habitats where fish exist. All of Idaho's native and introduced fish (except the Pacific Lamprey), are ray-finned fish.

A Rainbow trout.
Photo courtesy, Sara Focht, IDFG

Fishes of Idaho

Historically, before the arrival of European man, Idaho was home to 39 native fish species. Currently, there are 82 species of fish in Idaho. Native fishes include Salmonidae (trout, salmon, char), Cyprinidae (minnows), Catostomidae (suckers), Cottidae (sculpin), Petromyzontidae (lamprey), Acipenseridae (sturgeon), Percopsidae (trout-perch), Clupeidae (shad), and Gadidae (cod). Introduced fishes include Esocidae (pike), Ictaluridae (catfishes), Poeciliidae (livebearers), Centrarchidae (sunfishes), Percidae (perches), Cichlidae (cichlids), Cobitidae (loaches), and several game fishes of the family Salmonidae (e.g. brown trout, brook trout).

The Lewis and Clark Expedition of 1803-1806 recorded the first written accounts of Idaho fishes. Their accounts were not detailed enough for positive identification. According to Simpson and Wallace (1978) in their book *Fishes of Idaho*, naturalists, accompanying various early surveys of what is now Idaho, collected fishes for identification and description. The Pacific Railroad surveys of 1853 to 1855 collected specimens, mainly from the northern one-third of the state. In 1870-1871, fishes were collected from southeastern Idaho by the U.S. Geological Survey. A number of investigations under the direction of the U.S. Fish Commission were conducted throughout the Pacific Northwest in the late 1800s, which added to the general knowledge of Idaho fishes.

Idaho Water

While all of Idaho lies west of the Continental Divide, not all of its waters drain westward to the Pacific Ocean. Part of southeast Idaho drains into Bear Lake, which straddles the Idaho-Utah border, one of the largest interior drainage systems in the United States. In eastern Idaho, many isolated drainages do not flow into the Snake or Bear Rivers. These include the Lost Rivers and Birch, Medicine Lodge, Beaver, and Camas Creeks, collectively known as the Sinks drainages.

The remainder of Idaho's surface drainage flows into the Columbia River. Major river drainages in Idaho include the Kootenai, Pend Oreille, Spokane, and the Palouse in the north, and the Snake River drainage, which comprises the bulk of central and southern Idaho. The Snake River and its tributaries drain areas upstream and downstream of Shoshone Falls, a 212-foot high natural barrier in south-central Idaho. Major tributaries of the Snake River drainage above Shoshone Falls include the Henrys Fork and South Fork while major tributaries below Shoshone Falls include Salmon Falls Creek, and the Wood, Bruneau, Owyhee, Boise, Payette, Weiser, Salmon, and Clearwater rivers.

The major natural lakes of Idaho include Priest and Pend Oreille (Pend Oreille drainage), Coeur d'Alene (Spokane drainage), Payette (Payette drainage), Grays (Snake River above Shoshone Falls), Mud (isolated drainage), and Bear (Bear drainage). A great many reservoirs have been created on Idaho's rivers. Some of the major reservoirs include Dworshak (North Fork Clearwater River); Lower Granite, Hells Canyon, Oxbow, and Brownlee (Snake River), Cascade (North Fork Payette River), Arrowrock, Lucky Peak, Anderson Ranch (Boise River drainage), C.J. Strike (Snake River), Blackfoot (Blackfoot River), Palisades (South Fork Snake River), and Island Park (Henrys Fork Snake River).

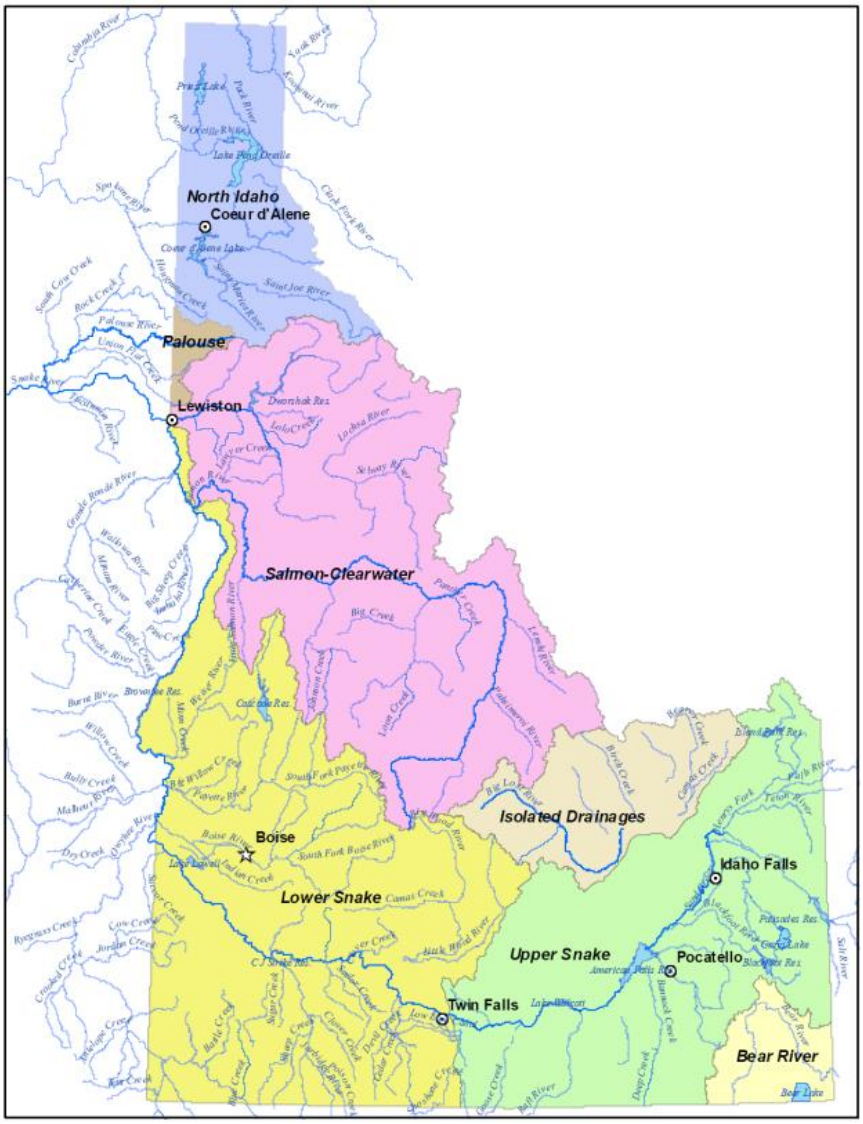
The river systems of Idaho have been profoundly impacted by lava flows and glaciation. Lava flows have changed the course of many streams including the mainstream Snake River. The effects of glaciation formed both temporary and more permanent lakes. Glacial melting caused tremendous floods by breaching temporary dams and resulted in alteration of river courses. These and other impacts have had a significant effect on the current distribution of native Idaho fishes.

In southern Idaho, the development of Shoshone Falls was a major influence on the historical distribution of native fishes and remains a complete barrier to their present dispersal. It is estimated that this falls was created 2-3 million years ago. The result of this barrier to fish distribution was to prevent any species of fish from extending its range upstream above the falls after its formation. Fish species that arrived in Idaho after this time, such as Pacific salmon and trout, were unable to penetrate the Snake River above Shoshone Falls. Any fishes found in the Snake River above the falls likely existed before the falls was created or extended their range to the Snake River drainage from the Great Basin or from east of the Continental Divide.

In southeastern Idaho, during the Pleistocene Era, the immense Lake Bonneville rose and overflowed into the upper Snake River. This great flood scoured out channels and water falls. Lake Bonneville rose and fell several more times and probably spilled out into the upper Snake River, but not with the great force of the first flood. A number of fishes from the Lake Bonneville fauna probably entered the upper Snake River in this way. The Great Salt Lake is a remnant of Lake Bonneville.

In northern Idaho, during the Pleistocene Era, an ice lobe blocked the ancestral Clark Fork River and formed glacial Lake Missoula, a huge lake that occupied much of the Clark Fork Valley all the way to Missoula, Montana. At least once, and possibly three or four times, the ice dam broke and huge floods occurred. These floods swept across eastern Washington toward the southwest and formed such features as Palouse Falls and Spokane Falls. These falls were barriers to post-glacial dispersal of fishes from the lower Columbia River, such as Pacific salmon and steelhead trout. Falls on the Pend Oreille and Kootenai Rivers acted as similar barriers.

For sake of this discussion, Idaho is divided into six areas including 1) North Idaho, 2) Salmon-Clearwater, 3) Snake River above Shoshone Falls, 4) Snake River below Shoshone Falls, 5) Isolated drainages and 6) Bear River (see map below).



Map created by Brent Thomas, IDFG, 2007

North Idaho

Priest River
Photo courtesy, Idaho Travel Council

Major river drainages of North Idaho include the Kootenai, Pend Oreille, and Spokane. The Kootenai River is the most northern river system in Idaho. Native game fish species include westslope cutthroat trout, inland rainbow trout, bull trout, mountain whitefish, white sturgeon, and burbot, while nongame species include lake chub, peamouth, northern pikeminnow, longnose dace, redside shiner, longnose sucker, largescale sucker, slimy sculpin, and torrent sculpin. The white sturgeon and burbot are unique to the Kootenai River system. The Kootenai River is the only drainage in Idaho where burbot are native, while the white sturgeon population is genetically distinct from the Snake River population.

The Pend Oreille River system in Idaho includes the Priest and Pack rivers, and Lightning Creek. Lake Pend Oreille is the largest natural lake in Idaho at nearly 90,000 surface acres reaching almost 1,200 feet deep. Priest and upper Priest Lakes are glacial lakes located just south of the border with Canada. Westslope cutthroat trout, bull trout, pygmy whitefish, and mountain whitefish are the only salmonids native to the Pend Oreille drainage of Idaho. Also present are native cyprinids, cottids, and catostomids.

Major tributaries of the Spokane drainage are the St. Joe, St. Maries, and Coeur d'Alene rivers, which all drain into 31,487-acre Coeur d'Alene Lake. Native game species include westslope cutthroat trout, bull trout, and mountain whitefish. Cyprinids, cottids, and catostomids are also present.

Salmon-Clearwater

The Salmon River drainage and its major tributary the Snake River encompass much of central Idaho, a vast region of forests, mountains, rivers, and wilderness. These large drainages provide much of the remaining habitat for Idaho's anadromous salmon and steelhead trout, and remnant populations of Pacific lamprey. Native fish species include spring/summer runs of Chinook salmon, steelhead trout, Pacific lamprey, westslope cutthroat trout, bull trout, mountain whitefish, inland redband trout, cyprinids, cottids, and catostomids. White sturgeon are found in the lower reaches of the Salmon River.

Snake River above Shoshone Falls

The Snake River, above Shoshone Falls, is the historical range for Yellowstone cutthroat trout, one of three subspecies of cutthroat trout in Idaho. Yellowstone cutthroat trout inhabit all of the

major tributaries to the Snake River above Shoshone Falls. Mountain whitefish are the other common salmonid species native to this part of the Snake River drainage. Other native species include cyprinids, cottids, and catostomids.

Snake River below Shoshone Falls

Shoshone Falls, near Twin Falls, Idaho
Photo courtesy, Idaho Travel Council

The Snake River, below Shoshone Falls, encompasses a huge area of southern Idaho. Once it reaches the Idaho-Oregon border, it makes an abrupt turn to the north as it forms the state boundary to the Lewiston, Idaho area. Shoshone Falls is the upstream terminus for the historical range of white sturgeon, spring/summer and fall runs of Chinook salmon, steelhead trout, and inland redband trout. White sturgeon are the largest freshwater fish in North America reaching lengths over 10 feet. Fall Chinook salmon spawn in the mainstream Snake River while spring/summer runs spawn in tributaries along with steelhead trout. Steelhead trout are the anadromous form of inland redband trout. Other native species include cyprinids, cottids, and catostomids.

Isolated Drainages

The Big Lost River Range, near Arco, Idaho
Photo courtesy, Idaho Digital Atlas

Isolated drainages that no longer have a connection to the Snake River in eastern Idaho include the Big and Little Lost river drainages, and Birch, Medicine Lodge, Beaver, and Camas Creeks. The streams of these basins originate from four major mountain ranges in eastern Idaho and flow generally east and south, eventually sinking into the fractured basalts of the Snake River Plain. These drainages are collectively known as the Sinks. The origin of aquatic fauna in the Sinks drainages remains unclear. Genetic data suggest that mountain whitefish in the Big Lost River originated from the upper Snake River drainage. Yellowstone cutthroat trout are native and present in Medicine Lodge, Beaver, and Camas creeks and most likely entered the drainage from the Henrys Fork Snake River drainage via Dry Creek. The distribution pattern of shorthead sculpin (Cottidae) within and around the Sinks drainages suggest that the shorthead sculpin within the Sinks drainages originated from the

Salmon River Basin. The presence of shorthead sculpin in all of the Sinks drainages suggests this species had entered the Sinks drainages prior to or during the most recent existence of Lake Terreton, about 10,000 years ago. Piute sculpin (Cottidae) appear to be native to the Big Lost River but it is unclear how or when this species entered the basin. Mottled sculpin (Cottidae) in the Sinks drainages likely originated from the Henrys Fork Snake River drainage within the same period and through the same mechanism as Yellowstone cutthroat trout. Whether or not bull trout and rainbow trout are native to any of the Sinks drainages remains unclear. However, if they are native, they likely entered the basin from the Salmon River basin via headwater connection.

Bear River

Bonneville cutthroat trout are native to the Bonneville Basin in Idaho, Nevada, Utah, and Wyoming. In Idaho, this trout is only found in the Bear River drainage. The Bonneville Basin covers approximately 51,216 square miles and once contained Lake Bonneville, a huge pluvial lake that covered over 20,000 square miles, comparable to the size of current Lake Michigan. During the Pleistocene Era, about 25,000 to 35,000 years ago, the Bear River was a tributary to the Snake River. Lava flows diverted the upper Bear River south into the Bonneville Basin. When the Bear River was a tributary to the Snake River, trout from that system (Yellowstone cutthroat trout) gained access to the Bonneville Basin and colonized it. There is a strong taxonomic similarity between Yellowstone and Bonneville cutthroat trout. When climatic change dried Lake Bonneville, about 8,000 years ago, many tributaries became isolated and their fish faunas began to evolve independently. Given the relatively short time of geological separation, the demonstrated close affinity of present day Bonneville cutthroat trout in the Bear River with Yellowstone cutthroat trout of the Snake River is not surprising.

In the Bear River, within Idaho, other native fish species that evolved with Bonneville cutthroat trout include mountain sucker, leatherside chub, Utah chub, redside shiner, longnose dace, speckled dace, mottled sculpin, Piute sculpin, and mountain whitefish. In Bear Lake, which straddles the border of Idaho and Utah, Bonneville cutthroat trout evolved with endemic Bear Lake whitefish, Bonneville whitefish, Bonneville cisco, and Bear lake sculpin.

Shapes of Fishes

Fishes come in a huge variety of shapes and sizes. The body form of a fish can be used to surmise their way of life. In other words, like many things in nature, *form follows function*. Fishes must expend a lot of energy in the aquatic environment overcoming the forces of water against their bodies. A common body form of fast-swimming, open water fishes like tunas is called *fusiform*. This body form is characterized by an ultra-streamlined configuration with an elliptical cross section. This shape minimizes the impedance of water to locomotion. Although

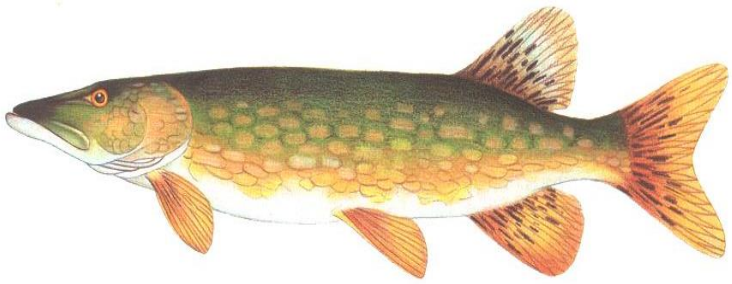
more laterally compressed than tunas, trout are similar in body shape. These shapes are inherent in fishes that are active, fast-swimmers.

Rainbow Trout has a common fusiform shape.
Illustration by Joseph Tomelleri

Fishes suspended in water, but swim slowly, are less constrained by the forces of water and assume a greater variety of shapes. Eel-shaped fishes are called *anguilliform.* Many fishes, that are not constantly moving, but which are capable of short bursts of speed, and markedly compressed laterally, are called *compressiform.* This includes sunfishes, snappers, and flounders. Fishes that are flattened dorsoventrally (like a pancake) are termed *depressiform* and include fishes such as skates, angel sharks, and toad fish. This shape suits fish for life on the bottom, but the greatly flattened mantas and eagle rays have adapted to a flight-like swimming above the bottom.

Idaho's Bluegill is an example of a fish with a compressiform shape.
Illustration by Joseph Tomelleri

Other terms used in connection with body shape are *filiform* for thread-shaped fishes such as snipe eels; *taeniform* for the ribbon-like shape of gunnels, pricklebacks, and cutlassfishes; *sagittiform* for the arrow-like shape of pikes and gars; and *globiform* for fish such as the lumpsuckers. Not all fishes have body forms described by these terms, but many are.



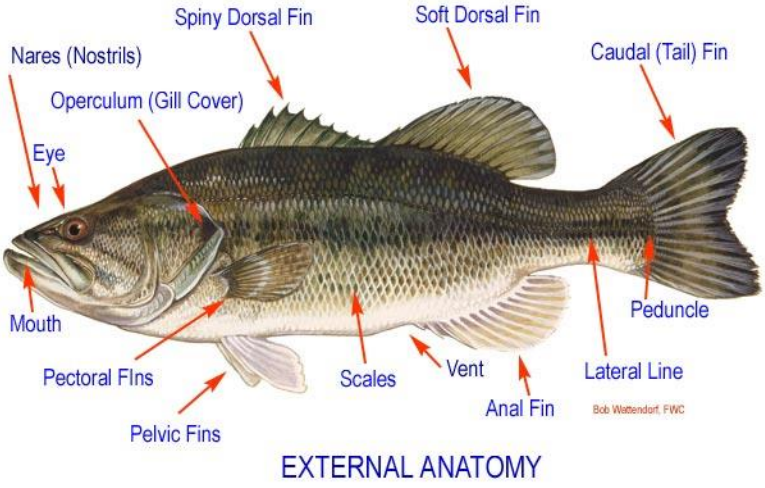
Saggiform describes the arrow-like shape of the Pike.
Illustration by Joseph Tomelleri

In summary, the shape of fishes is related to a number of factors in their particular habitat and the ultimate shape is a compromise among a host of issues concerned with movement, feeding, and staying alive. With a basic idea of the environmental constraints of different habitats, it is possible to examine the shape of a fish and to predict where it lives.

The shape is also determined by the genetic potential of the fish species. If the fish species does not have the genetic blueprint for a particular shape, the shape will not happen. For instance, ray-finned fishes, for the most part, are not depressed or flattened but apparently, there is a need for a flattened shape in benthic or bottom habitats. To compensate, one group of fishes have become compressed and then lie on their side to approximate a depressed shape. These fishes are the flatfishes, which include flounders, halibut, and sole. They start out their lives very much compressed but during development, one of their eyes migrates to the other side of the head and they assume a benthic existence by laying on either their right or left side. These fishes are truly unique among the vertebrates in being asymmetrical in shape. We can learn much by examining the shape of fishes and predicting their habitats, and realizing that evolution does not always follow the simplest path. The path followed is related to the genetic potential of the particular fish group.

Anatomy of a Fish

Some of the key parts of a fish body include the operculum, which covers the gill openings. The narrow "handle" of the fish just forward of the tail is the caudal peduncle. The conspicuous line along each side of a typical fish is called the lateral line, which is a continuation of the network of sensory canals on the head. The fins are conspicuous features on the fish body. These are supported by the skeleton and composed of two groups, unpaired and paired. The unpaired fins are the dorsal along the back, the caudal or tail fin and the anal fin. The paired fins are the pectorals pelvics (ventrals). Fins are stiffened by structures called rays, which can be soft and flexible or modified into spines. Caudal fins in particular, come in a variety of shapes and sizes, and often reflect evolutionary levels and relationships more than the other fins.



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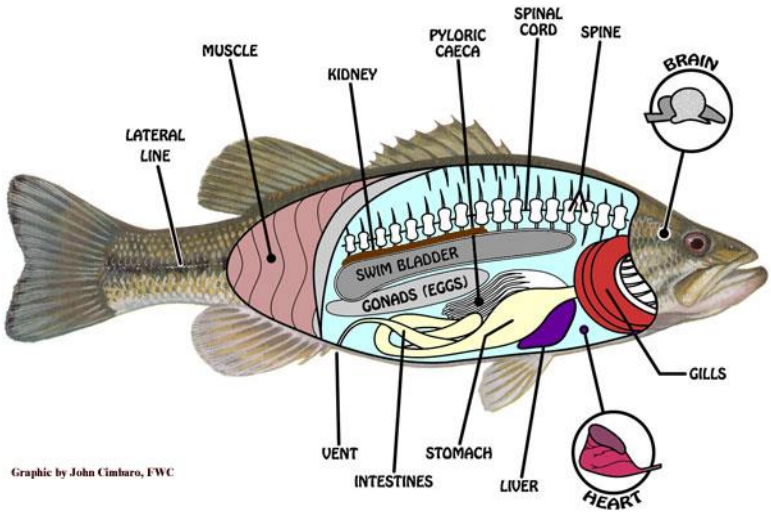
Why do different fishes live in different places?

Fishes are, for the most part, restricted to aquatic environments. Very few regions of the world lack fishes. Some fishes can live, for extended periods, out of the water. In freshwater, fishes are found in low oxygen swamps, ephemeral water bodies, torrential streams, and vernal pools. Some fishes occur in highly saline waters and others live in acidic environments. Fishes that live in anaerobic waters obtain their oxygen by means of lungs or other highly vascularized tissue that is brought into contact with the air. Fishes that live in temporary ponds resemble insects in that they grow and reproduce during the rainy periods but assume an inanimate state during dry periods. As the water dries up, their fertilized eggs drift to the bottom and go into an arrested development until the rains return. As the water rises, they undergo rapid development, and mature and spawn before the next drought. Fishes that live in torrential mountain streams like in the Andes of South America or Himalayas in Asia have flattened bodies, sucker-like mouths, and sucker-like fins or entire bodies that enable them to resist the water currents and to feed on the algae growing on the stream bottom. Fishes living in acidic waters have special hemoglobin that enables them to capture oxygen from the water. Idaho does not possess these sorts of challenging environments for fish to live in, but there is considerable variation in aquatic environments across Idaho that correlated with precipitation and stream flow, and the distribution of fish species reflects these factors.



In marine waters, fishes live from exposed tidal flats to depths of 8,000 meters, and from the tropics to polar latitudes with temperatures below -2 C. Fishes that spend much time above the water on the mud flats (mudskippers) obtain oxygen by means of vascularized organs, have thick integument that resists desiccation, and eyes that are adapted for sight on land. They gather their food on land and go into the water only to avoid desiccation or terrestrial predators. Fishes that live at great depths live in almost complete darkness, under extreme pressure, and in a very food poor environment. They have very reduced eyes, lack swim bladders, and have poorly calcified skeletons. Eyes are metabolically expensive and are greatly reduced or totally lost in environments in which they are not needed. On the other hand, these fishes have very acute senses of smell and touch. Because of the great pressure, fishes are unable to keep gas in their swim bladders, and there is little available calcium for skeletal structures. Fishes that live in super cooled arctic waters have an antifreeze system in

their blood that prevents them from freezing. The antifreeze is a protein that lowers the freezing point of the tissue below that of the water in which these fishes live.

How have fishes adapted to their environment?

The other groups of vertebrates display a wide array of feeding modes, but none rivals the fishes. Fishes range from omnivores (eating a variety of things), carnivores (eating meat), herbivores (eating plants), to parasites (feeding on another living organism), and the variety of feeding modes within each category is astounding. There are straightforward carnivores that hunt down their prey. Others lie and wait predators that lurk in the shadows or weed beds or lie buried in the sand and ambush unsuspecting prey. Many of the ambush predators are aided with great suctorial mouths to engulf prey or electric organs to stun their prey. Another group of fishes has a dorsal fin spine modified into a fishing lure to entice their prey within range. The relative size of prey varies tremendously. Some of the largest fishes such as the manta rays, basking sharks, and whale sharks feed on minute zooplankton that is filtered out of the sea. Deep-sea viperfishes are able to articulate their jaws, have greatly distensible stomachs, and engulf fishes larger than themselves. Many pelagic sharks and piranhas have cutting teeth and are able to take bites out of their prey. Pipefishes and seahorses have syringe-like mouths and suck individual zooplankton out of the water column. The archerfish dislodges terrestrial insects, from plants above the surface, by spitting water at them.

A large number of fishes are herbivorous (eating only plants). Most consume algae because much of it is rather easy to break up and digest compared to vascular plants. Few, if any, fishes are able to digest cellulose or have resident bacteria in their guts that can break down cellulose. Most herbivores simply graze and browse algae off substrates.

Parasitic fishes have a wide variety of ways to obtain nutrients from their host. A majority of lampreys attach themselves to other fishes by means of their suctorial discs. They rasp holes in the sides of their host, and live on the body fluids. The other jawless fishes, hagfishes, use their rasping jaws to burrow into dead and dying fishes and consume their hosts from the inside. A deep-sea eel feeds in a similar manner but, unlike the hagfish, has mandibular jaws. There are several fishes in tropical freshwaters that live on scales removed from their hosts. Some of the cichlid fishes from the great lakes of Africa make their living by parasitizing the scales, flesh, or young of mouth brooding fishes. In some cases, the parasite fishes closely resemble their host fishes thus enabling them to approach within striking distance. Aggressive mimicry is also practiced by a blenny that resembles the cleaning wrasses that set up feeding stations on coral reefs. The blenny, however, removed pieces of flesh and scales rather than parasites from its host.

Reproduction

Fishes have evolved many ways of reproducing. The vast majority of fishes are single sexed, males or females, and broadcast their sperm or buoyant eggs into the water. The sperm fertilizes the eggs and the fertilized eggs float off and are on their own. The adult fish end their parental involvement after spawning. This type of reproduction results in high mortality of eggs. Thus, fish species, like yellow perch, that practice broadcast spawning without nest construction, produce many eggs in hopes of some surviving to adulthood. Other species invest less energy in producing gametes (eggs and sperm) and more energy into ensuring that their fertilized eggs have a reasonable chance of survival. A number of fishes produce large sticky eggs that are fertilized and deposited in places relatively free of predators. Eggs are deposited on aquatic plants, shells, or buried in the bottom.

Idaho's native trout spawn in the spring during high water runoff conditions from mountain snowmelt. Spawning takes place in high velocity areas such as riffles in gravel substrate. Female trout dig a nest or redd in the stream bottom, lay their eggs. An attending male or males fertilize them. Then, the female covers the eggs back up with gravel where they receive a steady supply of oxygen and hatch out in the early summer. Cutthroat trout and bull trout oftentimes migrate upstream (rarely downstream) from large rivers and lakes to spawning locations in small tributaries, a journey often exceeding 20 miles or more.

White sturgeon live in large river systems and spawn in the spring during periods of runoff. Interestingly, only a small percentage of mature adults reach reproductive readiness in any given year. Females deposit their small, sticky eggs in broadcast fashion in swift currents where they eventually stick to suitable substrate for development. A large female can produce millions of eggs.

One of the more remarkable feats of reproduction is that undertaken by *anadromous* salmon and steelhead in the Pacific Northwest of the United States. Anadromous refers to a lifestyle where a fish spends most of its life in the ocean and migrates to freshwater to reproduce. Idaho's salmon and steelhead migrate downriver to the ocean as young fish from their natal rivers and streams. They spend anywhere from one to three years in the ocean environment growing to adult size. Then, remarkably, they undertake a grueling upriver migration to the same streams and locations where they were born to reproduce in one of nature's premier exhibits of "survival of the fittest." In Idaho, these migrations can approach 900 miles. Fittingly, Pacific salmon die after spawning as every ounce of their reserves is drained from their bodies following this exhausting and harrowing journey. Their carcasses decay and provide nutrients that contribute to the food chain of river ecosystems or other creatures that eat them. This is nature's way of recycling valuable resources.

Catadromous refers to a lifestyle where a fish spends most of its life in fresh water and migrates to the ocean to breed. The American eel is one such fish that demonstrates a catadromous lifestyle. American eels ascend streams from the Atlantic Ocean as elvers, the males remaining mostly in the lower sections and females traveling great distances upstream. Fresh water life lasts from four to seven years for the females and a shorter period for the males. After they descend the streams and enter the ocean, they virtually disappear.

How do fishes function in ecosystems?

Although fishes are generally considered to be near the top of the food chain, they occupy a number of trophic (food chain) levels from herbivores (bottom of the food chain) to top carnivores (top of the food chain) and tend to dominate a number of aquatic environments. In most habitats, fishes are more diverse in number of species than all other multi-cellular animals. Fishes also have a definitive effect on the other multi-cellular organisms through predation. In the oceans, large rivers and lakes, a number of fishes (planktivores) consume zooplankton by filtering them out of the water column. Larger fishes, mammals, or birds in turn, consume these fishes. Thus, fishes play a critical role to the well-being of the upper end of the food chain.

A number of freshwater and brackish water fishes consume larvae of terrestrial insects such as mosquitoes. Mosquitoes are vectors for disease. Thus, the fishes that consume mosquitoes are often important in the control of diseases.

Anadromous fishes are very instrumental in the transfer of nutrients as mentioned earlier. Their progeny and all other organisms benefit from their ultimate sacrifice. The migrating salmon also serve as an important food source for bears and humans.

The role of fishes in a particular habitat can be very subtle but crucial. A diverse group of herbivorous fishes occupies coral reefs. These herbivores keep algae closely cropped. The algae need the light to photosynthesize. A dense covering of algae will inhibit this process and result in the death of the coral polyp. If the reef-building coral dies, the reefs will erode away, and the entire ecosystem will be lost. Thus, the herbivores enable the reef building coral to stay ahead of the algae.

Fishes can also have direct impacts on humans. They are major food items of humans, serve as important recreational activities, and are objects of a very large pet industry. The worldwide harvest of fishes is 100 million metric tons. This total is thought to be at or slightly above the maximum sustainable level. In other words, the world catch of fishes cannot be further expanded without negatively effecting the populations of the exploited species.

What are some conservation concerns for fishes?

Fishes and Humans

Like other groups of organisms, fishes have been negatively impacted by humans and will be increasingly impacted as human populations expand and compete for resources. The history of fishes is a long story of exploitation. Through improvements in technology, humans have greatly increased the efficiency of harvesting fishes, and greater efficiency leads to exploitation. In many cases, fish species that were abundant prior to exploitation have not returned to their former abundance decades after the collapse of the fishery. Several species, such as some of the whitefishes of the Great Lakes in the Midwestern United States, have gone extinct due largely to overfishing. Management of fisheries is a difficult proposition. The initial population size and structure of exploited stocks is often not known and management measures are not generally put into place until the resource is in decline.

Dams have had a major impact on fish. Across the western United States, most, if not all, native game fish species and their habitats adversely affected by dam construction and operations. Dams on the Columbia and Snake River drainages, impact migrating adult and juvenile salmon and steelhead. Before the arrival of European man to the United States, millions of anadromous fish would enter the Columbia River on their migration to spawning areas upriver. In the modern era, dams have fragmented the migration corridors of Idaho-bound salmon and steelhead making an already long and arduous journey much more difficult. All of Idaho's native anadromous fish species are federally listed under the Endangered Species Act. Similarly, Atlantic salmon, on the eastern seaboard of the United States, have been impacted. The huge white sturgeon of the Snake River has met a similar fate. These goliaths of North American fishes would historically swim freely throughout the Columbia and Snake rivers. With all the dams now in place, these fish are restricted to segments of their former range without the ability to interact with their own kind in other reaches. Dams on the Colorado River in Colorado, Utah, Nevada, and Colorado are responsible for the decline of many unique native fishes such as Colorado River pikeminnow, humpback chub, and razorback sucker.

In addition to blocking fish migration, dams have a major impact on fish habitat. Dams convert rivers to slack water environments. Many riverine fish species do not thrive in such conditions. The water temperature profile of a reservoir is drastically different that a riverine environment. The water temperature in a river is generally the same from the top to the bottom (vertically uniform). This is very different from a reservoir where the temperature of water varies with depth as does dissolved oxygen content. Dams severely restrict the flow of sediments such as gravels that create habitat for aquatic invertebrates that fish feed on and spawning and rearing habitat for fishes. Reservoirs also tend to become nutrient rich, which can lead to algal blooms, and oxygen deficits, the result of which can be major fish kills. The operations of dams for irrigation, flood control, or hydropower also can have significant impacts on fish and fish habitat.

Irrigation reservoirs capture river flows for storage and release them to meet irrigation demand. This results in abnormally low fall and winter flows below dams, shifts in the timing of the hydrograph, and altered thermal regimes. Flood control operations depend on snowpack in the mountains. During years of heavy snowpack, reservoir operators draft large volumes of water to make space in reservoirs to capture snowmelt. These flood release flows can occur earlier than historic peaks and are discordant with natural flow patterns. Hydropower operations can vary but generally are run-of-river where inflow typically matches outflow where reservoir levels do not fluctuate greatly, or they can be power peaking operations. Power peaking is done to meet power demands at high use seasons such as winter and summer. Flows releases are decreased at the dam while water is stored in reservoirs to create maximum head, and then released to generate power through turbines in the dam. During off-times, flows are increased and reservoirs are drained to predetermined levels. These artificial flow fluctuations can alter a river ecosystem. All of these changes can have drastic impacts on fish.

In Idaho, a number of factors have affected fish, other than dams and water management. These include timber harvest, agricultural practices including livestock grazing, mining, overharvest, and non-native fish species. A rising factor in the decline of native species is due to past fishery management practices of introducing non-native fishes such as rainbow trout, brown trout, and brook trout. Additionally, these species are invading new areas inhabited by native species. In the case of native trout species like cutthroat trout, inland redband trout, and bull trout, interactions with non-native species are generally negative resulting from competition for food and space, as well as hybridization.

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Thank you to the Texas Master Naturalist Program for permission to use chapters and resources.

Rangelands

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Define what Rangelands are.
- Tell how much Rangeland is in Idaho.
- Describe the uses and values of Rangelands.
- Define Rangeland management.
- Identify the different types of Idaho Rangelands.
- Discuss the history of land use and ownership in Idaho.
- Tell who owns and manages Rangelands in Idaho.
- Identify types of Rangeland plants including: type, lifespan, origin, weed designation, woody or herbaceous, forage value, major Rangeland plants of Idaho.
- Differentiate major types of animals on Rangelands including: diet selection: plants, animals or both, digestion strategies of herbivores, wild, domestic, and feral animals.
- Tell habitat needs of Rangeland animals including: limiting habitat factors, stocking rates and carrying capacity.
- Describe Rangeland animal interactions including: types of interactions, livestock and wildlife interactions.
- Explain Rangelands including: ecological sites, soils, topography and watersheds.
- Tell what a watershed is including: uplands vs. riparian.
- Describe measuring and monitoring plant communities including: assessment and monitoring, and attributes.
- List and discuss the major drivers of ecological change: Grazing, ecosystem impacts of grazing, plant response to grazing, grazing changing plant communities, overgrazing; Invasive Plants, invasive plant terminology, why weeds are bad; Wildland Fire, wildfire versus prescribed burning, effects of fire on plants, fire return intervals, positive aspects of wildfire; Weather and Climate; Fragmentation of Rangelands.
- Find references, agencies responsible for Rangelands, glossary of Rangeland terms.

RANGELANDS

An Introduction to Idaho's Wild Open Spaces

University of Idaho
College of Natural Resources

IDAHO RANGELAND RESOURCE COMMISSION

Rangelands

An Introduction to Idaho's Wild Open Spaces

2009

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The Department of Rangeland Ecology and Management and the Idaho Rangeland Resource Commission are mutually dedicated to fostering the understanding and sustainable stewardship of Idaho's vast rangeland landscapes by providing scientifically-based educational resources about rangeland ecology and management.

Many people are credited with writing, editing, and developing this chapter including: Lovina Roselle, Karen Launchbaugh, Tess Jones, Ling Babcock, Richard Ambrosek, Andrea Stebleton, Tracy Brewer, Ken Sanders, Jodie Mink, and Gretchen Hyde.

Table of Contents

Rangelands Overview 4

Rangeland Plants 17

Rangeland Animals 22

Describing and Monitoring Rangelands 29

Forces of Ecological Change 38

Glossary of Rangeland Terms 50

Rangelands Overview

What are Rangelands?
How Much Rangeland Is There?
Uses and Values of Rangelands
What is Rangeland Management?
Idaho Rangelands
- Types of Rangeland in Idaho
  - Sagebrush Grasslands
  - Juniper Woodlands
  - Salt-Desert Shrublands
  - Pacific Bunchgrass
  - Coniferous Forest and Meadow
  - Riparian Areas
- History of Land Use and Ownership in Idaho
- Who Owns and Manages Rangelands in Idaho?

References and Additional Information

WHAT ARE RANGELANDS?

What are rangelands? Rangelands are lands that are not: farmed, dense forest, entirely barren, or covered with solid rock, concrete, or ice. Rangelands are: grasslands, shrublands, woodlands, and deserts. Rangelands are usually characterized by limited precipitation, often sparse vegetation, sharp climatic extremes, highly variable soils, frequent salinity, and diverse topography. From the wide open spaces of western North America to the vast plains of Africa, rangelands are found all over the world, encompassing almost half of the earth's land surface. Because rangeland landscapes are diverse and complex, they are called by various names around the world including prairies, plains, grasslands, swards, steppes, pampas, shrublands, scrublands, woodlands, savannahs, deserts, semi-deserts, and arid lands.

Grasslands are ecosystems that are dominated by grasses. Throughout the world, grasslands go by many names including prairie, steppe, pampas, swards, meadows and velds. In North America, grassland biomes include the tallgrass prairie, shortgrass prairie, alpine meadows, California annual grasslands, palouse prairie, southern mixed prairie, marshes, wet meadows, tundra grasslands, and desert grasslands.

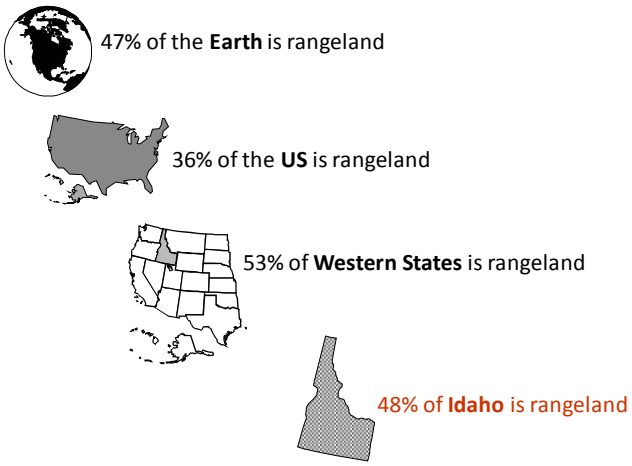
Shrublands are lands with abundant stands of shrubs with an understory of grasses and herbaceous plants-but shrubs dominate these ecosystems. Shrublands across the world are called chaparral, cerrados, shrub-steppe, maquis, and scrublands. In North America, shrubland biomes include chaparral, sagebrush-steppe, salt-desert shrublands, tundra shrublands, and mountain browse.

Woodlands and **Savannahs** are dominated by widely-spaced trees including junipers, oaks, mesquite and pines with an understory of grasses and forbs. Woodland ecosystems across the world take the names of the trees that dominate the landscape. In North America, the largest woodland biome is the pinyon-juniper woodland. Other woodland and savanna ecosystems include oak woodlands, aspen savannas, and mesquite woodlands.

Deserts are the driest rangelands and they experience extreme water shortage and unpredictable precipitation. These ecosystems are dominated by shrubs and succulent cactus plants. Deserts and arid lands in the world cover massive areas and include the Saharan, Namib, Arabian, Atacama, Australian Outback, and Kalahari deserts. The hot desert biomes in the North America are found in the southwest and include the Mojave, Sonoran, and Chihuahuan deserts.

HOW MUCH RANGELAND IS THERE?

Of the earth's total land surface, 47% is rangeland. In the U.S., 36% of the land area (nearly 1 billion acres) is rangeland. A total of 53% of the 19 states west of the Mississippi are rangeland. The state of Idaho encompasses 53 million acres. Nearly 26 million acres or 48% of Idaho's land area is classified as rangeland. The geographic and climate regimes of Idaho's rangelands are very diverse, which creates many unique plant communities and associations.



USES AND VALUES OF RANGELANDS

Historically, the primary use of rangeland has been to provide forage for livestock and wildlife. However, the importance of rangeland for recreation and water production is growing. Rangelands provide natural beauty, a diversity of wildlife, recreational opportunities like hunting, hiking, and camping, and economic values, including ranching, mining, and electrical power. Rangelands also serve as important watersheds for production of clean abundant water. The soils, vegetation, and water of rangelands are important to the ecological and economic health of the world, especially Idaho and everyone living it. Therefore, most rangelands are managed under principles of multiple-use which means that several uses or values of rangeland are managed simultaneously with care to avoid overuse or destruction of natural resources.

Though rangelands appear to be dry, unyielding landscapes, they provide important contributions of water to the streams, lakes, and aquifers that they contain. Because rangelands are located mostly in arid climates with low precipitation, water is doubly precious. The many miles of streams, lakes, and reservoirs scattered throughout rangelands become a water source for irrigation and urban areas. As human populations grow, water consumption and use increases, and healthy rangeland ecosystems are becoming increasingly important.

Rangelands also provide important **habitat** for **domestic livestock**, including cattle, sheep, goats, and horses. Most of the world's livestock live on rangelands and serve as a highly significant and necessary source of food and livelihood for people all over the globe. Ranching is an important endeavor that uses livestock to convert the nutritious and renewable grasses and other plants on rangelands into food, fiber, and other animal-based products for humans. Livestock have been grazing on North American rangelands since the mid-1800s, and they still exist today in familiar scenes over the grassy landscapes. Livestock production on rangeland is very important to supply meat for American and world populations. Rangelands are the primary source of our meat supply:

- Most calves and lambs fattened in feedlots are born and raised on range and pastureland.
- Nationwide, range and pasture provide 83% of nutrients consumed by beef cattle, 91% of nutrients for sheep and goats, and 72% of nutrients for horses and mules.
- Rangeland and pastureland in the 19 western states are home to 58% of all beef cattle in the U.S.
- Western rangelands harbor 79% of sheep and 88% of goats in the U.S.
- Livestock grazing occurs on 65% of Idaho's total land area and in every county throughout the state.
- Range livestock production is one of Idaho's major agricultural activities in terms of land used and cash receipts.

A diversity of **wildlife** thrive on rangelands habitats. Mammals, birds, amphibians, reptiles, fishes, and even insects make home in these complex ecosystems. Plants, water, and soils on rangelands provide unique environments for wild animals and plants, including threatened and endangered plant and animal species. Some rangelands are designated as special protection areas for wildlife.

The varied topography, scenic landscapes, and vast openness of rangelands are valuable to lots of people for recreation and tourism activities. Common recreational activities include hunting, camping, mountain biking, backpacking, hiking, horseback riding, and off-road vehicle touring. From mountains to plains, from lakes and rivers to deserts, rangeland areas are excellent places to have fun and enjoy life in these wild vistas and open spaces.

Rangelands can also provide a significant source of energy and other **natural resources**. Rangelands are used for hard rock mining, such as gold, copper, silver, or zinc, which benefits the economy of surrounding communities. Water coming from rangelands generates hydroelectric power. Mining and extraction of coal, oil, and natural gas are important energy resources gained from rangelands. Woody plants are also used for fuel, while grasses and other plants on rangelands can be harvested for ethanol and biodiesel production. Rangelands can also serve as suitable sites for attaining solar power, and wind

power from turbines. These uses of rangelands will become more valuable and common as the demand for more energy increases, especially clean renewable energy.

Federal public land is to be managed for "**multiple use**" and for the greatest good of all Americans. Individual states manage grazing lands to protect and enhance their value so they can achieve financial returns that benefit education and various state institutions. A century ago, most citizens considered rangelands "wasteland" and thought that meat production was the best use for rangelands. Recently, more and more people are enjoying rangelands for recreation and aesthetics. What will the next generations want from rangelands? Open space? Wind power? Carbon sequestration?

> *"…Rangelands may be far better at producing the stuff of myth and national identity than …beef and mutton products. Yet, it the long run, the production and perpetuation of national myth may be one of the most valuable resources harvested from public rangeland."* As reported by Hart (1994) from a National Academy of Sciences Report.

WHAT IS RANGELAND MANAGEMENT?

Rangeland management is the careful use and stewardship of rangelands to meet the needs and desires of those who live on and care about these lands. Rangeland management involves managing unforested lands with natural plant communities dominated by grasses, shrubs, and forbs. This endeavor is different from agriculture because plants and animals are not managed in isolation and for production purposes. Management decisions on rangelands are made with ecological properties in mind such as: soil health, vegetation, wildlife, invasive plants, and water quality. Range managers also need to consider the land owner's objectives that might include livestock production, open space, recreation opportunities, or energy production.

Rangeland management is a challenging endeavor because many of land resources and ecological forces that affect rangelands do not respect fences or property boundaries such as fire, invasive plants, wildlife, and water resources. Furthermore, even a single pasture used to manage livestock can include land owned by a rancher, the U.S. Forest Service, Bureau of Land Management and the State Department of Lands. This can often be the case when land parcels are not productive or sizeable enough to be managed on their own so they are managed in conjunction with adjoining ownerships. Many people do not realize that one pasture may include public and privately owned land. This creates a challenge in rangeland management because different agencies and individuals have different goals and opportunities for what they can or want to achieve on the land.

Because manipulating these intricate ecosystems requires a mix of science-based knowledge and practical experiences, rangeland management is described as both a science and an art. Although management decisions stand on scientific principles, there is no "silver bullet" nor are there pre-determined "correct" solutions that can apply to all rangeland management situations. This is why rangeland management is an art—it includes becoming familiar with every land element and having the knack for administering land management decisions based on what one knows or understands about that rangeland. A successful range manager embraces learning through experience built upon a foundation of scientific knowledge.

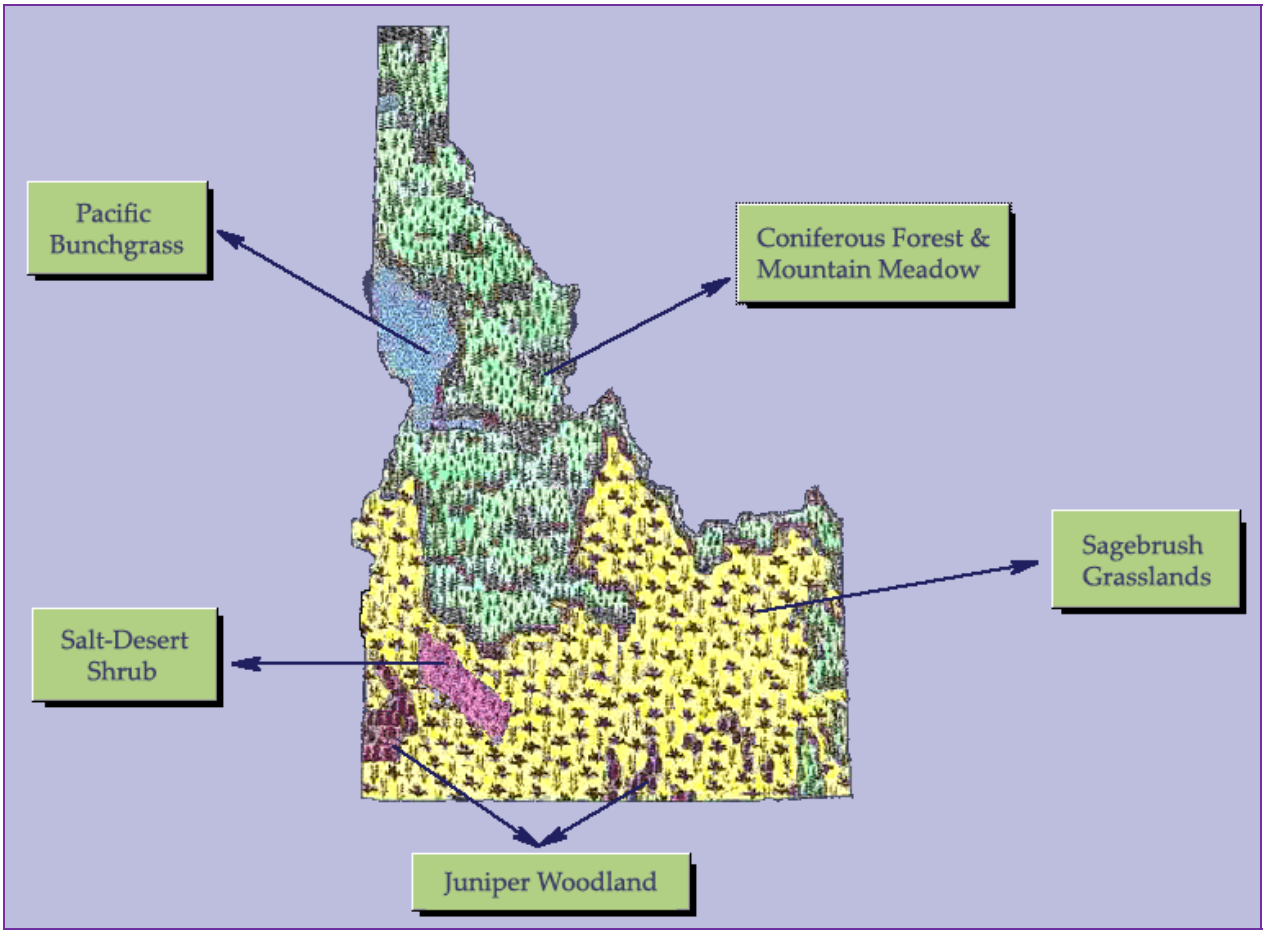
IDAHO RANGELANDS

Types of Rangeland in Idaho

Rangelands in Idaho include canyon grasslands, Palouse prairie, sagebrush-steppe, cold desert shrublands, juniper woodlands, aspen savannahs, mountain meadows, and streamside riparian communities. The geographic and climatic regimes of Idaho's rangelands are very diverse, creating many unique plant communities and habitats that are well adapted to these conditions. Low precipitation in these areas, often less than 10 inches per year, throughout most of Idaho creates plant communities, such as grasslands and shrublands, that can survive hot, dry summers. These plants have many adaptations such as extensive root systems that effectively gather soil moisture even in the driest of conditions.

Ecoregions are equivalent to small biomes within a specific geographic region. For example, in Idaho, the vegetation communities can be grouped in five "ecoregions": sagebrush grasslands, juniper woodlands region, salt-desert shrublands, pacific bunchgrass, and coniferous forests.

The following is an overview of the common ecoregions found in Idaho.



Sagebrush Grasslands

When people think of "The West", they often envision miles and miles of sagebrush. This classic western rangeland type is a mix of sagebrush and bunchgrass that dominates about 18.5 million acres in southern Idaho. These rangelands stretch across the plains, plateaus, and valleys south of the Salmon River. Lower elevations support stands of shorter and smaller shrubs compared to taller "savanna-like" stands at higher elevations. Precipitation generally ranges from 10 to 18 inches per year.

Big sagebrush is the main type of sagebrush in Idaho, but a keen observer may notice that there are about a dozen different species of sagebrush. The shrub-grass mix provides good spring and fall grazing for livestock and wildlife. Sage grouse, pronghorn antelope, deer, and black-tailed jackrabbits call sagebrush grasslands home, and rely on this type of ecoregion for survival.

Common plants in the sagebrush grasslands region include sagebrush; primarily big sagebrush, and other shrubs such as rabbitbrush. Perennial bunchgrasses that are found in this region are typically bluebunch or crested wheatgrass. Arrowleaf balsamroot and tapertip hawksbeard are also common forbs in this region which produce bright yellow flowers that characteristically paint this landscape.

Juniper Woodlands

In southern Idaho, two kinds of small evergreen trees, Western juniper and Utah juniper, create a kind of "pygmy forest" covering about 1.6 million acres. Juniper woodlands usually occur on the rougher terrain and can be dense or open depending on soils and topography. These woodlands usually occur in scattered patches rather than solid stands. Annual precipitation in this area ranges from 12 to 30 inches per year.

Out on the range, we humans generally try to fight wildfires. This fire suppression

benefits the juniper trees because they are usually killed by fire. Without natural wildfires, juniper expands into adjacent sagebrush-grasslands and displaces this ecoregion.

The juniper woodlands are important "watersheds" that yield water for agriculture and other human uses. The woodlands are also important winter range for wildlife, especially deer and songbirds. Plus, the juniper trees are often harvested for fence posts and other wood products.

Western and Utah juniper are both common types of juniper found on these rangelands. Big sagebrush is usually found growing in the understory. Grasses typically found on sagebrush-grassland, including bluebunch wheatgrass, bottlebrush squirreltail, and Sandberg bluegrass, are also present on juniper-woodland landscapes.

Salt-Desert Shrublands

"Desert" usually brings to mind hot, dry places with lots of blowing sand. In southern Idaho, equally dry deserts are created by salty soils and cold temperatures. Shrubs that are able to live in these salty soils dominate this "cold desert" covering 1.5 million acres. As the name suggests, soil salinity is a characteristic feature of this rangeland area. These shrublands get very little precipitation each year, usually 10 inches or less. Shrubs are generally

better suited for these harsh conditions than grasses or forbs because of their deep root systems. Because these shrubs have high nutritive value in winter, salt deserts are excellent winter range for pronghorn antelope and are considered some of the world's best range for winter sheep grazing.

Some shrub species that dominate this region are shadscale and fourwing saltbush, low sagebrush, and greasewood. It is likely to also see some native grasses like bottlebrush squirreltail or Indian ricegrass, and **half-shrubs** such as winterfat or the non-native **forb** Russian thistle.

Pacific Bunchgrass

When settlers arrived in northern Idaho in the 1880's, they found mostly forest except for a few rolling prairies of bunchgrass that dominated about 1.2 million acres. These exploring farmers found the deep rich soils and moist climate of the Palouse and Camas prairies favorable for growing wheat and other crops. Precipitation in this area ranges from 12-30 inches per year.

Today most of the prairies have been converted to farmland, and very little of the native bunchgrass remains. The existing canyon and foothill grasslands continue to provide high quality spring forage for sheep and cattle and good winter habitat for deer and quail.

Predominant native grasses in the Pacific Bunchgrass region are bluebunch wheatgrass, Sandberg bluegrass, and Idaho fescue. Snowberry, a shrub of the honeysuckle family, is also found on this type of environment, along with wild rose. One may also find arrowleaf balsamroot, biscuitroot, lupine and wild geranium.

Coniferous Forest and Meadow

Most of northern and central Idaho is dominated by evergreen coniferous forest totaling about 22 million acres. The forested ecosystems are much more moist than the shrublands and grasslands of southern Idaho, receiving 40 or more inches of snow and rain each year. Most of this area is dominated by dense forest interspersed with natural openings called meadows. In between the trees is vegetation

characteristic of rangeland (grasses, forbs, and shrubs) that is valuable habitat for all kinds of grazing animals. Shrubby vegetation near the forest edge is especially important for deer and elk, and the meadows are important summer range for both wildlife and livestock.

In the summer and fall, the region is a hotspot for backpackers, mountain bikers, hunters, fishers, and other outdoor enthusiasts. Ponderosa pine and Douglas fir are common tree species dominating Idaho's forests. On the forest floor or open meadows, one can typically find elk sedge and pinegrass, which are similar in appearance in that they have fine leaves and are often found together. Other grasses such as mountain brome and tufted hairgrass can also be found. It is also common to see woody plants such as antelope bitterbrush, ninebark, chokecherry or wood's rose. Wild geranium and fireweed are among the many types of bright wildflowers that may grow in this environment.

Riparian Areas

The lush ecosystem that consists of vegetation along bodies of water is called a **riparian area**. Riparian areas may surround lakes, ponds, wetlands, or fast or slow-moving rivers, creeks, or streams. There are riparian areas on Idaho rangelands surrounding the Snake River, and creeks that run through grazing lands, open meadows, and uplands. These areas provide nutritious vegetation for wildlife and livestock, and important habitat for fish and other aquatic species. Without proper management, these areas can be easily damaged by uncontrolled livestock and wildlife grazing.

Water-loving plants thrive in these moist areas of rangelands. Coyote willow, redosier dogwood, and cottonwoods typically grow along edges of the water. Otherwise, mostly sedges and rushes, such as Baltic rush, beaked sedge, and Nebraska sedge occupy the open moist soils.

History of Land Use and Ownership in Idaho

The lands in Idaho, and the Native Americans living there, were first documented by explorers Meriwether Lewis and William Clark in 1805. Lewis and Clark were among the first Europeans who made the journey through rough terrain and weather in Idaho and reported on many different grasses, forbs, and woody plants on the range. In fact, Lewis also described sage grouse and other animals still common today on Idaho rangelands.

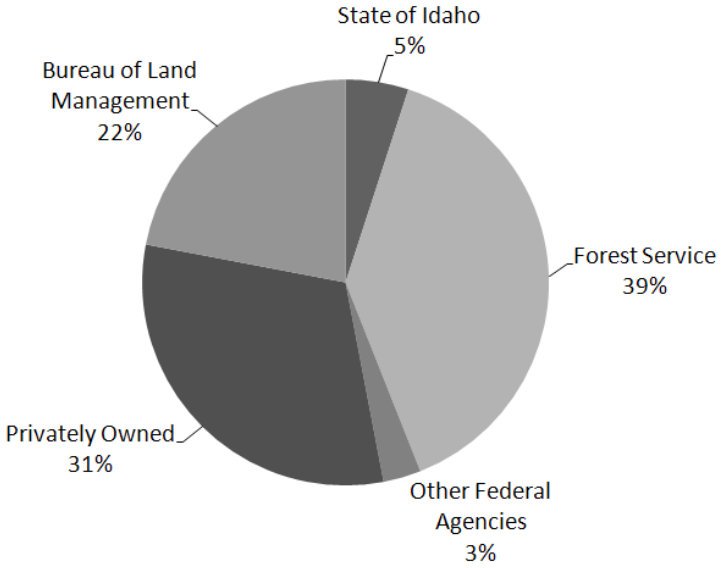
Lewis and Clark's discoveries from their journey through the Pacific Northwest were followed by increased interest in these uncharted lands. The idea of making dreams come true in the green and boundless west seemed appealing to many easterners. As a result, the first wagon traveled road was called the Oregon Trail and it crossed Idaho in 1843. In 1862, the Homestead Act helped to motivate the major settlement on rangelands, followed by additional laws to allocate land for settlement and human use. Most of these settlements surrounded water sources, such as the Snake River. Successful homesteaders in Idaho filed on land that had a natural source of water, before dams were constructed on the Snake River in the early 1900's. Between 1870 and 1900, rangelands were seen as land well suited for livestock production. The wide open spaces of western rangelands provided forage and habitat for sheep, cattle, and wildlife. By the late 1880's, the livestock production industry in Idaho peaked. Large ranches, running thousands of cattle and sheep, dominated the Idaho business sector.

The Forest Reserve Act of 1891 set aside about 47 million acres of National Forest to preserve forests and grazing lands. This act helped to set the foundation for the U.S. Forest Service, created in 1905 providing for management of rangelands and grazing practices. In 1934, the Taylor Grazing Act recognized the importance of controlling use on public grazing lands and their improvement. This led to the formation of the Grazing Service, which eventually was combined with the General Land Office to form the Bureau of Land Management in 1946.

The 1990's brought more and more people to Idaho's landscapes. Since the late 1800's, livestock grazing has been the predominant economic use of public rangelands, while hunting and fishing remained the main recreational uses until the mid-1900's. However, an increasing western population, greater individual wealth and a high degree of mobility has created demands for other forms of recreation on public lands. Since 1960, considerable conflict has occurred over the use of public lands. With an increase in population, Idaho citizens and visitors continue to find many uses of the land, such as hiking and all terrain vehicle (ATV) use. With this increased public use of rangelands, the Idaho Rangeland Resource Commission was created in 1994 with the goal of increasing the public understanding of Idaho's rangelands by providing factual information about economic and ecological aspects of rangeland management (www.idrange.org). Expanding knowledge about Idaho's precious lands helps to promote proper environmental stewardship and conservation for future generations to use and enjoy.

Who Owns and Manages Rangelands in Idaho?

In Idaho, about 68% of all land is publicly owned (33.1 million acres federal; 2.5 million acres state). Who owns or manages all this wild and vast country? These public rangelands in Idaho are primarily managed by federal agencies, which are the U.S. Forest Service, Bureau of Land Management, and National Park Service. Other public lands are also managed by the State of Idaho through the Idaho Department of Lands, Idaho Fish and Game, and Idaho Parks and Recreation. About one third of Idaho is owned by private individuals and families who manage their rangeland for economic benefit and personal enjoyment. Included in these privately owned lands are Native American Tribes, such as the Nez Perce and Shoshone-Bannock Tribes, who manage tribal lands that comprise about 464,077 acres or 1% of Idaho lands. The intermingled mosaic of land ownership across many western states creates challenges for rangeland managers because land management goals may not be the same across boundaries.



Idaho land ownership (1996) by percent of total land area (O'Laughlin et al. 1998)

Agencies Owning and Managing Idaho Rangelands	
Agency and Website	Major Purposes
Bureau of Land Management (BLM) http://www.blm.gov	Administers and manages land, and develops management and conservation programs.
United States Forest Service (USFS) http://www.fs.fed.us	Manages public lands in national forests and grasslands, and provides technical and financial assistance to state and private forestry agencies.
USDA-Natural Resources Conservation Service (NRCS) http://www.nrcs.usda.gov	Provides technical assistance to private land owners, serving through Soil Conservation Districts and the Farm Services Agency.
National Park Service (NPS) http://www.nps.gov	Preserves national parks for resource conservation and recreation.
Idaho Department of Lands (IDL) www.idl.idaho.gov	Manages endowment trust lands to protect Idaho's natural resources.
Idaho Fish and Game (IDFG) http://fishandgame.idaho.gov	Manages fish, wildlife, plant resources, and habitats for public use.
Idaho Parks and Recreation http://parksandrecreation.idaho.gov	Manages state parks, run registration program for boats and recreational vehicles.

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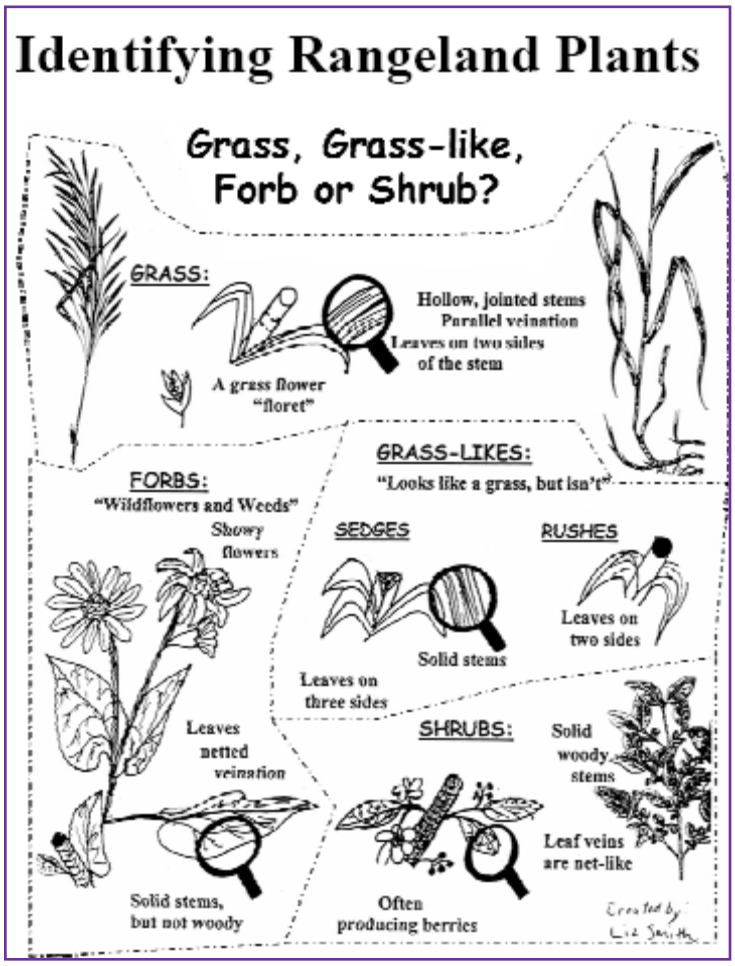
Rangeland Plants

Types of Rangeland Plants
- Plant Type or Life Form
- Lifespan
- Growth Season
- Origin
- Weed Designation
- Woody or Herbaceous
- Forage Value

Major Rangeland Plants of Idaho

References and Additional Information

Most management decisions on rangelands are made by first knowing the various range plants inhabiting them and knowing their growth habits. The identification of range plants is based on various plant characteristics and plant types. One of the most important identifying characteristics of plants is the shape of a plant's leaf. Other important characteristics include the margins and venation of leaves which are important when distinguishing plants.



TYPES OF RANGELAND PLANTS

Range plants can be classified and grouped in many different ways, including growth form, life span, season of growth, origin, and forage value.

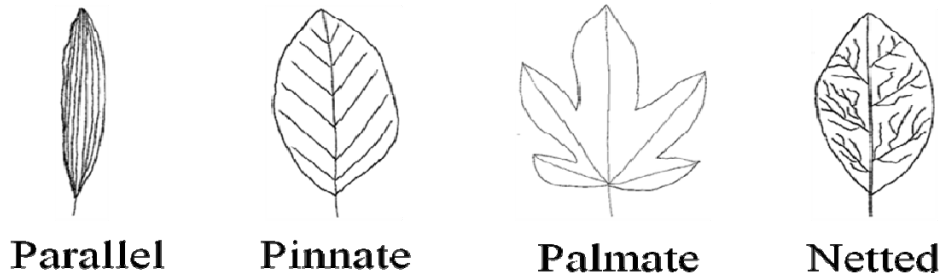
Plant Type or Life Form

Grasses are plants with long narrow leaves and hollow, jointed stems. Leaves on grasses are in two rows on the stem with veins that are parallel. Grasses do not have colored flowers and produce grain-like seeds. Ecosystems dominated by grasses i.e. grasslands cover more than one fifth of the earth's land surface.

Grass-like plants look like grasses but have solid stems (not hollow) without

joints. Stems are often triangular. Veins in the leaves are parallel. Sedges and rushes are in this group of plants.

Forbs are herbaceous (non-woody) plants that usually have broad leaves and showy flowers. Forbs have above-ground growth that dies back each year. Most forbs have net veins in the leaves, but a few have parallel veins. Most of the plants commonly called wildflowers and range weeds are forbs.



Shrubs are woody plants that usually have broad leaves. They are different from trees because they do not have a main trunk; instead, they have several main stems. Some plants can take both a tree and a shrub form, but most shrubs never grow up to be trees. The term browse is used to describe the part of a shrub plant that is used for forage by wildlife and livestock. The term mast is used to describe the seed and berries that shrubs produce and is especially important for wildlife.

Lifespan

The life span of a plant refers to the length of time from the beginning of the development of the plant to the death of the plant. In other words, how long it takes the plant to grow, flower, and produce seeds. Range plants can be classified as annuals, biennials, or perennials.

Annual plants live only one growing season. There are two types of annuals in the Pacific Northwest. Winter annuals germinate in the fall and form a small rosette of leaves through the winter. The following growing season, the plant continues to grow, flowers, produces seeds in the summer, and then dies. Summer annuals germinate in the spring and complete all growth by the end of the growing season and then die.

Biennial plants live for two growing seasons. During the first growing season, these plants normally form a basal cluster of leaves. During the second year, they send up a seed stalk that flowers before the plant dies back to the ground at the end of the growing season.

Perennial plants live from one year to the next. The plants produce leaves and stems from the same crown for more than two years. Most range plants are perennials.

Growth Season

The season of growth refers to when plants make their principle growth. Rangeland plants are categorized as cool season species or warm season species.

Cool season plants make their principle growth during cool weather. (These plants are sometimes called “C3 plants” because they have a specific photosynthetic pathway that first yields a 3-carbon sugar.) At lower elevations, these plants grow in the spring, set seed in late spring or early summer and new growth can appear in the fall if moisture is adequate. Plants that grow at high elevations are usually cool season plants because of the cool temperatures throughout the growing season. Most of the plants

in Idaho are cool season plants. Evergreen plants are woody plants that retain leaves throughout the year. They are cool season plants (photosynthesizing in winter) and are important forage in drought and winter.

Warm season plants make most of their growth during late spring and summer. (These plants are also called "C4 plants" because a 4-carbon sugar is the first compound that is the first compound produced from the specific type of photosynthesis of these plants). Seed develops in mid-summer and early fall. In Idaho, warm season plants only occur at low elevations and topographic exposures where warm growing conditions are reached in the summer. Southern states such as Texas and New Mexico have nearly all warm season plants. There is also another pathway for photosynthesis called CAM (Crassulacean Acid Metabolism) that is common in plants such as cacti, found in the desert regions.

Origin

The "origin" of a range plant is the area where it developed and evolved. Knowing the origin of a plant is important because it can affect the way the plant responds to the environment or help predict spread of species. Range plants can be characterized as either native or exotic.

Native plants are those that originated and evolved in North America.

Exotic or introduced plants are plants that have been brought to North America from another continent, either by intentional or accidental methods. Several plants have been introduced to rangelands because they have good forage value. Others were accidentally introduced, usually as contaminants in crop seeds. Weedy introduced plants were accidentally introduced or brought in for their ornamental value, but then "escaped" into rangelands.

Weed Designation

A **weed** is a plant that creates a problem for humans. Weeds might reduce yield of crops, pastures, gardens, or yards. Weeds can also be spiny and cause pain, be poisonous, or have odors or pollens that make it difficult to breath. These problematic plants can affect how ecosystems function by accelerating soil erosion, changing natural fire regimes, affecting populations of grazing animals or pollinators, or decreasing water infiltration into soil. Weeds are often detrimental because they outcompete and reduce populations of native plants on land or in streams, lakes, or other aquatic ecosystems. (More information at: The Weed Center www.weedcenter.org/inv_plant_info/impacts.html).

Woody or Herbaceous

Rangeland plants can also be described in terms of how much woody tissue they contain. This is important because it affects forage value, watershed characteristics of the landscape, habitat characteristics, and fire fuel loads.

Herbaceous plants include grasses, grass-like plants, and forbs. These plants contain little or no wood and they die back to the ground each year.

Woody plants are shrubs, trees, and woody vines that have woody stems. Wood is created by binding of plant fiber (i.e., cellulose) with lignin which is a strong and indigestible compound.

Trees are different from shrubs because they generally have a single main stem or trunk. Shrubs generally have several main stems. Woody plants can be **deciduous,** which means they lose their leaves every fall, or **evergreen** because they maintain some live leaves throughout the year, even winter.

Forage Value

The forage value of a plant refers to how well it provides nutrients to grazing animals. The forage value of a plant varies depending on which animal is eating it because nutritional needs and dietary preferences differ by species for grazing animals. For example, a plant could have excellent forage value for cattle and poor forage value for deer. Range plants can be classified as having high, medium, or low forage value or poisonous.

High forage value designates plants that are nutritious, palatable, and produce abundant forage. High forage value plants are high in crude protein, low in crude fiber, and are non-toxic.

Medium forage value plants are plants that will provide adequate nutrients if eaten, but it is not preferred by animals because they are not high in nutrient, are note highly digestible, or are relatively small plants and do not produce and abundant amount of forage.

Low forage value describes plants that simply do not provide adequate nutrients to the grazing animal. Low forage value plants are high in crude fiber, low in nutrients (including crude protein, minerals, etc.), have limited digestibility, and can be somewhat toxic.

Poisonous plants are rangeland plants that contain natural plant compounds that are toxic or poisonous to herbivores. These compounds include alkaloids, essential oils, tannins, and glycosides. When grazing animals eat excessive amounts of poisonous plants they suffer ill effects which include bloat, nausea, low intake, muscle tremors, skin sensitivity, birth defects, or death. Each year 3 to 5% of livestock grazing on rangelands suffer illness, reproductive problems, or death from toxic plants.

MAJOR RANGELAND PLANTS OF IDAHO

Idaho is a state of great plant diversity. Living in these wild habitats is an amazing variety of plants that are adapted for and survive harsh natural climates. These rangeland plants convert sunlight into leaves and fruit for animals to eat, roots to hold soil and flowers to provide aesthetic beauty. For more information and pictures of common Idaho rangeland plants, visit http://www.cnr.uidaho.edu/what-is-range/. A ***Backpack Guide to Idaho Range Plants*** featuring these common range plants is available from the Rangeland Ecology and Management Department at the University of Idaho (http://www.uidaho.edu/range) and the Idaho Rangeland Resource Commission (www.idrange.org).

Major Rangeland Plants of Idaho - 50 Common Plants
Common Name (*Scientific name)*

Grasses and Grass-Like Plants

Bluebunch Wheatgrass *(Pseudoroegneria spicata)*
Bottlebrush Squirreltail *(Elymus elymoides)*
Cheatgrass or Downy Brome *(Bromus tectorum)*
Columbia Needlegrass *(Achnatherum nelsonii)*
Crested Wheatgrass (*Agropyron cristatum)*
Great Basin Wildrye *(Leymus cinereus)*
Idaho Fescue *(Festuca idahoensis)*
Indian Ricegrass *(Achnatherum hymenoides)*
Medusahead Rye *(Taeniatherum caput-medusae)*
Mountain Bromegrass *(Bromus marginatus)*
Orchardgrass *(Dactylis glomerata)*
Red Threeawn *(Aristida purpurea)*
Sandberg Bluegrass *(Poa secunda)*
Smooth Bromegrass *(Bromus inermis)*
Western Wheatgrass *(Pascopyrum smithii)*

Grass-Like Plants

Baltic Rush (*Juncus arcticus)*
Elk Sedge *(Carex geyeri)*
Nebraska Sedge *(Carex nebrascensis)*

Noxious Weeds

Dyer's Woad *(Isatis tinctoria)*
Hoary Cress or Whitetop *(Cardaria draba)*
Leafy Spurge *(Euphorbia esula)*
Poison Hemlock *(Conium maculatum)*
Rush Skeletonweed *(Chondrilla juncea)*
Spotted Knapweed *(Centaurea stoebe)*
Yellow Starthistle *(Centaurea solstitialis)*

Forbs

Arrowleaf Balsamroot *(Balsamorhiza sagittata)*
Curlycup Gumweed *(Grindelia squarrosa)*
Indian Paintbrush *(Castilleja spp.)*
Low Larkspur *(Delphinium bicolor or D. nutalliana)*
Mules Ear *(Wyethia amplexicaulis)*
Penstemon or Beardtonge *(Penstemon* spp.*)*
Russian Thistle or Tumbleweed *(Salsola kali)*
Tailcup Lupine *(Lupinus caudatus)*
Tall Larkspur *(Delphinium occidentale)*
Taper-tip Hawksbeard *(Crepis acuminata)*
Western Yarrow *(Achillea millefolium)*
Wild Geranium *(Geranium viscosissimum or G. richarsonii)*

Woody Plants

Antelope Bitterbrush *(Purshia tridentata)*
Big Sagebrush *(Artemisia tridentata)*
Chokecherry *(Prunus virginiana)*
Coyote Willow *(Salix exigua)*
Curl-leaf Mountain Mahogany *(Cercocarpus ledifolius)*
Juniper *(Juniperus utahensis or J. occidentalis)*
Quaking Aspen *(Populus tremuloides)*
Rabbitbrush *(Chrysothamnus viscidiflorus or Ericameri nauseosa)*
Redosier Dogwood *(Cornus sericea)*
Serviceberry *(Amelanchier alnifolia)*
Shadscale Saltbrush *(Atriplex confertifolia)*
Snowberry *(Symphoricarpos albus)*
Winterfat *(Krascheninnikovia lanata)*

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Rangeland Animals

Major Types of Animals on Rangelands
- Diet Selection: Plants, Animals or Both
- Digestion Strategies of Herbivores
- Wild, Domestic, and Feral Animals

Habitat Needs of Rangeland Animals
- Limiting Habitat Factors
- Stocking Rates and Carrying Capacity

Rangeland animal Interactions
- Types of Interactions
- Livestock and Wildlife Interactions

References and Additional Information

MAJOR TYPES OF ANIMALS ON RANGELANDS

Rangelands provide habitat for countless mammals, birds, amphibians, fishes, and insects. A great majority (84%) of mammals found in North America spend at least a portion of their life in rangeland ecosystems. Large grazing animals such as bison, elk, pronghorn, and deer are perhaps the most iconic rangeland animals. Grazing livestock species including cattle, sheep, goats, and horses also inhabit rangeland landscapes. These hooved animals are called **ungulates**. Other mammals commonly found on rangelands include rodents and rabbits.

Rangelands are also characterized by a variety of birds. Large game birds such as grouse, quail, pheasants, and turkeys call rangelands home. Migratory song birds including meadowlarks, buntings, sparrows, and doves fill the grasslands, shrublands, and woodlands with color and song. Raptors including hawks and falcons can be often found in the rangeland skies. Some birds are so attached to rangelands that vegetation types are in their name like prairie falcon, meadow lark, sage thrasher, and scrub jay.

Insects are most prolific inhabitants of rangelands that are as diverse as the grasses, forbs, and shrubs on which they live. Insects play many ecological roles on rangelands, which can be either beneficial or detrimental. Periodically, large outbreaks of certain insects occur, namely grasshoppers or Mormon crickets, and can cause great devastation to rangeland ecosystems by eating rangeland plants and adjacent croplands. Insect herbivory competes directly with wildlife and livestock foraging, but because of their small size and inconspicuous nature, they are often overlooked is both stocking rate estimates and forage assessments. Insects are not only powerful herbivores that forage on native plants; they also can be introduced into areas to control undesirable plants such as noxious weeds, a process known as **biocontrol**. They also play a vital role in decomposing dead plant material in the soil and improving soil aeration. Insects are also the indispensable pollinators of plants that sustain genetic diversity among rangeland plants.

Diet Selection: Plants, Animals or Both

Animals that live on rangeland can be categorized based on their foraging patterns. For example, classification is first based on whether the animals eat plants, other animals, or both:

Herbivores are animals that eat plants.

Grazers – are animals, like cattle, elk and bison that eat mostly grasses.

Browsers – include deer and goats that eat mostly shrubs. The leaves and small stems of woody plants are called "browse" so these animals are called browsers.

Intermediate Feeders – eat a mix of grasses, forbs and shrubs depending on which is most nutritious at the time. Sheep and pronghorn antelope are basically opportunistic feeders that each eat grasses and forbs in the spring and summer and then switch to shrubs in the winter.

Carnivores eat other animals including insects, birds, reptiles, or mammals.

Omnivores are animals, including most humans, who eat a combination of animals and plants**.**

Digestion Strategies of Herbivores

Herbivores can be further classified based on how they digest the grasses and forbs that dominate rangelands. These plants are composed mostly of fiber or cellulose, which is a type of carbohydrate that cannot be digested by the enzymes of the grazing animal's stomach. However, many herbivores have a specialized fermentation organ and a symbiotic relationship with bacteria, protozoa, and fungi that can break down cellulose into compounds that can be used by the grazing animal.

Ruminants include animals such as cows, sheep, goats, deer, elk, and moose. These animals have specialized digestive systems that include a **rumen** to ferment the cellulose abundant in the cell walls of rangeland plants.

Hind-gut fermenters include rodents, rabbits, and horses. These animals have an enlarged cecum, which houses fermentation of forage particles to release energy from the cellulose. The cecum is located past the true stomach (i.e., behind the gut) – therefore these animals are called "hind-gut fermenters."

Concentrate-selectors are animals that do not have a way to digest fiber and must avoid cellulose by foraging carefully and selecting berries, seeds, or roots low in cellulose. These animals include birds and bears that find an adequate diet on rangeland by carefully selecting plant parts low in cellulose.

Wild, Domestic, and Feral Animals

Humans have developed varying levels of relationships with animals over the centuries. Our influence over animals can vary from strong and close to weak and distant.

Wild animals or **wildlife** are animals whose behavior, physiological, and genetics are largely not influenced by humans. There is a huge variety of wildlife species that inhabit rangelands including elk, deer, rabbits, insects, reptiles, and birds.

Domestic animals are those that have been strongly influenced by their relationship with humans. The behavior and breeding of these animals has been modified by humans creating new species from

their wild ancestors. Domestic animals include cattle, sheep, goats, horses, pigs, geese, chickens, dogs, cats, and honey bees.

Feral animals are those which were once domesticated but have severed their ties with humans and gone back to a "wild" lifestyle. Wild horses and burros are good examples of feral animals on rangeland.

HABITAT NEEDS OF RANGELAND ANIMALS

Food, water, cover, and space are the four basic habitat essentials required by all wildlife and livestock to survive, thrive, and reproduce. The specific combination of food, water, cover, and space required by a given species (called its "niche") is unique to every species that lives on rangelands. Because of these specific requirements, any time the habitat is altered, it is improved for some species but made worse for others. Additionally, because each species' niche is different, it is impossible to maximize the habitat quality of all wildlife at the same time. Therefore, trade-offs must be considered when managing habitat quality for wildlife and livestock.

Certain wildlife species depend solely on rangeland habitats, such as **sagebrush obligates.** These animals cannot exist without the habitat elements found only in sagebrush steppe communities. The Sage Grouse, Brewer's Sparrow, and Pygmy Rabbit are examples of sagebrush obligate species.

A habitat is basically the "home" of a species. This natural home of an animal includes all biotic, climatic, topographic, and edaphic (soil) factors that affect life. Rangeland habitats must provide animals four basic elements:

Food requirements for rangeland animals include energy, nutrients, and minerals**. Energy** sources in plants can come from starches, sugars, fats, and cellulose. **Nutrients** come mostly from protein and vitamins. **Mineral** requirements focus on phosphorus and potassium. When determining the food available to rangeland animals, rangelands must be evaluated on the basis of food requirements (the types of vegetation present and the diet preferences of animals) and the special arrangement of available food.

Different types of animals require different amounts of food each day. As a general rule, ruminants such as bison, deer, cattle, and sheep will eat about 2.5% of their body weight per day (in dry weight of forage); hind-gut fermenters such as horses and rabbits will eat about 3.5% of their body weight each day; and concentrate selectors such as birds, bears, and mice will eat about 0.25% of their body weight daily.

Water requirements vary depending on the animal species and weather conditions. In general, sheep and goats require 1-1 ½ gallons of water once every two days; donkeys require 3-4 gallons of water every day; horses require 5-8 gallons of water once or twice a day; and cattle and bison require 8-10 gallons of water every one to two days. Rangeland animals meet their water requirement by drinking fresh water and obtaining water from forage. Plants can contain significant amounts of water. For example, immature grasses may be up to 75% water by weight -- if an animal eats 28 pounds of immature forage, it will consume about 2.5 gallons of water.

Cover is required for shelter from weather conditions and from predators. **Thermal protection** is provided by plants when it offers animals shade in the summer and shelter from cold in the winter. Thermal cover for most rangeland animals is provided mostly by trees and shrubs. Plants can also offer **hiding cover** for animals to protect them from predators. Many animals use large plants to hide under or to gain protection through "visual obstruction." However, other animals, like pronghorn antelope and prairie dogs, gain protection from predators by a lack of visual obstruction. These animals prefer to be out in the open where they can see predators coming and escape by running away.

Space is an important consideration for breeding and nesting, home range, social intolerance, and disease transmission. An animal's home range is the area in which an individual animal conducts its normal daily and yearly activities. This area can be shared with other animals. The home range of an animal is directly related to its body weight; the larger the animals the larger its home range. Home ranges also vary by foraging habits; carnivores have very large home ranges; home ranges of herbivores are comparatively smaller.

Limiting Habitat Factors

Location and size of home ranges and habitats are set by limiting factors such as water, food, climate, and topography. These limiting factors are basic requirements that limit the size, growth, and/or vigor of an animal population. Rangeland habitats can be influenced by human activities that either add or remove limiting factors. For example, when ranchers add water tanks to pastures they may remove a habitat limiting factor (i.e., access to water) for wild and domestic animals. On the other hand, building roads and housing subdivisions may create factors that limit access to food and cover. However, habitat modification does not always affect a wildlife species' ability to survive, thrive, and reproduce.

One can envision habitat as resources that are held in a wooden barrel. The limiting factor is determined by the height of the lowest plank in the barrel. In this example, food is limiting the animal's ability to survive, thrive, and reproduce. If improvements to water, cover, or space occur, the species' population will not be affected. Similarly, degradation to water, cover, or space will not affect the population unless the degradations are so severe that one of these habitat essentials replaces food as the limiting factor. Habitat changes only affect a population when the species' limiting factor is enhanced or degraded. Therefore, if food is degraded, the species will be negatively impacted and if improvements to food occur, the species will benefit.

Stocking Rates and Carrying Capacity

The number of animals a piece of land can support on a long-term basis without causing damage to the range resource is the **carrying capacity** (or grazing capacity) of the land. **Stocking rate,** on the other hand is the number of animals a land manager places or maintains on a piece of land over a specified period of time. Thus, carrying capacity is set by Mother Nature, through soil and climate characteristics, while stocking rate is set by humans, through livestock or wildlife management.

The currency of stocking rates is the **animal unit** (AU). An AU is 1,000 pounds of grazing animal. In other words, a 1,000 pound cow equals 1 AU, a 1,200 pound bison is 1.2 AUs, and a 150 pound mule deer equals 0.15 of an AU. Stocking rate is often stated as the number of AUs/acre/year or acres/AU/year. For example, if the stocking rate of a pasture is 4 acres per AU per year (i.e., 4 ac/AUY) then it requires 4 acres to provide enough forage for 1 AU, such as a 1,000 pound cow, for a year.

An **animal unit month** (AUM) is the amount of forage an AU can eat in a month. Recall that a ruminant animal eats about 2.5% of its body weight each day. Therefore and AUM equals 750 pounds of forage (1,000 pounds of animal × 2.5% × 30 days = 750 pounds). The terms AU and AUM are widely used in rangeland management, but there is not universal agreement on the quantities each term expresses. Usually, 1,000 pounds of grazing animal equals an AU and an AUM is generally about 750 pounds.

More information on animal units and how to set a stocking rate, refer to "**Forage Production and Carrying Capacity: Guidelines for Setting a Proper Stocking Rate**". The article can be found at http://www.cnr.uidaho.edu/what-is-range/curriculum/Contents/MOD3/Stocking-rate-guidelines.pdf.

RANGELAND ANIMAL INTERACTIONS

Rangelands are very diverse habitats with a great variety of plants and geographic features. Livestock and wildlife often occupy the same area of rangeland. Interactions among livestock and wildlife on rangelands can be harmful, beneficial, or benign (no effect on either).

Types of Interactions

Any of the following relationships can exist depending on the animal and its habitat requirements:

- **Mutualism** (or Protocooperation): a relationship between two animals in which both benefit from the association. *For example -- Cattle Egrets (a type of bird) often perch on the backs of cattle or bison and eat insects and grubs. The insects benefit the birds as a food source. The cows and bison get the benefit of getting rid of the bothersome pests.*
- **Commensalism**: a relationship between two individuals in which one derives some benefit while the other is unaffected. *For example -- Dung beetles eat the feces of ruminant animals like cows or elk. The dung is a food source for the beetles (a benefit), but they have no effect on the ruminant animals.*
- **Antagonism**: one species benefits at the expense of another (i.e., predation/parasitism). *For example -- When a coyote eats a rabbit or lamb it gets a benefit as a food source, but the rabbit or lamb is harmed.*

- **Amensalism**: a relationship between two animals in which one is adversely affected and the other is unaffected by the association. *For example -- Bison can carry brucellosis (a bacterial disease) with no apparent symptoms. When bison interact with domestic cattle they can infect the cattle with brucellosis which can cause spontaneous abortion. The cattle are therefore harmed and bison are unaffected.*

- **Competition**: if two animals use the same resource (such as food or water) and if that resource is in limited supply this may cause harm to both animals because neither will have enough to meet their requirement. *For example -- When elk and cattle eat the same forage and it becomes limited both the elk and cattle may be harmed – they may not have enough to eat and may become thin. Competition only occurs when the common resource is used by both animals. Animals are "competing" for a resource only if there is not enough for both of them to meet their requirements.*

- **Neutralism**: a relationship between two species that interact or share the same habitat but do not affect each other. *For example -- Meadow larks or bluebirds are largely unaffected by cattle or elk. And cattle and elk have no real affect on meadow larks or bluebirds.*

Livestock and Wildlife Interactions

Ranch management and subsequent grazing management strategies can negatively or positively impact wildlife that utilizes similar landscapes as livestock. Livestock can be an important management tool for improving wildlife habitat. In other words, livestock grazing can be used to purposely manipulate forage to improve wildlife habitat for a chosen wildlife species. Livestock managers can alter the timing, frequency, intensity, and type livestock grazing to achieve wildlife habitat management goals. For example, spring grazing by cattle on the mountain benches near Boise encourages the growth of shrubs that are important winter forages for deer and elk. This process is referred to as prescribed or **targeted livestock grazing**, and is the strategic use of livestock grazing to achieve specific landscape goals.

In other situations, livestock grazing can damage habitat value if it is not carefully applied and purposefully planned with wildlife habitat in mind. Potentially negative impacts of livestock and wildlife interaction include parasite/disease transmission, reduction of cover, or changes of the types of plants available as forage. Several aspects of ranching such as fences and roads can also be detrimental to wildlife species.

Good land stewardship and conscientious grazing management strategies that account for wildlife can be used to limit negative interactions and enhance habitat quality and promote complementary relationships between wildlife and livestock on rangelands.

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Describing and Monitoring Rangelands

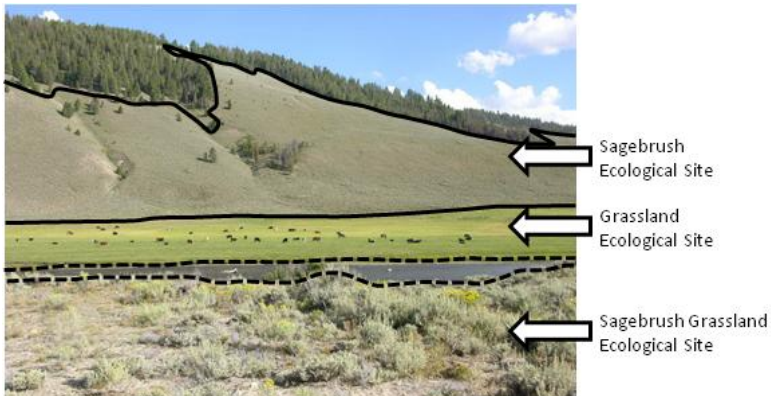
Describing Rangelands
Ecological Sites
Soils
Topography and Watersheds
What is a Watershed?
Uplands vs. Riparian
Measuring and Monitoring Plant Communities
Assessment and Monitoring
Attributes
References and Additional Information

DESCRIBING RANGELANDS

Rangelands are vast landscapes that are composed of differing **abiotic** (e.g. slope, aspect, minerals, moisture, temperature) and **biotic** (e.g. plants, animals, bacteria, fungi) components. Furthermore, rangeland ecosystems change dramatically from month to month and year to year. It is a great challenge for scientists and managers to describe and measure rangelands in ways that will help us understand what causes them to change or stay the same. Being good land stewards requires sound methods for describing rangeland conditions and monitoring their change over time.

Ecological Sites

Rangeland landscapes can be divided into **ecological sites** for the purposes of inventory, evaluation, and management. An ecological site is a distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation. The classification of ecological sites allows a land manager to map large areas into units with similar potential to grow specific types of plants. This might involve viewing shrublands different than grasslands or separating grasslands dominated by wheatgrass from those dominated by fescue.



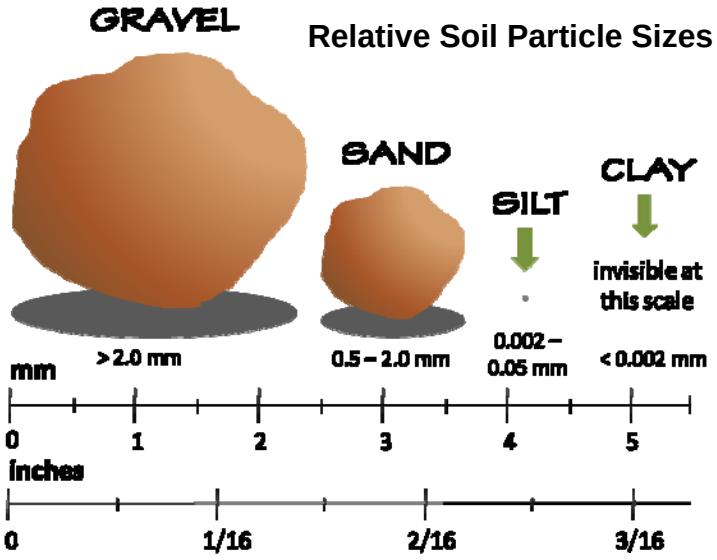
Many factors lead to the different ecological sites that create landscapes. These include differences in soil, slope, aspect, and place on the watershed. Plant communities on an ecological site

are typified by a specific group of species that differs from that of other ecological sites in the kind, amount or proportion of species present. An ecological site is the product of all the environmental factors responsible for its development, and it has a set of key characteristics that are included in the ecological site description. The site descriptions take into account physiographic factors, climate, water, soil, plant communities, and a rangeland health reference sheet. Site descriptions are available through the Natural Resource Conservation Service, and are accessible online at: http://esis.sc.egov.usda.gov/Welcome/pgESDWelcome.aspx.

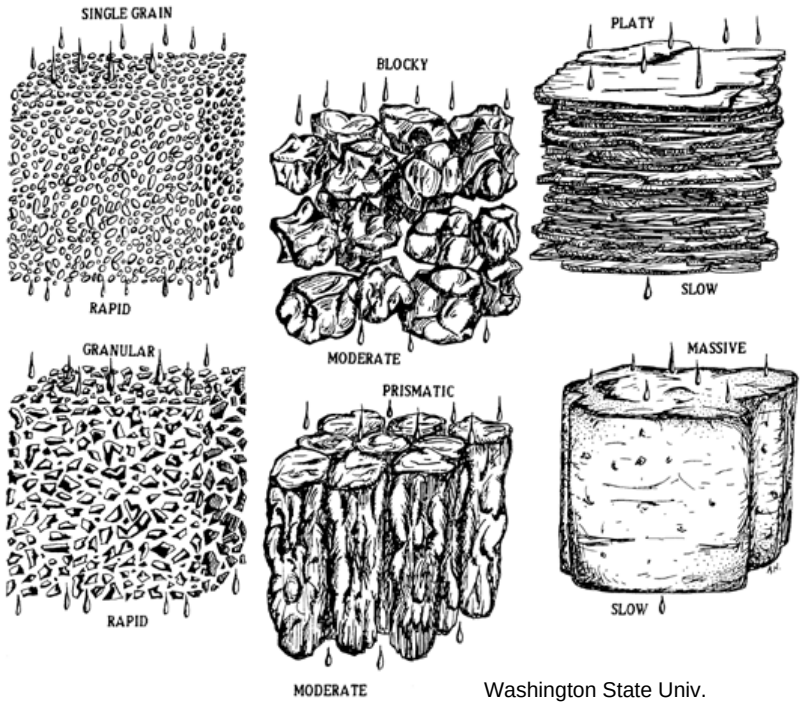
Soils

Soil is an important factor in rangeland communities and ecological sites have characteristic soils that have developed over time. Factors that affect soil development are parent material, climate, living organisms, topography or landscape position, and time. These factors lead to soil development or degradation through the processes of loss, addition, translocation, and transformation. Soil is defined as a complex mix of ingredients: minerals, air, water, and organic matter—countless organisms and the decaying remains of once-living things (Soil Science Society of America). Soil is formed into horizons (layers that are distinguishable from other layers by a change in composition of abiotic and biotic components) by soil forming processes. Two key physical characteristics of soil, texture and structure, strongly influence the vegetation type that occurs at a particular rangeland site.

Texture class is an important aspect of soils, and is related to weathering and parent material. The differences in horizons are due, in part, to the differences in texture of their respective parent materials. The texture of a soil depends upon the relative proportions of each type of soil particle within the soil. The three basic soil particles are sand, silt, and clay. Sand particles are the largest of the three particles. They are between .05 and 2.00 mm in diameter and are coarse and gritty. When moist, individual grains can be seen. The presence of sand particles within a soil decreases the capacity of soil to hold both water and nutrients. Silt particles are medium in size and range between .002 and .05 mm in diameter. Silt particles feel smooth and velvety. The presence of silt particles in soils increases water-holding capacity and nutrient capacity. Clay particles are the smallest of the soil particles and have a diameter of less than .002 mm. Clay particles have the greatest ability to hold both water and nutrients, but sometimes can bond very strongly with nutrients, making it difficult for plants to extract nutrients from the soil. Clay particles can also form very strong aggregates, decreasing the ability of water to penetrate and drain from the soil.



Soil particles seldom occur as separate units in the soil; rather they often combine to form larger aggregates that are primarily held together by the binding forces of clay and organic matter. **Soil structure** is a term which describes the arrangement of soil particles. The five major structural classes of soil include: blocky, platy, granular, prismatic or columnar, and massive.



Washington State Univ.

Soil structure and water movement

The texture and structure of soil directly influences the amount of air (pore) spaces found within the soil. These are important conveyors of water, nutrients, and air as well as providing spaces for roots to grow. In some locations, the soil will form impenetrable barriers that may substantially impede water infiltration and root penetration. These "**restrictive layers**" may be inherent (natural) or induced by land management practices. For example, a soil may become compacted due to excessive traffic on the land which in turn may alter the hydrologic function of that site.

It is normal for wind and water to move soil around a landscape. This soil loss is called **erosion.** Some natural erosion can be expected, however, when erosion can become excessive if vegetation is removed from the soil surface by overgrazing or other impacts such as high off-road vehicle use. It is important to manage vegetation so as to keep soil in place.

TOPOGRAPHY AND WATERSHEDS

Land managers care for rangeland, forests, and croplands by managing the health of the watershed. Managing for healthy and productive soil ultimately leads to a functional watershed system. Managers accomplish this feat by managing the vegetation within the watershed.

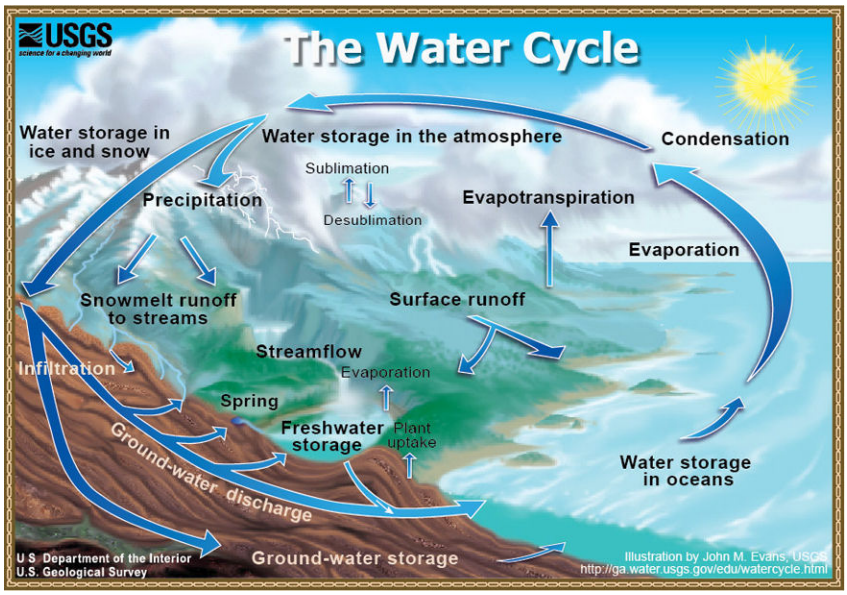
What is a Watershed?

A **watershed** is an area of land that drains water to the same endpoint. Watersheds can be defined at almost any scale, being as small as a single hill, or as large as the Mississippi river and all its tributaries. Watershed boundaries are determined by topography of the landscape. The highest features on the land, like ridgetops, form the perimeter of the drainage area or basin which water travels through as it makes its way to the lowest point. All the water within a region, including lakes, rivers, streams, and subsurface water flows, are part of the watershed classification.

Satellite image with a depiction of the Pashimeroi River watershed boundary and the local rivers and streams. All of the water within this region flows into the Salmon River (northwest corner) near Challis, Idaho.

Watersheds serve three primary functions in the **hydrologic cycle**; the capture, storage, and release of water. **Capture** refers how water from the atmosphere gets into the soil. The amount of water that is captured, or infiltrated, in the soil is related to the amount of both vegetated and non-vegetated ground cover (i.e., organic debris, rock) and the soil type. For example, in dense grasslands, infiltration rates are high because of the amount of plant cover and leaf litter which shelters the soil from the impacts of falling precipitation. However, many rangeland types include bare ground and exposed soils that can have low infiltration rates and result in the movement of soil and water across over the ground surface as **overland flow.** Unhealthy or degraded sites can have elevated erosion rates that reduce the hydrologic function of a site. Land managers can indirectly manage infiltration and erosion by managing the structure and density of vegetation.

Water that is captured by the soil is stored between the soil particles. The amount of water stored in the soil depends on the soil depth, texture, and structure. Soil moisture is lost through surface evaporation, plant uptake, or percolation through the soil where it continues to move through the watershed as subsurface flows. **Mesic** soils have more moisture present closer to the surface than are those areas that have drier or more **xeric** soils. The amount and kind of plants growing on a rangeland site can greatly influence the amount of water stored in the soil. For example, an infestation of leafy spurge, a noxious weed, can have a high density of plant roots deep into the soil profile that will extract soil moisture, resulting

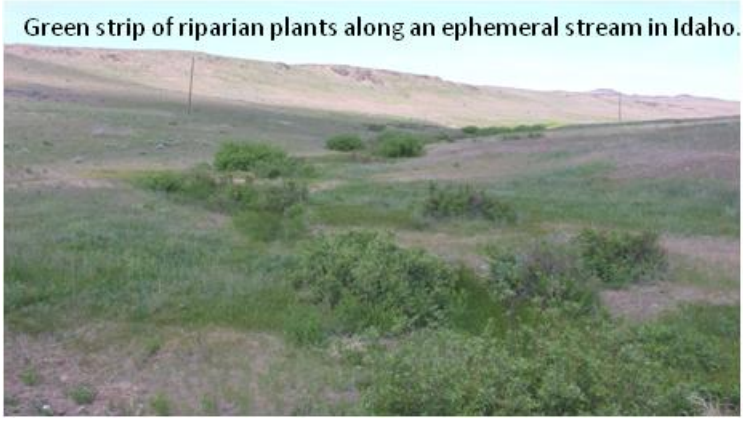


in the loss of soil water from a rangeland site. Another example is cheatgrass, an invasive annual grass with shallow rooting systems that uptake moisture near the soil surface before it can reach the deeper roots of other plants such as native grasses.

Once moisture enters the soil it can move deep into to the rocky substrate below the soil and held in aquifers that can be tapped into with wells. Or moisture can move horizontally within the soil profile as **subsurface flow**, ultimately flowing into springs, streams, rivers or lakes. Vegetation management at the transition zones of subsurface groundwater flows meeting with surface waters is important to maintaining good water quality. These transition zones are also where overland flows meet surface waters and managing for adequate ground cover provides a filter to prevent excess sediment from entering surface waters.

Uplands vs. Riparian

Rangelands are generally classified into three types of areas (upland, riparian, and wetlands) with each area having a distinct hydrologic regime, and a supporting plant community. **Uplands** are drier and only wet for short periods after precipitation events, resulting in water restricted systems. A **riparian zone** is adjacent to surface waters, such as streambanks and shorelines. Riparian vegetation can either associated with channels that have flowing water (**lotic** systems) or standing water (**lentic** systems). **Wetlands** are areas with **hydric** soils that are permanently or seasonally saturated by water. Wetland and riparian areas naturally function as water filters; removing sediment and pollutants from water. Riparian areas and wetlands areas stay green much longer into the season, and generally produce more biomass than upland systems.


Green strip of riparian plants along an ephemeral stream in Idaho.

Plant species that occur in wetlands and riparian areas require frequent water and are not killed by inundation by water. These species include cottonwoods, willows, alders, rushes, and sedges. Species found in the floodplain – an area above the stream channel that experiences periodic flooding – require less water and are less tolerant to inundation than species found growing close to or in the channel. Willows, maples, oaks, ash, snowberries, currants, ninebark, elderberries and many other species are frequently found in floodplains. Riparian plants are characterized by strong root system that can soil along the bank and protect it from the force of moving water.

Upland sites are composed of species that have adapted to survive with minimal water, according to the average precipitation of the region. Depending upon location, moisture levels can fluctuate from less than 10 inches a year in some arid rangelands, to greater than 30 inches on mountain pastures and the tall grass prairie. Fluctuations of moisture from year to year can vary greatly, and many areas in

Idaho receive their moisture during one critical period, winter. Many rangeland plants have evolved strategies to maximize extraction of available soil water such as the very deep root systems found in desert shrubs or the abundance of small roots of grasses found near the surface to capture precipitation. Upland plants also have strategies to conserve moisture once it absorbed such as waxy layers, narrow leaves, and the ability to go dormant or senescent during the hottest and driest season of the year. Common upland species include junipers, sagebrush, antelope bitterbrush, bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass, tailcup lupine, Indian paintbrush, and scarlet globemallow.

MEASURING AND MONITORING PLANT COMMUNITIES

Assessment and Monitoring

Rangeland ecosystems are dynamic and are constantly changing as a result of natures driving forces including climate, fire, insect outbreaks, flooding, wildlife foraging and weed invasion. Human induced disturbances such as urban expansion, domestic livestock grazing, recreational use, energy development, mining, road building, and landscape manipulations (e.g., disking, chaining, seeding) also impact soil, plant composition, and wildlife habitats on rangelands. Rangeland **monitoring** is a systematic approach to document vegetation changes over time. Data derived from monitoring can help land managers determine the effectiveness of their management practices and help them select appropriate future management strategies based on objectives.

Monitoring objectives are defined on a site-specific basis, each with a focus on specific attributes. For example, a rancher may implement a monitoring protocol to determine if a new grazing system is affecting establishment of sedges or willows along a stream improving the stability of stream banks. If the grazing system is not leading to the desired condition, the grazing plan could be changed or the stream could be fenced to remove grazing. Monitoring can also quantify how natural forces are affecting rangeland plant communities over time. For example, a land manager may implement a monitoring program to determine if and when a burned area recovers to the level of a similar plant community in an unburned area.

The first step to an effective monitoring plan is to establish a baseline of data – a point of reference from which managers can base decisions about the land use. This is accomplished through a rangeland **assessment**, providing a “snapshot in time” of the current conditions of the soil, plant community, site productivity, and wildlife habitat uses. Rangeland site assessments include specific attribute data and capture specific information about the site such as elevation, map coordinates (e.g., latitude and longitude or UTM), slope, aspect, soil texture and structure, watershed unit, and land ownership. It is also important to document evidence of wildlife, livestock, and human use (e.g., scat, ORV tracks, hoof prints, etc.) and hydrologic characteristics (e.g., rilling, gullying, soil pedestals, etc.).

Attributes

Though there are many way to measure plants, but, there are only 6 basic "attributes" that are commonly measured. Vegetation attributes are characteristics of vegetation that can be measured or quantified referring to how many, how much, or what types of plant species are present. The most commonly used attributes are:

- **Plant Species or Type** - What kind of plant was it?
- **Frequency** - Was the plant there or not?

- **Density** - How many plants were there in a specified area?
- **Biomass** - How much did the plants weigh?
- **Cover** - How much space did the plants cover?
- **Structure** - How tall were the plants and how were branches and leaves arranged?

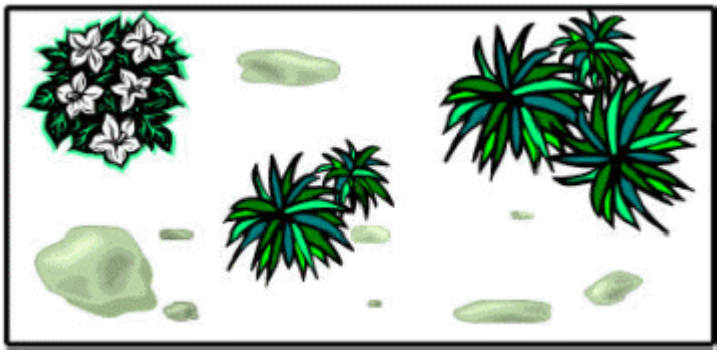
The most valuable skill that rangeland managers possess is the ability to differentiate between different **plant species**. Therefore, plant identification is essential to effective monitoring on rangelands. Plant species found on rangelands fall into five major types, or **life form** categories: grasses, grass-likes, forbs, shrubs and trees.

Frequency describes how often a plant occurs within a sampled area. For example, if a grid was laid out over a sample area, the frequency of a target species would be expressed as the percentage of the cells where the species was "present" out of the total number of cells possible. Because larger plots are more likely to capture the presence of a species, frequency measurements are dependent on plot size and shape. Therefore, frequency values between different sites or years are not comparable unless identical plot sizes are used. Frequency is most often used to compare plant communities and to detect changes in vegetation composition over time. In this way frequency can be used to assess vegetation **trend**.

Determining the **biomass** of a site is important because it is important for setting proper stocking rates, determining hydrological characteristics, and monitoring the effects of climate variation on a site. Biomass, or vegetative production, is expressed as weight per unit area (i.e., pounds/acre or kg/hectare). Total annual production is the production (growth) of all plants, whereas total forage production is the total production of plants that could be used forage by grazing animals. Biomass can be determined by clipping grasses, forbs, and browse to determine composition and weights. Or, if the ecological site is known, site guides can be consulted with estimates of production in years of favorable, normal, or unfavorable precipitation. Experienced range managers can also accurately estimate the weight of forage on a site just as a good livestock manager can skillfully estimate the weight of a cow. Being able to estimate biomass is a useful skill, and can be honed through experience.

Density is the number of individual plants per unit area (i.e., plants/ft^2 or plants/m^2). From a management perspective, density measures can be used to detect the response of plants to a given management action. In particular, density measurements provide evidence of plant mortality or recruitment on rangeland sites over time. For example, the density of a particular weed could be monitored over time to determine if an integrated weed management strategy is working. Because density is a count of plants per unit area, it is not affected by plot size and can be a useful measurement to compare different sites.

Cover is the area of the ground surface covered by vegetation or other solid objects including rocks, litter, moss, or bare round. Cover is expressed as a percentage. For example, if you look directly over the quadrat below, you might estimate that the area is covered by 35% grass, 12% white flower, and 15% rock. Subtracting the totals from 100% yields the amount of bare ground, 38%. Cover can be measured for the entire sample area (i.e., total vegetative cover was 45%), or can be applied to individual species (i.e., sagebrush cover was 15%).



Grass:

White Flower:

Rock:

Cover measurements are most often used to assess which plants dominate the solar, water, soil and nutrient resources on a site. Vegetative cover also influences the hydrologic function of a site and cover measurements may be used to interpret how well a rangeland site is able to capture, store, and safely release water from rainfall and snow. Cover is also an important management indicator, providing a variety of interpretations of direct concern to rangeland management, including erosion potential, the value of wildlife habitat, availability of forage, and trends in range condition.

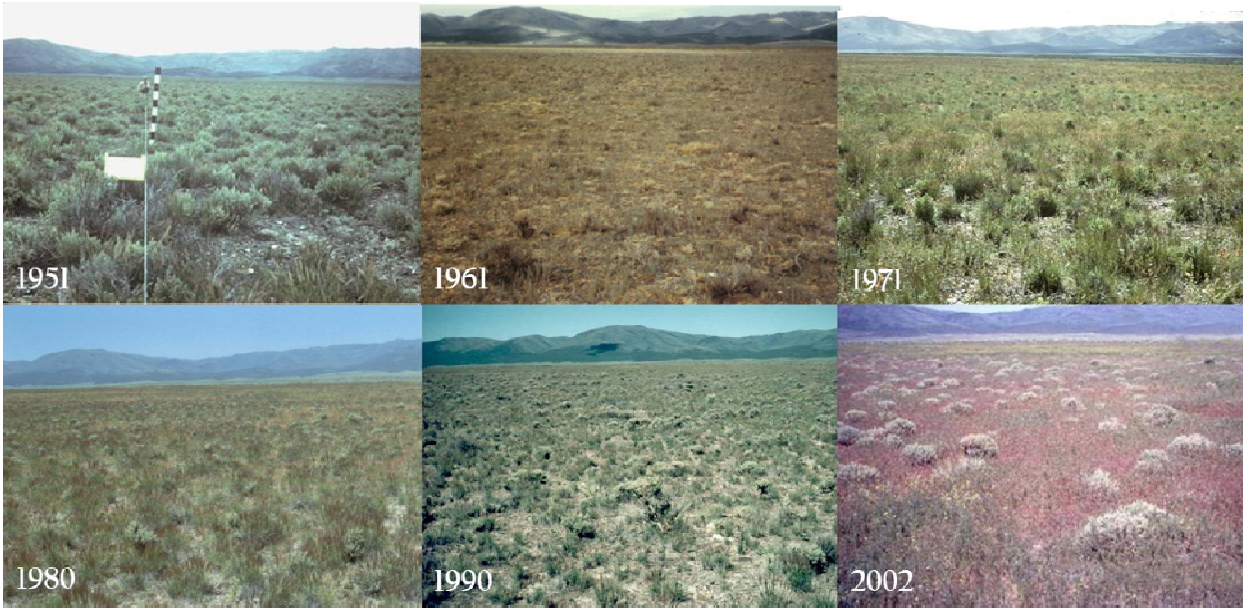
Vegetation **structure** describes the three-dimensional arrangement of a plant community. Structure measurements are primarily used to evaluate wildlife habitat elements (i.e., nesting cover, screen or hiding cover). Techniques used to quantify vegetative structure are generally applicable in a wide variety of vegetation types and are useful in evaluating changes over time. For example, the same method used to determine vegetation structure for sage grouse brooding habitat may also be used to quantify the amount of hiding cover for white-tailed deer.

In addition to measuring vegetation attributes to determine the effectiveness of management strategies, rangeland monitoring also helps mangers make observations about the health or vigor of plants and communities. In assessing and defining sites, we can combine the above attributes to create variables such as species composition, biodiversity of the site, or similarity with historic measurements.

Rangeland **plant composition** is the proportion (%) of various plant species (or life forms) in relation to the total plant species (or life forms) in a given area. Plant composition is important to measure in range management because traditional range guides for proper stocking rates and range ecological sites are based on plant composition. Measurement of composition over time can be used to determine if range condition is improving or declining in relation to traditional compositions. Finally, assessing composition helps to estimate the forage available for herbivores with differing feeding habits. Range managers commonly calculate composition from biomass or cover data.

Biodiversity refers to the total amount of different organisms found within a certain area. Benefits of a diverse rangeland plant community are that it contains a variety of forages that are available to insect and vertebrate species, contain more species that are capable of surviving disturbance, and are theoretically less likely to be invaded by noxious or opportunistic species. Measures of diversity can be derived from cover and/or density data.

The measure of **similarity** between communities based on species composition, or similarity index, is useful for comparing communities under different management or comparing communities over time. Similarity can be calculated from cover and/or density data.



Monitoring photographs of a rangeland shrub (shadscale) community in southern Idaho showing the dynamic nature of the site over time (1951 to 2002).

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Forces of Ecological Change

Major drivers of ecological change
Grazing
  Ecosystem Impacts of Grazing
  Plant Response to Grazing
  How Does Grazing Change Plant Communities?
  What is Overgrazing?
Invasive Plants
  Invasive Plant Terminology
  Why Weeds Are Bad?
Wildland Fire
  Wildfire versus Prescribed Burning
  Effects of Fire on Plants
  Fire Return Intervals
  Positive Aspects of Wildfire
Weather and Climate
Fragmentation of Rangelands
References and Additional Information

MAJOR DRIVERS OF ECOLOGICAL CHANGE

Rangelands are incredibly dynamic ecosystems. Drastic changes can be observed among seasons within a year and among years and decades. There are five major factors that cause rangelands to change over time – **grazing, fire, invasive plants, weather and climate**, and **fragmentation** due to human influences. These factors change the plants and animals that inhabit rangeland sometimes in ways that land managers and users find desirable and other times in ways that are considered adverse.

GRAZING

The grasses, forbs, and shrubs that grow on rangelands are important sources of forage for grazing animals. Rangeland plants photosynthesize and turn energy from the sun into organic compounds such as carbohydrates and proteins. When plant material is consumed, these compounds are digested and provide energy and nutrients for herbivores. Grazing is a natural ecological process that occurs on all rangelands.

Ecosystem Impacts of Grazing

Grazing animals have several direct and indirect impacts that can improve or degrade rangelands depending on the timing and intensity of grazing. Foraging animals affect rangelands by removing vegetation, roughing up and compacting soil through hoof action, and depositing minerals in the form of urine, feces, or the animal's carcass. Appropriate and well-managed grazing can favor desirable plants, improve habitat for wildlife, reduce weed invasion, reseed areas for restoration, reduce mulch accumulation, increase soil organic matter, and reduce fuel loads that promote wildfire. Overgrazing and prolonged poorly managed grazing can remove desirable plants, decrease water infiltration into soil, increase soil erosion, reduce water quality, increase weed invasion, and alter the plant community composition to a less desirable state. Therefore, the impacts of grazing depend on when and how it occurs.

Plant Response to Grazing

Plants live in ecosystems full of herbivores that range from small insects to large grazing animals. Losing leaves or stems to herbivores is a common event in the life of a rangeland plant. For rangeland plants to remain healthy and productive, enough vegetation must remain after grazing so that plants can photosynthesize and manufacture energy to produce more leaves, stems, and seeds. Plants also need to produce and store a little energy as starches and sugars in roots and crowns to successfully start the next season of growth. Only when too much of the plant is removed does the plant suffer in a way that yields lasting detrimental effects. Substantial damage to rangeland plants generally only occurs under repeated and heavy grazing.

The impact of grazing on plant growth depends greatly on when the grazing occurs during the growing season and at what stage of the plant's life cycle. Plants are generally less damaged by grazing early in the season when time, soil moisture, and nutrients needed for regrowth are abundant. Plants are most likely to be damaged by grazing when the plant is beginning to produce flowers and seeds. At this time, the plant has high energy demands to produce seeds, complete growth for the season, and store energy to get through the dormant season. Plus, this generally occurs at the peak of summer when the environment is hot and dry and not favorable for regrowth. Once the plant produces seeds and turns brown (i.e., becomes dormant), it is no longer sensitive to grazing. At this time, the leaves are not photosynthesizing and are no longer being used by the plant.

Because plants evolved with grazing animals, it is not surprising that plants have attributes and processes to reduce the potential of being eaten and to recover from the loss of plant material after grazing. One way that plants can reduce the impacts of grazing is to have characteristics that reduce the likelihood that herbivores will even take a bite. These characteristics that reduce the probability or severity of grazing are called mechanisms for **grazing avoidance**. These include physical characteristics like thorns, prickles, and spines that make plants less likely to be grazed by large herbivores such as cattle or elk. Similarly, a hairy or waxy leaf surface may be avoided by insect herbivores. The size, shape, or arrangement of leaves may also make it difficult for animals to access and graze the plant.

The buds or growing points (**meristems**) of a plant are especially important to protect from grazing because they will be the source of new stems and leaves for continued growth after grazing. Grasses have a unique strategy of protecting meristems – they are kept near the ground surface (within the crown of the plant) while the leaves and sheaths grow upwards. Some forbs also adapt this tactic by forming a basal rosette of leaves that photosynthesize right near the ground surface – out of the reach

of grazing animals. The meristems of these rosette forming plants are kept in the center of the rosette and are not elevated and made accessible to grazing animals until later in the growing season.

Some plants also contain compounds that are harmful to the grazing animal. These compounds, called **secondary compounds**, can cause illness, neurological disorders, birth defects, or even death. Secondary compounds such as alkaloids, tannins, and essential oils are common in plants. Most often these compounds don't kill the animal but, simply make it feel sick or nauseous so that the plant becomes distasteful and undesirable to the herbivore. However, some plants contain toxic compounds that are very powerful even in small amounts. For example, tall larkspur contains a mixture of alkaloids that if eaten can cause muscular paralysis, leading to respiratory failure, bloat and often death.

Plants also have attributes that facilitate their regrowth and recovery after grazing. The morphological and physiological characteristics that promote rapid plant growth are termed mechanisms of **grazing tolerance.** For instance, some plants have a higher potential to mobilize stored energy sources and replace leaves after defoliation.

Plants vary in how well they can tolerate and avoid grazing. In fact, many plants can benefit from the effects of grazing. For example, grazing animals can remove the older and less efficient leaves making space and resources for younger more efficient leaves. Grazing can also stimulate the plant to produce more seeds and stems than if they had never been grazed. So, the effects of grazing can be detrimental or beneficial depending on the: 1) plant species, 2) season when grazing occurs, and 3) intensity of grazing or how many leaves that remain after grazing.

How Does Grazing Change Plant Communities?

Many fence-line contrasts exist where a difference in plant community across the fence is caused by animals preferring some plants over others. When herbivores focus their grazing attention on one plant, or group of plants, the ungrazed plants can express themselves – sometime creating dramatic contrasts.

Sheep grazing in Montana (on the right-side of this fence) preferred the yellow forbs in this mountain meadow and almost completely removed them from where they grazed.

Goats grazing in Idaho (on the right-side of this fence) ate most of the leafy spurge (a noxious weed) out of their pasture.

Sheep grazing in a spring pasture in Idaho (on the left-side of the fence) reduced the abundance of yellow-flowering forbs (mostly taper-tip hawksbeard). Whereas, fall sheep grazing (on the right-side of the fence) reduced the cover of sagebrush.

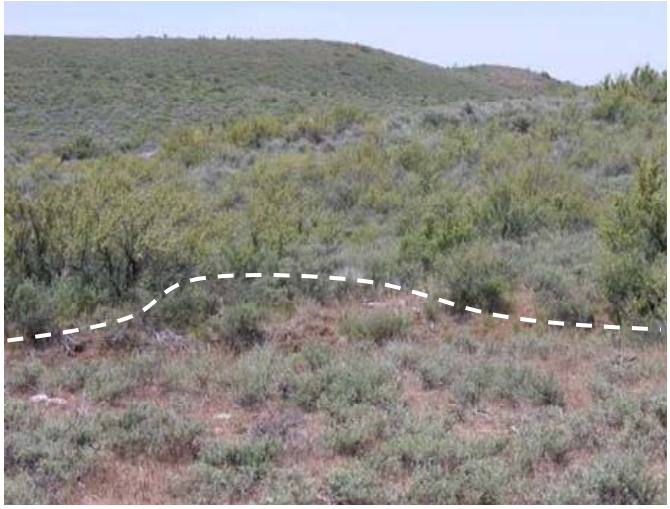
Elk grazing in Yellowstone National Park (on the right-side of this fence) preferred these willow species and removed them from the plant community.

What is Overgrazing?

Many people are concerned that excessive grazing by livestock or wildlife creates rangelands that are "overgrazed". Overgrazing is defined as repeated heavy grazing that results in deterioration of the plant community. Caution must be taken when declaring a range as "overgrazed" because it is difficult of truly assessing whether land is "overgrazed." Pastures can be heavily grazed but that may not lead to land degradation. In fact, some grazing systems designed to improve and restore rangelands are accomplished by grazing a pasture very heavily once and then giving the pasture several years of rest (e.g., Rest-Rotation or Management-Intensive Grazing). True overgrazing is when continued grazing exceeds the recovery capacity of the plant community and causes a shift in plant composition and soil condition away from a desired community. Overgrazing normally can be attributed to heavy, repeated grazing over several years.

It can be difficult to recognize overgrazing because not all rangelands are equally productive. Differences in soils and the presences of rocky subsurface layers can create large differences in kind and amounts of plants. The differences can create visible contrasts on the landscape. Therefore, a low amount of plant biomass or large proportion of bare soil does not necessarily indicate overgrazing. The "bare spaces" are, in fact, and important characteristic of many healthy plant communities. These open spaces usually have roots from adjacent plants under the soil to harvest precipitation and support plant growth.

Example of differences in soil creating different plant communities.



Loamy Ecological Site
dominated by Big Sagebrush
and Bitterbrush
750 to 1,100 lb/ac depending
on precipitation

- - - - - - - - - - - - - - - - - - -

Shallow Stony Ecological Site
dominated by Low Sagebrush
350 to 440 lb/ac depending
on precipitation.

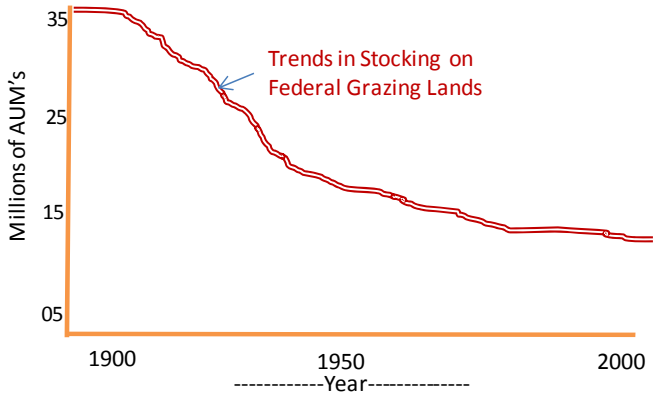
Overgrazed rangeland is often characterized by an increase in less palatable plants, increased soil erosion, increase in weedy species that thrive under disturbance, and decreased production of important forage plants. Rangeland deterioration results from animals continually and closely eating the most palatable plants until those plants are stressed so much they fail to reproduce and/or die. Overgrazing can also correspond with soil compaction or disruption of soil crusts resulting in decreased water infiltration and increased erosion. Due to the complex nature of animal preferences, areas of high preference in a pasture may experience overgrazing while other regions experience little or no use.

Range plants evolved to withstand grazing and can withstand a heavy grazing event if done in the right season and if plants are given enough time to recover after grazing. Most rangeland grasses and forbs can have 40-50% of their leaves and stems removed every year and still remain healthy and productive. In general, light use is considered less than 40%, moderate 40-65%, and heavy greater than 65% of biomass removed. The season during which the grazing occurs is very important. As described above, plants are most sensitive to grazing when they are flowering and forming seeds. After plants go dormant they are affected little by grazing. When considering effects of grazing on shrub species, one must look at the amount of usage of current year's growth – these include the leaves and young stems that are important for photosynthesis. The current year's growth of shrubs is the most digestible part of the plant and is the portion generally removed by browsing animals such as deer and goats. In winter, shrubs survive by using energy compounds (i.e., starches and sugars) stored in the stems. Thus, though the shrub is dormant, it is important to watch browsing of these stems. An indicator of overgrazing of shrubs is moderate or heavy hedging (i.e., growth of lateral stems just below a grazed point) and a lack of new or juvenile plants.

Hedging of Culleaf Mountainmahogany

Many of the signs of overgrazing seen on Idaho rangelands today occurred 75 to 125 years ago when much of Idaho was "open range" and livestock numbers were not controlled. The era of controlled and managed grazing was signified by the passing of the Taylor Grazing Act in 1934. This act was passed

to "*stop injury to public grazing lands and provide for their orderly use, improvement and development*." Idaho rangelands are in better condition today than ever before because they are now managed and monitored. A skilled rangeland manager can recognize overgrazing and take steps to correct it.



INVASIVE PLANTS

One of the most serious threats to the health and sustainability of rangeland ecosystems in Idaho is exotic invasive plants. As white settlers explored, homesteaded, and developed the West, they brought with them many plants that have colonized and taken up residence on Idaho rangelands. Some of these plants were introduced on purpose as ornamental plants, like leafy spurge and purple loosestrife. Others, like cheatgrass, came in accidentally in grains and feed. Some of the plants the people brought to Idaho have a malicious attribute of invading native rangelands, forests, and croplands, choking out the desirable native plants or crops.

Invasive Plant Terminology

The term "**weed**" can mean different things to different people. But, basically a weed is a plant in a place where it is not wanted or a plant of little value. Others describe weeds as plants that compete with crops and native plants or as troublesome pests that reduce the health of land and its value for livestock or wildlife. Ross & Lembi, in their book Applied Weed Science (1999), define weeds as "*plants that interfere with the growth of desirable plants and that are unusually persistent and pernicious. They negatively impact human activities and as such are undesirable*."

Exotic, **alien**, or **nonindigenous** plants are not native to a region and have been brought into the region either by accident or for a specific purpose. These exotic species often have an advantage over native plants because they lack the natural predators and diseases that kept them in check in their native environment. For example, spotted knapweed seldom dominates native communities in its homelands in Eurasia. In its native habitats, knapweed is naturally suppressed by insects that feed on the roots and seeds. When the plant made the trip across the ocean, these native insects were left behind. However, not all exotic plants are invasive or bad. Many plants were introduced as forages for livestock, like crested wheatgrass, or as agricultural commodities such as the plants we eat. These are exotic species but they seldom take over native rangelands and become weeds.

Invasive plants are those that exhibit "weedy" or aggressive growth characteristics. Once established, invasive species will out-compete native species and often spread and dominate wildland plant communities. Invasive species are not typical of one particular life form and can be grasses, forbs,

shrubs, or trees. Common examples of invasive plants in western North America include: cheatgrass, leafy spurge, spotted knapweed, and salt cedar. Invasive plants may persist at relatively insignificant densities for a period of time until ideal conditions occur and then the plant will spread and dominate a site. Most invasive plants of concern are exotic. However, some native plants, like western juniper, can become invasive and start to dominate plant communities.

"Noxious weed" is a specific term held for particularly problematic plants that are recognized by county, state, or federal governments as so serious that they need to be controlled or contained. **Noxious** is therefore a legal definition used to describe weeds that have been recognized by the government as injurious to public health, agriculture, recreation, wildlife, or property. Idaho state law has recognized 57 noxious weeds and requires that landowners attempt to control or contain these weeds when they occur on their property. If a landowner chooses not to take action, counties can treat the infestation, and bill the landowner for incurred expenses. See the following website for more information: www.idahoag.us/Categories/PlantsInsects/NoxiousWeeds/indexnoxweedmain.php

Why Weeds Are Bad?

Exotic invasive plants can have many detrimental effects on healthy rangeland ecosystems. The negative ecological effects can include:

- Reducing the abundance of native plants and animals – even rare plants can be displaced
- Replacing complex communities with a monoculture
- Reducing infiltration and changing the hydrologic characteristics of the land
- Increasing soil erosion and runoff
- Altering soil characteristics
- Altering fire intensity and frequency

Weeds can also have serious impacts on human activities and economics. Some weeds such as Scotch thistle and yellow starthistle can form dense, nearly impenetrable stands which reduce the value of land and inhibit recreation such as hiking and hunting. Weeds can also reduce the abundance of forage plants on rangelands thereby reducing their value for grazing. And, the cost and time spent controlling weeds and keeping them in check can seriously reduce the profitability of ranchlands.

WILDLAND FIRE

Fires are a natural disturbance that can have a positive or negative effect in the places where they occur. Wildfires are a natural part of rangelands and have helped shape the plant and animal communities that we recognize today. Fire naturally served a role in maintaining rangeland health, plant composition and diversity in many communities. Plants, animals, and insects in fire-adapted ecosystems have evolved mechanisms to tolerate or even benefit from fire. Adaptations include: long lived seeds that are activated by fire, quick germination and regrowth after fire, thick bark resilient to fire, and seed production activated by fire. For example, plants in the *Ceanothus* genus (a rangeland shrub) contain a waxy coating on the seed surface that is dependent on heat treatment from fire to break seed dormancy and promote germination. Antelope bitterbrush, rabbitbrush, and several other rangeland shrubs have adapted to sprout quickly after a fire, utilizing the increase of minerals and nutrients that are present in

the ash. Grasses often come to dominate shrublands and woodlands after fire because the woody plants are removed and the grasses are better adapted to fire.

This vast grassland landscape was created when the Murphy Complex fires of 2007 burned south of Twin Falls, Idaho and removed the sagebrush from nearly 500,000 acres. The sagebrush will one day return to this site, but it will take decades. In the meantime, the grasses and forbs will flourish.

Fire is one of nature's tools for consuming the dead and decadent biomass that can accumulate in rangeland plant communities. Most rangelands are characterized by dry climates which can slow biological decomposition – the rate at which plant material is incorporated into organic matter in the soil. Fire rapidly converts that dead and decadent plant growth into inorganic ash that frees nutrients and minerals for new plant growth. However, if fires are too frequent or intense, plant cover and organic matter at the soil surface can be reduced. Fire almost always results in a loss of nutrients through volatilization, oxidation, ash transport, and erosion. However, fires can also convert nutrients to inorganic forms that are more available to plants for growth. Fire also increases soil nutrient turnover rates and affects the distribution of nutrients in the soil horizons. Of course, the potential damage to plants and amount of dead plant material that is converted to bio-available nutrients depends on how hot the fire burned. Generally, low intensity burns increase plant productivity, while high intensity burns result in decreased productivity and plant diversity.

Wildfire versus Prescribed Burning

All fires need heat or a source of ignition, oxygen, and fuel. However, fires can occur under two scenarios: wildfire or prescribed burning. The main difference between a wildfire and a prescribed burn lies in how and when they are ignited. Wildfires could be naturally caused through lightning, or man-made through foolish actions such as improperly attended or extinguished campfires, lit cigarettes that are discarded, and arson activity. Prescribed burns are set for specific regions, at a certain time of year when the environmental conditions will accomplish desired management goals and allow containment. Prescribed burns avoid hot, dry, and windy conditions that can cause the rapid an unmanageable spread of fire which poses a serious threat to life and property.

Effects of Fire on Plants

The effect of fire on rangeland plants depends largely on the growth form (i.e., bunchgrasses, forbs, shrubs), plant adaptations, and season of burning. Many native rangeland plants are well adapted to fire, thus plants that return quickly after fire are termed "fire resistant." These plants will often have their meristems (i.e., plant growing points) located just below the soil surface so that they are not damaged by the heat of fire. This adaptation allows the plants to resprout from the base unlike less fire resistant plants that have elevated meristems which can be removed and damaged by the heat of the fire. Burning during the hot, dry, summer months is the most harmful to plants because of the high intensity fires, while late summer and fall burns are the least harmful because of increased moisture and cooler temperatures.

Fire Return Intervals

A change of fire interval (i.e., the time between fires) or improper timing of fire during the season can deplete native plant communities of desirable perennial plants. Over time, repeated burning can result in severe impacts, including loss of perennial plants, an increase in frequency of weedy plants, increased erosion, and a change in nutrient cycling. Many weedy plant species are able to take advantage of the available soil nutrients, water, and growing conditions after a fire and outcompete more desirable plants. In Idaho and many other western states, land managers are concerned about cheatgrass invasion and its ability to shorten the interval between fire events. When cheatgrass goes dormant it creates a bed of fine fuels that are easily ignited and can burn rapidly and frequently across the landscape. Perennial grasses and shrubs find it difficult to recover and grow when wildfires occur every few years which can happen on cheatgrass-dominated rangelands.

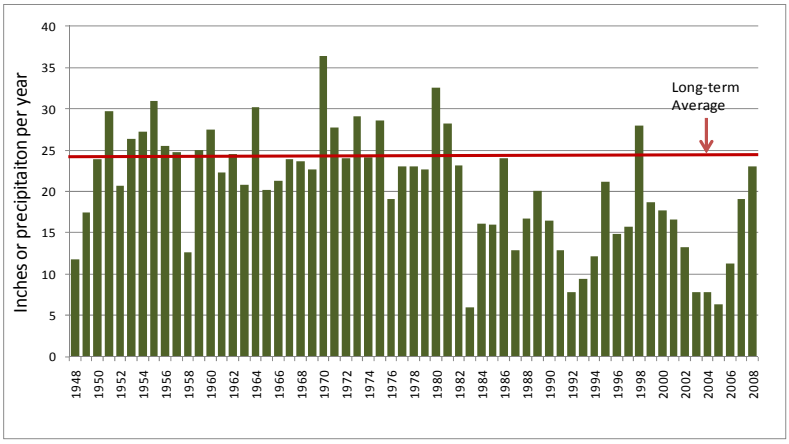
Fine fuel created by cheatgrass

Fire suppression or the exclusion of fire can also impact landscapes over time. Fire suppression policies and actions over the past century were aimed at controlling fires when they occurred on rangelands. Fire suppression can result in an unnatural accumulation of fuels that may increase the probability of large, high-intensity wildfires and pose a threat to the long-term sustainability of the ecosystem. Fire suppression has also lead to an increase in woody species, and problems with the invasion of juniper and other evergreen trees in onto rangelands naturally dominated by shrubs and grasses. Thus, a lack of fire can upset the balance between shrubs, grasses, and trees giving the trees a competitive edge to dominate landscapes.

Positive Aspects of Wildfire

Fire can have some positive implications on range livestock and wildlife management. The flush of nutritious and digestible green plant growth following fire creates patches of nutrient-rich habitat that draw domestic and wild animals. Wildfires and prescribed burns can also create patchy landscapes of grasslands, shrublands, and woodlands that provide a diversity of habitats for wildlife.

WEATHER AND CLIMATE



Weather and climate are highly influential factors determining how rangelands change over time. Water is the primary limiting resource on rangelands, and vegetation production depends heavily on water availability and suitable growing temperatures. Idaho's rangelands, while for the most part are very dry and cool, can experience great variation in moisture and temperature depending on region, slope, and aspect. Idaho landscapes vary greatly depending on their aspect and elevation which affects the amount of solar radiation and moisture loss. Precipitation that is received on a landscape each year can vary substantially from year to year. For example, on this site near New Meadows Idaho, the long-term average is about 24 inches per year. However, that annual amount can vary from 6 to 36 inches per year. In other words, there can be a 6-fold increase or decrease in the precipitation that occurs from year to year.

These vast swings in the precipitation that a site receives each year, results in massive variation in the amount of biomass that the site can produce annually. For example, biomass of grass varied from 140 to 1,090 pounds/acre on a site where crested wheatgrass biomass was measured yearly for 35 years near Malta, Idaho.

1969 –
Annual grass production = 262 pounds/acre
Annual precipitation = 10 inches

1971 –
Annual grass production = 1,090 pounds/acre
Annual precipitation = 16.5 inches

The role of global climate change on rangelands has been a topic of debate and consternation. It is clear that climate is changing. But, the specific role that climate changes will have on any specific rangeland ecosystem in Idaho is uncertain. Concerns include the role that warmer winters might play on reduced snow pack or enhanced growth of winter annuals like cheatgrass. There is also concern over weather climate change will lead to more frequent droughts or hotter drier summers that will

encourage wildfires. Still other climate models call for areas of greater precipitation and cooler temperatures in parts of Idaho. All of these changes in climate are of great concern to land managers and those who live on rangelands because it will change the type of plants and animals that will dominate an area and how invasive plants or fire might affect these sites. Unfortunately, it is almost impossible to control or predict climate and weather. Land managers are stuck with finding strategies to accomplish sustainable management in dynamic ecosystems.

FRAGMENTATION OF RANGELANDS

The western United States is experiencing rapid population growth, with many people drawn by the appeal of open space, dry climates, and an abundance of public rangelands and forests on which to recreate. The dream of many westerners is a house and a few acres of land on which to enjoy western landscapes and wildlands. "Ranchette" is a term used to describe a small parcel of land created by the splitting up of larger ranches. An increase in rural subdivision has resulted in a drastic fragmentation of rangelands in many areas. The same geographic features that make the land appealing to wildlife such as proximity to streams, gentle slopes, and timbered draws also makes the land appealing to developers and people looking to build.

Fragmentation has had several major impacts caused by the increase in roads, buildings, and human activity. Rural subdivision and fragmentation usually lead to an increase in weeds, a loss of biodiversity, and degradation of pasture lands. Wildlife still inhabit fragmented landscapes, but the species present change from specialists like moose, mountain lions, and buntings to more generalist species like deer, coyotes, and robins. Roads also become more dangerous and aversive to wildlife as the number of cars traveling on roads increases. Houses built on wildlife winter habitat prevent animals from moving down in winter months, or result in increased stress from interactions with humans and their pets. Loss of key areas such as migration corridors, wintering habitat, or nesting and breeding areas can have drastic impacts upon animals and humans.

The effects of rural subdivision on plant communities can also be devastating. Ranchettes have a higher frequency and density of exotic invasive species in comparison to adjacent ranches. Roadways and paths are areas of disturbance for invasive species to establish. Small horse pastures are frequently overgrazed and highly degraded resulting in loss of habitat, and increased soil erosion. Many rare and sensitive species who are specific to certain ecological sites may find themselves in danger.

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Glossary of Rangeland Terms

ANIMAL UNIT – Considered to be one mature (1,000lb.) cow or the equivalent based upon average daily forage consumption of 26 lbs. dry matter per day. Abbr., A.U. cf. *animal-unit conversion factor*.

ANIMAL-UNIT MONTH – (1) The amount of feed or forage required by an animal-unit for one month. (2) Tenure of one *animal-unit* for period of one month. Not synonymous with *animal-month.* Abbr., A.U.M.

ANNUAL PLANT – A plant that completes its life cycle and dies in 1 year or less.

ARID – A term applied to regions or climates where lack of sufficient moisture severely limits growth and production of vegetation. The limits of precipitation vary considerably according to temperature conditions, with an upper annual limit for cool regions of 10 inches or less and for tropical regions as much as 15 to 20 inches. cf. *semi-arid*.

BROWSE – (n) That part of leaf and twig growth of shrubs, woody vines and trees available for animal consumption. (v) To consume, browse. cf. of *graze*.

BUNCHGRASS – A grass that grows in tufts, or bunches. Its roots extend downward and outward from the base of the bunch, but do not sprout laterally like sodgrasses.

CARRYING CAPACITY – The maximum *stocking* rate possible without inducing damage to vegetation or related resources. It may vary from year to year on the same area due to fluctuating forage production. Syn. *grazing capacity*.

CLIMATE – The average weather conditions of a place over a period of years.

CONSERVATION – The use and management of a natural resources according to principles that assure their sustained, highest economic and/or social benefits without impairment of environmental quality.

CONTINUOUS GRAZING – The grazing of a specific unit by livestock throughout a year or for that part of the year during which grazing is feasible. The term is not necessarily synonymous with *yearlong grazing.*

COOL-SEASON PLANT – A plant which generally makes the major portion of its growth during the winter and early spring, because it is adapted to climates with winter precipitation and summer drought. *cf. warm-season plant*.

DECREASER – Plant species of the original or climax vegetation that will decrease in relative amount with continued *overuse*.

DEFERMENT – Delay or discontinuance of livestock grazing on an area for an adequate period of time to provide for plant reproduction, establishment of new plants, or restoration of vigor of existing plants. cf. *deferred grazing*.

DEFERRED GRAZING – The use of *deferment in grazing management of a management unit*, but not in a systematic rotation including other units. Cf. *grazing system*.

DESERT – Land that experiences extreme water shortage and unpredictable precipitation, dominated by shrubs and succulent plants such as cacti.

DROUGHT – Prolonged dry weather, generally when precipitation is less than the average annual amount.

DURATION OF GRAZING – The length of time animals graze a pasture or grazing allotment.

ECOLOGY – The study of the interrelationships of organisms with their environment.

ENVIRONMENT – The sum of all external conditions that affect an organism or community to influence its development or existence.

EROSION – (v) Detachment and movement of soil or rock fragments by water, wind, ice or gravity. (n) The land surface worn away by running water, wind, ice, or other geological agents, including such processes as gravitational creep.

FINE FUEL – Light, thin plant material with high surface area, typically grasses, that fire can easily ignite and consume quickly.

FIRE REGIME – The frequency, intensity, and severity that fire burns.

FIRE RETURN INTERVAL – The time interval between wildfire occurrences.

FORAGE – (n) All browse and herbaceous foods that are available to grazing animals. It may be grazed or harvested for feeding. Cf. *concentrating feed* and *cured* and *range forage*. (v) Act of consuming forage. Syn., *graze*.

Terms from A Glossary of Terms Used in Range Management 2nd edition, Society for Range Management, 1974.

FORAGE PRODUCTION – The weight of forage that is produced within a designated period of time on a given area. The weight may be expressed as either green, air-dry or oven-dry. The term may also be modified as to time of production, such as annual, current year's or seasonal forage production.

FREQUENCY OF GRAZING – The recurrence of grazing—how soon animals are put back in a pasture after grazing it previously. Or, how soon an animal takes a second or third bite from the same plant during a grazing period.

FORB – "Weeds and wildflowers." A broad-leaved flowering plant that is not a *grass* or *grass-like plant*, often having netted leaf veination and solid non-woody stems. These plants die back to the ground every year.

FOREST LAND – Land on which the native vegetation (potential natural community) is forest.

FREQUENCY OF GRAZING – How often or the number of times animals return to the pasture or allotment in one year or growing season.

FUEL – Living or dead plant material, which provides organic matter for fire to consume.

FUEL LOAD – The amount of fuel present on a specified land area.

GRASS – A member of the plant family *Poaceae (Gramineae*). Grass has round, hollow stems with leaves that connect to stems (jointed).

GRASS-LIKE PLANT – Herbaceous plants that look similar to grasses; members of the sedge or rush family. They typically grow in moist environments like forest floors or riparian areas.

GRASSLAND – Land on which grasses are the dominant plant cover. Syn., *grassveld*.

GRAZE – (1) The consumption of standing forage by livestock or wildlife. (2) To put livestock to feed on standing forage.

GRAZING CAPACITY – Syn., *carrying capacity*.

GRAZING PERIOD – The length of time that livestock are grazed on a specific area.

GRAZING SEASON – On public lands, an established period for which grazing permits are issued. May be established on private land in a grazing management plan.

GRAZING SYSTEM – A specialization of grazing management which defines systematically recurring periods of grazing and deferment for two or more pastures or management units. Descriptive common names of different grazing systems such as "Merrill," "Hormay," "South African switchback," etc., may be used. Cf. *deferred grazing*, *intermittent grazing*, *deferred-rotation grazing*, and *short duration grazing*.

GROWTH FORM – The characteristic shape or appearance of an organism.

HABITAT – An area that provides forage, water, cover, and space; the "home" of a species

HEAVY GRAZING – A comparative term which indicates that the stocking rate of a pasture is relatively greater than that of other pastures. Often erroneously used to mean overuse. cf. *light and moderate grazing*.

HERBACEOUS PLANT – A non-woody plant (cultivated or non-cultivated) that has leaves and stems, such as grasses and forbs.

INCREASER – Plant species of the original vegetation that increase in relative amount, at least for a time, under *overuse*.

INTENSITY OF GRAZING – The level of grazing a pasture experiences. This takes into account stocking rate, and frequency and duration of grazing.

INTRODUCED SPECIES – A species not part of the original fauna or flora of the area in question. cf. *native* and *resident species*.

INVADER – Plant species that were absent or present in very small amounts in undisturbed portions of the original vegetation of a specific range site and will invade following disturbance or continued *overuse*.

LIGHT GRAZING – A comparative term which indicates that the stocking rate of one pasture in relatively less than that of other pastures. Often erroneously used to mean *underuse*. cf. *heavy* and *moderate grazing*.

NATIVE SPECIES – A species which is part of the original fauna or flora of the area in question. cf. introduced and resident species. Syn., *indigenous*.

NOXIOUS WEEDS – A subset of invasive plants that are recognized and designated by local, state, and federal governments as requiring control or attention.

OPEN RANGE – (1) Range which has not been forced into management units. (2) All suitable range of an area upon

which grazing is permitted. (3) Untimbered rangeland. (4) Range on which the livestock owner is not required to confine his livestock.

OVERGRAZING – Continued overuse creating a deteriorated range.

OVERSTOCKING – Placing a number of animals on a given area that will result in overuse if continued to the end of the planned grazing period. Not to be confused with *overgrazing* because an area may be overstocked for a short period, but the animals may be removed before the area is overused. However, continued *overstocking* will lead to *overgrazing*.

OVERUSE – Utilize an excessive amount of the current year's growth, which, if continued, will result in *overgrazing* and range deterioration. Syn., *overutilization*.

PASTURE – (1) A grazing area enclosed and separated from other areas by fence. (2) Forage plants used as food by grazing animals.

PASTURELAND– Grazing lands, planted to primarily introduced or domesticated native forage species that receive periodic renovation and/or cultural treatments such as tillage, fertilization, mowing, weed control, and irrigation.

PERENNIAL PLANT – A plant that has a life cycle of three or more years.

PLAIN – A broad stretch of relatively level, treeless land.

POTENTIAL NATURAL COMMUNITY (PNC) – A historical term originally defined by A. W. Kuchler as the stable vegetation community which could occupy a site under current climatic conditions without further influence by people; formerly called "climax".

PRAIRIE – An extensive tract of level or rolling land that was originally treeless and grass-covered.

PRESCRIBED BURNING – The use of fire as a management tool under specified conditions for burning a predetermined area. Cf. *maintenance burning* and *reclamation burning*.

PRIMARY SUCCESSION – The process of initial plant establishment and growth upon bare rock or soil that has never had plants before—ever.

PROPER GRAZING – The act of continuously obtaining proper use.

PROPER STOCKING – Placing a number of animals on a given area that will result in proper use at the end of the planned grazing period. Continued proper stocking will lead to proper grazing.

PROPER USE – A degree and time of use of current year's growth, which, if continued, will either maintain or improve the range condition consistent with conservation of other natural resources. Syn., *proper utilization*.

RANCH – An establishment with specific boundaries, together with its lands and improvements, used for the grazing and production of domestic livestock and/or wildlife.

RANCHER – One who owns, leases, or manages a ranch.

RANGE – Embraces *rangelands* and also many *forest lands* which support an understory or periodic cover of herbaceous or shrubby vegetation amenable to certain range management principles or practices. Syn. *veld*. cf. *grazable woodland*.

RANGE CONDITION – The current productivity of a range relative to what the range is naturally capable of producing.

RANGE CONDITION CLASS – One of a series of arbitrary categories used to classify range condition and usually expressed as either excellent, good,

RANGE IMPROVEMENT – (1) Any structure or excavation to facilitate management of range or livestock. (2) Any practice designed to improve range condition or facilitate more efficient utilization of the range. (3) An increase in the grazing capacity of range, i.e., improvement in *range condition*.

RANGE INVENTORY – An itemized list of resources of a management area such as range sites, range condition classes, range condition trends, range use, estimated proper stocking rates, physical developments and natural conditions such as water, barriers, etc.

RANGE MANAGEMENT – A distinct discipline founded on ecological principles and dealing with the use of rangelands and range resources for a variety of purposes. These purposes include use as watersheds, wildlife habitat, grazing by livestock, recreation, and aesthetics, as well as other associated uses.

RANGE SCIENCE – The organized body of knowledge upon which the practice of *range management* is based.

RANGE SITE – A distinctive kind of rangeland, which in the absence of abnormal disturbance and physical site

deterioration, has the potential to support a native plant community typified by an association of species different from that of other sites. This differentiation is based upon significant differences in kind or proportion of species, or total productivity. Syn., *ecological site*.

RANGE TREND – The direction of change in an attribute observed over time, and is described as up, down, or not apparent.

RANGELAND – Land on which the indigenous vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs, or shrubs and is managed as a natural ecosystem. If plants are introduced, they are managed similarly. Rangeland includes natural grasslands, savannas, shrublands, many deserts, tundras, alpine communities, marshes and meadows. cf. *range*.

REST – Absence of grazing for the entire growing season for one year, instead of just a portion of the year.

RESTORATION – The process of a rangeland being improved in health and function after it has been degraded or largely disturbed.

RETROGRESSION – The change from a more highly developed plant community to a less developed plant community due to a physiological disturbance; *succession* that recedes from the *potential natural community*.

RIPARIAN AREA – Referring to or relating to areas adjacent to water or influenced by free water associated with streams or rivers on geologic surfaces occupying the lowest position on a watershed.

ROTATIONAL GRAZING – System of pasture utilization embracing short periods of heavy stocking followed by periods of rest for herbage recovery during the same season. Generally used on *pasture* or *cropland pasture*.

RUNOFF, SURFACE – The part of runoff that travels over the soil surface to a stream channel. Syn. *overland flow*.

RUSH – A general type of grass-like plant that has a round, solid stem and two leaves clasped around it.

SAVANNAH – A grassland with scattered trees, whether as individuals or clumps; often a transitional type between true grassland and forest. Syn. *bushveld*.

SECONDARY SUCCESSION – The development of a new plant community on a site following a disturbance.

SEDGE – A general type of grass-like plant. Instead of round, hollow stems, the stem is solid and has edges or has a triangular shape when a cross-section is viewed.

SHRUB – A plant that has persistent, woody stems and a relatively low growth habitat, and that generally produces several basal shoots instead of a single bole. It differs from a tree by its low stature and nonarborescent form.

SHRUBLAND – Land that has shrubs as the dominant plant form.

SOIL – (1) The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for the growth of land plants. (2) The unconsolidated mineral matter on the surface of the earth that has been subjected to and influenced by genetic and environmental factors of parent material, climate (including moisture and temperature effects), macro-and micro-organisms, and topography, all acting over a period of time and producing a product soil-that differs from the material from which it was derived in many physical, chemical, biological, and morphological properties and characteristics.

STOCKING RATE – The relationship between the number of animals and the grazing management unit utilized over a specified time period. May be expressed as animal units per unit of land area (animal units over a described time period/area of land). *cf. stocking density*.

SUCCESSION – The concept that vegetation communities change throughout time until a relatively stable plant community persists.

TARGETED GRAZING – "Prescription grazing." A special grazing system that involves the application of livestock grazing at a specified season, duration and intensity to accomplish specific vegetation management goals of reducing weeds.

UNDERSTOCKING – Placing a number of animals on a given area that will result in *underuse* at the end of the planned grazing period.

UNDERUSE – A degree of use less than desired.

UNDESIRABLE SPECIES – (1) Species that are not readily eaten by animals. (2) Species that conflict with or do not contribute to the management objectives.

USE – (1) The proportion of a current year's forage production that is consumed or destroyed by grazing animals. May refer either to a single species or to the vegetation as a whole. Syn., *degree of use*. (2) The putting of range to a purpose such as grazing, bedding, shelter, trailing, watering, watershed, recreation, forestry, etc.

VEGETATION – Plants in general, or the sum total of the plant life above and below the ground in an area. cf. *vegetative*.

WARM-SEASON PLANT – A plant which makes most or all of its growth during the spring, summer, or fall and is usually dormant in winter.

WATERSHED – (1) A total area of land above a given point on a waterway that contributes runoff water to the flow at that point. (2) A major subdivision of a drainage basin.

WILDLIFE – Undomesticated vertebrate animals considered collectively, with the exception of fishes. cf. *game*.

WOODLAND – Land dominated by widely-spaced trees including junipers, oaks, mesquite, and pines, with an understory of grasses and forbs.

YEARLONG GRAZING – *Continuous grazing* for a calendar year.

Effects of Urbanization on Natural Systems

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Understand urban system characteristics.
- Understand and explain the practices and effects of urbanization in natural systems.
- Describe the effects of channelization in urban systems.
- Describe the three broad plant categories in urban systems and the threats to them because of urbanization.
- Describe the fauna of urban systems and the effects of urbanization on these species
- Become familiar with the Best Management Practices (BMP's) for urban areas.

Introduction

Urbanization affects many aspects of natural systems. No matter the level of urbanization that occurs, soils, temperature, hydrology, nutrient cycling, vegetation, and wildlife are altered. This alteration of natural systems can have negative consequences, but not always. There are things we can do to help mitigate the negative effects of urbanization.

An example of the wild land-urban interface is a house adjacent to Forest Service land.
Photo by Bob Nichols, USDA photo center

Urban Zones

Urban areas have been categorized into three zones. **The Rural-Urban interface** is prevalent in Idaho. This zone has disturbed the natural systems the least. There is potential for maintaining relatively natural systems in this zone. For example, it is the best zone for maintaining naturally occurring wildlife because native plants, waterways and space still exist. This zone consists of large lots, or ranchetts. Development is dispersed and often thought of as "country living."

Suburbia is more developed than the rural-urban interface zone. One or two family homes with schools, churches, hospitals, parks and cemeteries characterize this zone (Bolen and Robinson, p. 378). Many neighborhoods in Idaho's towns fit this description, on the outskirts of a larger

metropolitan area, or smaller towns. Most natural systems are disturbed in the suburban landscape. However, wildlife can still exist as remnants of former population and diversity levels. These areas may be dominated by large numbers of just a few species, such as geese, and sometimes non-native animals like starlings, pigeons, and house wrens. This zone represents an area of great potential for wildlife. Backyard habitat programs encourage residents of suburban areas to landscape with native plants and provide nesting boxes and platforms for wildlife. Urban wildlife managers strive for a balance of enticing wildlife to urban areas to meet the needs of people who want and need wildlife and controlling the damage some wildlife can create on personal property. Suburbia can be an especially challenging area for this balance.

A Boise, Idaho subdivision

Idaho Department of Fish and Game's *Backyard for Wildlife* leaflet is an excellent resource to learn more about how to enhance your backyard or office building landscaping to attract native wildlife.

Metropolitan Centers are few in Idaho. As you can imagine, they modify natural systems to a large degree. Open space, parks, and greenbelts are often planned in urban centers to help maintain some natural systems, or at least the appearance of natural systems.

Downtown Boise, though not far from natural habitat, provides little food, water, and shelter for wildlife.

How Urbanization can affect Soils

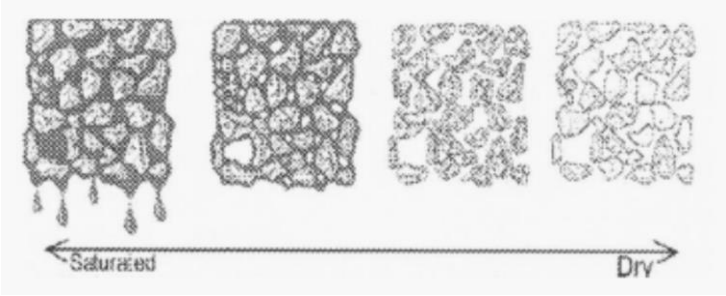
The soils of urbanizing systems are the same as those of the natural systems that exist in the area. The important thing to examine is what happens to our soils during the process of urbanization.

Grading/Scraping

Grading/scraping is one of the most visible effects urbanization has on local soils. New developments often bring in heavy equipment and begin "sculpting" the land to meet project needs. At the low-impact end, this may involve moving soil around and mixing up horizons. At the high-impact end, it may involve completely removing the topsoil and depositing it elsewhere. Removing topsoil eliminates the layer containing organic matter and its associated microbes. It is the organic matter and associated organisms that help make the soil productive. Removing topsoil devastates the soil community.

Compaction

A less visible, though equally damaging, process that happens to urban soil is compaction. Healthy soil is loose and contains many voids, or pockets, filled with air or water. Compaction occurs when anything applies sufficient pressure to the soil to compress these air pockets. Foot traffic compacts soil to a degree. Riding lawn mowers compact the soil to a larger degree. Automobiles compact the soil even more. Bulldozers, road graders, etc. are called heavy equipment for a reason. They are heavy! They cause a great deal of soil compaction.



Pockets between soils may be filled with water or air.

Why is this damaging? Air pockets in the soil provide the oxygen that roots and microorganisms need to function. (It is true that trees take in carbon dioxide through their leaves. However, roots need oxygen to survive.) Without oxygen in the soil, life begins to die. Roots often have a difficult time penetrating and surviving in compacted soil.

Soil compaction not only affects the life in the soil, but also its absorption potential. Loose, aerated soil, with extensive root systems, absorbs a great deal of runoff. When soil becomes compacted, it becomes relatively impervious. Roots can no longer thrive. Water can no longer infiltrate the soil. The result is increased runoff. Water that was once taken up by plants and evapotranspirated, or captured and stored as groundwater, is lost.

Erosion and Sedimentation

Due to construction, urban soil is often left exposed to the elements for extended periods. Wind, rain, and ultraviolet radiation all take their toll on the soil. Wind and rain erode the soil. UV radiation kills the living organisms.

Contaminants

In addition to grading, compaction, and exposure, other urban practices damage the soil. Several homeowners were having problems growing plants in certain areas of their yards. The homeowners were completely puzzled until they dug down and found the contractor who built their homes apparently buried all the scrap mortar, bricks, lumber, etc. in their yards!

Best Management Practices (BMPs) for Urban Soil

Grading and scraping

This will inevitably remain a part of the urbanization process. However, we can work to ensure that it is kept to a minimum. We can also work to require developers to stockpile topsoil and redistribute it once the construction is complete.

Compaction

To reduce or reverse the effects of compaction, we can mechanically aerate the soil. By planting native plants, we can use their extensive root systems to break up the packed soil. We can further aerate the soil by encouraging the growth of soil microorganisms and invertebrates. We can prevent or reduce compaction before it occurs by putting down a 6-8" layer of shredded tree trimmings in areas where there will be pedestrian or vehicular traffic.

Exposure

We can eliminate the impacts of exposure by reducing the amount of soil that is denuded and by mulching all soil that is bare.

Contaminants

We can reduce the contaminants in soil by eliminating toxic pesticides, herbicides, and salt-based fertilizers. We can work to implement stricter controls on developers. We can stop them from burying their construction rubble (scrap mortar, bricks, lumber, etc.) in yards and contaminating the soil.

How Urbanization Can Affect Temperature

Altered Temperature

In urban areas, we see a proliferation of concrete and asphalt as well as a reduction of vegetative cover. This change in the physical character of the land affects ecological factors including the local temperature. Have you ever noticed on the news that the temperatures are generally higher in the city than in the outlying areas? In fact, urban temperatures are on average 1-6 degrees higher than outside the city (Landsberg 1981, and Herold 1991). It is because of this that urban areas are said to be “heat islands.” Two primary factors contribute to this phenomenon.

One contributor to the heat island effect is the urban "hardscape." Concrete and pavement capture heat from the sun and radiate it into the atmosphere well after the sun goes down. This not only increases local temperatures, but also makes them more stable during a 24-hour period.

The other major contributor to the heat island effect is the reduction of vegetation. Reducing vegetative cover does two things. First, it reduces shade. This allows for more of the sun's energy to strike the urban hardscape, and be radiated back into the atmosphere. Secondly, reducing vegetative cover reduces evapotranspiration. Plants lose water to the atmosphere as they transpire. This evaporative process cools the surrounding air. When the vegetation is gone, the cooling effect is gone.

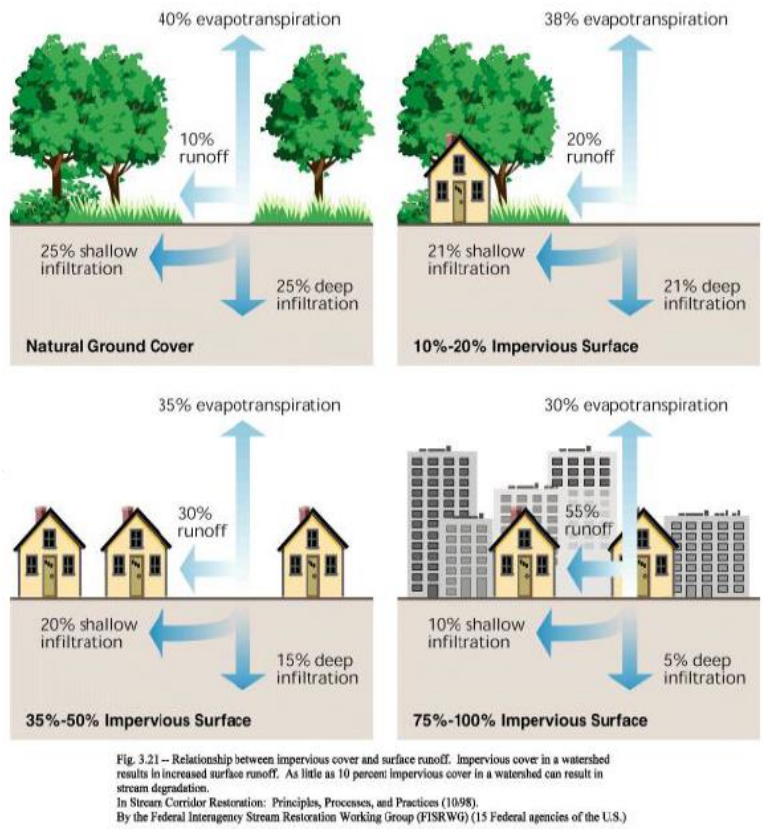


Fig. 3.21 -- Relationship between impervious cover and surface runoff. Impervious cover in a watershed results in increased surface runoff. As little as 10 percent impervious cover in a watershed can result in stream degradation.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
By the Federal Interagency Stream Restoration Working Group (FISRWG) (15 Federal agencies of the U.S.)

Diagram courtesy of The Federal Interagency Stream Restoration Group

BMPs for Altered Temperature

The primary way to reduce this effect of urbanization is to reduce the amount of hardscape (concrete, etc.) allowed and by shading that which is allowed with native vegetation. This one practice would go a long way toward reducing the "heat island" effect.

How Urbanization Can Affect Hydrology

The hydrological cycle can be greatly disturbed in urban areas. Many of the changes occur because of impervious surfacing. Rooftops, parking lots, streets, sidewalks and compacted soil all restrict or eliminate infiltration of water into the soil. Precipitation that once was absorbed into the soil and replenished groundwater supplies now hits these impervious surfaces and becomes runoff. Groundwater supplies diminish while surface runoff is increased.

Groundwater supplies are important because they are often what keep streams flowing during dry times of the year. When excessive, impervious surfacing interrupts the groundwater recharge

process, streams are affected. Because of this interruption, some urban streams are flooded during rainy seasons and go dry when the rains stop.

Contaminants

Urban water is often contaminated by point and nonpoint source pollution. Point source pollution can be traced to a specific point. For example, discharge from a factory. This type of pollution is easy to monitor and control.

Non-point source pollution is that which seems to have no specific point of origin. Rather, it comes from many different sites throughout the watershed. Examples of non-point source pollution are fertilizers and pesticides from yards, petroleum residues from streets and parking lots. Acid rain does not fall just in cities.

As runoff travels across yards and paved surfaces, it picks up contaminants and carries them to the nearest watercourse. Contrary to popular belief, water that enters storm drains does not usually get treated before it enters streams. Sometimes it does, at least through swales, etc. Consequently, streams and lakes contain contaminants.

Although chemical contaminants are a problem in urban streams, ponds, and lakes, they are not the only problem. Increased sediment loads are also a problem. Runoff picks up sediment (from erosion) and carries it into watercourses. The increased volume and velocity of water in streams caused by increased runoff also scours the stream banks, releasing more sediment. Sediment increases the turbidity (cloudiness) of the water. This alters the light penetration level that, in turn, affects the aquatic vegetation. Sediment may also be deposited on the bottom of streams and ponds, covering gravel beds, adversely affecting wildlife.

Sediment in water also increases the temperature of the water due to the sun's ability to absorb darker colors more easily. As water temperature increases, the ability of that water to hold dissolved oxygen decreases. This can be deadly to some fish.

Channelization

To deal with some of these problems, many cities have channelized their streams.

Channelization usually involves removing trees and other vegetation from the stream bank, then sculpting the bank into a smooth, straight channel. This channel may then be seeded with grass or worse yet, lined with concrete. Converting natural streams into concrete channels accomplishes two things. First, a concrete channel conveys more water, more quickly than a natural stream does. Second, lining the channel with concrete separates the water from the soil, thus reducing erosion at a particular site. Channelizing a stream can be useful, but it has problems.

- *Stream Channelization removes the native riparian (streamside) vegetation.* This eliminates habitat for wildlife such as beavers, amphibians, kingfishers, herons, etc. that depend on that vegetation.

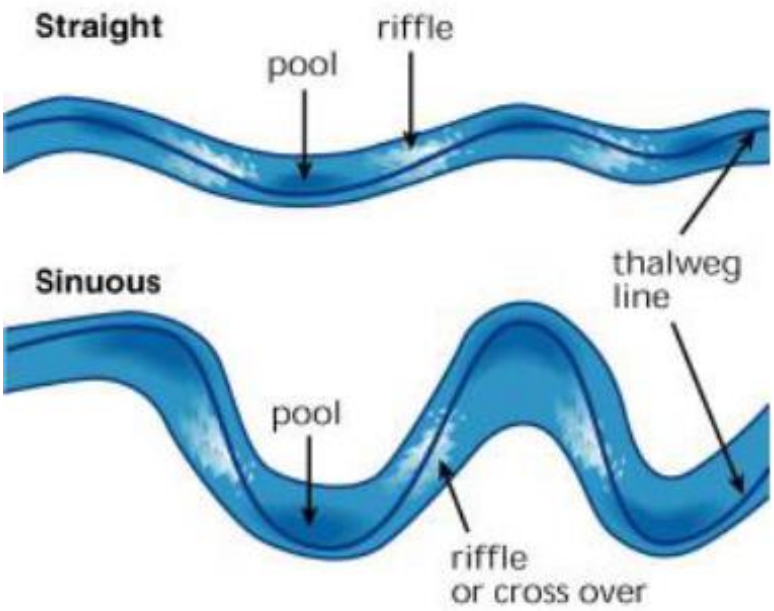


Fig. 1.33 – Sequence of pools and riffles in (a) straight and (b) sinuous streams. In Stream Corridor Restoration: Principles, Processes, and Practices (10/98). Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).

  Replacing vegetation along streams with concrete eliminates the natural beauty of the stream. Since people prefer to live adjacent to natural areas, (Lane 1991, Adams, Dove, and Leedy 1984) property values tend to be higher. In Wichita, Kansas, lots bordering a wetland sold for 50% more than comparable lots away from the natural area (Ferguson, 1998). Natural areas provide natural beauty. Once that natural beauty is removed, property values are adversely affected.

  Removing the native vegetation along streams eliminates the water polishing ability of the vegetation. It has been widely documented that aquatic vegetation locks up excess nutrients and contaminants found in the water. Wetlands, planted with aquatic vegetation, are currently being used to clean up or polish wastewater (APWA 1981, Hammer 1997). By removing riparian vegetation, we remove its polishing abilities.

  Removing the vegetation along streams removes the cooling effect that shade has on the water. Water that flows down a shadeless concrete channel becomes overheated by the sun, resulting in low dissolved oxygen levels and a reduced capacity for supporting life.

- *Stream Channelization eliminates pools and riffles.* Natural streams usually have a pattern of pool and riffles. Pools are deeper sections with slower flowing currents. Riffles are shallow, with faster currents. These habitats support different plant and animal species. Channelizing a stream destroys these habitats along with the plant and animal species that depend upon them.

- *Stream Channelization harms the food web.* Most stream systems rely on organic material carried in from outside the system to form the basis of the food web. Channelization eliminates some of this transfer.

- *Stream Channelization increases water velocity.* The smooth concrete sides of the stream channel increase the velocity of the water in the channel (Riley, 1998).

- *Stream Channelization eliminates infiltration.* The concrete lining of the channel separates the water from the soil. As water passes down the channel, it is not allowed to infiltrate the soil. Therefore, the amount of water in the channel is actually increased as more is added and none is allowed to infiltrate the ground (Riley, 1998).

- *Stream Channelization increases downstream flooding and erosion.* At some point, the water, with increased velocity and volume, has to be discharged from the channel. When this happens, the area downstream from the channel may be flooded and scoured during peak flows.

- *Stream Channelization increases danger.* Swiftly moving water rushes down these smooth-walled channels.

Water Temperature

The sun heats water in shadeless concrete channels. Parking lots, rooftops, and streets all become very hot during the summer. Runoff, travelling across these surfaces also becomes heated. This heated water enters the streams raising stream temperatures. Populations of invertebrates and other wildlife can be affected by a change of only a few degrees in the water temperature.

BMPs for Altered Hydrology

This is a complex problem that will require a complex, holistic solution.

- *Reduce impervious surface* - Cities must begin to restrict the percentage of impervious surface that a development can have. By doing this, and by aggressively pursuing alternatives to impervious pavement, we can reduce the amount of runoff that is generated.

- *Detention / retention ponds* - We can require developers to deal with runoff they generate on-site. The city of Austin, Texas requires developers to install detention ponds to accommodate the runoff that they generate. It is a start. However, it may not be the best solution. By requiring developers to install a series of swales and retention/detention ponds, we can create wetland habitat and recharge the groundwater supplies while simultaneously accommodating the runoff generated on site.

- *Aquatic vegetation* - We should encourage aquatic vegetation around the edges of ponds. This will not only filter impurities from the water before it reaches streams, but will also provide food and shelter for aquatic wildlife.

- *Regional stormwater wetlands* - We cannot only require developers to deal with their runoff in this way, but entire cities can develop stormwater wetlands to deal with increased urban runoff. These facilities are effective, inexpensive, and create habitat/open space at the same time. For a detailed discussion of creating stormwater wetlands, see *Creating Freshwater Wetlands 2nd ed.* by Donald Hammer or *Integrating Stormwater into the Urban Fabric* (Conference Proceedings). For design specifications for the city of Austin, Texas see Glick and Chang (1998).

- *Upland buffers* - There are benefits to allowing aquatic plants to grow in and around the edges of urban ponds. There are also benefits to maintaining upland buffers of vegetation. These buffer zones provide critical habitat for wildlife associated with the pond, not necessarily in the pond. These zones also help filter runoff before it reaches the pond.

- *Reduce contaminants* - Beyond filtering, we can reduce the damage to water quality by reducing or eliminating contaminants, reduce or eliminate toxic pesticides and herbicides, use organic fertilizers, and use less toxic cleansers.

- *Eliminate channelization* - Channelization is extremely damaging and should be eliminated! It should be replaced by bioengineering methods that use a combination of native plants and manmade design to stabilize stream banks. These methods fix erosion problems and eliminate all of the problems that channelization creates. For a detailed discussion of these techniques, see *Biotechnical and Soil Bioengineering Slope Stabilization: A Practical Guide for Erosion Control*, by Donald Gray and Robbin Sotir, or *Restoring Streams in Cities: A guide for planners, policymakers, and citizens*, by Ann Riley.

- *Encourage prairies* - Prairies have a tremendous capacity to absorb runoff. By planting prairie restorations in currently mowed areas, we can greatly increase the absorptive potential of the land. This will reduce runoff while simultaneously reducing maintenance and providing wildlife habitat.

How Urbanization Can Affect Organic Cycling

Natural ecosystems constantly recycle nutrients. Some urban practices short-circuit this critical process. Grass, leaves, logs, and other organic matter that would ordinarily be recycled are raked,

bagged, and hauled away. These practices remove nutrients and trace minerals from the system. Many people fertilize their property to make up for missing nutrients and trace minerals. Unfortunately, commercial fertilizers can end up in surface runoff, particularly if not applied correctly, and they do not always replace all the nutrients and trace minerals the plants need. This adds to watershed pollution.

BMPs for Altered Organic Cycling

The best ways to deal with altered organic cycling is to re-instate the natural processes of decomposition. Use a mulching mower and allows grass clippings and leaves to decompose where they lay, or compost them and return them to the soil from which they came. In addition to recycling organic matter on site, use organic fertilizers, if needed. These fertilizers are healthier for the soil and do not contain the potentially harmful salts others have.

How Urbanization Can Affect Vegetation

Understory Clearing

The understory is the shrub/ground layer of a plant community. The shrub layer and bottom limbs of trees are commonly removed in urban areas. There may be good reasons to clear understory. Creating play areas for pets and children, protecting your home against wildland fire, and controlling pests might be a few reasons to clear the understory. However, understory may often be cleared just because it is common to do so. There are benefits to keeping understory in place. Wildlife can thrive in the understory.

Many homeowners are concerned about shrubs hiding criminals. Others like the aesthetic of a more open understory. These concerns and values should be balanced with their understory's value to urban ecology.

Fragmentation

Roads, homes, trails, and utility easements all cut into habitats, fragmenting them. Corridors, fragments, and barriers are all related. A strip of woodland stretching across grassland to connect two forest fragments acts as a travel corridor for the woodland species. It also acts as a barrier, which fragments the grassland habitat.

Edge Created

As habitat is fragmented, "edge" is created. The zone where two biomes (or habitat types) meet is termed the "edge." For every home or ball field built, every road cut, edge is created. This effect can have significant impact on wildlife.

Restoring Natural Vegetation in Urban Systems

What natural vegetation would be growing where you live if your home were not there? In many cases, planting native shrubs, grasses, shrubs, and other species requires less additional irrigation and fertilizer and helps wildlife. Local Extension offices can recommend native landscaping materials for your site, and direct you to places where they can be obtained.

BMPs for Altered Vegetation

- *Understory* - We simply must stop clearing understory! This practice is much too damaging to our forests and their associated wildlife to allow it to continue. We must educate neighbors, city employees, and law enforcement officials about the value of this layer of the forest. We must work tirelessly to protect and restore understory in our cities.

- *Fragmentation* - We can work with homeowner's associations, city planners, and private landowners to minimize fragmentation, create and maintain habitat corridors that connect existing fragments of habitat.

- *Edge* - We can work with planners, city officials, developers, and others to locate trails, roads, etc. where they reduce fragmentation and the resulting edge habitat.

Flora of Urban Systems

As an area undergoes urbanization, a pattern begins to emerge which categorizes plant communities into three broad categories (Adams, 1994). These are; natural remnants, derelict lands, and planted communities.

Natural Remnants

Despite urbanization, remnants of the natural vegetation often persist in pockets or patches within the city. These remnants retain the characteristics of the native plant community that existed before urbanization and are often blessed with a diversity of species and physical layering. These remnants face many threats once they become surrounded by urbanization.

- *Fragmentation* - As these patches become smaller and the distance between patches becomes larger, pollination and dispersal of species becomes increasingly difficult. In addition, as naturally vegetated remnants are carved up, specimens that were once found within the fairly protected interior must now deal with the harsher conditions found at the edge of the habitat (wind stress, increased temperature fluctuations, etc.).

- *Altered hydrology* - Urbanization affects the local hydrology. This inevitably affects the hydrology of the natural remnant plant communities persisting in urban areas. Species that can tolerate the change may persist. Those that cannot, disappear.

- *Exotic species* – Exotic species often spread from surrounding neighborhoods to take over the remnants. Common exotics found in our Idaho's natural systems include:

  - Musk Thistle
    Carduus nutans
  - Orange Hawkweed
    Hieracium aurantiacum
  - Perennial Pepperweed
    Lepidium latifolium
  - Perennial Sowthistle
    Sonchus arvenis
  - Poison Hemlock
    Conium maculatum
  - Puncturevine
    Tribulus terrestris
  - Purple Loosestrife
    Lythrum salicaria
  - Rush Skeletonweed
    Chondrilla juncea
  - Russian Knapweed
    Acroptilon repens
  - Yellow Toadflax
    Linaria vulgaris
  - Black Henbane
    Hyoscyamus niger
  - Buffalobur
    Solanum rostratum
  - Canada Thistle
    Cirsium arvense
  - Common Crupina
    Crupina vulgaris
  - Dalmatian Toadflax
    Linaria genistifolia ssp. *dalmatica*
  - Diffuse Knapweed
    Centaurea diffusa
  - Scotch Broom
    Cytisus scoparius
  - Scotch Thistle
    Onopordum acanthium
  - Silverleaf Nightshade
    Solanum elaeagnifolium
  - Skeletonleaf Bursage
    Ambrosia tomentosa
  - Spotted Knapweed
    Centaurea stoebe ssp. *micranthos*
  - Syrian Beancaper
    Zygophyllum fabago
  - Tansy Ragwort
    Senecia jacobaea
  - Toothed Spurge
    Euphorbia dentata
  - Yellow Starthistle
    Centaurea solstitialis
  - Hoary Cress
    Lepidium draba ssp. *draba*
  - Houndstongue
    Cynoglossum officinale
  - Japanese knotweed
    Polygonum cuspidatum
  - Johnsongrass
    Sorghum halepense
  - Jointed Goatgrass
    Aegilops cylindrica
  - Leafy Spurge
    Euphorbia esula
  - Matgrass
    Nardus stricta

- Dyer's Woad
  Isatis tinctoria
- Eurasian Watermilfoil
  Myriophyllum spicatum
- Field Bindweed
  Convolvulus arvensis
- Giant knotweed
  Polygonum sachalinense
- Meadow Hawkweed
  Hieracium caespitosum
- Meadow Knapweed
  Centaurea debeauxii ssp. *thuillieri*
- Milium
  Milium vernale

Vacant Lots / Derelict Lands

These properties can be found along fence lines, roads, in neighborhoods, etc. They have been disturbed by construction at some point so succession has been set back. Therefore, these lands are characterized by invasive exotic species (such as those listed previously) and native pioneer species (such as Ragweeds).

There are several problems with these types of lands. First, like remnants, they are often small patches of habitat that are disconnected. They are often low in biodiversity with some of the plant species (Ragweeds) producing copious amounts of allergens. Because of neglect, they are often "weedy" in appearance.

Planted Communities

This category of vegetation represents the majority of the urban area. It is largely artificial. The landscape is usually highly structured requiring extensive maintenance to keep it that way. The use of exotic species in traditional landscaping is most common. Many of these species come from Europe and Asia. As a result, these landscapes often require a great deal of water, fertilizer, and pest management.

Typical Landscape Structure

Most every home or business will have a row of evergreen hedges around the perimeter of the building. These are called "foundation plantings." Unwanted views will usually be "screened" with a row of evergreen hedges as well. Large shade trees may have grass beneath them, or a groundcover of some type. Often, you will see a flowerbed at the base of trees. Throughout the landscape, there are often beds designed to contain flowering perennials to add color. But quite frequently, the landscape is dominated by vast expanses of mowed grass.

Turf grass is a non-native species and provides very little for most native wildlife species. Lawns like this one require water and fertilizer to keep it green. Water being pumped out of rivers to irrigate lawns, and the use of fertilizers, are both harmful to wildlife.

Why does our society seem to be in love with the monotonous, sterile lawn? To understand this affinity for the lawn, we must examine our culture's history. According to Warren Schultz's book *A Man's Turf; The Perfect Lawn* (1999), small strips of lawn began to show up in formal gardens in Europe during the 17th and 18th centuries. It was also during this time that vast expanses of short grass began to show up in the European countryside. Originally, these vast expanses of grass were kept grazed by flocks of sheep. The larger the expanse, the more sheep the landowner had. The more sheep he had the wealthier he must have been. Therefore, vast expanses of short grass became a symbol of wealth and power.

Many of the early colonists that came to the U.S. came from this cultural influence. George Washington was one of the first to install a lawn around his home (Schultz, 1999). However, the lawn was still not a common sight. It was primarily for the rich. The lawn, as we know it today, did not start to become popular until the late 1800's. The development of "improved" turfgrass varieties were pushed by the golf industry, which was in its infancy at this time. This, combined with the invention of the lawn mower, made the lawn available to the common homeowner. The lawn became a "transition zone" from the hard street to the softer and more welcoming living room. The lawn today has come to be a symbol of territory creating a sort of a "green moat" around our homes. Schultz (1999) says that a well-kept lawn has come to indicate that the man of the house is powerful, in control of nature, and is taking care of business at home. He also states that a well-kept lawn announces to our neighbors that we are abiding by the rules of society. These messages and practices would be acceptable, if traditional landscaping was ecologically sensitive, or even neutral, but it is not. Traditional landscaping creates many ecological problems.

- *Exotics* – As discussed earlier, exotics are often used in traditional landscapes. To survive, these exotics require maintenance that is more intensive. Some may escape into our natural systems and become invaders, upsetting the species composition of those systems.

- *Pollution* – Traditional landscaping requires extensive maintenance. This maintenance significantly increases the pollution in our urban areas. Running a lawn mower for one hour releases as much hydrocarbon into the air as driving a car for 11.5 hours (Schultz, 1999). In addition to the increased atmospheric pollution, traditional landscaping practices significantly decrease our water quality. According to Schultz (1999), 70 million pounds of chemicals are applied to lawns in the U.S. each year! The majority of these chemicals are washed into our local streams and reservoirs.

- *Increased demand on water supplies and facilities* - Exotic landscapes require more water than native ones. This increase in demand puts more pressure on water supplies

than is necessary. The increased levels of toxins in water increase the demand on water treatment facilities.

- *Loss of habitat* - As exotics replace native plants in the landscape, habitat is lost. As native plants are lost, food sources and shelter are lost. The practice of removing the emergent vegetation along the edges of urban ponds eliminates entire populations of wildlife.

Overall results of these practices cause habitat in urban areas to be simplified. At worst, it is completely destroyed. However, the history of our landscapes may not be the future. In the words of Schultz (1999), "The lawn will shrink, no doubt about it, and be replaced by meadows, prairies, woodlands, and hardscaping." What do you think?

BMP's for the Flora of Urban Systems

- *Natural Remnants and Derelict Lands* - The BMP's for these two categories can be discussed together. First, these lands should be protected from development and fragmentation by any means possible. They provide valuable open space within the urban fabric. Second, these lands need management. Exotics that have escaped into these areas should be removed and the natural plant community should be replaced where it has been lost. Third, these areas need to be used in educational programs so that the public understands their value and appreciates them.

- *Planted Communities*

    - Reduce lawn - Vast expanses of lawn are low in biodiversity yet they are economically and ecologically costly. In 1990, there were 30 million acres of lawn in the U.S. The average 26 Urban Systems cost per year to maintain an acre of lawn is $327.00 (Schultz, 1999). The average cost to maintain lawns in the U.S. each year is around 9.8 billion dollars! According to Schultz (1999), there are 70 million pounds of chemicals applied to lawns each year! The best way to reduce these costs is to reduce the amount of lawn in our landscape.

    - Use natives - Using plants native to the local ecological region helps reduce cost of maintenance while providing wildlife habitat. Natives require little to no fertilizer or pesticides. Once established, they require little to no supplemental water as well. Natives can be used in the home landscape, or they can be used to recreate or restore entire plant communities such as prairie plots or native woodlands.

- Leave snags - As you now know, snags are as important to the forest and its associated wildlife as living trees. Therefore, these landscape features should be retained

Fauna of Urban Systems

All of the practices and characteristics of traditional urbanization exert pressure on wildlife populations resulting in radical, yet predictable shifts in the species composition.

Altered Species Composition

We have discussed the soil, vegetation, hydrology, and ecosystem processes in urban areas are disturbed. These perturbations change the environment and the wildlife capable of surviving there. As traditional urbanization occurs, some predictable shifts in wildlife populations emerge.

- *Predators* **-** Traditional urbanization selects for small, adaptable predators. As mentioned earlier, urbanization fragments habitat. Large portions of intact habitat decrease or are lost entirely. Large predators require large territories to hunt. As habitat is lost, they decrease. In contrast, small, adaptable predators (such as raccoons or coyotes) actually increase in numbers. These predators do not require large territories and often find ample prey (rodents, pets, bird eggs) in cities.

Raccoons are generalists and thrive in urban settings.

- *Generalists* **-** As a rule, specialists decline in urban areas. Specialists are those species that have very strict requirements (such as diet or nesting site specifications) for survival. As traditional urbanization alters our natural systems, specialists cannot adapt. Generalists, on the other hand, are capable of adapting. Because of decreased inter-specific competition, reliable food supplies, etc., generalists not only survive in urban areas, but also do very well.

- *Exotics* **-** Exotic species that thrive in our cities are generalists. As their numbers increase, they can even begin out-competing native species. European Starlings, Pigeons, and European (House) Sparrows are all non-native birds that thrive in an urban environment.

- *Edge Species* **-** Habitat often is fragmented in urban areas. This increases edge habitat while reducing interior habitat. A corresponding shift in wildlife follows. Those that prefer edge habitat increase.

The European Starling is an example of an exotic generalist in an urban setting.

- *Granivores/Omnivores* - Along with all of the other shifts, similar shifts can be seen according to feeding preference. Generalists are usually omnivores, so they increase. Urbanization allows another group to increase. Many people have provided birdseed for many years. The result is an increase in granivores (seedeaters), (Adams, 1994).

- *Effects on Behavior* - It is not only the species composition that is affected by traditional urbanization. Behavior is affected as well. As artificial food (birdseed, trash, and pet food) increases, the need for traveling large distances to eat decreases. This results in smaller home ranges for many urban species (see Adams, 1994 for a summary of pertinent literature). As discussed earlier, urban environments are "heat islands" and are warmer in the winter. This stability of temperature allows for longer breeding seasons (see Adams, 1994 for a summary of pertinent literature).

- *Wildlife Conflicts* - Because generalists do very well in urban areas, they will often reach population densities higher than densities found in rural areas (Adams, 1994). As these densities increase, conflicts between humans and wildlife are bound to occur. A wild animal may become a problem if it takes up residence in an attic or beneath a house. Wild animals and pets may not get along. To avoid problems, it is usually enough to eliminate food supplies or shelter opportunities that attract the offending critter. Do not leave pet food out overnight. Secure trash can lids. Seal all outside access points to the attic or under the house. Trapping and relocating the animal does not work. Research shows that the relocated animal will most likely die (Adams and Leedy, 1991). If the situation that allowed the animal to become a nuisance is not corrected, a "new" critter will simply replace the "old" one. If these simple suggestions do not eliminate the conflict, see Living with Wildlife by Diana Landau and Shelley Stump and The Humane Control of Wildlife in Cities and Towns by Guy R. Hodge for additional help solving wildlife problems.

BMP's for Urban Fauna

The goal for implementing BMP's for urban fauna is to increase densities of some species of wildlife while limiting the densities of others. This can often be tricky. In general, this can be accomplished by increasing natural food sources and shelter opportunities while eliminating or reducing manmade ones. To do this, these suggestions are offered:

- *Do not provide supplemental food* - By throwing out food scraps, you are feeding overpopulated wildlife. Species like raccoons, skunks, grackles, etc. love to get supplemental food. To help limit their numbers, do not provide supplemental food.

- *Do not provide accidental food* - Accidental food includes pet food, spilled birdseed, and trash. Take precautions (secure lids to trash, clean up bird seed, store seed and pet food in side, do not leave pet food in the dish overnight) to ensure that this type of food

is not available. Only the overpopulated species use these food sources. Eliminating these sources will help limit their populations.

- *Do provide natural food* - Plant native plants! Food sources, such as berry-producing shrubs, flowers, etc., attract wildlife that is not overpopulated in urban areas.

- *Do not provide accidental shelter* - Accidental shelter includes attics, sheds, under houses, etc. The species that use these shelter opportunities are not the ones we need to be helping. Seal all openings and not allow access.

- *Do provide natural shelter* - Plant native plants! Native vegetation and snags provide shelter for native wildlife that we want to attract.

- *Provide a variety of water* - Water attracts all types of wildlife. Be sure to provide various types water features in different parts of the landscape. Provide a small pond, with moving water, in one area and a birdbath in another, etc. Doing this will increase the diversity of wildlife that can use your landscape.

- *Actively manage pest species* - Pest species include non-natives as well as a few prolific natives. Do not allow Starlings or House Sparrows to nest or feed in your landscape. Physically remove their nests and use feeders that do not allow them to feed. Do not allow rodents to live in your home. They are not the native ones. Trap them and eliminate them. Prolific natives, such as grackles, like to have canopy trees with mowed lawn beneath them. Landscape your yard so these natives do not prefer your yard. By reducing the populations of pest species, and increasing the populations of others, we will increase the wildlife diversity and have much healthier populations overall.

References and Credits

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Plants

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Explain why it is important to be familiar with plant names.
- Describe the four major growth forms of plants.
- Describe the parts of a plant and a flower.
- Name the placements and arrangements of leaves and flowers.
- Explain what a noxious weed is and give some examples.

Why Study the Natural History of Plants?

Humans have relied on plants for survival and pleasure for many centuries. Today, either directly or indirectly, our dependence on plants persists as almost everything we do is influenced by plants. The plant is the foundation of range, forest and aquatic ecosystems and the primary producer of foodstuffs for consumers - including range livestock industry and natural occurring wildlife or animal species. Knowledge of plants is fundamental to the Master Naturalist. This knowledge, when united with knowledge of soils and climatic conditions, forms the basis for the fundamental principles of ecological systems. Knowledge of plants is important, as plants provide a tool for monitoring the effects of environmental change.

The Clark's nutcracker and the white bark pine have evolved together and formed a symbiotic relationship. The bird gets food from the pine and the pine gets seed dispersal. Photo courtesy of Nadine Hergenrider, USFS.

Idaho is large, with extreme variation in environmental conditions. This variety provides growing conditions for about over 3,000 species of flowering plants that have been named. Idaho is diverse, both in elevation and in latitude, with northern boreal forests to southern sagebrush deserts. There are 56 plant species that are endemic, only growing in Idaho!

Wildlife and plants belong together. However, animals and plants do not necessarily exist for each other's convenience. In fact, it appears that plants will adapt in many different ways to avoid being

eaten. Plants will crawl under rocks, grow thorns, give off obnoxious odors, taste bad, grow inaccessibly high in the air or low to the ground, become unpalatable, change from high nutrient quality to low and produce toxic or poisonous chemicals.

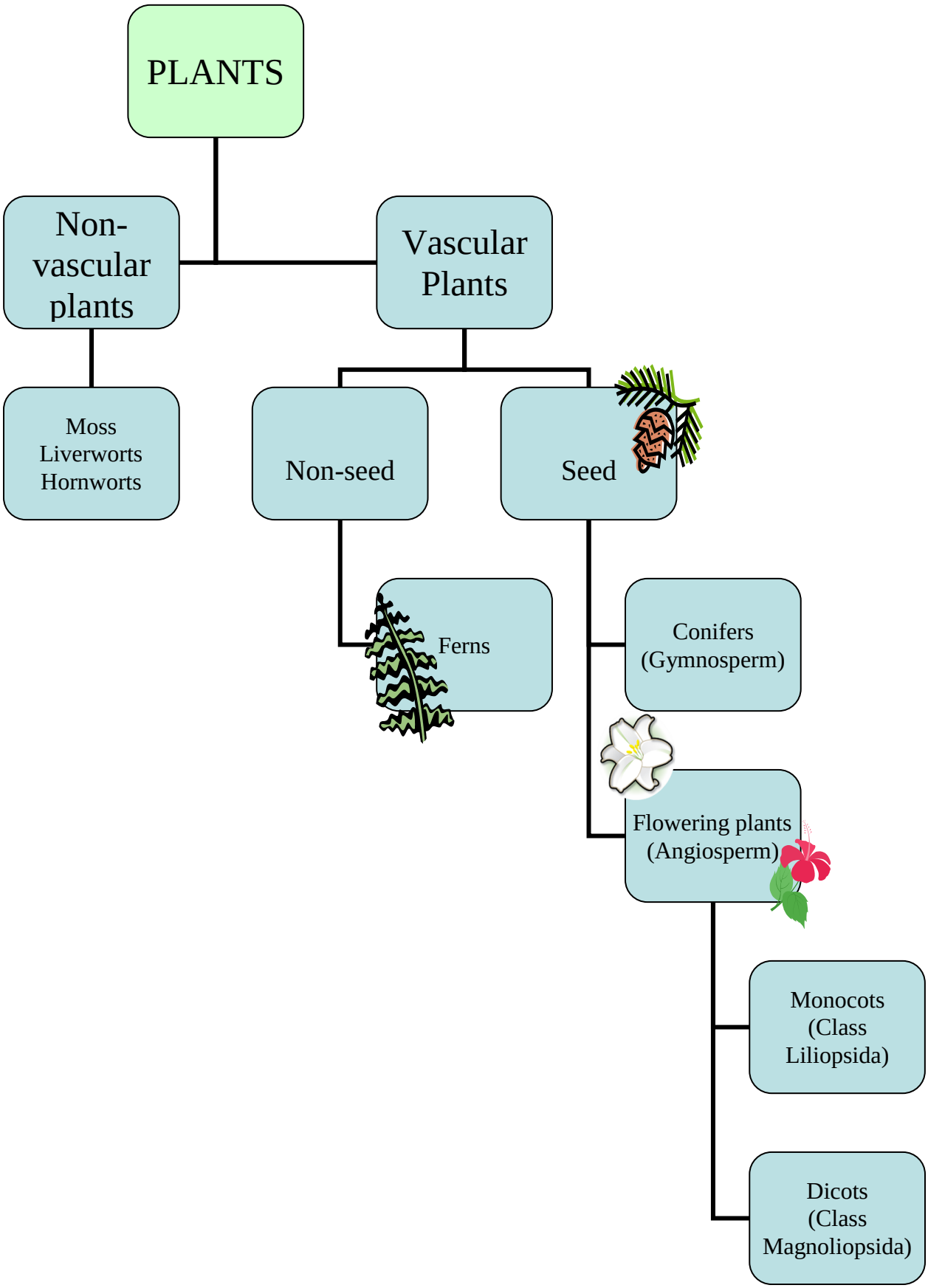
Why Know the Names of plants?

"Aster" photo by Collen Moulton, IDFG

Some people know plants by sight or general appearance when encountered on the land. Many people have lived close to plants for a long time and have come to recognized, consciously or unconsciously, the many points that make plant species different from each other. Others have learned the value of a plat through experience with that plant. However, some plants are easier to distinguish than others are. Anyone can learn to identify a number of things, people, dogs, guns, cow breeds, or plants. It has always been one of our human characteristics to name things and organize them in some orderly fashion.

For example, take the experience of Farmer Brown had as he was watching "Ole Bessie," the cow eat. One day, he saw here take a bite of a plant and start to chew it. After about 30 seconds of chewing, "Ole Bessie" became very sick and died there in front of Farmer Brown. Farmer Brown became very excited over this event. He raced to the house to call his local veterinarian. He explained to the vet what had happened. The vet asked Farmer Brown what the name of the plant was and said he would look it up in his poisonous plant book. Farmer Brown scratched his head and admitted that he did not know the name of the plant. The vet, highly educated at the university and with lots of experience, asked him what the plant looked like. Farmer Brown told the vet that the plant was green, about a foot tall and had a yellow flower. The vet laughed and stated that Farmer Brown had just given the description of about 300 species of plants in Idaho. The moral of the story has emerged. We name plants to communicate with one another. We find the plant name becomes the communication medium whereby all information about the plant is attached. Without a name, we cannot look it up in a book and find all the information that others have written and discovered. Without the name and the attached information, we can only learn about plants through experience. This could be costly and detrimental.

Elephant Head (Pedicularis Groenlandica) is a common wildflower (herbaceous plan) in wet meadows in Idaho.


PLANTS
Non-vascular plants
Vascular Plants
Moss
Liverworts
Hornworts
Non-seed
Seed
Ferns
Conifers (Gymnosperm)
Flowering plants (Angiosperm)
Monocots (Class Liliopsida)
Dicots (Class Magnoliopsida)

Plant Classification

Kingdom (plants)
Division (seed plants, non-seed plants)
Sub-division (angiosperms, gymnosperms)
Class (monocot, dicot)
Order
Family
Genus
Species
Variety

You will most likely be working with angiosperms and gymno sperms at the Family level or below. Some common families of angiosperms include:

- Rose family (Rosaceae) - Bitterbrush, cinquefoil, chokecherry, and strawberry.
- Sunflower family (Asteraceae)-Arrowleaf balsamroot, sagebrush, arnica, yarrow, and knapweed (weed).
- Lily Family (Liliaceae)-Camas lily, yellow bell, sego lily, wild onion.
- Pea Family (Fabaceae)-Lupine, milkvetch, clover.
- Buttercup family (Ranunculaceae) - Columbine, larkspur, buttercup, globeflower.
- Figwort family (Schrophulariaceae) - Penstamens, Indian paintbrush, elephant head.
- Willow family (Salicaceae) - Poplars, cottonwood trees, aspen.

The most common family of gymnosperms in Idaho is the Pine Family (Pinaceae) - Lodgepole pine, larch, ponderosa, spruces and firs.

A classic member of the lily family, this avalanche lily has three petals, three sepals and parallel leaf veins. Photo courtesy, Sara Focht, IDFG

All paintbrush species belong to the Schrophulariaceae family whose members have bilaterally symmetrical flowers, usually 4 stamens and produce a capsule fruit. Photo courtesy, Joshua Olson

Plant Classification According to Structure

Another way to classify plants is to use growth structure or life cycle. There are two main categories of terrestrial plants based on their growth structures: 1) **herbaceous plants**, those that generally die back to the ground level at the end of every growing season; 2) **woody plants**, those that persist above the ground level during the winter season and have significant secondary woody growth in their stems. The herbaceous plants include:

- *Annuals* - plants that sprout, grow, go to seed, and die all in a single year.
- *Biennials* - plants that grow for two years before going to seed and dying).
- *Perennials* - plants that live for many years, generally flowering and seeding every year. The woody plants are all perennials.
- Herbaceous and woody plants are often subdivided into four general growth forms:
    - *Graminoids* are herbaceous grasses and grass-like plants, including the grasses (Poaceae), sedges (Cyperaceae), and rushes (Juncaceae). The graminoids have generally narrow leaves with parallel veins (blades) and flowers that are much reduced and possess chaffy bracts rather than the usual petals and sepals.
    - *Forbs* are non-graminoid herbaceous plants and include many flowering plants and ferns.
    - *Shrubs* are woody plants that are usually less than 5 meters (16 feet) tall and generally have multiple stems arising from or near the ground.
    - *Trees* are woody plants that are usually greater than 5 meters tall and have a single main stem (trunk).

Structure of Plants

Plants are like people, each is an individual. Some may look alike; others do not. Each plant species has some part or parts which are different from all other plants. The majority of plants have some basic structures in common; those structures being roots, stems, leaves, and reproductive structures. The variations in those common structures are nearly endless.

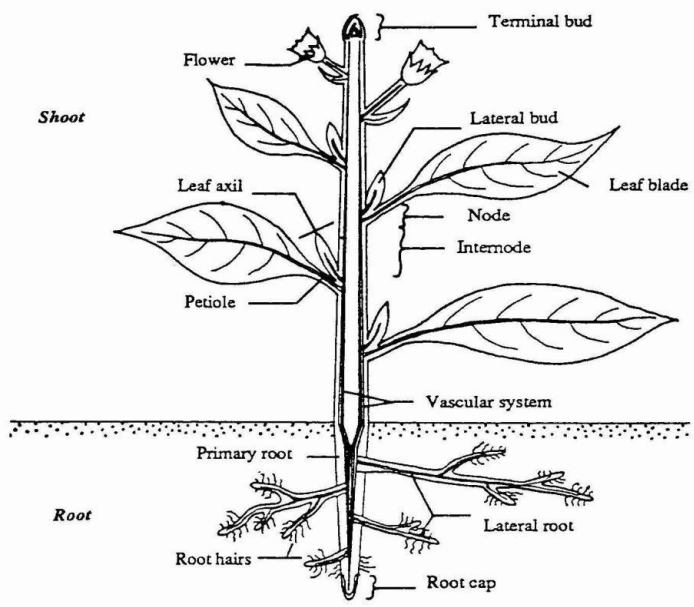


Fig. 18. Parts of a vascular plant.

Roots

Roots often are not fully appreciated by those who study plants. Roots are under ground and go unnoticed, but they are as important as the showy above ground parts. Roots serve a variety of functions for plants. The most obvious function is to absorb water and minerals from the soil. The plant would die very quickly if it did not have these vital resources. Roots also secure the plant in place and provide structural strength to hold the above ground portions of the plant. Think of the strength that to roots must provide to hold up a massive tree during a wind storm. Roots are storage organs that store food and water for the plant. This is especially true for biennial and perennial forbs and grasses. Carrots and turnips specialized and enlarged fleshy root that store large amounts of reserve food and water in their tissues.

Roots anchor the plant using a fibrous or tap root system or sometimes a combination of both. A "fibrous root system" is made of many long, slender, branched roots of the same diameter. This type of root system is typical of grasses. Most forbs have a "tap root system" that develops from a prominent structure called the primary root. Offshoots from the primary root are called secondary roots. If the primary root remains prominent during the growing season, as occurs in beats and carrots, it is known as a "tap root."

Stems

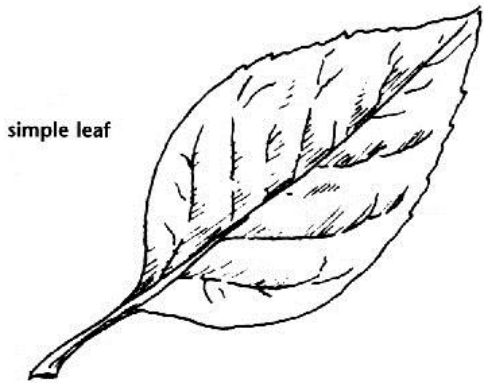
One of the major above ground vegetative structures of a plant is the stem. The stem's main function is to transport water and minerals from roots to leaves and manufactured food from leaves to roots. Stems also give rigid structure to a plant, providing a platform for suspending leaves where they can get sunlight. The stems also provide a means to raise the reproductive parts of the plant off of the ground where insects or the wind can enhance pollination and seed dispersal.

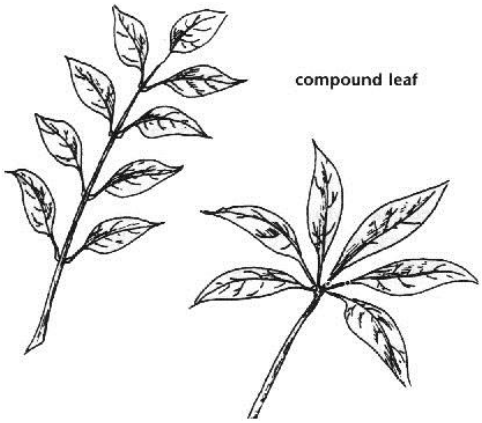
Fritillaria pudica
Yellow bell is a common member of the lily family.

Stems of grasses are made up of nodes (joints) where the leaves are attached and internodes (length of stems between nodes). Stems of forbs, like grasses, have nodes and internodes. Branches of stems and new leaves arise from buds at the nodes of the stems. Many species of forbs, such as the common dandelion, have a modified stem without leaves known as a scape. The purpose of the scape is to support the flower. Some forbs, such as the dwarf onion (*Allium simillimum*) have virtually no stem at all. Their leaves and flowers emerge directly from the ground.

Not all stems are aboveground. Some plants have creeping, underground stems with joints and leaf-like scales. These are known as "rhizomes." Rhizomes permit the plant to spread over an

area asexually (by vegetative means) producing clones of itself, occasionally, over the length of the rhizomes. Canada thistle (*Cirsium arvense*), quackgrass (*Elymus repens*), and aspen (Populus tremuloides) are three examples of plants that spread with rhizomes. Rhizomes are also used to store food that is manufactured in leaves. The potato is an example of a plant that uses underground stems to store food. The enlarged underground stem is called a "tuber." "Stolons" are similar to rhizomes, except they are aboveground, prostrate stems. Runners of strawberry plants are stolons. Stolons vegetatively produce new plants and store food. Stolons may bear normal leaves or the leave may be highly reduced.



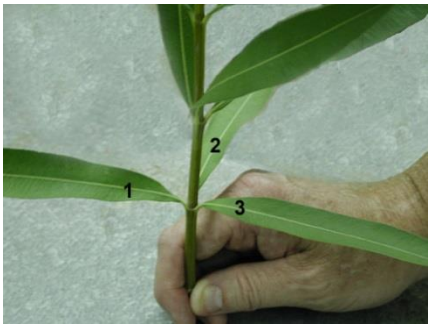


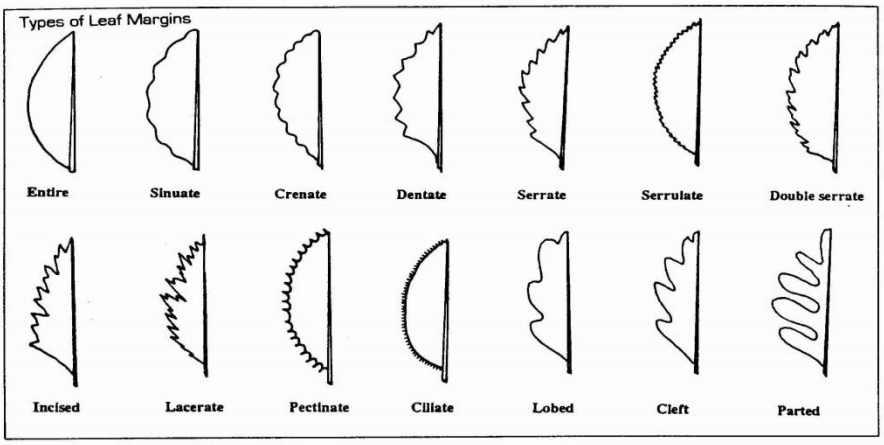
Leaves

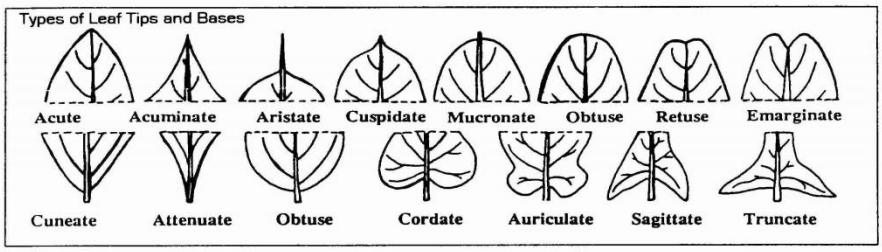
The leaf is the primary organ of plants responsible for photosynthesis (making food). Leaves are generally flat and broad to the maximum area for gathering light for photosynthesis. Leaves vary considerably and consist of several parts. Leaves commonly have three main parts: 1) *blade* - expanded part of the leaf; 2) *petiole* - stalk that connects the blade to the stem; 3) *stipules* - a pair of small appendages situated at the base of the petiole. Often the stipules are absent. Occasionally, other leaf parts, such as the petiole, are also missing. Leaves are classified as being either simple or compound. Simple leaves are those with a single blade and petiole, while compound leaves have several blades or leaflets. Compound leaves are either pinnately or palmately compound.

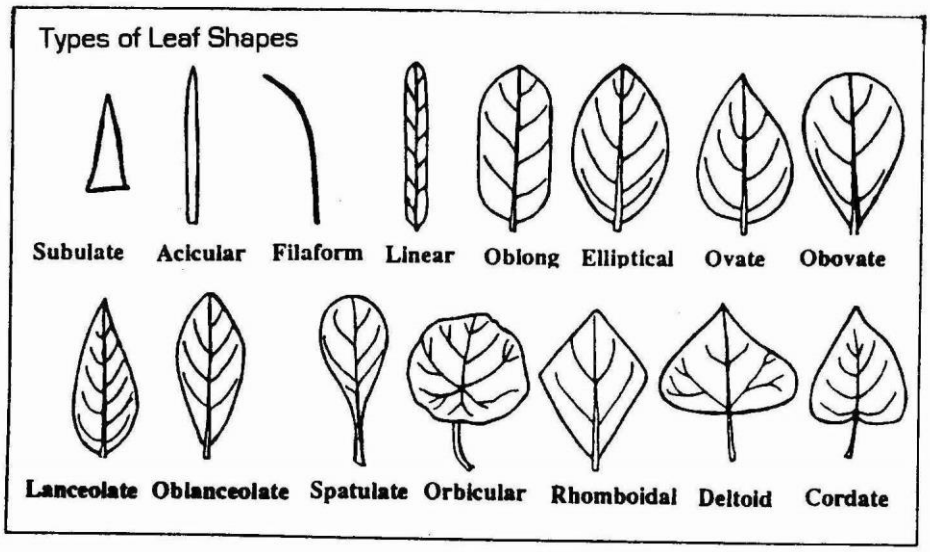
Leaves arranged alternately (top), opposite (middle), and whorled (bottom photo).

The arrangement of leaves on the stem also varies greatly. The three basic patterns are "alternate, opposite, and whorled." In the "alternate" leaf arrangement pattern, a single leaf arises from each node. The leaf at next node arises in the other direction from the previous leaf. The single leaves alternate directions up the stem. In the "opposite" leaf arrangement pattern, a pair of leaves arises from each node on opposite sides of the stem. The "whorled" leaf arrangement pattern has multiple (3 or more) leaves arise at each node. These leaves are spaced evenly around the stem.

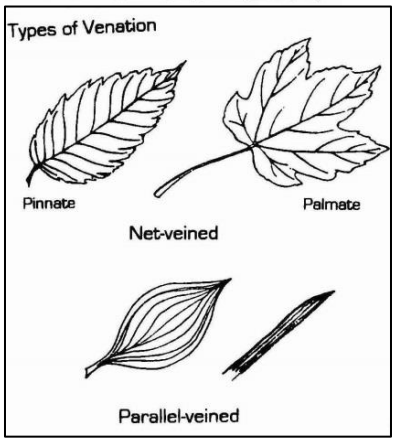








Leaf margins, shapes and venation are all attributes that can be used when attempting to identify a plant. These diagrams are used here with permission from University of Idaho Extension's Master Gardener Program.



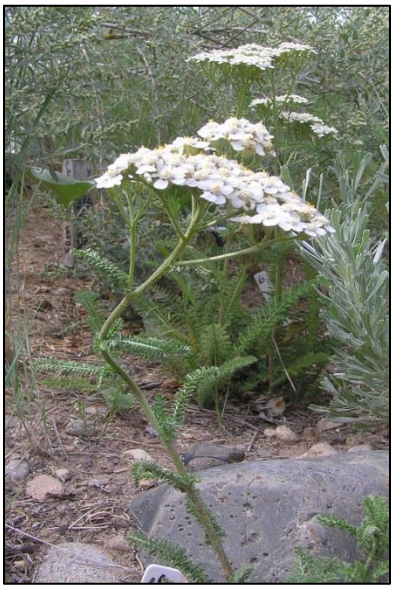
Reproductive Structures

Ferns, horsetails, clubmosses, and their allies reproduce by spores (non-seed vascular plants). The remainder of the vascular plants reproduce by seeds and are referred to as the seed plants. One type of seed plants is the gymnosperms (such as pines and junipers) that produce seeds that are borne naked on the scales of cones. These are often referred to as the conifers. Another type of seed plant produces its seeds enclosed in an ovary. These are the flowering plants. The remainder of this section will concentrate on the flowering plants.

On the underside of the fern leaf are sori, clusters of reproductive spores. These plants must live near water to reproduce. Photo by Ian Shackleford, USFS.

Variations in flower parts are almost limitless in arrangement and design. Floral parts are the major characteristic used to identify flowering plant species. The parts of the basic flower are as follows. The basic flower parts are: 1) *receptacle* - the expanded part of the stem to which other floral parts are attached; 2) *sepals* - (collectively known as the calyx) are usually green and make up the outer row of the floral bracts; 3) *petals* - (collectively known as the corolla) are usually showy or brightly colored and positioned just inside the sepals; 4) *stamens* - male portion of the flower located inside the petals. Each stamen consists of a "filament" or slender stalk and an "anther" or pollen sac attached to the end of the filament; 5) *pistil* - innermost part of the flower. This is the female part of the flower and is composed of the stigma, style, and ovary. The "stigma" is the tip of the pistil where pollen grains are received and germinate. The "style" is the slender central portion of the pistil that connects the stigma with the ovary. The "ovary" is the basal portion of the pistil and contains one or more ovules, which mature into seeds.

Ponderosa pine cone. Seeds are found resting on the bracts of the cones. Photo © Susan McDougnal @ USDA-NRCS PLANTS Database



Yarrow Achillea millefolium. Photo courtesy, Sara Focht, IDFG.

Plants many produce flowers singly, but often they produce flowers in an "inflorescence." The flowers in the inflorescence

can be arranged in a variety of patterns. There common patterns are spike, raceme, and panicle. In a "spike," all flowers are sessile (attached directly) on the un-branched main inflorescence axis. Common mullein (*Verbascum thapsus*) is an example of a spike flower arrangement. In a "raceme," all flowers are borne on individual flower stalks (pedicels) attached to un-branched main inflorescence. The inflorescence of chokecherry (*Prunus virginiana*) would be an example of a raceme. A "panicle" is a branched inflorescence. The inflorescence of common yarrow (*Achillea millefolium*) would be an example of a panicle.

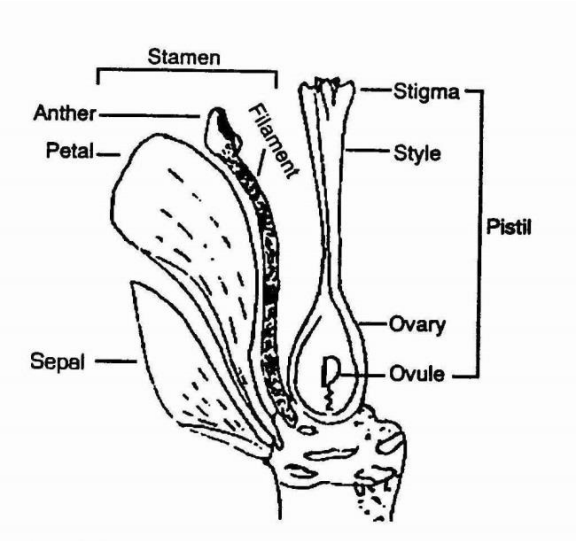


Diagram courtesy of University of Idaho Extension's Idaho Master Gardner Program.

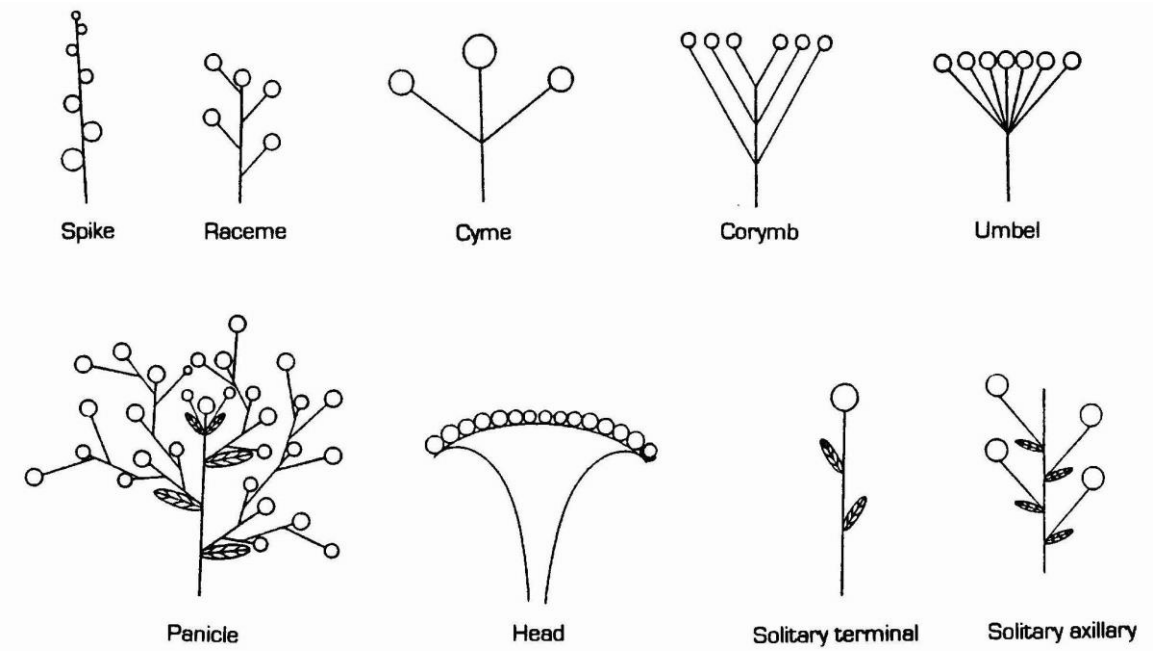


Fig. 13. Types of inflorescences.

Invasive and Noxious Weeds

The following information comes from the Idaho Weed Awareness Campaign Strategic Plan. http://www.idahoweedawareness.net/background/pdfsdocs/StrategicPlan.pdf

Most weeds are non-native plants that have characteristics that make them troublesome, such as adaptation to a wide latitudinal range in the native habitat. Reproductive mechanisms that provide an advantage over native or desirable plants may include high seed production, the ability to reproduce without specialized pollinators, self-fertility, the ability to reproduce vegetatively, and/or the production of small seeds or seeds with appendages that facilitate transport.

Orange Hawkweed. It may look beautiful, but it is a noxious weed in Idaho. Photo courtesy of the Idaho Weed Awareness Campaign

These plants are considered to be invasive if they are able to move into and dominate native or managed systems and disrupt the ability of those systems to function normally. Invasive plants often initially establish after soil disturbance, particularly following human activities such as road construction, non-intensive farming, poorly managed grazing or logging, urban development, and high impact recreation.

Weeds are designated as noxious by state law or county ordinance because they cause, or can cause, negative economic and ecological impacts and because control is usually difficult and expensive. Idaho's Noxious Weed Law (Chapter 24, Title 22, Idaho Code) specifies responsibilities of landowners, counties, and state agencies concerning management of noxious weeds.

Canada Thistle. Photo courtesy, Idaho Weed Awareness Campaign http://www.idahoweedawareness.net

Invasive species have been introduced into Idaho in a variety of ways. For most invasive plant species in Idaho, little is currently known as to how most made their way into the state. Many times the knowledge of who brought the plant to the state or why is now lost and forgotten. Initially, these kinds of plants could have been those whose seed stuck on the clothing of early pioneers or were contaminants in feedstuffs brought from Europe, Asia, or Africa. This type of introduction occurred long before we had "weed seed free hay," the Idaho Noxious Weed List or regulations regarding imports and exports. Many times these plants were introduced intentionally, for beneficial purposes, but later turned out to be

invasive and did not stay where they were planted. Humans seldom knew the biology of an introduced plant or speculated on where a plant might be in the next 30 years. Plants from foreign countries are often planted without humans having knowledge of what the plant might do in the future or in the environment once established. Idaho specific examples of grasses/other plants introduced.

"Butter and eggs" used as an ornamental before listed as a noxious weed in Idaho. This snapdragon-like flower is lovely, but invasive! Al Schneider, www.swcoloradowildflowers.com and USDA Plants Database

To be successful in land management, and to maintain a healthy functioning ecosystem in the 21st century, it is paramount that public land managers, visitors to public land, private land owners, and all Idahoans understands the impact of non-native plants on wildlife, fisheries, scenery, crops and economics of Idaho. It is everyone's responsibility to fight noxious weeds in Idaho.

Recreationists can follow recommendations and regulations regarding washing/rinsing motorized equipment before and after recreating on public land. Livestock owners can abide by the National Forest Service's "weed seed free" certified hay program. Reporting weeds and their locations to land management agencies is everyone's responsibility.

Noxious weeds are, very simply, plants that have been placed on the official state noxious weed list. State law requires landowners and land managers to take action to control these plants. The official list is maintained by the Idaho Department of Agriculture and can be found on their website (www.agri.state.id.us). The counties can augment the state noxious weed list by designating additional plants as noxious within their jurisdiction. Plants can be designated as noxious because they cause negative economic or ecological impacts. The state list currently contains 57 different species including weeds such as Canada thistle (*Cirsium arvense*), spotted knapweed (*Centaurea stoebe*), and Johnsongrass (*Sorghum halpense*). Not all invasive plants are noxious weeds. For instance, cheatgrass (*Bromus tectorum*) is a serious invasive plant but it is not on the state noxious weed list (though it may be on some county lists). Homeowners should be careful not to plant noxious ornamentals such as butter and eggs (Linaria vulgaris) also known as

Yellow toadflax used to be planted as an ornamental. This weed is now on Idaho's noxious weed list. Photo courtesy, Idaho Weed Awareness Campaign. http://www.idahoweedawareness.net

yellow toadflax. These weeds cannot be sold legally in Idaho, but they are still available in some areas.

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Ornithology

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Understand the causes of bird diversity.
- Understand and discuss the habits of bird migration.
- Identify the primary flyways of North America and Idaho.
- Explain bird's adaptations to environments and environmental changes.
- Develop an awareness of how bird populations are monitored and managed.
- Identify and communicate how birds function within ecosystems.
- Become aware of, and communicate, conservation concerns for birds.

Why Study the Natural History of Birds?

Throughout the course of history, birds have been a favorite natural wonder of humans. From many of the earliest civilizations, such as Egypt and Rome, we have descriptions of birds. This is due in part to the ease with which they can be observed in a natural setting. Observation of birds has been used by many groups of humans, such as sailors looking for land and Native Americans to locate the direction to water. Birds also have been used in many capacities throughout history, both as a means of obtaining food (falconry) and as a major food source (eggs, young, and adults). Many birds also have been sought out as a means of decoration for costumes and head wear, and as pets for their bright colorations, singing ability, and/or ability to mimic human speech. The most notable of these birds are the parrots, but there are many other less known species of birds such as the Hill Myna (*Gracula religiosa*) of India and the Black-billed Magpie (*Pica pica*) of North America that are kept as pets. In more recent times, humans have begun to use bird watching and feeding as a leisure activity.

The American Kestrel, Falco sparverius, the smallest and most colorful falcon is commonly seen in town. These birds perch on posts or wire, scanning for mice.

From singing in the early mornings and evening to nesting in the backyard, birds appear less concerned about human activity than some other groups of animals. With this in mind, it is not

hard to understand why there are many books dedicated to the study of birds, whether they are field identification guides, photo journals, or works on the natural histories of a group such as hummingbirds. Guides and photo journals are made to enhance the enjoyment of many people who enjoy viewing birds, whether going on a birding vacation or watching birds at the backyard feeder.

Natural histories give a more intimate look at the lives of birds. Included in many natural histories are descriptions of nests, eggs, and preferred habitat types. This information provides a better understanding of each bird and its life requirements. Knowledge of migration patterns, breeding behavior, life span, and potential mortality factors, aid in predicting year to year changes in population abundance. Declining bird abundance has led to recent concern in Idaho for grassland birds such as the Burrowing Owl (*Athene cunicularia*) and Grasshopper Sparrow (*Ammodramus savannarum*). Idaho, in particular, has over fifty birds that are identified by the Idaho Comprehensive Wildlife Conservation Strategy as "Species of Greatest Conservation Need." Among these are Mountain Quail (*Oreortyx pictus)*, Harlequin Duck (*Histrionicus histrionicus)*, and Flammulated Owl (*Otus flammeolus)*. With the understanding of the natural histories of all birds, changes in land management practices have greatly improved the chances of bringing species back from the brink of extinction and can prevent species from becoming rare in the future.

The continued study of the natural history of bird species will give greater insight into how anthropogenic (human-centered) changes affect birds. Among these changes is an increase in urban areas; with this increase there have been some dramatic changes in the populations of some bird species. The Eurasian Collared-Dove (*Streptopelia decaocto*) formally resided as a non-native, invasive species in Florida during the mid-1980's. However, these birds have expanded their range westward and into Idaho. Now their numbers are growing. With this change in distribution pattern, it is important to understand how the change in distribution is affecting other dove species.

Diversity of Birds

Birds are an amazingly diverse group of animals. Worldwide, ornithologists estimate that there are nearly 10,000 species of birds. Birds (Class Aves) are separated into 29 major taxonomic groups, or Orders. The birds in each Order are a lineage of related species. The diversity of birds reflects their evolutionary adaptation to a great variety of habitats and modes of life. Birds occupy forests, fields, deserts, shorelines and nearly every habitat in-between. A diversity of bill sizes and shapes, legs, feet, wings, modes of locomotion, diets, behaviors, and physiologies lend to the many ecological opportunities for birds. Due to its size and rich mixture of avifauna, Idaho demonstrates the vast possibilities of avian diversity and complexity. Idaho hosts approximately 400 species of birds in a unique blend of river, mountain, forest, and desert habitat, and is among

the first to offer a truly statewide birding trail - a connected network of the best places to view birds in the state - that totals approximately 2,000 miles. For these reasons, Idaho is attracting ornithologists and birdwatchers from across the nation.

Red-tailed Hawk, Buteo jamaicensis, returns to Idaho early in the spring to nest. The distinct reddish-brown tail can also be light colored, making it difficult to identify with this feature alone. Red-tailed hawks have a black leading edge on the underside of their wing. Photo courtesy, Jack Cafferty, The Peregrine Fund.

To examine bird diversity, we can separate birds into six categories based on their lifestyles and habitat. The categories include:

- songbirds (e.g. thrushes, warblers, sparrows, and wrens);
- waterbirds (e.g. egrets, grebes, rails, herons, gulls, and pelicans);
- waterfowl (e.g. ducks, geese, and swans);
- shorebirds (e.g. sandpipers, plovers, and curlews);
- raptors (e.g. hawks, eagles, and owls); and
- upland birds (e.g. grouse, quail, turkeys, pigeons and doves).

Similarly, we can separate birds into categories based on their food habits. Birds can be plant eaters and eat flowers, pollen and nectar. Other plant eaters feed on fruits and seeds, while others eat fibrous plant materials including leaves and stems. Species that eat animals may be insectivorous, eating insects and/or small invertebrates. Animal eaters also may be strictly piscivorous and feed on fish, amphibians, and larger aquatic invertebrates. Some animal eaters are carnivorous and feed on warm-blooded prey. Birds also can be either scavengers or omnivores. Within a taxa (Order, Family, or Genus), food habits differ greatly.

Although the above two methods of separating groups of birds are artificial and not based on taxonomic relationships, they help us understand the diversity of birds and their habitats.

Why do Different Birds Live in Different Places?

Birds occupy habitats that meet their needs for various resources; for food, water, space, and nesting locations and materials. Generally, different birds match, or correspond to, different environments. They "fit" into a particular environment due to past conditions of the environment and the characteristics passed on through generations of that bird species. They inhabit environments having favorable conditions for life. For example, the Flammulated Owl (*Megascops flammeolus*), a species identified by the Idaho Comprehensive Wildlife Conservation Strategy as a "Species of Greatest Conservation Need," is suffering from habitat loss due to widespread anthropogenic manipulations of their breeding habitat. Dependent upon

transition coniferous forests and mature ponderosa pine stands, these dwindling habitats provide the necessary resources for the owls. In addition, as insectivores, Flammulated Owls are affected by changes in forest structure that may impact forest insect abundance during the breeding season.

Species select environments that meet their habitat requirements. Shorebirds, like American Avocets (*Recurvirostra americana*), are found along marshes and on mudflats where they forage for aquatic invertebrates. Swallows, like the Violet-green Swallow (*Tachycineta thalassina*), spend large amounts of time in the open rural areas and grasslands of Idaho where they forage on insects. The number of specific examples is nearly endless, as each species fits a particular portion or type of environment.

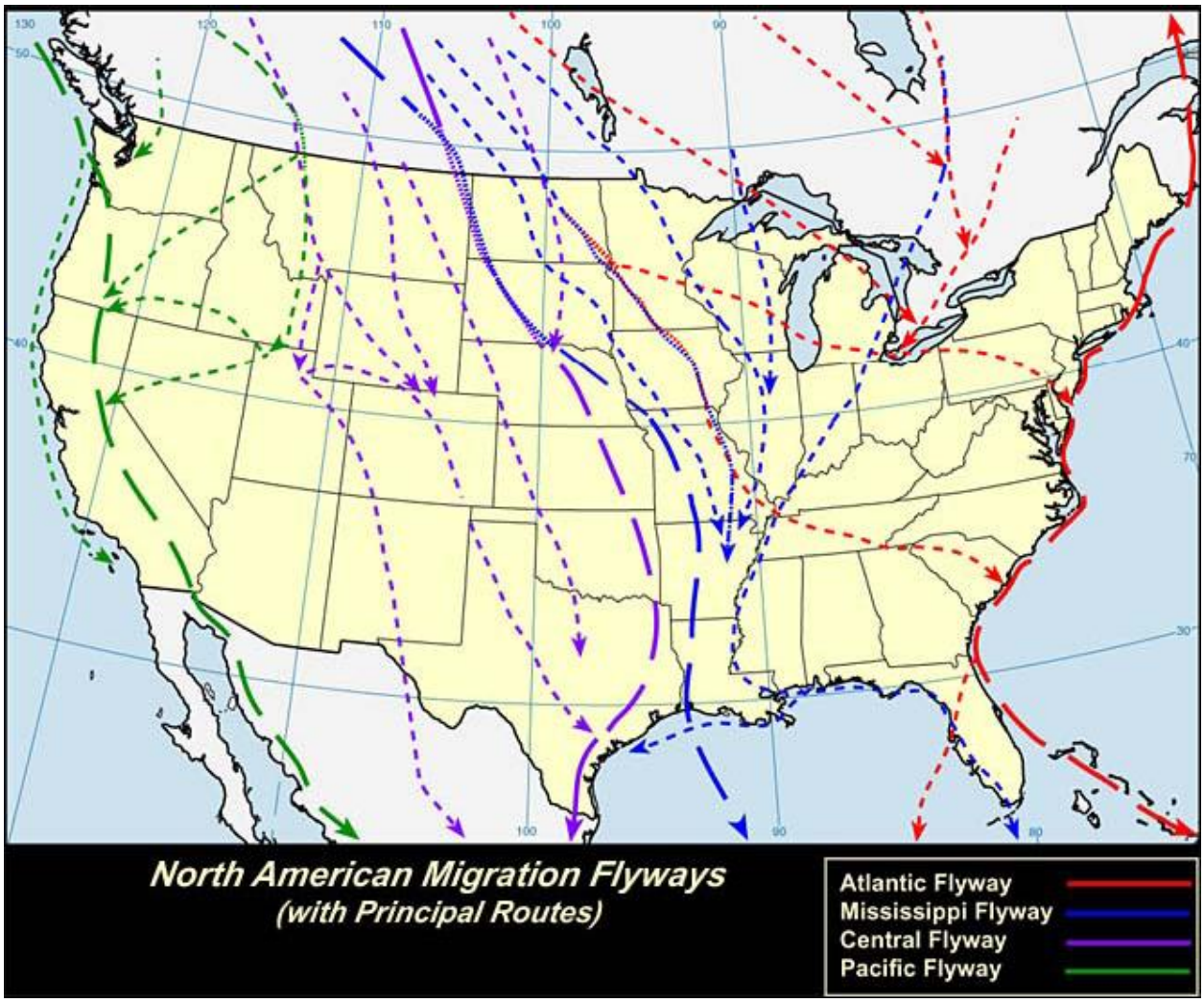
Bald Eagles were removed from the Federal Endangered Species List in 2007. Photo by Laura Whitehouse, USFWS.

Migration

Although birds have specific adaptations for a particular environment, they also must tolerate the changes their environment experiences—seasonal changes, long-term directional changes, and erratic changes. More than any other group of animals, birds deal with seasonal changes of environments by extraordinary feats of long distance migration. Migration is closely timed to the patterns of seasonal changes and is a yearly cycle. The driving force behind migration is the availability of resources, mainly more stable food source. Birds migrate to escape unfavorable climates, where food becomes difficult to locate, and exploit favorable conditions in other climates where resources are plentiful. Some species that nest (breed) in the temperate climates of Canada and the United States, migrate to Central and South America and the Caribbean during the winter. These species are called Neotropical migrants. Others species relocate to the Gulf Coast states of the southern U.S. Flying south allows these birds to escape the physiological stresses of winter, take advantage of food supplies and the milder climate of the southern regions during winter months. The migrants return north in the spring to exploit the productive tem perate regions abundant food supplies, longer daylight hours of the northern latitudes, and less competition for nesting space. Some migrants travel greater distances than others to reach their wintering or nesting grounds—from just a few miles to thousands of miles.

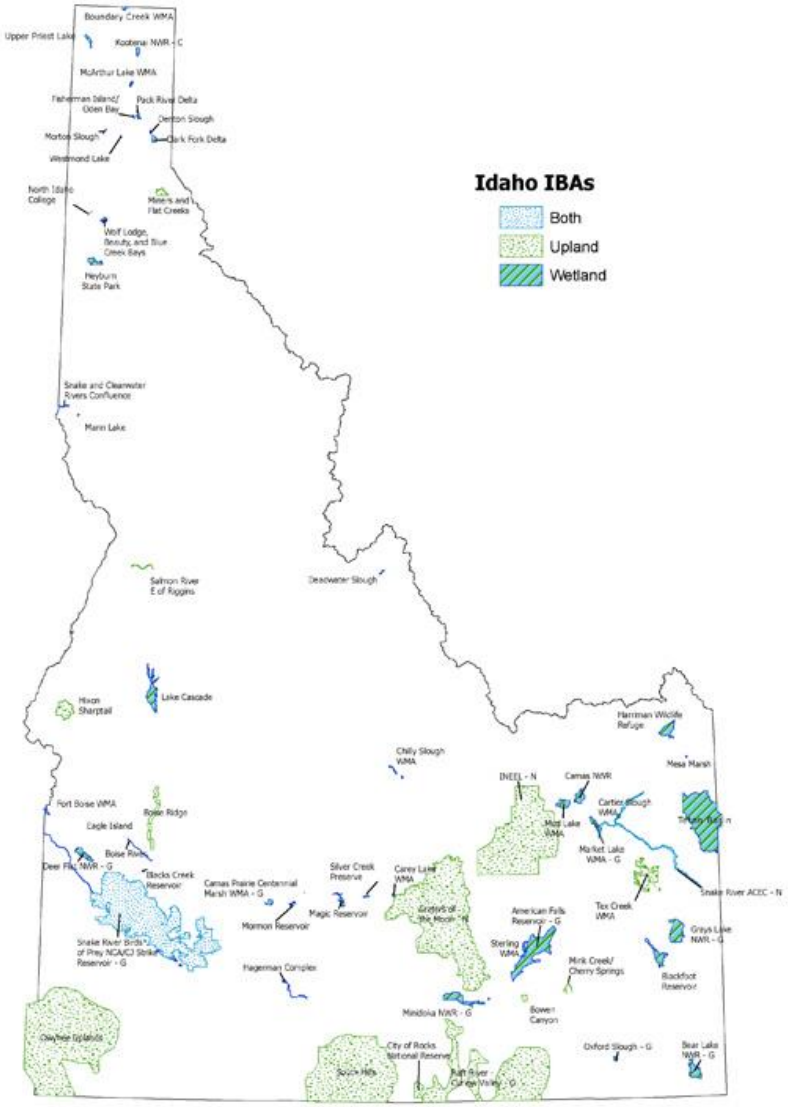
The Idaho state is the Mountain Bluebird. Arriving in early March, this migrant is a cavity nester. Snags and natural holes in trees serve as nesting sites. Bluebirds benefit from nesting boxes and will take to them readily. Photo by IDFG.

Of more than 800 species of birds that occur regularly in North America, approximately 400 can be found in Idaho at one time or another throughout the year. Most of Idaho's birds are regular breeders (243 species), whereas a handful occur in the state only in the winter or during migration. Approximately half of Idaho's breeding bird species are considered migrants - that is, they come to Idaho only to nest and raise a family. Idaho is situated along the Pacific Flyway, a principle route used by North American birds. These species may spend their winters in states to the south (e.g., California, Arizona, Texas) or may travel thousands of miles to countries in Central and South America, (e.g., Mexico, Costa Rica, Venezuela, and Brazil). Species traveling south of the U.S.-Mexico border are called Neotropical migratory birds and are of particular interest to ornithologists because so many of them are experiencing significant population declines. Due in part to these declines, a number of Idaho's birds have been classified as priority species by Idaho Partners in Flight.



Idaho provides important wintering and breeding habitat for birds throughout the year. Critical habitat and the places they occupy have officially been recognized as Important Bird Areas in Idaho, representing 3.8 million acres of public and private wetland and upland habitat throughout the state. Idaho's IBA sites are a small part of an international network of sites that provide critical habitat for birds. To date, 61 sites have been identified as IBAs in Idaho - 46 are wetland sites and 15 are upland sites; 11 are being reviewed for global-recognition, such as American Falls Reservoir, which supports thousands of shorebirds during migration, is the breeding site for the largest population of California and Ring-billed Gull colony in the state, and a wintering area for Bald Eagles. Other globally important locations include Blackfoot Reservoir and Minidoka National Wildlife Refuge.

Some areas are important because they serve as "migrant traps" which provide shelter for migrants following a "fallout" episode. When southward migrating birds encounter storms or strong headwinds, they stop their migration abruptly and seek shelter in the forests and riparian areas, appearing to "fall out" of the sky. One such place is the Boise Ridge, just north of downtown Boise. The ridge marks the southern end of 7



Idaho's mountain ranges and overlooks the arid lava flows of the Snake River Plain. The Idaho Bird Observatory conducts research that has found that the mosaic of habitats on the Boise Ridge, especially including the interface between deciduous shrubs

and coniferous forest, provides an important migration stopover area for an abundance and variety of western migratory songbirds.

How do Birds Cope with Changes in Their Ecosystem?

Organisms operate in their environment under specific ecological constraints. Bird populations are limited by four factors: habitat, climate, food and water, disease and parasites. Organisms, by nature, change the ecosystem in which they live. An ecosystem consists of both the physical environment and the biological communities. Organisms affect their ecosystem by altering conditions, adding or subtracting resources, and interacting with other individuals. The physical environment itself may change due to abiotic factors. For example, climatic variations may affect temperature and food availability. Within bird communities, a number of species interactions are at work to establish community structure, including competition and predation. We'll examine how birds deal with these and other "pressures" within their environment.

Competition

Competition occurs when the use or defense of a resource by one individual reduces its availability to other individuals. This may be the single most important factor responsible for determining community structure. "**Interference competition**" can be acted out as aggression towards other individuals so that one individual or species is excluded, or more commonly as "**exploitation competition**" where all individuals have equal access to a resource but differ in their ability (speed or efficiency) to exploit that resource.

Birds compete for a number of different resources including food supplies, nest sites, nest materials, mates, and territories. Often, the territories contain one or more of the other resources. To cope with competition for food supplies, some species participate in **"resource partitioning**." Different species either feed in different parts of their shared habitat (as do many warblers having similar habitat preferences), or take food of different sizes. If individuals do not share overlapping resources, they will "**defend territories"** as a strategy for reducing competition. Some types of territories are simple and are defended for a single resource, such as the feeding territories of hummingbirds. However, many breeding territories include food, mates and nest sites. Territory size depends on population density and on the availability of resources. Territories can be very small, such as the nest and a small area around it in gull colonies, or quite extensive such as the territories of Bald Eagles (*Haliaeetus leucocephalus*).

Competitive encounters elicit antagonistic behavior. However, most birds will go through much effort to avoid physical contact with another individual. The encounters involve displays of threat or submission. In defending territories, birds advertise their presence vocally.

Predation

Many strategies, such as mobbing, calls and displays, flocking, selection for small clutches and cavity nesting and colonial nesting exist as strategies to deter predators.

"Mobbing" is one of the most obvious displays of anti-predator aggression. Small groups of songbirds can be seen chasing and calling around a hawk or owl. This behavior is most common around breeding grounds. The purpose of this behavior is to divert the predator away from nesting areas or simply to confuse the predator and urge it on its way. "**Alarm calls,"** associated with mobbing function, alert other individuals of the same species and other species of the presence of a predator. Other birds may join in the mobbing, or are protected by being put on alert. Why the predators do not turn on the mobbing birds and attack is not known. It may be that these predators rely on surprise as an integral part of their hunting strategy or it may just be that the predators are so much larger than the mobbers that it would be an energy drain to try to get revenge on each one.

Killdeer often display a wing injury to distract predators from their eggs on the ground.

Another conspicuous anti-predator strategy is the exaggerated "**injury display**." For example, instead of remaining quiet and on the nest, an adult Killdeer (*Charadrius vociferous*) will feign a broken wing or tail while fluttering away from the nest with the intent of diverting the predator from the nest or young. Similarly, some birds will assume a "crouching" position and dart back and forth across the ground doing a "rodent-run" maneuver to distract the predator. Single species and multispecies "**flocks"** have distinct advantages when predators pose a threat. Birds in flocks can focus on feeding and relax. Because many individuals are present, flocks have better predator detection than individuals. In addition, from an individual bird's perspective, their chances of being eaten by a predator are decreased, if they are in a flock. Birds within a flock also communicate with each other. Alarm calls alert others and remove the possibility of a surprise attack by the predator. Large flocks also cause predator confusion upon flushing.

Another strategy to avoid predation is "**cavity nesting**." One half of all Orders of birds build nests inside cavities or holes. Cavity nests are safer from predators than open nests or those constructed on the ground. Nest placement and construction is important, as predation is the

greatest cause of nesting failure by birds. "**Clutch size"** also seems to be related to the type of nest built by a particular species. Species that nest in holes or cavities tend to have a greater number of eggs per clutch. Some research has suggested that, over time, increased predation has selected for smaller clutch sizes. Birds that lay small clutches require less time for egg laying, during a period when they are particularly vulnerable. Smaller clutches are less noisy and conspicuous to predators. In addition, laying a small clutch allows birds to risk fewer eggs at a time to predation and keeps available the possibility of re-nesting. Anti-predator behavior associated with nesting includes removal of eggshells from the nest by adults. Clean nests are less likely to attract predators.

Like birds in large flocks, "**colonial nesting"** birds have an advantage in predator detection. It appears that some birds form colonies in response to food sources, while other species are colonial nesters due to the predator protection afforded by the lifestyle. Yet, some colonies expose the birds to an even greater predation risk. Colonial nesting is a widespread habit among the various taxonomic groups of birds. Gulls, swallows, penguins and herons participate in this behavior. Colonial nesters can detect predators more easily and can form larger mobs to threaten advancing predators. Predation is heavier on the nests at the outer edges of a colony than those on the interior. Usually, more experienced, older birds acquire central nesting sites. "**Predator saturation**" may occur with colonial breeders. Eggs and young birds represent a significant food resource to predators. When so many nestlings are available for such a brief time, predators may be unable to build their populations to a large enough size to completely benefit from this overwhelming food source.

Gulls are colony nesters. This colony is located on an island of Mormon Reservoir in south central Idaho. The island protects them from predators and nesting in large groups allows them to defend nests together. Photo courtesy, Colleen Moulton, IDFG.

Parasitism and Disease

Birds are host to quite a variety of parasites and microscopic pathogens like bacteria and viruses. Common bird parasite residents include chewing lice that live on dandruff, blood, or other fluids, fleas, louse flies, relatives of bed bugs, ticks, and mites. Internal worms and flukes also are common.

Although little is known about the impact of such organisms on most bird populations, ecto-parasites (those living externally on a bird) can increase nestling mortality in birds living in large

colonies. Such is the case with Cliff Swallow (*Hirundo pyrrhonto*) nestlings where bedbug-like parasites infest the nests and feed on fledglings.

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www.idahobirds.net

To combat parasites and pathogens, some birds practice **"nest sanitation"** by removing fecal packets produced by nestlings. Other species carefully select nest materials that are known for their ability to inhibit bacteria and ecto-parasites. For example, European Starlings (*Sturnus vulgaris*) select green plants, such as yarrow, as nest lining. The sprigs of green plants are added to the nest before hatching and continue to have fumigant effects. Starlings also remove fecal packets of their young but only for a limited time early in the life of the nestlings. This species is particularly hardy and can withstand large populations of nest mites.

Some species reuse old nests, while others build new nests rather than risk the threat of parasites. In large colonies, where parasites are a greater problem than in small colonies, Cliff Swallows prefer to construct new nests. Swallows also may move the entire colony to a new site to escape the threat of parasites.

Birds that frequent backyard bird feeders may be susceptible to some diseases that are spread through shared food or by conditions that encourage disease (damp, contaminated food or fecal droppings).Four common diseases are salmonellosis, trichomoniasis, aspergillosis, and avian pox.

- **Salmonellosis** is caused by a group of bacteria that can spread throughout the body causing abscesses that form on the lining of the esophagus as part of the infection process. The bacteria are passed from the infected bird through fecal droppings. This is a problem at bird feeders where droppings can easily contaminate food. Salmonellosis is seen more frequently than any other bird feeder disease. Prevent contamination by droppings by cleaning feeders regularly and using fresh, dry stored food.

- **Trichomoniasis** comes from a group of protozoan parasites that afflict pigeons and doves. The Mourning Dove is very susceptible. Trichomoniasis typically causes sores in the mouth and throat. Unable to swallow, the bird drops the contaminated food or water, leaving it for other birds to consume, thus spreading the disease.

- **Aspergillosis** is a fungus that grows on damp feed and in the debris beneath the feeder. The bird inhales the fungal spores and the fungus spreads through the lungs and air sacs causing pneumonia and bronchitis.

- **Avian pox** is more noticeable than other diseases due to the wart-like growths on the featherless surfaces of a bird's face, wings, legs, and feet. Direct contact with infected

birds spreads the virus. Shed viruses are picked up by healthy birds from food or feeders, or by insects that mechanically carry the virus on their body. Disease cannot be overlooked as a complication of backyard bird feeding. Sick birds are less alert and less active. They feed less and may cower on a feeder and be hesitant to fly. To reduce the risk of spreading disease at feeders, it is important to provide adequate space around feeders, clean waste year to year with changes in weather.

Avian Pox
Courtesy of USGS

These common birdfeeder diseases can be prevented by washing bird feeders in warm soapy water every 2-3 weeks, rinsing with a diluted bleach solution, rinsing, and drying thoroughly before refilling. Also, keeping bird seed dry and away from rodents will help reduce these diseases. Hummingbird feeders need to be cleaned every week in very warm weather. Four parts water to one part sugar should be use. No food coloring or honey should be used. Moving bird feeder locations occasionally may also help prevent droppings from accumulating and spreading diseases.

Habitat Alteration

Habitat alteration is currently one of the most contentious issues related to many bird species today. Declining numbers of many species of birds is due in part to the changes that are occurring in their given habitat. The changes include loss of preferred nesting areas and decrease or increase in resources. Many alterations in habitat have negatively affected bird populations. However, in the case of some species, changes in habitat have increased numbers. One example, the Lesser Snow Goose (Chen caerulescens chencaerulescens) whose numbers have dramatically increased in the past 20 years. While the numbers of the Lesser Snow Goose have increased, there is growing concern about how the species is affecting its own summer/breeding habitat due to the foraging habits of this species and what affect this might be having on other species sharing the same summer/breeding range.

Habitat alteration is being used in management practices to restore areas back to what was thought to be historical habitat. This manipulation of habitat is being used in the attempted recovery of many grassland birds. One method that is being used to manipulate/restore habitat is the reintroduction of fire into ecosystem management of grasslands. For example, increasing fire frequency in some sites in the Great Basin is resulting in the suppression of western juniper and pinyon-juniper in mountain big sagebrush and Idaho fescue habitat. Prescribed fire is also being used to improve the health, vigor and sustainability of existing aspen stands in central Idaho. Aspen declines throughout large portions of the West have federal forest managers concerned.

One of the most concerning habitat alterations is an increased amount of urbanization. Increases in urban acreage have led to fragmented habitat, which in many cases is detrimental to bird populations. Many birds need to have large contiguous tracts of land; these include many grassland and woodland bird species. Fragmentation of habitat leads to what is called "edge effect." For some wildlife species, increased edge provides more accessibility to resources, but for birds, these edges become predator corridors. This leads to increased mortality and, in many cases, decreased nest success, both affecting the overall population numbers of birds.

Food Availability

A bird's food supply is not a constant, unchanging resource. Food supplies—whether they are plant or animal—change from season to season and year to year with changes in weather. Population size, and the growth of a population, is limited by the quantity and quality of available food. Abundant food supplies do not present a problem. However, birds may engage in particular behaviors to deal with food shortages or anticipated food shortages.

In preparation for winter weather, Gray Jays (*Perisoreus canadensis*) store food in special places to save for later. They store the less perishable items such as berries, insects and mushrooms by coating them with sticky saliva from special glands. These stick balls of saliva-covered food are tucked behind flakes of bark, under tufts of lichen, in the foliage or in forks of trees. Other birds also save food for later. The Loggerhead Shrike (*Lanius ludovicianus*), known for impaling prey on cactuses and barbed wire, will do the same to prey items intended for later meals. Birds in the families Sittidae, Paridae, and Corvidae commonly create seed caches. They take advantage of temporary food surpluses by accumulating "leftovers" for time of food shortage. In contrast to food gathering, some species disperse in great numbers over long distances to escape widespread food shortage.

Species that defend territories for food resources may alter the territory size depending on food availability. In cases of food shortage or low-quality food, birds may expand their feeding territory. In species with extended family units, the birds may be engaged in cooperative feeding of the young when food is limited or of poor quality for a given season.

Environmental conditions, like food supply, can affect the timing of reproduction in birds. When food is not adequate, females can delay egg production, thereby limiting clutch size. From a different perspective, however, evidence of abundant food very early in the spring can trigger early reproduction. Year round availability of high-quality food allows many tropical species to engage in two breeding seasons annually. If food is insufficient, parents may not be able to nourish their chicks adequately. The smallest chicks of a brood may starve when older, larger nest-mates out-compete them for food.

Some species may take advantage of abundant food resources. Sufficient, predictable food supplies may cause individuals in some populations of a species, but not others, to mate with multiple females. Generally, food resources that are either clumped and/or defended in a territory lead to multiple mates.

Temperature Changes

Birds are endothermic, meaning they generate internal heat to regulate their body temperature. They are able to maintain relatively high body temperatures throughout a wide range of air temperatures. This ability allows birds to inhabit environments with extremes in climate—tropics, temperate, and polar zones. Birds regulate their body temperature, "thermoregulation," when ambient temperatures are outside their thermo neutral range —when temperatures are either too warm or too cool. Mechanisms must be in place to aid in heat loss and birds must take in sufficient energy (food) for metabolic heat production. Birds use both behavioral and physiological means for thermoregulation.

Birds can be susceptible to heat stress. To manage this problem, birds use panting to cool themselves by increasing their respiratory rate to rapid, open-mouth breathing. This results in water loss from the surfaces of the mouth, nasal passages and lungs. Sweat glands are not present in birds, so ridding the body of water by sweating is not an option. It is also likely the apteria (areas of the body from which feathers do not grow) and other un-feathered surfaces (legs) aid in heat loss.

Birds may engage in a variety of behaviors to stay warm. Many birds select microclimates that provide warmth or shelter from the elements. Some nest sites, holes and burrows protect birds from the cooling effects of wind. Small birds, having a higher body surface area to mass ratio, may be particularly vulnerable to heat loss and therefore seek protection. Other birds may seek the warmth and protection provided by other individuals. Northern Bobwhite (*Colinus virginanis*) are known to huddle together. Some birds add additional feathers to their body to stay warm. Another way to stay warm is to "fluff" feathers for better insulation. This creates air pockets between the feathers and the skin that help retain heat. Birds can also stay warm by shivering. Humans do this too, but for birds shivering helps maintain a temperature of about 106-109 degrees. Those that can survive the coldest nights of winter have a special behavioral adaptation called "torpor." During torpor, metabolism slows down, body temperature lowers and heart rate reduces to conserve energy. Finally, in order to maintain body temperature at a level that will keep the bird warm, a bird must eat plenty of food that is high in fat to boost metabolism. Birds spend most of their time searching for food in order to keep warm and stay alive.

How do Birds Function in Ecosystems?

Since nothing in nature stands alone, birds, like all other organisms, are connected in some way to individuals of the same and other species. The presence of a particular bird in an ecosystem affects the diversity of the whole bird community and determines which other species can coexist in the same area. Birds affect the vegetation of an ecosystem, the invertebrate populations of an ecosystem and the vertebrate populations of an ecosystem. On a smaller scale, organisms like fungi and microbes also are important to the ecosystem dynamics. Birds, due to their great diversity, have many roles within an ecosystem. They are foragers, predators, and prey. Additionally, they have evolved special relationships with other species. Some birds are plant pollinators and some are hosts to parasites.

Predators

The role of birds as predator is one that helps keep populations of prey species from becoming too abundant, which in an extreme case can cause starvation of the prey species. Predators also help to improve the overall health of a species by removing sick, old, and injured animals from the population. By removing these components of the population, those that remain can more easily obtain resources that ensure the "most fit" birds are able to reproduce. Predators are a vital component of ecosystems, either of which many bird species function as exclusively or in a limited capacity throughout the course of their life.

Raptors such as hawks, owls, and eagles, with their large talons and sharp beaks, are readily identified as predators. Raptors prey on many different types of organisms from insects (American Kestrel; *Falco sparverius*) to birds (Peregrine Falcon; *Falco peregrinus*) and fish (Osprey; *Pandion haliaetus*) to animals as large as Pronghorn Antelope fawns (Golden Eagle; *Aquila chrysaetos*). There are several other bird species that function in the role of predator that are not as easily recognized. These predators range from the Common Merganser (*Mergus merganser*), which feeds on fish, to Black-Chinned Hummingbird (*Archilochus alexadri*), which feeds its young insects.

Prey

Prey species are those that serve as a food source for other species in a given ecosystem. Many species of birds are considered prey species, which may include having eggs taken and eaten from nests, to adults serving as a food source for larger predators, which includes reptiles, mammals, and other birds. Most predation on birds occurs in the early stages of life as either an egg or nestling. Many adult birds are a heavily used prey species for many other organisms in the ecosystem. Some of the better-known prey species are sought out by humans a food sources. Collectively known as game birds, this group includes, but is not limited to, Ring-Necked Pheasant (*Phasianus colchicus*), Northern Bobwhite and Wild Turkey (*Meleagris gallapavo)*.

Seed Dispersal

Birds also function in the role of seed disperser. This occurs at all levels of the ecosystems. Birds that have thick bills, such as Finches, Grosbeaks and Sparrows specifically exploit seeds as a food source. Most bird species that exploit seeds as a food source cannot process all the seeds consumed. Seeds are passed out of their system from within sight of the plant where they were consumed to several hundred miles away during migration. Some Corvids such as Blue Jays (C*yanocitta cristata*) and Clark's Nutcrackers (*Nucifraga columbianan*) actually store seeds in the ground for a winter food source. Even with exceptional spatial memories, birds, like squirrels, cannot consume all of the seeds that are stored over the course of the winter. Thus, they unknowingly plant seeds from many different plant species.

Pollinators

The role of birds as pollinators in an ecosystem has been well documented. Many species of birds function in the role of pollinators; among these are hummingbirds and orioles. Both groups rely on nectar as a primary food source, collecting pollen on their heads or backs and disperse this to other flowers while feeding. This exchange of pollen ensures that plants produce viable offspring, which includes fruits, nuts and seeds. All of these plant offspring are then used by other organisms, including birds, as a food source later in the year.

This hummingbird was banded by the Idaho Bird Observatory. The photo was taken just before release. Hummingbirds join bees, flies, and beetles as important pollinators for Idaho's native plants. Photo courtesy, Deniz Aygen, IBO.

What are some conservation concerns for birds?

There are many conservation concerns for birds today. The greatest are declining numbers of many species of birds and loss of habitats associated with these same species. Many organizations, both public and private, are involved with both of these aspects in conservation.

How are Birds Monitored?

Birds are most often monitored through survey methods such as point counts, transects, and observation; each of which can be easily conducted.

Point Counts

Point counts are conducted from a set of pre-determined points by a surveyor. While at these points, the surveyor will count the number of birds of each species observed and heard within a given area. These counts are then used to determine what species are present and within what habitats the birds are found. Point counts are also used to determine population trends and local

bird densities of the survey area. Many point counts are conducted on an annual basis to better understand how bird numbers and bird diversity are doing on a year to year basis.

A California gull colony count at Mormon Reservoir. Photo courtesy, Colleen Moulton, IDFG.

Transects

Transects are another survey method commonly employed to count the number of birds, as well as the number of bird species, along a survey line. Transects are generally linear with set limits on the distance for which birds are to be counted. Dimensions of the transect are set prior to conducting the survey by those doing the survey. Length can range from under 100 yards to several miles with the width also being variable but generally from 15–20 meters on either side of the transect's center line. The way in which birds are counted depends on the goal of the person conducting the census. If it is to determine what species are present in the area, both songs and visual identification count toward the number of bird species on that particular line. Some transects are used only to count those birds that appear to be using the particular habitat and may only count the number of visually-identified birds that are within the set boundaries performing activities such as perching and feeding.

Some transects are conducted annually to see if there are fluctuations in the number of birds and bird species from year to year. This method is commonly employed in areas where there is concern about specific bird species. Transects are used by the Idaho Department of Fish and Game to estimate forest grouse populations, help set hunting limits and compare data from year to year.

Rare Bird Reports

Rare bird reports are used to document the occurrence of birds outside of what is thought to be their accepted range. Rare bird sightings have to be authenticated by local Audubon Societies to determine if each sighting is valid. With the occurrence of a rare bird sighting, many people, anxious to add a particular bird to their life list, will drive several hundred miles for a chance to see the bird.

Public Involvement

Additionally, several survey methods are conducted annually throughout the U. S. These include the Audubon Society's Christmas Bird Count, the Breeding Bird Survey, and the Great Backyard Bird Count, which are conducted annually at different times of the year. All of these surveys rely on the participation of the general public and would make a great Master Naturalist volunteer project. With these counts, volunteers are asked to survey birds that are in their area and give the

number of bird species and individuals of each species they observe in a given time period or along a given route. These survey methods are used to monitor population trends of bird species at a given time of the year and to determine if bird species are increasing or declining overtime.

Visit www.idahobirds.net for more information on Idaho's birds.

Suggested Readings and Additional Resources

Books and other resources covering birds are numerous. Many can be located off the website resources listed.

American Birding Association http://www.americanbirding.org

Cornell Lab of Ornithology http://www.ornith.conrell.edu/

Idaho Birding Trail Website http://www.idahobirdingtrail.org

Idaho Bird Observatory Website http://www.boisestate.edu/biology/ibo/

National Audubon Society http://www.audubon.org/

Electronic Resources of Ornithology http://www.chebucto.ns.ca/Environment/NHR/bird.html

Professional Ornithological Societies
American Ornithologist's Union http://www.aou.org/Association of Field Ornithologyhttp://www.afonet.org/index.html

Cooper Ornithological Society http://www.cooper.org/

Wilson Ornithological Society http://biology.boisestate.edu/raptor/

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Entomology

Chapter Goals:
After completing this chapter, volunteers should be able to:

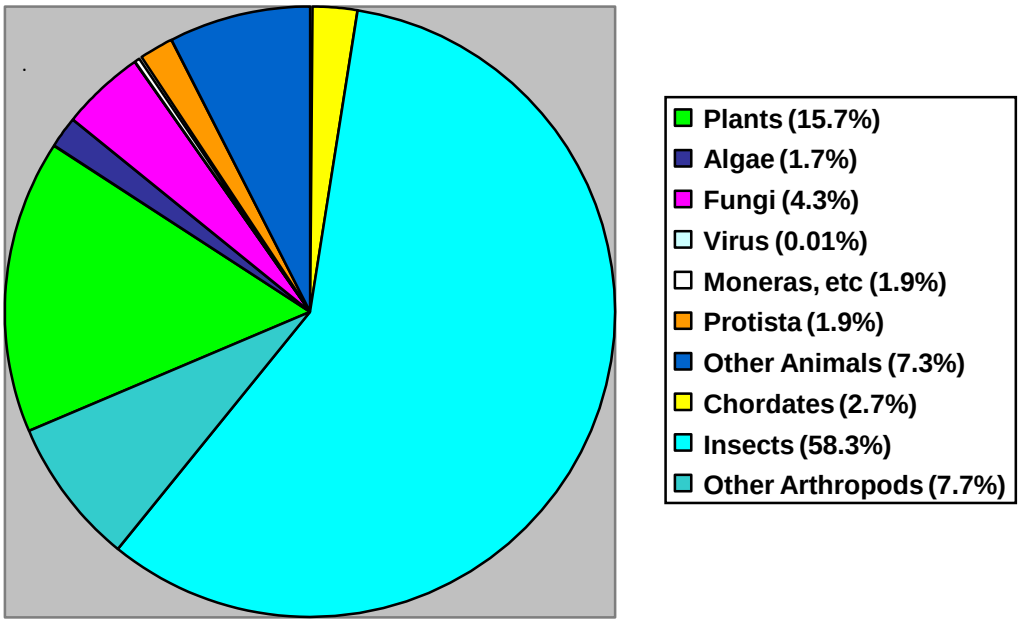
- Explain the organizational structure of common Classes within the Phylum: Arthropoda, including the Order of Insects.
- Be familiar with field guides available for reference and current accepted practices for collection.
- Differentiate types and characteristics of insect wings for identification.
- Name the most common places to look for bed bugs in a hotel.
- Identify three insects that are beneficial and three that are pests.
- Use the Orders Attachment as a quick identification guide to characteristics of Insects.

Introduction

From the high alpine tundra to the southern deserts and everywhere in between, Idaho is richly populated with insects. Idaho offers opportunities to view some of nature's most amazing insect spectacles: Mormon cricket swarms in the desert steppe lands, Pine Whites in the ponderosa pines along the Payette, dragonfly migrations on the Cotterel Mountains in the fall, and, of course, mountain meadows filled with butterflies – after all this is Idaho! The superlatives abound, insects are the most specious, most abundant, most ecologically important, most colorful, most cryptic, most awesome, and most fun!

Why Study Insects?

Insects make up a nearly 60% of all life on the planet (Figure 1). They were around before the time of dinosaurs and they are still around today. They are the most successful form of life, utilizing all imaginable niches and some you cannot imagine. In this chapter, we will discuss some of the common orders and families of insects with a special emphasis on insects common to Idaho, a brief overview of insect study, and some of the adaptations and behaviors that make insects the most successful life form on the plant. This chapter is a meager beginning to the vast riches of knowledge, wonder, fascination, and joy that can come from insect study, if you choose to wander down the entomological path.



Adapted from Grimaldi, D. and M.S. Engel. 2005. Evolution of the Insects. Cambridge University Press, New York.

Figure 1: Diversity of Life on Earth

Insects are astonishing because they are so diverse and have adapted to fill thousands of niches that many people may not even know exist. Of the 800,000 or more species known to exist, less than 0.1% are considered pests. Actually, most are considered beneficial. Most people know of the "good" insects, like pollinators and butterflies, but most people do not realize the overall importance of insects. Insects are detrivores, predators, plant feeders, and bloodsuckers. They build soils, influence plant distributions, and generally make most non-marine ecosystems function. They are important in determining ecosystem health because many act as bio-indicators. Because insects have highly specialized habitats, if a particular insect is thriving, it is assumed that the specialized habitat is healthy.

Many insects are part of what we like to call "Mother Nature's Clean-up Crew." Imagine if we did not have insects. What would the planet be like? They eat just about anything you can image, including many that eat things we wouldn't like to have piled around us, like decaying plant vegetation, dead animals and poop. Nevertheless, they consume these "delicacies" and recycle them back into the soil.

They have astounding behaviors: mimicry, bizarre mating rituals and defense mechanisms. Some insects are parasitic; others can learn and communicate. Some insects have social hierarchies. Insects can exhibit parental care. Some are brightly colored or metallic and have been used for jewelry since the time of the ancient Egyptians. Some insects have been used

medicinally to clean or suture wounds. In some countries, some insects are even considered delicacies. Insects are also effective biological control agents for a wide variety of undesirable organisms.

Insects are capable of long-range dispersal as demonstrated by our State Insect, the Monarch Butterfly. Passive, long-range dispersal can also occur via storm systems, driftwood, or other such means. Human activities also provide a medium for passive long-range dispersal of insects. Some of these dispersal events (or introductions) are intentional such as biological control agents; *Hylobius transversovittatus* is a European weevil introduced to control purple loosestrife. Other introductions are accidental. An example, furniture is produced from trees grown in Asia. Wood-boring insects feed as larvae inside the trees used to make furniture sold in America. Sometimes, once the furniture is brought into your home, a critter comes out that hitchhiked unnoticed. Similar pests have been introduced on foods we import. The U.S. government has an agency that monitors goods coming into the country. However, many insects are missed. Insect populations that develop as a result from these events may or may not persist in the environment. Several introduced insects have done very well in Idaho. The Cabbage White, Asian Multicolored Ladybug, and European Earwig are just three of many introduced insects that have become commonly encountered members of Idaho's insect fauna. The designations: native and introduced are utilized to indicate whether humans or human behaviors were the agent of the introduction. This becomes blurred when human caused habitat alteration enables the colonization of new territories, i.e. range expansion. As you spend time in the field, you will find, and maybe even document, some long-range dispersers and possibly even first occurrences within the State.

Another interesting aspect of insect study is insect societies. Many insects will be found in large aggregations at some point. The famed over-wintering sites of the Monarch are an example of this phenomenon (Figure 2). Aggregations are worthy subjects of study, but insect societies are a step beyond mere aggregations. Termites, ants, bees, and wasps exhibit social behaviors in which: young are cooperatively reared, generations overlap, and polymorphism of members exists, i.e., members of the colony look different from one another.

Polymorphism facilitates the division of task specialization within a caste society, i.e., reproductive and non-reproductive individuals, workers, or soldiers, etc. Insects that have a caste system are often called "*eusocial*" and the individual colonies of these societies may be thought of as a single 'super-organism' comprised of all members of the colony. These colonies can last for decades. These insects demonstrate language, communication, and learning and are fascinating subjects for study.

Lastly, we wish to discuss an area of study that is rapidly expanding - insect conservation. We have attempted to describe the significance of these creatures so that you understand our world relies on theirs. Given the importance of the ecological services provided by insects, it is imperative that insect diversity is considered in conservation planning. As an example, given the sometimes intricate interdependence of pollinator and plant; conservation of a rare plant may require conservation of a rare pollinator. Data from Great Britain and Canada suggests that insects show the effects of habitat change before bird or plant species do, making insects the better "canary in the coal mine" or a bio-indicator for monitoring environmental change.

Figure 2: Aggregations of Monarchs, Pacific Grove, CA

How Does One Study Insects?

Entomology can take many different forms and professions in entomology are almost as diverse as insects. An entomologist can have a career in ecology, taxonomy, museums/zoos, agriculture, forestry, urban pest control, and veterinary, physiological, behavioral, genetic, medical and forensic sciences to name a few. Engineers study mechanics of insect behaviors and movement to aid in the development in new technologies. Therefore, there are many different approaches to study insects and a beginner can easily become overwhelmed. Do not despair. There is help. The Idaho Entomology Group (http://my.collegeofidaho.edu/campus/community/museum/IEG/index.html) is a fantastic place to find help filled with many wonderful, entomophilic people (i.e. bug-loving people). Membership dues are $5 / year (US $10 / yr overseas), used to cover costs of the newsletter. Application can be made to the Idaho Entomology Group, c/o Museum of Natural History, The College of Idaho, Caldwell, ID 83605, USA. To achieve maximum, benefit you should try to participate and attend group-sponsored events.

The North American Butterfly Association has a Fourth of July Butterfly Count program (http://www.naba.org/). This program is similar to the Christmas Bird Count. Idaho has quite a few of these counts and beginners are always welcome. Other entomological happenings occur in Idaho, your local Audubon chapter and Idaho Department of Fish Game non-game biologist may be able to help.

Traditionally, the study of insects has involved making collections. Insect collections are excellent to help you understand insect taxonomy, distributions, and timing of life stage. Borror and DeLong's *Introduction to the Study of Insects* (various editions) has instructions for creating and preserving an insect collection that will get you started. Many schools, government agencies,

and museums have insect collections that you may be able to visit. The Lepidopterist's Society (www.lepsoc.org) statement on insect collecting is a good guideline to collecting ethically. In 1974, noted lepidopterist (butterfly guru), Robert Michael Pyle, and Seattle Audubon put out a book called *Watching Washington Butterflies* which ushered in a new, more insect friendly, "catch and release" paradigm for recreational enjoyment of insects. Unfortunately, some people have become strident anti-collectors and this has polarized the entomological community in some states. Luckily, Idaho has avoided these problems so far. Each side has much to gain and learn from the other and together represent a balanced and efficient approach to insect study – to be respectful of other people, natural communities, and the insects.

The development of close focusing binoculars has greatly enhanced insect study. Many binoculars now exist that can focus within five feet. This allows up close views of insects without disturbance and can yield important behavioral observations. Many of the birding binoculars are also excellent for insect watching, and you may already own this observational tool.

Another recent development is high-quality digital cameras (both still and video). They have facilitated field photography of insects. Digital cameras that have a screen instead of a viewfinder allow you to move the camera, as opposed to your head, allowing a much closer approach to the insect (Figure 3). The gear required is neither expensive nor cumbersome. For example, the Nikon S7c is a fantastic camera that will give good results under most conditions, costs under $200, and fits in a shirt pocket (many of photographs in this document were taken with the Nikon S7c). Good photography is not a result of having the best gear.

Figure 3: Taking photos can assist in the identification process when specimens are not collected

Knowing how to use your camera and being willing to become intimately involved with your subject is what leads to good photography. Insect photography is so prevalent that photographs are now accepted as vouchers to document occurrence for many taxa. Another advantage of photography is it makes a great addition to your field notes, allowing you to continue your learning from time in the field, long after the outing. Your photography can be even more powerful by utilizing it to document occurrences and distribution of various insects. Two of the best county distribution sources, *Butterflies and Moths of North America* and *Odonata Central*, are on the web at www.butterfliesandmoths.org and www.odonatacentral.com. Both sites have ready access to distribution data and easy to follow submission protocols.

In addition to simple occurrence, insects offer wonderful opportunities to observe and study behavior. Niko Tinbergen's 1984 book, *Curious Naturalists* demonstrates the value of an observational approach to insect study. Photography and video are both great tools for documenting behaviors.

Another popular insect study avenue is rearing insects. Many books exist on this subject, but Borror and DeLong's *Introduction to the Study of Insects* (various editions) will get you started. Usually, this approach will yield insight into insect interactions with plants. However, as those of you who have seen the Conservation Seeding and Restoration, Inc. dermestid beetle colony at various fairs and events know, you may find out how insects interact with a dead antelope or other food sources.

Borror and DeLong's *Introduction to the Study of Insects* has instructions for building a net, and you will find that you can make much of your equipment. Some things you will find it easier to buy. There are many biological suppliers, such as www.bioquip.com that sell specialized entomological equipment. Equipped with a net, close-focusing binoculars, camera, field notebook, and appropriate field guides you are now ready to embark on a journey into the world of insects!

Identification of many insects can be tricky as the identification resources exist in scattered technical journals if they exist at all, not to mention all the scientific jargon that requires an entomological dictionary to decipher the language in technical journals. Nobody goes into the field expecting to identify every species encountered. A good, general guide is Kaufman and Brock, *Insects of North America*. It will usually take you at least to "family." There are many web based identification tools. Currently, www.bugguide.net is the best general on-line guide. As you specialize, you will find others. There are numerous, excellent field guides that exist for many of the most watchable species. Tim Maniolis, *Dragonflies of California*, covers Idaho amazingly well. Robert Michael Pyle, *Butterflies of Cascadia*, is wonderful. *A Field Guide to the Tiger Beetles of North America* by Pearson, et al. is great introduction to an awesome group of insects. There are many others. The identification of these animals will require knowledge of the different types of antennae, legs, mouthparts, etc. Below, this information is presented in general terms.

Characteristics of Arthropoda

Before we get started on the insects, it is beneficial to begin at a higher level of organization because many animals are called insects but they are only relatives. Therefore, we will start by examining Arthropods (Figure 4) and work our way to insects.

Arthropods have segmented bodies, usually grouped in two or three distinct regions. They have paired segmented appendages. They have bilateral symmetry, which means, if you divided the animal in half longitudinally, the left side is a mirror image of the right side. They have exoskeletons made of chitin and the exoskeleton is shed periodical during growth processes. They have a tubular alimentary canal that connects a mouth to the anus. They have an open circulatory system, striated muscles, a simple nervous system, and a respiratory system that is composed of gills, trachea or spiracles. There are usually both males and females instead of one animal having the capability of being both male and female.

Classes of Arthropods

Classes in the phylum Arthropoda are contained within three subphyla.

- Chelicerata - spiders, scorpions, whipscorpions, pseudoscorpions, and mites
- Crustacea - crayfish, crabs, copepods, isopods, barnacles, and water fleas
- Atelocerata - millipedes, centipedes, symphylans, and insects.

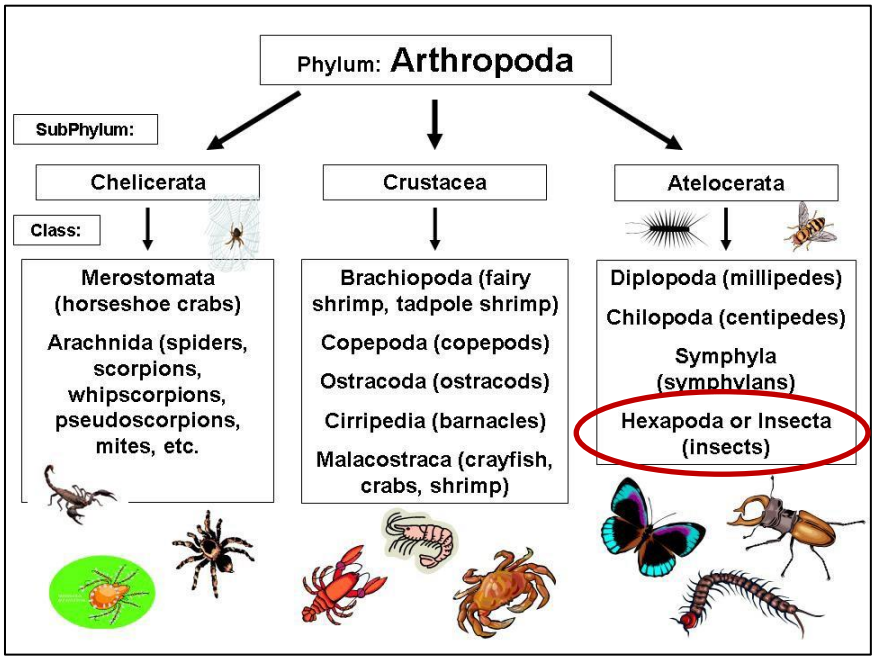


Figure 4: Flow chart depicting the organizational structure of common Classes within the Phylum: Arthropoda.

Of these varied and fascinating organisms, only insects are truly insects.

The animals more commonly confused by lay people as insects are: Arachnidia, Diplopoda, and Chilopoda. Arachnidia (spiders, mites, etc.) are in a different subphylum and have two body parts, the cephlathorax and abdomen. They have four pairs of legs and no antenna or wings. Diplopoda are the millipedes and they feed on decaying plants and fungi. However, if populations get large enough, they can sometime injure healthy plants. They have two pairs of legs per segment, which causes them to be much slower than their cousins, the centipedes.

Their body is round in cross section and they have relatively short antennae. Chilopoda are the centipedes. These animals have only one pair of legs per segment and are capable of moving

much faster than millipedes. This is good because they prey on other arthropods which means they need to be quick. Centipedes produce toxins to kill their prey, and will bite humans if they are disturbed or feel threatened. Unlike millipedes, they are flat in cross section and have longer antennae. Now that we know what an insect is not, let us begin with insects.

Insecta

Class Insecta has three distinct body segments (head, thorax, and abdomen), two pairs of wings (if present) and three pairs of legs. In this section, we will discuss each portion of the body of the insect to understand the morphology of these animals.

Head

On the head, there will be one pair of antenna, mouthparts and compound eyes (Figure 5).

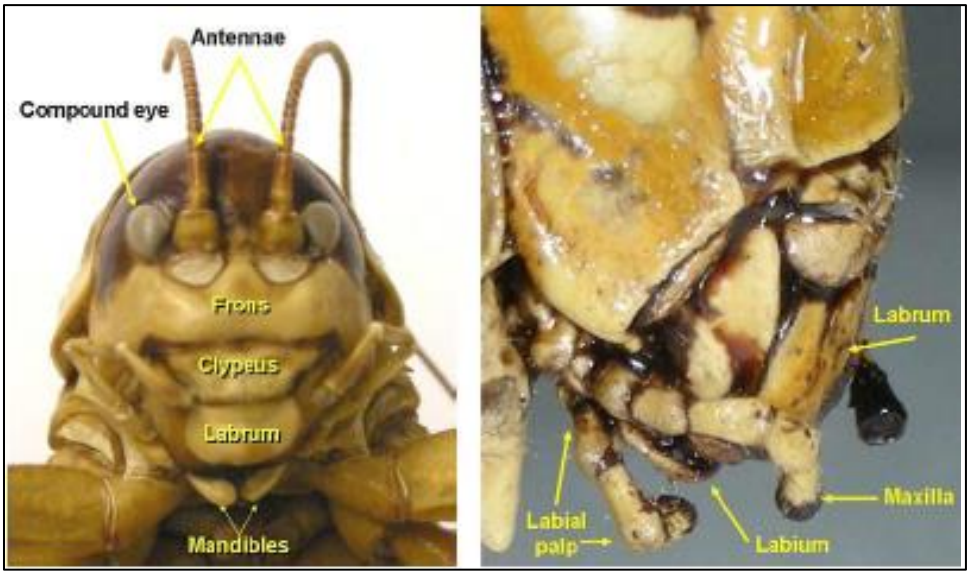


Figure 5: Structures located on the head of and insect.
The photograph on the left is front view of the face of a camel cricket and the right is a side view of an Acridid grasshopper

Mouth

As we study the mouth of an insect, you will see, in many ways, it is just like ours. They have two lips and a tongue. However, their jaws and teeth are a single unit. Mouthparts are often arranged in such a way that structures do not look the same when comparing the different types of mouths. Hence, you will see there are extreme variations of the mouth. There are two main categories of types of mouths: *mandibulate* (chewing) and *haustellate* (sucking).

- *Mandibulate (chewing) Mouthparts* - The classic depiction is shown in Figure 5. Chewing mouthparts are found in most insects, such as beetles and dragonflies. The labrum is the "upper lip" and the labrum is the "lower lip" of an insect. The labium has a feeler-like structure on both sides of the labium called a *labial palp*. *Mandibles* are the jaws and teeth wrapped up in one (Figure 6). They are located between the lips. Most mandibles have grooved surfaces or 'tooth-like' projections. They are aptly named, *mandibular teeth* (Figure 7). Mandibles move side to side instead of up and down as they masticate food. The shape of the mandible can be quite varied. The maxillae are another pair of feeler-like structures located behind the mandibles. Both maxillae and labial palps assist in the maneuvering of the food. The *hypopharynx* is a tongue- like structure located behind the mandibles and is not visible without the mandibles.

Figure 6: Sickle-like mandibles used to tear apart food.

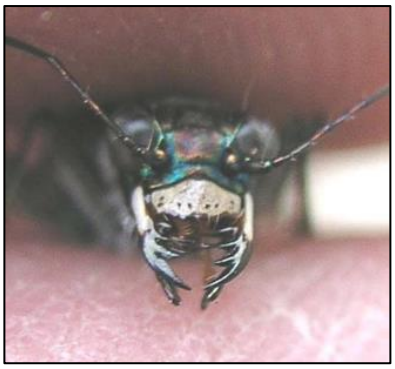


Figure 7: Mandibular teeth on a tiger beetle.

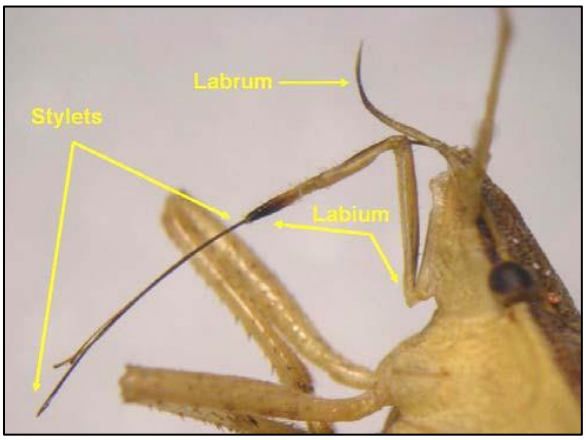


Figure 8: Slender mouth of pythophagaous stinkbug (top); broad mouth of a predaceous assassin bug (bottom).

- *Haustellate (sucking) Mouthparts* - The mandibles in haustellate insects are modified such that they are not used for chewing but are adapted for sucking. In some cases, the mandibles may even be lacking. This form of mouth is often referred to as Proboscis, or a beak, and is found on flies, true bugs, butterflies, and others. Within the haustellate groups, there are variations of sucking mouthparts.

The Hemiptera, or true bugs, have a beak (Figure 8) that is modified for piercing and sucking. The outer sheath of the beak is the labium, which is segmented, and houses the stylets. There are four stylets, which are modified mandibles and maxillae. The mandibles and maxillae form the salivary and food channels. Hemiptera will often inject their saliva into to their food to assist in the digestion of their food. Within the predaceous Hemiptera, such as Assassin Bugs, the saliva can paralyze its victim for easier eating. When a Hemipteran pierces its food, the stylets are the only portion that penetrates the food while the labium folds up. The labium is not involved in the piercing of the food. Since the Hemiptera all have piercing-sucking mouthparts, it may be beneficial to know that most predaceous Hemiptera have shorter, broader mouths than the pythophagaous (plant feeding) Hemiptera. This can be useful when handling Hemiptera, because like most animals, when threatened they may bite!

Figure 9: Mouthparts of Tabinid Flies

Figure 10: The flexible, drinking straw-like mouthparts of the Western Tiger Swallowtail.

There are other variations of sucking mouth parts. We will not go into all the specifics as to what makes the sucking mouth parts of flies and butterflies different from those of a true bug, but by looking at Figures 9, 10 , and 11, one can see how the mouths look different. Even though the mouths look VERY different, most if not all of the same mouth parts are present, but they are arranged differently. Biting flies also have haustellate mouthparts for piercing and sucking. The mouth of a mosquito is almost needle like,

Figure 11: Sponging/lapping fly

whereas, horse flies have a more knife-like mouth. It is partly because of the differences in mouthpart size that you can feel the bite of a horse fly more so than a bite of a mosquito.

Many of the Lepidoptera have mouthparts that can be described as a flexible soda straw (Figure 10). When not in use, the straw is carried neatly rolled up between the labial palps. This arrangement allows the "straw" to delve into flowers at the appropriate distance to exploit the nectar in deep flowers, while also providing aerodynamic efficiency and protection to valuable mouthparts. Sponging/Lapping flies - The proboscis (i.e., beak-like mouth) of non-biting flies consists of two main parts, the rostrum and haustellum (Figure 11). This arrangement is very efficient for handling the liquid and semi-liquid diets of the adult Diptera and is subject to great variation within the families of the order.

Antennae

Antennae are located on the head, usually between or below the eyes. There are three (Figure 12) parts to an antenna: scape, pedicel and flagellum. The scape is where the antenna attaches to the head. The pedicel is between the scape and the flagellum. Everything beyond the pedicel is the flagellum. There can be as many as 70 antennal segments and 68 of them would be considered the flagellum. The primary purpose of antennae is olfactory receptors. Essentially, they are the insect's nose. They also can be involved with regulating speed and stability of speed during flight. Some insects use antennae for holding prey while eating, while others use them in their courtship and mating rituals.

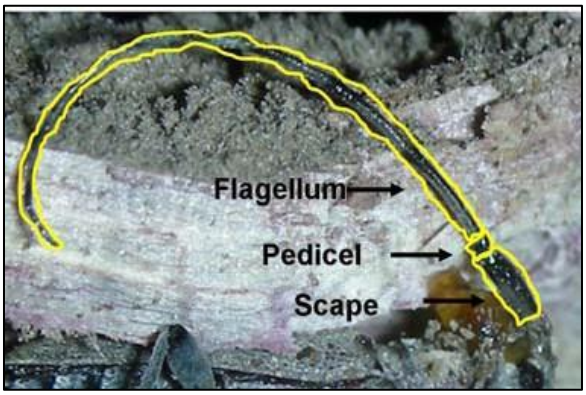


Figure 12: Antenna Morphology

Antennae are quite variable between insect groups and they are important in the identification process. Attachment 1 provides the terms and brief descriptions of antennae as well as some insects that have a particular antennal type.

Compound Eyes

The compound eye is made up of several (or several thousand) individual units called ommatidia. This is different from our eyes, which, while complex, function as a single unit. This means insects perceive the world differently than we do (Figure 13). At 20 frames per second, we see a movie – movies made for insects would need 180 frames per second. (This may be why most cartoon studios do not make cartoons for insects). This allows insects to perceive

form even when in rapid flight. Some insects even have stereoscopic vision allowing them to accurately judge distances. Insects can see ultraviolet light. Some insects can even analyze polarized light. The mosaic theory of insect vision (as depicted in figure 13) is old, but insect vision is not yet fully understood.

Figure 13: Simplistic depiction of what humans see (left) compared to what an insect sees (right).

Thorax

There are three segments making up the thorax. Each segment possesses a pair of legs. Wings, if present will also be on the thorax.

- *Locomotive appendages* - Legs are located on the thoracic segments, one pair of legs per thoracic segment. Legs typically have six segments: the coxa, trochanter, femur, tibia, tarsus, and pretarsus (Figure 14). The coxa is where the leg attaches to the thorax. The trochanter is usually one segment and is in between the coxa and femur. The femur is the first long segment of the leg, followed by the tibia. The tarsus is a part of the leg that appears to have multiple segments, but is actually more like sub-segments. Lastly, the pretarsus is the 'foot' so to speak, the claws and pads at the end of the leg. On immature forms of certain insects, there are leg-like structures, prolegs, on the abdomen. These are used for locomotion also, but they are not true legs and are not segmented. Prolegs are, however, useful in identification.

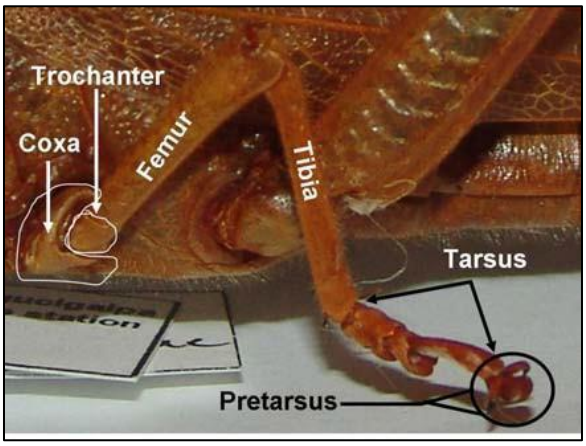


Figure 14: Morphology of an insect leg.

The primary and most obvious purpose of legs is for locomotion. However, insects such as dragonflies have legs that are not designed for locomotion. They are adapted to form a basket to assist in the capture of prey. Bees, butterflies, and flies have structures on their legs that are used to taste plants before ingesting them. Some insects also have modifications that are used during the grooming process. Additionally, the shape of the legs can also reveal information about the insect's behavior and/or habitat. For example, raptorial legs are adapted for grasping and holding prey; having raptorial legs suggest a predatory life style.

Another character that is often associated with predaceous animals is quickness for capturing prey. Many predaceous insects have cursorial (long, skinny legs) for running. However, not all long, skinny-legged, fast running insects are predaceous. For example, roaches are not predaceous but have cursorial legs. An insect with *nautorial* legs (many long hairs on the legs) is often a sign that it is an aquatic insect. The hairs on the legs assist with swimming. Another leg modification is for insects that live underground and have to dig to get underground. The leg type is called *fossorial*. The legs are broad and usually have tooth- like projections that assist in the shoveling of the dirt to maneuver themselves underground. A sampling of different leg types is shown in Figure 15.

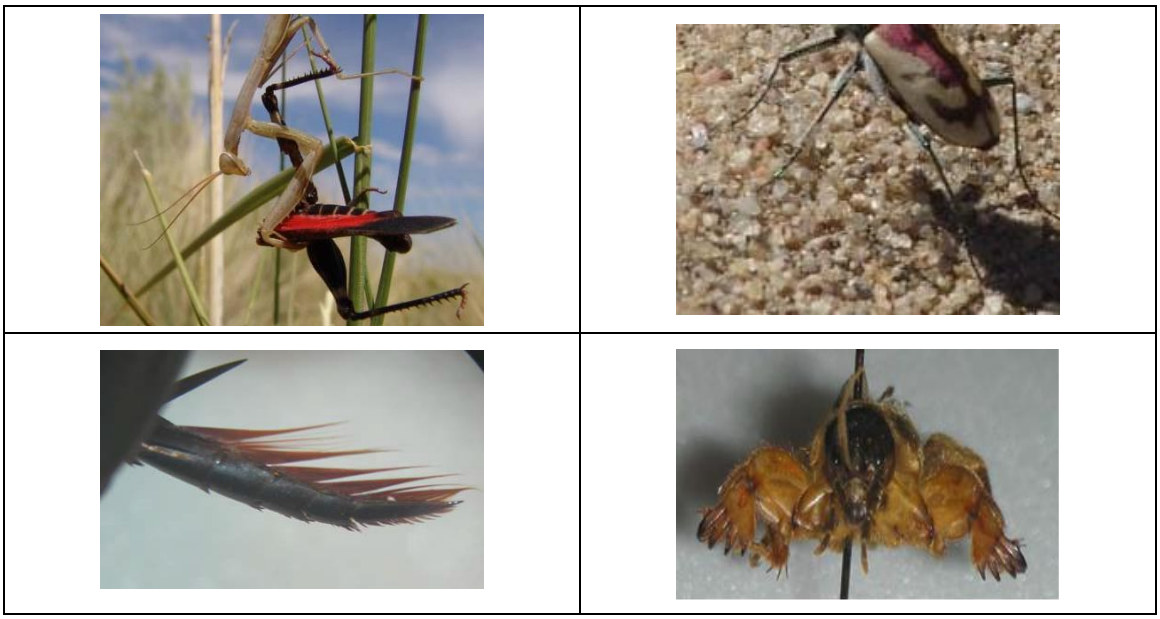


Figure 15: Types of legs: *raptorial* legs on a preying mantid (upper left), *cursorial* legs of a tiger beetle (upper right), *nautorial* legs of a water beetle (lower right), and *fossorial* legs of a mole cricket (lower left).

- *Wings (if present)* - Although the primary purpose for wings is flight, there are several variations of the wings. Most insects have two pairs of wings, the forewing (the first pair of wings) and the hind wings (the second pair of wings). Wings are attached to the second and third thoracic segments. Some insects are wingless and true flies have modified hind wings called halteres. Often the wing type is a good clue as to where to begin in identifying an unknown insect. Insect wing types, descriptions, and insects that exhibit the wing types are shown in Attachment 2.

  In many insect groups, the pattern of venation is an important clue as to species identity. The veins are hollow structures that may contain nerves, trachea, and hemolymph (insect blood) and serve to provide strength to the wing. As might be expected with something so important, several systems exist to name these veins. Do not be surprised to find that

different references utilize different terminologies for the same structure. Do not get frustrated. Utilize it as an opportunity to become more diverse!

Abdomen

The abdomen of an adult insect does not have appendages for locomotion. However, immature forms may have leg-like structures on the abdomen. There may also be a variety of abdominal appendages though, like cerci. The abdomen also harbors the reproductive structures.

Figure 16: Crochets on a proleg.

- *Genitalia* - The external genitalia of male insects are diverse beyond imagination and can actually resemble a Swiss Army knife in both form and function. In many insects, determining which species you are examining may require examining the genitalia. Secondary sexual structures can also be important. Happy is the photographer whose dragonfly photo has a clear shot of the cerci of the male because determining the species photographed has just gotten much easier.

Figure 17: Cerci of earwig.

- *Abdominal Appendages* - *Prolegs* are abdominal appendages that several caterpillar-like larvae possess (Figure 16). Prolegs are not true legs, but they are used for locomotion. Beetles do not have prolegs but Lepidoptera; some that have prolegs (sawflies) look similar to Lepidopterous caterpillars. However, they have more than 5 prolegs. Additionally, Lepidopterous larvae have crochets (hook-like structures on the "feet" of prolegs), and sawflies do not have crochets.

Cerci (Figure 17) come in all shapes and sizes. There are numerous uses for them. Earwigs have forcep-like cerci sometimes used as a defense mechanism and can be used to assist in the capturing of prey. Some insects, like the dragonflies mentioned above, use cerci when mating.

Metamorphosis Types

Insects undergo a process (metamorphosis) where they transform from the immature form (most often referred to as the nymph, larva, or caterpillar) to the adult stage. One common myth about insects is that if the insect is small, even if it has wings, it is a "baby" insect. If an insect has its wings, it is an adult and it will not get larger in time – the exoskeleton limits how big an insect can get. There are several processes that baby insects utilize to become adults. As an immature insect increases in size, it will shed its old exoskeleton and produce another, larger exoskeleton until it reaches adulthood. The old exoskeleton they shed is called an *exuvium* (exuvia is the plural form) as shown in Figure 18.

Figure 18: Exuvium of a grasshopper.

Simple/Incomplete/Gradual Metamorphosis

There are multiple types of simple metamorphosis. It is also called incomplete or gradual metamorphosis. Insects that go through an egg stage, immature stages, and adult stage experience simple metamorphosis. One common aspect of this type of metamorphosis is that wing development is external, if wings develop. Additionally, there is no period of inactivity as in complete metamorphosis.

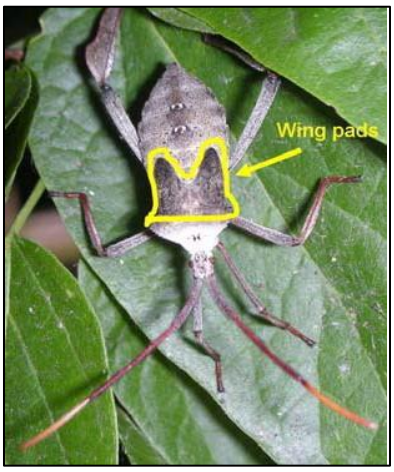


Figure 19: Photograph of wing pads of a leaf-footed beetle.

- *Ametabolous Metamorphosis* - During ametabolous metamorphosis, the immature forms look identical to the adult form but smaller. Eggs are laid and the immatures pass through several molts (nymphal stages) until they reach sexual maturity and are then called adult. The number of molts will vary depending on the species. An example of an insect that undergoes this form of metamorphosis is silverfish.

- *Hemimetabolous Metamorphosis* - Another form of simple metamorphosis is hemimetabolous metamorphosis. In this type of metamorphosis, the immature forms look different than the adults. They, like insects that undergo ametabolous metamorphosis have several molts as immatures. The number of molts is species specific. Dragonflies and mayflies complete their life this way.

- *Paurometabolous Metamorphosis* - Insects that undergo this type of simple metamorphosis look similar to the adult as immatures. Their wing pads (Figure 19) become more noticeable as they get closer to adulthood. The true bugs of the Hemiptera are an example of an insect group that undergoes this type of metamorphosis.

Complete Metamorphosis

Holometabolous Metamorphosis - Complete metamorphosis differs from simple metamorphosis in that wing formation is internal and there is a period of inactivity called the pupa. Insects that undergo complete metamorphosis have an egg, immature stage (usually called larva), pupa and adult.

Figure 20: Larval types: vermiform (deer fly) [top left], elateriform (wireworm) [top right], eruciform (Noctuid moth) (center), campodieform (lacewing) [bottom left], and scarabaeiform (white grub) [bottom right].

- *Larval Types* - Finding larval insects in the field is always exciting. Because they often look very different from the adult forms, being familiar with the different larval types will prove useful. Photographs of each larval type are provided in Figure 20.
    - *Vermiform* larvae are maggot-like or worm like. They are legless and may or may not have a well-defined head.
    - *Elateriform* larvae are cylindrical shaped with short legs. This form is representative of the wireworms.
    - *Eruciform* larvae are caterpillar-like larvae. They have well developed heads with short antennae. They have both true legs and prolegs.
    - *Campodeiform* larvae have an elongated, somewhat flattened body. They usually have well developed antenna.
    - *Scarabaeiform* larvae are grub-like and are usually C-shaped. They have well developed heads and only true legs.
- *Pupal Types* - From science class, you have more than likely heard "chrysalis" or "cocoon" to describe the stage where a larva transforms into an adult. That terminology is

correct but there are more names to describe the stage. Pupa is a general term that is always correct for this stage, whereas, cocoon refers to a type of pupa. Knowing the pupal type (Figure 21) will give you some idea as to what to expect when the adult hatches from the pupa.

- Insects with *obtect pupal* forms have the appearance that their appendages are "glued" to the body within the pupal case. The pupa may be protected within a cocoon. Lepidoptera and some Diptera have this pupal type.

- The appendages are "free" in *exerate* pupal forms. These pupae resemble a mummified adult. They are not covered by a cocoon. This is probably the most common pupal type of insects that undergo complete metamorphosis. However, Lepidoptera and Diptera will not have this form.

Figure 21: Obtect (top-left), Exerate (top-right), and Coarctate (bottom) pupae.

- The *coarctate* form is similar to the execrate pupa, but the appearance is different in that the pupa is covered with a hardened cuticle. Therefore, it does not have the appearance of a mummified adult. Diptera often have this pupal type.

Insect Senses

We touched on some of the senses that insects have, but it is important to realize that the world we share with insects is perceived differently by the different insects and by us. Most of the sensory components are located on the antennae and legs, but insects can have sensory organs in places that we cannot imagine. In some cases, there are structures that appear to be sensory in nature, but for which the function has eluded entomologists. An interesting case in point is the Noctuid moths. Many male Noctuids find females ready to mate by following a pheromone trail well below our threshold of detection. Often, these same moths can hear the ultrasonic "radar" of bats (fearsome nocturnal moth predators) with their abdomen and take appropriate actions. Probably they see wavelengths of light we can't, and taste chemical differences in plants of the same species. Some bees can sense the Earth's electromagnetic field. Many insects have the ability to see polarized light and others have the ability to track time. It is not that we are not

exquisitely adapted to our world; it is just that sometimes understanding insect behavior will require thinking outside of our own sensory box.

Habitat Utilization

Figure 22: Adult and immature aphids being tended by ants.

One of the reasons insects are so successful is many orders of insects avoid competition between offspring and adults by having a holometabolous life style (i.e. complete metamorphosis). A good example of this lifestyle is one of Idaho's most stunning butterflies, the Gillette's Checkerspot (Euphydryas gillettii). Eggs are typically laid on carefully selected leaves of twinberry honeysuckle in montane meadows. The caterpillars (or larvae) hatch out from the eggs and feed for 1-2 years on the leaves of the host plant accumulating the biological capital (i.e., stored fats from feeding) that the adults will later spend. In the pupal stage, the magic of transformation occurs and results in an adult butterfly. The adult Gillette's Checkerspots feed primarily on flower nectar – their tubular mouth parts are entirely different from the chewing mouthparts of the caterpillar. The adult is designed for reproduction and dispersal. The caterpillar is a perfect eating machine and consumes the vast majority of the food intake during the butterfly's life span. Furthermore, some adult insects, like mayflies, do not have functional mouthparts – their sole purpose is to produce offspring and disperse.

Figure 23: Asilid fly with dragonfly prey - an example of predation on predators.

Not all insects follow this life cycle pattern. Many orders have simple or incomplete metamorphosis processes. In some of these orders you will find adults and nymphs utilizing the same food resource. Next time you see aphids, take a closer look and you will see adults and the very similar nymphs (larvae) feeding side by side (Figure 22). An incomplete metamorphosis doesn't necessarily mean adults and larvae will utilize the same resource. Adult dragonflies and dragonfly nymphs are both obligate predators; but the adults are masters of the air, and the nymphs are aquatic predators. Competition between life stages is minimized by utilizing different food resources.

Insect habitat utilization can be demonstrated by thinking of spinach as a food resource; for us it is a little vinaigrette, a fork and bon appétit. Insects don't always approach leaves the same

way. Because of size related issues (a.k.a. scale), many more niches or ways of exploiting this resource exist. In addition to defoliating, insects may be skeletonizers, miners, gallers, borers into leaf petioles or main stems, or feeders on vascular tissues. When the entire plant is considered, the number of niches increases. Some insects prefer young leaves compared to old leaves. The cuticle of older leaves may be too tough for some insects, while others may utilize an older leaf because certain plant compounds may be diluted in the old leaves (due to the relative surface area between younger, small leaves compared to older, big leaves or vice versa). Insects even feed underground on the plant roots.

Of course, this many insect herbivores create opportunities for insect predators (Figure 23). There are a plethora of insect predation strategies. In addition to the various outright predation strategies, insects have developed a bewildering array of parasitism lifestyles (Figure 24). If you examine caterpillars in the wild, you will find some with external parasites. If you rear larvae collected from the wild, you will also have some larvae that become something other than the species expected – you will have reared internal parasites. As TV commercials say: "but wait there's more…" In the orders: Diptera, Coleoptera, and Hymenoptera, there are species that have taken on a lifestyle of hyperparasitism. A hyperparasite is parasitic on an external or internal parasite of a host insect. In other words, the parasite has parasites. This highly evolved lifestyle can be obligate (the insect can only parasitize parasites) or facultative (can be a primary or secondary parasite). In addition, it is important to note that there are generalized parasites that can utilize many insect species as a host, and specialized parasites that are more restricted to feed on a few species.

Figure 24: A moth caterpillar, *Helicoverpa zea*, with an unknown Hymenopteran internal parasite leaving the host to pupate.

As a vertebrate, you think of habitats as immense things and ultimately, everything is connected. We hope that the above discussion has created an awareness that insect habitats can be on an entirely different scale than most people are used to thinking about them. (The movie *Microcosmos* (1996) is an enjoyable, visual tour of the scale issues we are trying to communicate. Viewing this movie is highly recommended.). We have discussed two resources that insects eat (plants and insects), but insects utilize many other resources (e.g. fungus, humans, carrion [Figure 25]) and do so with similar degrees of complexity.

Orders of Insects

We are now ready to begin discussing the different orders of insects. It is probably appropriate to refresh our memories of exactly what is an order. An order sits in between class and family in the taxonomic hierarchy (a.k.a., Kingdom, Phylum, Class, Order, Family Genus, and Species). As an example, the woodpeckers are the in the order Picoformes, of which there are quite a few in North America. Compared to the flies (order Diptera), of which there are almost 20,000 species, the order Picoformes does not appear so diverse.

Figure 25: Carrion

As has been mentioned, insects are hyperdiverse to the point that your head is probably spinning. There are many insect orders and species in North America (Attachment 3). It may be helpful to know the general taxonomic lingo before going further. When you come across "*ptera,*" it signifies that we are talking about the Order of insect, e.g., Coleo*ptera*, Hymeno*ptera*, etc. The names that end in "-*idae*" are the insects in Family level (Carab*idae*, Formic*idae*, etc.), and groups that end in "*idea*" is often shortened by calling it, "-*id*" (Carab*id*, Formic*id*, etc.).

In the following pages, we will examine a few of the orders and families that you may have the opportunity to enjoy in the field or of which you should at least be aware. Remember, we are only scratching the surface of the deep body of insect knowledge. It is our hope that this scratching of the body will lead to an itching for more knowledge, and ultimately, the calamine lotion of discovery!

Collembola

Have you ever been working in the garden, overturned a stone or leaf litter, and seen what appear to be small grey dots jumping? Those are Collembolans or springtails. Collembolans have a structure called the collophore once thought to allow springtails to adhere to surfaces because it is wet and sticky. It was later determined that the primary purpose of the structure involves water uptake. However, Collembolans were named for the collophore before the true purpose was determined (*coll* meaning glue and *embola* meaning a bolt or wedge).

The common name "springtails" came about due to their behavior of jumping when disturbed. They have a structure, the furcula, on the underside of the abdomen that is held in place by a clasp-like appendage, the retinaculum. Once disturbed, they release the furcular moreover, the furcula acts like a springboard, allowing them to propel themselves. They can "jump" 75 –

100mm (3-4 inches). That is quite impressive considering their size is 3-6mm (0.1-0.2 inches). To put that in terms we may better understand, a 5ft human would be able to propel him/her as high as 165 ft. into the air!

With only 6,000 species, this group of insects account for less than 1% of the known species of the world. There are a little less than 700 species within seven families in North America, north of Mexico. Collembola are primitive insects. Some taxonomists do not call them insects because they are so primitive. They put Collembola in a different class all together. They have limited vision and are wingless. Because it is such a small group and they are cryptic, many people never see these critters. Some species occur on vegetation, but most species live in the soil, leaf litter, under bark, decaying logs and in fungi. They can reach large population sizes of 100,000 springtails/m^3 (2800 springtails/ft^3). They are important insects because they are part of "Mother Nature's Clean-up Crew". They feed on (clean-up/remove) decaying plant material, fungi and bacteria. They also take care of pollen, algae, and arthropod poop. Few species feed on vegetation that may also become pests in gardens, greenhouses, and mushroom cellars. They are also important to environmentalists because they are studied as indicator species of soil health. If you have high populations in the soil, it is likely that you have a healthy soil system. The next time you are working in your flowerbeds, look to see if you see any grey jumping dots.

Microcoryphia and Thysanura

In this segment, we will discuss two small orders of wingless insects: jumping bristletails (Order: Microcoryphia) and bristletails (Order: Thysanura, Figure 26). These insects undergo simple metamorphosis, meaning that the immature forms look similar to the adults but smaller. They are considered the bridge between the primitive wingless insects and the winged insects. The differences and similarities are mostly technical, morphological characteristics that will not be mentioned here. Both are fascinating and worth exploring further.

Figure 26: Silverfish

Microcoryphia is derived from the Greek words *micro* meaning small and *coryphia* meaning head. This is a small group with only 350 species worldwide. In North America, north of Mexico, there are 24 species within two families. They are similar in appearance to the other order we will talk about, the silverfish, but jumping bristletails are cylindrical and have an arched back. They have three appendages coming off the last segment of the abdomen and they have leg-like structures (styli) off each abdominal segment. Their bodies are covered with scales that may form a pattern, but they are worn off easily, especially if handled. Their preferred habitat is in leaf litter, under bark and rocks, and in

dead wood and they feed primarily on algae. They are active at night and they are capable of "jumping" 25-30 cm. That is more than 10 inches! When these critters molt, they have to glue themselves to a substrate with a substance that looks like poop. If the glue does not harden to the substrate or the substrate is not firm, the insect is not able to molt and it will die. Bristletails comprise another small order that has 370 species worldwide. There are 20 species in North America, north of Mexico, within three families. Their name comes from *thusanos*, meaning bristle or fringe and *oura*, meaning tail. There are two common groups in this order: the silverfish and firebrats. They are approximately ½ inch to ¾ inch in length. Their bodies are covered in scales. They have three appendages (tails) that are "fringed" with "bristles" coming out of their abdomen. They have compound eyes and chewing mouthparts. They can be quite long-lived, may take three years to reach maturity, and may continue to live five additional years as adults.

The more commonly encountered members of this group, because of their association with humans, are the silverfish and firebrats. Silverfish like cool damp places whereas firebrats like warmer places near furnaces and boilers. Both are fast runners and feed on starchy substances. They can be pests in libraries and in homes because they feed on book bindings, wallpaper glue, starched fabrics like curtains or clothing, and starchy foods that humans also like to consume. They are nocturnal. Therefore, they are not often seen damaging items around the house. More than likely, their damage may not be discovered for several years until you pick a book off the shelf after many years and the pages fall out or you move a box from the attic. When you pick it up, the bottom breaks because all the glue from the tape has been eaten by these critters. Some less common bristletails live in decaying trees, caves, mammal burrows, and even ant and termite mounds.

Ephemeroptera

Adult mayflies are soft-bodied insects that have two or three thread like tails (Figure 27). The forewings are triangular-shaped. The hind wings are smaller than the forewings and somewhat rounded. Both pairs of wings are membranous and held together over their body. The immature form is called a nymph. They live in water and breathe, using gills, which are found alongside the abdomen. They have three tails in the immature stage. They are often confused with stoneflies. However, stoneflies have two tails, not three and the gills are on the thorax, not the abdomen. They undergo a form of simple metamorphosis. It is unique and no other order of insects follows this metamorphosis type. The immatures look very different from the adults. The nymph will swim to the surface of the water and molts into a winged form, the *subimago*; however, it is not a true adult yet. The

Figure 27: Mayfly adult

subimago will fly a short distance to solid ground or vegetation where it will enter its final molt to an adult. The subimago is similar in appearance to the adult, but hairy.

These insects are named for the adult lifespan, which is very short. (*Ephemera* means "for a day" or short-lived, and *ptera* means wings). These insects are synchronous in their development, which leads to huge mating swarms. After mating, females will oviposit (lay eggs) on the surface of water or objects in water. Females die shortly after oviposition occurs and males die shortly after mating. When they die, they have been seen in piles over three feet in height. In situations where carcasses are so plentiful, they can be hazardous to drivers because roads can become slippery with their internal contents smashed onto road surfaces.

Figure 28: *Libellula saturata*, with prey in mouth, on *Agave* at Idaho Botanical Garden.

These insects are considered good biological indicators of water quality. Different species have different habitat requirements and some are very specialized. Environmental changes are apparent in the mayfly populations. Huge swarms use to be present in the mid-1950's around Lake Erie. However, water pollution increased and mayfly populations substantially decreased. In time, when water quality is restored, large mayfly populations may occur once again. Mayflies are also a large food source for fish. Many fishing lures have been developed to mimic their appearance. Fly fishermen are usually aware of the presence of mayflies. They are also food for birds, predaceous insects, spiders and amphibians.

Figure 29: A dragonfly nymph in a mountain lake (above) and an empty nymphal skin, or exuvium of a dragonfly (below).

Odonata

Odanates are incredible! Adult dragonflies (Figure 28) are masters of the air: fast flying, extremely maneuverable and equipped with extraordinary senses. They are large, colorful, sometimes territorial, predatory insects with fascinating behavior. They display most of the hunting characteristics of raptors (hawks and falcons). Their prey can eat anything from smaller flying insects to other odonates. Odonates go through three stages in their life cycle: egg, aquatic larvae (Figure 29) and adult.

Many species of odonates insert their eggs into emergent vegetation. When emergent vegetation around a body of water is removed, these species are also removed. Some odonates will lay eggs in soil near bodies of water, which makes them susceptible to trampling and other such disturbances. Because fluctuating water levels often preclude the establishment of aquatic vegetation, reservoirs are poor habitat. A lack of aquatic vegetation greatly reduces dragonfly production. If the aquatic habitat is free of fish, dragonfly larvae are usually the top aquatic predator. Waters that contain fish will produce significantly less dragonfly adults (according to some studies, 80-90 percent less) due to predation by fish.

This can put Odonate conservation at odds with fish stocking for recreational purposes in otherwise fishless waters (i.e. mountain lakes) because some species of Odonata simply cannot survive in the presence of predaceous fish.

Dragonflies are powerful predators as adults. Remember, it is as larvae that the bulk of their eating and growing is performed and the larvae are usually the ecological significant predator. As a child, I kept dragonfly larvae in a small aquarium and can vouch for the fact that they eat many aquatic insects and even small fish! There are two sub-orders of Odonata: anisoptera (dragonflies, Figures 28-30) and zygoptera (damselflies Figure 31).

Figure 30: *Cordulegaster dorsalis*, a showy and widespread dragonfly that had not been noticed in Idaho until recently.

The usage of the term dragonflies to refer to the anisoptera is not universal. When outside North America, the term dragonfly refers to all Odonata. Adult anisoptera will typically hold their wings flat when at rest. The hind wing is wider than the forewing, and their eyes typically touch or are in close proximity on the head. Adult zygoptera will typically hold their wings over the back when at rest. The hind wing and forewing are similar in shape. The eyes are widely separated on the head. Many people think zygoptera are "baby dragonflies" and some people think the sting of a dragonfly will kill you. These are more examples of insect myths. Dragonflies are typically fast fliers and damselflies are typically very

Figure 31: *Argia vivida* in the Sawtooth NF note the mites on the thorax.

maneuverable and can hover. All adult Odonata can be recognized by large eyes, which occupy most of the head, small bristle-like antennae, chewing mouthparts, four elongate wings, and a long, slender abdomen. The legs are not designed for walking but for perching and grasping. The larvae have a unique hinged lip that can be thrust out, like a basket, to capture prey items.

Plecoptera

The Plecoptera are the trout of the insect world. They are most common where freshwater is cold, clear, and delicious. Trout anglers know these insects as stoneflies. They plan vacations based on adult hatches (when fish gorge upon them) and quiver when they speak of about "good hatches." Turning over rocks in a clean, cold mountain stream will acquaint you with the flattened, often brightly patterned, predaceous nymphs (larvae). Six strong legs tightly grip the rock; two antennae up front, two cerci on the back end, and gills along the thorax should allow you to identify the nymphs. The adults may superficially look like roaches, but lack the hooded pronotum. Another good clue that Plecoptera are about is the abundance of adults you will find when you are near the water. These animals are important indicators of water quality. Idaho is blessed with many healthy stoneflies populations. A visit to a local fly shop will often give you a good idea, which species are hatching, from which streams.

Orthoptera

Insect taxonomy is always in flux as our understanding of the animals changes. The order Orthoptera is a perfect example of this process. The old Orthoptera referred to as the straight wings (*ortho* = straight, *ptera* = wing) included many members: mantids, stick insects, cockroaches, crickets, etc. The new, improved understanding of the order, emphasizes jumping abilities and those crazy hind legs; which leaves the grasshoppers, crickets and katydids as the only members of the order. Orthoptera have a simple metamorphosis.

- *Grasshoppers (multiple families)* - Grasshoppers (Figure 32) are the Orthoptera with short antennae. Antennae length may seem to be a small issue, but the grasshoppers sing, mate, hear and lay eggs differently than the members of the Order with long antennae. Grasshoppers are familiar, day-active, mostly vegetarians. Grasshoppers eat a variety plants. Some can be crop pests, others eat weeds, and others eat native plants that may be problematic for ranchers (e.g. rabbit brush). Grasshoppers often have brightly colored hind wings in addition to their strikingly colored and patterned bodies.

Figure 32: Recent hatch of grasshopper eggs.

Many Idaho butterfliers refer to the grasshopper *Dissosteira carolina*, as the "Mourning Cloak Mimic" because it looks a lot like that butterfly when in flight. The front wings, tegmina, are shown in the above introductory materials. The hind wings fold accordion-like under the tegmina when at rest.

Because these insects are defoliators and can cause significant injury to agricultural crops, pastures and rangelands, many resources exist to monitor populations, such as http://www.sidney.ars.usda.gov/grasshopper/Handbook/intro.htm. The Idaho State Department of Agriculture has a grasshopper and Mormon cricket control program and conducts monitoring of grasshopper populations within the state. One interesting tidbit about grasshoppers, they are often considered wasteful-feeders because they because they tear off more food than they actually eat, leaving a mess on the ground. They may eat as little as 25% of what they clip from plants – meaning 75% is wasted – or if you prefer, made available to other organisms.

- *Crickets and Katydids (multiple families)* - The members of the order Orthoptera with long antennae are as interesting, if not more so, than the grasshoppers. The songs of crickets and katydids are just as much a part of summer as the songs of birds. It is true that crickets and katydids change their songs in response to temperature, but it is easier to use a thermometer to tell temperatures than to count the number of chirps per minute and do the math. A great website is Singing Insects of North America (http://buzz.ifas.ufl.edu/) where you will find recordings, links, references, and other insect song related items. Adult females of this group have obvious ovipositors such as shown on the tree cricket (Figure 33).

Figure 33: Tree Cricket

A favorite cricket is actually a shield-backed katydid, the Mormon cricket, Anabrus simplex (Figure 34). Whether you view this creature as a traffic hazard, danger to alfalfa, or a majestic component of Idaho's rangelands depends on your point of view, but the spectacle of several adult Mormon Crickets per square foot as far as the eye can see and dominating the soundscape cannot be denied. Just as all Idahoans should go watch Greater Sage-Grouse on the leks, all Idahoans should spend some time in a Mormon cricket swarm – it is a special part of our little slice of heaven.

These critters played a big role in Mormon history. In 1848 Mormon, crickets devastated their farmland. Sea gulls moved in and had an "all you can eat buffet" of Mormon crickets. The Mormons considered it the "Miracle of the Gulls" and erected a monument of two gulls in the Temple Square in Salt Lake City. We were searching for Mormon crickets, in the Bennett Hills area in 2006 (Figure 35).

Figure 34: Two different color morphs of Mormon crickets (above).

When we topped the hill, the sky was white with ring- billed gulls. I remembered the aforementioned story and knew we had arrived! The road was not covered as anticipated. When we got out and looked around, the vegetation was black, covered with Mormon crickets. The gulls were not saving any farmland, so they were not miracles in Idaho but they did make the swarm easy to find!

Figure 35: Sea gulls feasting at Mormon cricket swarm.

The Jerusalem Cricket (Figure 36), also called the potato bug, is a native to the western United States, along the Pacific coast and into Mexico. Its face is thought to resemble that of a human and, as a result, it has many common names like cara de niño (child's face), old bald-headed man, and my favorite, Niño de la tierra (Earth Child). The Navajo people called them wó see ts'inii (skull insect). Regardless of its many names, it is not a true cricket and definitely not a bug. These animals live underground and primarily, feed on decaying roots. They have a song, but it is not chirping sounds like other Orthoptera, it beats its abdomen on the ground like a drum. They also make a hissing type noise by rubbing their legs on their abdomen. It is thought that this is done to frighten potential predators.

Figure 36: Jerusalem Cricket

Blattodea

Popular wisdom has it that cockroaches (Figure 37), a 300 million year-old order, will be around, pretty much unchanged, long after humans have poisoned themselves out of existence as a species. Roaches are primarily tropical, but I was lucky enough to live a few months in a Twin Falls motel that was blessed with a thriving population of these nocturnal ambassadors of tropical climes. Roaches are identified by the overlapping wings, hooded pronotum, and a characteristic roach smell. In addition, roaches can be incredibly fast!

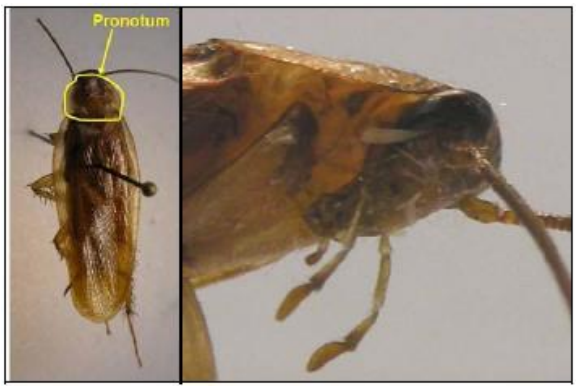


Figure 37: Adult roach (eastern species) and a close up of the head, which is concealed by the pronotum.

Most roaches prefer to live outside in trees, but when conditions are not optimal (i.e., too wet, too cold, too dry, etc.); roaches seek refuge in our homes. Most species do not want to be in your home and are only temporary residents. They will typically leave when their outdoor habitat gets back to normal. There are, however, species like the German cockroach, an introduced pest from Asia, that has evolved to co-exist with humans and are pests in the true sense of the word. Even though they seem gross, they are actually fairly clean animals – that is, as clean as their environment. If a household is dirty, the roach will also be dirty and is likely to spread germs throughout the house. They can also pose other health risks. Some people are allergic to them, especially asthmatics.

The entomologically aware naturalist is not limited to enjoying exotic roaches in their home. There are native, wild cockroaches that live primarily in rotting wood or under bark and can be important nutrient cyclers. These roaches will look very similar to the household roach and reflect the beauty of a very successful body plan!

Mantodea

In Southern Idaho, the Praying Mantis (Figure 38) can seem to be everywhere in late summer. We have even found adults and egg cases up on Lucky Peak at the Hawk Watch site. The egg cases are a tannish, hard, Styrofoam-like blob. They overwinter in the egg cases, and in spring, baby mantids hatch looking like and wingless adults and immediately begin eating each other.

Figure 38: Praying mantis, Buhl, ID

It is true that the female eats the male's head after mating. Some writers even say this is necessary for successful copulation. Mantids are amazing predators. There is a YouTube video and a Birdwatchers Digest article about Praying Mantises taking hummingbirds as prey! The Praying

Mantis, a successful, introduced species, is a favorite of children and considered very beneficial by gardeners. Introductions are continuing and mantis egg cases are available for purchase via garden supply stores and the internet. The impact of the introduced species on its prey and native mantids is understudied and not well understood.

Dermaptera

Earwigs (Figure 39) are another primarily tropical group that has some representation in our area.

Figure 39: Earwig

Earwigs are sexually dimorphic, but the large cerci (a.k.a. pinchers) and short elytra are exhibited by both sexes. The introduced European Earwig, Forficula auricularia, is the most commonly encountered and often massively abundant earwig in Idaho. Earwigs are omnivorous, but the introduced European earwig has a discriminating palette and is able to find the best vegetables in the garden.

Isoptera

Some primal termite knocked on wood
Moreover, tasted it, and found it good!
That is why your Cousin May
Fell through the parlor floor today. "The Termite" - Ogden Nash

Isoptera, the Termites, share a common ancestor with roaches and Mantids and are ambassadors of more tropical climates. The poem above is most likely what one thinks about when it comes to termites – damage to buildings, or indirectly, a dead, but standing, infested tree weakened to the point it falls on a home (Figure 40). Termites are best known, and hated, for the damage they cause to our homes as well as other structures constructed of wood. In our climate, you will not see many termites running around on the soil surface because most species of termites are subterranean (i.e., live underground), but you may see evidence of their activity. I have found termite colonies associated with buried wood a couple times in the South Sawtooth National Forest. These wild termite experiences were very

Figure 40: Termite damaged tree

surprising but involved small, white insects that were underground. They will not ever be the sole reason for a "Watchable Wildlife" site. As colonial insects, they have some phenomenal capabilities and an amazing symbiotic relationship with cellulose digesting bacteria. These critters are often confused with ants. Termites have straight, bead-like antennae and ants have elbowed antennae. Winged termites have wings of the same size. Ants have hind wings that are smaller than the forewings. Termites do not have a waist. Ants have a narrow waist. They also have different metamorphosis types where baby termites look like the adults and ants undergo complete metamorphosis where adults and immatures look different. A remarkable fact: Queens live for 25 years or more and lay as many as 60,000 eggs in her lifetime!

Thysanoptera

Thysanoptera, or Thrips, (Figure 41) are tiny insects that are a little bigger than the size of the dash at the end of this sentence: -. Thrips are strange little guys with weird metamorphosis, with two non-feeding instars (stages): pre-pupa and pupa. Its metamorphosis type is incomplete metamorphosis and was not previously discussed due to the complexity.

Figure 41: Thrips adult

Thrips have a unique wing type that resembles a feather (Attachment 2). They may also be recognized by their characteristic feeding damage on plants. They have a unique mouth that rasps away epidermal layers of the plant tissue and then sucks up the plant juices. It is often referred to as a sucking-rasping mouth type and it resembles a bird's beak. Thrips are so small that their feeding destroys individual plant cells, but leaves the cell walls intact. You should key into the empty cells when looking for thrips damage. Because thrips can occur in great abundance, they can be economically important. If you want to find thrips, take any flower in bloom, shake the blossom over a white piece of paper and look for moving "dashes." If you have a microscope or a hand lens, you will likely discover the moving "dashes" are thrips. Thrips is both the singular and plural word form. You can have one thrips or 10, 000 thrips!

Hemiptera

Hemiptera is a group of insects that have undergone a taxonomic restructure recently. Hemiptera previously housed the "true bugs" and Homoptera housed aphids, hoppers, scales and others. Now, both Hemiptera and Homoptera are Hemiptera with three sub-orders, Heteroptera (true bugs), Auchenorrhyncha (hoppers and cicadas), and Sternorrhyncha (aphids, whiteflies, and scales) (Figure 42).

Placing the two former Orders into one has made this one of the most diverse Orders in Class Insecta. The decision to place all these insects into one Order was based on their mouthparts (piercing-sucking, previously discussed). There is a difference though, some Hemiptera have mouthparts that arise either from the front of the head (Heteroptera) or from the back of the head (Auchenorrhyncha and Sternorrhyncha). Where the mouthparts originate was the artificial division of Hemiptera and Homoptera prior to them being merged into one Order.

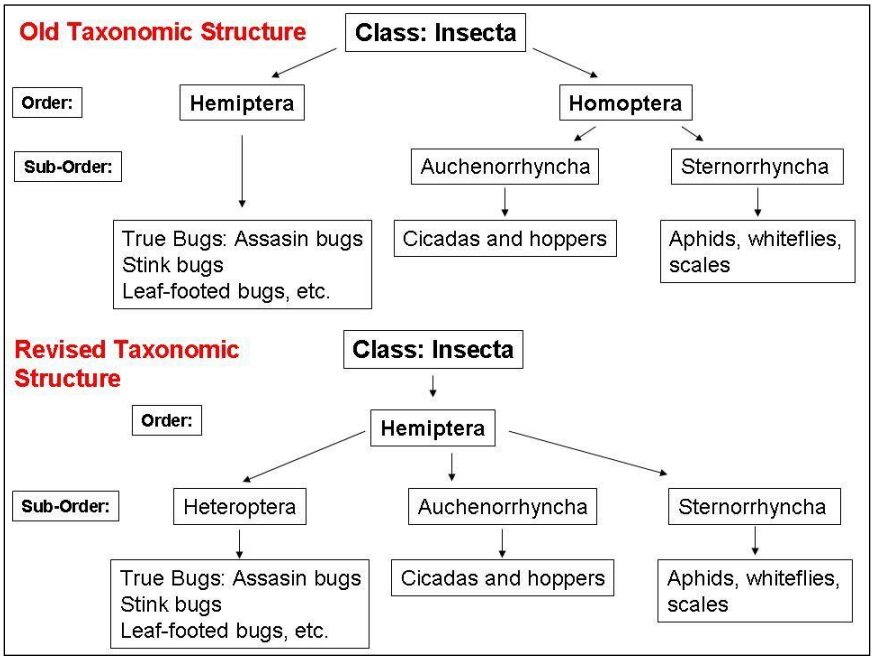


Figure 42: Flow chart describing the revision of orders Hemiptera and Homoptera

Lygaeidae (Seed Bugs)

Monarch Butterflies (our State insect) are not the only reason to plant milkweeds in your garden. If you are extremely lucky, your milkweeds will support a colony of milkweed bugs (Figure 43).

Figure 43: Milkweed bug

The beautiful orange and black milkweed bugs (there is more than one species) are members of the family Lygaeidae, and they will feed on the juices of your milkweeds. As you might guess, an orange and black colored milkweed feeder is a distasteful meal for most predators – just like another orange and black, bad tasting insect – Monarchs. The Lygaeidae used to be huge family, but recent taxonomic shifts have split it into ten families leaving the Lygaeidae with about 75 species in North America.

Water Bugs (Multiple Familes)

The families Belostomatidae and Gerridae are two of many families of Hemiptera associated with water in Idaho (Figure 44).

Given the importance and diversity of water resources in Idaho, it is recommended that a serious student take the time to learn these and other families of aquatic bugs. Occasionally, a Belostomatid (Water Bug) is found in the hatch houses of the commercial trout farms in the Hagerman Valley. The Belostomatid feed on the abundant supply of young trout. The hatch house technician often learns that, when mishandled, these creatures can inflict a painful bite – just look at its thick, broad proboscis. This group of insects represents the "single fathers" of the insect world. Females lay eggs on the backs of males and it is the responsibility of the males to protect and care for his progeny. They are among the few insects that exhibit male-parental care. The Gerridae, or water striders, are ubiquitous wherever water slows down and is still. These insects are a magnet for small children and hours can be spent watching, catching, and chasing these amazing predators, which are exquisitely adapted to life on the interface between air and water.

Figure 44: Belostomatidae adult and close up of its piercing mouthpart (left, center) and a water strider (right).

Pentatomidae

The stinkbugs, or Pentatomidae, are a trophically diverse group (some are predators, some are generalist plant feeders, and some are specialized plant feeders) that all appear physically similar (Figure 45).

Figure 45: Two different species of western stink bugs.

The five segmented antennae (penta = five) is found in all members of the family, but the basic family resemblance is uncanny. Given time, you will know these bugs on sight without counting antennae. Many insects produce an odor. Some insects produce stronger and/or more disagreeable odors. The reason stink bugs are so named is they are the most commonly encountered of the stinking insects. That said a collection of the stink from stinkbugs was used to flavor a beer brewed specially for a recent national meeting of the Entomological Society of America. This flavorful, thirst quenching, healthful, and piquant brew was enjoyed by many and pronounced delicious, by some. During the auction, a single 12 oz. bottle sold for $30! Stinkbugs, due to the wide trophic diversity among species, can be beneficial or detrimental to human goals. Regardless, when you look into their little cross-eyed

faces, they are just so darn cute it melts your heart. Even though some farmers may not agree, the world is a better place because we can share it with stinkbugs.

Cimicidae

I have been studying insects for almost 12 years, but it was not until a couple of years ago that I saw my first bed bugs. In Idaho, I had extension responsibilities, and received a specimen from Lemhi County. In addition, a pest control operator visited my office asking me to verify his finding. Both cases were the dreaded bed bug (Figure 46). Upon visiting with the man, he informed me that he has treated one home in Twin Falls, and knows of three other infestations in the Magic Valley area. Bed bugs are not an overwhelming problem to date (2008), but they are likely to become one...and could become a bad one.

Figure 46: *Cimex lectularius*, the Bed Bug, posing with a penny to show size. Twin Falls, ID, 28-Feb-2004.

Bed bugs were virtually extinct in the mid to late 60's in the United States but since 1998-1999, there seems to be a resurgence of these creatures. A nationwide survey conducted in 2005 by a group of entomologists revealed only about 30% of pest control companies treat for bed bugs but 67% of all surveyed companies report they have had an increase in bed bug calls in 2005 compared to 2004. So what exactly are bed bugs? They are small nocturnal insects that typically feed on animals while their victim is sleeping. Their bite is considered painless. Most people do not even feel the bite. When feeding, they inject their saliva into the victim which can cause an allergic reaction in some individuals that results in a welt that may itch (welt and itch severity varies). Reactions can occur in as little as one hour following the bite or may not appear for three or more days. These blood feeders (Figure 47) are not like mosquitoes that require a blood meal to produce offspring. Bed bugs only feed on blood of mammals and birds. The only positive side to these insects is they are NOT known to transmit any human diseases.

Figure 47: *Cimex lectularius*, the Bed Bug.

The top insect has fed recently. The bottom insect has not. Twin Falls, ID 28- Feb-2004.

Why are they becoming a problem all of a sudden? No one is sure the exact cause. Some thoughts on the subject include: insecticides that were once used heavily in the 60's and 70's are starting to break down and are no longer effective; resistance has developed to current

insecticides; and international travel. There are no data available to support the ideas associated with insecticide, but there is circumstantial evidence associated with travel. It appears that the majority of initial outbreaks were associated with metropolitan cities and subsequent infestations are in smaller, less metropolitan areas. People visit big cities, stay in a hotel, and unknowingly pack up some unwanted souvenirs of the vacation.

What do you look for? If you wake up with unexplained red bumps, this an indicator that something may be going on but does NOT mean you have a problem. It just means since bed bugs are on the rise, it is something to consider. Pest control operators have said the most common places bed bugs are found are in/on the mattress and box spring, on headboards, along baseboards, in carpet, and cracks and crevices of furniture. Some of the more uncommon places were inside cars, radios and other electronic devices, the kitchen, a showerhead, on curtains, and on a person. These critters are small, flat and cryptic and can hide almost anywhere so a thorough inspection is essential.

What can be done about bed bugs? Since these pests virtually did not exist for nearly 40 years, research on bed bugs is lacking. The first and foremost thing to do is a thorough inspection. It is also advisable to have a pest control professional assist. Homes often have to be treated with an insecticide that causes the homeowner to be at greater risk to insecticide exposure. Therefore, it is better to let a professional handle this pest. Of all situations involving pesticide misuse, homeowners are usually the number one offender. It is one thing to apply a 5X rate to your roses accidentally, but to apply a 5X rate to your bed that you sleep on is another. Insecticides are poisonous and can make people sick or can be deadly. Due to the nature of this insect and its relationship with humans, it is best to contact a licensed pesticide applicator for this critter. Because these insects are cryptic, hiding in the smallest of nooks and crannies, control is hard to achieve.

The previously mentioned survey also mentions that only 6% of infestations were controlled successfully by only one visit. The majority of infestations required 2-3 visits and 11% requiring 5-6 visits. There are non-chemical options. This can be discussed with a professional so that he/she can work with you to train you what to look for and where. While we may not like the thought that we are sleeping with blood feeding insects, it is becoming more of a reality. The best defense is to minimize clutter around the house (places for them to hide), avoid getting used furniture because you do not know the reason someone is getting rid of it, and when traveling, check behind wall mounted headboards as they are the number one bed bug hiding place in hotels. Remember, sleep tight and do not let the bed bugs bite!

Reduviidae

The nasty-looking beak perched on the front of the head (Figure 48) characterizes assassin bugs, or the Reduviidae.

The beak is designed for punching through other insects exoskeletons like a child punching a straw into a juice box. There are accounts of Reduviids with painless bites, but that is not our experience. In Idaho, you will most likely experience excruciating pain from defensive chemicals and/or digestive enzymes associated with the bite. Many assassins are brightly colored, perhaps to advertise the danger inherent in handling them. A budding Idaho entomologist would not touch any Hemipteran due to extremely painful experiences with Reduviids. I hope that you will be lucky and avoid being bitten as you study these fascinating and important creatures.

Figure 48: Immature assassin bug with lightening bug prey. Not an Idaho photo.

Cicadidae

Cicadids (Figure 49) are another insect famous for their singing ability. They can be extremely long lived, the 17 year periodicity of adult emergence of Magicicadia (what an appropriate name), reflects a 17 year larval period. In the juniper woodlands of Southern Idaho lives a cicada that first feeds on the outer branches of the juniper tree, then drops to the ground for a couple years of root feeding, and finally becomes an adult to fill the juniper-scented summer days with song. The red, dying outer branches of the juniper trees that result from the feeding of the freshly hatched nymphs are very distinctive and can be numerous. Big sage (Artemesia tridentata) also has a cicada species.

Figure 49: Cicada adult at Jim Sage Mountains (top) and exuvium from an immature cicada before the final molt to adulthood at South hills (bottom).

Cercopidae

Spittlebugs, or Cercopidae, are small but often beautiful as adults. As nymphs, different species feed on different plant species encased in a frothy "spittle" that results from fluid voided from the anus mixed with mucilaginous secretions from epidermal glands. From within this living room of their own making, the little spittle bugs can

feed in privacy and safety. The spittle can be a conspicuous component of meadows as shown in Figure 50. The spittle can survive rains and heavy dew, and probably protects nymphs from desiccation, predators, parasites and other unfavorable environmental parameters.

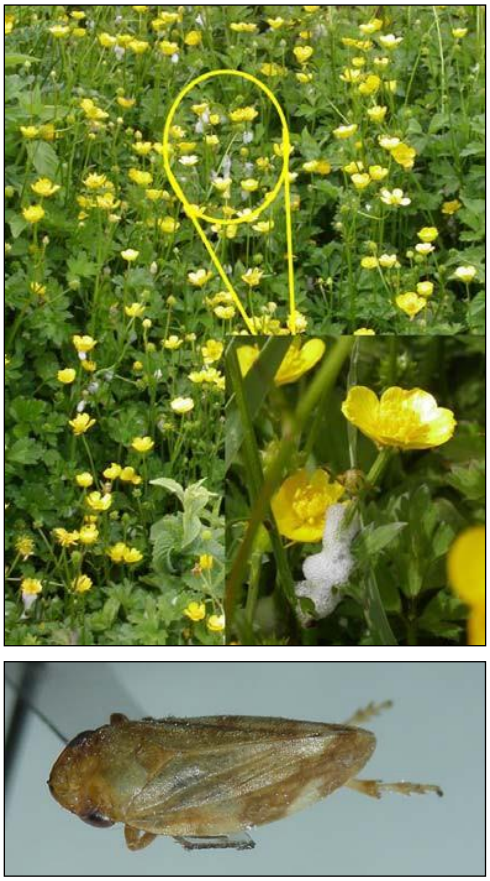


Figure 50: Spittlebugs on *Ranunculus* (top), spittlebug adult (bottom).

Aphidae

There are about 4,400 species of aphids. Aphids (Figure 51) utilize a variety of plants, parts of plants, life histories and mating systems.

The typical rose aphid is small, pear-shaped, soft- bodied insect, with long legs and antenna, and a pair of short tubes, called cornicles protruding from the hindquarters. These cornicles produce the chemical clouds by which aphids communicate. Some entomologists will tell you that the typical rose aphid will feed on blackberries, apples. Other rose family members other entomologists will tell you each plant has a different species of aphids. Most adult aphids are wingless and female. Winged adults appear in spring and fall, or when there is a declining food source that signals a need to move a colony. Although aphids are sometimes found singly, they are more often found in dense clusters on the tips of new growth. Small numbers of aphids do little damage, but as numbers of aphids increase, stunted shoots, loss of vigor in new growth, less production of blooms and virus transmission are problematic for the plant. The aphid wants sap, the nutritious lifeblood of the plant. The aphid targets soft, growing tissue where nutrients are dense. Aphids force their mouthparts into the plant tissue with their bodyweight. The aphid then injects chemicals into the plant to improve the flow of nutrients, beginning the chemical warfare between the plant and the aphid. A healthy plant responds by sending tannin glues and reducing flow of nutrients to the "leaking" area. The tannin seizes up proteins within the aphid, slowing its pumping. Aphids attempt to get around the plants defenses by picking on the weaker plants that are environmentally stressed. Once a successful feeding site is found, the aphids cluster together more closely, overwhelming plant

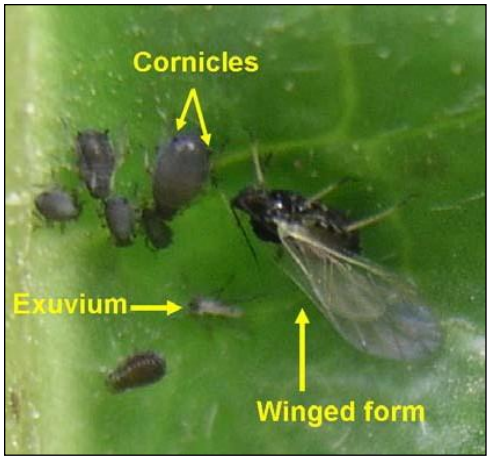


Figure 51: Aphids

defenses. Teamwork is great, but as numbers build so does the potential for discovery by predators. The clustering is regulated through communication by chemicals injected into the plant and/or gases released through the cornicles. Interestingly, aphids can detect the chemical presence of ladybugs (a major predator) and are deterred from feeding where ladybugs have been.

Feeding aphids do not move when disturbed because of the inserted feeding tube. This makes them sitting ducks for predators, including ladybugs, flowerfly larvae, wasps and lacewing larvae. Aphids rely upon sheer numbers, speedy reproduction and a few chemicals for survival. Ants can become involved in the predator/prey relationship by "farming" aphids for "honeydew" excreted by the aphids (Figure 22). Like any good farmer, the ants protect their livestock from predators – a job made easier by the clustering habits described.

In spring, female rose aphid nymphs will hatch from eggs that have over wintered on canes and begin to feed. Over the next ten days, depending on temperature, the nymph molts four times before becoming an adult. During most of the season, most aphids reproduce asexually (parthenogenesis), with adult females giving birth to live nymphs (that are already pregnant), as many as 12 per day. Each newborn is ready to produce young of its own in ten days. Now you know why things can get so bad so fast.

In late summer and early fall, female aphids begin to produce male and female aphids that hold eggs instead of giving live birth. Eggs require fertilization by the male, after which the female lays eggs that will over winter for the next season. Aphids get to your plants by flying, or more accurately drifting. Poor aerodynamic design and fuel problems (sap is heavy) limit flight time and distance. While in flight, the aphid has a sensing device that detects the distinctive infrared signal of a green plant in distress. When a suitable host is detected, it is communicated to other nearby aphids, and all drop to the intended host and the miraculous cycle begins anew.

Neuroptera

Neuroptera encompass many insects that look similar to Odonata (dragonflies and damselflies). They have long slender bodies and large membranous wings, but they have long antennae (Odanota have short setaceous antennae). Neuroptera also have smaller eyes than the Odanota. The wings of Neuroptera have more veins than Odanota and are typically held roof-like over the

Figure 52: Brown lacewing adult (left) and grass with lacewing eggs (right).

abdomen.

- *Chrysopidae and Hemerobiidae* - Lacewings (Figure 52) are delicate, beneficial insects. They are fierce predators of aphids, and eat small eggs of other of insects. There are two families that look similar, the brown (Hemerobiidae) and green (Chrysopidae) lacewings. They are primarily differentiated by their colors. They lay eggs that look like little white footballs on hairs stuck to plant leaves.

- Myrmeleontidae - When I was a child, my father showed me a small hole in the dirt and then stuck a piece of pine straw down in the hole and proceeded to say, "Doodlebug, Doodlebug, come out, come out – your house is on fire." Then a prehistoric looking creature came out of the hole. It was an ant lion. As larvae, these insects live underground, and wait for ants or other small insects to crawl over the hole. The insect above ground disturbs the dirt causing some dirt to fall on top of the ant lion larva in its hole. The ant lion pops out of the hole and captures the prey. An adult ant lion is shown in Figure 53.

Figure 53: Antlion adult

- *Mantispidae* - Mantispids are unique, (Figure 54) because they look like baby preying mantids but with wings.

  They have the raptorial front legs of a praying mantis, but have membranous wings instead of leathery/parchment-like wings. Larvae are parasitic on eggs sacs of spiders. There is also an unusual Mantispid in Idaho that, literally, looks like a cross between a wasp and a praying mantis. It is striped yellow and red with a wasp-like abdomen, but it has raptorial front legs.

Figure 54: Wasp mimicking Mantispid

- *Raphidiidae* - Hee-yaw Partner! In North America, these odd fellers are only in the West. The snakefly reminds one of the elusive Jackalope, except that snakeflies are REAL! The larva feed on invertebrates under loose bark and the adults are predators. The snakefly in Figure 55 is a female – the weird,

Figure 55: Snakefly

curved ovipositor is plainly visible.

Coleoptera

The Coleoptera, or beetles, are a huge group with many species. Weevils, a single type of beetle, may contain 10% of all species (all life forms!) known to this planet. The defining characteristic of this holometabolous order is the hard, protective forewings called elytra, that when they meet, make a straight line down the middle of the insect's back. Even flightless beetles possess this trait. In some beetles, the elytra are reduced but still meet in this characteristic manner.

- *Carabidae* - The Carabidae or ground beetles are important predatory insects. This is a very large family of mostly beneficial insects (~2600 species in North America) although a few do feed on plants and many will feed on seeds when prey is not available. The Carabidae, as currently understood, contains insects that were formerly placed in other families, such as, the Cicindelidae or tiger beetles. Tiger beetles (Figure 56) have the distinction of being "honorary butterflies" and as such are well liked and accepted readily onto conservation lists.

Figure 56: Cicindella arenicola

Tiger beetles tend to inhabit open, disturbed habitats. Therefore, it is not surprising that Idaho's two major sand dune systems: Bruneau and St. Anthony Sand Dunes both support endemic tiger beetles known only in Idaho! Because of the human interest in the tiger beetles, study of these insects is greatly facilitated by the presence of many good books. Northern Idaho is blessed because John Acorn's Tiger Beetles of Alberta covers the fauna well. The South will be best served by A Field Guide to the Tiger Beetles of North America by Pearson, et al.

Figure 57: Weevil from Palouse Prairie area.

- *Curculionidae* - There are more species of weevils (Figure 57) than there are vertebrate species living on the planet today. Even though these beetles can have very long, thin snouts, at the end of

the snout are the chewing mouthparts of a beetle – however tiny they may be.

Weevils can be pests of economic importance and some species have lifestyles that intimately associate with fungi that they vector from plant to plant. Yet, when an invasive and noxious weed is threatening, we often turn to the weevils to put on super hero cape and tights work for us as biological control agents of the problem species. Weevils, in addition to the aforementioned snout, also possess characteristically clubbed and elbowed antennae, and a sturdy and robust exoskeleton.

- *Scarabaeidae* - June bugs, dung beetles, chafers are all scarabs. This group has individuals that are the largest insects on the planet (although, the big guys aren't found in Idaho). As larvae, they all have that characteristic "C" shaped white grub morphology. The scarab shown in Figure 58 feeds on sagebrush roots as a larva.

Figure 58: Paracotalpa granicollis

We have found adults to be common in big sage stands in early summer. This beetle is sagebrush obligate just like the Greater Sage-Grouse – the difference is up until now you probably did not know it existed! Scarabs are also responsible for the rising and setting of the sun. According to the ancient Egyptians, this myth stems from the dung beetle forming perfectly round balls of dung and rolling them. The Egyptians saw the sun as a perfectly round ball that was rolled from one side of the sky to the other.

- *Dermestidae* - Dermestid are a very important group as they clean up the dead stuff that would be piled high and stinky if we did not have their help. Conservation Seeding and Restoration had a colony that was very popular with children at fairs, schools, and other public venues. These beetles also have a fondness for your insect collection and clean up all those dead insects, if the collection is not cared for correctly. We know of a pickup truck, used for backlighting, that develops a dermestid colony every summer. The dermestids kept the truck smelling fresh and clean. Dermestids can also be household pests feeding on: carpet, stored foods, dog food, etc.

Dermestids are also the Crime Scene Investigation bugs (C.S.I.). These critters, along with maggots and others, can be useful in predicting time of death in homicide cases. Therefore, they are useful to law enforcement agencies. Researchers in some of the

southern states have examined them in terms of poaching of wildlife cases. Therefore, poachers beware. In the future, these critters may help put illegal hunters behind bars.

- *Coccinellidae* - Lady bird beetles (a.k.a. ladybugs) are one of the most recognizable insects. They are characteristically red with black dots on the wings. The larvae are alligator-shaped. Both adults and larvae (Figure 59) are voracious predators of aphids.

  An Australian lady bird beetle was the first insect used as an introduced, biological control agent for control of an introduced scale. Additionally, multi-colored Asian Ladybugs were brought to the United States for as a biological control agent. However, it has become a pest in households because they move into homes during winter, because they, too, like warm places during the winter. Rather large populations can establish themselves in homes and offices. A concern is that they may be displacing our native ladybug species.

Figure 59: Lady Bug adult and larva.

  Another thing that many people may not be aware of is when it comes to lady bugs…if disturbed or if they feel threatened – they will bite. They do not hurt but you will know that you were bitten!

- *Gyrinidae* - Whirligigs are the black, oval beetles swimming en mass on the surface of quiet waters. The adults are scavengers and feed on insects that have fallen into the water. The larvae are aquatic predators. The easiest way to identify these guys is when they are alive in water. They are known to whirl around in circles rapidly, hence their common name, whirligigs. Figure 60 captures the circular ripples in the water due to this behavior. The most distinctive morphological characteristic of this family is the pair of compound eyes situated for vision in air and a pair of compound eyes situated for vision under the water surface. When you live on the water-air interface, you may benefit by tracking both. According to Borror and DeLong, 56 species of Gyrinids live in North America.

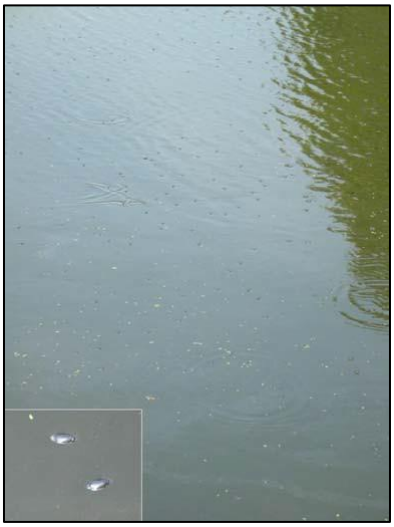


Figure 60: Water beetles

- *Silphidae* - The carrion beetles (Figure 61), or Silphidae, could be named for their diet or the way they smell. They are large and colorful. www.bugguide.net covers the group pretty well.

  Be aware that there is an endangered member of the family. You will want to be certain of the species if you choose to collect, as killing an endangered species is illegal.

  Some carrion beetles are called burying beetles because they will find a small dead bird or mammal and bury it. (No, they are not called "buryin'" carrion beetles.) A female will lay eggs in the soil. Larvae will hatch and begin to feed on the bird or mammal carcass. Another interesting fact about this insect group is that burying beetles exhibit parental care. Adults will feed larvae and protect their children's food from other carrion feeding insects.

Figure 61: Carrion beetle

  This group is mentioned because they appeared to have a population increase in Idaho in 2006. Carrion beetles need carcasses for their larvae. Small bird carcasses are ideal for this group. The first year West Nile Virus (WNV) was widespread in Idaho was 2006, and WNV killed many songbirds. The beetles likely responded to the abundant resource. Unfortunately, data do not exist to back up this observation, but the beetles seemed to be everywhere during the 2006 insect season.

Wood Boring Beetles

- *Bark Beetles* - Females make a tunnel between bark and lay eggs. Larvae hatch and feed on tissue behind the bark creating elaborate tunnels called galleries that can eventually girdle the tree. Adults emerge and leave pinhead-sized holes in the bark that gives the bark a "shot hole" appearance. Mountain pine beetles are problematic in pine forests throughout the west. They are small insects that create noticeable damage. (Figure 62). They prefer ponderosa and lodgepole pines over

Figure 62: Mountain pine beetle damage to forest.

pinyon pines. These beetles are known to attack trees that are already stressed. Once a couple of beetles locate a good source of trees, they send out a signal to other beetles and invite them to a party, which can do a lot of damage to the trees that host them.

- *Buprestidae and Cerambycidae* - These beetles lay eggs singly or in groups on the bark or in crevices in the bark. The eggs will hatch and move into the tree to overwinter as small larvae or they overwinter as eggs and hatch in the following spring. Young larvae mine the inner bark or wood creating tunnels that are flattened, usually oval in cross section, and gradually enlarging as the larva increases in size (Figure 63). Mines are tightly packed with fine sawdust. Upon exiting the tree, flat- headed borers leave a characteristic oval/elliptical shaped hole in the bark and long-horned beetles leave circular holes.

Figure 63: Damage to tree from wood boring beetles.

  Although they can devastate a tree, these can be some of the more beautiful beetles (Figure 64). The other common names for the flat-head borers are jewel bugs and metallic wood boring beetles. Their shape resembles a bullet and they are often brightly colored and/or metallic colored. Long horn beetles are aptly named because their antennae are at least half as long as their body, but are more often the length of the entire body or longer. These are often brightly colored or have marked elytra.

Figure 64: Herbaceous milkweed long-horned beetle (top) and Metallic wood boring beetle (bottom).

- *Meloidae* - Blister beetles (Figure 65) are necessary to mention because of the secretions they produce. They are in the family Meloidae and they secrete a juice, cantharadin, from their joints. When cantharadins contact human skin it burns, and in most cases, one will develop large, somewhat painful blisters (Figure 65). Sometimes, they are brightly colored to warn you of the imminent danger that may result from handling them. However, many are not. A quick general rule is that the thorax is narrower than both the abdomen and head. You may want to

refrain from causing yourself some pain! Eating these beetles while grazing must be problematic for mammalian herbivores due to blistering and swelling of the throat and mouth. Several years ago, in the mid-west, blister beetles were found in hay fed to horses. The beetles caused the deaths of several horses that consumed the blister beetle infested hay. The cantharadin from a European blister beetle is the active ingredient in the famous aphrodisiac, "Spanish Fly." Beetles were once ground up to make a powder that was then sold for its supposed aphrodisiacal properties.

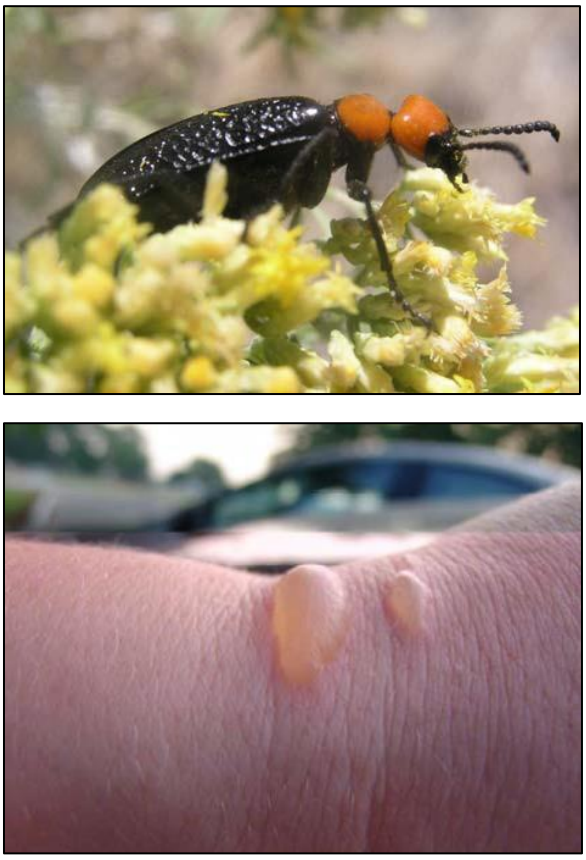


Figure 65: Blister beetle adult (top) and the injury they can cause if the cantharadin contacts the skin (bottom).

- *Tenebrionidae (a.k.a. "Stink beetles")* - These insects, when disturbed, emit a foul odor. It is for this reason that it has been given the common name "stink bug". (Figure 66). First, beetles are not bugs. The name "bug" technically only corresponds to insects in the Order: Hemiptera. Second, just because an insect emits a foul odor, does not mean it is a stink bug! The correct common name for these insects is "darkling beetle" or a Tenebrionid. Many insects will produce a stinky smell when bothered. It is a defense mechanism. Most animals, including humans, leave these "stinky insects" alone because they do not like the smell. Another interesting bit of information about this family of insects (Tenebrionidae) is that they typically have fused elytra and are not able to fly.

Figure 66: A darkling beetle often wrongly called "stink bug."

Mecoptera

The Mecoptera are considered to be closely related to flies and can be recognized in all adult forms by the peculiar head shape and chewing mouthparts (Figure 67). Males will often have a scorpion-like stinger structure on its abdomen. If you are spring skiing, you may see Snow

scorpion flies on the snow. Because of the Snow scorpion flies small size, most skiers do not notice these amazing insects.

Figure 67: Short-faced Scorpionfly Seven Devils.

Tricoptera

Tricops, or caddisflies, are favorites of trout, trout fishermen, and architecture students. YouTube (http://www.youtube.com/watch?v=WQviNYeBb9g) has videos of caddisflies building their distinctive larval cases out of precious materials. Cases such as these (Figure 68), but made with semi-precious gems, can be epoxied, as a preservative, and made into jewelry. Conversation with one person doing this confirmed that there is no need to harm the larva. They just wait until the caddisfly is done with its case. Cases can be built out of materials other than gemstones or stones for that matter. In addition to their building skills, Tricops are also important indicators of water quality.

Figure 68: Tricoptera larval cases

Lepidoptera

The Lepidoptera often function as the "starter drug." Unsuspecting naturalists will often dabble in butterflies recreationally, only to wake up in the gutter of the Pentatomidae (or other HARD insects) with months of their life just missing! People love butterflies. Butterflies are unique among the insects in that they are almost universally accepted and valued by people. The Xerces Society (www.xerces.org), the premiere insect conservation organization, has a red list of insects of conservation concern with 22 butterfly species and two moth species listed. When one realizes that there are ten times more moth species than butterfly species, one questions why more moths? Are butterflies more delicate? Are more butterflies habitat specialists than moths? No, people just like them more. That makes butterflies a special case in the world of insect

Figure 69: Caterpillar of Anise Swallowtail

conservation. In addition, butterflies are out, during the day, when people are also out, whereas moths are out at night when we are asleep. Consider how difficult it would be to have a specialized mosquito species listed on the Endangered Species list compared to a butterfly.

The Lepidoptera are holometabolous insects, or insects that go through a four different life stages: egg, caterpillar (Figure 69), pupa (Figure 70), and adult. Lepidopteran caterpillars are ecologically important, because it is as a larva when the bulk of predation occurs and the vast majority of food is consumed. Some Lepidoptera eat strange diets such as turtle shells, hair, or aphids but, usually, if you find a lepidopteran caterpillar, you can assume safely that it eats plants. Some caterpillars will only eat certain parts of certain plants. Others might eat plants within a certain genus, while some (e.g. Gray Hairstreak) will eat almost anything. The tubular mouthparts (proboscis) of the adult limit adult foods to nectar, and occasionally pollen. This proboscis is usually carried coiled between the labial palps on the head. The availability of nectar resources influences adult fecundity (reproductive abilities) in most lepidopteran species. This is why many butterflies are drawn to flowers and the underlying reason butterfly gardening is so popular.

Figure 70: Anise Swallowtail pupa

The difference between butterflies and moths is largely an artificial, human construct. However, butterflies have clubbed antennae and tend to fly during the day. Moths have various other antennal types, and mostly fly at night. Most moths also have a structure called a frenulum, that functions to keep the wings aligned, but you will not see that in the field. Initially, concentrating on butterflies will keep you busy. But, as time passes, you will encounter so many beautiful and interesting moths, you will realize that a butterfly-only avenue of study is like a peanut butter sandwich without the jelly – satisfying, yet without the sweetness.

Two books by Robert Michael Pyle stand out as important resources for Idaho butterfliers: Handbook for Butterfly Watchers and Butterflies of Cascadia. Armed with these two books, you are ready to begin your quest. If you travel outside of the region, you will want the Kaufman butterfly guide or one of the Glassberg Butterflies through Binoculars series. The fact that a butterflier has more than one field guide to choose from is testimony to how popular these insects are. There currently is no one, go-to source for Idaho moths.

The Butterflies and Moths of North America web site (www.butterfliesandmoths.org) offers lists of Lepidoptera documented Idaho counties. Documenting the Lepidoptera in your county is a

worthwhile and engaging activity. Many counties have small lists, not because they are bad habitat, but because no one has looked.

Figure 71: Pine white butterfly

Robert Michael Pyle writes about the beauty of the Pine White (Figure 71) flight along the Payette River and I must concur. This really is a soul-enriching spectacle. These butterflies have a beautiful and graceful flight and are worth seeking out. Spending some late-summer time along the Payette is a treat in itself. Try not to let the butterfly carnage from Highway 55 discourage you. When in bloom, the high mountain meadows throughout Idaho offer very rewarding butterflying and should be sought. The Southern Idaho deserts and shrub steppe habitats are very interesting in springtime when the marbles, Juba Skipper, and Spring Whites are flying. Five families of butterflies are well represented in Idaho: Hesperiidae (the Skippers), Papilionidae (Swallowtails), Pieridae (Whites and Sulphurs), Lycaenidae (Blues, Coppers, Hairstreaks, and Metalmarks) and Nymphalidae (the Brushfoots) (Attachment 4).

Figure 71: Malacosoma larvae

Idaho's moth fauna is also varied and interesting. In fact, there are typically ten times more species of moths in a given habitat than there are butterflies. There are also about ten times more families. A neophyte will encounter: Geometridae (inchworms), Saturniidae (Silk Moths), Sphingidae (Hummingbird Moths), Noctuidae (various names for subfamilys), and Arctiidae (Tiger Moths) (Attachment 4). Many moths will be encountered as caterpillars. The conspicuous webbed nests of Malacosoma (Figure 71) can be inspected to reveal a mass of caterpillars. Tussock moths feed on a wide variety of trees and, in an outbreak year, caterpillars can seemingly be everywhere in Idaho's forests. Idaho's moth fauna is not well documented. A serious student will find great riches. From the day flying beauty of the Arctiid moth Platyprepia, to the night-time Saturniid grandeur of Antheraea, to the Sphingid hummingbird-mimic Hyles, Idaho's moths are fascinating and will greatly repay the investment in time that their study requires. Hemileuca awaits you!

Diptera

The Diptera is an order of holometabolous insects defined by the presence of two wings, instead of the normal four found in the other winged orders. The hindwings are actually present, but have been modified into structures called halteres. The common name for this order is flies. You may have noticed that dragonfly, damselfly, and mayfly are one word and that is because they are not true flies. Only true flies have the distinction of having names with two words.

Figure 72: Golden poop eater. Scataphagidae.

Fly larva are varied: some are parasites; some are scavengers; some are predators; some are detrivores; and some are herbivores. Physically, fly larvae are usually legless and wormlike creatures called maggots, but some larva are exquisitely complex in form, such as mosquito and black fly larva. As one might assume, a wide diversity of body types and diet lends itself to exploiting a wide variety of habitats. Many adult diptera are important predators and pollinators. The adult mouthparts are designed for feeding on liquids and the primary food source of numerous families of Diptera is blood of vertebrates, including humans. As a result, everyone is aware of the stable fly, the horse fly, black fly and, of course, the mosquito. Diptera can serve as disease vectors. The spread of West Nile Virus is due to mosquito vectors. Diptera are amazing creatures (Figure 72) with many complex mating rituals and dances – they even exhibit lekking behaviors. Sage grouse are entertaining, but to watch flies strut their stuff is nothing short of amazing. A brief introduction to some of the Diptera follows:

- *Culicidae* - Mosquitoes (Figure 73) are of interest to anyone who has ever spent time outdoors. They are known as the Dipteran family Culicidae to entomologists. Mosquitoes have aquatic larval stages, and adults that are recognized by scaled wing venation, wings outlined with fringe and a long proboscis. Mosquito pupae are more mobile than most insect pupae and can be seen in most still bodies of water.

  If you have never seen mosquito larvae and pupae, you can easily do this by putting a bit of yeast and some grass clippings or leaves in a bucket, placing the bucket in a shady location, and

Figure 73: Mosquito

keeping water in the bucket. Eventually you will be able to see wrigglers (the larvae) and tumblers (the pupae) in the bucket at the water surface. Although these are aquatic larvae, they breathe air and must come to the water surface to breathe. If you transfer some of your water and larval and pupal mosquitoes to a clear-sided container, you will be able to enjoy the antics of these beautiful Dipteran larvae. Adding a predator such as an Odonate larva to the container will make your jar of water a Disney true-life adventure! If you see female mosquitoes on the water surface, they are probably laying eggs. It is fascinating to watch any animal lay eggs. The artistically inclined may wish to use the bucket and inhabitants as models for photos and drawings. The scientifically inclined may wish to quantify various aspects of the bucket and find out how different variables will affect the mosquitoes. Mosquito larvae are typically feeders on algae and organic debris but some are predators on other mosquito larvae.

It is true that only female mosquitoes bite. They need protein to make healthy eggs. Not all mosquitoes bite humans. Humans are not the preferential host for many mosquito species. Some mosquitoes feed on birds. Some feed on mammals. Some will feed on birds or mammals. Still others feed on only nectar. It is the mosquitoes that feed on birds and mammals that are most responsible for West Nile Virus.

Humans are abundant and conveniently filled with blood. Therefore, they can be a good blood meal for many mosquito species. Males feed on other liquids, typically plant juices and nectar. Females, when searching for food, will also nectar, if they are not in need of a blood meal for offspring production. In some situations, observations of large numbers of nectaring male mosquitoes would lead one to believe that they may actually be important pollinators.

Differentiating the species of mosquitoes requires a dissecting microscope. There was an Idaho-specific key to adult female mosquitoes circulating around county extension offices during the summer of 2006. Perhaps copies of that document are still available.

- *Chironomidae* - The family Chironomidae is also known as midges (Figure 74). These delicate and ubiquitous insects are often mistaken for mosquitoes. Before you douse yourself with bug spray, check for these characteristics: no scales on wings and no long proboscis. Another characteristic that midges typically have is very long front legs often mistaken for antennae.

  If you have ever encountered a large swarm of mosquitoes, it probably was not exsanguinating mosquitoes. It was likely an impressive swarm of midge flies. One such swarm provided learning opportunities about insect numbers for a group of blind students birding at the Minidoka National Wildlife Refuge. At a height of about 50’ above our

heads, hundreds of thousands of midges created a ceiling. The children were able to tune into the beating of all those wings that created a terrific level of sound.

Figure 74: Midge adult (left) and larva (right).

Most midges have aquatic larvae, but some will live in decaying matter. The bright red insect larvae you find in the muck at the bottom of the pond are Chironomids that have hemoglobin to help them obtain oxygen. It is one of the few insects that has hemoglobin. These larvae can be an important food source for other aquatic creatures. Midges are very specious. We do not know of a key for Idaho midge species.

- *Ceratopogonidae* - The family Ceratopogonidae is known as "no-see-ums" to you and me. For something so small, the bite is huge. Remember, all Diptera feed on a liquid diet as adults. The liquid that no-see- ums want is your blood and biting is how they get it. Many no-see-ums are reported to utilize insects as food sources, sucking hemolymph (i.e., insect blood) from many different insects, including mosquitoes! According to Borror and DeLong, many no-see-um species will not travel far from where the larvae live and moving away a few yards can often alleviate the pain that these flies can inflict. The no-see-ums have broader, more patterned wings than midges and the wings are held flat over the back. The larvae are aquatic to semi-aquatic and have poorly known feeding habits.

  In Riggins, the hotels have signs warning patrons not to sleep with windows open, as the screens will not prevent all biting insects from entering. Based on this information, Riggins may be a good place to acquaint yourself with these insects. The Chamber of Commerce will probably be able to assist you with timing your stay.

- *Simuliidae* - By now, you probably have a good understanding that Diptera feed on a liquid diet and blood is a liquid that is very desirable because of rich protein content. The Simuliidae, or Black Flies, can aggressively seek your blood and have been reported to cause deaths (humans and livestock). The larvae live in streams and attach to hard surfaces. According to Borror and DeLong, about 165 species of black flies live in North America.

- *Muscidae* - The family Muscidae is a very large group that can be found almost anywhere. This group includes the housefly and the stable fly. The stable fly is a biter, and unlike most other Diptera species, both sexes feed on blood. The larvae of the house fly feeds on filth (excrement and decay). The stable fly larvae feed on rotting straw. The annoying flies coming from the dairies are in this family. The Muscidae vector many diseases and can be vexatious to both livestock and humans.

- *Tabanidae* - At this point, you may feel that Diptera view you as a walking blood source. The Tabanidae is yet another family of Diptera that are more than willing to take advantage of you. You probably know these creatures as deer and horse flies. Females tear your skin and suck your blood. The males are peaceful creatures and consume nectar and pollen. They say the eyes are the windows to the soul (Figure 75). You will not stare into more beautiful eyes than those of the Tabanidae. The larvae (Figure 20) of most species are aquatic predators. The presence of the strong flying adults means you are within a few miles of water.

Figure 75: Eyes of a Tabinid.

  One thing to consider about most of the biting flies is, as larvae, they live in water. If there are numerous flies biting, that is truly a good thing. It means the water quality in the area is clean and able to support life, which in turn means the ecosystem is in decent shape.

- *Asilidae* - The Asilidae, or robber flies, are a fascinating and fun group of flies to study. Asilids are predators and take a wide variety of insects. Some Asilids mimic bumblebees (Figure76), but the true identity is given away by a characteristic head shape and the presence of distinctive mouthparts that look like a goatee. (Figure 77). Asilids can be found in flight taking dangerous prey much larger than themselves. Three examples are bumblebees, other Asilids, and dragonflies. They pierce the exoskeleton

Figure 76: Asilid flies mating.

of their prey with their "goatee," inject digestive enzymes to paralyze their prey, and then suck out the contents (remember adult Diptera have liquid diets). Documentation of dragonfly occurrence has been facilitated by utilizing the empty exoskeletons that remain after Asilid predation. County moth records have been established with photos of the moth in the clutches of an Asilid. A tiger beetle, or dragonfly, chew up their prey.

Figure 77: Goatee of Asilids.

Therefore, it is difficult to know what they are eating, but the gentile habits of the Asilidae lend themselves nicely to prey item studies. A checklist to Idaho Asilids (Lavigne, Barr, and Stephens, 2001) is available on the web (as of June 14, 2008) at:

https://zeus.collegeofidaho.edu/campus/community/museum/IEG/Downloads/IDAHO_ASILID_CHECKLIST.PDF

Hymenoptera

The order Hymenoptera is known by having four membranous wings with relatively little venation. The hindwings are smaller than the front wings and often hooked to the front pair via the hamuli (Attachment 2 – Insect wings). The first abdominal segment is narrowed to a waist in many forms. This holometabolous order contains some of our most beneficial and damaging of insects: bees, wasps, sawflies, and ants. This order also contains most of our social insects.

- Formicidae - Ants are important: predators, scavengers, recyclers, seed harvesters, soil builders, and more. Everyone has seen an ant, as both are abundant and ubiquitous. Few people see how important these animals are and show them the respect they deserve. There are as many ant species worldwide as there are bird species – but there are many more pounds of ants than birds on our fair planet! Ants are challenging to identify because they exist in many forms or castes: one or more kinds of workers, soldiers, queens, and males. Superficially, each caste can be more like members of the same caste of other species than it is like members of its own species. Ants live in social units where, nominally, all the ants are related. These social units can have animals that live among the ants – social parasites. Some ants do the unthinkable. They enslave other ants. Some ants "kidnap" ants of a different species and have them do the day-to-day chores!

Numerous species of insects are tended by ants (Figure 78), where the ants protect the animal in question. This animal pays tribute to the ants, usually a sweet, sticky substance. Conservation of many of the Lycaenid butterflies probably requires conservation of the ants which protect the larvae.

Figure 78: Ant tending a Western Pygmy-Blue larva.

Figure 79 shows Thatch Ants of the genus Formica. Thatch ants build mounds of thatch, which may be three feet tall and can be a conspicuous feature of the Southern Idaho landscape. The mounds serve several functions - thermoregulation is one.

Figure 79: Thatch Ants

Another important Idaho ant is Pogonomyrmex, the Harvester Ant. These ants actually modify the vegetation around their nests. The nests can be spotted from the air. They are a persistent feature in the landscape. Queens can live for 60 or more years! Horned Lizards are intimately associated with Pogonomyrmex in a specialized predator/ prey relationship. (Figure 80)

- *Bees (many familes)* - Honeybees are well known and well liked. Because we know that a honeybee sting is fatal to the bee, the fact that they can sting only adds to their allure. Colony Collapse Disorder (CCD) has been big news lately as honeybees do not return to the hive after they leave. The commercial honeybee, Apis mellifera, is an introduced species.

  Honeybees are a big business and honeybees are trucked all over the area. We work honeybees hard. We move their hives to pollinate different crops, expose them to mites and diseases as they mingle with other hives from other places. We treat hives with pesticides as a prophylaxis

Figure 80: Horned Lizard, a voracious ant predator.

against disease. The cause of CCD is not currently known but may have something to do with the stressful life we ask these animals to live. Some orchards are responding to CCD, with good success, by managing field margins and fallow lands to provide native bees as pollinators.

CCD is interesting, but there is so much more of interest in the behaviors exhibited by these animals. The Schwänzeltanz, or waggle-dance, is wonderful. The story of how Karl von Frisch discovered this amazing set of communication behaviors is well worth reading. The amount of information communicated is unbelievable too. Scout bees will leave in search of nectar and a bee will return with directions to the source of nectar. She communicates the directions through dance! She will tell worker bees in which direction the nectar is and how far the location is from the hive. Honeybees are well researched. There is still much we do not know. In addition to hive dynamics, pollination ecology is another area that bee students will find worth studying.

Figure 81: Bumble bee nectaring.

The Honey Bee has perennial hives with thousands of workers. Our native bees form primarily annual colonies, if they form colonies at all. Bumble Bee (Figure 81) colonies are much smaller, subterranean dwellings. The Alfalfa Leafcutter Bee is an important pollinator in Idaho agriculture. A visit to www.xerces.org will get you started learning to appreciate native bees.

- *Wasps (many families)* - The term wasp includes several families of Hymenoptera, and numerous lifestyles. Wasps are extremely beneficial insects. Most homeowners will not tolerate them around the home. I have found my garden does much better when yellow jackets (Figure 82) are nesting nearby because they kept pests from damaging the vegetables. In late summer, after the queen is dead and there are no larvae to feed, yellow jackets turn into "sugar punks." Unfortunately, the new diet also includes your soda. Drinking yellow jackets is an unpleasant experience. My daughter said that Winnie-the-pooh is much more humorous when he has a mouth full of bees than I was when I had the unfortunate experience of finding yellow jackets in my soda! The saddest part of the summer festival of wasps is that only mated queens survive the winter. Idaho is richly populated with wasps: Velvet Ants (they may be called ants, but they are

wingless wasps), Spider Wasps, Braconid Wasps, Thread-waisted Wasps, Digger Wasps, Gall Wasps, Ichneumonid Wasps, and others. All are fascinating and worth discovering.

Figure 82: Wasp

It is our hope that this document has inspired you to watch for insects as you go about your naturalist activities and has sparked your curiosity about these fascinating animals. As has already been stated, insects are hyper-diverse and exploit just about every possible resource and niche. A naturalist can contribute important, new information to the scientific literature because so much is still unknown about these animals. It seems that field observations always reinforce the adage that: "There are no rules in the Animal kingdom." At first, it may seem insane to spend time chasing creatures that weigh less than a piece of paper, fit easily upon a quarter, and can have extremely short life spans. Once you realize the importance of these creatures, you will realize that it is insane not to pay attention to insects. The orders on the following pages are appended to assist you a quick identification characteristics of Insects.

INSECT ORDER	COMMON NAME	MOUTH PARTS	WING TYPE	METAMORPHOSIS TYPE	LARVAL TYPE	PUPAL TYPE	KEY CHARACTERISTIC OF ADULT
Collembola	Spring tails	Chewing	Absent	Simple (A)	n/a	n/a	Furcula
Thysanura	Silver fish/ bristle tails	Chewing	Absent	Simple (A)	n/a	n/a	No wings, 3 cerci
Ephemeroptera	Mayflies	Chewing/ vestigial*	Membranous	Simple (H)	n/a	n/a	Large membranous front wings and small hind wings held sail-like over the abdomen
Odonata	Dragonflies/ Damselflies	Chewing	Membranous	Simple (H)	n/a	n/a	Large eyes occupying most of head, setaceous antennae
Orthoptera	Grasshoppers/ Crickets/ Katydids	Chewing	Tegmina	Simple (P)	n/a	n/a	Hind jumping leg
Phasmatodea	Walking sticks	Chewing	Tegmina	Simple (P)	n/a	n/a	Resembles a stick with legs
Dermaptera	Earwigs	Chewing	Elytra	Simple (P)	n/a	n/a	Reduced elytra and forceps-like cerci
Plecoptera	Stoneflies	Chewing	Membranous	Simple (H)	n/a	n/a	Membranous wings held flat over abdomen when at rest, long antennae, two cerci

INSECT ORDER	COMMON NAME	MOUTH PARTS	WING TYPE	METAMORPHOSIS TYPE	LARVAL TYPE	PUPAL TYPE	KEY CHARACTERISTIC OF ADULT
Isoptera	Termites	Chewing	Mostly absent, altates - membranous	Simple (P)	n/a	n/a	Mostly light-colored, ant-like but moniliform antenna not geniculate
Mantodea	Preying mantids	Chewing	Tegmina	Simple (P)	n/a	n/a	Triangular-shaped head, long antenna, tegmina, raptorial legs
Blattodea	Roaches	Chewing	Tegmina	Simple (P)	n/a	n/a	Head concealed by pronotum, tegmina
Hemiptera	True bugs/ aphids/ scales/ hoppers	Piercing-sucking	Hemelyltra	Simple (P)	n/a	n/a	Sucking mouthparts – very diverse group; wings – hemelytra, or held tent-like over abdomen
Thysanoptera	Thrips	Rasping-sucking	Fringed wing	Intermediate	n/a	n/a	Fringed wings
Psocoptera	Book and Bark lice	Chewing	Membranous	Simple (P)	n/a	n/a	Swollen clypeus (busted upper lip)
Phthiraptera	True lice	Chewing or sucking	Absent	Simple (P)	n/a	n/a	Wingless, flattened body
Coleoptera	Beetles	Chewing	Elytra	Complete	Campodeiform, Vermiform**, Scarabaeiform**, Elateriform**	Exerate	Elytra, NO cerci

INSECT ORDER	COMMON NAME	MOUTH PARTS	WING TYPE	METAMORPHOSIS TYPE	LARVAL TYPE	PUPAL TYPE	KEY CHARACTERISTIC OF ADULT
Neuroptera	Lace wings/ antlions	Chewing	Membranous	Complete	Campodeiform	Exerate	Membranous wings, antennae may be filiform or other, but not setaceous
Hymenoptera	Ants/ wasps/ bees	Chewing-lapping*	Menbranous	Complete	Eruciform**, Vermiform	Exerate	Membranous wings with the anterior margining of hind wing with hamuli
Trichoptera	Caddisflies	Chewing-sucking*	Hairy, held roof-like	Complete	Campodeiform	Exerate	Moth-like but hairy wings NOT scaly
Lepidoptera	Butterflies/ moths	Chewing-sucking*	Scaly	Complete	Eruciform, Vermiform**	Obtect	Scaly wings
Siphonaptera	Fleas	Sucking	Absent	Complete	Vermiform	Exerate	Wingless, laterally flattened
Mecoptera	Scorpionflies	Chewing	Membranous	Complete	Eruciform	Exerate	Head extends below eyes and is often elongated to form a 'beak'
Diptera	Flies/ mosquitoes	Sucking/ spongy	Halteres	Complete	Vermiform	Coarctate, Obtect	Halteres

* mouth parts differ between adult and immature forms
** not the most common larval form of the order

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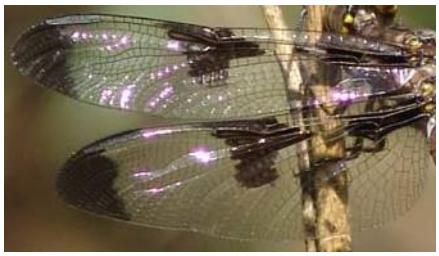
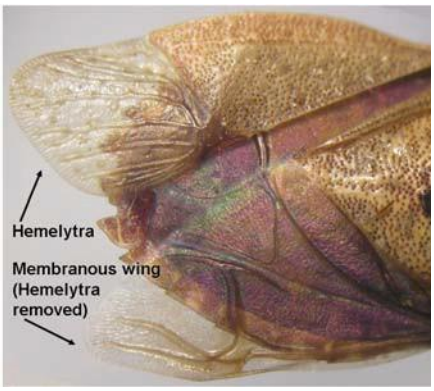
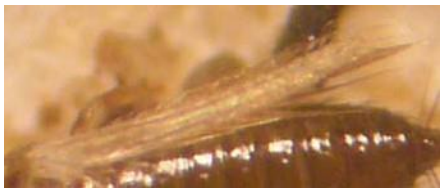
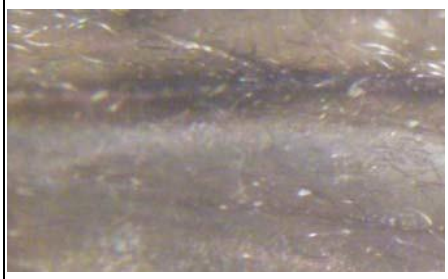
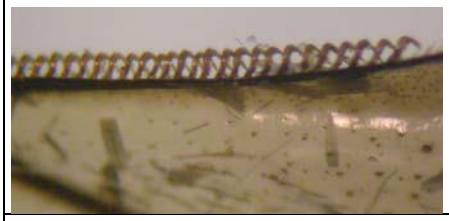
Attachment 1
Descriptions and Terminology of Antennal Types

Monilform, or bead-like, antennae are found on termites and others	Filiform, or thread-like antennae are found on roaches, Carabids and others	Pectinate, or comb-like, antennae are found on male glow worms and others
Setaceous, or bristle-like, antennae are found on true bugs and dragonflies	Serrate, or saw-toothed, antennae are found on click beetles and others	Aristate antennae are pouch-like with a lateral bristle and are found on some flies
Lamellate, or plate-like, antennae are found on scarabs	Geniculate, or elbowed, antennae are found on ants, bees, and weevils	Plumose antennae are feathery and found on male moths and male mosquitoes
Capitate, or clubbed, abruptly make a ball at the tip of the antennae –found on butterflies.	Clavate antennae gradually forms a ball at the tip of the antennae – found on the carrion beetles and others	

Attachment 2
Descriptions of Types and Characteristics of Different Insect Wings

	TYPE / CHARACTERISTIC	DESCRIPTION	INSECTS THAT HAVE THIS TYPE
	Tegmina	Forewing is leathery or like parchment in texture	Roaches, preying mantids, and grasshoppers Orthoptera, Mantodea, Blattodea
	Membranous	Clear wings with many veins, with or without color or patterns	Dragonflies, mayflies, termites and lacewings Odonata, Ephemeroptera, Neuroptera, and Isoptera (when present)
	Hemelytra	Front wing that is leathery at the base and membranous near the tip, hemelytra covers a membranous wing	True Bugs Hemiptera (Heteroptera)

	TYPE / CHARACTERISTIC	DESCRIPTION	INSECTS THAT HAVE THIS TYPE
		Wings held roof- like over abdomen	Leaf Hoppers Hemiptera (Auchenorrhyncha and Sternorrhyncha – formerly Homoptera)
	Fringe-wing	Wings are feather-like (rachis-like structure with fringe or hairs coming off the rachis)	Thrips Thysanaptera
	Scaly	Front and hind wings covered in scales	Butterflies and moths Lepidoptera
	Hairy	Hairy wings, not scaly	Caddisflies Trichoptera
	Elytra	Forewings hard/ sclerotized protect membranous hind wings; forewings meet in the middle covering the abdomen and form a straight line	Beetles and earwigs Coleoptera and Dermaptera

	TYPE / CHARACTERISTIC	DESCRIPTION	INSECTS THAT HAVE THIS TYPE
	Hamuli	Tiny hooks on the anterior margin of hind wing	Bees and wasps Hymenoptera
	Halteres	Forewing is membranous, the hind wing is reduced to a knob- like structure	Flies Diptera

Attachment 3
Numbers of Insects*

ORDER	NORTH AMERICA	WORLD ESTIMATES	FAMILIES IN AMERICAN NORTH OF MEXICO
Protura	73	500	3
Collembola	812	>6,000	12
Diplura	125	800	4
Microcoryphia	24	350	2
Thysanura	20	370	3
Ephemeroptera	599	2,000	21
Odonata	435	5,000	11
Orthoptera	1,210	>20,000	16
Phasmatodea	33	>2,500	4
Gryllobattodea	10	25	1
Mantophasmatodea	-	3	-
Dermaptera	23	1,800	6
Plecoptera	622	2,000	9
Embiidina	11	<200	3
Zoraptera	2	30	1
Isoptera	44	>2,300	4
Mantodea	30	1,800	2
Blattodea	67	<4,000	5
Hemiptera	11,298	3,5000	90
Thysanoptera	695	4,500	7
Psocoptera	264	>3,000	28
Phthiraptera	941	>3,000	18
Coleoptera	24,085	>300,000	128
Neuroptera	400	5,500	15

ORDER	NORTH AMERICA	WORLD ESTIMATES	FAMILIES IN AMERICAN NORTH OF MEXICO
Hymenoptera	20,375	115,000	74
Trichoptera	1,415	>7,000	26
Lepidoptera	11673	150,000	84
Siphonaptera	314	2,380	8
Mecoptera	83	500	5
Strepsiptera	91	550	5
Diptera	19,782	>150,000	103
Total	**95,553**	**826,108**	**698**

***An estimation of the number of insects in each order in North America and the world. Adapted from Borror and DeLong's; *Introduction to the Study of Insects*.**

Attachment 4
Commonly Encountered Lepidoptera in Idaho

	FAMILY/COMMON NAME	BRIEF DESCRIPTION
	Hesperiidae/ Skippers	33% of all butterflies in North America; “teddy bear-like butterflies;” small butterflies; cute round, fury faces with big eyes; strong fliers; wing color and patterns variable
	Papilionidae/ Swallowtails	Largest and most showy butterflies, hind wing typically has a “tail”
	Pieridae/Whites & Sulphurs	Most are medium sized; most are either white or yellow; many have black markings; not all white or yellow butterflies are Pieridae
	Lycaenidae/ Blues, Coppers, Hairstreaks, & Metalmarks	Typically small, delicate butterflies; underside of wing is different color than upper wing surface; reddish upper wing surface bluish or orange; some have hair-like “tails” on hind wings

	FAMILY/COMMON NAME	BRIEF DESCRIPTION
	Nymphalidae/ Brushfoots & Monarch	Front legs reduced (may appear to have only 4 legs) and bristly, hence “brushfoots;” wing patterns and colors variable; Monarchs and Painted ladies
	Geometridae/ Geometer Moths	Large family; many adults rest with their wings spread; caterpillars are called inchworms.
	Saturniidae/ Silkmoths	Largest Idaho moths, although not all are large; furry bodies, small heads, vestigial moth parts, adults do not feed and are short lived
	Sphingidae/Sphinx or Hawk Moths	Fast powerful fliers; larvae are have a “horn” on the last abdominal segment (hornworms); some species are mistaken as bees or humming birds because they nectar at flowers during the day

	FAMILY/COMMON NAME	BRIEF DESCRIPTION
	Noctuidae/Owlet moths	Largest family of Lepidoptera (25% of all Lepidoptera); variable; they range from small to large; most are non-descript patterned with grey and brown; some are brightly colored; many "worms" are agricultural pests
	Arctiidae/Tiger moths	Most are brightly colored and heavily marked; larvae are hairy or spiny – "woolyworms"

Mammalogy

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Compare the diversity and distribution of mammals in Idaho and demonstrate familiarity with the different groups of mammals.
- Explain the systematic relationships among various groups of mammals.
- Summarize the general characteristics of the major mammal groups.
- Discuss basic principles of mammal behavior, physiology, and ecology and relate these principles to environmental adaptations.
- Tell the habitat needs of various groups of mammals.
- Give examples of the role that mammals play in local ecosystems and various other ecosystems in Idaho.
- Demonstrate estimating/measuring mammal populations.
- Relate methods for trapping, marking, and monitoring mammal populations.
- Communicate the 11 major characteristics of mammals.
- Differentiate the three major taxonomic groups of mammals and name the characteristics that make those groups.

Introduction

American Pronghorn, Antilocapra americana is the fastest land animal in North American, able to run 54 miles per hour. Photo Courtesy, IDFG.

Mammals were originally four-footed animals and most living mammals retain this basic structure. Over the past millennia, mammals have diversified to fill a great number of niches. Mammals now encompass a wide variety of animals. Some are of minor importance and some of greater importance to humans. Most mammals are terrestrial (land). However, there are about 1,000 species, mostly bats, and 80 aquatic species, mostly whales and dolphins included as mammals. While not a large group, about 4,450 species compared with more than 9,000 species of birds, 21,700 species of fishes, and one million species of insects, members of the class Mammalia provide humans with food, clothing, recreation, crop protection, insect control, and sometimes are nuisance problems.

This section of the Master Naturalist curricula only provides a broad overview of mammals. Entire books have been written covering single species, families, or orders. Lengthy physical description, lists of habitats, gestation periods, and other factual data are readily available in scientific works, encyclopedias, and on the Internet.

Why Study Mammals?

Wildlife professionals study mammals to identify problems and to promote conservation and other policies based on sound science. Many professionals and conservation-minded individuals feel a duty to protect all species from extinction. Human well-being is ultimately tied to the web of plants and animals on this planet. Other people want to be able to identify the tracks, hair, skulls, or other animal signs for their own enjoyment. Some see mammals as food resources. Whatever your reasons for studying mammals learning about their characteristics, habits, and identifying features can provide a lifetime of enjoyment.

Diversity of Mammals

Major characteristics of Class Mammalia

Mammals are an advanced group in the animal kingdom that share unique features not found in other animals. Distinguishing features of mammals include:

- Body covered with hair, reduced in some.
- Integument with sweat, scent, sebaceous, and mammary glands.
- Mouth with teeth.
- Movable eyelids and fleshy external ears.
- Four limbs, in most, adapted for many forms of locomotion.
- Four-chambered heart.
- Respiration system with lungs and larynx; muscular diaphragm.
- Brain highly developed.
- Endothermic and homoeothermic.
- Internal fertilization; eggs developed in a uterus with placental attachment (except in monotremes).
- Young nourished by mammary glands.

Key characteristics unique to mammals are hair and mammary gland. The mammary glands produce milk that nourishes the young, and the hair helps insulate the body and maintain a warm, constant body temperature. Also serving a protective barrier is the skin, a layer of epidermis over a layer of fat.

Classification of Mammals

Mammals are divided taxonomically into three major groups by their mode of reproduction and embryonic development. The three groups include monotremes (subclass Prototheria), marsupials (subclass Metatheria [formerly Marsupialia]), and placentals (subclass Eutheria).

Monotremes

Monotremes are mammals that lay eggs. The eggs are incubated in subterranean nest. After the eggs hatch, the young feed on the milk secreted by the mother.
Females possess no teats and the milk oozes along special hairs. Only three living monotremes exist, the duck-billed platypus and two species of echidna, or spiny anteaters. All three are only found in Australia and New Guinea.

Marsupials

Marsupials are the second type of mammal. Marsupials give birth to live young that are born tiny, very immature, and must climb into the mother's pouch, called a marsupium. Once in the pouch, they grab a hold of a teat and do not leave until they are mature. The most recognized example of a marsupial is the kangaroo. The Virginia opossum is the only marsupial native to the United States. Though not native to Idaho, the Virginia opossum is the only Marsupial that lives in Idaho.

Placentals

Placentals are the most common type of mammal. Placentals are those whose young develop over a long period of time in the female's uterus. Over 95% of mammals worldwide are placentals, including humans.

In addition to being classified by their mode of reproduction, mammals are further classified by what they eat into:

- Herbivores-eats only plants. Examples include rabbits, muskrat, and deer.
- Carnivores- mostly eat other animals. Examples include weasels, mountain lions, and wolves.
- Omnivores- eat plants, meat and other food sources. Examples include raccoons, opossums, coyotes, bears, and humans.
- Insectivores- eat insects. Examples include bats and shrews (shrews are also carnivorous).
- Granivores – eat seeds and nuts. Examples include squirrels and pocket mice.

There are also few other specialized feeders such as frugivores (fruit), piscivores (fish), sanguinivores (blood), and nectarivores (nectar).

Identification Techniques

The mammals of North America are a diverse and fascinating group. However, because most mammals are nocturnal, secretive, and quiet, they tend to be elusive. For instance, on a walk through the forest, you might expect to see only five or six species of mammals: chipmunks, squirrels and deer. Nevertheless, the woods contain many other kinds of mammals that are not easily discovered. Because many mammals are secretive, you must pay close attention to the evidence they might have left behind. Some of the signs left by mammals that can be used for identification purposes include trails, tracks, droppings (scat), burrows, nests, dens, and hair remains.

Wolverine tracks are followed by Idaho's nongame biologists each winter in their snow track survey. Wolverines are one of Idaho's most elusive mammals.

Identifying Tracks

When outdoors, look closely at the mud along streams or ponds and you will probably find an abundance of mammals tracks. Examine the forest floor. You will probably find an abundance of rabbit and deer droppings. You might find scat from a carnivore with pieces of bone and hair. A good field guide for identifying animal tracks is an important tool for a mammalogist. Olaus J. Murrie's (1954) book *A Field Guide to Animal Tracks*, by Houghton Mifflin, is a good reference and still in print.

Animal tracks can be divided into three broad categories: unguligrades, digitigrades, and plantigrades.

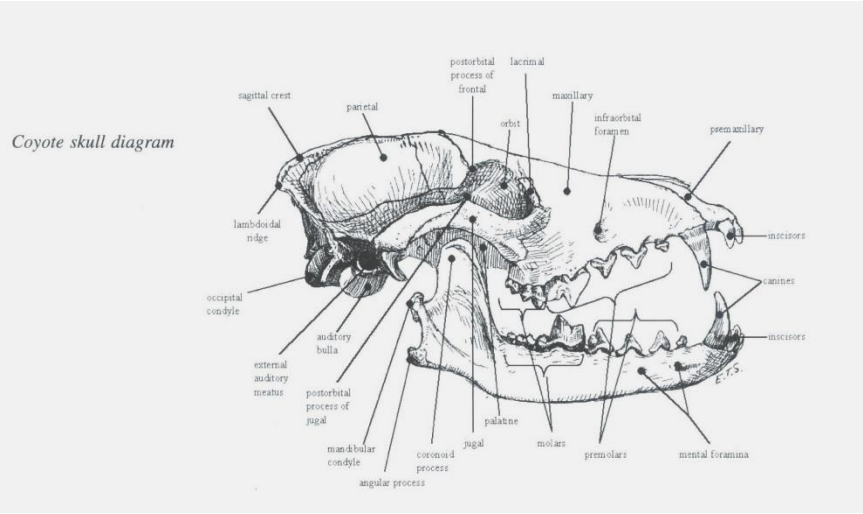
- *Unguligrades* walk on their "fingernails." These animals include deer, elk, bison, and pronghorn - all ungulates.
- *Digitigrades* walk on their digits. Lions, wolves, and coyotes are examples.
- *Plantigrades* walk on their entire foot. Humans and other primates, in addition, bears are plantigrades.

Identification by Hair

Whole books have been written on how to identify mammals by their hair. However, identification by hair characteristics is not a useful field technique since you need a microscope to view hair scales and other key identifying features. Because hair identification is not a useful field technique, it is not covered in the Master Naturalist curricula.

Identification by Skull

One of the most common and important methods for identifying mammals is by looking at the skull and teeth. Teeth are often the most important characteristic identifying mammals. The types, shape, and number of teeth are important.



Mammals have four main types of teeth. Each type has a different purpose. Some mammals have all four types while some have only two or three types. Herbivores, like white-tailed deer, have tall molar teeth with flat upper surfaces. Rabbits have well developed "incisors" for biting and cutting vegetation. Wide "molar" teeth with low bumpy crowns are found on omnivores like coyotes. Carnivores like bobcats must have sharp "canine" teeth in order to grab and stab the flesh of their prey. In addition, carnivores have "carnassials" that are used for shearing meat. In adult carnivores, the carnassials are the last upper "premolar" and the first lower molar. If you articulate (put the two together at the joint) the mandible and skull and then open and close the jaw, it is easy to see which pair of teeth would shear meat. This will help distinguish between premolars and molars. The only carnivore species that does not have well developed canines is the raccoon. Despite this fact, it still looks like a carnivore skull and is not difficult to recognize.

The figure above provides an overview of the key features of a skull and teeth that may be used in identifying mammals. Again, mountains of minute details on skull features have been collected and published in a variety of texts. Refer to the field guides on the Idaho Master Naturalist Booklist for help identifying skulls.

As you become familiar with mammals, you will find that the skulls of mammals from different orders look very different from each other. After a short while, you will not have trouble telling the skull of an insectivore from that of a carnivore. The skulls of mammals in different Orders are very distinctive. However, learning traits to identify mammals at familial (family) or generic (genus) level gets more complicated. Keys to identifying skulls and teeth are available.

The tooth formula is one of the easiest ways to identify mammals at the generic level. In many cases, the tooth formula is a distinguishing trait by itself. Tooth formulas are expressed as I 2/1, C 1/1, PM ¾, M 3/3. Translated, this means:

- *I 2/1* - 2 incisors in each half of the upper jaw/ 1 incisor in each half of the lower jaw.
- *C 1/1* - 1 canine in each half of the upper jaw/ 1 canine in each half of the lower jaw (one canine/mouth quadrant).
- *PM ¾* - 3 premolars in each half of the upper jaw/4 premolars in each half of the lower jaw.
- *M 3/3* - 3 molars in each quadrant of the jaw (3 in each upper half, 3 in each lower half).

Mammals in Idaho

Idaho, with its wide variety of soils, climate, vegetation, and topography is home to 113 species of mammals (six are not native).

Group	Order	Characteristic Species	Number of species in Idaho
Marsupial	Didelphimorphia	Opossum (not native)	1
Placental	Chiroptera	Bats	14
	Insectivora	Moles and shrews	8
	Lagomorpha	Hares and rabbits	6
	Rodentia	Rodents and squirrels	51
	Carnivora	Coyote, weasel, bear	20
	Perissodactyla	Odd toed ungulates	1
	Artiodactyla	Even toed ungulates	9

Characteristics of the Major Groups of Mammals in Idaho

The following information provides a brief description of the characteristics of each of the order of mammals in Idaho. The number of species within each order that occur in Idaho is also noted. A complete listing of the species in each order in Idaho is located at the end of this chapter.

- *Order Didelphimorphia* - Didelphimorphia is among the oldest and most primitive of mammals. The chief characteristic of this order is the marsupium or pouch on the abdomen of females. Young are born after only partial development and conclude their development in the marsupium.

The Virginia Opossum, not native to Idaho, but Idaho's only marsupial resident.

- *Order Insectivora*- The insectivores are a hodge-podge of primitive placental mammals encompassing 373 species worldwide. Most are small and nocturnal and feed extensively on insects and other invertebrates, playing a large role in controlling insect pests. One species of mole and seven species of shrews are in Idaho.

- *Order Chiroptera* - Chiroptera, known as the order of bats, are the only mammals capable of true flight. Chiroptera is the second largest order of mammals worldwide with 942 known species. Only rodents outnumber bats in species. As a group, bats are crepuscular (dawn and dusk) or nocturnal (night) with small inefficient eyes but well developed ears. Some species hibernate, while others migrate seasonally.

- *Order Lagomorpha* - Lagomorphs include rabbits, hares, and pikas. Worldwide, there are 65 species of lagomorphs. They are distinguished from rodents by an additional pair of upper incisors located just behind the larger anterior pair. In addition, the number of premolars is /2/ or 3/2 and rodents have 2/1 or 0/0. Food is almost entirely vegetable matter.

Pygmy Rabbit, Idaho's smallest rabbit species. Photo Courtesy, Wendy Estez-Zumpf, University of Idaho.

- *Order Rodentia* - This is the largest of all mammalian orders with 1,686 species worldwide. The main distinguishing feature of rodents is their incisors, which grow continuously throughout their life. Most rodents eat vegetation but some, like the grasshopper mouse, feed on animal matter. Most rodents do not hibernate but some, like ground squirrels, may. Thirty species of rodents occupy Idaho making this the most diverse group of mammals in this state.

Golden-mantled ground squirrel.
Photo courtesy, IDFG.

- *Order Carnivora* - Generally defined as flesh-eating animals, there are 238 species worldwide in this order. All animals in the order Carnivora eat flesh, although some, like the raccoon or coyote, may feed almost exclusively on vegetation, especially in the spring and summer months. Idaho has 20 carnivore species.

- *Order Perissodactyla* - The only species of the order Perissodactyla in Idaho is the non-native wild horse. There are 17 species worldwide. Other members of this order include the rhinoceroses and tapirs.

Wild horses roam Owyhee County.
Photo courtesy, Sara Focht, IDFG.

- *Order Artiodactyla* - The artiodactyls have either two or four (usually) hoofed toes on each foot, with the exception of the peccary, which has four toes on each forefoot, but only three on the hind foot. The order includes our most important domestic animals along with the majority of the large mammals in the world encompassing 192 species. Artiodactyls are further divided into suborders by gastrointestinal features. Those with a two or three chambered non-ruminating stomach include the families Suidae (two chambers), and Hippopotamidae (three chambers). The Camelidae and Tragulidae have three chambered non-ruminating stomachs, while Antilocapridae, Bovidae, and Cervidae have four-chambered ruminating stomachs. Idaho has nine species of Artiodatyla.

Bighorn Sheep can easily be viewed in Idaho along the Salmon River Scenic Byway west of Challis and north of Salmon. Photo courtesy, Dick Nachbar.

Why do Different Mammals Live in Different Places?

Distribution of Mammals in Idaho

The geography of Idaho and its large size are key factors in the diversity of plants and animals found within the state. Wide variations in soils, climate, and topography make the vegetation and animal life of Idaho diverse. We have dry upland sage deserts in the south and lush boreal forests in the north.

The distribution of mammals throughout the state is often a result of the vegetative habitat that the animal prefers. Some mammals are found throughout the state and are called ubiquitous species (black bear, golden-mantled ground squirrel, and raccoon).

Other species have very particular habitat needs and are found only in certain plant communities (pygmy rabbit, mountain goats, American martin).

An American pika needs a very specific habitat. They require high elevation rocky (talus) slopes.

Mammals are distributed in Idaho based on

habitat needs (food, water, shelter, space) and their niche within that habitat. Competition from other species or predator presence may also effect where a certain mammal can be found.

How have mammals adapted to their environment?

Embryonic Development

Placentals, like their closest relatives the marsupials, give birth to live young. In placentals, however, the young are nurtured within and from the body of the mother by the placenta, which allows nutrients to pass from the blood of the mother into the young's bloodstream. The placenta also provides oxygen to reach the developing young, thereby making more energy available than in marsupials.

Marsupial young are born hairless and helpless, and must crawl to a special pouch where they continue development. Some placental mammals, such as rodents and some carnivores, are not very different from marsupials. The young are born hairless and blind, and must be nurtured by their mother for a time before they can begin to live on their own. The primary difference in these cases is that the young are not carried in a pouch, as are marsupials.

The degree of development at birth varies greatly among different placental groups. Young ungulates (hoofed mammals) may be able to walk within minutes of being born, while human children may take years to accomplish this. The length of parental care following birth also varies greatly, from about a month to several years.

Reproductive Strategies and Advantages

One of the primary advantages of sexual reproduction is comparatively greater genetic variation. Genetic variation provides an animal the potential ability to meet environmental changes by adaptation.

This white-tailed deer fawn will be walking soon after birth.

Mammals can be divided into two groups, those that bear young and those that bear precocial young. Each mode is typically associated with a different life history strategy.

Mammals with altricial young live under generally unstable conditions with seasonal or unpredictable food resources. They are small in size and subject to heavy predation. Normally, litters are large (>7), the young are born in a nest, and the gestation and suckling periods are

short. The young reach sexual maturity rapidly and have short life spans. Under favorable conditions, breeding may occur throughout the year. High reproductive rates allow these mammals to take advantage of even brief periods of food abundance. With such opportunism go high population densities that are unstable seasonally and annually. A variety of mammals exhibits this pattern of reproduction including most rodents, rabbits, and shrews.

Mammals with precocial young, including the ungulates, some rodents, and cetaceans, typically live in a stable environment with a predictable food base. These animals are often large, reach sexual maturity late, and the gestation period is prolonged. Although these mammals have a slow reproductive rate, the survival rate of young is high because of the extended maternal care. Population stability, a low reproductive rate, low population turnover and dependence on a stable environment make these animals vulnerable to habitat alteration. Excellent examples of the advantages and disadvantages of this type of reproduction are typified by grizzly and black bears, wolverine, bighorn sheep, and mountain goats.

How are mammals monitored?

The goals of managing animal populations are mostly expressed in terms of population size. For example, when dealing with endangered or rare species managers often try to increase population size. When dealing with pest species, or in specific cases when a species reaches high populations and may cause damage to habitat for itself and/or other species, managers may try to reduce population size. Population size is the measure by which the success of management is judged, and estimating populations is critical to modern wildlife management.

This transect rope was laid out on the ground and walked by the scientist. Along the transect, each occurrence of scat was counted and recorded.

Methods for estimating populations are many and varied. Each method's accuracy and precision is affected by a wide variety of factors including, weather, time of day, observer variability, limited time and money, observability of the animal (i.e. is it easily visible and readily recognizable), seasonal time of year, and abundance and distribution of the animal to name a few variables. In addition, a single estimate of population size at one point in space and time is usually of limited value and provides little information on population status and trend.

Aerial surveys are often performed for big game species (mule deer, elk, bighorn sheep, mountain goats, and moose). **Harvest data** is collected for harvest data for black bears, mountain lions, and furbearers. **Pellet counts** are popular for rabbits and hairs. **Live trapping** is a common method for small mammals, such as rodents. **Line transect** surveys and burrow counts for pygmy rabbits. **Mist nets and acoustic** (bat detectors) monitoring for bats.

IDFG field technicians empty a small mammal trap. Photo courtesy, IDFG.

Capturing Mammals

Mammals are captured for food, research, fur, or when they are creating a nuisance problem for individuals or groups of landowners. Varieties of capture methods exist and can be used to capture and release an animal unharmed or capture and kill the animal for harvest. Traps are broken into five categories; live traps, leg hold traps, body gripping traps, snap traps, and snares.

Live traps capture small mammals unharmed. Live traps are effectively used in residential areas or in situations where the animal creating a problem may be transplanted to another area. For example in the case of beaver, Bailey and Hancock live traps which resemble an open suitcase and a half open suitcase are used to trap and relocate beaver. These traps are used primarily to catch individual beaver and are not effective for intensive trapping efforts.

This trap is a leg hold trap and is used to capture wolves in Idaho for monitoring and collaring. These traps do not harm the animal. Photo courtesy, Michael Lucid, IDFG.

Leg-hold traps are manufactured in several sizes and are available in padded and unpadded jaws. Properly used, let-hold traps are one of the most effective and economical ways of trapping animals for any reason. Leg-hold traps are used extensively for beaver, muskrat, wolves, coyote, and raccoon. Traps are set in travel lanes or near burrow openings, with or without bait.

Body-gripping traps, most commonly the Conibear, are chiefly used in water sets for muskrat and beaver. Conibear's do not allow for the release of the animal, resulting in a quick kill. These traps are typically placed at the entrances of burrows or lodges, and in runs or slides. Most states prohibit use of Conibear traps in dry-land habitats.

Snap traps are used to control mice and rats and have the advantage of providing little danger to non-target species. Typical baits used with snap traps include peanut butter, oatmeal or apples. Snap traps can be used outdoors to capture rodents when only few animals are involved or to capture animals for identification or population indexing purposes.

This Northern Idaho Ground Squirrel has been marked with hair dye in a capture and mark study by IDFG nongame biologists. Photo courtesy, Diane Evans-Mack, IDFG.

Snares are made of a light wire or cable looped through a locking device or a small nylon cord tied so it will tighten as the animals push against the snare. Many states strictly regulate the use of snares. Snares are very effective and are placed on well-defined trails or at a specific entrance such as a hole in a fence. Snares are effective on a wide variety of animals such as coyotes and red fox. (Specially designed foot snares are used for capturing bears.)

Mammal Marking Techniques

Although the capture techniques outlined above are often used to control animal populations, they are also effective in capturing animals for study. Once an animal is captured for study however, sometimes it needs to be marked for monitoring and possible recapture at a later date. Animals are typically marked to track problem individuals, for mark recapture studies to estimate numbers. Marking of animals takes some expertise to prevent injury or inhibiting an animal's movement and should not be conducted without expert assistance. Many states and the federal government may require individuals to obtain a license or permit to mark animals.

Ear tags and collars are commonly used for ungulates. Photo courtesy, IDFG.

Mammals may be marked with special ear tags made from metal or plastic in a variety of shapes and colors. Tags are usually designed to be interlocking, self-locking or a rivet design that cannot be easily pried apart. Tags should be placed in the lower inner region of the ear where there is heavier cartilage to reduce tearing of the ear or losing the tag. Tags should be loose enough not to interfere with blood circulation. Puncture holes in the animal's ear should be treated appropriately to prevent infections.

Neck collars and bands have been designed for field identification of free ranging animals. Collars are expansible to allow for growth and are highly visible. However, their longevity depends on the manufacturing material, climate, and behavior and sex of the animal collared. Collars are typically used on ungulates, but are also used on carnivores, and waterfowl.

Collared mountain goat.
Photo courtesy, IDFG.

Paint marking/paint ball guns have been used to temporarily mark animals. Small mammals are sometimes marked in capture-recapture studies.

A Complete List of Idaho's Mammals

- *G - Game species whose harvest is regulated by the Idaho Dept. of Fish & Game through bag limits and seasons.
- *L - Species not under control of Idaho Dept. of Fish & Game that fall under the purview of the Idaho legislature.
- *P - Protected Nongame species for which it is illegal to collect, harm, or otherwise remove from its natural habitat except as provided under Idaho Code or Commission Regulations.
- *Exotic - Species that humans intentionally or unintentionally introduced into an area outside of a species natural range.

Opossum

- Virginia Opossum (Didelphis virginiana) *Exotic

Moles and Shrews

- Masked Shrew (Sorex cinereus)
- Vagrant Shrew (Sorex vagrans
- Dusky Shrew (Sorex monticolus)
- Dwarf Shrew (Sorex nanus)
- Water Shrew (Sorex palustris)
- Merriam's Shrew (Sorex merriami)
- Pygmy Shrew (Sorex hoyi)
- Coast Mole (Scapanus orarius)

Bats

- Little Brown Bat (Myotis lucifugus) *P
- Yuma Myotis (Myotis yumanensis) *P
- Long-eared Myotis (Myotis evotis) *P
- Fringed Myotis (Myotis thysanodes) *P
- Long-legged Myotis (Myotis volans) *P
- California Myotis (Myotis californicus) *P
- Western Small-footed Myotis (Myotis ciliolabrum) *P
- Silver-haired Bat (Lasionycteris noctivagans) *P
- Western Pipistrelle (Pipistrellus hesperus) *P
- Big Brown Bat (Eptesicus fuscus) *P
- Hoary Bat (Lasiurus cinereus) *P
- Spotted Bat (Euderma maculatum) *P
- Townsend's Big-eared Bat (Corynorhinus townsendii) *P
- Pallid Bat (Antrozous pallidus) *P

Pikas, Rabbits, and Hares

- American Pika (Ochotona princeps) *P
- Mountain Cottontail (Sylvilagus nuttallii) *G
- Snowshoe Hare (Lepus americanus) *G
- White-tailed Jackrabbit (Lepus townsendii) *L
- Black-tailed Jackrabbit (Lepus californicus) *L
- Pygmy Rabbit (Brachylagus idahoensis) *G

Rodents and Squirrels

- Least Chipmunk (Neotamias minimus) *P
- Yellow-pine Chipmunk (Neotamias amoenus) *P
- Cliff Chipmunk (Neotamias dorsalis) *P
- Red-tailed Chipmunk (Neotamias ruficaudus) *P
- Unita Chipmunk (Neotamias umbrinus) *P
- Yellow-bellied Marmot (Marmota flaviventris)
- Hoary Marmot (Marmota caligata)
- White-tailed Antelope Squirrel (Ammospermophilus leucurus)
- Piute Ground Squirrel (Spermophilus mollis); subspecies artemisiae in Eastern Idaho is protected *P

- Merriam's Ground Squirrel (Spermophilus canus) *P
- Northern Idaho Ground Squirrel (Spermophilus brunneus brunneus) *P
- Southern Idaho Ground Squirrel (Spermophilus brunneus endemicus) *P
- Uinta Ground Squirrel (Spermophilus armatus)
- Belding's Ground Squirrel (Spermophilus beldingi)
- Columbian Ground Squirrel (Spermophilus columbianus)
- Rock Squirrel (Spermophilus variegatus) *P
- Golden-mantled Ground Squirrel (Spermophilus lateralis) *P
- Wyoming Ground Squirrel (Spermophilus elegans); subspecies nevadensis in Southwest Idaho is protected *P
- Red Squirrel (Tamiasciurus hudsonicus) *P
- Eastern Gray Squirrel (Sciurus carolinensis) *Exotic
- Eastern Fox Squirrel (Sciurus niger) *Exotic
- Northern Flying Squirrel (Glaucomys sabrinus) *P

Pocket Gophers

- Townsend's Pocket Gopher (Thomomys townsendii)
- Northern Pocket Gopher (Thomomys talpoides)
- Idaho Pocket Gopher (Thomomys idahoensis)

Pocket Mice and Kangaroo Rats

- Little Pocket Mouse (Perognathus longimembris) *P
- Great Basin Pocket Mouse (Perognathus parvus)
- Dark Kangaroo Mouse (Microdipodops megacephalus) *P
- Ord's Kangaroo Rat (Dipodomys ordii)
- Chisel-toothed Kangaroo Rat (Dipodomys microps)

Beaver

- American Beaver (Castor canadensis) *G

Mice, Rats, and Voles

- Western Harvest Mouse (Reithrodonotomys megalotis)
- Deer Mouse (Peromyscus maniculatus)

- Canyon Mouse (Peromyscus crinitus)
- Pinon Mouse (Peromyscus truei)
- Northern Grasshopper Mouse (Onychomys leucogaster)
- Desert Woodrat (Neotoma lepida)
- Bushy-tailed Woodrat (Neotoma cinerea)
- Southern Red-backed Vole (Clethrionomys gapperi)
- Heather Vole (Phenacomys intermedius)
- Meadow Vole (Microtus pennsylvanicus)
- Montane Vole (Microtus montanus)
- Long-tailed Vole (Microtus longicaudus)
- Water Vole (Microtus richardsoni)
- Sag ebrush Vole (Lemmiscus curtatus)
- Muskrat (Ondatra zibethicus) *G
- Northern Bog Lemming (Synaptomys borealis) *P
- Norway Rat (Rattus norvegicus) *Exotic
- House Mouse (Mus musculus) *Exotic
- Western Jumping Mouse (Zapus princeps)

New World Porcupines

- North American Porcupine (Erethizon dorsatum)

Carnivores

- Coyote (Canis latrans) *L
- Gray Wolf (Canis lupus) *P
- Red Fox (Vulpes vulpes) *G
- Kit Fox (Vulpes macrotis) *P
- Black Bear (Ursus americanus) *G
- Grizzly (Brown) Bear (Ursus arctos) *P
- Northern Raccoon (Procyon lotor) *G
- American Marten (Martes americana) *G
- Fisher (Martes pennanti)
- Ermine (Mustela erminea) *L
- Long-tailed Weasel (Mustela frenata) *L
- American Mink (Mustela vison) *G
- Wolverine (Gulo gulo) *P
- American Badger (Taxidea taxus) *G

- Northern River Otter (Lontra canadensis) *G
- Western Spotted Skunk (Spilogale gracilis) *L
- Striped Skunk (Mephitis mephitis) *L
- Mountain Lion (Puma concolor) *G
- Lynx (Lynx canadensis) *P
- Bobcat (Lynx rufus) *G

Ungulates

- Elk (Cervus elaphus) *G
- Mule Deer (Odocoileus hemionus) *G
- White-tailed Deer (Odocoileus virginanus) *G
- Moose (Alces alces) *G
- Woodland Caribou (Rangifer tarandus caribou) *P
- Pronghorn (Antilocapra americana) *G
- Mountain Goat (Oreamnos americanus) *G
- California Bighorn Sheep (Ovis canadensis californiana) *G
- Rocky Mountain Bighorn Sheep (Ovis canadensis canadensis) *G
- Feral Horse (Equus caballus) *P

Credits

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Thank you to the Texas Master Naturalist Program for allowing us to use this chapter.

Conservation Education - Interpretation

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Discuss what interpretation is.
- Identify and understand components of an interpretative experience.
- Understand the differences between a topic and a theme and the importance/functions each serves.

It is Saturday morning. You are waiting at the benches near the trailhead at the local nature center. A number of your nature hike participants have already arrived – a boisterous group of Scouts, a family with two children probably under the age of six. A young couple holding hands and they are followed by a mature woman with two or three guidebooks tucked under her arm. The hands on your watch reach 10:00 a.m. It is time to start the hike.

Many Master Naturalists will fulfill their service hours working directly with the public as volunteer guides for local sites or as program presenters for schools, summer camps or other public functions. This kind of public contact work may be broken into three broad areas of function:

- *Orientation* – Greeting visitors to a site, collecting fees, directing visitors to site opportunities and providing operational information.

- *Education* – Formalized experiences and transfer of information that meets specific learning objectives, usually within a non-voluntary setting. Participants may be driven by external motivations, such as grades or certifications.

- *Interpretation* – Informal or recreational experiences and transfer of information, within a voluntary setting. Participants are internally motivated by an intrinsic satisfaction with their experience, with the experience viewed as another recreational opportunity.

What is interpretation?

The term "interpreter" came into common use in the 1930's. It is a confusing term. Interpreters are often asked ". . . and what languages do you speak?" However, it is still considered the best term for the profession. After all, the secrets of nature and history are often "foreign" to our audiences!

While many people mark the birth of interpretation with Freeman Tilden's classic work *Interpreting Our Heritage* (1957), others point to Enos Mills' *Adventure of a Nature Guide* and *Essays in Interpretation,* as the philosophical foundation of the profession. Enos Mills was an interpretive guide in the Rocky Mountains from the late 1880s to the early 1920s. He published his work in 1920. This book was a pioneer in the development of interpretation as a profession. Mills was a close friend of John Muir. The principles set forth by Tilden and Mills have many things in common and remain standard in the field today. Definitions of "interpretation" may offer insight into the profession:

> "An educational activity which aims to reveal meanings and relationships through the use of original objects, by firsthand experience, and by illustrative media, rather than simply to communicate factual information" (Tilden, 1957).
>
> "Interpretation is a communication process designed to reveal meanings and relationships of our cultural and natural heritage to the public through first-hand experiences with objects, artifacts, landscapes, or sites." - Interpretation Canada, 1976
>
> "Interpretation is a process, a rendering, by which visitors see, learn, experience and are inspired firsthand . . . Interpretation is revelation based upon information" (Beck and Cable, 1998)

The operative words seem to be "reveal experiences, meanings and relationships." Good interpretation is always based on factual information, but it goes much further. Sam Ham, the author of *Environmental Interpretation: A Practical Guide for People with Big Ideas and Small Budgets*, "Tilden saw interpretation as an approach to communicating which stresses the transfer of ideas and relationships rather than isolated facts and figures. Although an interpreter may use factual information to illustrate points and clarify meanings, it's the points and meanings that he or she is trying to first communicate, not the facts. This is what distinguishes interpretation from conventional instruction" (Ham, 1992). This communication, coupled with a quality experience, forms memorable interpretation.

Interpretation has been described as "an approach to communication" (Ham, 1992, pg.3). It is a "certain way" to communicate or educate, that has been developed and proven successful in formal and non-formal educational settings. Anything can be communicated using interpretive techniques: medical information, 17th century literature themes, and even historical events! As a future Idaho Master Naturalist, you may be participating in education activities. We encourage you to use interpretation as an approach to education. As you learn about interpretation and apply it to teaching about nature, remember the principles of interpretation can be applied to any subject.

In general, interpretation takes one of two forms. The names of these forms may vary from author to author, but the categories remain the same:

• *Static interpretation* – Any interpretive contact that does not involve a living person to facilitate the contact. Brochures, signs, exhibits and posters are all examples of static interpretive items. Keep in mind that your resource base – the plants, buildings, artifacts, landscapes, smells and sounds – is, in and of itself, a static interpretive display.

• *Personal services interpretation* **–** Interpretive contacts that are facilitated by a living person. Guided tours, slide shows, living history demonstrations and campfire talks are common examples.

While this chapter focuses on personal services interpretation, the "thinking process" relates to static items as well. Practiced interpreters find that an organized thinking process becomes second nature to program and materials development.

Components of an Interpretive Experience

The information you present is only a part of the total interpretive experience. To be truly effective, you must consider the factors that will influence your presentation. These include visitor, presentation, and resource components. Each of these is worthy of separate study.

Examination of the **visitor component** can include marketing, sociology, psychology, learning theory and demographics. The **presentation component** includes the mechanics of speech, audio-visual aids, personal presentation styles and organization of information. **Resource components** can include safety information, access, conservation and multiple-use issues, in addition to the natural and cultural resources themselves.

The Visitor Component

New interpreters are frequently advised to "know the visitor." This includes who they are, where they are from, basic cultural orientation and other demographic information. In practice, this is

no simple matter! Sites frequently operate for years without gathering specific visitor information. If you are working with a more homogenous group, such as a school or hobby club, you may have a good feel for your visitor. For many interpreters, the first glimpse of the visitor comes when they arrive for the program. One thing is known about all visitors; they come to a site or program for their own reasons. Interpreters must acknowledge and respect the validity of those reasons. John Veverka gives an example: ". . . the main activities of interest cited by most zoo visitors are picnicking and being with friends and family. Seeing the animals is often third. Learning about the animals is "way down the list." He cautions us to remember that visitors are in a "vacation frame of mind" and says, "They don't want to become experts in the subject you are presenting, they just want to have fun learning about the site or topic at hand." (Veverka, 1994).

Think about the diverse group described in the introduction and list possible reasons for their attendance at the fictional hike. The Scouts may be earning a badge or enjoying a visit with friends. Mom and Dad may be seeking a diversion for their young, active children. The young couple may wish to share some time together in a pleasant setting. The mature woman might hope to see a new bird. Awareness of these motivations gives the interpreter a better feel for the visitor.

Visitors bring their own set of "baggage" with them when attending a presentation. Meaning is inherent in people, not in words or terms. Your idea of a "tall tree" depends on your mental picture of all the trees you have ever seen. It would not mean the same to a visitor from the Kansas plains or the redwood forests of the Pacific Coast. This is why good interpreters frequently use comparisons to common objects to describe characteristics accurately. This simple technique helps close the experience gap in very diverse groups of visitors.

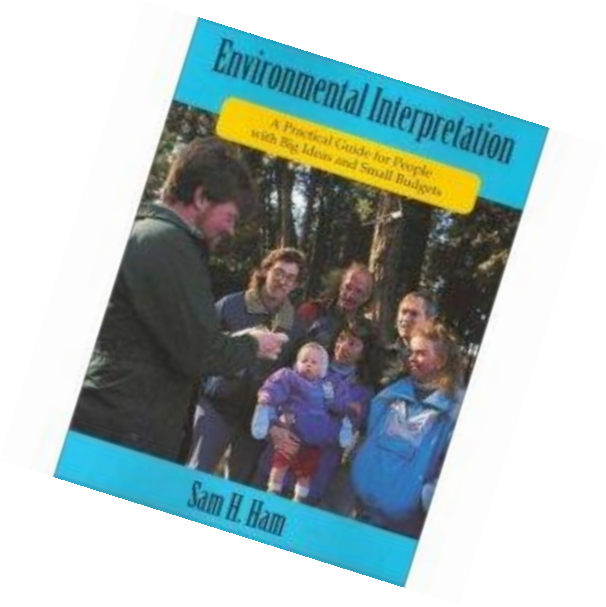
The Presentation Component

All interpreters benefit from an occasional review of good public speaking practices. Many good manuals are available for this purpose. More important is the mindset of the interpreter, who must never forget that the interpretive experience is not about the presenter. It is "about the visitor" and the resource. The interpreter is not the experience. They only interpret by acting as a conduit, facilitator, and intermediary between the visitor and the resource. Think about your own interpretive experiences. Chances are the most memorable were those where the interpreter was not the focus of attention.

Interpretation should be:

- Pleasurable
- Relevant
- Organized

- Thematic
- Credible



If you are properly practicing interpretation, your audience will be having fun. They will not be daydreaming, looking around, answering their cell phone, or having side conversations, because whatever is being said or done will be **pleasurable.** Our brains produce endorphins when we are engaging in pleasurable activities. These chemicals make us feel great. When we are not having fun or getting pleasure from an activity, the chemicals decrease. We start to daydream. Daydreaming takes our brain to a place where we find pleasure and produce more endorphins! If you want people to learn, make their experience pleasurable. Some ways to increase pleasure are smiling, humor, music, and two-way communication.

Talks, walks, guided tours and individual contact with a visitor can make interpretation more pleasurable for the audience if you do some simple things. Smile, make eye contact, use hand gestures, use props and be enthusiastic. If you do not care for your topic or theme, you probably will not have much fun doing the program. Your audience will sense it.

Relevancy can be broken down into two sub-categories: meaningful and personal. A presentation about the biodiversity of the Galapagos Islands is interesting, but if given at Round Lake State Park, in northern Idaho, it is irrelevant. This aspect of interpretation makes a lot of sense. Plan your educational program with relevancy in mind. Think about where you are and with whom you are talking. Make new information meaningful to your audience by helping them connect it to something they already know. An interpreter at Mount St. Helens National Volcanic Monument might describe the eruption of the volcano using everyday items. Using honey, toothpaste and a bag of flour, the interpreter can help visitors understand that the consistency of Mount St. Helens lava was more like toothpaste and less like honey. The ash (pulverized rock) emitted was like flour.

Being personal is another way to create relevancy when you teach. We talked about connecting new information to something that the audience "knows." Being personal connects new information to something about which the audience "cares." How do you know what that is? While you do not know specifics, you can count on your audience caring about "themselves, their family, their well-being, quality of life, values, principles, beliefs and convictions" (Ham

1993, pg. 13). Use the word "you" in your interpretive talks. Better yet, get to know the names of some audience members and use them. Find out where people live or what their occupation is, how many kids they have or if they have pets. You can incorporate some of this into your talk to make your message more personal.

Organization is key to successful interpretation. If your information is organized, people do not have to think hard to follow your train of thought or connect the concepts. Spoon-feed them the connections. People's minds start to wander if they are required to think too hard about how the information fits together. Imagine opening a novel to page 50 and trying to figure out what is happening. It would take a lot of effort to organize the characters and the story line.

Introduce your points in a logical progression. This requires planning. A co-worker described another co-worker's presentation style, "Tom is a great presenter. He is so enthusiastic and funny. He is passionate and knowledgeable. The kids love him, but he is all over the place." It appears this person is a pretty good teacher, but lacks organization. The messages might be organized in his mind, but he is not thinking of how the information is presented to the audience.

The final characteristic of interpretation is **thematic.** Themes are different from topics. Your talk, brochure, website, or whatever medium you choose should have both! "Native plants" is a topic. "Native Plants Can Increase Your Quality of Life" is a theme. "Bees" are a topic. "You Would Go Hungry If It Weren't for Bees" is a theme.

Credibility is a major factor in the presentation component. Commentary and experiences, based on fact not perception or personal bias, will establish credibility. This is more difficult than it appears on the surface. Examine the facts you plan to present. Can you actually point to a documented source for that information? Just as the visitor sees everything through his own experience, so does the interpreter. It is acceptable to express an opinion or to include undocumented oral traditions in a presentation and be sure to present them as such. Balanced presentations fairly represent all sides of an issue or topic. They can actually increase the amount of support for an important idea, by establishing the credibility of the speaker.

The Resource Component

To be effective, the information you are presenting should be solidly rooted in the resource confronting the visitor. One experienced interpreter expressed this as an interpretive rule. "If you can't see it, you don't get to talk about it." While some see this as a limiting factor, it actually helps interpreters identify creative avenues for presenting complex information. For instance, when talking about a prescribed burn, the interpreter might bring photographs of the field prior to the burn, a month after the burn, a year after the burn to show the progression of that fire-disturbed area. The interpreter could then challenge the group to predict changes for the area, based on what they know. Pointing out charred bits of stumps, heightened canopy, lack of

dense, dead vegetation and other clues can help the visitor "see" the fire and feel successful in their ability to "discover" evidence that the fire occurred. The more you can base your presentation in the immediate resource, the higher your chances of facilitating a memorable, effective experience.

Take inventory of all the available resources. Stretch your mental resource inventory beyond visible plants, animals, buildings and artifacts. Landscape vistas, smells, sounds or silence and reflective space may be valuable resources that help the visitor visualize and internalize the information presented.

Remember, the resource can tell its own story. You are only the interpreter. You do not have to talk the whole time. You can pose questions. Allow people time to explore, think about answers and the place they are visiting.

One Approach to Developing Interpretive Experiences

Like any other skill, program planning involves practice, evaluation, correction and more practice. Although each individual has their own formula for program development, many perform the following steps at some point:

Review the Site Mission

Why the site or resource is there? Why is it accessible to the public? Keep this vision and mission in mind. Your program should be a part of the larger whole for the site. Interpretation that does not relate, benefit or integrate with other site functions is likely to fall victim to a lack of budget, staffing, support and visitor interest.

Inventory the Resource

What resources will the visitor contact? With what do you have to work? Do not solely rely on your own impressions, especially if you are very familiar with the site. Often, familiarity blinds us to the resources in front of us. Invite a friend who has not been to the site to walk through with you. What do they notice? What generates questions, invokes interest, or appeals to them? Another critical consideration is what does the condition of the resource communicate to the visitor? Studies reveal that visitors believe what they see and pay less attention to what they are being told. On a tour through a historic site, the visitor will mentally "include" the grounds around any buildings. If the grounds, plants and arrangements do not accurately reflect the time period being interpreted, we unconsciously send the message that "This is the way it was." even though we may say something different. Similarly, an eroded, poorly maintained nature trail sends the subliminal message that "This is okay. This is nature." Make sure what you are saying is accurately reflected by the resource in front of the visitor. Carefully weigh the risks of interpreting degraded resources or consider integrating a "call to action" into your presentation.

Choose Specific Ideas and Outcomes

This is the most important part of your program or experience. It is frequently bypassed in the development process. Choose one specific "big idea" or theme. Then decide what you want the visitor to feel, learn or do because of your program. As Veverka says, "If you don't want the visitors to use the information being interpreted to them, then why are you giving it to them?" (Veverka, 1994). Determining your success can be very simple. Did the visitors ask any questions? Did they interact among themselves about the topic at hand? Did the visitors model the interpreter's behavior, such as picking up trash, avoiding a dangerous plant or actively listening to birdcalls? If you do not know why visitors came or what they enjoyed about your presentation, simply ask them. Beverly Serrell, a well-known authority on static exhibits, put it bluntly. "I used to think evaluation was optional. It's not. It's mandatory" (Serrell, 1996).

Develop a Theme, and Focus All Activity on That Theme

A theme is the central idea of any presentation. Frequently, novice interpreters mistake a topic for a theme, failing to narrow, focus and support a single idea that the visitor can "understand." The interpreter may choose to do a program on "trees." 'Trees" is a topic and a body of subject matter. A theme is a specific message about the subject matter, such as "The trees surrounding you are apartment buildings for local wildlife." Themes are complete thoughts and sentences. Topics are not. The process of narrowing and focusing encourages interpreters to select interesting, unusual, important facts for their presentations and avoid generalizations. Good themes make the program's development simple. Experienced interpreters know when they are struggling to find good visitor activities or fun information to include, they need to re-examine the program theme. Sam Ham makes several points about themes:

- "Thinking thematically focuses your attention and therefore reduces your work."
- "Most audiences find thematic communication easier to comprehend and more interesting. When audiences know, in advance, what your theme is going to be, they are able to see the relevance of the rest of the information you give them."
- "Most audiences will remember the theme, along with five or fewer main ideas used to present it. They will forget most of the rest. Begin your presentation with a clear, interestingly worded statement of your theme. End your presentation with a reinforcing, restatement of that theme."

Select Resource Contacts and Methods to Support the Theme

What can visitors actually do to help themselves reach the outcomes identified earlier in the process? If you have a good theme, this part should be less difficult. For the "Trees as apartments" theme, you might pass around chunks of wood from the local tree species. Allow visitors to examine the grain, feel the weight and predict the use for that kind of wood. Is it dense and therefore good for furniture? Is it a light, fast growing species good for fuel? Challenge them to look above and below eye level for shape and length. Which trees might be best for fence posts, floor planks or windbreaks (deciduous versus evergreen)? Which will break in the winter winds? For the informed interpreter, this approach provides plenty of room for

solid scientific fact. "Theme first" thinking keeps the interpreter focused on a central idea, rather than letting isolated facts clutter the mental landscape. Allow the visitor's personal experiences and opinions to become part of the program. Provide opportunities for the audience to see how the information personally relates to them.

Avoid the temptation to "tell it all." Beck and Cable quoted Anatole France, "Do not try to satisfy your vanity by teaching a great many things. Awaken people's curiosity. It is enough to open minds; do not overload them. Put there just a spark. If there is some good inflammable stuff, it will catch fire" (Beck and Cable, 1998). The recipe for good interpretation includes a few good ideas, supported by credible facts, presented with direct resource contact.

Present your Program with Confidence and Enthusiasm

Show respect for the visitor, the resource, and yourself. The visitor has chosen to spend time with your program, for whatever reason. " . . . Through our passion for the resources we interpret, we may bring out a similar passion in those we interpret to. To draw visitors into a full appreciation of the interpretive setting, the interpreter displays an affinity for the resource and a respect for humanity. We introduce visitors to something we love, not something we own" (Beck and Cable, 1998).

Audience Management Techniques

A few techniques for live, personal services interpretive programs are listed. Good technique can also be gained from auditing tours and programs at your site or at similar sites. Take tours and participate in programs with your focus on the presenter's technique and audience responses. Observe how visitors interact with the presenter and with each other.

Know Your Audience and Plan Your Presentation Accordingly

This topic is so important. Well-planned programs that accommodate audience motivations and needs have few problems. When faced with the generic "general public" audience, arrive at the program ahead of time and informally visit with the group. Be prepared to change a technique or include different information based on your observations. One experienced interpreter advises presenters to have ten times the information needed for the program you plan to present.

Sit the Audience Down Whenever you Can

Commentary that exceeds two minutes makes standing a problem. Shuffling feet, heads bobbing to gain a better view, "personal space" issues, and talking with each other will inevitably occur and distract from the presentation.

Consider Viewing Perspectives and Sound Qualities

This is especially important on guided walks and nature tours. If you must point out an object at any distance, use some simple focusing tools, such as a cardboard tube, or other picture frame. When you practice your walk, take time to stoop down or climb a little higher. Look at your object from differing heights. Avoid having the audience looking into the sun while trying to look at you. The interpreter should be looking into the sun. When you must talk for two or more minutes, plan stops so that listening will not be a problem. When guiding a large group, walk

with the middle of the group instead of front or in back where only part of the group may be able to hear you.

Create a Distinct Physical Environment to Focus Attention

All sorts of stimuli are bombarding our audiences all the time. Create physical parameters for the audience. Use shrubbery to form a wall, unusual seating objects, or simple visual cues to form a distinct space for the visitor's experience. This focuses attention and makes the audience more confident about their role.

Avoid Giving too Many Directions or Instructions at a Time

This is critical with younger groups and mixed groups with wide variations in ages. Groups, being led through an action, may be very unfamiliar with it and may have trouble with doing activities that have become simple for the interpreter. Break instructions into groups that make sense. Take care not to "talk down" to your audience.

Modeling Behavior is a Powerful Tool

Your persona will affect the audience. Your speech pacing, body language and actions will be reflected in the group, especially if they perceive you as an "expert." Act the way you want them to act. Do the things you want them to do. Feel the things you want them to feel. Challenge yourself to design interpretive communications that require no words.

Integrate Cultural and Natural History

Look for ways to add the 'people story" to any interpretation of natural history, and vice versa. Always strive to show people that they are part of the overall picture. They are significant to the topic of your presentation.

Team Up

Presentations using two interpreters can add interest; keep pacing lively and short circuit problems, especially with large groups.

Be Watchful When Passing Objects Around the Audience

We want folks to touch and handle objects. It can be problematic, especially with younger groups. Kids often become more interested in getting to touch the object than participating in the presentation. Use multiples, teams, or other methods to control object sharing.

"If You Can't See it, Don't Talk About it"

Try to find analogies, examples, or other physical manifestations for every topic, even the most complex.

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Citizen Science
Learning About the World with Science

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Describe the steps in the scientific process and understand that science is one way of learning about the world.
- Understand quantitative scientific research designs.
- Understand the concept of using samples and the importance of randomization in research.
- Identify a variety of data gathering methods.
- Explain the importance of accurately recording data and following protocol during field studies.
- Understand the benefits and shortfalls of using standardized research designs.

A Review of the Scientific Process

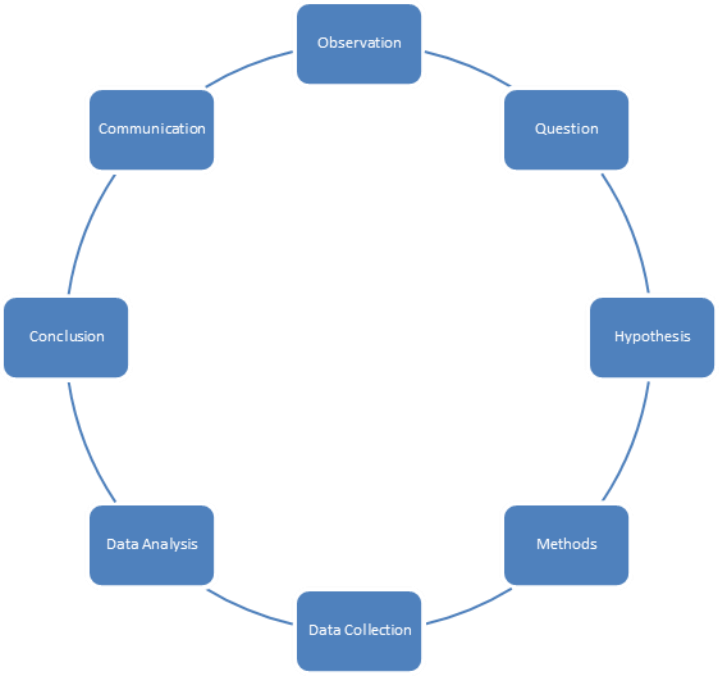
As a Citizen Scientist, you might find yourself collecting data as part of your volunteer work. Data collection is just one step in the important process of science. Sometimes, when we think of science, we think of the data collection phase, because it is when we are out in the field measuring things. It is often time consuming and labor intensive. Before data collection can occur, other very important steps must take place. Likewise, after the data are collected, important work remains. Chances are, no matter what your profession, you were taught the scientific process in school. Though it can be formal process, we practice it all the time in everyday life, unconsciously! Let us review the scientific process and see where data collection fits.

Observation

Nearly all scientific investigations start with observations made by people. "Observation" does not have to be done with our eyes. Using any of our senses, we can notice things around us. If you open your refrigerator one morning, and smell something…well, unique, you might instantly and without much thought, begin the scientific process. Your olfactory nerves just "observed" the smell of something rotten.

Question

The whole reason to initiate scientific process is to answer a question or solve a problem. Without a question or problem, why collect data? In our example, your question might be, "What is rotten in the fridge?" You might think of it as a problem, rather than a question, "There is something rotten in the fridge. That is a problem!"



8 Steps of the Scientific Process

Hypothesis

A hypothesis is an educated guess about the answer to your question or the solution to your problem. Based on other information or experience you have, you might have a good idea to answer to your question, but you are not entirely sure. You may be very sure of your answer. In order to convince others, the scientific process is necessary to show how you came to your conclusion using science. Standing in front of your refrigerator, you might think, "Oh, I bet it is the milk." That is what you think is producing the smell, but you are not 100% positive.

Research Design and Methods

This step involves planning how you are going to test your hypothesis to see if you are right or wrong. Research designs and methods in scientific endeavors *can* be complicated. At this point, a researcher uses their question to determine whether to collect data quantitatively or qualitatively.

It is not the goal of research to confirm the hypothesis.

Most of this chapter is written with quantitative examples. Most likely, it is the type of science you will be helping with in the Idaho Master Naturalist Program. The term science is used broadly, encompassing many ways to gain knowledge. You might choose to open the milk first and smell it. If the milk is good then, systematically you check other containers.

Data Collection

This is when things are measured and counted. You see people collecting data all the time. Counting cars at an intersection, weighing birds at a banding station, counting white blood cells in a laboratory, or measuring dissolved oxygen in a stream are all examples of data collection. It is important in the data collection phase to follow precisely the methods the researcher decided upon in the previous step. To deviate from the methods will produce results that will not give accurate answers to the question posed. Collect your data the way you said you were going to….open that cap on the milk and take a whiff!

Data Analysis

Your analysis of the milk will not take long! You will know right away if your hypothesis was correct or not.

Sometimes data analysis is time consuming. Data usually needs to be entered into a database and statistical tests run to test the hypothesis.

Conclusion

The conclusion of research is determined in the data analysis step. The conclusion in our scenario is either the milk was the culprit or it was not the milk but the baked beans from the Fourth of July picnic…..last year! It is important to remember that it is NOT the goal of research to confirm the hypothesis. It is as important to find results that do not support your hypothesis, as to find results that do support the hypothesis. To find out the stench is *not* coming from the milk is a great first step and will prevent you from dumping it down the drain. Sometimes, the conclusion is…..well, inconclusive. What if you have checked the milk, thrown out the baked beans months ago, and every other item in the refrigerator looks and smells just fine. In this case, your hypothesis was not correct. You did not actually find the answer or solve the problem. However, you *did* find out what *was not* causing the smell. Research and science often create more questions than answers. Although frustrating to some, it can be exciting. The process begins again.

There you stand, refrigerator door open, looking at the food with no mold. You look around (observation). You ask more questions. You wonder about new problems. "I wonder what if it could be something outside the refrigerator." Could the smell be coming from somewhere in the refrigerator I cannot see? (questions). The whole process continues.

Communication

Without communication of scientific results, the information gathered is only helpful to the researchers who performed the research. To maximize the benefit of research and results, one must communicate the results to another audience. It may be in the form of an article, in a scientific journal, written mostly for the use of other researchers and professionals in that field.

It could be a presentation at a conference. Research results are often used to make management decisions. Research results may be presented to policy makers, or managers. There are endless ways to communicate results. The important part is that some communication occurs. In our example, you might just tell your spouse, who walks into the kitchen, there is something that smells bad in the fridge and you know the milk is safe.

Science is a way of knowing, a process that perpetuates itself and adds to a collective body of knowledge to be shared by all. Some people think science is supposed to be value-free, objective, and free from human influence and opinion. Since humans do science, it is full of judgments, decisions, opinions, and interpretations. Remember, science is a human activity that is never completely free of bias.

Other Ways of Learning About the World

Science is just one way of knowing. In our society, science is held in high regard and respected. This was not always the case. Most natural resource agencies believe science is the best method to answer the kinds of questions they are asking.

In their book, *Research Methods: A Process of Inquiry*, Anthony Graziano and Michael Raulin outline six different ways of knowing (Graziano & Raulin, 2006, p.10). As you read these brief descriptions, try to think of an example in your own life using each of these methods.

- *Tenacity* - accepting knowledge as true because it has been accepted as true for so long.
- *Intuition* - accepting ideas because you have a "gut instinct."
- *Authority* - accepting ideas because someone who you respect and has authority tells you it is true.
- *Rationalism* - using existing ideas and logic to arrive at valid ideas.
- *Empiricism* - making observations to gain knowledge.
- *Science* - Using rationalism to develop theories and using empiricism to test the theories to gain knowledge.

Different ways of knowing and perceiving the world are not to be deemed good or bad. They are just different. Conservation and natural resource management is a mix of ways of knowing. Often science is needed for decision-making, budgets, and actions by governments, policymaking, and influencing public opinion.

Consider a management decision based partially on public opinion. Public opinion might be gathered very scientifically, using the scientific process. Public opinion itself might be a reflection of people's intuition or tenacity.

The Idaho Master Naturalist Program strives to be a science-based program. The Citizen Science Track was designed specifically to help you participate in scientific projects. Knowledge can be gained to conserve Idaho's natural world. Your journal is a space where you can record not only your scientific pursuits, but also your experiences with other ways of knowing.

Examples of Common Research Questions

No matter what field of natural resource work in which you will be volunteering (forestry, ornithology, fisheries, plant ecology), there are some typical questions posed. Below is a list of five general categories into which many natural resource research questions will fit.

Biology

- *General* - What is the conservation status of species and their habitats?
- *Specific* - distribution (presence/absence), abundance, trends, threats, biodiversity hot spots, gaps in species protection, corridors and linkage zones?

Basic Wildlife Biology, Ecology, and Behavior

- *General* - What is it about a species that may determine or limit its population?
- *Specific* - Sex ratio, age ratio, age at first reproduction, gestation, litter/brood size, den/nest sites, mortality, home range size, dispersal capability, population dynamics, population genetics, social organization and structure, food habits, energetics, parasites and disease, intra- and interspecific interactions, courtship/breeding behavior?

Estimating Numbers in Populations

- *General* - How many individuals/populations do we need to conserve the species for survival or a human purpose (trees for paper, wildlife for hunting, and plants for medicine)?
- *Specific* - Indices of abundance, estimates of abundance and density, population modeling, population viability analysis.

Wildlife/Habitat Relationships

- *General* - What is the relationship between this species and its habitat?
- *Specific* - What habitats are used and for what purpose (food, denning, shelter), at what times of year, in what juxtaposition, how large an area, fragmentation, quality, foraging behavior?

Human Dimensions

- *General* - What does a population of people know, believe, want, and think about a particular subject? Who are the people in this population?
- *Specific* - Knowledge, beliefs, values, opinions, demographics?

More about Questions-Choosing a Research Design

Now that you have reviewed the scientific process and have seen common categories of questions in natural resource conservation, you can see where data collection fits and how questions and problems drive the system. The question will dictate what research design will be implemented. In turn, that helps the researcher choose the methods and drives how data will be collected. The type of data collected determines the proper analysis steps.

Analysis of the data usually produces a conclusion. Each step helps a researcher decide what to do next. Below are examples of research questions about an animal. As you read the question, think about how each question would lead the researcher to choose *different* approaches and use *different* tools.

- How many Peregrine falcons are there in Idaho?
  Estimating numbers in populations

- Where do Peregrine falcons nest?
  Wildlife/habitat relationships

- Has the population of Peregrine falcons changed in the last 10 years?
  Biology/trends

- What do Peregrine falcons need to survive?
  Basic wildlife biology, ecology, and behavior

- What are the habits of Peregrine falcons when raising chicks?
  Basic wildlife biology, ecology, and behavior

- How are Peregrine falcons affected by human presence?
  Wildlife/habitat relationships

- Should Peregrine falcon eggs be collected by falconers?
  Human dimensions, Biology

- Does the public know the conservation status of the Peregrine falcon?
  Human dimensions/Communication

- Is this area appropriate habitat for Peregrine falcons?
  Wildlife/habitat relationships

Peregrine Falcon © IDFG

The questions are endless. The design for the research will be decided based on the question. There are some general categories of research design that have varying levels of constraint. Constraint refers to the demands on the adequacy of the information you are collecting (Graziano and Raulin, 2006, p. 47) Previously, we discussed different ways of gaining knowledge (tenacity, intuition, authority, rationalism, empiricism, and science). Science is the way of knowing that requires the most demands on the adequacy of the information (Graziano & Raulin, 2006, p.14), However, within quantitative science designs, there is another continuum of constraint. Some scientific designs are more demanding than others. Again, judgment should not be made when comparing these research designs. Low and high levels of constraint do not coincide with bad and good science! Each level of constraint comes with positive and negative qualities.

The research design examples given below are quantitative designs. Qualitative designs will not be covered in this chapter.

Low Constraint Research

Naturalistic Observation

This type of research is defined by systematic recording of naturally occurring events, in their natural settings, by the researcher. The researcher's level of involvement with what is measured is usually low. The researcher may take measures not to be noticed and not to get in the way of what is being observed and recorded to

…to describe

assure events are taking place as they would if one was not there. These observations are later used to develop hypotheses about why the events took place. Jane Goodall is an example of a famous scientist who practiced this form of research. This design is usually chosen when the researcher want to observe, describe, or identify something.

Case Study Design

Case studies are used when a researcher wants to study something in depth. Case studies are bound by time and space. Something specific is studied, in a certain location, for an identified period. Multiple sources of information are usually used in a case study. For example, in SW Idaho, sport fishers are complaining that the American pelican population is reducing the quality of the local fishery on the Snake River. A case study might be appropriate.

…to identify a relationship or better understand a complex issue

Researchers can employ a variety of techniques to answer questions. A public opinion survey, a fish count, water quality testing, habitat monitoring, pelican banding, and a historical document search might be implemented to come to a conclusion about what effect pelicans are having on the fishery. The goals of a case study usually involve the need to describe or understand something in depth, or identify relationships that are occurring. Case studies are often a hodge-podge of high and low constraint research all directed toward answering one question or a set of questions about a phenomenon.

Higher Constraint Research

Correlational Design

A correlational study seeks to find a *correlation* or relationship between two variables and determine the strength of the relationship. Do not mistake this for cause and effect! The goal is not to find out if X causes Y. In a correlational designed study, causation cannot be claimed. Ice cream sales and the number of violent crimes committed in a city are correlated. There is a positive relationship between these two variables. As ice cream sales go increase, the number of violent crimes also increases. However, the sale of ice cream does not cause more crime that is violent. Rather, there is another variable that explains both levels of these variables, temperature. As the temperature increases in the summer, ice cream sales increase. As the temperature increases, violent crimes also increase. It is important to note the difference between correlation and causation. Do not to fall down the slippery slope of confusing them.

…to predict future scenarios

Just because science shows a *relationship* between two variables, it does not necessarily mean one causes the other. Only experimental and quasi-experimental research designs can determine cause and effect. Correlational research can be used to predict future events. If research shows a negative relationship between the amount of human disturbance and bald eagle reproductive success, we cannot say that increased human disturbance causes bald eagles to reproduce less. We can predict that if a new development is to be built near a river where bald eagles nest, their reproductive rate is likely to decrease.

Differential Design

Any research or science that measures the difference of a variable between two pre-existing groups is a differential design. The opinions about wolves in Idaho (the variable) could be compared between ranchers (group one) and Sierra Club members (group two). The fertility level (variable) of the Selkirk Grizzly bear population (group one) and the Yellowstone Grizzly population (group 2) could be compared. There are many kinds of differential designs. These types of research projects investigate at least one variable and measure it in two pre-existing groups.

…to compare two groups

Highest Constraint Research

Experimental Design

An experimental design is science done with the highest levels of constraint. The image of a scientist in a lab coat, measuring the different amounts of poison into hundreds of Petri dishes to find the "lethal dose" is an image of an experimental design. Experimental designs have two important qualities:

…to determine cause and effect

- All variables are controlled by the researcher.
- Groups that receive different amounts of the independent variable are chosen at random.

In our "mad scientist" example, the researcher has hundreds of Petri dishes prepared exactly the same way. Perhaps the researcher grew a plant in each Petri dish and the plants are genetically identical. They are all kept at the same exact temperature. They get the same amount of light. They get the same amount of movement and nutrition. All the variables have successfully been controlled. Then, different amounts of the independent variable (poison) are administered to groups of Petri dishes, including a control group, where no treatment of the independent variable

(poison) is given. How much poison each group of Petri dishes receives is controlled. Any difference in how the groups of plants in the Petri dishes react to the poison can be explained by the amount of poison given. Any difference seen in the plants after poison is added is due to the researcher's action, because all other variables were held constant. Cause and effect can be determined. Experimentally designed research is common in medicine and engineering, biology and chemistry. It is often not ethical or practical to control all the variables in natural resources and conservation.

Quasi-Experimental Designs

As the name implies, quasi-experimental designs are like experimental designs (Graziano and Raulin, p. 306). Often, the researcher has a little less control over some of the variables or groups that receive different levels of the independent variable were not randomly assigned. It would be difficult to grow two genetically identical forests in a laboratory, burn one forest and then compare amount of elk habitat in each forest after 5 years. In the real world, you could find two similar forests, burn one, and measure the amount of elk habitat in each forest after 5 years. The difference is that the two forests were not identical initially. They might have been very similar. The aspect might be just slightly different. There might be a better water source in one forest. One forest might have more recreation in it, or slightly different plant species. All of these things might affect the amount of elk habitat. If done properly and carefully, quasi- experimental research can conclude cause and effect relationships.

A final note on levels of constraint within science: After reading the descriptions of the quantitative research designs, note the higher the level of constraint research the further the investigation moves away from real life situations. Compare Jane Goodall, sitting quietly in a rainforest observing gorillas, taking copious notes (low constraint research), with the "mad scientist" in a sterile laboratory, delivering poison to plants in Petri dishes with a mechanical

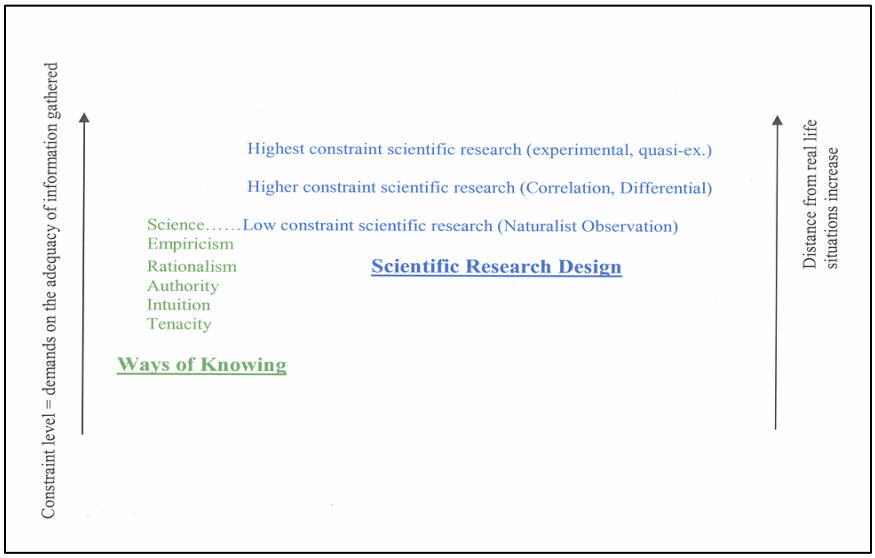


Figure 1: Various ways of knowing are listed in a column on the left, with science as the method that requires the greatest demand on the adequacy of information. Within science, there are different quantitative research designs with different constraint levels. Note the right arrow indicates the higher the constraint level in science, the further the research is from real world situations. Concepts used for this diagram from Graziano and Raulin, 2005.

eye dropper (high constraint research). The former example is without researcher intervention and is recording how the real world works (see Figure 1). The later example will help determine the powerful cause and effect relationship. When matched properly with the research question, all constraint-level research designs are appropriate.

Methods

Choosing how to collect data is to decide if and how to sample. Before discussing particular data collection methods, understanding the difference between census and sampling is important.

Ideally, if we want to know how many elk there are in Idaho, we would count all the elk. That would give us a precise number and it would be 100% accurate, because everyone was counted. This is **a census**. This would be next to impossible. Censuses are ideal, but rare. The United States Census is an attempt to do just that every 10 years. The Idaho Master Naturalist pre-program survey is another example of a census. Since there are not many IMNs, it is cost effective, time efficient and possible to ask each person the questions.

When a census is impossible, which is most of the time; we use samples to make inferences about populations. Not every park visitor across the state can asked about state park use if the Director of Idaho State Parks and Recreation wants to know something about state park visitors. There is not the time, money, or resources to do so. It is not necessary. A sample number of visitors can be asked questions. In this case, the "population" is all state park visitors in Idaho in a given year. The people chosen to ask questions to are the sample. The results of the "sample" are analyzed and inferences can be made about this population, only if the sample is chosen correctly. Asking questions to only five people at Three Island Crossing State Park one day in May would not be a valid sample. A sampling plan must be developed to assure the samples will be representative of the whole population of state park visitors. Years could be spent learning the appropriate way to sample. What is important in science is samples can be used to make inferences about populations using statistics.

In citizen science work, you may be asked to measure something within a sample. Fortunately, you will not be asked to plan the research design, make inferences about the population or statistically analyze the data.

We use samples to make inferences about populations.

Figure 2 illustrates the use of samples. The researcher might have a question about a population. Imagine working with the Forest Service, near your town, to determine the percentage of forest cover that is tamarack trees. The "population" is the whole area you are studying… perhaps a whole hillside, or forest. The population is always well

defined and usually can be mapped. It would be too hard to go measure all the tamarack in the forest to determine how much canopy cover they provide in the forest. Instead, you will probably go collect information about tamarack in several sample locations. By using the data in your random samples, if enough samples are taken, the researcher can accurately infer how much canopy cover are tamarack trees within the entire population area.

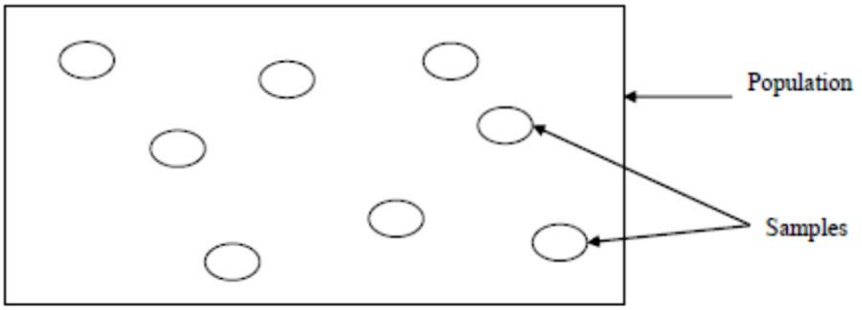


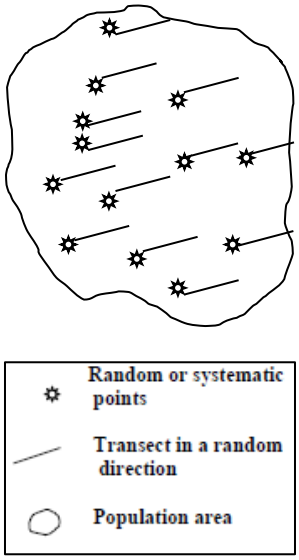
Figure 2: Samples are taken from a population. If samples are chosen randomly or systematically, represent the population, and enough samples are taken, inferences can be made about the population.

The samples must represent the population well to be able to make inferences about a population based on data collected only from samples. In the above example, we would not sample only tamarack along the prominent trail through the forest being studied. Trees along a trail might be different from trees elsewhere in the forest. Because tamarack trees might grow differently at the lower elevation, than at a higher elevation, we would not measure the canopy cover of tamarack trees in the lower elevations of the population (forest) being studied. Foresters know that tamarack trees grow very differently at the edge of a forest than in the middle of a forest. In order to make statements about the whole population in the end, samples really must be taken over all the population's area.

Samples must be representative of the population.

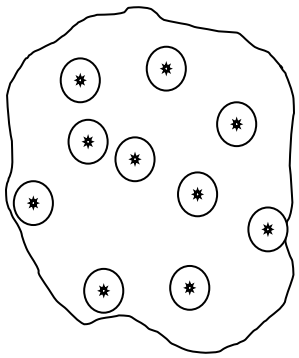
Transect

A transect is a common technique used in many disciplines including wildlife management, forestry, botany, soil science, and entomology, to name a few. Most of the time, a transect is a sample taken when it is too difficult to measure an entire population or area.



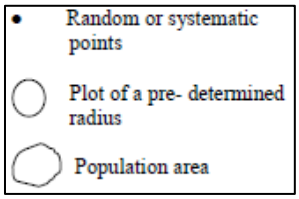
The transect counts or measures whatever is being studied, along random line segment (one sample) within a defined area (population). To find the relative abundance of different plants in the sagebrush-steppe community, the researcher would find a random point, within the population area, and stretch a tape measure in a random direction for 100 feet. Then, walking along the transect, the researcher would measure exactly how many inches of sagebrush, bitterbrush, rabbit

brush etc. was touching the tape. Many transects would be performed within the population area. The data would be entered and analyzed. Using statistics, the relative abundance of different plants in the sagebrush-steppe community could be inferred for the population.



Plot

A plot is much like a transect, but instead of a line, it is an area. Sometimes, a plot is a circle, radiating from a randomly chosen point in the study area. Sometimes, plots are square. A census of whatever is being studied is taken within each plot. A forester might want to know the abundance of downed and woody debris (DWD) in a forest in preparation for a prescribed burn. Plots are selected randomly and, within each plot, measured for how many and how large the DWD is. If plots are selected randomly, and enough are measured, a forester can make inferences about the population using the measurements from the plots (sample).



Sampling is used in nearly all natural resource disciplines. Once a sample location is found, there are many different ways to collect data. The following five natural resource disciplines and some typical data collecting methods for each are explained.

Common Methods in Plant Ecology

For plant ecology, many research questions are answered by using plots and transects. Measuring canopy cover, diversity, seral status (level of succession), and presence of weeds are commonly done with plots and transects. Measuring the plant structure of different layers of vegetation (grass, shrubs, and trees) is commonly performed with Robel Poles. These are large poles that a data collector props up at random points in a population area and record the visible number area of the pole.

Common Methods for Birds

A common way to use plots when collecting data on birds is a **call and response** survey. For this data collection method, a researcher will find a random point. Instead of counting something, a recording of a bird, for example an owl, is played. Then one listens for a pre-determined amount of time and records if a response is heard. The protocol may require several attempts at each random location.

About to be released, this Chestnut-sided warbler shows off her new leg band after being captured in a mist net. Photo by Jay Carlisle, Idaho Bird Observatory.

Point counts are another way to use plots. A random point is found. The researcher records birds heard or seen for a given

period of time at that point.

Mist netting is a common way to collect information on birds and bats. Mist nets are very thin nets that span from the ground to about 8 feet high. Usually, many nets are set up in a general area. Birds cannot see the net. They are caught in the delicate webbing when they fly into the net. Researchers quickly collect the birds, band them, weigh, sex, measure and identify the species before letting them go. Bats are not banded.

Common Methods for Mammals

Capture-mark-recapture methodology is used often in determining population estimates and mortality rates in small mammals. In this technique, a population is sampled at least twice. Each time, every unmarked animal is uniquely marked and previously marked animals are recorded. This methodology requires the data collectors to trap or somehow capture small mammals (live traps) and mark the individuals caught before releasing. Information about the mammals is recorded, such as sex, age, species, and weight.

Pygmy rabbit, Wendy Estes © 2005

Aerial surveys are commonly used to determine big game population levels and distribution. Often, it is not likely you will be able to see an animal to count it. Several methods require the researcher to count animal sign. **Snow track surveys**, **scat surveys, burrow surveys**, and **hair snag surveys** are all ways to determine if a species is present and in what quantity, without having to actually see the animal.

Common Methods for Fish

Electrofishing is the use of electricity to capture fish. Most typically, this involves using boats or backpack mounted units to sample water bodies. Generally, boats are used to sample shorelines along ponds, lakes, reservoirs, and large river systems. Backpack units are employed in small streams. Electro fishing is a sampling technique for sampling shallow waters. The vulnerability of fishes to electro fishing varies among species due to differences in anatomy and behavior. Species that inhabit shoreline habitat such as bass, minnows, and perch are most easily sampled by electro fishing. Fish size is also an important determinant of sampling efficiency using electro

Electrofishing in shallow water.
Photo courtesy, Friends of the Teton River,
http://www.tetonwater.org

fishing.

Generally, larger fish are more easily captured than smaller fish. Data analysis, using electro fishing gear, might include the development of population abundance information such as catch per unit effort, fish per unit area (e.g. adults/km), or size structure.

Direct underwater observation of fishes is a valuable tool in fisheries management. **Snorkeling** is employed where good visibility is available. A common application of underwater methods is estimating population abundance. Counts made by snorkelers can be used as estimates. Most typically, multiple snorkelers are used. The stream and river channel is divided. Each snorkeler keeps track of species and sizes observed. The area sampled is then measured and density estimates can be developed. Sometimes, multiple passes are done to refine the population estimate.

Netting - Passive capture gear involves the capture of fish by entanglement or entrapment in devices that are not actively moved. The use of nets and traps are widespread. They are most often used in still or slow moving waters. Entanglement devices capture fishes by holding them ensnared in a fabric mesh. Gill nets are entanglement gear. Entrapment gear captures fishes, which enter an enclosed area through one or more funnel or V-shaped openings. They cannot find a way out. One example of entrapment gear is a hoop net. These are used to sample fish in a wide range of habitats. Passive sampling gear, if employed in a standardized fashion, can be used to estimate catch per unit effort. Additional estimators are length-frequency (size structure) and age composition.

Common Methods for Human Dimensions

One of the easiest and most common ways to collect data about people is simply to watch them. **Observation** can be very insightful! A researcher might want to know how many people stop and read the new information board just installed at a state park. A data collector sits across the road from the information booth and counts the number of visitors that stop to look at the board and the number that do not. When collecting data about people, there are ethical considerations. Human dimensions researchers must pass rigorous ethical standards for approval by most universities and institutions. Some research projects, involving human subjects, do not require approval by the Human Assurances Committee like observing visitors at an information booth. Projects that need approval are reviewed to assure the rights of the participants, to check for unnecessary risks to the participants, and to ensure the participants gave informed consent.

Another common way to collect information about people is to ask them. **Face to face interviews** and **written questionnaires** are two of the most common techniques. This methodology requires a sampling plan, just like plots, transects, and snow track surveys. Data are entered into a statistical program to be analyzed like other quantitative data.

The Importance of Following Protocol when Collecting Data

No matter what methods are chosen, as a data collector, it is paramount to follow the protocol of the researchers. Any deviation from their directions or their chosen methods compromises their ability to answer their question with confidence. Methods can be right or wrong, good or bad, appropriate or not appropriate for a given research project. It is not your job as a data collector to make these judgments. It is your job to make sure the data are collected the way it was intended. **Validity** and **reliability** are constantly being strived for in science. One way researchers ensure validity is by choosing the right method for measuring. If you wanted to know how much you weigh, you would not choose to use a thermometer to measure your weight. You would choose a bathroom scale. This is an obvious example. Let us say a researcher had a question about the population distribution of a reptile. There are certain methods that would be better than others to answer this question. There are standard methods, used by other people that have been tried and tested.

Researchers train their data collectors to measure the same way to ensure reliability. Often, this is in a written format called a protocol. In the bathroom scale example, to be reliable, the scale would have to give the same weight each time you stepped on it. If you stepped on the scale three times in a row and got different readings, the scale would be valid, because it measures weight. It would not be reliable, because it measures the weight differently each time. In field research, there is always the fear that data collectors will not follow the protocol. Different people will measure things differently. There is always going to be some variation in how data is collected because humans performed the data collection. It is your job to follow the protocol as closely as you can. It is NEVER okay to make up data, omit data, or change data in any way. It is NEVER okay to make up your own way of collecting data.

As a data collector, you do not have the power to change protocol because of circumstances in the field (fatigue, bad weather, short staffed). You can communicate any data collection concerns to the researcher. Often, a method looks good on paper and just does not work in the field. You cannot change the methods. Certainly, in these cases, you can contact the researcher and explain the circumstances. They might be able to find another method of collecting the data that will be more appropriate.

Validity and reliability can be compromised when data collectors are not properly trained. If you feel you need more help understanding the protocol for data you have been asked to collect, do not hesitate to ask for help.

Standard Data Collection Methods

There are hundreds of different ways to collect data. Standard procedures have been adopted in most disciplines. By choosing to follow a standard research design, the researcher can compare results with others who have used the same procedure or with procedures done at an earlier time. This is a powerful ability in science. The downfall is that the standardized method might have big flaws. Let us look at an example. Breeding Bird Surveys (BBS) have been performed in the United States since 1966, using a standard method, to track the status and trends of North American bird populations.

> "Each year during the height of the avian breeding season, June for most of the U.S. and Canada, participants skilled in avian identification collect bird population data along roadside survey routes. Each survey route is 24.5 miles long with stops at 0.5-mile intervals. At each stop, a 3-minute point count is conducted. During the count, every bird seen within a 0.25-mile radius or heard is recorded. Surveys start one-half hour before local sunrise and take about 5 hours to complete. Over 4100 survey routes are located across the continental U.S. and Canada" (USGS, 2007).

Because everyone uses this standardized method across the country and over time, breeding bird populations can be compared to each other. Declines or increased can be detected. Standardization increased the reliability of the results. Reliability is consistency. However, the standardized method for breeding bird surveys is fundamentally flawed because birds are only looked for along roadways, not in random samples of the population area. In addition, determining distance of a birdcall is very difficult, even for seasoned birders. Other methods could be more valid. Even though the BBS has some flaws, it is still used widely and following the protocol is important.

This chapter was written to help you increase your knowledge and understanding of the scientific method. In addition, some concepts were present that will help you see your volunteer work as Citizen Scientists in a broader picture of quantitative scientific inquiry. Many concepts in this chapter are steps in the scientific process you will not be doing. However, it is important to understand the work performed before and after data collection. Feel free to ask questions about the details of the project you are working on because the better you understand the whole process of science, the better Citizen Scientist you will be.

Inventorying and Monitoring

It is important to note that data collection is not always done in the name of research. Often, data is collected for inventory and monitoring purposes. Inventory is usually done to find presence,

absence or abundance of a species in a specific location. It seems hard to believe that we do not have data like this for all species, but we do not. Many nongame animal and plant species in Idaho are not well studied. In order to "manage" a species, you first must know where it lives and in what quantities. An inventory gives us a snapshot in time, but provides no trend data. An inventory can be thought of as baseline data. We must first know where Pygmy Rabbits live in Idaho in order to protect them. Then, management actions can be taken and monitoring can occur to see if the management actions were effective. Monitoring serves to find trends over time and effects of management actions.

References and Credits

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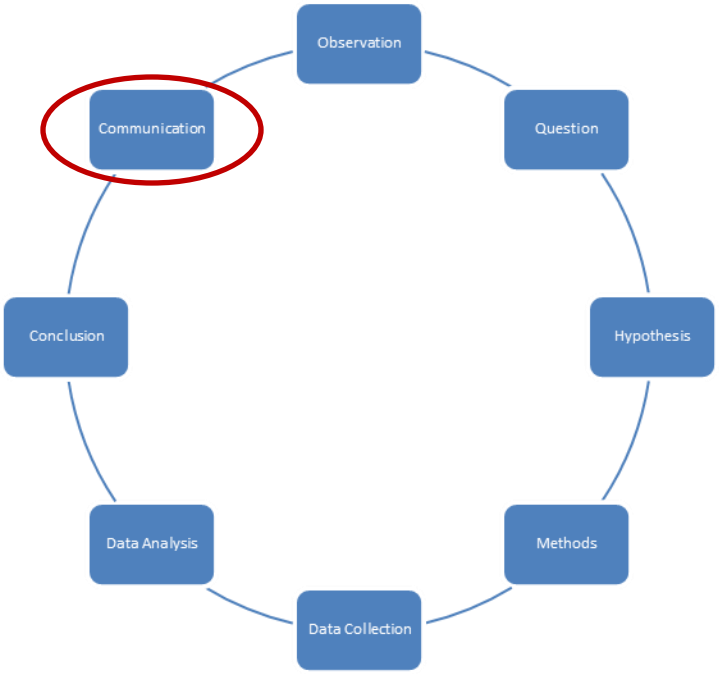
Citizen Science Practical Scientific Experience

Chapter Goals:
After completing this chapter, volunteers should be able to:

- Review a scientific article and identify the steps in the scientific process.
- Participate in data collection as a group and learn how it fits into the larger scientific process.
- Demonstrate the ability to successfully use GPS receivers and read topographical maps.
- Identify and demonstrate proper field safety techniques and Leave No Trace principles.

Reading a Peer-Reviewed Scientific Article

One of the first steps, in the scientific process outlined in the Citizen Science Learning about the World with Science chapter, is "communication." Sharing results of research with others, as well as giving others a chance to scrutinize the scientific process, is an important part of science. Some research projects are published in peer-reviewed scientific journals.



8 steps of the Scientific Process

Peer-reviewed journal articles can be intimidating to read. One factor contributing to this is

scientists, who write for scientific journals, write for other scientists, not the public. Scientific journal articles that are written well are understandable with a little effort. A variety of scientific journal articles will be provided for you to read. You are welcome to find your own, those that cater to your interests. Try to identify all the steps in the scientific process. You may not understand some of the content of the sections in these papers. Some of the data analysis description can be very technical with statistical details. Skim the parts you do not understand.

If you do not find all the parts of the process explained in the paper, do not worry. The author may have had limited space to write and left one step out on purpose. Generally speaking, it is unacceptable to leave out large portions of the process in a scientific paper. The point of papers like these is to share information, knowledge, and create an opportunity for other scientist to scrutinize your work and process.

Nature Journal Entry:

Group Data Collection Exercise

Date:
Time:
Location:
Weather:
Agency/Organization Volunteering for:
Researcher:

What was the research question? What was the hypothesis?

Why was this data being collected? For what will the data or conclusions be used?

How did you collect the data?

Was the protocol for collecting data clear and easy to perform?

Did you take samples?

Nature Journal Entry:

Reviewing a Scientific Journal Article*

Journal:
Title of Article:
Year:
Authors/Researchers:

Research Question:
Was the research question(s) explicitly stated? If so, what was it? If not, what do you think the question(s) was?

Hypothesis:
Did the authors explicitly state the hypothesis? If so, what was the hypothesis? If not, what do you think their hypothesis was?

Methods:
Without going into too much detail, were the methods adequately explained, in your opinion? Briefly, what were the methods of collecting data?

Data collection:
Was data collection described and/or was data presented?

Data analysis:
Was data analysis described? How did the authors analyze data?

Conclusion:
Were the authors clear about the conclusion of their research? Did they reject or fail to reject their hypothesis?

Communication:
Do you think the authors communicated their research process and findings clearly? How was the writing style? Did they communicate all the steps?

Did the authors reveal any limitations to their process? Did they disclose any threats to the validity of their research findings? Do you see any problems with their process?

***In the IMN core curriculum, there is a Nature Journaling chapter. When a participant gets to this part of the Citizen Science curriculum, they will have already read the chapter on how to keep a nature journal.**

Field Safety Basics

While working in the field collecting data or helping with a citizen science project, there are several safety considerations to keep in mind. Most safety procedures are common sense and are things we do to keep safe, no matter how we spend time outside. The most important thing to remember when doing field work is if you ever feel uncomfortable with what you are doing, you feel it is unsafe or risky just do not do it. No data is more important than your health and safety. If you are not safe, there is no data. Take care of yourself first. Then, concentrate on your data collection task.

One of the most important aspects of field safety is being prepared. Having the supplies you need and the proper clothing for the task and weather are essential. Consider making a list of everything you need for a day's work in the field and checking it each time you leave. Below is a suggested list, although, it is best to make your own.

Water

Keep well hydrated, no matter how thirsty you are. Thirst is actually a poor indicator for hydration. If you are thirsty, you are way behind in hydration. The outside temperature, how strenuous the field work is, and what you are eating are just a few factors that will determine how much water you should drink. Your urine should be "light colored" or "clear." That is right. To meet this goal, you need to pack a lot of water or bring a water purification system with you. Never drink directly from a lake, stream or spring. If you will not be far from a vehicle for long periods, store extra water there.

Food

It is better to bring too much food than not enough. Bring things you like and foods you are used to eating. Store extra granola bars, or candy bars in your backpack or vehicle, for times when you need a little more nutrition.

Raingear/Warm Gear

You know Idaho's weather changes suddenly. Wind could be the culprit, not rain. In either case, a good raincoat will provide you with protection. Raincoats should be carried at all times, no matter the weather. If nothing else, it is nice to sit on if the ground is wet. Bring an extra warm layer of clothing.

Sun Protection

While volunteering for an agency or organization, sun protection is not a choice. You need to cover your skin with fabric or sunscreen. Sunburn will speed up your dehydration and makes you miserable. A wide brimmed hat and sunglasses will help too. Covering your skin for sun protection can also double as a barrier to mosquitoes and ticks!

Pen/Journal/Data Sheets

Have pens, pencils, and back up writing utensils. Have plenty of data sheets. Take more than you think you will need. Make sure to have a clipboard or hard surface to write on and a plastic bag to store data sheets, in case it rains.

Tools for Work

Take measuring tapes, tape recorders, thermometers, binoculars, flagging. Whatever is needed for data collection must be packed. The knowledge of how to properly use each tool is essential for safety. Be sure the tools you have are right for the job and in good working condition. Do not hesitate to ask for materials you need to do the job right.

Trowel/Toilet Paper

When nature calls, you will need to listen. See the *Leave No Trace* information below for specifics on proper disposal of waste where there are no developed outhouses or bathrooms available.

First Aid Kit

More important than a first aid kit, is the knowledge to know how to use it. Familiarize yourself with first aid techniques, or take a class. If you need any special medication throughout the day, or if you are allergic to bee stings, make sure you have what you need. Some general pain relief medication, such as aspirin or Ibuprofen, might help minor discomforts.

Map/Compass

Only bring these if you know how to use them. If your project requires you to do map work, make sure you have the correct maps.

Cell Phone (If there is service.)

Just in case you need to ask questions or call for assistance bring your cell phone. Be sure to carry the phone numbers of the office or the researcher. Program them into your phone, or keep them handy. Cell phones have a built in GPS that could aid Search and Rescue if you were to become lost or injured.

Trash Bag

A plastic bag can serve many purposes in the field. You can pack out your trash from lunch and project flagging in addition to trash you might find. Though trash collection is probably not what you will be out in the field doing as your volunteer service, picking it up is good stewardship. Do not go out of your way while collecting data in the field. However, if you see trash in the parking area or your work area, toss it in your plastic bag and pack it out when you leave.

Insect Repellent

IDAHO DEPARTMENT OF HEALTH & WELFARE

www.westnile.idaho.gov

Idaho's mosquitoes may carry West Nile virus. Twenty percent of people infected will develop symptoms. The virus can be fatal. To prevent infection, wear protective clothing and use insect repellent. Dead crows, ravens, and magpies in an area may indicate the virus is present in the area. "Fight the Bite!"

Flashlight

Unless you are helping with owl or bat surveys, you probably will not be volunteering at night. However, it is a good idea to keep a flashlight or headlamp in your backpack for unexpected emergencies.

Knife

A pocket knife comes in handy to cut your bagel for lunch or free some flagging from a tree. Knives always seem to get used in field work.

Whistle

Some recommend a whistle for emergencies. It is a way to signal to others if you need help. Commercial emergency whistles are light and designed to have a sound that carries up to a half mile.

CD

A used/old CD is lightweight and can be used for digging, holding items together or as a light signal in an emergency.

Gloves

Gloves can protect your hands from cuts, scratches, insect bites, and poisonous plants. They are helpful when you need to pick up something in the underbrush or disposal of waste.

Space Blanket

A space blanket can be purchased at most outdoor shops for under $5. This is a safety item in case you get caught in bad weather or are out for longer than anticipated.

Camera

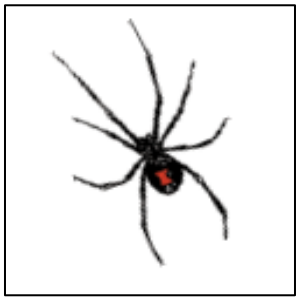
A camera can come in handy during data collection, even if photos are not required in the protocol. If you have trouble identifying something, or you see something you have a question about, or seems interesting, you might want to take a photo of it. It is important, when taking a photo of something you are supposed to be recording, to write down where you took the photo,

what time it is, the sample plot you are in, your aspect and photo direction. You must use your compass. Having an inanimate object, such as a pen or shoe in the photo, helps with perspective.

Whew! That is a lot to carry! There are also many things you can carry in your head that will help you be safer in the field.

Hazards Associated with Animals and Insects

Hobo Spiders (above) and Black Widow spiders (below) are Idaho's poisonous arachnids.



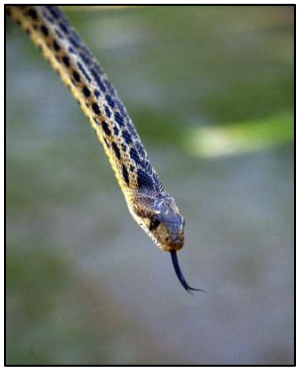
Spiders

We have discussed West Nile Virus and preventing infection while working in the field. There are two poisonous spiders in Idaho worth being able to identify! **Hobo spiders** prefer undersides of rocks and debris. They are not good climbers. Note the "boxing gloves" on the male's reproductive structures. The abdomen has chevron (V- shaped) patterns (possibly many of them) down the middle, with the chevrons pointing towards the head. **Black Widow spiders** like woodpiles and holes. They have a "red hourglass" on their back. Their nest looks like a large, white cotton ball.

Snakes

There is only one snake in Idaho that is a concern. The **Western Diamondback Rattlesnake** has a triangular head shape and rattles on its tail. **Gopher** snakes look similar, but they have a much narrower head and, of course, no rattle! Rattlesnakes are not found in high elevations, or in the northern Idaho Panhandle Region.

Western Rattlesnake, © Loren Thomas.



Gopher Snake. Notice the slim head. (stockphotos.com)

Black Bears and Grizzly Bears

The best way to deal with bears is to avoid them. This requires knowing some situations that might indicate bear activity. Large, turned over rocks and logs, berry patches, and fresh scat may indicate there may be bears nearby.

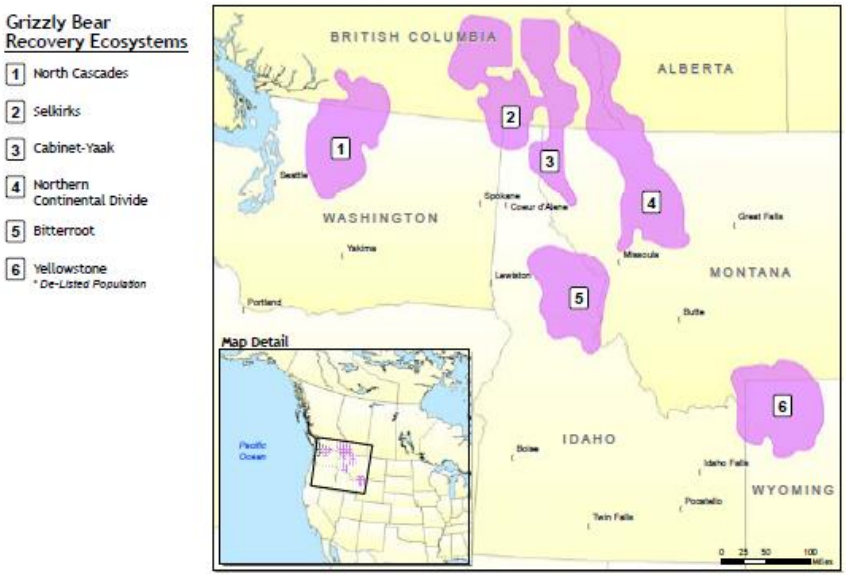
Most black bears will run away from humans! Sometimes, when they are caught off guard, have a cub, or are defending a food source, black bears can be aggressive and initiate a predatory attack.

Comprehensive information on black bears and grizzly bears is located on the *Center for Wildlife Information* website: http://www.centerforwildlifeinformation.org/index.html.

Read the opening letter on this page, and then click on the *"Be Bear Aware"* button on the left. From there, click on *"Bear Encounters," "Bear Spray" and "Black/Grizzly ID"* and read the information.

Black bears live in almost all forested areas in Idaho. Notice the flat, slanted profile.

Grizzly bears live in the shaded areas numbered 1-6. Notice the distinct shoulder hump and relatively small ears. The snout of a Grizzly bear is more dish-shaped than a black bear. Photos © IDFG.



Grizzly bear range in the western United States. Map created by Brent Thomas, IDFG.

Nature Journal Entry:

While reviewing the Center for Wildlife Information website (http://www.centerforwildlifeinformation.org/index.html) answer the following questions.

FEATURE	WHICH BEAR?	
Dish snout profile	Black Bear	Grizzly Bear
Brown	Black Bear	Grizzly Bear
Track with smallest pad below other pads, horizontally	Black Bear	Grizzly Bear
Does not have a distinct shoulder hump	Black Bear	Grizzly Bear
Ears smaller and more rounded	Black Bear	Grizzly Bear
Can climb trees with 1 ¼ inch claws	Black Bear	Grizzly Bear

What are the two types of confrontations with bears?

According to this website, conflicts with wildlife are primarily due to what?

If you see a bear, what are some behaviors it might display to show you it is upset?

If you must administer bears spray, about how far away should the bear be from you?

Poisonous Plants

As a general rule, when out collecting data or doing field work as an Idaho Master Naturalist, do not eat any plants. Even if you can properly identify plants and you know they are safe, it is best not to take this risk while working. The Panhandle National Forest, in northern Idaho, lists 28 species of poisonous plants!

Poison Ivy, Jennifer Anderson @ USDA - NRCS

Driving

When volunteering on a citizen science project, you are representing the agency for which you are volunteering. Drive according to the laws. Be courteous, no matter if you are driving your own car or an agency vehicle. If in an agency vehicle, know the agency's protocol for recording mileage and buying gas before you begin your work.

Notification

Letting someone know where you are going and when you will be back is important. This can be someone from home or someone from the agency or organization for which you are working. Many agencies have their own field safety requirements. We will not list all of them here. Know the field safety protocol of the agency for which you are volunteering and ask about hazards associated with the work.

Leave No Trace

Leave No Trace (LNT) is a non-profit educational organization that promotes low impact outdoor recreation. Most state, federal, educational, and private organizations that provide recreational opportunities, or employ field personnel, follow *Leave No Trace* principles as part of their policy and/or regulations.

Visit LNT.ORG

No matter how you recreate in nature on your own time, you will be expected to follow LNT principles to the highest degree while volunteering for an agency or organization as an Idaho Master Naturalist. It is your responsibility to know these principles and the skills needed to follow them while you are in the field.

A detailed description of LNT skills is available on the website. Use this information to familiarize yourself or update your LNT knowledge. LNT principles change over time, based on new science or social conditions. It was once acceptable to bury your garbage while working or recreating in the field. Now, this practice is completely unacceptable and rarely practiced. It used to be taught that toilet paper should be burned or put in the "cat hole" after use. Now, this not recommended at all. Packing out your toilet paper is suggested and is practiced by most experienced field staff and recreationists.

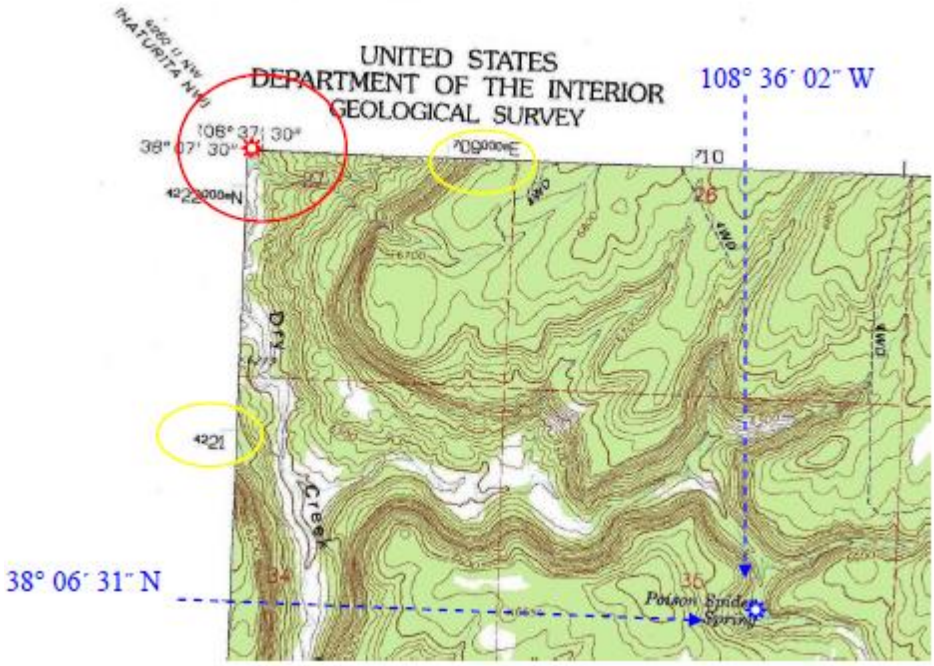
7 Principles of Leave no Trace

1. Plan ahead and prepare.
2. Travel and camp on durable surfaces.
3. Dispose of waste properly.
4. Leave what you find.
5. Minimize campfire impacts.
6. Respect wildlife.
7. Be considerate of other visitors.

Remember, how you are used to minimizing your impacts in the field may be outdated! That is no problem! You can adopt new practices and join the growing group of people setting the example for others. Keep an open mind. Remember, it is part of your responsibility, as an agency representative, to practice LNT.

Using Maps, Compasses and GPS Units

Being proficient using maps, compasses and GPS units takes considerable training. Depending on what project you volunteer for, you may or may not need these skills. Below is a brief overview of map features and skills, and GPS skills. Consider this just an introduction. If you are interested in learning more about maps, compasses and GPS units, consider taking a class on these skills as part of your continuing education requirements.



Topographical Maps

- *Name of map* - The name of the map is located in the top right corner of the map margin. The name is usually associated with a prominent feature on the map.

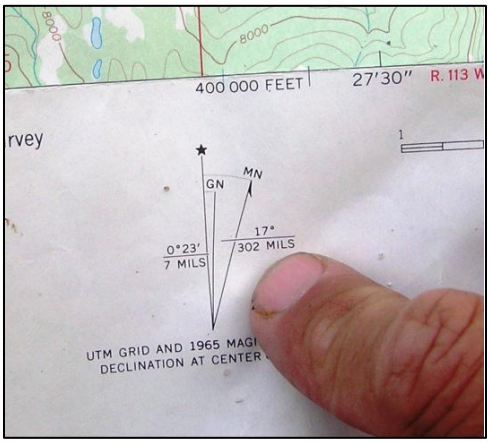
- *Scale* - the map scale should be shown in the margin of the map. This will give you an idea how far apart features are and how much area your map covers.

- *Latitude/Longitude* - You will notice around the margins of your map there are two sets of numbers. In the corners, there are numbers that represent the latitude and longitude lines. More latitude numbers are evenly spaced along the sides of the map. More longitude numbers are evenly spaced along the top and bottom of the map. You can place a numeric value for the location of anything on the map using a latitude value and a longitude value. For example, if you were located on the * dot in the upper left hand corner (see the above map), your latitude, longitude reading would be 38° 07′ 30″ N (latitude) and 108° 37′ 30″ W (longitude). If you were located at Poison Spider Springs, you would be at 38° 06′ 31″ N and 108° 36′ 02″ W.

- *Universal Transverse Mercator (UTM)* - It is the other set of numbers along the edges of your map (see circles on the left margin and along the top margin of the above map). This system also uses a set of coordinates to locate points on the earth. The easting and northing are the two coordinate numbers reported for each location. Above, Poison Spider Spring is located at 12 710360 E and 4220584 N.

  When collecting data for an agency or organization, as a citizen science volunteer, be sure you understand how the agency wants point coordinates to be recorded; in latitude, longitude or UTMs. If you are using a GPS unit, collecting this information is as easy as the touch of a button. If you need to figure coordinates from a map, you may need additional training and practice.

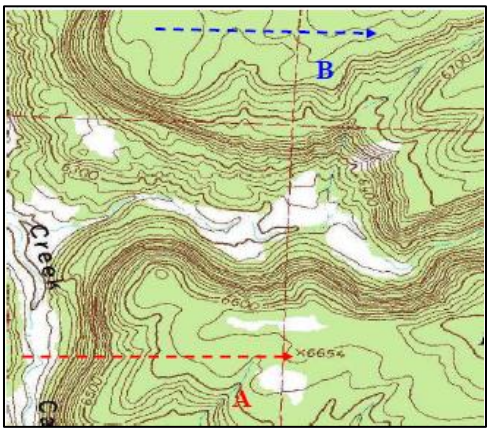
- *Declination Arrow* - A declination arrow is located in the middle of the bottom margin of a topo map. It will tell you the difference (in degrees) between true north (what your map was drawn from) and magnetic north (where your compass points). In Idaho, the compass will point a little to the east of true north. The declination is said to be easterly. Declination must be adjusted when using a map and compass. See the compass skills section below to learn how to adjust for declination.



Magnetic north is labeled MN, where true north is designated with a star. Your compass will point to magnetic north. Your map is printed to true north.
Photo, Sara Focht.

- *Contour Lines* - One of the most striking features of topographical maps is all the brown wavy lines! These contour lines represent the topography, the relief, or the "lay of the land." Contour lines are lines drawn on a map that connect points of equal elevation. If you walk along a contour line, you neither gain nor lose elevation. Each line represents X number of vertical feet, depending on your map. When you see contour lines very close together, get ready for hard hiking. The

terrain is steep. When contour lines are very far apart, you will be walking on flat ground. Contour lines represent a line that has the same elevation. Each line on the map represents 200 vertical feet. Following the dotted line, A, from the creek bottom to the peak, you would be walking up a very steep hill, probably a cliff. Line B represents a nearly flat walking surface.

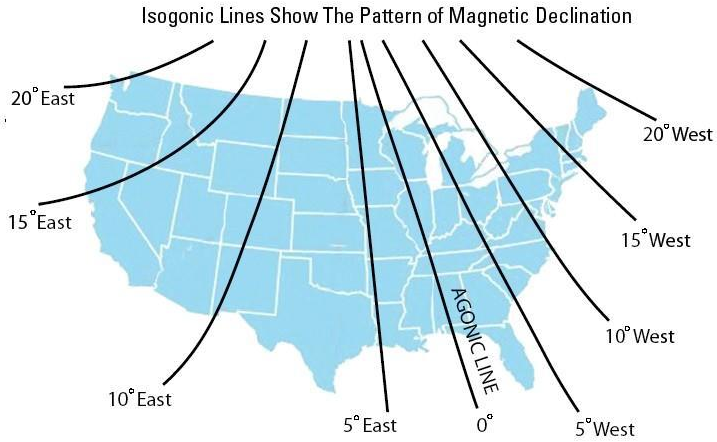


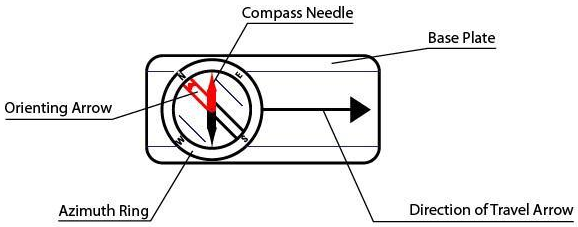
Map showing contour lines.

- *Colors* - Different colors represent different types of topography.
    - Green – vegetation
    - Blue – water
    - Purple - updated information
    - Pink - built-up (urban) areas
    - Brown - topographic contours
    - Red - land division system grids
    - Black - transportation and buildings

The Concept of Declination

Declination is the difference between true north, and magnetic north (expressed in degrees). Your compass will always align itself with magnetic north. Your map is aligned to true north. Why would mapmakers do this? The magnetic poles on earth actually change in time. Mapmakers always print maps pointing to true north, so they do not constantly have to make new maps! If you to ignore declination while working with a map and compass, you will be incorrect in everything you do!





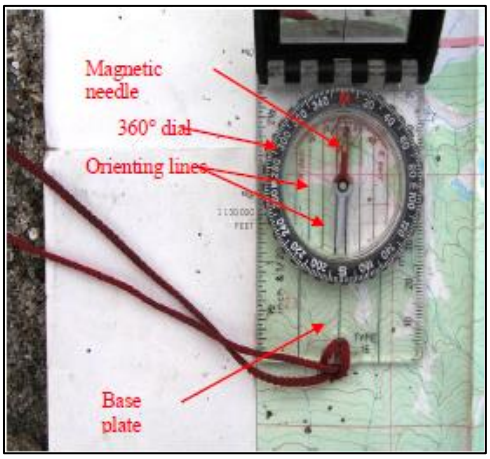
Magnetic declination varies through time and space. You can look up the current declination for any area in the United States on line. Map used with permission from USGS.

In Idaho, declination is said to be "easterly." This means your

compass reads magnetic north, just slightly to the east of true north. In the eastern United States, the declination is said to be "westerly." This means the compass would read magnetic north just to the west of true north. If your USGS map is more than 15 years old, it is advisable to get a reasonably current figure because declination varies over time. If you were standing in the Panhandle of Florida east of Panama City, your declination would be "zero." Magnetic and true north are the same. You would not have to deal with all this declination business! See Figure 1 for a map of the United States and declination.

There are many ways to adjust for declination.

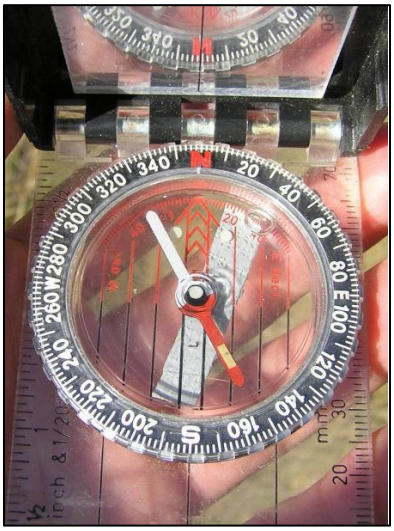
- Use tape to mark your declination on your compass.
- Buy a compass with a declination adjustor.
- Add and subtract the declination when you are using your map and compass skills.
- Draw declination lines across your map.



Parts of a compass.
Photo by Sara Focht, IDFG.

Compasses that have declination adjustors are expensive. Adding and subtracting declination is a little tricky. In addition, drawing declination lines on your compass can be difficult to get accurate. The following four map and compass skills are going to use the tape method. Before you begin practicing these skills, place a piece of tape on the back of your compass corresponding with the declination for the area. If the declination of the area is 15 1/2 degrees easterly, place the tape on 15 1/2 degrees on your compass. This could be the declination somewhere in Idaho.

If you have previous compass experience, you may have learned using one of the other methods listed. If so, you probably remember hearing about "boxing the arrow" or "put red Fred in the shed." These two terms are used to help people remember to line up the magnetic needle with the red rectangle on the base plate . Using this tape method, to adjust for declination, you will have to be "boxing the arrow" or "putting red Fred in the shed." You will always be using the tape to line up your magnetic needle. "Put red Fred on the tape" just does not seem to have the same ring to it. Maybe it is just silly enough to remember.


Notice the tape place at 15 1/2 degrees east.
Photo by Sara Focht, IDFG.

Before practicing compass skills, remember that compasses are always held flat, as if the compass were sitting on a table. If you are working with a compass, and are not holding it flat, there is a

risk the needle will give you a false reading. Hold the compass at your abdomen, flat out in front of you, as if it were a lunch tray. To avoid “tipping your lunch tray,” be sure to hold it flat.

Valuable Skills for You to Acquire

Skill #1 - Orienting Your Map to True North

Why should you do this? Orienting your map to true north is helpful if you want to have your map match the landscape. If you orient your map to true north, adjusting for declination, you do not have to adjust for declination later.

When wanting to find north, or orient your map to true north, put tape on the back of your compass along the degree of declination for your area. 2. Turn the dial on the compass to North. 3. Rotate with your compass until the magnetic needle is lined up with your tape edge.
Photo by Sara Focht, IDFG

- Make sure the tape is on your compass along the degree of declination for your area!
- Turn the dial on the compass so North is aligned with the direction of travel arrow.
- Turn your body and compass until the red magnetic needle is aligned with your tape.
- Put your map on the ground. Carefully place your compass on top of it. Turn the map only until the orienting lines on the map are parallel to the north/south lines on the map.
- Your map and the landscape are perfectly aligned.

Skill #2 - How to Take a Map Bearing and Use it for a Field Bearing

Why should you do this? If you know where you are on a map and you have located another point on the map that you would like travel to, you can take a map bearing to help you travel to that location.

When taking a map bearing, for travel to a destination, you must adjust for declination somewhere in the process. There are several places in the process to do this. You may observe other people adjusting for declination differently.

- Make sure your tape is on your compass!
- Place your compass on the open map with one edge of the base plate lined up with your current location. Rotate the base plate so its

edge lines up with where you want to go.

- Turn the compass dial until the orienting lines are parallel to the map's north/south lines.
- Read your bearing.
- Stand up and hold the compass properly. Turn the compass and your body until the needle points to the tape.

Skill #3 - How to Plot a Field Bearing Onto a Map

Why would you do this? You may see a feature on the landscape that you cannot identify on the map. If you know where you are, you can take a field bearing to help you identify the feature. If you do not know where you are on a map, but you can identify several features on the landscape and map, you can plot several field bearings to find your location (triangulation).

Josh lines up the peak in the distance with the notch on his compass. Notice he is holding the compass flat. Photo by Sara Focht, IDFG.

- Make sure your tape is on your compass!
- Hold your compass in the direction you want to travel, or toward the feature you are trying to identify. Line up the feature in the notch of your compass.
- Turn the compass dial until the needle points to the declination tape. Use your mirror to do this, if you have one, being careful to keep the compass flat. Read your bearing!
- Place your compass on your oriented or un-oriented map.

Turn your compass until the orienting lines on the compass line up with true north lines on your map. Do not worry about the needle. Align the rear corner of the compass base plate with your current location and draw a line. The line should go through the feature on the landscape on which you took the bearing.

Skill #4 - How to Walk a Field Bearing

Why would you do this? If you see a feature on the landscape that you would like to travel to, a field bearing will help you travel straight there, even when you cannot see the destination.

- Follow steps 1-3 of plotting a field bearing.
- Keeping the needle on the tape, walk in the direction of the traveling arrow on the compass.

Global Positioning System

The **Global Positioning System** consists of 24 GPS satellites, portable GPS receivers, and various ground-based support facilities.

GPS receivers are the units you hold in your hands when you are hiking, collecting data, or geocaching.

A GPS receiver can:

- *Tell you where you are. (Marking a Waypoint)* - Your GPS can tell you exactly where you are, within a few feet, anywhere on the planet. This is the first thing that your GPS will do. Put the batteries in, turn it on, and stand outside. The GPS will do the rest for you.

- *Tell you which way to go next. (Finding a Waypoint)* - You can load destination coordinates into your GPS. The GPS will tell you which way to go to get there. Loading this information and using it to travel is the most important part of using a GPS.

- *Tell you where you have been. (Tracking)* - This is called "Tracking," and involves recording "Waypoints." (The GPS Primer, 2007).

All About Waypoints

A waypoint is a record of coordinates, that is, longitude, latitude and altitude. There are two ways to find Waypoints. You can get them from someone else, enter them in your GPS, and have it guide you there (Finding a Waypoint) or you can use your GPS to record your present location for later use (Marking a Waypoint).”

Waypoints must be named. If you do not name them, the GPS will automatically name them and begin with 001, 002, 003, etc.

To take a waypoint, press and hold the ENTER/MARK key until the waypoint is displayed. Highlight SAVE and ENTER to save the waypoint.

To find a waypoint, press GOTO and select a WAYPOINT that has been entered into your GPS by you or someone else. Use the Compass, Map, or Highway page to navigate toward the waypoint.

Tracking

Automatically recording waypoints at set intervals as you travel is called “tracking.” These can be transferred to a map (manually or by computer download) to show where you have traveled. This is like a breadcrumb trail of where you have been.

- Turn on Track Log feature by choosing it on the Main Menu or Setupage.

- Choose how you want the Track Log to record. There may be three choices: off, wrap, or fill.
- Choose how frequently you want a waypoint to be taken: time, distance, or automatic.

This chapter was written to guide you through some practical experience you may need before volunteering as a Citizen Scientist. Hopefully, reading articles in scientific journals has helped you solidify your understanding of the scientific process that you read about in the Citizen Science: Learning about the World with Science chapter. Safety and LNT features were highlighted to remind you of the important things to remember while volunteering for agencies and doing conservation work in the field. Map and compass skills, as well as GPS skills, need to be practiced. Do not just read about them. We hope you have the opportunity to practice these skills in training, or have been informed where you can get more practice.

Resources and Credits

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