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.

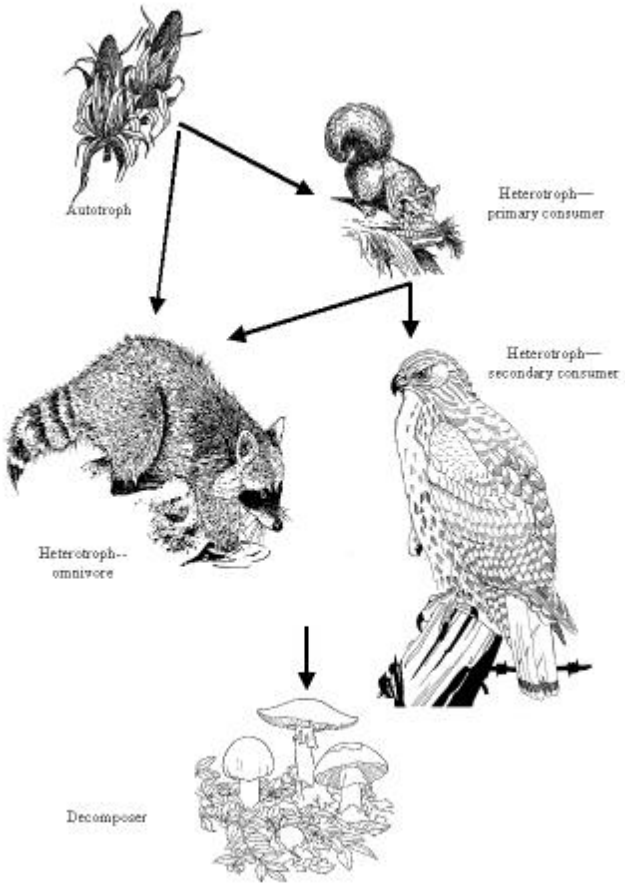
Drucker (1974) states that "Management always has to consider both the present and future--both the short run and the long run. A management problem is not solved if immediate profits are purchased by endangering the long-range health, perhaps even the survival, of the company. A management decision 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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http://texnat.tamu.edu (source of information on range and wildlife management and water)
http://rangeweb.tamu.edu/trm (source of Extension information on Total Resource Management)

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