Social and Political Issues in Ecological Restoration

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Abstract — There are four major questions affecting the future of ecological restoration. The first and most serious question is philosophical. Should we attempt to restore ecosystems? Some people want to separate humans from nature because they believe that human intervention is bad or imperfect. They define "natural" as the absence of human influence. They also think restoration should consist of drawing lines around ecosystems and keeping people out. If this philosophy prevails, ecological restoration has no future. The second question is social. What do we want to restore? The third question is scientific. What can we restore? The fourth question is political. Who decides what we will restore? Large-scale restoration projects cannot begin without answering these questions. This paper explores the implications of these questions.

INTRODUCTION

Ecological restoration can trace its roots back to three scientists who had the foresight to see that people can play a constructive role in preserving ecosystems. It began with Aldo Leopold who advocated constructing samples of native plant communities in the University of Wisconsin Arboretum (Jordan 1983a). In his dedication speech for the Arboretum on June 17, 1934, Aldo Leopold said "The time has come for science to busy itself with the earth itself. The first step is to reconstruct a sample of what we had to start with" (Jordan 1983b). Aldo Leopold's son, Dr. A. Starker Leopold, emphasized the importance of using historical ecosystems as a model for future management. He also recognized that Indians played an important role in creating and maintaining those historical ecosystems. For example, as chair of the Committee on Wildlife Management in the National Parks (the Leopold Committee) he helped clarify the goal of national parks. The committee recommended that "the goal of managing the national parks and monuments should be to preserve, or where necessary to recreate, the ecologic [sic] scene as viewed by the first European visitors" (Leopold et al. 1963). A National Academy of Sciences Advisory Committee supported this goal and it was incorporated into the administrative policies of the US Park Service (National Academy of Sciences 1963; US National Park Service 1968). In 1965, Dr. Edward C. Stone published a paper in Science that advocated training "vegetation preservation managers" to carry out the recommendations of the Leopold Committee (Stone 1965). He also developed criteria for educational programs to train these specialists. Such educational programs do not yet exist but the rapid growth of restoration ecology ensures that they will exist in the future.

Today, restoration ecologists pursue a well defined set of professional goals (Bonnicksen 1988a). First, ecological restoration involves repairing ecological communities, or reestablishing them on the same sites if they are destroyed, or replacing those communities with synthetic communities on other sites if the original sites can no longer be used. Second, ecological restoration involves maintaining ecological communities, or protecting communities from unwanted influences so that they can change in desired ways. Third, ecological restoration involves using restoration projects to advance knowledge about ecological communities. In each case, restoration ecologists use the historical or indigenous structure and function of an ecosystem as the model for restoration.

There are four major questions that must be answered to further develop restoration ecology as a field of science and management. The first and most serious question is philosophical. Should we attempt to restore ecosystems? The second question is social. What do we want to restore? The third question is scientific. What can we restore? The fourth question is political. Who decides what we will restore? This paper explores the implications of these questions.

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SHOULD WE RESTORE ECOSYSTEMS?

Some people believe that nature is sacred. This belief reifies nature, or converts nature in the abstract to nature as a real thing. Since nature is a sacred thing, adherents to this philosophy define humans as unnatural. They exclude humans from nature. As Frankena (1979) points out, they believe that what is natural "is right and the virtuous." They also believe that humans are inherently destructive and that beauty only exists in dehumanized landscapes, so nature must be left alone. Such misanthropic beliefs form the foundation of many environmental organizations. Consequently, they believe that restoration should only protect ecological communities from human influence. Supporters of this philosophy assume that "nature" will restore itself without human help. What "nature" creates is not important, only the absence of human influence is important. Their watchword is to "let nature take its course," despite the potential for sacrificing other values. In short, if the "nature as sacred thing" philosophy dominates resource management then ecological restoration has no future. Supporters of this philosophy would answer the question posed above by saying that people should not restore ecosystems.

The opposing philosophy accepts humans as part of nature. Supporters believe that ecological communities should serve human needs, but that the needs of other beings must be considered. They believe that excluding humans from nature is an unnatural change that would ultimately destroy ecological communities. Examples include the rapidly deteriorating ancient forests within national park and wilderness areas throughout the United States. They argue that the removal of humans as a natural force will begin unnatural chains of events and create new and artificial ecological communities. If this philosophy dominates resource management then the future of ecological restoration is assured. Supporters of this philosophy would answer the question posed above by saying that people should restore ecosystems.

Since restoration ecology uses historical or indigenous conditions as a model for restoring ecological communities, it includes an implicit recognition of the effects of past human use. Restoration ecologists point out that humans played a natural and decisive role in guiding evolutionary change for at least 2.6 million years. Humans used tools and fire to help shape and maintain plant and animal communities throughout the world. Thus restoration ecologists use the past, including historical human influences, as a model for the future. On the other hand, people who believe that humans are not part of nature place no value on historical conditions. Instead they value the abstract idea of "letting nature take its course." To them, future ecological conditions are "good" no matter what changes occur. The remainder of this paper assumes that people will accept their role in nature and that restoration ecology will grow in importance.

WHAT DO WE WANT TO RESTORE?

Ideology

Most of the legislation creating US national parks, wildernesses and reserves refer to the goal of maintaining natural conditions (Bonnicksen and Stone 1985). Regulations governing Canadian national park and wilderness areas also refer to maintaining the "natural state" (Parks Canada 1983). However, naturalness remains undefined. Some people advocate "letting nature take its course," others advocate restoring historical conditions, still others argue that everything is natural. In each case the definition of naturalness seems clear to advocates, but ambiguous to managers.

Ambiguous definitions of naturalness provide a false sense of understanding that often leads to useless debates over ideology. For instance, the US National Park Service argues strongly for the "let nature take its course" ideology. They even allowed huge and unprecedented wildfires to burn 50 percent of Yellowstone National Park in 1988 because of this ideology (Bonnicksen 1989). In contrast, however, the Park Service also uses logging, burning and mowing to remove native herbaceous plants, shrubs and trees for aesthetic purposes in other national parks. Why is it unnatural for native shrubs to invade a meadow in one park, and natural for human-caused wildfires to burn large areas in another park? Unfortunately, there are no criteria for making this choice, so they are ad hoc decisions made by local Park Service officials. This inconsistency shows that ambiguous ideological statements cannot serve as useful goals for resource management.

The Canadian Park Service avoids such inconsistencies by requiring an approved vegetation management plan for all units of the system. These plans emphasize the goal of restoring or maintaining "ecological and historical integrity" that includes the effects of past use by native people (Parks Canada 1983). In short, instead of debating the meaning of naturalness or "letting nature take its course," Canadians manage their parks. They decide what they want in each park and then they find the best way of getting it. This is what the Leopold Committee recommended for US national parks back in 1963. Dr. Leopold reiterated this recommendation in a letter dated June 9, 1983, (his last written statement on restoration). He told the Park Service that restoration issues "involve judgment, followed by action" and that such issues "are not resolved simply by allowing natural ecosystem processes to operate.'" He concluded by saying that "I still espouse the idea of active manipulation." The US Park Service still has not carried out the Leopold Committee recommendations. In contrast, the Canadian Park Service took the recommendations seriously and applied them successfully.

Vegetation management plans for Canadian national parks must conform to a set of overarching principles. First among these principles is the prudent goal of "minimal interference" (Parks Canada 1983). Managers can manipulate park resources when neighboring lands, public health and safety, and park facilities are threatened. They can manipulate resources to "restore the natural balance" or to substitute human action for "a major natural control" that is absent. They also can interfere in natural processes to protect rare and endangered plants and animals. Most important, they can manipulate resources when "the population of an animal species or stage of plant succession which has been prescribed in the objectives for a park, cannot be maintained by natural forces." Unlike the United States, the Canadian people decide what they want to restore in their parks in unambiguous terms. Then they provide their Park Service with the flexibility and resources to achieve the goal.

Restoration Goals

Goals define what should be done. They provide an idealized sense of direction for restoration projects. There are three broad categories of restoration goals: structural, functional, and wholistic (Bonnicksen 1988a). Structural goals concentrate on the parts of an ecological community, functional goals concentrate on processes and wholistic goals include both.

Structural Goals

Structural goals use physical features to describe the desired future condition of an ecological community. The type of function that is used to produce the desired condition is less important because function is a means to an end, not the end itself. Unless prohibited, chain saws, prescribed fire and chemicals are legitimate means to restore the structure of the ecological community. The Canadian Park Service, for example, must use restoration techniques that "will duplicate natural processes as closely as possible" (Parks Canada 1983). Nevertheless, a historically authentic function, such as the use of old agricultural practices, may be essential for perpetuating an ecological community in some historical structural condition. Structural goals include: 1) the biotic diversity goal, 2) the special species goal, 3) the special community goal, and 4) the cultural landscape goal (Bonnicksen 1988a, 1990).

1. The biotic diversity goal focuses on the number and kinds of "things," such as native species, in a particular area. The arrangement of "things" in space and time may also be an essential attribute of biotic diversity. Biotic diversity is only used for ecological restoration when it is based on a historical or indigenous model.
2. The special species goal focuses on favoring one native species over another. Animal or plant species that are identified as more important to humans than other features of the ecological community, such as the northern spotted owl, are known as special species. Special species include those that are threatened with extinction, outstanding specimens of the total population, or species that are highly valued by some social groups for other reasons.
3. The special community goal focuses on restoring historical associations of native plants and/or animals. Past human activities may or may not have been important as the dominant force responsible for creating a special community. Society may value special communities, like special species, because they are rare, spectacular, or important to a particular social group. Special communities can also serve as historically accurate ecological settings for cultural artifacts.
4. The cultural landscape goal focuses on restoring culturally derived associations of plants and/or animals. Cultural landscapes are ecological communities that resulted from, or coexisted with, human habitation. Artifacts, such as buildings and quarries, may or may not be important elements of the landscape. Cultural landscapes range from those that appear unoccupied, but were maintained by aboriginal peoples, to intensively managed agricultural landscapes.

Functional Goals

Functional goals do not include the structure of ecological communities because function, such as wildfire and plant succession, are more important. Thus any structure is acceptable if it is created by, or sustains, the desired function. What is important here is not the authenticity of the structure but the authenticity of the function. Functional goals include: 1) the unimpeded processes goal, and 2) the analogical processes goal (Bonnicksen 1988a, 1990).

1. The unimpeded processes goal is designed to perpetuate a desired historical function rather than the structural attributes of an ecological community. It is laissez-faire or passive management. Humans simply observe historical non-human forces at work. These forces are allowed to operate freely despite alterations to the structure of an ecological community. This is an abstract goal because the presence or absence of a function, such as wildfires, determines success. However, structure and function are inseparable. Therefore, in order to sustain the historical function, the starting structure of the community must approximate past conditions, or the condition that would have existed without degrading influences.
2. The analogical processes goal focuses on reestablishing a desirable historical function, such as plant succession or the cycling of soil water reserves, or eliminating an undesirable function,

such as soil erosion. The structure of an ecological community can be modified as needed to support the desired function.

Wholistic Goals

Wholistic goals consider both the structure and function of an ecological community. Wholistic goals include: 1) the controlled evolution goal, and 2) the synthetic community goal (Bonnicksen 1988a, 1990).

1. The controlled evolution goal is based on an evolutionary perspective that accepts changes in the structure and function of ecological communities. However, selected attributes of these communities are controlled by keeping them within the limits that society finds acceptable and desirable. The starting point for controlling evolutionary change can be the historical condition or an estimate of what the current ecological condition may have been without degrading influences.
2. The synthetic community goal uses structure and function as equally important measures of authenticity. Synthetic communities resemble other ecological communities that may have been lost. It means starting from nothing and knowing enough to include the relevant parts of the system, along with essential interconnections and ecological processes.

WHAT CAN WE RESTORE?

Restoration ecologists follow a systematic procedure for carrying out restoration projects to achieve a goal. Underlying this procedure is the principle that a historical or indigenous model, or reference ecosystem, is always used as the target for restoration. Standards for assessing the success of restoration come from measurable attributes of the reference ecosystem. Whenever possible, restoration practices mimic the historical or indigenous processes that operated to maintain the reference ecosystem. Thus restoration usually involves 1) selecting a reference ecosystem and documenting the difference between current conditions and the reference ecosystem; 2) developing measurable standards from the reference ecosystem that serve as a target for management; 3) documenting historical processes and developing restoration practices that mimic the effects of those processes; 4) projecting the consequences of management to improve restoration practices before intervention; 5) monitoring the results of intervention and revising management practices to ensure success. The first three steps in this restoration procedure determine what can be restored.

Reference Ecosystems

The most important decision in ecological restoration is selecting the reference ecosystem. Since future changes in an ecological community will always be dictated by its starting structure, the starting structure must accurately represent the reference ecosystem during the historical period. Restoration can only proceed after the reference ecosystem has been documented using measurable standards of authenticity (Bonnicksen 1990, 1988a, 1988b; Bonnicksen and Stone 1985, 1982a, 1982b).

The historical structure of a reference ecosystem can be documented by several means. Sources of evidence include archeological materials, historical accounts, old photographs, early land surveys, sediment analysis, pollen analysis, soil maps, climate maps and existing vegetation. For example, pollen analysis was used to describe the vegetation surrounding Fort Necessity, Pennsylvania, as it appeared in 1754 (Kelso, Karish and Smith 1993). The fort was built by Lt. Col. George Washington to defend against a French-led Indian force. However, using existing vegetation is the most direct and accurate approach for reconstructing historical conditions (Bonnicksen and Stone 1982b; Henry and Swan 1974).

Using existing vegetation to reconstruct historical conditions involves rolling woody plants back in time and developing a description of the historical structure (Bonnicksen and Stone 1982b, 1981). Spatial patterns of seral stages, and non-woody vegetation, which comprise the vegetation mosaic are also important structural features. Differences between the current and historical conditions are then used to describe a target condition for restoration.

This approach to documenting a reference ecosystem provides a sound scientific basis for management. For example, the ancient mixed-conifer forests of the Sierra Nevada mountains of California are seriously degraded due to a century of fire suppression and the elimination of Indians. Today's forest is thicker and older than the ancient forest. Shrubs, oak trees and wildflowers are less abundant, and white fir is gradually becoming the dominant species. These changes present a serious threat to wildlife and the biological diversity of the forest. Unfortunately, many people that advocate restoring these forests use unscientific images as a guide for restoration.

A persistent myth about ancient mixed-conifer forests is that they were composed mostly of large old trees. Old trees were present, but young and middle-aged trees, shrubs and wildflowers also were a prominent part of the ancient forest. Studies by Bonnicksen and Stone (1982b, 1981) within a 2042-hectare watershed in Kings Canyon National Park showed that aggregations of sapling size trees covered 17 percent of the watershed when it was an ancient forest. Aggregations of pole-size trees covered 15.4 percent of the watershed, and 19 percent was covered by shrubs. Only 17.6 percent was covered by aggregations of large old trees when it was an ancient forest. The remainder of the watershed consisted of meadows, gaps, tree seedlings and rocks. Therefore, the ancient forest was a mosaic of vegetation, not a dense forest of large old trees. Such scientific studies are essential to prevent using myths in the description of reference ecosystems.

Sometimes existing vegetation cannot be used to reconstruct historical conditions. The 39,000 acres of cutover redwood forest added in 1978 to Redwood National Park, California, is a dramatic example. Not only were these lands clear-cut by logging companies, but they were seeded to Douglas-fir and hand planted to redwood before being added to the park. Fortunately, uncut old-growth redwood forests, which have changed little over the past century, surround these cutover lands. Thus relict native ecological communities, such as these uncut redwood forests, are especially valuable as reference ecosystems for restoring severely damaged communities.

Restoration Standards

If restoration goals define what should be done then standards provide a way of determining how well it was done. Standards are equivalent to objectives because they provide measurable targets that are supposed to be achieved in a specific period. They lead toward goals, but they are not the equivalent of goals. Standards are also imperfect representations of the reference ecosystems they document. Everything in an ecosystem cannot be measured nor can the measurements themselves be flawless. Thus standards represent the goal and measure how successfully it has been achieved. In short, standards define what can or will be restored.

Restoration standards can be illustrated with the controlled evolution goal. This goal requires taking repeated measures of both the structural and the functional attributes of an ecological community and comparing them with predetermined quantitative standards. Monitoring pinpoints undesirable changes at an early stage so that manipulations can be used to guide the ecological community back to the desired trajectory.

Structural standards for the controlled evolution goal could include the presence, number, size, vigor, genetic composition, and horizontal and vertical arrangement of species. The pattern characteristics of mosaics of plant aggregations that comprise ecological communities may also be important standards, such as random, uniform, or clumped patterns, and their intensity and grain. Several diversity indices also measure evenness in the distribution among species, including soil biota and plant aggregations. Measures of microbial biomass and the insularity of communities also may be critical to sustainable management. Functional standards for the controlled evolution goal could include fire cycles and burning patterns, microsymbiont effectiveness, biomass productivity, and biogeochemical and soil nutrient cycling indices. The standards used to guide restoration will depend on what is feasible and desirable in particular situations. The problem is finding the mix of standards that come closest to representing the goal.

Restoration Practices

Restoration ecologists recognize that ecological communities are too complex to either completely understand or fully control. Therefore, restoration will always be imperfect. Nevertheless, restoration can help to counteract the continued and widespread degradation of ecosystems. Like a doctor of medicine, a restoration ecologist does not have to fully understand how an organism or an ecosystem works to restore it back to health (Jordan 1983c). Thus restoration ecologists are more like gardeners than engineers because they can only guide ecological communities toward a goal (Bonnicksen 1988a).

The first step toward developing effective restoration practices is to better understand the historical processes that led to, and sustained, the reference ecosystem. Changes in most ecological communities are driven by periodic disturbances. For example, forest aggregations can be traced back to some destructive event, such as fire or wind throw. Others can be traced back to insect outbreaks and the effects of root pathogens. Thus the types of disturbances that affect particular ecological communities must be determined, also their scale, frequency, intensity and impact.

It is important to know the historical scale and frequency of disturbances. The size of the area undergoing restoration, and the period for assessing past conditions, must fit the scale and frequency of disturbances in the reference ecosystem. Some types of destructive events can cover a wide area, such as crown fires, hurricanes and avalanches, producing correspondingly large aggregations. Such large-scale disturbances usually occur infrequently. Small-scale disturbances may involve single tree falls or frequent light surface fires that open gaps in a forest canopy and create small aggregations. Thus the size of the area and period for assessing historical conditions must be larger for communities affected by infrequent large-scale disturbances than for communities affected by frequent small-scale disturbances.

It is also important to know the agent responsible for disturbances in a reference ecosystem. In the northern Rocky Mountains, for example, many open ponderosa pine forests appeared untouched when first seen by European settlers, but they were kept open by an interaction between frequent Indian burning and lightning fires (Barrett and Arno 1982). The elimination of Indians and the suppression of lightning fires resulted in succession toward more shade tolerant tree species, thickening understory vegetation, heavier fuel accumulations, and a concomitant increase in the potential for massive wildfires. Without Indian burning, lightning fires cannot be relied upon to restore these forests because they occur too infrequently to prevent fuels from building up and causing catastrophic fires (Bonnicksen 1990). Since the agents of disturbance are gone the effects of burning must be simulated using either prescribed fire or mechanical methods. As Dr. Leopold said in his 1983 letter to the US Park Service, "A chain-saw would do wonders."

Regulations to control air pollution, and the reluctance of Congress to appropriate funds for prescribed burning, are serious barriers to restoration. As a result, future restoration efforts may require a greater emphasis on mechanical methods. Mechanical methods may also be needed to harvest resources that can be sold to pay for restoration. For example, old growth forests cannot be sustained unless a continuous supply of young trees is produced to replace the old trees that die. In the past, Indian and lightning fires created the openings in the forest needed to regenerate young trees. Today restoration ecologists can mimic the effects of these fires by creating similar openings with carefully managed logging.

The best way to mimic the effects of ancient fires is to cut groups of trees in a way that ensures that all essential ages of trees and associated vegetation exist in the forest mosaic. The sizes of openings, and the optimum mixture of old growth and other stages of tree growth, will vary depending upon local ecological conditions. Restoration cuts could maintain the same proportion of old growth in the future forest that existed in the ancient forest. Thus decadent old growth cut in one part of the mosaic would be replaced with renewed old growth as the trees grow larger in another part. Thus dramatic stands of old growth would float around the future landscape in the same way that they floated around the ancient forest landscape. Using logging as a substitute for Indian and lightning fires would sustain old growth, increase biodiversity, provide a secure economic future for local communities and pay the cost of restoration.

WHO DECIDES?

Since restoration goals are value judgments that describe the preferred condition of an ecological community, goal-setting is a social or political decision, not a technical or professional decision. The courts provide an inappropriate forum for setting restoration goals because they address specific cases that usually involve an alleged violation of law. Similarly, resource managers are no better qualified than the public to choose goals for restoration projects. Scientists possess essential technical knowledge, but they are even less qualified than managers to make value judgments for the public. Therefore, restoration goals are best set through legislation or cooperative decision-making.

Since most legislation is vague, cooperative decision-making should be used whenever possible to formulate restoration goals and establish standards for management. Cooperative decision-making involves managers and the affected public, or stakeholders, working together as partners to formulate and carry out decisions (Bonnicksen 1993). It is based on the idea that it is wiser to include affected groups in making decisions than to try to guess how they may react. It is also wasteful to ignore the knowledge possessed by people who spend their lives dealing with an issue. Cooperative decision-making also discourages conflict and fosters teamwork. Thus it is the best method for setting restoration goals because it provides opportunities for stakeholders to exchange information, weigh arguments and make the tradeoffs that are needed to reach acceptable compromises.

CONCLUSIONS

Ecological restoration requires a new perspective in resource management. It requires thinking about how to put back together the ecological communities that analytical studies have taken apart. It requires working with a variety of disciplines so that the essential parts of a community can be reassembled and sustained. It also requires working with the public to select restoration goals and the standards needed to measure success in achieving those goals. Finally, restoration requires accepting the constructive role of humans in nature and working cooperatively to restore and maintain ecological communities.

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