THE PHILOSOPHY AND THEORY OF ECOLOGICAL RESTORATION

A Thesis Submitted to
the Faculty of Graduate Studies and Research
In Partial Fulfilment of the Requirements
for the Degree of Master of Arts
in Geography
University of Regina

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Regina, Saskatchewan
1998

0-612-30477-9

ABSTRACT

We are in the midst of an unprecedented crisis of declining biodiversity. Due to the extent of ecosystem devastation and degradation, reversing the trend requires the restoration of natural systems. Such "ecological restoration" ranges from reparation of damages to complete re-creation of natural ecosystems.

This study presents the context for the practical application of ecological restoration. In doing so, it aims to increase the recognition and understanding of the philosophical and theoretical issues that are fundamental to restoration. The major points of discussion concerning ecological restoration, in terms of theory and strategy, are explored through literature review and expert interviews.

Typically, modern Western society has viewed itself as separate from nature. Restoration requires that a new relationship, based on belonging, be defined between humans and the rest of the natural world. The ideology of restoration may lead to both the repair of ecosystems and of the relationship of humans with their habitat, the key to true conservation success.

The inclusion of humans in ecosystems is reflected in landscape ecology and ecosystem management. Based on systems theory, both of these approaches are focussed on the interactions within and among natural systems on a variety of scales. They view the world as interconnected and dynamic. Ecological restoration can be soundly based in such perspectives.

Ecosystem integrity is the main goal of ecosystem management and is an appropriate goal of ecological restoration. An ecosystem with integrity is generally one that is diverse in its biota and able to sustain and perpetuate itself. However, defining ecological integrity in a measurable way proves very difficult. Restoration workers must choose integrity indicators that are appropriate to specific sites and projects. Managing for integrity involves problems of bias and uncertainty, problems that are inherent to all management decisions.

A restoration planning model is presented in an attempt to integrate these various and complex concerns. A restoration project should be built upon a project "vision" - the combination of the guiding principles of the workers, the project goals, and the site in question. It should be undertaken with consideration of the wider philosophical and theoretical context.

ACKNOWLEDGMENTS

I would like to thank my thesis supervisor, Dr. David Gauthier, for his support, careful criticism, and insight.

I am grateful for support through Dr. Gauthier's SSHRC grant that enabled my travels to restoration sites in the United States. I would also like to acknowledge the Faculty of Graduate Studies and Research and the Department of Geography for support provided through Teaching and Research Assistantships.

Thanks to Rob Cunningham for his patience, thoughtfulness, and interest.

Finally, I wish to express my appreciation to those who shared their experience and knowledge about restoration with me during interviews. I feel fortunate to have had the opportunity to meet and learn from these individuals.

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1.1. Background

> Over the past 300 years the Earth's biota has undergone massive changes: world vegetation cover has been profoundly altered, the world's wild land and sea animal populations have been sharply reduced in number and range, and even the physical composition of the oceans and the atmosphere may have experienced subtle changes. At the same time [human] control over the natural environment has risen to the point that the natural order is virtually an anthropogenic or [human]-determined system (Richards 1986: 68).

Human exploitation of landscapes and waters for the purposes of settlement, industry, agriculture, and resource acquisition continues as our population grows exponentially. More rapid and thorough environmental destruction is stimulated by the global economy and enabled by technology. While over-exploitation of renewable resources and environmental deterioration have occurred locally throughout the history of humanity (Ehrlich and Ehrlich 1990), Wilson (1989: 5) suggests that the scale of the current loss of biological diversity "...seems destined to approach that of the great natural catastrophes at the end of the Paleozoic and Mesozoic eras - in other words, the most extreme for 65 million years." One major difference between the earlier catastrophes and the present crisis is that plants escaped relatively unscathed in the former upheavals. The current biodiversity crisis thus goes beyond the earlier ones in that plant diversity is being severely reduced (Wilson 1989).

The spread of human rural settlement and the expansion of arable land since 1700 have played large roles in the changing environment. The most significant changes have occurred since 1860, with the rapidly increasing conversion of land for agricultural purposes (Richards 1986). Richards (1986) estimates that in 1860, the area of arable land in the world was 600 $x10^6$ hectares, while the expansion in arable land between 1860 and 1979 alone amounted to about 852 $x10^6$ hectares. "We may presume, therefore, that unprecedentedly severe and all-encompassing environmental changes in world habitat have occurred since the nineteenth century" (Richards 1986: 56).

Biological diversity is essential to "...the normal functioning of ecosystems and the biosphere as a whole" (WCED 1987: 13). Humans, like all other life forms on earth, are utterly dependent upon the continued existence of "...the external biophysical environment for air, water, food, and material resources, and to serve as a sink for their wastes" (Robinson et al. 1990: 38). Yet entire watersheds, ecosystems, and landscapes are being degraded, and clean air, water, and soil are becoming luxuries.

For example, before Europeans first set foot in North America, the diverse North American prairie biome stretched from what is now southern Canada to Texas in an intricate web of climate, topography, plants, animals, and humans. Although humans had modified the prairie vegetation for thousands of years, and in fact may have caused significant extinctions of large mammals (Diamond 1992), a healthy and well-functioning ecological system was maintained (Rowe and Coupland 1984). The changes brought about since Europeans settled the Great Plains have been substantial. The alterations include the transformation of the societies and economies of the indigenous peoples, the extirpation of the bison, and the conversion of prairie to European style agriculture (Finnamore 1992). The major perturbations upon which the grasslands were dependent, fire and buffalo grazing, were removed while major tracts of grasslands were destroyed. Natural cycles and processes that functioned for millennia have been significantly impacted. The impacts on the land and the biotic communities have destroyed many species of plants and animals, while placing many more in peril.

By 1920, in the 50 years after the Hudson Bay Company had transferred its land to the Dominion of Canada, the prairies had become "...the most altered ecosystem in Canada" (Finnamore 1992: 17). Exotic plants and animals were introduced, both purposefully and accidentally, and ecosystems became fragmented, with significant repercussions. The effects of the drought of the 1920s and 1930s were devastating. Drought is a regular occurrence in the semi-arid prairies and the grassland ecosystem had adapted to it with plant root systems that reduced wind erosion of topsoil and allowed for a quick recovery of vegetation. The agricultural system that replaced much of the native grassland did not replicate the natural system. "Instead, 60 years after the event, the area affected in the dust-bowl has still not recovered. A soil environment 10,000 years in development was lost in a few dry years" (Finnamore 1992: 18).

The Prairie Conservation Action Plan (WWF n.d.) outlines the state of the Canadian prairies by the late 1980s, estimating that over 80 percent of the native landscape of the Canadian prairies has been destroyed or altered by agriculture, urbanization, and industrialization. The remaining areas are generally the least fertile, considered marginal for agricultural use. These remnants are threatened, not only by development but by exotic "weed" species, over-grazing, pollutants carried in air and water, and by their limited size (WWF n.d.). They are severely fragmented, and thus populations are divided and often barred from successful dispersion. The effects of these restrictions on the normal gene flow within a species are unknown (Finnamore 1992). The prairies are presently described as "...one of the most endangered natural regions in Canada" (WWF n.d.: 3).

It is out of such conditions that ecological restoration has become of interest:

> ...the trend is toward the loss of ecological complexity and loss of resiliency. This can only be reversed by an active effort to maintain what remains of native ecosystems and to restore at least part of what has been lost (WWF n.d.: 5).

Ecological restoration ranges from the repair to the complete re-creation of natural systems. Because so little remains, the simple preservation of natural ecosystems has a very limited ability to aid dwindling populations of animals and plants. Instead, it becomes necessary to attempt to recreate ecological communities in order to repair some of the damage that has been done:

> ...we must mobilize the broadest possible societal coalition to stop further harm to our

> life-support systems. The damage is occurring so fast - scarcely an instant on a geological time scale - that we cannot act too quickly to stop it. Yet stopping it will not be enough: we must also repair the wounds made, both to prevent further deterioration and to recreate the living natural heritage that connects us biologically and historically to the past (Berger 1990: xvi).

Largely, the interest in restoration is directed toward the technical and scientific problems that restoration poses, while restoration policy and planning are seen as separate and less important issues. Therefore, experiments to determine what seed mixtures to use, when to burn, where specific species should be planted, and how to ensure good germination are enthusiastically undertaken and there is much literature on these technical issues. However, the question "why restore?" is seldom broached, and when it is, it is often discussed as a separate subject in the environmental philosophy journals, rather than integrated into the scientific discussion (Light and Higgs 1996).

Rather than being considered esoteric musings, the values and goals that justify restoration should direct the planning process. For example, if a restoration is meant to produce a historical prairie landscape similar to the pre-European settlement landscape, the question of when to burn will be answered based on historical records. If a restoration is meant to re-create a healthy and functioning grassland ecosystem, the burn schedule may be judged according to its impact on ecosystem integrity. Furthermore, if humans are seen as destructive forces in natural areas, the restoration design may discourage visitors and the ultimate goal of the restoration may be a system that sustains itself without human presence. If, on the other hand, great value is given to reconnecting humans with their natural habitat, the restoration plan may involve volunteer labour and accommodation for low-impact trails and education centres.

It is apparent that values influence goals, and that these in turn influence objectives and methods. Not discussing restoration values and goals throughout the restoration process will significantly hinder the success of the project.

1.2. Purpose, goals, and objectives

A restoration project should begin with explicit acknowledgment of the beliefs of those involved and clarification of the purpose(s) of the project. This should include careful consideration of the potential benefits of restoration as well as analysis of its limitations. This process provides a sound foundation for the subsequent design, implementation, and management of a restoration project.

This thesis has been undertaken for the overall purpose of delimiting the philosophical and theoretical issues that are fundamental to ecological restoration. To accomplish this, two major goals are set forth. The first is to provide a comprehensive discussion of the main issues relevant to developing a strategy for restoring ecosystems. The second is to provide a conceptual model of the steps involved in developing such a strategy, to act as a guide to restoration workers and planners. The first goal sets the theoretical context for the second. Diverse perspectives are integrated as a foundation upon which to build restoration work.

Both the discussion and the model depart from the majority of the restoration literature by considering societal conceptions of nature and of the relationship between humans and nature. Those conceptions are treated as integral to the restoration planning process and to management decisions, rather than as separate, philosophical issues. The importance of human values in conservation and management agendas is also emphasized. Values do and should inform management decisions, and as such the implications of values must be clearly and fully considered throughout the management process.

The first objective required to meet the goals of the thesis is to identify the most important issues surrounding ecological restoration, from the perspective of restoration policy and strategy (rather than techniques of implementation). The second objective is to present and discuss different restoration rationales, approaches, goals, management practices, and evaluation techniques.

1.3. Methods

The two methodological approaches to the study are literature review and expert interviews. The results of the literature review and interviews are interspersed throughout the thesis. As ecological restoration is applicable to all ecological systems, from desertified landscapes to riparian areas, it is necessary to limit the scope of the review. The North American prairie is used to set the practical context for the issues discussed. Interviews and literature review are focussed around this ecological region.

The prairie is chosen for several reasons. The prairie is considered "one of the most endangered natural regions in Canada" (WWF n.d.: 3) and is therefore of high conservation priority. Also, the earliest attempts at ecological restoration occurred on a grassland ecosystem, giving prairie restoration a 60 year history in North America. It should be noted that although parts of the discussion will refer to the prairie region, much of it is relevant to the restoration of all natural ecosystems.

The literature review consists of intensive research into several areas: human / nature dualism; conservation ideologies and approaches; theoretical approaches to ecosystem- and landscape-scale management (focussing mainly on systems theory, landscape ecology, and the concepts of biodiversity and ecological integrity); and restoration design, implementation, and management.

Those interviewed are involved in restoration or fire management in some capacity, from a native plant nursery owner to professors of biology to employees of government departments of natural resources (Appendix 1 lists the interviewees). They were selected based on a survey of the literature and in some cases on verbal referrals from their colleagues.

The interviewees all work in the United States, and mainly in Wisconsin and Illinois. The rationale for this is based on the very active and well-developed restoration "culture" in these states. For example: a) Wisconsin and Illinois are home to the oldest prairie restoration projects; b) the founders of restoration ecology (John Curtis, Henry Greene, Ray Schulenberg, Robert Betz, William Jordan) hail from these states; c) Madison, Wisconsin is home to the Society for Ecological Restoration; d) the universities conduct significant research in restoration ecology, and; e) they support many native plant nurseries. As the interviews were limited in number, it was most practical to focus on what is arguably the geographical "heart" of ecological restoration, relative to the prairies.

The interview process was given ethical clearance by the University of Regina's Research Ethics Review Committee (Appendix 2). Interviewees were contacted by telephone or written communication in order to arrange a personal meeting time. A consent form was signed to agree to the participation in the interview process (Appendix 3). Each interview was guided by a list of questions (Appendix 4) roughly corresponding to three categories: restoration rationale, goals, and planning and management issues. The list of questions was extensive, and in most cases, not all questions were posed. In others, additional questions arose out of the discussion itself. The interviewees were allowed to guide the discussion somewhat, and therefore not all of the questions are addressed in the thesis. Each interview was taped and transcribed. A transcription was mailed to each respective interviewee, inviting any required amendments. If no changes were sent, it was understood that excerpts from the transcript could be used and referenced in this thesis.

The interviews are not intended to be a representative sample from which to draw generalizations or statistically valid conclusions. Rather, they reflect meetings with people who have expertise in certain areas of the restoration spectrum, meant to complement the literature review. The interviews fit into the category of "non-schedule standardized" interviews (Monette et al. 1986; Denzin 1970). Non-schedule standardized interviews are described as those which seek "...certain types of information...from all respondents but the particular phrasing of questions and their order is redefined to fit the characteristics of each respondent"

(Denzin 1970: 125). The interview is conversational in nature, allowing the interviewer to probe and allowing the respondent to express ideas more fully (Monette et al. 1986). The interviewees will often raise important points that are not contained in the list of questions (Denzin 1970). The interviews employ open-ended questions, that is, questions which do not ask for a response from a predetermined set of choices. This type of questioning "...allows unexpected, but important, responses" (Mitchell and Jolley 1988).

Concerns around the use of less structured interview and questioning formats generally have to do with the larger influence of interviewer bias and the lowered comparability between interviewee responses (Mitchell and Jolley 1988). Where rigorous hypothesis testing is to occur, a highly structured, standardized interview may be more appropriate (Monette et al. 1986). In this case, however, the flexibility of open-ended questions combined with flexibility in the questioning process allowed the exploration of different areas of expertise with the different interviewees. As well, the experts were able to lead the interview into areas of discussion that often proved enlightening.

The interview results made a considerable contribution to the thesis by providing insight into the practice of restoration. This aided to direct the literature review toward areas of significance. Much of the information incorporated into the final text originates from the literature, however. Once gathered, the information was synthesized and organized in order to present a logical summation of current restoration literature and thinking. A conceptual model was developed through a critical review of this information.

1.4. Thesis outline

Chapter 2 introduces the philosophical underpinnings of restoration, with special emphasis on conceptualization of the human / nature relationship. These considerations are revisited throughout the thesis, in discussions of science and goal-setting. Chapter 3 summarizes the scientific theories that inform the study and understanding of ecosystems.

Initially, the fundamentals of systems theory are presented. Systems theory itself is not often referred to in land management papers, but it forms the basis of more commonly discussed large-scale land management and research approaches such as landscape ecology and ecosystem management. Landscape ecology and ecosystem management are then outlined in terms of the context they provide for land management.

Chapter 4 examines some key concepts relevant to restoration goal-setting, namely biodiversity and ecological integrity. The complexity of these concepts is tackled in discussions about spatial and temporal scale as well as the difficulty in measuring system integrity with any degree of confidence. Chapter 5 integrates the concepts introduced in the earlier chapters into a restoration planning model. Each chapter concludes with a brief summary. The thesis concludes with an overall summary of the major issues raised and general remarks about the place of ecological restoration in our society.

2. ISSUES OF VALUES AND BELIEFS

Values and beliefs underlie all decisions that have been and continue to be made in reference to the landscape. Identifying and analysing the sources and impacts of human beliefs about the human/nature relationship is necessary in the development of successful conservation strategies. It is also an important first step in the conservation planning process.

2.1. The separation of humans from nature

The fundamental attitudes about nature in modern Western society are expressed in three statements: (1) "Nature is *there*, rather than *here*..."; (2) nature existed before humans; and (3) nature, on its own, is balanced, eternal, and unchanging (Turner 1985: 46). The first statement, that nature is "there," points to the opposition created between humans and nature wherein nature is defined as the absence of humans or as that which is not human. "The prevailing view in our society is that nature exists only where human activity is not in evidence" (Aber and Jordan 1985: 399). In this way, it is understood that humans (or at least technologically and economically advanced humans) are fundamentally separated from nature; nature and culture are perceived to be in utter opposition:

> If nature, in our myth, is eternal, unchanging, pure, gentle, wise, innocent, balanced, harmonious, and good, then culture (*qua* technology) is temporary, progressive, polluting, violent, blind, sophisticated, distorted, destructive, and evil (Turner 1985: 48).

Evidence of this perception abounds, as in Brown's (1994: 370) definition of a natural system: "A system may be natural in terms of its species composition or it may be natural because ecosystem functions and population interactions occur in the absence of humans."

This dualism is also apparent when attempts are made to define wilderness. Block (1984: 76) defines wilderness as "...relatively independent of human influences, generally uncultivated and uninhabited, and shaped only by the interactions of air on water, water on soil, soil on plant and animal." The dualism is entrenched in policy, as aptly demonstrated in the much-quoted United States Wilderness Act of 1964 which states:

> A wilderness, in contrast with those areas where man and his works dominate the landscape, is hereby recognized as an area where the earth and its community of life are ***untrammeled by man***, where man himself is ***a visitor who does not remain***" (cited in Grumbine 1994b: 229, emphasis added).

This definition separates society from its habitat. Humans are seen only as destructive elements, out of place in a wild area. The "traditional conservationist," then, maintains that wilderness is "...enhanced and maintained in the absence of people" (Gomez-Pompa and Kaus 1992: 271). Grumbine (1994b) maintains that this conception of wilderness and nature is based on "pre-Darwinian" understanding.

The second nature myth as outlined by Turner (1985) is that nature existed before humans. This is echoed in Meier's (1984: 152) definition of wilderness: "Wilderness is nature in her original condition, undisturbed and unadulterated by human beings." This, too, emphasizes that humans are aliens in the world, capable only of impacting negatively upon their landscapes.

Thirdly, Turner (1985) observes that nature is seen as balanced, eternal, and unchanging. Daniel Botkin (in Pollan 1990: 27) discusses the metaphor of nature as machine which came into popularity in the nineteenth century, coalescing with the ideal of nature as perfect, divinely ordered: "This union of ideas yielded the false view of nature as a single pristine state - undisturbed and without man." This attitude is made explicit in Meier's (1984: 156) description of wilderness:

> ...wilderness is by no means chaos: it is most admirably ordered and organised, quietly obeying the laws of nature. As long as it is not interfered with too badly, it functions beautifully.

The assumption is that human involvement is "interference."

Nature has not always been seen as perfect and divine, however. In fact, nature was often demonized. Foreman (in Pollan 1990: 28) maintains that the exploitation of North

America and the approach to wild nature goes back to the Puritans who colonized this continent:

> The Puritans brought with them a theology that saw the wilderness of North America as a haunt of Satan, with savages as his disciples and wild animals as his demons - all of which had to be cleared, defeated, tamed, or killed. Opening up the dark forests became a spiritual mission....

These attitudes toward nature and wilderness have many implications. For example, the manicured and weedless lawns, flowerbeds, and shrubbery that dominate the urban landscape illustrate a relationship with other living things which is based on domination and control. The people who "own" that land "control" natural processes of change and succession, e.g., no new trees are allowed to sprout, no flowers are left to ramble at will, no plants but the exotic turf grass may exist in the lawn. The evidence of these attitudes about nature is demonstrated in areas other than urban landscapes. Artifacts of exploitation such as abandoned strip mines, clearcut hillsides now barren of soil, and zoos holding the last remaining survivors of a species are commonly linked to human attitudes about earth. The traditional view of wilderness, however, is of a place where humans do not have control and believe they do not belong.

Nature preserves also reflect the dualistic ideology of modern Western culture:

> ...[The] ideological opposition of culture and nature - with no mediating term - has had real consequences. More often than need be, Americans confronted with a natural landscape have either exploited it or designated it a Wilderness Area. The polluter and the ecology freak are two faces of the same coin; they both perpetuate a theory about nature that allows no alternative to raping it or tying it up in a plastic bag to protect it from contamination (Turner 1985: 48-49).

Grumbine (1994b: 228) agrees that human/nature dualism has informed both the resource conservationist:

> ...whose adherents believe that natural resources exist to be utilized for human benefit... [and the wilderness preservationists] ...whose followers argue that a significant portion of landscapes should be protected in an undeveloped condition.... *[B]oth* resource conservationists and wilderness preservationists, as long as they view nature as a collection of resources for humans, inhabit a world that categorically denies

> the full range of symbiotic relationships that may exist between people and wilderness.... [B]y focusing on nature as a fountain of inspiration or source of products, modern people have neglected the ecological theater and evolutionary play that drives the dynamic, ever-changing patterns and processes of Earth.

Traditional conservationists tend to be blind to the involvement of humans in the landscape, or at least they tend not to see value in the human role (Gomez-Pompa and Kaus 1992), a view that has led to the park mentality, whereby nature is preserved by closing it off to traditional and modern human uses. Yaro (in Pollan 1990) claims that the "wilderness ethic" that draws boundaries between nature and humans is *the* fundamental environmental problem. He comments that on one side of the boundary the motto is, "Keep your hands off," while on the other the basic attitude is, "Take the money and run" (in Pollan 1990: 28). Western (1989: 158) argues that this approach to conservation can not possibly be successful when "[t]he human realm occupies 95% of the earth's surface...."

Gomez-Pompa and Kaus (1992) assert that two assumptions, that of powerful scientific knowledge that allows the manipulation of nature and that of the "...perceived pristine state of uninhabited areas" (272), "...have led to unrealistic and contradictory tenets in our natural-resource management policies" (272-3). On the one hand, there is a belief that mitigation of environmental damage is possible, while on the other, it is assumed that cordoning off "pristine" areas will preserve their ecological integrity.

Brinck et al. (1988) contend that ironically, the results of the dualism seem to reinforce the human/nature dichotomy somewhat. As areas become degraded to a hazardous state, humans become alienated from their surroundings. Consider that the sun itself is becoming a health threat, that water in streams, lakes, oceans, and underground is polluted, that soils and air contain toxic contaminants. Lodwick (1994), however, sees the situation in quite the opposite way. She proposes that the damage that humans have inflicted upon the earth returns to haunt them. She proposes that humans now feel closer to nature in that they almost feel *trapped* within nature.

Many would argue that separating humans from nature not only has negative impacts on the functioning of the earth, but has no logical basis. Turner (1985) asserts that defining nature as that which is not human is essentially a creationist argument, for evolution precludes human exclusion from nature. Some, like Elliot (1994) and Katz (1993), maintain that culture is what sets humans apart from the rest of nature. However, Turner (1985) suggests that culture itself is natural, that the bodies and the brains of humans, as well as the human tendency to be social, have been naturally selected.

Nor is the belief in a "wilderness" that is "...an area without people" (Gomez-Pompa and Kaus 1992: 272) tenable. For example, what was once considered the vast wilderness of North America was actually a landscape that was altered and managed by aboriginal people for thousands of years (Looman 1977; Rowe and Coupland 1984).

Furthermore, "nature" is by no means perfect, balanced, and unchanging. As Botkin (in Pollan 1990: 27) states, "There is no such nature. Ecological systems have values other than 'peak performance.'" Nature may also be characterized as "...violent, unbalanced, improvisary, dynamic" (Turner 1985: 47).

Western (1989) points out that the concept of nature is a subjective one. While most Western cultures exclude humans from its definition, "Many Asian and African cultures do not distinguish between the human and the natural realm, with good reason; there is no clear-cut separation....Wilderness...is meaningless to many societies living side by side with nature" (Western 1989: 158). But what exactly is "living side by side with nature"? What does the statement, "Humans are part of nature" really mean?

Jordan (1994a: 30) suggests that there is a common notion within environmentalism that "...indigenous cultures are 'natural' people who live more or less unself-consciously in harmony with nature" and this notion "...serves as a kind of ideal and as the foundation for much thinking about the proper relationship between humans and the rest of nature." However, most anthropologists "...see in all cultures evidence of a tension between nature and culture, which is then mediated or dealt with in various ways that to a considerable extent define the culture and lend it its distinctive characteristics" (Jordan 1994a: 30). This tension is a result of the human capacity of self-awareness, and cannot be avoided by living "closer to nature." Rather, "it is part and parcel of being human; it comes with our genes" (Jordan (1994a: 30). Grumbine (1994b: 236) comments:

> ...harmony between people and nature is not so much a balanced state of grace as it is a dynamic complementarity that must be continuously renegotiated as individuals, cultures, and ecosystems evolve.[1]

Recognizing complementarity does not entail erasing the differences between self and other,

> ...but rather...recognizing the organic connections. The resolution of the paradox is found not in denying the distinctions between humans and other species, wolves and invertebrates, or any members of Earth's community of life, but in what we decide to make of the differences (Grumbine 1994b: 233).

This stands in stark contrast to the common perception of the relationship between self and "other" which Birch (1990: 7) describes as "adversarial":

> [Western culture]...presupposes that opposition is fundamentally conflictive, rather than complementary...or ecosystemic.... The central presupposition is...that we exist fundamentally in a state of war with any and all others.... Thus, in practice, others are to be suppressed or, when need be, eradicated.

Western societies have developed a relationship with nature, the "other," that is based on either "...gaining power by dominating the world through objectifying the diversity of life and reducing it to resources for human consumption..." or "...simply obliterating nature on a large scale and replacing it with developments...of various kinds" (Grumbine 1994b: 233).

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[1] Grumbine's (1994b) use of the concept of "negotiating" between humans and nature is not entirely appropriate, as nature is not actually involved in any negotiations. The idea, however, seems to be that humans must re-orient themselves in relation to their surroundings as conditions change.

This way of understanding differences comes out of a long tradition of dualistic ideology in Western thought. This dualism suggests that polar opposites do not exist at either end of a continuum, but are in fact separated from each other, such that one can exist without the other. Western dualism is not restricted to the human/nature relationship. Mind and body, black and white, man and woman, all self/other relationships have been painted as conflictive. As Colwell (1987: 112) states, "Dualism...is a fundamental expression of the entire sweep of modern culture."

Capra (1982: 35) compares this ideology with that of the Chinese philosophers who,

> ...saw reality, whose ultimate essence they called Tao, as a process of continual flow and change. ... In the Chinese view, all manifestations of the Tao are generated by the dynamic interplay of...two archetypal poles [yin and yang], which are associated with many images of opposites taken from nature and from social life. It is important, and very difficult for us Westerners, to understand that these opposites do not belong to different categories but are extreme poles of a single whole. Nothing is only yin or only yang. All natural phenomena are manifestations of a continuous oscillation between the two poles, all transitions taking place gradually and in unbroken progression.

Dualism also stands in contrast to the worldview of indigenous North American peoples, a worldview characterized by interrelationship: "Everything, animate and inanimate, is interconnected. One cannot separate out one element and act upon it without affecting everything else in the system" (Jostad et al. 1996: 571).

Grumbine (1994b: 234) suggests that even if human concepts of "...wilderness, wildness, and self/other..." are evolving, even if humans have begun to "...feel [their] way from conflict to complementarity," old concepts and especially old behaviours do not disappear quickly. Environmental philosophers still fall short of truly integrating this idea into their discourse: "...[T]he idea that humanity is part of nature...is usually acknowledged to be true; yet very little of significance follows from it" (Colwell 1987: 101-102).

World view is fundamental to human relationships with the earth:

> Human culture and ideology form the basis of the interaction of humans with ecosystems. The nature of this interaction is defined by our ability to manipulate the

> environment, mediated by culture and modified by the environmental response (Finnamore 1992: 15).

The above quotation refers to all humans, from indigenous societies to post-industrial urban dwellers. Modern societies now have the ability to impact the earth to the point that most existing life forms would be extinguished. The ability to have such an impact is relatively recent. Throughout history, people have been able to create local devastation and local extinctions, but the global scale of modern human impacts is unprecedented. How this ability impacts upon the environment is largely a result of how culture mediates behaviour.

Dasmann (1976) draws a distinction between people who limit their actions so as to maintain healthy ecosystems and those who have a frontier approach to the environment, that is, those who exhaust the resources of one area with the assumption that they can always find a new, bountiful landscape. He refers to those who engage in global trade and therefore use the resources of ecosystems worldwide as "biosphere people." If an area is devastated, they can relocate. "Ecosystem people," on the other hand, "...depend almost entirely upon a local ecosystem, or a few closely related ecosystems" (Dasmann 1976: 283). They cannot afford to degrade the system and so act within the constraints the local system imposes.

McNeely (1989) uses Dasmann's distinction between biosphere and ecosystem people to illustrate how each type of society mediates their behaviour so as to conserve their resources to some degree. Ecosystem people assure a balance with their habitat through "...religious belief and social custom..." (Dasmann 1976: 283). For example, ecosystem people generally believe that there are spirits in all living things:

> The belief in nature spirits in many cultures has provided a brake on overexploitation of natural resources. When complex rituals are required for chopping down a tree, for example, then trees are only taken when really necessary (McNeely 1989: 152).

This belief, along with limited technology and strong peer pressure, "...effectively kept human greed under some sort of control" (McNeely 1989: 152).

Biosphere people, on the other hand, were equipped with more powerful technology and the tempting possibility of increased consumption was difficult to resist, so they invented national parks, within which no exploitation was allowed, in order to conserve some of the natural resource. McNeely (1989: 150) suggests that "National parks...might be seen as part of the adaptation of *Homo sapiens* to an ecological niche which covers the globe." He also points out that the need for national parks is simply an indication of our "exploitative relationship with nature" (McNeely 1989: 150). It is only since the industrial age, when humans began to exploit the environment out of greed rather than need and when ecosystems began to be exploited on a global, rather than a local scale, that a need for parks developed (McNeely 1989) (see Figure 1).

McNeely (1989) does not feel that parks are an adequate mediation, however, and suggests that those cultures which successfully maintained a mutually beneficial relationship with their surroundings should serve as models. McNeely (1989) proposes several amendments to the current conservation strategy, both to ensure the health of parks and to supplement their conservation role. In general, the behaviour of ecosystem people must serve as a guide, embodied in four principles of change:

(1) Shifting Control over Resources:

It is vital that a diversity of resource exploitation be employed, and that the approaches be specific to the local environment and the local people. Conservation strategies should follow traditional approaches. Because of this, McNeely (1989: 156) recommends that local peoples should "...reassume the custodianship that was traditionally theirs."

(2) Expanding the Concept of Protected Areas:

Protected areas alone "...will never be able to conserve all, or even most, of the species, genetic resources, and ecological processes they were established to protect" (McNeely 1989: 157). Therefore, the concept of protected areas will have to broaden so that they are no longer

BIOSPHERE PEOPLE 	ECOSYSTEM PEOPLE 
•USE RESOURCES ON A WORLDWIDE SCALE	•USE RESOURCES ON A LOCAL SCALE
•HAVE POWERFUL TECHNOLOGY THAT ENABLES INCREASED CONSUMPTION AND DEVASTATION OF LARGE AREAS	•HAVE SIMPLE TECHNOLOGY THAT LIMITS THEIR ABILITY TO MANIPULATE THE LANDSCAPE AND TO COOPT RESOURCES
•MOVE ON IF THEY DEVASTATE AN AREA	•ACT WITHIN CONSTRAINTS OF LOCAL ECOSYSTEMS
•ATTEMPT TO *COMPENSATE* FOR THEIR RESOURCE EXPLOITATION WITH THE ESTABLISHMENT OF PARKS	•*MEDIATE* THEIR RESOURCE EXPLOITATION WITH SOCIAL CUSTOMS AND RELIGIOUS BELIEFS
INADEQUATE MEDIATION OF BEHAVIOUR RESULTS IN LARGE-SCALE DEGRADATION OF ECOSYSTEMS	*ADEQUATE MEDIATION OF BEHAVIOUR RESULTS IN THE MAINTENANCE OF HEALTHY ECOSYSTEMS*

Figure 1. A summary of Dasmann's (1976) and McNeely's (1989) distinctions between biosphere and ecosystem peoples.

simply "...islands of anti-development, but rather...critical elements of regionally envisioned harmonious landscapes" (McNeely 1989: 157). In other words, protected areas must be integrated with social and economic development or sustenance.

(3) Seeing Conservation as Primarily a Human Problem:

McNeely (1989: 157) emphasizes that "...conservation is far more a *social* problem than a *biological* one." Social scientists, theologians, and politicians must be involved in developing conservation strategies.

(4) Conserving Both Cultural Diversity and Biological Diversity:

Just as ecosystem people have integrated conservation behaviours and beliefs into their "cultural fabric," biosphere people must make conservation "...part of the new national culture, rather than just a discrete responsibility of a wildlife or national parks department" (McNeely 1989: 157).

Grumbine (1994b: 244) agrees that it is helpful to turn to ecosystem cultures in order to learn "...what values, if any, limit people's use of wild nature...." He proposes that the concept of sacredness played a large role in limiting behaviour. Whereas it may be believed that indigenous peoples had no need to set limits, in fact they "...have often developed relations with wild places where only a limited human presence is allowed under certain circumstances" (Grumbine 1994b: 244). Grumbine (1994b: 248) suggests that the modern conservation movement must emphasize the spiritual dimension of the human relationship with the earth:

> ...in terms of the biodiversity crisis, legal reform..., economic changes..., scientific shifts..., as well as the cultural revision of the Western idea of wilderness will probably not be sufficient to carry us very far beyond the threshold of sustainability. For the long term, what we need are cultural practices that resacralize the world.

Indeed, one of the main components of the belief systems of indigenous North American peoples is that "all is sacred," and that "...to separate or ignore the spiritual aspects of creation is to violate the basic principles of the system itself and results in abuse" (Jostad et al. 1996: 570-571).

It is important to realize that just as ecosystems are dynamic and changing, so is the human relationship with their habitat:

> Humans of the past were not exempt from the self/other paradox and it appears that *Homo sapiens* requires a period of adjustment as it settles in to new habitat before any possibility of sustainable ecosystem behaviour may be achieved (Grumbine 1994b: 245).[2]

Jostad et al. (1996: 578) suggest that the first peoples of North America can "...offer an identifiable ethical system of beliefs and subjective values that can be used to guide and direct objective management policies." They continue:

> Expanding a Euro-American land ethic to include Native American land ethic beliefs can result in a truly American land ethic, a synthesis of old and new, subjective and objective, spiritual and secular - a balanced and self-sustaining land ethic that works because it reflects the natural system (Jostad et al. 1996: 578).

2.2. The ideology of conservation

Parks and reserves have been the central focus of landscape conservation in North America. More recently, though, ecological restoration of degraded or destroyed natural areas has been considered or undertaken. The dominant Western ideology of human/nature dualism, however, has led to some strong opposition to restoration, or at least to a questioning of the human right to "interfere" in nature's processes. Essentially, the debate is between a hands-off approach (preservation) and a management approach (restoration) to conservation.

Many express concern over a conservation strategy that focuses on preserving natural areas. A system of protected areas within which behaviour is more or less controlled but outside of which human developments and environmental degradation continue unabated simply is inadequate for the conservation of ecosystems and species. Therefore, some authors

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[2] Here Grumbine (1994b) cites Burch (1971: 49-50) and Soule (1991: 746).

question the wisdom of the ideology that led to the establishment of national parks for two main reasons: the concept of preservation conflicts with the understanding of ecosystems as ever-changing, and there is very little "pristine nature" left to preserve (Baldwin et al. 1994b).

Jordan (1994a: 19) notes that preservation "...in the strictest sense is impossible....It is impossible either to stop a living ecosystem from changing or to prevent its change from reflecting our influence." Jordan (1994b: 246) suggests that the preservation of nature in an idealized form will ultimately be "..at the expense of actual species and ecosystems," because mild disturbance will likely lead to the extirpation and extinction of species while the changes go unacknowledged. Restoration, on the other hand, "...holds out at least the possibility of conserving the system, not by stopping change, but by directing it, and not by ignoring human influences, but by acknowledging and seeking to compensate for them" (Jordan 1994a: 19). Pletsch (1994) agrees, arguing that like it or not, humans must accept responsibility for their disproportionate impacts on the functioning of the earth systems. Nature has always seemed independent, not in the sense that humans did not have an impact, but rather in that nature, as a whole, was not threatened by human culture. Presently, though, there is a perception of an emergency state, that humans are, in fact, posing a very real threat to nature. Pletsch (1994: 88) observes:

> Having already altered nature immeasurably, having brought about countless extinctions and permanently altered significant portions of the earthly biosphere, humankind has obviously been exercising an anarchic, selfish, and destructive sovereignty over nature for a long time.... Even in order to guarantee life to future generations of the human species, people must learn to assert some form of hopeful, reasonable, and collective sovereignty over nature.

The second major problem with a preservation strategy is that so much of the land base has already been degraded. In the end, nature is ultimately "given" small areas of most often "inferior" land (Western 1989). At the same time, the area outside the park has been virtually ignored: "Wildlife beyond parks has been left to hunters and ignored by conservationists as too unnatural to merit serious attention" (Western 1989: 158). Many species cannot possibly be protected in the land in reserve alone.

Some, like Loucks (1994), believe that restoration is not necessary, except out of concern for resource availability. He uses the example of the recovery of forests after glaciation to demonstrate that "...human guidance is not necessary - only respect and modest protection are" (Loucks 1994: 135). But Jordan (1988b) proposes that several facts are forcing humans to realize that restoration is a necessary conservation technique in North America:

- extensive areas of both land and water have been highly degraded or altered;
- humans will continue indefinitely to alter natural areas;
- climate change, and other changes beyond human control, will impact upon even the most remote preserves;
- seldom are existing wilderness areas extensive enough or "shaped" in such a way as to ensure long-term sustenance of many species;
- many rare, threatened, and endangered species have very little, if any, suitable habitat remaining, and creation of suitable habitat is the only hope for their survival; and
- conservation of species outside of their native habitat is pointless in the long term without also considering the provision of habitat.

Jordan (1988b: 312) asserts that these factors force humans to recognize that restoration must accompany preservation initiatives:

> All these considerations push us, unwillingly it seems at times, beyond a preoccupation with preservation, either *in situ* or *ex situ*, as the single strategy for the long-term conservation of diversity and toward a recognition of the importance of an active role for our species in reversing change or repairing damage.

The message is that preservation alone is inadequate: "...the quality of the environment is ultimately going to depend...upon the *equilibrium* we are able to maintain between the forces of destruction - or change - on the one hand and the forces of recovery on the other" (Jordan

1988b: 315). Restoration is a necessary tool in the positioning of this equilibrium (Jordan 1988b).

Restoration is an important means to conserve indigenous plant and animal species. Relative to the North American plains, Wilhelm (pers. comm.) notes that the prairie restoration at the Morton Arboretum near Chicago was born out of:

> ...the disgust that the person who built it [Ray Schulenberg] had with the landscape...dominated by about a hundred weeds. He [Schulenberg] knew that we had a much more biodiverse flora here that was all but obliterated and wanted to find a home for it....[It amounted to a rather] desperate, inchoate attempt to have something alive besides ourselves in the world where we live.

Both Betz (pers. comm.) and Powers (pers. comm.) talk about restoration as a way in which to save some pieces of native ecosystem puzzles, in hopes that one day humans will live in such a way as to nurture indigenous species and systems at a large scale. As Betz (pers. comm.) states "We're building Noah's second ark.... You carry these animal and plant species through the deluge of humanity that's going to destroy everything, and you try to keep this boat afloat as best you can." Powers (pers. comm.) echoes this: "I decided that just in case we didn't destroy everything in a nuclear holocaust, the next most important thing was to keep as many species as we can with us on the planet...until somebody wakes up and then at least we'll have the species, we'll have the building blocks."

Beyond the restoration of species, there is the restoration of ecosystem health and integrity. Kline (pers. comm.) talks about "...putting things back in some semblance of natural order," and the resulting improvements in soil and air quality when large areas are turned back to diverse native prairie systems. Wilhelm (pers. comm.) points out that:

> ...Eurasian agriculture weeds..are adapted to highly disturbed, traumatized landscapes....It's just that the whole world now is so traumatized that it's dominated either by pavement or weeds or agriculture. Land inhabited by such things does not know how to make itself new again. It can't live. It doesn't have the genetic memory to carry on life, the biodiversity to coalesce itself into a self-replicating, self-sustaining, evolving landscape.

Wilhelm (pers. comm.) likens the act of restoration to taking "...little bits of living tissue of the earth that still are able to make themselves new again, thousands and thousands of years hence, and...[grafting] that back into the scar tissue. And gradually, by degrees, slowly but surely, ...[this will] cause the world to come alive and...to move forward again in evolution."

Vital hydrological processes may also be restored along with the prairies systems. Wilhelm (pers. comm.) uses the example of the typical corporate landscape of Kentucky bluegrass (*Poa pratensis*) turf, which cannot absorb the great amounts of rain that fall very quickly over much of the prairies:

> ...we have Kentucky bluegrass lawns with shallow little root systems over clay that basically turn rainwater to filth and send it to New Orleans dirty. It accumulates in little retention basins and seeps like lethal injections into our streams from throughout the Midwest, and [we] wind up with one big bowel movement in the Gulf of Mexico, having created...basically sewers in our major streams from here to there. And now we're losing estuaries or the spawning grounds of the Gulf of Mexico at about 40 to 50 square miles per year. ...The Gulf of Mexico is dying.... It's become our protocol to create these landscapes that...turn rainwater to filth.... Then the land is bereft of water and we have to mine water out of the ground to keep these landscapes efficient at divesting themselves of water.

Wilhelm (pers. comm.) contrasts this with a remnant or restored prairie:

> ...[the] deep roots of the prairie connect the heavens to the earth, and the water that falls stays...and then the water goes back out through life itself.... [So] instead of having an outdoor living room...you have landscapes full of flowers, full of living things, and people wander out amongst them; a landscape that can hold water, a landscape that requires only the annual burn and thereby is essentially expenseless once installed. The landscape renews itself - it holds its own water, it holds its own resources, and renews [them].

Another positive result of restoration is the opportunities for learning that it presents. First, restorations allow the observation of how prairie ecosystems function, a service which cannot be met by the limited number and scale of remaining remnants in many regions (Kline, pers. comm.). Second, restorations provide many people with the opportunity to learn what prairie is, something which is unknown even to many people who live in areas formerly dominated by this ecosystem type (Powers , pers. comm.). Third, the restored site may be used as a living laboratory to further knowledge of these systems and how to restore them, a use which many consider too risky with the tiny unploughed or unpaved remnants which still exist (Nyhoss, pers. comm.).

Wilhelm (pers. comm.) sees even small restored areas as useful in terms of changing human attitudes:

> [Gradually] the aesthetic of life begins to replace...[the] aesthetic of emptiness. When you let nature itself begin to form the aesthetic in the people then people start to want it, people start to find it comfortable instead of becoming ever more comfortable with dead things and more discomforted with living things. The trend begins slowly to shift.... [People] have no experience with life, and they're now discomforted by it because they're not habituated to it....

Jordan (1988a) points out another change in attitude that is almost required by restoration. The persistence of many communities may depend upon indefinitely managing and maintaining a site, that is, a sort of "low key restoration." Jordan (1988a: 18) sees this as a lesson, "...the lesson that a program of continual management and restoration is critical to the survival of many communities in the presence of human influence." In this way, restoration deals with the reality of human impacts upon natural areas. "...[W]hereas [traditional, protection-oriented] environmentalism has tended toward a kind of idealism in its conception of nature, restoration is relentlessly pragmatic" (Jordan 1994a: 27).

While Grumbine (1994b: 243) concedes that wilderness preserves are part of the current environmental dilemma, he makes the important point that "...it is difficult to imagine wilderness protection as contributing to environmental problems to the same degree as the development projects of industrial capitalism." It is the values and attitudes that guide a focus on preservation that must be examined. So although protecting wilderness areas in itself is not detrimental (in fact, it is likely vital), some of the principles that guide this approach may be. Furthermore, protection is simply inadequate. Restoration and construction of landscapes go beyond preservation, offering the opportunity to do something about ecological degradation

(Baldwin et al. 1994b). Restoration is now a necessary conservation strategy.

Beyond the direct ecological implications of a hands-off conservation approach are the implications of this approach in terms of the human/nature relationship. Birch (1990: 7), for one, argues that the creation of wilderness areas "...is an attempt to *bring the law to wildness....*" He likens this action to incarcerating aboriginal North Americans on reserves, "...even with the putatively well-intended aim of making them over into 'productive citizens,' in place of the former practice of slaughtering them" (Birch 1990: 8). The dealings with both wildness and aboriginal peoples are indicative of how mainstream Western culture perceives of the other as an enemy. While the earlier European settlers of North America attempted to "...subdue wildness by destroying its manifestations..." (Birch 1990: 9), the destruction of forests, bison, and aboriginal peoples did not remove *wildness*. More recently, a new approach to controlling wildness has been undertaken, that follows "...a more subtle strategy of 'cooptation,' or appropriation, through *making a place for wildness within the imperial order and putting wildness in this place*"(Birch 1990: 9, emphasis added).

Birch (1990) likens this cooptation of wildness to imprisonment, the "lock-up" of wildness. Wilderness areas are like prisons in that they fall firmly under the control of the dominant society:

> Wilderness reservations are not meant to be voids in the fabric of domination where 'anarchy' is permitted, where nature is actually liberated. Not at all. The rule of law is presupposed as supreme. Just as wilderness reservations are created by law, so too they can be abolished by law. The threat of annihilation is always maintained (Birch 1990: 10).

Besides symbolizing domination, parks tend to remove those who many believe should be most involved in caring for the land - the local people. Harris and Eisenberg (1989: 167) write:

> Because deep-seated cultural values of landowners were frequently disregarded when the land was originally appropriated, and because parkland and resource use by local agrarians is generally prohibited, the parks philosophy frequently creates hostility

between traditional land-user groups and the national administration.

While locals are removed, tourism is actively encouraged, and "...great emphasis is attached to making the resource available to tourists" (Harris and Eisenberg 1989: 167).

The outcome is essentially that strong relationships with natural areas are removed by restricting access and behaviour. Environmentalism should work not to protect or rescue nature from humans but to provide humans with the opportunity to "...achieve full citizenship in the biotic community" (Jordan 1994a: 21). Jordan (1994a) believes that modern environmentalism has not allowed full citizenship or what Aldo Leopold called a "mutually beneficial relationship" between humans and nature. Rather, it has emphasized the ideal of wilderness as "unspoiled" by humans, as a place where humans should leave no traces; it has promoted an "ethic of 'minimum impact.'" This severely limits the involvement of humans in the landscape, in fact the human experience is hardly considered. This attitude confines humans to:

> ...the role of visitor - an observer of nature rather than an active element of the land community. Ironically, such a perspective turns us all - hiker, birder, and strip miner alike - not into members of the community but into users and consumers of the natural landscape (Jordan 1994a: 21).

Restoration has the potential to redefine the human relationship with nature in several ways. For example, because restoration requires active involvement in the landscape, "...it literally gives us business there, making us vital inhabitants of the system - not outsiders, but active participants" (Jordan 1988a: 19). This human/nature relationship includes "...an actual ecological interaction with the natural landscape that benefits both it and us - and [does] so without requiring us to repudiate the achievements or abandon the accoutrements of civilization" (Jordan 1994a: 21). Restoration allows for this type of relationship, one that is "both positive and mutually beneficial" (Jordan 1994a: 22). Furthermore, restorations themselves provide "...*tangible evidence* that human activity can have a positive effect on the landscape" (Aber and Jordan 1985: 399, emphasis added).

Restoration projects also resolve the dilemma of over-use without restricting access. The visitor to a natural area is no longer a negative and consumptive influence but a constructive and contributing one. So restoration frees humans to imagine a relationship with nature that is both positive and engaging. In other words, while it may seem that entering into a meaningful relationship with nature may require the abandonment of modern civilization, "restoration engages a range of physical, intellectual, social, and emotional faculties and actually entails a kind of recapitulation of cultural evolution, a redeployment of all the skills exercised and achieved by human beings..." (Jordan 1994a: 24). Turner (1988: 50) agrees, observing that restoration provides the basis for a "...new kind of environmental ethic, one which accepts human participation in nature as essential for us and for the world, and which actively seeks out ways in which that participation can be deepened and extended."

Another potential role of restoration is helping humans define themselves in ecological terms. Restoration is essentially compensation "...for our presence and our influence," and in this way restoration actions become "...a kind of meditation on our influence and an extended definition of who we are in terms of the ecology of the system" (Jordan 1988a: 19):

> [The] continual effort to sustain the [restored] system against the pressure of our own influence makes restoration...a powerful tool for exploring and defining our relationship with the system, and for achieving what might be called an ecological definition of who we are - that is, a definition written in terms of our impact on other species and ecosystems (Jordan 1994a: 32).

Several of the restoration workers who were interviewed comment on the direct benefits that restoration can have on the human psyche. Kline (pers. comm.), for example, states that she and others who work at the University of Wisconsin-Madison Arboretum are "...convinced that the act of restoration is good for people: it gives them a new relationship with the land; it's good for their emotional development." Similarly, according to Egan (pers. comm.), the act of restoration gives us "...a chance to engage ourselves - our intellects, our emotions - within a really dynamic system that we used to be an intimate part of." Wilhelm (pers. comm.) contends that restorations grow out of a:

> ...yearning to find something solid, something grounded, something fundamental, something incorruptible, and to develop a wisdom based on that rather than a wisdom based upon cleverness or ego or some of the more mundane aspects and artifacts of modern culture. Not only in restoration is there an interest in repopulating the earth with landscapes that can live, but also landscapes within which human beings can find their humanity.

At the very least, restoration is a sincere attempt to make up for past and continuing transgressions against the environment. As Betz (pers. comm.) comments, "If in the end it all fails, at least they'll say that some people in our generation tried to do something."

Not everyone is so enamoured with ecological restoration, however. Kirby (1994: 239) suggests that restoration is presently "insubstantial and distracting" and "...an expensive self-indulgence for the upper classes, a New Age substitute for psychiatry" (240).

The relationship that restoration builds between humans and their habitat, however, goes beyond the psychological benefits to humans to teaching new values, values which are guides to more ecologically beneficial behaviours. As the degraded state of the world is fundamentally a result of the attitudes and values of the human inhabitants of it, the solution to environmental degradation must include changing these attitudes and values (Jordan 1988a). Jordan (1994a: 23) dreams that restoration will become "the principal outdoor activity of the next century" and that nature will be transformed from "...an 'environment' into a habitat for human beings."

This is where the ritual aspect of restoration becomes relevant. Jordan (1994b) outlines what he sees as the fundamental elements of a new environmental paradigm. The first element is the assumption that humans are "inextricably linked" with ecosystems, local and remote. The second element is the belief that the existence of natural ecosystems in the future depends on the deliberate restoration of those ecosystems to compensate for the inevitable "novel influences" that will impact them. The third element suggests that environmental problems are in part due to inadequate ritual in human societies, as ritual is "essential" to mediating the tension between nature and culture. Restoration may serve as a source of ritual, a means to restore sacredness as well as health to the earth. As discussed earlier, ritual serves, in part, to mediate the relationship between humans and nature, and restoration "...provides an ideal basis for the development of a modern system of rituals [to define] our relationship with the rest of nature" (Jordan 1994a: 30).

Fire, for example, has taken on a sort of ritual role in restoration. In Turner's (1988: 54) words:

> The discovery of the need to burn...emancipated the naturalist; burning can even be seen as a sacrificial rite of redemption for our ecological guilt....Burning showed that nature needed us, needed even those most Promethean and destructive elements of ourselves symbolized by fire.

Ritual can help lead humans not into a state of harmony, but into "...an ongoing dialogue with the natural landscape" (Jordan 1994a: 31).

Willeke (1994), however, takes issue with the emphasis on the ritual aspect of restoration. While Willeke (1994) admits to the importance of restoration, he balks at taking it beyond a technical, scientific process to one imbued with spiritual or aesthetic aspects. He finds the notion of ritual "unappealing" and seems to resent the implication that "...only through ritual can humans achieve a satisfactory relationship with the non-human natural world" (Willeke 1994: 91).

More commonly than not, the importance of ritual in conservation is ignored or explicitly rejected, but Jordan (1994b: 247) emphasizes that all societal choices, including those that result in the degradation of nature are "...rooted in human ideas, values, and beliefs." Ritual is one way to "...change widely shared ideas, values, and beliefs without imposing change from the outside or from the top down" (Jordan 1994b: 247). Further, he says, ritual and its implications are "serious questions" that are dealt with in a variety of disciplines, and simply dismissing it as the fancy of an elite intellectual or an "eccentric pleasure" is irresponsible.

Baldwin et al. (1994a: 261) suggest that the opposition raised and discomfort felt in reference to management of natural areas and especially to ecological restoration stems, fundamentally, from "...the conceptual dichotomy of nature/culture that separates humans from nature [that] is as old as Western civilization." Conservation approaches will be largely determined by the answer to one question: do healthy ecosystems exist only in the virtual absence of humans, or are humans 'members' of nature? (Baldwin et al. 1994b). As Baldwin et al. (1994b: 5-6) write:

> If we understand ourselves to be other, different from, and opposed to nature, it makes sense to attempt to protect nature, to isolate and preserve portions of nature from human incursions. The theory of preservation in its strictest sense is founded on this premise....
>
> If, however, we consider ourselves as one among many creatures in a grand community of species, although perhaps the most privileged, then the prospect is altogether different. Inextricably entangled with the rest of nature, we are products of evolution like everything else, and inevitably affect all the other elements of nature. ...[A]long with our inevitable influence upon the community of species we also have a large degree of responsibility for the whole. At this juncture our responsibility is to discover how to restore what we have been destroying.

It is at the level of the assumptions and beliefs about the character of nature and what is natural where the debate truly begins. While it may seem that preservation and restoration should be allies, there is a dissonance between the two strategies for maintaining natural ecosystems (Kane 1994). Turner (1994a) identifies different streams within the modern ecology movement, including the conservationist, the preservationist, and the restorationist. The conservationist view of nature is that of a "...vast resource, physical and spiritual, that must be wisely husbanded so that it may continue to yield a rich harvest for human beings" (Turner 1994a: 35). The preservationist confers intrinsic value to nature, "...the greater for being untouched by humankind, and seeks to keep it inviolate and unpolluted" (Turner 1994a: 35). The restorationist attempts to reassemble "classic" ecosystems, based on the assumption that "...to do so is not only possible, given nature's own easygoing and flexible standards, but also an important part of the human role within nature" (Turner 1994a: 35).

The restorationist differs from the conservationist in appreciating the intrinsic as well as the utilitarian values in nature, while unlike the preservationist, the restorationist believes that a restored landscape is "...no less natural - and may even be more natural in some senses - than an 'untouched' one" (Turner 1994a: 35). This assumption is based on the understanding of nature as inherently "touched" - whether by earlier peoples, other species, natural disasters, or present human inhabitants. "Nature is the process of everything interfering with - touching - everything else" (Turner 1994a: 36).

Elliot (1982) is a quintessential example of Turner's "preservationist." In his article "Faking Nature," he argues that restored or "faked" natural areas have less value than "original" natural areas as a result of their "genesis." He begins the article by establishing what he refers to as the "restoration thesis," this being the premise that an area may be destroyed for mining or exploitation of some sort and then restored to its original condition *and value*. Based on several assumptions, including the definition of "natural" as "unmodified by human activity" (Elliot 1982: 84), Elliot sets out to disprove the restoration thesis by drawing analogies between faked art and faked nature. He claims that just an original painting will be valued more highly than even a perfect replica, so too a natural landscape will be more valued than one which has been perfectly recreated. This is because, he argues, humans value the origins of things. For example, humans value natural areas partly "...because they are representative of the world outside our dominion, because their existence is independent of us" (Elliot 1982: 86), and because of what he calls their "...causal continuity with the past" (Elliot 1982: 87). In a more recent article, Elliot (1994: 144) makes clear that he believes that "...the difference between human agency and the agency of other living and non-living things is profound..." and that his "...anti-restoration thesis depends upon the assumption that human activity is distinctively different from natural processes, including the activity of nonhuman animals" (Elliot 1994: 136). While he acknowledges that there are degrees of naturalness, and that all places have now been affected by human activity, he maintains that humans are indeed apart:

> ...for better or for worse we are not just another species. It is accurate to say that as creatures of culture and technology we have transcended nature: we are members of a natural species; we are animals with natural instincts, drives, etc.; nevertheless, much of what we do is not natural (Elliot 1994: 143).

Gunn (1991) agrees with Elliot (1982) in his assertion that we value things for more than their tangible properties; the history or origin of something may add to its value. Gunn (1991) cannot accept, however, Elliot's (1982) rejection of the restoration thesis because he does not see a clear distinction between human-caused and otherwise-caused events. "Implicit in the restoration thesis is the *refusal* to accept the sharp distinction between the 'human' and the 'natural'" (Gunn 1991: 296).

While Elliot (1982) raises valid concerns about the use of restoration as a justification for continued degradation, he fails to distinguish between restorations that are planned in order to allow environmental degradation through exploitation to continue and those that are undertaken for healing, conservation, or aesthetic purposes. A restoration that is intended as a healing act may indeed have a very special value to humans, albeit different than that of an "original" landscape. Where restoration is used as a rationale for destruction, however, one may indeed feel defrauded by the fake nature. The intention of an action is important, but only to humans. In the end the most important priority in conservation is not how humans perceive a place, but what role the place plays in the integrity of the ecosystem.

There are more problems with Elliot's argument. For example, he views human destruction or even impact as unnatural, and as removing continuity with the past. If an area was once devastated by a volcano or a glacier, or any force that was not human-induced, however, the present landscape does have continuity with the past. Somehow, Elliot (1982) sees humans "...as disruptors of natural history" (Cowell 1993: 28). The difference between a non-human devastation and a human devastation can indeed be significant in outcome, but it can also lie simply in the fact that humans may feel sorrow that they as a species have knowingly or purposefully caused such an event.

Furthermore, although he is a philosopher, Elliot simply assumes that to be natural is to be unmodified by human activity, an attitude entrenched in human/nature dualism. He does not address the point that all of North America, by his own definition, was "unnatural" long before the Europeans arrived.

Like Elliot, Katz (1993) believes that human involvement in a natural area radically affects its value. First he distinguishes between artefacts and natural entities for the purpose of differential valuation. He defines artefacts as "human creations" made "...for the achievement of human tasks" (Katz 1993: 223). The key distinguishing feature between artefacts and natural entities, as Katz sees it, is that artefacts exist only because of human intention while natural entities do not. While Katz (1993: 225) believes that "humans are in some sense natural beings...," he claims that "...not everything that humans do or make is natural." He separates humans from other creatures because of the fact that the "...primary sphere of human activity is the realm of culture..." (Katz 1993: 225).

On this basis Katz (1993: 227) proposes that, "The redesign and management of natural systems is thus a paradox: once human intervention occurs, there is no longer a natural system to be preserved, there is only an artefactual system." In fact, he views management simply as a means of control:

> Intervention in nature creates environments based on models of human desire. This is the human project of the domination of nature: the reconstruction of the natural world in our own image, to suit our human goals and purposes (Katz 1993: 231).

Again like Elliot, Katz does not consider that by his definition, North America was an artefactual system when Europeans arrived. The crux of his argument is based on the unexamined assumption that "civilized" humans are somehow "other" than the rest of nature (which, however, seems to include indigenous human societies). He does not consider the fact that the goal of preservation is fundamentally the same as that of restoration - to preserve ecological integrity and diversity. Does the simple existence of a human goal or purpose render an action to be domination? Does the very interest of humans make something artefactual by Katz's reasoning? And if so, why is preservation not viewed in the same light as restoration - as an act of domination? Furthermore, how would Katz deal with the subject of invasive exotic species which were accidentally or purposefully brought to North America? Does removing them make nature into artefact or does leaving them? Katz's distinctions between natural and artefactual are too simple to be useful in guiding a society's actions.

At the opposite end of the spectrum, Turner (1994b) rejects the notion that "originals" exist in the first place. He points out that nature itself "...is already in the business of reproduction and copying, and thus the linear and dualistic distinction between authentic original and artificial reproduction is profoundly questionable" (Turner 1994b: 253). Turner (1988) claims that restorationists are in fact simply imitating nature. Nature copies and recopies itself every spring. And, like a restoration, "...nature's copying is not exact," in fact, "...nature...goes beyond copying to innovation..." (Turner 1988: 52). This belief is part of Turner's rationale for advocating landscape restoration.

Turner also absolutely rejects the idea that humans are somehow unnatural. In fact, Turner (1994a) proposes that human beings are not only natural, they are the epitome of naturalness. Human qualities are much like those of other species, although perhaps heightened. Even the speed of human transformations is natural, considering that complex organisms "...evolve faster than do more primitive organisms, as these in turn do so faster than nonliving systems" (Turner 1994a: 43). The degree of human self-awareness likewise correlates with their complexity. In fact, Turner (1994a) suggests that nature could be defined as "acceleration." Humans may be "...the closest approximation nature has found to its own direction and tendency" (Turner 1994a: 44). Turner (1994a: 44) writes:

> If human beings are what nature comes up with given the freest play of development and the richest and stablest environment of complexity and available energy, then we might rightly assume that if we want to know what nature is *really* like, we should look at ourselves.

Just as not all restorationists agree with all of Elliot's views, not all "preservationists" hold positions as extreme as those of Katz or Elliot. Kane (1994) argues that the basic criticism of preservationists is ill-conceived, owing to the fact that preservationists are usually involved in a wide variety of environmental issues, not simply wilderness preservation. Kane (1994: 71) writes:

> To think that...preservationists are fundamentally inspired by the nature-humanity dualism and a misanthropic view of human beings is not at all a necessary, or even a very reasonable, inference. To be sure, they *are* worried about the impact that humans are now having on natural systems, and they do think that human activity at the present time is alarmingly destructive of nature. But so do many others, including restorationists, who would not think of solving the problem through a policy of apartheid for humans and nature. It makes more sense to think that these preservationists are driven, not by the notion that human contact and commerce with nature should be kept to a minimum, but by the desire that humans avoid the kind and magnitude of interaction with nature that destroys the health of the world and the beings, human and nonhuman, to which it is home.

Similarly, Willeke (1994) argues that it is unfair to portray preservationists as naively believing that pristine nature exists and that humans can be isolated from nature by establishing boundaries by law. Willeke (1994: 90) disputes this depiction, claiming that "...human influence is widely acknowledged..." in the establishment of wilderness preserves. Noss (1983) also refutes the notion that aiming to preserve a pre-settlement condition is an attempt to keep nature static. "Rather, *preservation* should imply perpetuating the dynamic processes of presettlement landscapes" (Noss 1983: 703).

Many preservationists acknowledge that the management of protected areas is a necessity, but differentiate between restoration and management. Restoration, though, is part of a management continuum based on the degree of influence exerted on the system. Many of the same techniques (e.g., burning and weed control) are used in conserving existing, relatively natural sites as are used in the restoration of damaged ones (Jordan 1994a; Jordan et al. 1988). Seeing management simply as a "subtle" form of restoration, on a continuum of human influence, is helpful in that it "...explicitly acknowledges the role of the human in the process..." (Jordan 1994a: 33). Some, like Louck (1994) and Gunn (1991), distinguish between "maintenance restoration" where the disturbance is mild and "re-creation restoration" in areas of severe disturbance. Jordan (1994b: 245) argues that this distinction is simply a way in which to preserve "...an *idea* of nature as that which is not human and not influenced by human activities." In the words of Noss and Cooperrider (1994: 28):

> All land management is biodiversity management, whether intended or not. All land-use decisions - including a decision to designate a reserve, put a fence around it and leave it alone - are land management decisions with significant consequences for biodiversity. It is much better to manage biodiversity by design rather than by default....Accepting responsibility for our actions means not only that we carefully consider the effects of management on biodiversity, but also that our management programs be designed explicitly to protect and restore native biodiversity.

Ultimately, the discomfort with management in general (including restoration) is based on a misunderstanding of nature as balanced, perfect, and distinct from humanity. From this perspective, human intervention in nature, through management, is a contradiction. As Olwig (1984: 90) asks, “How can nature be defined as primordial, the antithesis of man-made, needing protection from man, and yet require human intervention to remove the vegetation that grows when it is thus protected?”

Some argue that while restoration is portrayed as the great integrator, capable of reforming human understanding of their place in the world, it may not be the integrating force it purports to be. Cowell (1993) suggests that *in practice* restorationists do not involve themselves fully in nature. The restoration goal is most often to restore conditions that resemble those of pre-European contact, and Cowell (1993: 29) maintains that "in accordance with this definition, once restoration of a site has achieved its structural and/or functional goals, humans ideally best serve the area by leaving it alone." The goal, then, remains to create a community that is essentially conceived of as *the* successional climax. The conceptualization of nature as static has led to restorations that are essentially "...museum-piece pre-European landscapes" (Cowell 1993: 32). Kirby (1994: 240) agrees, perhaps more strongly:

> The best one might say of restoration ecology is that...it raises consciousness about our society's contempt for nature. Consciousness thus raised, however, leads nowhere except to museums - or strange outdoor churches.

Cowell (1993) concedes that recently restorationists have begun to acknowledge and account for the dynamic nature of ecosystems. The goal of restoration in light of this assumption then becomes "...the reintroduction (or simply the uninhibited operation of) presettlement forces" (Colwell 1993: 30). However, Cowell (1993) maintains that even here humans are viewed as "disruptors," and are still excluded from nature "in the long run." Restoration, then, like preservation, can reinforce "...the human-environment dichotomy that maintains the existence of two separate landscape options: nature preserves and human-dominated 'productive' lands" (Cowell 1993: 32). Cowell (1993: 31) argues that active participation in the ecosystems is necessary if humans are to bridge their philosophical separation from nature:

> In order to achieve full, long-term participation...[there must be] new goals for restoration that include human activity, including consumption, as another process within ecosystem dynamics.

Likewise, while Kane (1994: 74) promotes the idea that human participation in nature is inherent and potentially positive and admires the search for a mutually beneficial relationship between humans and nature that restoration offers, he worries that the role of a restorationist may too closely resemble the role of a human under the old domination paradigm, where humans are the highest authority and the "lords of creation." Human choice can dictate the landscapes of the future, as it has in the past, with the main difference being that the restorationist considers the benefits to other species and to ecosystem health. Kane (1994: 76) acknowledges the parallels between the domination and the restoration paradigms:

> The degree of anthropocentrism and human control that still remains in restoration, although not as crude as in domination, could still make restoration seem more a part of the environmental problem than its solution.

And further:

> ...the unwillingness of restorationists to make room for an ethic of trust in our dealings with nature, and their reliance instead on a program of control, is precisely what makes them fellow travellers with the old-fashioned dominationists (Kane 1994: 78).

While restorationists have a very different goal in mind than the dominationists:

> ...they do nothing to scale back the role of humans in the world, and nothing to correct the mismatch between their unlimited task and their limited qualifications. As a consequence, restoration offers the world no realistic protection against continuing social and ecological disasters of our own making (Kane 1994: 78).

The point Kane (1994) tries to make is that humans must cease to assume the role of "lords of the earth." No matter what the goals, humans will "certainly produce havoc" when they assume a role which they are simply not able to fill. Kane (1994: 79) points out that many projects that were born out of the domination paradigm "...were motivated by what were considered the noblest intentions, and were backed by the best science of the day - just as the new programs of control are touted now." Kane (1994: 79) believes that restoration is utterly necessary, but clarifies that restoration must be done not "...for the grandiose reason that we have ultimate responsibility for the health and well-being of the biosphere, but on the more homely grounds that when we make a mess we should do what we can to clean it up."

Jordan (1994b) refutes the billing of restoration as asserting domination or sovereignty over nature (see Kane 1994; Pletsch 1994). Rather, it involves "...accepting responsibility for our influence over nature" (Jordan 1994b: 248) as Kane suggests we should. Any strategy of conservation is recognized as a result of human choices. Restoration, preservation, and inaction are choices that are equally value-laden:

> Unless we are to renounce further progress in science and technology, and reverse secular trends in economic development, population growth, progress toward more equal standards of living, and so on, it seems that the techniques of landscape construction and reconstruction will become more rather than less important to us. The pressure of events is far more likely to force us to do something than to motivate us collectively to refrain from what we have done for centuries. In fact, if we are now coming to realize that our species has always interfered with nature, then involving ourselves with nature in this new way that we term restoration may be more consistent with the character of our species than preservation. To restrain our interference with nature may be the one impossible option. Yet we lack a shared paradigm for our relationship to the earth and the rest of life, a template to guide our intervention (Baldwin et al. 1994b: 10-11).

The lack of a shared paradigm remains unresolved. While discussions about what is natural abound, a guiding ethic is missing. Neither Elliot's (1982; 1994) and Katz's (1993) nor Turner's (1994a) definition of what is natural is helpful. On the one hand, humans simply cannot do anything natural, that is, they cannot do anything that will positively affect an ecosystem. On the other, everything humans do is ultimately natural. Neither of these extreme definitions can realistically guide human actions. Botkin (in Pollan 1990: 28) believes that there *can be* a difference between changes brought about by humans and those brought about by non-human nature (such as ice age transitions), based on the "...rate of change and man's introduction of novel actions." For example, while trees may migrate and vegetation change in response to a changing climate, humans logged 19 million acres of Michigan in under 100 years. Likewise, ploughing and the introduction of chemicals are "novel actions," and Botkin believes they should therefore be avoided whenever possible. Botkin (in Pollan 1990) suggests that natural actions may simply be those which work at nature's speed and are modelled on nature's ways. In other words, perhaps natural actions are those which are sensitive to the local and global systems, and which can be sustainably undertaken.

The basis for the concept of sustainable development is that humans are capable of being integrated within their habitats such that some sort of healthy and dynamic balance is maintained. After all, people the world over have always altered the landscape and the ecosystems with which they had contact. Is this a difference, however, between indigenous (ecosystem) peoples and modern Western society (biosphere people)? Does this mean that post-industrial societies simply cannot interact in a mutually beneficial way with the earth? It is evident that North Americans do not know how to live in wildness. Even in countries as wealthy as Canada and the United States insufficient land has been set aside for purposes other than economic development and resource extraction (Grumbine 1994b). Nonetheless, "...not all modern societies use destructive technologies, and the benefits of human interference in ecological processes are not restricted to tropical zones or past times" (Gomez-Pompa and Kaus 1992: 274).

What is important "...is not whether people lived (or live) in wild places, but *how* they lived and continue to dwell in wildlands while accommodating wildness and what we might learn today about land health from considering their ways of life" (Grumbine 1994b: 236-237). Foreman (in Pollan 1990) believes that in order to change the land ethic humans must return, in a metaphorical sense, to the "pilgrim shore." "Let's seek to learn from the land this time. I do believe that humans are tied into nature....But we must discover our proper place in that dynamic" (Foreman in Pollan 1990: 28). The bottom line is that "...there must be limits on how much habitat humans can appropriate for themselves to the detriment of other living beings" (Grumbine 1994b: 237).

It is evident that the definition of naturalness is often troublesome in conservation issues. Perhaps distinguishing between actions in terms of their "naturalness" is not a constructive approach. Perhaps the argument should focus on whether or not human actions are sustainable or unsustainable, on whether or not those actions contribute to significant degradation. Perhaps human actions should be evaluated on their impacts on ecosystem integrity and health. Historical (i.e., indigenous peoples') practices should be looked upon as useful models of conduct rather than as "natural acts." A more practical approach distinguishes between positive and negative human actions, based on intent and consequences. Decision making should be guided not by asking, "Is this action natural?" but rather, "Is this action beneficial?" That is, is the action compatible with the maintenance or recovery of ecological integrity and/or ecological diversity?

Ecological integrity is a useful restoration goal - it gives highest priority to the wholeness, the health, and the maintenance of the ecosystem. As Grumbine (1994a) points out, in most of the conservation literature the goal of ecological integrity is held to be the most important, the one goal that must take precedence. Grumbine (1994a: 34) believes that "...if the goal of ecological integrity becomes the norm, management a century hence holds great promise for not only sustaining ecosystems but also for integrating culture with nature." The concept of ecological integrity will be dealt with more fully in later chapters. Ultimately, both preservation and restoration are vital to the conservation of biodiversity at all scales, and regardless of their histories or potentially negative implications, it is possible to shape them to whatever humans want or need them to be.

2.3. Summary

Humans in modern Western society generally view themselves as separate from nature. They may see tribal peoples as being or having been a part of nature; however, this is often perceived as a state of idyllic harmony rather than as a successful and usable model of human/nature relationship. Yet even these "ecosystem peoples" have or had to mediate the tension between nature and culture.

As biosphere people, post-industrial societies exploit ecosystems on a global level. The potential for exploitation is at a scale previously unknown. Biosphere peoples have unsuccessfully attempted to mediate the tension between nature and culture by protecting designated areas from exploitation. The protection approach to mediating the human/nature relationship grows out of the belief in human/nature dualism. Human involvement in the nonbuilt landscape is perceived as intrusive and even destructive, therefore certain of these areas are designated to be "protected" from humans. This attempt has been unsuccessful for two main reasons:

(1) strict protection is at odds with the dynamic nature of ecosystems; and,

(2) protection is inadequate in relation to the extent of exploitation outside of protected areas.

Rather, compensating for the unprecedented changes in indigenous ecosystems and landscapes will require a comprehensive conservation effort that includes protection but is increasingly committed to management and restoration. Focussing conservation efforts on restoration and management requires a fundamental shift in beliefs and values. Restoration inherently recognizes the connection between humans and nature. Humans are not somehow out of place in natural areas or wilderness. However, new connections must be constructed and integrated into the cultural fabric - connections that respond to the circumstances of post-industrial societies and their habitats. While humans and human actions are natural, naturalness does not directly correspond to desirability. Actions must be assessed on the basis of their impacts, especially the impacts on ecosystem integrity.

Therefore, the fundamental shift in beliefs must be towards acceptance of human "belonging" and of the potential for beneficial human involvement in the landscape. Furthermore, value should be placed on the restoration of the human role as a citizen in the ecological landscape. As a society, it is necessary to learn to live in "dynamic complementarity" with the landscape, rather than in conflict. Indigenous peoples can provide many clues as to how this may be accomplished, including:

- shifting control over resources to local peoples;
- applying measures to sustain integrity in all landscapes, not just in those which are "protected";
- approaching human involvement in the landscape as a means to conservation;

- integrating conservation values into the cultural mores (McNeely 1989);
- "resacralizing the world" (Grumbine 1994b).

Restoration of ecosystems has the potential to play a vital role in reintegrating humans with their habitat in a meaningful way, while simultaneously healing non-human nature. Restoration may thus help to achieve successful conservation, both by restoring ecological integrity, and by restoring the relationship of humans with their home. As Jordan (1994a) maintains, restoration may provide humans with a way to conceive of the world as their habitat rather than their environment.

3. THE THEORY AND MANAGEMENT OF ECOSYSTEMS

The interest in and debates surrounding concepts of nature are rooted in concerns over environmental degradation. This degradation also affects how the management of natural areas is approached (Grumbine 1994a; Reive et al. 1994). Reive et al. (1994) suggest that park management philosophy has changed in three major ways as awareness of human-induced environmental degradation has increased:

- the management focus is moving from the species to the ecosystem level;
- active as opposed to "hands-off" management of natural areas is being recognized as necessary for the maintenance of many park characteristics; and,
- the importance of the larger system within which parks are situated is being considered in terms of park management.

These changes are reflected in active discussions of ecosystem management and landscape-scale management. A major stumbling block, however, is the lack of scientific knowledge of the structure and function of ecosystems. Conventional science is predominantly mechanistic and reductionist in nature. Thus, while a tremendous amount of knowledge has been gained in regards to the parts within an ecosystem, conventional science has not provided adequate concepts to understand relationships and complex wholes. Systems theory and landscape ecology are two theoretical approaches that hold some promise for the understanding of ecosystems and landscapes. These approaches provide a theoretical context for the discussion of ecosystem and landscape management, as well as later discussions of ecological integrity and restoration design, implementation, and management.

3.1. Systems theory

Systems theory developed as a response to the failure of reductionist science to aid in the understanding of complex living systems. Systems theory "...is an approach that helps science deal with the circular, rather than linear, aspects of connectedness and context" (Paul 1987: 3). Unlike conventional science, in which systems are reduced and their component parts are analysed, systems theory attempts to understand the qualities of systems that are a consequence of their wholeness and of the interactions among their component parts. Systems theory also provides a method of modelling the dynamic nature of systems, attempting to understand change in terms of the self-maintaining and self-organizing abilities of systems.

There are several concepts which are basic to systems theory, as summarized by Laszlo (1972), who proposes that all natural systems are a function of four independent variables or properties (Figure 2).

3.1.1 Systemic state property (Ordered wholeness)

All natural systems possess the properties of wholeness and order. Wholeness refers to the fact that a system is non-summative, that is, it is other than the sum of its constituent parts. The focus here is on the relations between the parts, from which properties emerge that do not exist in reference to the parts alone. Order refers to fixed forces or regularities of the constituent parts which "...determine the functional behaviour of the totality" (Laszlo 1972: 38).[3]

3.1.2 System-Cybernetics I (Adaptive self-stabilization)

Laszlo (1972) borrows the term cybernetics ("steermanship") from the field of engineering, and uses it to refer to "...the study of processes interrelating systems with inputs and outputs, and their structural-dynamic structure" (Laszlo 1972: 38). Hence the system is understood in terms of its "relevant environment." The first type of system-cybernetics refers

[3] Andras Angyal, in his 1941 book *Foundations for a Science of Personality*, proposed that the identity of a system is not a result of its actual physical components - all organisms, for example, are constantly replacing dying parts, or growing. Rather, says Angyal, the identity lies within the relationships that are maintained among the component parts. This "...framework or plan exists as an imminent fact of the system; it is not merely 'in' the pattern of relations, but rather *is* the pattern of relations....[The] fact that it is a characteristic of the whole, rather than the parts, means that logically it cannot be reduced to any of the parts" (in Oates 1989: 111).

PROPERTIES OF NATURAL SYSTEMS

Ordered Wholeness

Systems exhibit emergent properties - they are other than the sum of their constituent parts.
The fixed relationships between the constituent parts determine the function of the whole system.

Adaptive Self-Stabilization (negative feedback)

Systems adapt to certain perturbations by dampening their effects, thus maintaining the original state.

Adaptive Self-Organization (positive feedback)

Systems adapt to extreme perturbations by re-organizing to a new and sometimes unrecognizable state.

Intra- and Inter-Systemic Hierarchies

Every system is at once made up of sub-systems and a sub-system of another more complex system.
As the level of system organization increases, so to does the diversity of system functions and properties.

Figure 2. The properties of natural systems as outlined by Laszlo (1972).

to the negative feedback responses of a system, that is, the system's error-reducing responses to perturbations which allow it to return to a previous state. Thus, systems may adapt to perturbations that do not exceed their capacity for self-stabilization by dampening their effects.[4]

3.1.3 System-Cybernetics II (Adaptive self-organization)

The second type of system-cybernetics is also a form of adaptation, but in this case the response to perturbation is that of positive feedback, i.e., the perturbations are amplified. Here the fixed forces that characterize a system are re-organized and the state of a system evolves in order to adjust to a perturbation that exceeds the self-stabilization threshold of the previous system. The new state is more resistant to the perturbation than was the former state. The organization of a system is thus "...a function of maximal resistance to the forces which act on it in its environment" (Laszlo 1972: 43). In natural systems, this "natural selection" tends toward a "complexification of structure," resulting in systems which are less stable. "Hence systems evolve toward increasingly adapted, yet progressively unstable states, balancing their intrinsically unstable complex structure by a wider range of self-stabilizatory functions" (Laszlo 1972: 44).

3.1.4 Holon-Property (Intra- and inter-systemic hierarchies)

This property of systems refers to the vertical organization of systems. At any given level on the hierarchy, a system contains systems at lower levels (sub-systems) and is part of a system at a higher level (a supra-system). Each higher level of organization in the hierarchy possesses a greater diversity of "functions and properties," while at the same time contains

[4] This process is also referred to as "homeostasis," a term borrowed from Walter Cannon who, in 1932, wrote a book entitled *The Wisdom of the Body* in which he explored the ability of the human body to regulate its internal state. He named this process homeostasis (Oates 1989).

fewer systems. Hierarchy is used here not in the rigorous sense, which denotes a one-directional flow of power, importance, or action, but more in the sense of Chinese boxes. The hierarchy is infinite in theory, but empirical understanding requires that we define the hierarchy on a finite basis. Laszlo (1972) maintains that the difficulty of empirically demonstrating the existence of natural hierarchies does no more than prove a lack of useful methodology.

Each of these properties provide an important conceptual foundation from which to understand ecosystems at many scales. For example, Oates (1989) discusses the cybernetic property of systems in reference to conventional thermodynamic theory. The tendency of living things and systems is to move from simple to more complex forms (i.e., evolution, succession). Non-equilibrium thermodynamics refers to the characteristic of living systems to complexify (Kay 1991a). As Kay (1991a) explains, non-equilibrium thermodynamics theory suggests that as ecosystems (and other systems under certain conditions) develop they move further away from equilibrium while simultaneously becoming more organized. These self-organizing systems develop in spurts - "...phases of rapid organization to a steady-state level followed by a period during which the system maintains itself at the new steady state" (Kay 1991a: 484). Change is made possible by the addition of "...new pathways for energy flow, which connect old components, or of new components and their associated new pathways" (Kay 1991a: 484). "Each spurt occurs when random environmental conditions exceed a catastrophe level threshold for the system" (Kay 1991a: 484). This development path is referred to as the "thermodynamic branch."

An ecosystem is said to be at its "optimal operating point" when its own forces of organization and the external forces of disorganization are in balance, i.e., the climax community. This point is temporary since the system and its environment are dynamic and evolution will proceed (Kay 1991a). The transformation of a system is the cybernetic response of self-organization (system-cybernetics II). The maintenance of the system at the new steady state is the cybernetic response of self-stabilization (system-cybernetics I). "...[T]he many kinds of ecosystem self-regulation...can be understood as information circuits that control the future by resisting uncontrolled change" (Oates 1989: 124). For example:

> In climates with well-defined seasons, most ecosystems have...well-defined structures ***already in place*** that anticipate and neutralize the stress of changed conditions....[This indicates that] information has been structured into the ecosystem on every level, from the genetic to the systematic, during the processes of succession and evolution (Oates 1989: 124).

3.2. Landscape ecology

Landscape ecology is a young science that provides useful concepts for ecosystem study and management. Landscape ecology applies many of the concepts of systems theory, such as studying ecosystems in terms of hierarchy, change, and component interactions. While descriptions of the discipline vary, there are some basic concepts that are common in the literature (Schreiber 1990). Forman and Godron (1986: vii) explain that landscape ecology focuses on three areas of investigation: "(a) the distribution patterns of landscape elements or ecosystems; (b) the flows of animals, plants, energy, mineral nutrients, and water among these elements; and (c) the ecological changes in the landscape mosaic over time." Zonnefeld (1990: 4) states that: "The subject of study in landscape ecology is the land or landscape, its form, function, and genesis (change)."

Landscape ecology studies "...vertical and horizontal heterogeneity within landscapes..." (Zonnefeld 1990: 7). It is interested mostly in:

> ...the spatial dimensions, regularities of arrangement, distribution, and contents of the ecosystems in a landscape sector, and the roles of spatial configuration in affecting function (i.e., fluxes, interactions, and changes). In essence,...[it consists of] a mostly horizontal, boundary-crossing spatial research in and between ecosystems (Schreiber 1990: 25).

The principles of structure, function, and change within landscapes are studied, but so too is the application of these principles, i.e., "...the use of these principles in the formulation and solving of problems" (Forman and Godron 1986: 11). Zonnefeld (1990: 9) contends that landscape ecology is unique in that it approaches a landscape as "...a holistic entity, including all its heterogeneous components." Further, the human elements of the landscape are explicitly included in the analysis. As Forman and Godron (1986: 286) state, "Nearly all characteristics of landscape structure, functioning, and change operate at levels of - and are confined by - political, economic, and social forces."

Landscape ecology is interested in the "vertical" components of landscapes, that is, the "land attributes." These include characteristics such as "...rock, soil, landform, vegetation, atmosphere [climate], animals, and humans including artifacts..." (Zonnefeld 1990: 13). It is also interested in the "horizontal" components of the landscape, known as landscape "elements." "These can be single trees, or patches or clumps of plants, or parcels, but on a wider scale complex areas composed of mosaics of components can also be elements of mosaics of a higher order of magnitude, as units of land (land units)" (Zonnefeld 1990: 13).

Landscape ecologists classify and name landscape elements in order to study them and their interrelationships. Risser (1990) describes *landscapes* as heterogeneous areas ranging from "several to many kilometers" and made up of ecosystems. He uses the term *ecosystem* to refer to a relatively homogeneous area, such as a grassland or deciduous forest, whose "internal processes are driven by characteristics of that ecosystem"[5] (Risser 1990: 45). Risser (1990) states that the difference between a landscape and a *region* is scale - regions are more complex

[5] It is prudent to avoid appropriating the term "ecosystem" for this hierarchical classification of landscapes. "Ecosystem" is widely and rather generally used to refer to a "...physical or abiotic environment in addition to biological components..." (King 1993: 20). In other words, an ecosystem can describe an assemblage of the abiotic and biotic elements of some area, ranging in size from the micro to the universal. Talking in terms of ecosystems may reflect a certain perspective rather than refer to a spatial scale (King 1993).

and spatially heterogeneous than are landscapes. The broad scale of a region makes process studies at that scale impractical:

> ...in the hierarchical sense, landscape ecology focuses on that crucial level where natural and human-influenced processes are consequences of the heterogenous landscape composed of contrasting ecosystems, and at the spatial and temporal scale where these processes can be analyzed" (Risser 1990: 45).

While the system of classification described above dominates the literature, it is not standard and different terms are often used (see Table 1). Some researchers refer to what Risser calls "ecosystems" as *ecotopes* (e.g., Haber 1990, Schreiber 1990, Zonnefeld 1990). As Zonnefeld (1990: 14) explains, the "...smallest homogeneous pieces of land have been called **ecotopes** in landscape ecology...." Ecotopes usually range in size from 100 m^2 to a square kilometre. Interestingly, ecotopes may be considered landscapes in themselves or as an element within a landscape. Zonnefeld (1990: 14) points out that the consideration of ecotopes as elements within a heterogeneous landscape "...emphasizes the character of the landscape as a chorologically heterogeneous complex," and that "the definition of ecotope, as either a landscape or just a landscape element, depends on the weight given within landscape ecology to the chorological versus the topological approach." Zonnefeld (1990: 14) concludes that the most practical description of an ecotope is "...a tract of land where at least one attribute - landform, soil, or vegetation - is homogeneous."

Haber (1990) points out that similar ecotopes share many characteristics in common, and therefore can be distinguished as ecotope types (or *ecotypes*) in order to characterize a landscape. Just as there are common and rare species within ecosystems, there are common and rare ecotypes within a landscape. Therefore, ecotype diversity can be thought of in much the same way as species diversity.

Rather than using the term ecotope, Forman and Godron (1986: 12) talk about *landscape elements* which they describe as "...the basic, relatively homogeneous, ecological

Table 1. **Common classification of spatial scales in landscape ecology.**

TERM:	DESCRIPTION:	SPATIAL SCALE:
Region	•A large area made up of *landscapes* •Too complex and spatially heterogenous for practical study	LARGE ↓
Landscape	•Heterogenous areas ranging from several to many square kilometres •Made up of *ecotopes / landscape elements*	↓
Ecotope / Landscape Element	•Relatively homogeneous areas from 100 to 1000 square metres •Made up of *tesserae* •The most extensive system at this scale is referred to as the *matrix* as it plays the dominant role in the functioning of the landscape •Other systems within the matrix system are referred to as *patches*	↓
Tessera	•The smallest homogeneous unit visible at the landscape scale	SMALL

elements or units on land... (whether they are of natural or human origin). From an ecological perspective these elements may be considered ecosystems." Forman and Godron (1986: 13) identify "...the most homogenous portions within...[an element] as tesserae. A *tessera*...is the smallest homogeneous unit visible at the spatial scale of a landscape."

Forman and Godron (1986: 159) go on to describe how landscapes contain several or many types of landscape elements. "...The most extensive and most connected landscape element type [is called the *matrix*], and...[it] plays the dominant role in the functioning of the landscape (i.e., the flows of energy, materials, and species)." Embedded in the matrix are *patches*. A patch is described as "a nonlinear surface area differing in appearance from its surroundings..." (Forman and Godron 1986: 83).

Patches are a useful concept in terms of understanding changes in the landscape pattern (chorology). For example, Forman and Godron (1986) identify several patch types which correspond to different landscape processes, such as disturbance patches (a result of isolated or chronic disturbance), remnant patches (left untouched within a matrix of disturbed landscape), environmental resource patches (due to uneven distribution of resources such as water or soil types), and introduced patches (originating from human introduction of plants or animals foreign to the site). Indeed, landscape ecology is becoming increasingly interested in going beyond description of landscapes to analysing the processes occurring within them, especially in terms of energy, nutrient, and species flow (Risser 1990). The hierarchical classification of landscapes, whatever the terminology, is very useful for understanding landscape processes. As Woodmansee (1990: 58) states, this hierarchical conceptualization:

> ...allows the placement of processes at meaningful levels within the hierarchy. For example, photosynthesis and nutrient uptake are directly associated with organisms and only indirectly with sites or landscapes. Likewise, erosion and leaching are site-scale rather than broad-scale processes.

This ties in well with the concept of patch dynamics. Pickett and Thompson (1978: 29) define patch dynamics as the dynamics which are "...generated by patterns of disturbance and subsequent patterns of succession...." The characteristics of patch size, density, and frequency are a result of the disturbance regime. Vegetation patches may be created by a number of things: fire, wind and windstorms, ice and snow, natural death, disease and herbivory, and animal disturbance (Pickett and Thompson 1978). When designing a reserve or restoration the disturbance regime must be understood, as must the effects of the disturbances on individual species in the vegetation community. It is important to pay heed to "rare and extensive" disturbances as well as the more regular ones. Pickett and Thompson (1978: 30) suggest that "The critical characteristics of disturbed patches are their size and frequency of occurrence in time."

By approaching the landscape as a unit of study, landscape ecologists can study landscape-level processes and structure. By actually studying heterogeneity, "...an understanding of the whole emerges" (Forman and Godron 1986). This knowledge is useful "...as a basis for planning, managing, improving, and conserving land" (Zonnefeld 1990: 12). As Zonnefeld and Forman (1990: 215) point out, land management must be approached at the scale of a landscape: "...the piecemeal approach [to planning and management] focussing on each little parcel, when combined with broad-scale natural processes and population growth, is leading landscape after landscape toward degradation." Further,

> Understanding the regulatory or control mechanisms in the landscape system is difficult but essential to enlightened planning and management. Mosaic stability, adaptability, and often irregularly cyclic, slowly-changing variables are key descriptors. Integrating hierarchy theory and systems analysis provides a framework for understanding landscape regulation and human decision making (Zonnefeld and Forman 1990: 216).

Both systems theory and landscape ecology concepts prove valuable tools with which to approach landscape and regional management. However, Woodmansee (1990: 58) emphasizes that they *are* concepts and tools, not reality:

> It is important to remember that nature is not simply a grand hierarchy of systems at various levels of organization; rather, ***nature simply is***. We, as humans, can derive great intellectual benefit by using models such as levels of organization and hierarchies as conceptual tools for synthesis and integration.

3.3. Management approaches

While several ecologists advocated an ecosystem approach as early as the 1930s, it was not until the 1980s that it was "...supported by many scientists, managers, and others" (Grumbine 1994a: 28). Grumbine (1994a) points out that the book *Ecosystem Management for Parks and Wilderness* edited by Johnson and Agee (1988) was the first devoted to the subject of ecosystem management. Johnson and Agee (1988) "...embedded ecosystem management within a dynamic pattern-and-process view of nature" (Grumbine 1994a: 28-29), "...brought people directly into the equation..." (Grumbine 1994a: 29), and "...made a key assumption that since what is natural 'cannot be scientifically resolved' management goals must rest on achieving 'socially desirable conditions'" (Grumbine 1994a: 29). Since the publication of this book, there has been an abundance of papers treating the concept of ecosystem management (Grumbine 1994a).

Grumbine (1994a: 29) comments that while ecosystem management "...has not been uniformly defined or consistently applied...," a consensus appears to be forming in the "academic literature." Grumbine (1994a) reviewed a vast amount of literature on the subject from which he drew ten dominant ecosystem management themes:

A. *Context*
Management must be approached from a systems perspective, that is, a perspective that accounts for the interactions between levels in the "biodiversity hierarchy."

B. *Ecological Boundaries*
Management must cross political or administrative boundaries to work within ecological boundaries.

C. *Ecological Integrity*
Management must work to conserve or restore the integrity of the ecosystem.

D. *Data Collection*
Management requires that more research be done and data collected, while also putting the existing data to better use.

E. *Monitoring*
It is vital that the impacts of management strategies be monitored and evaluated quantitatively in order that management practices may be suitably amended.

F. *Adaptive Management*
This is directly related to monitoring. The assumption is that all management practices are in essence "experiments," and that managers must be flexible to adapt their strategies to new information and surprise.

G. *Interagency Cooperation*
Crossing administrative and political boundaries requires the cooperation of various government agencies as well as private parties. The success of ecosystem management is in large part to be determined by the success of this cooperation.

H. *Organizational Change*
Implementation of ecosystem management will require "...changes in the structure of land management agencies and the way they operate" (p. 31).

I. *Humans Embedded in Nature*
Management must be based in the belief that human influence cannot be excluded from the ecosystem to be managed. "Humans are fundamental influences on ecological patterns and processes and are in turn affected by them" (p. 31).

J. *Values*
Management goals are always fundamentally based on value judgements.

From these themes, Grumbine (1994a: 31) defines ecosystem management:[6]

> *Ecosystem management integrates scientific knowledge of ecological relationships within a complex sociopolitical and values framework toward the general goal of protecting native ecosystem integrity over the long term.*

Ecosystem management represents an approach to conservation that is based in some fundamental shifts in attitudes. First, there is a definite shift to a large-scale perspective. Second, there is a recognition that natural systems are ever-changing. Third, there is a commitment to active management and, where necessary, restoration. Fourth, there is an

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[6] In ecosystem management, "ecosystem" is used to refer to a "perspective" that includes the abiotic and biotic components as well as to imply a relatively large-scale approach. The exact scale is not specified as it is within landscape ecology. This description of ecosystem management, however, would point to the landscape and regional level as outlined in the previous section.

explicit acknowledgment of human influence on natural areas. Finally, there is special attention paid to human values as integral to the management process. Ecosystem management rejects the "nature myths" discussed in the previous chapter. Instead, the beliefs are that nature is *here* not there, humans and nature are inseparable, and nature is dynamic and constantly changing. It is interesting to note that an ecosystem management approach to conservation is compatible with McNeely's (1989) principles as discussed in Chapter 2.

One example of an ecosystem management approach is the landscape- or regional-scale approach. Noss (1987) outlines what might be some components of a conservation strategy from a landscape perspective. First, the primary goals of the strategy must "...be ecologically cognizant and be based on a defensible ethical position" (Noss 1987: 4). Noss (1987) stresses that while all science is inherently value-laden, conservation biology may be more so than any other discipline. Therefore, a value system should be explicitly outlined in order to guide the development of goals and objectives.

Second, Noss (1987: 4) stresses that large areas are "...more defensible and will contain larger populations that will be less vulnerable to extinction...." Where the reserve cannot contain a "minimum dynamic area"[7] (as is often the case), natural areas may be arranged to act as a system of connected patches which "...may provide some of the functions of a minimum dynamic area, such as recolonization sources, gene flow, a mix of habitats in the system as a whole, and alternative refugia for species to escape natural enemies and disturbance episodes" (pp. 4-5). Noss (1987) emphasizes, however, that it may still be critical to preserve or restore habitat of necessary extent to allow the persistence of those species which require the largest areas, such as large predators.

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[7] Noss (1987) cites Pickett and Thompson (1978: 34) who define a minimum dynamic area as "...'the smallest area with a natural disturbance regime, which contains internal recolonization sources, and hence minimizes extinction'". Special attention is given to conserving "...'the most extinction-prone taxon,' such as a large carnivore" (Noss 1987: 4).

Third, Noss (1987) points to the necessity of designing a system of reserves that represents the many community variations over space. In this way, a wider variety of diversity is protected.

Fourth, Noss (1987) discusses the importance of "multiple-use zoning." Buffer zones around core protected areas can mitigate against boundary threats. Zoning, in combination with corridors, can be used to develop "...an integrated network of clustered reserves." Figure 3 illustrates multiple-use zoning.

Finally, Noss (1987) raises the important role of ecological restoration and management in the conservation strategy. Restoration, to some degree, is required in almost any situation, the impact of human activities being so extensive. In highly altered landscapes, such as some areas of southern Saskatchewan, the core preserves themselves may need to be, in part or entirety, areas that have been restored to the pre-cultivation community types. Indeed, without extensive restoration work, the concept of a multiple-use reserve network may not be feasible.

The impetus for the change in management scale is that the site scale approach is not effective in conserving many species. Noss (1987) emphasizes that many of the threats to conservation of protected areas are a result of a focus on the "elements" contained within a site, rather than a landscape level approach. Some of the threats that result from the element-based approach are habitat fragmentation, road networks, inappropriate boundaries, and inappropriate management. For example, with a site-by-site management approach, most sites are managed for habitat diversity, as the edges between different community types or successional stages contain the most diverse assortment of species (Noss 1983). This type of management, argues Noss (1983: 701), is "...deeply entrenched in the land management profession." But there are several problems with this approach. For one thing, edge species tend to be rather widespread, "rarely in danger of extinction" (Noss 1983: 702). Second,

Multiple-Use Reserve Network

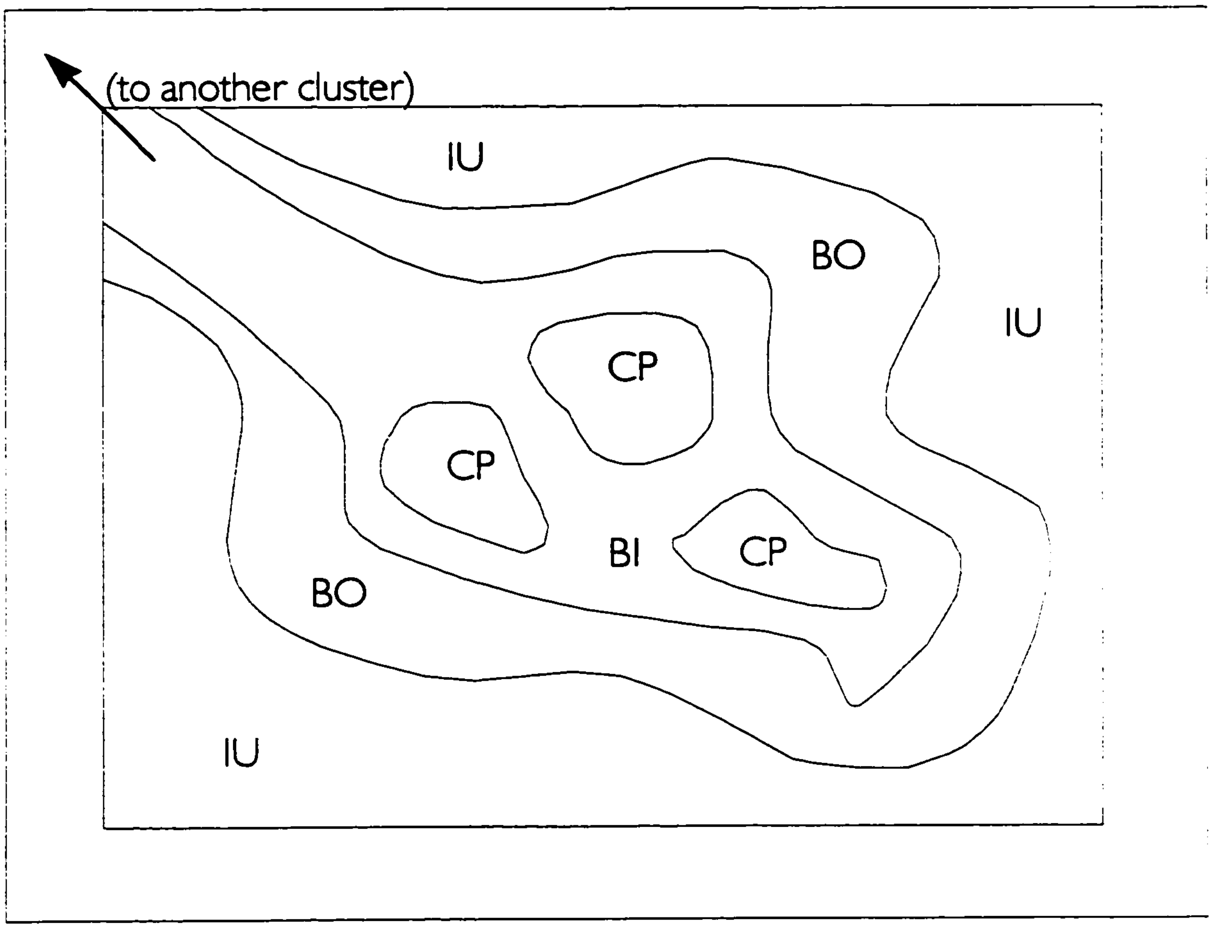

Figure 3. An example of a multiple-use reserve network.

The three core preserves (CP) are within a larger inner buffer zone (BI) that receives only low-intensity use. This contiguous area is further protected by the outer buffer zone (BO) that serves to shield the complex from the surrounding intensive land use (IU). This cluster of preserves is linked to another cluster (not shown) by a broad habitat corridor (after Noss 1987: 7). In most landscapes, restoration will be required to establish corridors, and in many cases, the reserve clusters themselves will be the products of restoration efforts.

because the sites are small to begin with, maintaining patch diversity within them further restricts the area of suitable habitat. Many species require larger areas than provided by these patches. In other words, "...habitats are fragmented within preserves in addition to outside them..." (Noss 1983: 702). Often, the species which are threatened are those which have not been able to adapt to fragmentation in the first place.

Noss (1983) argues that the regional landscape is a more appropriate scale at which to manage for diversity. A regional-scale perspective on biodiversity conservation may lead to quite different management decisions. For example, loss of a species on a particular site may not have consequences on regional biodiversity where the species is abundant on a regional or global scale (O'Connell and Noss 1992). Ecological processes are also more likely to be sufficiently considered under a regional perspective. For example, hydrological processes that are regional in nature are unlikely to be conserved under a site-specific strategy. "Rather than endorsing a specific set of land-use practices, a regional and global perspective simply puts site management in a broader, more ecologically-informed context" (O'Connell and Noss 1992: 438).

Noss (1983) argues that a landscape perspective reveals patterns that are not obvious at a smaller scale. This is consistent with the system property of "ordered wholeness" (Laszlo 1972) - a system exhibits emergent properties as a result of the interactions of its constituent parts. Such emergent properties or patterns include "...regional trends in extinction and colonization, relative abundances of species and habitat types, and spatiotemporal dynamics of the structural components of a landscape" (Noss 1983: 704). A regional conservation perspective focuses attention on the composition and abundance of species, rather than on numbers. It also focuses attention on species which have been seriously reduced in numbers and territory rather than on those which are widespread or even over-abundant (Noss 1983). Noss (1983: 704) contends that land management which concentrates on providing "maximum critical habitat area" and on protecting those species which are most threatened with extinction is "...the most prudent approach to long-term conservation."

Noss (1987) believes that landscape ecology can provide a foundation from which to develop a conservation strategy that deals with these and other threats to natural areas. From this perspective, O'Connell and Noss (1992) develop a land management plan for private land owners in a series of steps. The first step is a site inventory of species, communities, and major ecological processes. The second step is to place the site in the context of its surroundings. What are the relationships between the site and neighbouring areas and what role does the site play in terms of regional and global biodiversity? O'Connell and Noss (1992) suggest that this analysis allows managers to evaluate the site and classify it in terms of its relative significance to regional and global conservation, thereby permitting an informed land-use strategy to be put in place.

O'Connell and Noss (1992) suggest six classes of sites, ranging from those of high significance to global diversity down to those which are degraded and contain no natural communities and few native species. Each classification outlines "Management objectives...[which] provide guidance to develop site plans integrating economic land use with biodiversity conservation" (O'Connell and Noss 1992: 440-441). This is of concern to private land owners in particular.

Noss and Harris (1986: 303) argue that the large scale (both spatial and temporal) at which many ecological processes take place implies that "...isolated protected areas (even when quite large) are an inappropriate design for long-term conservation." In order to restore or maintain some of these large scale processes, the focus must be on the landscape and the long term when designing a conservation plan (Noss and Harris 1986). Noss and Harris (1986) suggest approaching the conservation plan in terms of nodes, networks, and multiple-use modules [MUMs]. Nodes refer to sites of "unusually high conservation value." These sites would have highest priority protection, but they "...must be buffered, interconnected, and permitted to interact with surrounding natural habitats" (Noss and Harris 1986: 304). A system of connections between nodes - the network - consists of linear corridors which serve to facilitate movement among nodes:

> The network must provide for the dispersal and maintenance of adequate populations of native species, with the most demanding species...being ultimate indicators of failure or success. A network could conceivably also facilitate the shifting of habitat patches across the landscape in mosaic patterns of disturbance and recovery, that is, by providing colonization sources and refugia (Noss and Harris 1986: 305).

MUMs[8] (here) refer to degrees of protection in a landscape, with highly protected core areas (in this case nodes) buffered by zones of land use that increase outward in terms of human use.

Noss and Harris (1986) maintain that funding and staffing constraints force a narrowness of vision upon resource managers and conservationists - a narrowness of both "spatial and temporal dimensions." However, with a landscape perspective, it becomes evident that although local fluctuations can be severe, on a landscape level species composition may remain surprisingly steady: "A landscape can...be understood as a heterogeneous and ever-changing entity that nevertheless maintains a constancy and predictability of disturbance and recovery patterns in a time scale meaningful to human beings" (Noss and Harris 1986: 300). However, "...the processes that maintain spatiotemporal heterogeneity in 'whole' ecosystems are generally not functional in small, isolated nature preserves" (Noss and Harris 1986: 300).

Noss and Harris (1986) summarize what they see as the four major limits to conservation. They suggest that conservation can be limited based on the extent to which it:

> (a) is static (that is, does not effectively deal with continuous biotic change), (b) focuses on individual parks and preserves (*content*) instead of whole landscapes (*context*), (c) focuses on populations and species instead of the larger systems in which they interact, and/or on relatively homogeneous communities rather than on heterogenous mosaics, and (d) is oriented toward maintenance of high species diversity instead of characteristic 'native diversity' (Noss and Harris 1986: 301).

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[8] Noss and Harris 1986 cite Harris (1984).

Reive et al. (1994) outline a management program for Southern Ontario's Point Pelee National Park which illustrates how the recent changes in management philosophy may be operationalized. The program considers "...park operations and park integrity running in parallel with regional ecosystem integrity and institutional arrangements as major components with restoration integrated into ecosystem management" (Reive et al. 1994: 11). The two goals of the program are to: "Maximize the ecological integrity of Point Pelee National Park by contributing to the conservation of natural diversity of the Carolinian biome in Canada...."; and, "Maximize the ecological integrity of the Carolinian and southern Great Lakes marsh ecosystems within Point Pelee National Park" (Reive et al. 1994: 12).

There are several ecosystem management characteristics evident in this program, and correspondingly, the program is quite successful in fulfilling McNeely's (1989) recommendations. Of special note is the expanded concept of protected areas. One of the two main program goals at Point Pelee National Park is centred around region-wide initiatives that extend well beyond the park boundaries. The park is seen within the context of a region, i.e., the park boundaries are recognized to be insufficient and regional conservation goals are considered. At the same time, the park is seen within the context of social institutions, i.e., human social structures are accounted for. Attention is paid to the encouragement and support of local conservation initiatives. This concern could potentially contribute to the broadening of the responsibility for conservation beyond government agencies. Finally, there is a commitment to active management and even restoration, with ecosystem integrity being a central goal.

Grumbine (1994a: 34) sees the move toward ecosystem management as part of a fundamental change in how this society views and values nature. Ecosystem management forces humans to acknowledge their utter involvement with the earth, and in this way it "...gains importance far beyond finding new ways to manage parks and forests." Grumbine

(1994a: 35) argues that:

> ...the success of ecosystem management is tangled up with the degree to which this fence [that has been erected between people and nature] must be reduced or discarded, if maintenance of the boundary is the root problem that has created the biodiversity crisis in the first place.

Ecosystem management is valuable to restoration management and planning. It is a holistic approach that focuses on whole system thinking and the linkages between humans and natural habitats.

3.4. Summary

Systems theory attempts to address whole systems rather than the separate system components. Interest lies in the connections and changes within and between systems, whereas reductionist science tends to remove connections by the very process of breaking systems down into separate components. Central to systems theory are four main properties of natural systems as outlined by Laszlo (1972): systems display properties that emerge out of the relationships between their constituent parts, and therefore these properties are not observed when the constituent parts are studied separately; systems may adapt to perturbations by dampening the effects of the stress in order to return to the pre-perturbation state; systems may adapt to perturbations by amplifying their effects, which results in a system reorganization to a new state; and, systems display vertical hierarchies of organization, that is, every system is composed of sub-systems and is itself a sub-system, with each higher level of organization possessing more diverse functions and properties. These four properties are fundamental to the rationale behind many aspects of current management and planning techniques.

For example, landscape ecology grew out of the systems theory perspective. Like systems theory, landscape ecology is concerned with issues of scale and change, and the interactions within and between systems. Landscape ecology can be seen as an application of systems theory to natural systems planning, management, and research.

More generally, the "ecosystem management" approach to conservation has its roots in a systems theory perspective. Ecosystem management is characterized by a concern with scale interactions and an ecosystem or landscape scale perspective. Ecosystem management also illustrates a change of attitudes and beliefs. Humans and social constructs are considered part of the ecosystem, and the role of human values in conservation is emphasized. There is acceptance that management decisions are value based. Further, active management in "natural" areas is seen as necessary and appropriate, as are restorative efforts. Ecosystem management, then, may be seen as the approach that integrates holistic values and beliefs, values and beliefs that emerge from seeing the world (in which humans are firmly intertwined) as interconnected and dynamic.

Restoration of ecosystems can be soundly based on these perspectives. The whole-system approach to conservation planning and management as provided by landscape ecology theory and ecosystem management is vital to conservation success. Furthermore, the inclusion of human influences and values in the conservation problem is in keeping with a guiding principle of restoration - humans are inseparable from the world around them. Ecological integrity will be examined in the next chapter, as it is a natural out-growth of these approaches and is a conservation/restoration goal that integrates the values and beliefs that lead to more holistic dealings with human habitats.

4. DEFINING, MONITORING, AND RESTORING ECOLOGICAL INTEGRITY

There are two issues central to successful conservation that are also fundamental goals of ecological restoration - biodiversity and ecological integrity. Both of these terms suffer from misuse and misunderstanding. The following discussion will attempt to clarify the meanings and implications of these terms, as well as their relevance to issues of restoration.

4.1. Biodiversity

Biodiversity is a term that appears frequently in discussions about species, ecosystem, or landscape conservation. It may be safe to say, however, that relatively few people consider the full meaning of biological diversity. The concept of biodiversity involves several levels of organization - usually "...genetic, population/species, community/ecosystem, and landscape or regional" (Noss and Cooperrider 1994: 5). Each of these levels can then be considered in terms of their compositional, structural, and functional characteristics. Noss and Cooperrider (1994: 5) explain:

> Composition includes the genetic constitution of populations, the identity and relative abundances of species in a natural community, and the kinds of habitats and communities distributed across the landscape. Structure includes the sequence of pools and riffles in a stream, down logs and snags in a forest, the dispersion and vertical layering of plants, and the horizontal patchiness of vegetation at many spatial scales. Function includes the climatic, geological, hydrological, ecological, and evolutional processes that generate and maintain biodiversity in ever-changing patterns over time.

Based on these ideas, Noss and Cooperrider (1994: 5) provide a definition of biodiversity[9]:

> Biodiversity is the variety of life and its processes. It includes the variety of living organisms, the genetic differences among them, the communities and ecosystems in which they occur, and the chorological and evolutionary processes that keep them functioning, yet ever changing and adapting.

Noss and Cooperrider (1994) discuss in greater detail the goals of biodiversity

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[9] This definition is referred to by the authors as a "...modification of a definition developed by the Keystone Dialogue...." (Keystone Center 1991).

conservation at each level of organization (see Figure 4). Important issues at the genetic level include the maintenance of genetic variation both "...within and among populations of species...," as well as the continued normal functioning of processes of genetic differentiation and gene flow (Noss and Cooperrider 1994: 6).

At the species level, concerns include the maintenance of "...viable populations of all native species in natural patterns of abundance and distribution" (Noss and Cooperrider 1994: 7). Because managing for every species is impractical, it may be prudent to focus attention on certain species. "Umbrella" or "flagship" species, for example, are those which have the most demanding habitat requirements, such as grizzly bears. Theoretically, providing adequate habitat for viable populations of these species should ensure that the needs of other species will be met. However, certain species would not be protected by such an approach alone, e.g., species with very limited ranges. There are also species which are especially sensitive to human activity, and which therefore need special management attention in order to conserve viable populations (Noss and Cooperrider 1994).

At the level of the community ("an interacting assemblage of species in an area") or ecosystem ("a biotic community plus its abiotic environment"), biodiversity conservation is fundamentally concerned with "representing all native ecosystems in a network of protected areas..." (Noss and Cooperrider 1994: 9). The reasoning behind this is that by maintaining "...intact, ecologically functional examples of each type of ecosystem in a region, then the species that live in these ecosystems will also persist" (Noss and Cooperrider 1994: 9). [10]

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[10] Simply protecting a percentage of each landscape type would likely not ensure the conservation of biodiversity. As previously discussed, protecting small areas of the landscape while exploitation continues outside of these boundaries is inadequate. While at least some portion of each landscape type should be assured a relatively high level of protection, this should not be to the exclusion of conservation management and appropriate use across the rest of the landscape.

GOALS OF BIODIVERSITY CONSERVATION

Genetic Level of Organization

• maintenance of genetic variation within and among populations
• maintenance of normal functioning of genetic differentiation and gene flow processes

Species / Population Level of Organization

• maintenance of viable populations of indigenous species in historic patterns of abundance and distribution
• maintenance of normal interactions among populations, such as inter-breeding and inter-pollination

Ecosystem / Community Level of Organization

• representation of native ecosystems in a network of protected areas
• maintenance of historic disturbances and ecosystem processes

Landscape / Regional Level of Organization

• maintenance of a diversity of habitat types and communities across a large and contiguous land area
• maintenance of disturbances, migration, hydrological processes, and landform evolution at the regional scale

Figure 4. The goals of biodiversity conservation relevant to four levels of organization.

The characteristics of composition, structure, and function vary with the scale of organization, as do goals of biodiversity conservation (after Noss and Cooperrider 1994).

Some of the important processes to be maintained include "...natural disturbances [such as fire], hydrological cycles, nutrient cycling, plant-herbivore interactions, predation, mycorrhizal interactions between tree and shrub roots and fungi, and soil building processes" (Noss and Cooperrider 1994: 9).

Noss and Cooperrider (1994: 11) define a region as "...large landscapes that can be distinguished from other regions on the basis of climate, physiography, soils, species composition patterns, and other variables." Landscape and regional biodiversity involves maintaining the natural patterns within and among landscapes: "Landscape or regional diversity is pattern diversity - the pattern of habitats and species assemblages across a land area of thousands to millions of acres - and can be considered a higher level expression of biodiversity" (Noss and Cooperrider 1994: 11). These patterns have effects that are translated through the lower levels of organization, and changes may affect "...species composition and abundances, gene flow, and ecosystem processes" (Noss and Cooperrider 1994: 11). Therefore, one of the main conservation goals at the landscape and regional level is the maintenance of "..complete, unfragmented environmental gradients" (Noss and Cooperrider 1994: 12). This means that protection must exist for more than simply the most species-rich areas or (as is more often the case) the areas which are marginal for economic uses:

> Preserving only...portions of environmental gradients is no solution, because different species occupy different portions. Conservation programs must strive to maintain natural ecosystems and biodiversity across the full extent of environmental gradients (Noss and Cooperrider 1994: 12).

Extending biodiversity conservation to the landscape and regional scale is critical, as many ecological processes (such as "natural fire regimes, migration of large animals, landform evolution, and hydrological cycles...") will only persist at this scale of protection (Noss and Cooperrider 1994: 12-13).

The major processes that serve to maintain biodiversity are: energy flows, nutrient cycles, hydrologic cycles, disturbance regimes, equilibrium processes, and feedback mechanisms. Threats to biodiversity, then, are those forces that interfere with the normal functioning of the basic forces which are responsible for the persistence of biodiversity (Noss and Cooperrider 1994).

4.2. Ecological integrity

Another term that has come into popular usage but is perhaps less understood than biodiversity is "ecological integrity." In Chapter 2 it was proposed that ecological integrity may be a useful goal of restoration. However, scientists themselves disagree on a standard definition of ecological integrity. It is difficult to define this term since ecological systems are extremely complex and knowledge of them is limited. There is a measure of uncertainty inherent in determining which system characteristics indicate integrity. Another difficulty is that value judgments play a large role in defining desired ecosystem characteristics, a role that is heightened because of the lack of clear and proven scientific explanations in this area.

In the midst of the unanswered questions conservation and management decisions must still be made. Although the definition of ecological integrity remains in a developmental stage, it is still an important concept, as it considers the state of the entire ecosystem. As King (1993: 24) writes:

> Integrity...generally refers to the soundness or completeness of some thing, the state of being whole and unimpaired....We understand, intuitively, what it means for an ecosystem to be in that state. However, monitoring, managing, quantifying, analyzing, or legislating ecosystem integrity requires a more precisely defined, more objective or empirical, concept of ecosystem integrity.

In addition to the vagueness of the term, "...there are significant differences of opinion as to the meaning and relevance of 'ecological integrity,' and...there is disagreement as to the measures that should be used to index it" (Steedman and Haider 1993: 47). The various conceptions of ecological integrity will be examined in an attempt to clarify the issues surrounding its use as a tool of environmental assessment.

The concept of ecological integrity is intuitively understandable, but intuition alone is not sufficient to guide management decisions (King 1993). One problem is that there are no "simple, rigorous models" to guide the search for qualities of integrity.[11] How, then, do researchers approach the problem? Some assume that the attempt to develop simple, rigorous models is a "wrong-headed" approach to the problem, or that a simple definition of ecological integrity is not possible because of the nature of ecosystems:

> When we are dealing with ecological systems, we are dealing with complex systems which require complex descriptions that are case specific. Simple answers, definitions and hypotheses (like species diversity leads to ecological stability) are never adequate for discussing complex systems and, by implication, ecological integrity (Kay 1993: 201).

Regier (1993: 13) also admits that "we know of no way to sketch the concept of ecosystem integrity in a linear, closed way," but adds, "in fact, to do so would be contradictory to its meaning."

In a general sense, however, most commentators maintain that the integrity of a system involves both the structure and function of that system. In other words, a system with integrity maintains and organizes itself, at the same time as it supports indigenous biota similar to that present when little cultural stress[12] was imposed upon it (Karr 1993). In this sense, Noss (1994: 28) claims that "a sound definition of integrity must be based on evolutionary and biogeographic context." That is, a well-functioning ecosystem alone does not exhibit integrity. The ecosystem must also structurally and compositionally resemble the ecosystems that have evolved in that place.

King (1993: 25) agrees that structure is part of the concept of integrity, but believes that "...the intuitive concept of ecosystem integrity is biassed towards functional integrity, the

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[11] Keddy et al. (1993: 61) cite Peters (1991) and Rigler (1982).

[12] The term stress is used to mean "...a detrimental or disorganizing influence" (Odum 1985: 419).

state of being unimpaired." The reason for this bias may be that redundancy in an ecosystem often allows similar functions to be performed by more than one structural component. This redundancy means that ecosystems are very resilient to changes in their structure (King 1993; Odum 1985).

The bias towards functional integrity is evident in definitions of ecological integrity that focus on the self-maintenance and self-organizational abilities of ecosystems. Systems theory provides an approach to defining ecosystem states within a context of continuous and complex change. For example, Kay (1993: 205) uses the term "optimum operating point" to describe "the point where the disorganizing forces of external environmental change and the organizing thermodynamic forces are balanced...." From this, it is proposed that an ecosystem that has the ability to "...maintain an optimum operating point under normal environmental conditions" may be considered healthy (Kay 1993: 205). Ecosystem health, then, can be characterized by self-maintenance under normal stress conditions. Because of the dynamic nature of living things, however, it is insufficient to describe integrity in terms of the maintenance of a stable equilibrium state (Kay 1993). An ecosystem with integrity has the characteristics of health as well as the ability to "...attain and maintain an optimum operating point when stressed" (Kay 1993: 205), and to "...continue evolving and developing, that is, continue the process of self-organization on an ongoing basis" (Kay 1993: 206). Ecosystem integrity goes beyond the concept of ecosystem health. An ecosystem with integrity must in some way be able to adapt to unexpected perturbations and to continuously incorporate new "information" into its organization.

This definition of integrity, though, is not easy to apply in practice. Noss (1994: 29) agrees that integrity implies the continuation of ecosystem development, but questions whether anyone "...who is not a systems modeler could distinguish an 'optimum operating point' or know when an ecosystem is or is not continuing the process of self-organization."

Along with the difficulties in defining ecological integrity imposed by the complexity of ecosystems, the inherent role of human values in determining ecological integrity can be problematic. Rapport (1990) discusses the role that values play in assessing the condition of an ecosystem. He states, for example, that perceiving stability as an indicator of health "...arises naturally in a technocratic society where the importance of control and dependability is paramount" (Rapport 1990: 127-8). Likewise productivity may be perceived to be an indicator of health, but again this grows out of the values of a society that is "...oriented toward achieving high levels of economic well-being" (Rapport 1990: 128). Therefore, although growth, production, and reproduction may increase in certain species when normal system regulatory mechanisms break down, cultural biases may lead to the interpretation of such changes as favourable; a system may be assessed as being in the peak of health just before it breaks down entirely (Ryder 1990). Issues of values must be set within a context of ecological realities. For example, although acidified lakes are clear and offer improved swimming and boating opportunities, they should not be considered as representing a desired state (Rapport 1990).

Values enter the discussion of integrity in another way. Both Regier (1993) and Kay (1991a; 1991b; 1993) emphasize that any system has a number of optimum operating points (or "end-states" in the language of Regier) that could be considered as exhibiting integrity. Thus, "there is room for choice in the kinds of ecosystems with integrity that humans might prefer" (Regier 1993: 16). Evaluating ecological integrity must go beyond the scientific evaluation of integrity because more than one state of integrity can exist. As Regier (1993: 3) writes, "The notion of ecosystem integrity is rooted in certain ecological concepts combined with certain sets of human values." Kay (1991b: 30) maintains that "...if the concept of integrity is to be useful, it must have an anthropocentric component that indicates which changes in the ecosystem are considered acceptable by human participants."

So it is ***unacceptable*** change in the optimum operating point that is considered to indicate a "loss of integrity" (Kay 1993: 208). Change in itself is not undesirable - in fact it is unavoidable:

> ...the reorganized ecosystem is usually just as healthy as the original, even though it may be different. There is no *prima facie* scientific reason that an existing ecosystem should be considered to be the only one to have integrity in a situation, just because of its primacy (Kay 1993: 206).

In fact, while certain ecosystems may be considered to be at their climax, on a larger time scale such a system is only transitory (Kelly and Harwell 1990). All of these considerations of human value judgements underscore a fundamental systems theory perception that the observer is always part of the observations. Kelly and Harwell (1990: 529) quote Levin (1987): "...one must recognize that the pattern seen as characteristic of any system is 'neither a property of the system alone nor of the observer, but of an interaction between them.'"

While these difficulties are recognized, attempts are still made to define and assess integrity. Ecological integrity cannot be directly measured, however (Noss 1994). In order to put the concept of ecological integrity to practical use, variables that indicate the integrity or lack of integrity of a particular ecosystem must be chosen and measured:

> ...to define ecological integrity is to define a set of ecological characteristics to monitor for change beyond specific values. To operationalize the notion of integrity requires the development of a monitoring framework and its associated measures and indicators (Kay 1993: 208).

As the issues discussed above illustrate, defining ecological integrity is no small task. "When we define ecological integrity, we are undertaking to integrate everything we know about an ecological system and where we want it to be" (Kay 1993: 210). There are many challenges inherent to the assessment of ecosystems and to ecological integrity in particular. From the definition to the operationalization of integrity, there are scientific and social obstacles. The limitations of science are significant, but the reality is that decisions must still be made:

> Although existing knowledge is not sufficient to make absolutely reliable resource decisions, neither can we afford the luxury of placing natural resource decisions on hold until that level of knowledge is available (Karr 1993: 84).

Because of the lack of scientifically proven knowledge, many decisions will be made as much on the basis of "the intuition and experience of biologists..." as on "...empirical research and theory" (Noss 1994: 52).

Action can be taken that will aid in decision making in the long term, however. Setting up large scale, long term experiments in which ecosystem characteristics can be monitored in both relatively pristine and perturbed areas will help to illustrate in a quantifiable way how ecosystems exhibit integrity or a lack thereof (Schindler 1987).

Perhaps the necessity to address the difficult issues of bias and values in our assessment of ecosystems will force attention toward the conceptual alienation of humans from "natural" systems and a problem that modern Western society has yet to solve: "How can this society interact positively with the environment?" Perhaps understanding will emerge through attempting to "...seek and maintain the integrity of a combined natural/cultural ecosystem which is an expression of both ecological understanding and an ethic that guides the search for proper relationships" (Regier 1993: 3). Certainly the difficulties in defining and assessing integrity are not reason to abandon the search for understanding. However, since ecological integrity is not fully understood, care must be taken to employ this term appropriately. Proposed indicators of ecological integrity will now be discussed.

4.3. Monitoring integrity

The monitoring of ecological integrity should be based on a broad range of parameters. In practice there has tended to be a "...reliance on single measures (e.g., diversity or productivity) for identification of a health state or condition...because the number of proven diagnostic tests known for ecosystems is small and often unspecific" (Schaeffer et al. 1988: 446). However, "the complexity of ecological systems limits the likelihood that any single attribute can be used to assess all forms of degradation and be sensitive across the full range of degradation" (Karr 1993: 92-93). Therefore, a wide range of indicators or suites of indicators (Noss 1994) must be measured in order to obtain a clear and comprehensive picture of ecosystem integrity. Karr (1993) points out that measuring a number of attributes also provides several somewhat independent assessments of the ecological state of an area. A range of measures also allows for the important assessment of cumulative impacts:

> ...as with a [human] patient, we can monitor a series of infections, none of which exceeds dangerous levels, but the patient is still dying from the overall weakening of the body. Ecosystem monitoring focuses on sets of indicators to establish the cumulative impact and causes of all sources of pollution and disturbance harmful to ecosystem health" (Marshall et al. 1993: 122).

This broad range of integrity indicators must include social as well as physical and biological components. Social issues and values are often excluded from ecosystem analysis, perhaps because of the belief in objective science - a science that is free of human values. The inclusion of social issues destroys any illusion of objectivity by bringing qualitative and "fuzzy" information into the study (Kay 1993). Characteristics of an ecosystem that are associated with social factors, however, "...should not be excluded by a prejudice for natural, ecological, or scientific perspectives" (King 1993: 27). The inclusion of social issues and values is vital to the assessment of ecological integrity simply because they are a reality (Kay 1993). "...[A] discussion of ecological integrity without a discussion of the social, economic, political and policy concerns is not a meaningful discussion" (Kay 1993: 202).

Another consideration is that a relatively precise definition of the indicators of integrity can only be developed in reference to unique ecosystems (Kay 1991a; 1991b; 1993; Woodley 1993). Therefore, the development of a monitoring framework must rely on "...an analysis of the system we are examining" (Kay 1993: 201). Besides identifying the unique characteristics of the system, this analysis must consider scale and hierarchy, i.e., the relationships between the various scales (Kay 1993). First, the spatial and temporal boundaries that will define the ecosystem should be identified, based upon either existing management units or system processes (King 1993). Not only does this aid in understanding the ecosystem in question, it helps to clarify which variables are pertinent to the study (Kay 1993) as the potential parameters and relevant ecological processes vary with the level at which the particular system sits within the "ecological hierarchy" (Keddy 1991; Schaeffer et al. 1988; Shackell et al. 1993). As King (1993: 29) points out, "concepts of normalcy, constancy, variability, and thus, ecosystem integrity are only meaningful within the bounds set by the scale of observation."

The choice of scale is an issue both in terms of time and space. To illustrate, consider the impact of fire on an ecosystem. The effects of fire may be quite devastating to an ecosystem in the short term as well as to many individual organisms permanently. When viewed on a larger time and spatial/hierarchical scale, however, it becomes apparent that it is the *absence* of fire that may threaten the persistence of the ecosystem overall (King 1993; Odum 1985).

Temporal perspectives have other consequences on the perception of impacts. Certain changes may not immediately impact an ecosystem but may have "...implications for the ability of an ecosystem to respond to future environmental changes..." (Kay 1991b: 31). Or, troublesome changes may not be serious in the long term: "...if the degree of degradation of ecosystem health is limited by system resiliency or managerial intervention" it may be acceptable (Schaeffer et al. 1988: 448). In fact, "...recovery...is possible and often leads to improved system resistance to future...insults" (Schaeffer et al. 1988: 447).

Differing perspectives on the spatial/hierarchical scale also leads to differing interpretations of ecosystem change. King (1993: 34) uses basic systems theory concepts to explain how undesirable changes at lower levels in the hierarchy of an ecosystem are dampened so that they do not seriously affect higher level functions:

> The responses of higher levels are integrated, averaged, responses of lower levels. Thus, a detectable response of a higher level to perturbation, fluctuation, in a lower level requires either very strong change in one or a few lower level components or very extensive change in most or all of the lower level components.

However, when a perturbation impacts the higher level, its components (lower levels) are usually constrained to feel the impacts as well. This is what King (1993: 34) refers to as the "...asymmetry of interaction in the vertical structure of a hierarchical system...." This has obvious implications for both monitoring strategies and the assessment of measured changes in an ecosystem. On the one hand, it leads us to believe that macro scale measurements are most practical, based on the assumption that the well-being of the ecosystem should ensure the well-being of the species within it (Keddy 1991). There is a practical advantage in measuring ecosystem scale characteristics, in that such characteristics will more likely indicate the state of the entire system while requiring a minimum number of observations (King 1993). There are doubts that species scale monitoring could adequately characterize the condition of the ecosystem, especially since most species level research focuses on species in isolation (Spellerberg 1991).

The "asymmetry of vertical interaction" also makes clear, though, that ecosystem level measures alone may be inadequate if early detection of stress is desired, as changes at the ecosystem level would usually indicate either serious lower level fluctuations or a breakdown in the feedback mechanisms of the system (King 1993; Odum 1985; Schaeffer et al. 1988; Schindler 1987). At this point, remedial action may not be successful.

Whereas it is extremely difficult to detect small changes in "large open systems," microorganisms, for example, often respond very quickly to environmental changes (Odum 1985). Therefore, while ecosystem level monitoring is extremely useful, there needs to be both ecosystem level and component level research. Large scale indicators should be accompanied by finer measurements, so that significant trends may be easily detected while finer scale indicators of developing problems are also monitored (King 1993). The various subdisciplines of ecology, which are divided according to the particular level of organization that each examines (organism, population, community, ecosystem), should also concentrate on their interdependencies (Brown and Roughgarden 1990). Different levels of organization need to be studied and understood in terms of their relationships within the ecosystem hierarchy.

Because a disturbance will affect the various ecosystem components and the ecosystem in different ways, in different degrees, and for different lengths of time, Kelly and Harwell (1990: 531) believe that suites of indicators should be made up of indicators that refer to "...only some chosen facet of the ecosystem - biotic or abiotic, structural or functional - at some spatiotemporal scale of observation." No measure or suite of measures on its own could fully represent the state of the ecosystem, but together they can provide a relatively comprehensive representation of the ecosystem condition.

In terms of monitoring integrity in national parks, Woodley (1993) proposes that an ecosystem level monitoring approach should be carried out alongside threat specific monitoring where individual stresses have been identified. Meanwhile, Noss (1994: 41) advocates a:

> ...hierarchical coarse filter approach where sites are evaluated from the broadest scale first. When higher resolution or greater detail is desired, one can work down the nested hierarchy to communities and populations in a stepwise fashion.

Whatever the approach, it is extremely important that the unique qualities and/or limitations of the chosen scale be explicitly considered at all stages in the assessment process.

Because indicators of ecological integrity must be chosen from an almost infinite number of possible measures, a great deal of consideration is required to identify those that are relevant to the ecosystem in question. Keddy et al. (1993) suggest that indicators might be selected in several ways, one of which is to rank the factors that are essential to the maintenance and control of a particular community type, and then to choose indicators that signal changes in those factors. Another method is to study damaged or stressed ecosystems in order to learn which measurable characteristics accompany the degraded condition.

There are many suggestions as to what characteristics these indicators should have so that they are as useful and practical as possible. The following is a sample of some of the proposed criteria that indicators of integrity should meet:

1. Indicators of integrity should grow out of a conceptual framework that is strongly rooted in current ecological principles of ecosystem behaviour (Karr 1993; Munn 1993). The relationship between the indicator and the integrity of the ecosystem should be valid, and the correspondence between them should be regularly tested (Noss 1994).

2. Indicators should be extremely sensitive; they should signal potential problems by responding quickly to stresses. In other words, they should indicate that there is a potential of degradation before serious damage is done (Keddy et al. 1993; Kelly and Harwell 1990; Marshall et al. 1993; Munn 1993; Noss 1994; Schindler 1987; Woodley 1993).

3. The processes of choosing, quantifying, and evaluating the indicators should be based on "good science;" that is, procedures should meet high standards of objectivity, quality, and reproducibility (Karr 1993; Marshall et al. 1993; Munn 1993; Steedman and Haider 1993).

4. Indicators should be relatively simple to measure (Keddy et al. 1993; Kelly and Harwell 1990; Marshall et al. 1993; Noss 1994; Schindler 1987; Woodley 1993) and relatively inexpensive to measure (Noss 1994; Schindler 1987) so that they may "...survive budget cuts in funding agencies during periods of austerity" (Schindler 1987: 14).

5. Indicators must account for the open system nature of ecosystems, i.e., externalities must be monitored (Munn 1993).

6. Ideally, indicators should be able to detect degrees of degradation and/or integrity on a continuum from stressed to non-stressed (Woodley 1993).

7. The indicator should be able to distinguish between human-induced changes and normal ecosystem fluctuations (Noss 1994).

With these criteria in mind, indicators can be identified. Although a decision may be made about which characteristics or qualities in an ecosystem represent integrity, choosing indicators that help establish whether or not those qualities are present is a difficult task (Noss 1994).

Each ecosystem will respond to and be subject to stress in varying ways, but there are some commonly observed indicators of stress response (Freedman 1989). Many general indicators of ecosystem integrity and health and/or disease have been proposed. Several are listed here, most of which are retrospective indicators of stress, i.e., they are symptoms of stress. These indicators generally rely on the observation of change in some system characteristic. In the case of a relatively new restoration this is not a practical approach, but some of the indicators may be re-interpreted so as to be useful:[13]

- *Species Diversity, Abundance, and Composition*[14] (Odum 1985; Rapport et al. 1985; Schaeffer et al. 1988; Shackell et al. 1993; Woodley 1993)

Several indicators of stress can be considered in relation to these variables. Diversity usually falls in a stressed ecosystem (Rapport et al. 1985). However, where the stress is manifested as a change in ecosystem structure (as in patch cuts in a forest), species diversity may actually increase (Odum 1985; Rapport et al. 1985). It is also important that the proportion of native species be considered when assessing diversity (Rapport 1990). "The greater the number, cover, or biomass of exotic species (plants or animals), the lower the integrity" (Noss 1994). Also, the magnitude of the normal fluctuations in species populations should increase in stressed ecosystems (Rapport et al. 1985). Stress should also induce a proportional increase in the number of opportunistic species, and this is directly related to the successional reversion as discussed below (Odum 1985; Rapport et al. 1985).

Of particular relevance to restored areas is the measurement of exotic species. As suggested by Noss (1994), the number, cover, or biomass of exotic species is related to the

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[13] It is important to note that Schindler (1987) found that aquatic systems seem to respond quite differently to stress than do terrestrial ones. While terrestrial ecosystems may exhibit changes in nutrient cycling or respiration, no such trends were observed in the lakes that Schindler studied. Also, Schindler's experimentation with lakes and streams showed that, "...both eutrophication and acidification tended to cause the average size of organisms to become larger rather than smaller" (Schindler 1987: 20).

[14] Of course not all species can be monitored, but Noss (1994) suggests that certain species should be monitored, including those that (a) require large amounts of natural habitat, (b) are "taxonomically distinct," (c) are keystone species, or (d) are threatened with extinction.

state of ecosystem integrity. The measurement of opportunistic species could also be useful, as a decrease in their relative abundance may indicate the presence of integrity, as ecosystem succession is in process.

- *Change in the Average Body Size of Species*

Stress generally reduces the number of large-bodied species in an area (Odum 1985; Rapport 1990; Rapport et al. 1985). Odum (1985: 421) suggests that this is because large organisms are usually higher on the food chain and are thus vulnerable to bioaccumulation of toxins, as well as being "more sensitive to disturbance." From the perspective of a restored area, the appearance of larger species may indicate that integrity has increased.

- *Change in Successional Stage*

A large scale reversion in the overall structure of the ecosystem toward an earlier stage of succession is often a result of severe stress (Rapport et al. 1985; Schaeffer et al. 1988). Monitoring for this indicator may be useful in established restorations. In newer restorations, integrity may be signalled by continued succession in the ecosystem as a whole.

- *Area Suitable for Habitat of Native Species*

Here one must consider two main issues - the minimum area requirements for long term survival of species (both flora and fauna) as well as the impact of habitat fragmentation caused by human disturbance or natural perturbations such as fire (Woodley 1993). Spatial extent and pattern of habitat must be evaluated while also taking the quality of the habitat into consideration (Keddy 1991). These characteristics are as relevant to restorations as they are to protected areas.

- *Change in the Incidence of Disease*

Disease incidence may increase or decrease, depending on whether the parasites or their hosts are most compromised by a particular stress (Rapport et al. 1985). Usually it will be the host that is weakened and therefore disease incidence increases (Rapport 1990). This indicator may be most useful in an established restoration. However, it may be illuminating to compare disease incidence in the restored area to that in an existing and comparable remnant area.

- *Increase in Community Respiration*

Odum (1985: 420) states that stressed ecosystems display "...a low efficiency of converting energy to organic structure" as energy is diverted to damage repair. Therefore, respiration tends to increase and biomass production tends to decrease in ecosystems that are subject to stress. Conversely, then, as restored areas gain integrity respiration should decrease and biomass production should increase.

- *Change in Primary Productivity*

Rapport et al. (1985: 622) state that "changes in primary productivity often follow changes in nutrient availability." In aquatic systems, eutrophication is accompanied by an increase in productivity, while other stresses usually result in a decrease of productivity (Rapport et al. 1985). This indicator may apply to restored ecosystems that are somewhat established, as well as be used in comparison between a restored and a protected ecosystem.

- *Change in Nutrient Cycling*

There is a trend in stressed ecosystems for nutrient turnover to increase and nutrient cycling to decrease. The end result is an accumulation of nutrients that are then often lost from the ecosystem (Odum 1985; Rapport et al. 1985). In other words, "horizontal transport increases and vertical cycling of nutrients decreases..." (Odum 1985). This, too, may be looked at in terms of tracking the increase in integrity in a restoration as horizontal transport of nutrients decreases and vertical cycling of nutrients increases.

- *Presence of Contaminants*

The accumulation of toxins in both the biotic and abiotic elements of an ecosystem indicates a loss of integrity because in normally functioning systems toxins are isolated "...in sediments and soils or are transformed and rendered harmless by a variety of chemical and biological processes" (Rapport 1990: 125).[15] The ability of a restored system to cope with toxins, then, may be an indication of integrity.

- *Density of Roads*

Noss (1994) regards this as the best overall indicator of integrity, as many problems accompany human access to natural areas and roads themselves often have damaging effects. Density of roads may be measured in a restored area. However, it may be important to note that prairie restorations are reliant upon fire breaks, which essentially create "edges" in the system. Also, human access to restored areas is a management requirement, in order to manage weeds, for example.

The direction of change of an ecosystem characteristic may not be as important as the magnitude of that change (Rapport et al. 1985). At the same time, however, stress can be inadvertently imposed on an ecosystem when measures are taken to smooth out "...marked oscillations in ecosystem behaviour which are normal to the long-term maintenance of the system..." (Rapport et al. 1985: 626).

The above list of indicators is not complete. Nor should observers expect to see all of these indicators before assuming that an ecosystem is subject to stress, especially in the short term (Freedman 1989). Rapport et al. (1985) suggest that indicators of distress in ecosystems seldom occur singly. Rather, they tend to occur in groups and in sequence, and this may act as an alert to both the potential and the degree of loss of integrity in an ecosystem. Rapport et al. (1985) outline a progression of ecosystem responses to stress that parallel responses of mammals:[16]

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[15] Here Rapport 1990 cites Neuhols and Ruggerio (1975).

[16] Rapport et al. (1985) loosely model their "ecosystem distress syndrome" on Selye's (1973) model of mammalian stress response, and also use some of Selye's terms.

Alarm Reactions: These are the initial responses to stress and are thus the "early warning" indicators. They are usually exhibited at the "...reproductive and species-specific levels," for example as "...abnormal fluctuations in sensitive populations or communities, abnormalities in reproduction, [or] changes in the distribution of sensitive species" (Rapport et al. 1985: 629). Sometimes alarm reactions are evident at the ecosystem level as "...impaired decomposer activity" or "...increased nutrient leaching," for example (Rapport et al. 1985: 630).

Coping Mechanisms: These are the feedback mechanisms that attempt to dampen or mitigate the impacts of stress. There are some general indicators that these mechanisms have been activated. For example, species that are more sensitive to stress may be replaced with "...functionally similar, but more resistant species" (Rapport et al. 1985: 631). Also there may be increased community respiration, as discussed above.

Ecosystem Breakdown: When coping mechanisms cannot adequately mitigate the stress(es), the system will transform or break down. Once system breakdown occurs, removal of the stress alone may not ensure the recovery of the original ecosystem state. For example, extensive loss of nutrients or substrate could make recovery, at least at a time scale of interest to humans, highly unlikely (Kelly and Harwell 1990).

These progressive suites of indicators may be useful in tracking the increase in integrity of a restored system just as they are useful in indicating system breakdown.

As previously discussed, integrity measures must ultimately be chosen in reference to specific ecosystems. Munn (1993: 110) provides a list of some questions to ask when developing a monitoring framework, and these types of questions bring up case specific issues:

1. What are the most critical limiting factors for sustainability?
2. In what ways is ecosystem integrity already threatened?
3. Are there likely to be any irreversible trends if current development pressures increase, and if so, how much time is available to take remedial action?

4. What are the interactions...among the various sectoral interests in the region?
5. What kinds of surprises/discontinuities might occur over the next 30 to 50 years to shock the system?
6. What kinds of questions will the monitoring system be expected to answer?

Consideration of these questions should identify some of the issues that are relevant and unique to the system under investigation.

Reive et al. (1994) present the attributes of ecological integrity that will be monitored as restoration work is carried out in Point Pelee National Park, Ontario. Five attributes are identified, and questions that aid in assessment are proposed. The first attribute of integrity is the ability of the system to recover from perturbation. Four questions should be answered in order to assess the existence of this attribute:

- Are there areas of earlier successional flora and fauna being maintained that favour disturbed environments and will facilitate recovery from perturbation? (Yes = higher ecological integrity)
- Have potential sources of undesirable (non-native) species of flora and fauna that may prevent the establishment of desired communities been eradicated? (Yes = higher ecological integrity)
- Are unnaturally large populations of herbivores present that could inhibit establishment of an early successional phase (e.g., deer or mice)? (No = higher ecological integrity)
- Have changes to soil, topography, and drainage, resulting from former agricultural uses, been mitigated to facilitate ecosystem recovery? (Yes = higher ecological integrity) (Reive et al. 1994: 10)

The second identified attribute of integrity is long term persistence with only a low level of human management. Two questions are to be posed in reference to this:

- Is there a decrease in the amount of management required to maintain park ecosystems? (Yes = higher ecological integrity)
- Is there a decrease in the amount of park maintenance in general? (Yes = higher ecological integrity) (Reive et al. 1994: 10)

The third integrity attribute is the long term stability of the ecosystem. Reive et al. (1994) point out that the first two attributes actually indicate stability, but they add one further question:

- Is the direction of development for park ecosystems, as a result of succession and recovery from prior disturbance, consistent with that expected from stable [persistent] systems? (Yes = higher ecological integrity) (Reive et al. 1994: 10)

The fourth attribute concerns the species diversity in the park. In terms of exotic species, four types have been identified as most threatening to ecological integrity. These are: (1) species that are able to hybridize with indigenous plants; (2) species that have significantly displaced indigenous species; (3) aggressive species that could potentially spread in range; and (4) species that prefer disturbed areas and may therefore be invasive in areas recovering from disturbance. Diversity is thus assessed by the answers to two questions:

- Have numbers of non-native species that are listed in priority class I, II, and III been reduced in the park? (Yes = higher ecological integrity)
- Is the richness and diversity of native species in the park increasing? (Yes = higher ecological integrity) (Reive et al. 1994: 11)

The final indicator of integrity concerns the state of park communities, diversity, and "functional organization" as compared to similar remnant natural areas. However, Reive et al. (1994: 11) state "we do not know of any method for evaluating functional organization and this is best left out of the evaluation for now." The question relevant to this indicator, then, is:

- Is the structure and diversity of natural communities at Point Pelee becoming similar to relatively undisturbed and representative sites on the nearby Erie Islands? (Yes = higher ecological integrity) (Reive et al. 1994: 11)

This is an excellent example of adapting the notion of integrity to a specific ecosystem and the associated management program.

Once indicators have been selected and measured, the data must be evaluated. Standards against which to compare individual ecosystems may be derived from theoretical assumptions about the behaviour of ecosystems (Steedman and Haider 1993) or from reference to the condition of a similar ecosystem that is considered healthy and largely undisturbed (Karr 1993; Steedman and Haider 1993; Woodley 1993). No North American ecosystems remain unaltered by recent human activities, so we cannot assume that variables in even the most pristine areas are unchanged (Schindler 1987). In light of this, a more appropriate method of evaluation may be to "analyse trends" in order to detect changes over time that indicate stress (Woodley 1993), such as those already presented.

There are several conceptual considerations involved in evaluating an ecosystem's state of integrity. For example, Kelly and Harwell (1990) state that recovery from disturbance must be assessed in terms of the degree and the timing of recovery. The recovery often relates to specific qualities of the stress, such as the "...intensity, frequency, and duration..." of the stress, the "novelty" of the stress, and "...how the action of the disturbance is partitioned throughout the ecosystem in time and space" (Kelly and Harwell 1990: 527). However, Rapport et al. (1985: 636) write that "the progression of appearance of symptoms under intensifying stress levels may be interrupted temporarily..." by regulatory mechanisms of the system, and this interruption could ostensibly be interpreted as recovery.

Further, changes that are detected must be considered "...against a backdrop of constant fluctuations, replacements, and processes" that are intrinsic to any ecosystem (Kelly and Harwell 1990: 533). Kelly and Harwell (1990) refer to this as discerning the signal from the noise. A "signal" is change that is considered apart from the normal dynamics of the ecosystem, and it must be evaluated as to its importance, i.e., it must be determined if the change will be of consequence to the integrity of the ecosystem (Kelly and Harwell 1990).

Further research is necessary in order to adapt these integrity indicators to restored areas. The indicators discussed above have generally been developed for systems that are in the later stages of succession, whereas restorations begin in an early successional stage. Also, restorations may display changes that are uncharacteristic of systems that establish themselves without human aid. As Egan (pers. comm.) points out, ecosystems are dynamic, and standards of success must be appropriate to the age of the restoration:

> I think the first years you're looking more at cover and you're not so concerned about species diversity and abundance. You're just trying to make sure you get plants growing for the first three years or so.... After that you can probably start looking at diversity and other indicators that are typically used in grasslands. You can certainly do that the first few years, too, but I think it doesn't mean a whole lot at that point because the system is just starting to get going and you're going to see a lot of changes right away.
>
> You need to look not only at what plant species are there, but over the longer term what animal species are using it - not only larger mammals but insects, soil microbes, bacteria. And just looking at the soil itself is a big indicator and there has lately been more technical ways of doing that as well.
>
> [That would be an indication of] how it's moving from a disturbed state or whatever state it might be in, toward a restored state. There are different indicators that help you do that.

The restoration workers who were interviewed generally measured success by species diversity, in reference to native prairies. As Powers (pers. comm.) suggests:

> ...the most important indicators [of success] are the absence of non-natives and the diversity of the natives.... The closer it approximates a real remnant prairie the more successful it is. Of course you have to understand that the remnants are over 10,000 years old and the restored ones are no more than 60. But there are some pieces that I've done that really look very much like natives - they have a good dispersion of native plants and lots of diversity.

Egan (pers. comm.) agrees that remnant prairies are important models: "Restorationists need remnants as measuring sticks. You're moving towards some model from a disturbed condition."

Generally, the interviewees have a rather "hands off" approach to changes in the restoration. Kline (pers. comm.) contends that "if..[a species is] dying out you're not providing habitat for it so you're wasting your time to try and put it back in. In some cases you can provide the habitat.... But generally you're just going to have to accept what happens. You put the process in, which is fire, have the plants there and turn the prairie over." Egan (pers. comm.) takes a similar approach, noting that:

> Restorations are dynamic, rather than static, processes. There are certain species that will be there early, others that will be there later. As long as the system itself seems to be functioning, the species that are present, while important, are not everything.... You have competition and the randomness of weather and animals and any number of other factors and they just create change. As long as that change maintains and/or

enhances the sustainability of the system [it is acceptable].

Kline (pers. comm.) makes the critical point, however, that more interventionist management is required on a small-scale restoration:

> If your prairie is small you're going to...[set] some restrictions - you're not going to let it be taken over by aspen or reed canary grass. But if your prairie is very large your restrictions may not be as rigorous. We [at the UWM arboretum] fight brush and I imagine the original prairies were actually quite brushy in many areas. But we want the area that wasn't brushy!

Powers (pers. comm.) maintains that certain changes must be accepted as natural or inevitable. She gives an example of an "evolutionary process" that she has seen at work:

> ...there are two species that meet at about this [geographical] point. Most of the books say that one of them grows east of Madison and one of them grows west. It's not quite true because I happen to collect the seeds of both of them on the same hillside west of here on a remnant. So the dividing line isn't that sharp. But they've always been separated apparently by different blooming times - they're two species in the same genus. Last year because everything was so screwed up with the weather there was overlap, and there are now seedlings that are hybrids in my restoration. So, should I take these plants out because it isn't historically accurate? Or, should I assume that this is a plant community in process and that the climate may be changing? It's been very clear for the last five years the plants are responding very differently than they did before that. They look different, they're growing differently, some of their blooming times are changing. And we know that the climate is changing. So maybe I'll leave those there. Maybe those are the plants that are going to make it in the coming times.

In light of these and other unknowns, Noss (1994) emphasizes that a large margin of error must be allowed. That is, in attempts to determine the thresholds where change is deemed problematic rather than normal, or where those changes require immediate and drastic management intervention, one must always err on the side of over-protection. For failing to "...detect or predict a real effect..." is a more serious mistake than misinterpreting "noise" as a "signal" (Noss 1994: 51).

4.4. Ecological restoration

The concept of ecological integrity has much relevance to the restoration of ecosystems. Of course, restoration projects may be undertaken for reasons other than restoring integrity. For example, Joyce Powers, a native plant nursery owner who restores sites of a variety of scales, has a very flexible working definition of restoration that "...isn't necessarily an historic one except in the sense that I do try to work with the plants that historically have grown in the area"(pers. comm.). Powers (pers. comm.) comments:

> ...if it's a garden, you don't want as many different kinds of plants in it because it's too complex - people won't like it. It's not aesthetically acceptable to most people, who are used to seeing large expanses of one species. So while I may like a really diverse planting, when you're working with a city lot there just isn't enough room for that many plants.

In the case of reclamation of slag heaps, Powers (pers. comm.) is not attempting to recreate the pre-mine condition: "I'm not replacing what was there before, I'm just putting back a native plant community so that there's a place for butterflies and pollinating insects and birds and whatever...." Often, however, restorations are concerned with restoring the pieces and the interactions of ecosystems that existed before an extreme, human-caused disturbance occurred. It is this type of restoration that involves ecological integrity, and on which this discussion will focus.

Bonnicksen (1988) characterizes three restoration "goal types": structural, process, and holistic. Within each of the restoration goal types there are different restoration goals. Structural goals focus "...on the elements or parts of biotic communities, such as species composition and the arrangement of those species in space" (Bonnicksen 1988: 28). The goal of biological diversity is a structural goal, as is the maintenance or re-establishment of rare or unique species. Similarly, special communities may be identified, based on their rarity, uniqueness, or social importance. The maintenance of relict prairies with managed fires is an example of restoration based on special community. The primacy of structure is evident in that restoration of these ecosystem parts need not be accomplished through historical processes. For example, mowing may replace fire, and herbicides are often used to remove unwanted plant species. Another structural goal may be the maintenance of a cultural landscape, that is, a landscape that expresses the impact of human societies. Such areas may appear "primeval," such as those maintained by indigenous peoples, or they may even be agricultural landscapes (Bonnicksen 1988).

Process goals, "...such as wildfire and plant succession...," concern the production and sustenance of unique ecosystem processes (Bonnicksen 1988: 30). Here, then, the focus is on "...the authenticity of the process" rather than the product (Bonnicksen 1988: 30). Such goals may be based on a desire for "unimpeded" process, which is founded on a philosophy wherein even extinctions are perceived as "nature's will." In such a case, the restoration ecologist acts to protect an area from human impact. A second process goal is that of re-establishment of a natural process or the elimination of a detrimental process (e.g., soil erosion). Bonnicksen (1988) uses the example of mine reclamation, where vegetation and productive soils are re-established. The goal is to reduce erosion and allow plant succession, without too much concern for the endemic authenticity of the species involved. The goal is to restore a "...process analogous to the one that originally occurred on the site, or to one that occurred elsewhere..." (Bonnicksen 1988: 30).

Finally, Bonnicksen (1988) discusses holistic restoration goals. Such goals "...are based on a holistic, or ecological, perspective in which structure and process are inseparable" (Bonnicksen 1988: 30). Both ecosystem structure and process are conceived of as equally important goals of restoration. There are two main approaches within holistic restoration that differ in the degree of "repair" the system requires. The first is the "controlled evolution goal." The objective here is "...to allow evolutionary changes to continue...while at the same time ensuring that no species becomes extinct and that human life and property are not threatened" (Bonnicksen 1988: 31). The initial step in such a restoration is the re-establishment of "natural" conditions, which Bonnicksen (1988) defines as "...either presettlement conditions or the conditions that would have existed today if post-settlement human influences had not interfered with aboriginal and other ecological processes" (Bonnicksen 1988: 31).[17] Activities of indigenous peoples may have to be mimicked, such as purposeful fire setting, as well as ecological processes such as wildfires. Each ecosystem will be unique in terms of what restoration techniques will be necessary to achieve the controlled evolution goal (Bonnicksen 1988).

The second potential holistic goal is the "synthetic community goal." A synthetic community may be constructed "...to resemble other biotic communities" (Bonnicksen 1988: 32). The distinction here is that the restoration ecologist is operating in a situation where the natural community has been entirely removed and needs to be "rebuilt." This is the most challenging restoration goal and perhaps the most scientifically enlightening (Bonnicksen 1988).

Todd (1988) also characterizes restoration ecology by rather distinct streams, although he does not discuss a holistic approach. Rather, he identifies species-specific and structural restoration. Todd's species-specific restoration corresponds with Bonnicksen's (1988) structural restoration in that it is primarily concerned with re-creating an historical ecosystem, complete with authentic species mixes and ecological relationships, where possible. Todd's description of "structural" restoration corresponds with Bonnicksen's (1988) process restoration; it is most concerned with restoring the "structural integrity" of the original ecosystem. Function is emphasized - "equivalent species" may be chosen over native ones because they may have a secondary quality such as economic value. A forest may be thus recreated to perform may of the same functions as the original, but containing economically viable, non-native trees (Todd 1988). Figure 5 summarizes the goal types as discussed by Bonnicksen (1988) and Todd (1988).

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[17] As has been discussed previously, this definition of "natural" is by no means unanimously agreed upon.

GOAL TYPE:

1. *STRUCTURAL* (Bonnicksen 1988). This corresponds to what Todd (1988) names the "species specific" goal type.

A restoration undertaken with structural goals is concerned with authenticity of ecosystem structure, including:

- biodiversity
- species composition
- community composition
- ecological relationships

Structurally-oriented restorations may be achieved and/or maintained by non-authentic means. In other words, the structure is not being sustained by natural ecosystem processes.

2. *PROCESS* (Bonnicksen 1988). This corresponds to what Todd (1988) names the "structural" goal type.

A restoration undertaken with process goals is concerned with authenticity of ecosystem processes, such as:

- succession
- water filtration
- wildfire
- nutrient uptake

Process-oriented restorations may result in non-historic ecological communities, as species that can perform similar functions as the indigenous species may be used. This may be the case where the "equivalent species" may be economically useful, or where restoration of indigenous species is impractical.

3. *HOLISTIC* (Bonnicksen 1988).

A restoration undertaken with holistic goals is concerned with authenticity of ecosystem structure and processes, as listed above.

Holistic restorations may aim to re-establish conditions that allow natural processes to occur while ensuring that indigenous species and communities are maintained. This may require rehabilitation of degraded but indigenous ecosystems or the entire re-creation of an ecosystem that has been destroyed.

Figure 5. Goal types of ecological restoration as classified by Bonnicksen (1988) and Todd (1988).

Each of these goals may be appropriate to different restoration projects, and be dependent upon the scale and the context of the project. Bradshaw (1996) suggests that full restoration of ecosystem function and structure may not always be the most practical endpoint. Rather, rehabilitation towards the original ecosystem or replacement with a different ecosystem (i.e., functional restoration) can be "proper options." Both rehabilitation and functional restoration "...may provide an endpoint that is more valuable than what was there in the first place [i.e., the degraded ecosystem]" (Bradshaw 1996: 4). Todd (1988) believes functional restoration which includes economic benefits is critical to conservation on a global scale. He states that providing "...a wide variety of marketable products as a by-product of the restoration process" (Todd 1988: 345) is essential if restoration is to be extensively applied. Restoration, Todd (1988: 345) asserts, must become "...a major economic activity."

Hobbs and Norton (1996: 95) include the rehabilitation of productive capacity in their description of the variety of restoration activities: "Restoration at the landscape scale will involve restoring a combination of some landscape components for productive purposes and some for conservation purposes." They advocate the application of a continuum of restoration strategies across an entire landscape.

Such an approach is an absolute necessity. If humans preserve and ecologically restore certain areas, but continue to extract resources from a majority of the landscape using current practices, the result will be pockets of native ecosystems. These may not conserve biodiversity in the long term. Traditional conservation approaches must be combined with a reworking of our economic activities, especially farming and logging. As Todd (1988: 346) argues: "Linking together nature's restoration requirements with the economic needs of people may be the only way the terrestrial fabric of the planet can be rebuilt."

Restoring ecological functions alone, though, cannot recreate a healthy, integral earth. Indigenous biodiversity, the expression of millions of years of evolution, must be conserved at all levels (from genetic to landscape) wherever possible. That is why the focus on ecological (holistic) restoration, i.e., the restoration of species, inter- and intra-specific relationships, and biotic and abiotic interactions and processes, is necessary.

In practice, however, the goals of ecological restoration are not simple to define. Noss (1983; 1987) advocates the maintenance of both the species and the ecological processes indigenous to a place. This superficially simple statement is anything but straightforward. For how do we define "indigenous" or "natural" ecosystems?

The tendency is to define them as the pre-European settlement ecosystems, and thus to define the goals of restoration as the maintenance or recovery of the characteristics of these ecosystems. Howe (1994), however, strongly disagrees with the conservation goal of pre-European settlement conditions. He argues that humans should "...encourage the varied conditions that favored many prairie taxa over their 30 million year evolution" (Howe 1994: 692), rather than mimic the conditions of "...the immediate past of human occupation of less than 15,000 years - one two-thousandth of the evolutionary period in question" (Howe 1994: 696). He maintains that this historic fact is the "... justification for what should be conserved or restored" (Howe 1994: 696).

Most would concur with Noss (1983: 703), though, who writes, "for any landscape, the model natural ecosystem complex is the presettlement vegetation and associated biotic and abiotic elements." He argues that pre-European settlement ecosystems are "...relatively ancient and stable, and provide a baseline against which to measure the vicissitudes of [intensively] humanized landscapes" (Noss 1985: 5).

Indeed, using the ecosystems that evolved with 15,000 years of human occupation as a baseline for restoration seems easily defensible. It is unlikely that any plant communities or species that required conditions that were precluded by humans are any longer in existence. Still, though, there is very little data on what exactly were these pre-European settlement conditions. Furthermore, the argument can be made that mimicking aboriginal burning regimes in parks, for example, could arguably be imposing a "...*static* process when, in fact, Indian culture, like all human cultures, was not static and could not be expected to have continued its practices in the same way indefinitely" (White and Bratton 1980: 23).

Added to the complications of definition is the subjectivity of what is being conserved or restored. It is widely accepted to attempt to eradicate parasites and small pox, for example (Brown 1994). "While we strive for the extermination of that biodiversity labeled as pests, we generally view as calamitous the present rates and trends of species extinction. We seek a diverse yet kinder, gentler nature" (Brown 1994: 355).

The subjective nature of restoration and conservation goal setting must be explicitly recognized and addressed. Bonnicksen (1988: 33) suggests that because restoration goals are inherently value judgements, "...goal-setting...[must be] a social or political decision, not a professional decision." Howe (1994), however, argues that efforts should be made to increase the scientific rationale for restoration goals, i.e., to ensure that restoration goals are those that are most beneficial to ecological integrity and diversity.

The wisest initial goal of any restoration may be to implement experiments to research specific problems and generate data that is directly applicable to the project.[18] Howe (1994) points out that most of our knowledge about tallgrass systems has been derived from remnants or restorations that have been managed with dormant season burns and with grazing exclusion. He proposes that without "...much experimental evidence, varied management regimes, or a theoretical rationale for dormant-season fire and grazer exclusion..." we cannot know if this management strategy is wise (Howe 1994: 692).

Howe (1994) promotes the goal of maximum diversity. One of his main concerns is

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[18] Nuzzo and Howell (1990) cite Zedler et al. (1982).

that fairly similar treatments occur on most of the remnant and restored tallgrass prairie parcels, and this "...artificially simplifies what probably was once a far more varied set of communities than now exists" (Howe 1994: 700). Another of his concerns is that current management practices promote the abundance of a handful of species, while the rest are maintained at "infrequent or rare" levels. This, he argues, leaves many species vulnerable to local extinction.

Howe's (1994) goal of maximum species and ecosystem diversity, however, is also open to question from a scientific basis. Pavlovic (1994: 186) cautions against obtaining higher densities of rare plants than is "natural:"

> Although high densities are tempting restoration goals, they may alter evolutionary directions, and their management may result in natural community degradation. Therefore, management should strive to maintain not only the species, but also its natural environmental context.

Noss and Harris (1986: 301) also suggest that conservation success can be limited when management "...is oriented toward maintenance of high species diversity instead of characteristic 'native diversity.'" Despite the lack of historic data and arguments against limiting the conception of "native ecosystems" to one particular time period, most researchers maintain that attempting to emulate pre-European settlement conditions in some manner is still the best option.

Defining the criteria for ecological restoration is one of the most difficult issues in restoration ecology, and it is one based primarily on subjective judgment. As discussed, naturalness is not a helpful guide to restoration goal-setting. At the same time, the concerns over the mimicking of cultural activities, specific to certain groups in a certain time period, are difficult to resolve. This leads the discussion of ecological restoration goal-setting back to a logical place - aiming to attain integrity of the ecosystem.

There are several examples of restoration goals based more on integrity than on achieving historic accuracy. Hobbs and Norton (1996: 101) suggest that restoration goals that are focussed on a particular historic state are "...unrealistic, unachievable, and static." Rather, restoration goals should be "...dynamic, and take into account the changing nature of the environment" (Hobbs and Norton 1996: 101).

Egan (pers. comm.) maintains that the restoration should be holistic, that it should "...not only replace the system, but...replace and include the processes that made that system operate in a way that it would be self-sustaining." Once established, a restoration should be allowed to "...evolve within the context of today's environment" (Egan, pers. comm.). Meanwhile, while Noss (1983; 1987) talks of restoring the indigenous ecosystem, he clarifies that this is not a static goal:

> The goal is not to re-create a certain vegetation pattern that was established in the past under probably different environmental conditions but to allow the natural landscapes to evolve as their constituent populations respond to a dynamic earth (1987: 7).

The above quotations refer generally to the goal of ecological integrity. As already discussed, Kay (1991a) argues that there is no one single state of ecological integrity that can be identified. The dynamic nature of ecosystems makes it impossible "...to identify a single organizational state of the system that corresponds to integrity. Instead there would be a range of organizational states for which the ecosystem is considered to have integrity" (Kay 1991a: 484).

Hobbs and Norton (1996) cite the concept of a "scorecard"[19] that rates the restored ecosystem in terms of a number of key attributes (see Figure 6). For each attribute, which could include indicators of ecological integrity, an estimated range of natural variability is determined, and the restored ecosystem is measured against this range. Designing a scorecard for ecological integrity might be very useful in measuring a restored ecosystem against a suite

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[19] As developed in Caraher and Knapp (1995).

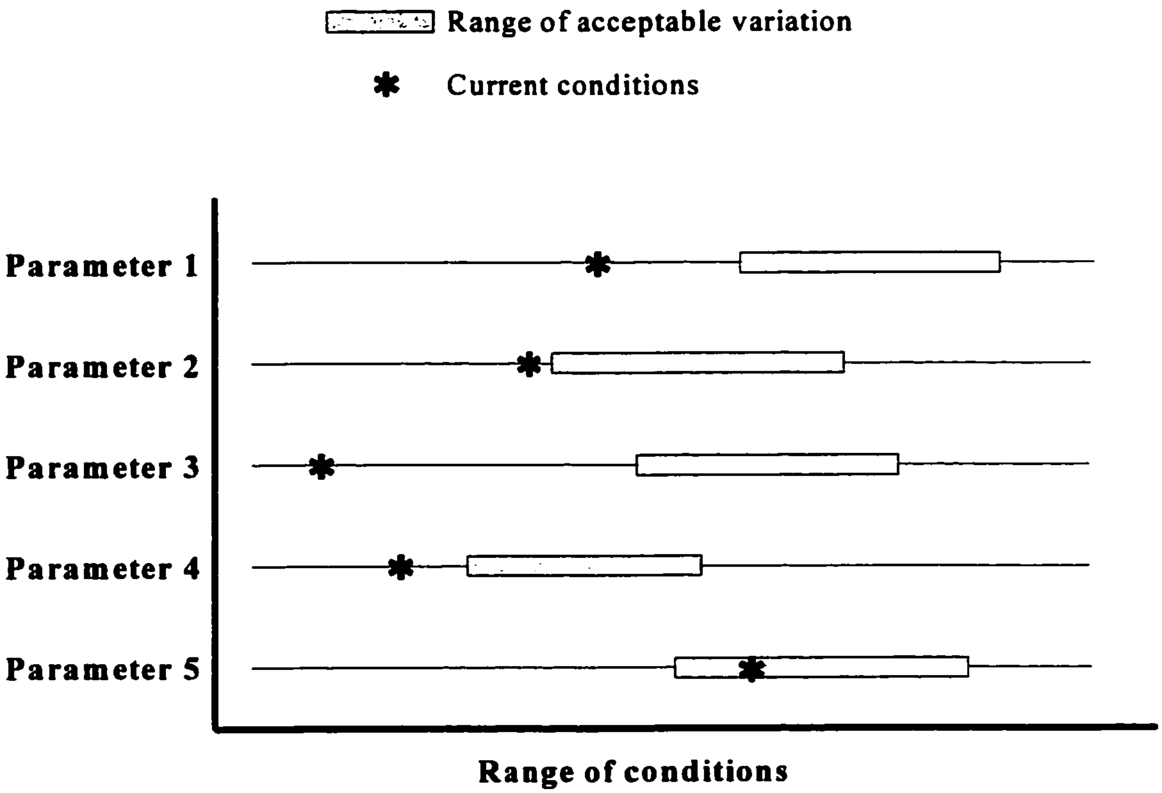

Figure 6. An example of a restoration "scorecard."

The scorecard is used to assess the current condition of a restored ecosystem in relation to parameters which indicate ecological integrity. For each parameter, a range of acceptable variation is identified (after Hobbs and Norton 1996).

of integrity indicators, while allowing for wide variation in the particular combination of characteristics that can indicate integrity.

In practice, however, restoration goals are often much less stringent. At the UWM arboretum, Curtis's book *The Vegetation of Wisconsin* has been used as a loose guide. Written in the 1940s, this book documents the remnant prairie vegetation of the state, providing indicators of the likelihood of the presence of each species in each type of prairie, as well as how common that species was within the prairie (Kline, pers. comm.). Curtis's book is consulted in terms of which species should be present, but they "...don't deliberately try to match it" (Kline, pers. comm.). Kline (pers. comm.) hastens to add that while it is not known what the pre-settlement state of the area was, "much less do we know what it would have been at this point in time if we [European settlers] hadn't come into the picture." In the end, the workers at the arboretum "...introduce the species, ...introduce the process of fire, and then...watch to see what happens. Some...[species] spread well and some of them don't, ...[but the workers] don't...interfere very much with that" (Kline, pers. comm.). In summary, Kline (pers. comm.) describes the general approach at the Arboretum:

> I think we've made the commitment we want to keep it open with fire and we would like the plants that grow here to be native Wisconsin plants. We're not going to come up with exactly the same thing [as was here in pre-settlement times] because we aren't going to have bison, or to burn when the fires likely took place (we're restricted to the least hazardous seasons). And maybe that's not a problem at all. I don't consider that we have to make it exactly like Curtis's list. That just gives us an idea of what species were here, what ones like sun or stand fire, and we'll put them together and accept what happens.

Betz (pers. comm.) emphasizes the importance of studying remnant prairies which have not been heavily grazed in order to get some idea of the pre-settlement state. He cautions, however, that these remnants are not to be copied but rather can provide some indication of the native plant communities. Studying remnants "...gives you an idea of what was in the area and then you head for something like that - probably - but never take it as for sure" (Betz, pers. comm.). The lack of precise models is simply a fact with which restoration has to deal. Where there are no examples of ungrazed remnants, Betz (pers. comm.) maintains that:

> ...you just have to do what you can and keep on moving forward as best you can - throw a lot of things in and then see what comes up and then burn it. You have to do some studies on the fire and the impact of fires. You can't say 'Oh it's already known' - it's not already known. People have already made up their minds - but they should burn it and see what happens.... And you may never reach the point of how it was because things have changed - there are atmospheric changes, pollutants - but you may approach what it was. It may be 97 percent of what it was like.

The lack of historical ecological data means that every restoration is an experiment, inevitably laden with the biases of the restorationist(s).

4.5. The human role in restoration

Another consideration in restoration is the human component of the ecosystem. This type of attention corresponds to what Higgs (1997) presents as an expanded conceptualization of "good restoration." This expanded definition includes three "layers of context" (see Figure 7):

(1) Effectiveness or Ecological Fidelity: this includes replication of structure, composition, and function of the "natural" system, as well as long term persistence of the restored ecosystem;

(2) Efficiency: this refers to the restoration inputs of time, labour, resources, and materials;

(3) Expanded Conception: this involves the inclusion of other considerations, such as historical guidelines, cultural practices, local participation, political implications, aesthetic principles, and moral issues.

Historical goals and implications of cultural practices, included as part of Higgs' (1997) "expanded conception," were discussed in section 4.4. Of particular interest here are the other considerations in this third "contextual layer," all of which fundamentally revolve around local participation and support.

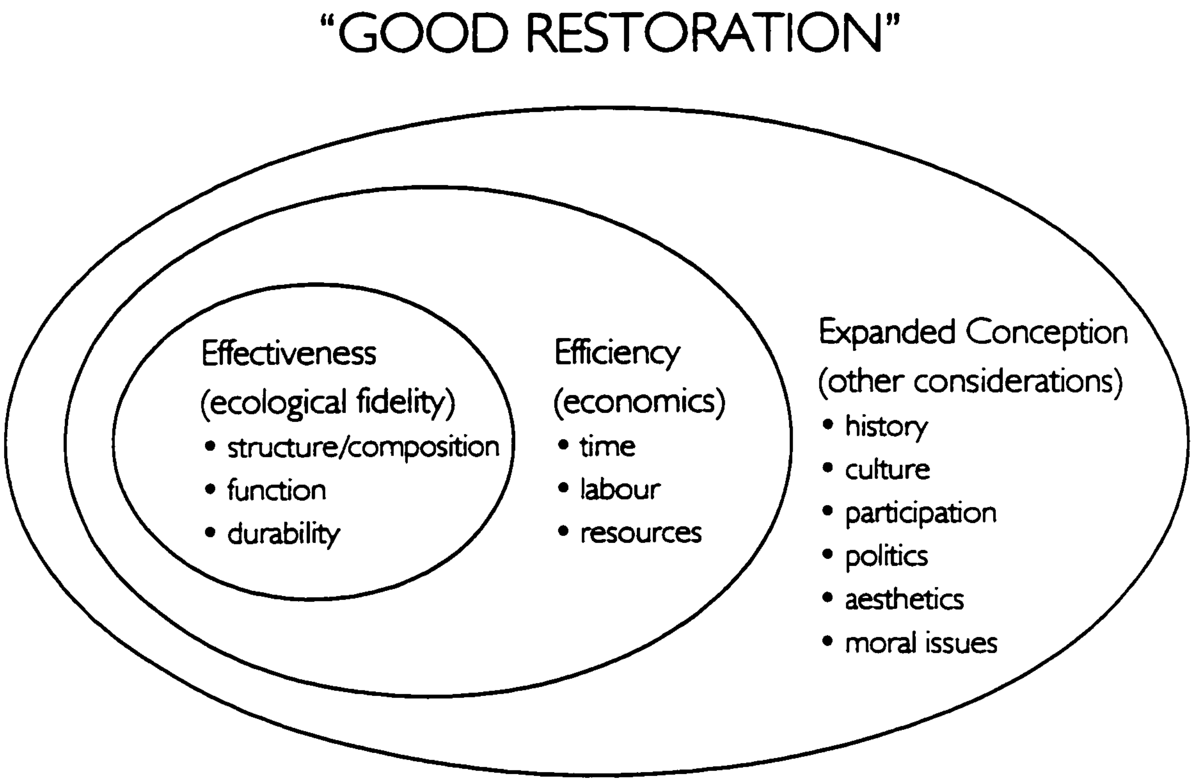

Figure 7. An expanded definition of "good restoration."

Goal setting and assessment of restoration success must go beyond the ecological product of restoration activities (after Higgs 1997: 346).

Dealing with public opinion is a challenge to restoration workers, but public support is an important goal if the project is to be successful. As Cairns and Heckman (1996: 170) state, "Social realities are often as important to restoration plans as scientific theories and predictions." Many aspects of restoration may seem potentially controversial, but none more so than prescribed burning. It is interesting, however, that none of the restoration workers who were interviewed indicated any problems in this regard. As Kline (pers. comm.) says of burns at the UWM Arboretum, which lies within the city limits of Madison, "[People are] used to it [burning] and we're so good at it. The crew is so good that we've never had a serious escape or a bad experience." Burns are planned such that smoke will drift away from the highway. Similarly, burns are highly controlled and planned at the Fermilab:

> We fix our burns, we have tracts divided in such a way that we know we have to have a certain wind.... We have to wait until the wind blows in [a certain] direction to blow the [smoke and ash] away. So ordinarily we don't have any trouble with that [objections from neighbouring landowners], because we burn so it's away from the houses or the lab buildings, or even roads (Betz, pers. comm.).

Egan (pers. comm.) comments:

> I burn a public greenway of prairie grasses and forbs that runs between some $250, 000 - $450,000 [US] [residences] every spring. It's been simply a matter of education - notifying the people that you're going to be doing it and why you're doing it, and then letting them know, as best you can, the day you're going to do it and letting them be there so they can see what's happening. I've had really good success with that. I haven't had any complaints at all. What typically happens is that I have to keep the kids away and the adults have been very cooperative. For a larger scale project I would think that some of those basic concepts would hold true....There may be a whole educational process there where fire stops being a threat - it may even become an advantageous thing. If you design your system with firebreaks and do it properly and have the proper equipment out there - there's always a chance that it's going to get away - but if you do it correctly there's enough scientific information, enough experiential information now that, if properly done, you can control things pretty well.

In terms of fire use in parks, Sieg (pers. comm.) agrees that education is vital, but first it is the managers who must be educated:

> I find that the managers are also afraid of using fire. Historically here the lightning fires occurred in July and August, so I've been working on these guys to do summer

> burns. But ...you have to start small and show them that it's controllable and that it does what you want it to do. First of all you have to get the managers so that they feel very comfortable burning, and then they make good sales people to the public. And we give a slide talk to explain the ecological end of things - a lot of times that helps. You have to win people over, they have to understand.... We have to work on our attitudes and then talk to the public.

The National Park Service in the United States is committed to using fire in their management:

> The National Park Service has made it very clear that fire is part of their management tools, and they just do it.....We need to tell the public that, 'Yes, we understand your concerns but we're here to manage ecosystems which evolved with fire and these are the important aspects of using fire' (Sieg, pers. comm.).

Despite the lack of negative public reaction to burning as of yet, Kline (pers. comm.) is certain that burning will be called to task on the potential atmospheric effects:

> I'm expecting that people are going to start questioning the use of fire. I'm looking for data. Apparently the long term picture...is that if you burn you're adding CO_2 to the atmosphere and some particulates, although research shows that those are not serious. But you have to balance that against the fact that the prairie is a tremendous sink for CO_2. You release some but you tie up a lot more, so the balance is in favour of the prairie. But people are going to begin to ask that. If you're going to take care of all of the causes of pollution you have to look at which ones are simply detrimental and which ones pay off in the long run. I think we need to have the data at our fingertips, which we don't.

Where there are fears or objections to management practices, efforts should be made to address these. For example, the Wisconsin Department of Natural Resources had employees spend the night to ostensibly guard a fire, when in actuality the fire posed no danger. It was a case of managing public fears and concerns (Foy, pers. comm.).

Deer management is another problem. When their non-human natural predators are removed, deer can be present in overly large numbers and do significant damage to restored prairies. In response to the public opposition to deer culls, both Fermilab and the Goose Lake Prairie State Natural Area [GLPSNA] near Chicago have had to establish scientific studies to assess deer damage. The studies will act as leverage to sway public opinion (Betz, pers. comm.; Nyhoss, pers. comm.).

Another potential problem is that local residents may not be supportive of the restoration project. For example, the local residents in the area of GLPSNA were not in favour of the establishment of a park. As Nyhoss (pers. comm.) commented:

> Originally, nobody was in favour of a prairie park. They had visions of selling this to industry and doing something with it.... I think time helps. I've been here since '69, so a lot of problems that people felt, the couple of families that had to move off the property, all these things dissipate with time. People move away, people die. Things that were real big in the beginning just go away.

The potential of restoration to transfigure the human perception of their surroundings from one of "environment" to that of "habitat" or "home" has already been discussed. It is important that this receive attention alongside the issue of ecological integrity. Commonly, however, restoration goals are focussed on the ecological product of restoration (Higgs 1997).

As discussed in Chapter 2, it is vital that post-industrial societies learn ways to live in a mutually beneficial relationship with their surroundings. Therefore, another goal of the restoration may be to change the human / habitat relationship. Light and Higgs (1996: 237) assert that not fulfilling the inherent potential of restoration to build relationships between humans and their habitats should be considered "...a failing of a restoration project...." Allowing restoration to more commonly become the project of corporations, for example, largely removes the ability of the restored area to enhance "...the local relationship with nature, and [serve] as a vehicle for public participation in ... nature..." (Light and Higgs 1996): 242). Nurturing this ethical and spiritual relationship to the land is important in developing respectful behaviours toward the land (Knight 1996).

McNeely's (1989) recommendations for change in conservation strategy, based on the behaviour of ecosystem people, may be appropriately incorporated into restoration goals. The principle of shifting control of resources back to the local people, for example, can be addressed by including local people in the planning and implementation of the restoration. The principle of expanding the concept of protected areas may translate into expanding the restoration beyond the original site and onto private property - even into urban settings. Also, restoration can be promoted as a personal responsibility, with provisions made for active participation by volunteers and school groups. Grumbine's (1994b) suggestion that we must "resacralize the world" may be undertaken by encouraging the celebration of the healing of the land.

In prairie environments, one way of involving local people has been to hire farmers to do some of the work, like tilling and seeding, something which has happened at Fermilab (Betz, pers. comm.), GLPSNA (Nyhoss, pers. comm.), and Goose Pond Sanctuary (Martin, pers. comm.). This not only involves local people, but makes use of existing expertise. As Egan (pers. comm.) states:

> There have been some restoration projects that have concluded that to really get something done...[you must] bring the farmer into the picture, let him do the work. They have an incredible amount of knowledge....Just ignoring the knowledge of that kind of resource is crazy - those are the people you have to bring in rather than see...as the enemy. That's something that has to get built in [to a restoration project].

Another method of involving local people is through volunteer programs. The UWM Arboretum makes extensive use of volunteers. As Kline (pers. comm.) explains, "We have a big volunteer program. And they're involved in all aspects of the arboretum - from having them at the desk during the day to helping cut brush. And out on the Curtis prairie in particular we depend on volunteers to help control sweet clover."

Wilhelm (pers. comm.) has witnessed very strong relationships grow out of a volunteer program in the present day, as a result of involvement in restoration and management. He likens these relationships to the historical relationships of indigenous peoples to their habitats:

> ...I was reading that the name the Indians had for themselves very often meant 'the human beings.' ...And then I was reading about the plight of the Shawnees in Ohio - a bunch of the Shawnee nation was so unable to accommodate the white man that they left. Some of their elders went to the "far and distant land" of Missouri and southern Illinois, and there were terrified because they didn't know where the bulbs were or where the waters ran or how to curate the springs... because that's where others were the 'human beings' and they were the others. So the 'human beings' were defined according to their place and their relationship with this place.

In a similar way:

> The Nature Conservancy in Illinois has a stewardship program. About 20 years ago they started remediating some stricken landscape in northern Cook County which is north of Chicago. They were ignorant utterly. But gradually, ...they started learning their plants, their sedges, their butterflies, and in the process became to know more and more of what that land required to produce more and more of those and make all those species healthier and to watch the weeds diminish. These people became very attached to what they call the North Branch - actually the north branch of the Chicago River. By now they have a little sort of *de facto* elder system evolving. They go out on a Saturday or Sunday, ...without specific organization and specific instruction, but the elders quietly, almost nonchalantly, with nods and looks and assurances guide people to do this or to do that and they wander over and they do it. And they do remarkable things - clearing out the underbrush, then they do the burning, and they follow the same trail out every day. They're developing now little ceremonies, ways of relating. And when they go now to that far and distant land of southern Cook County, where people have been doing this in the Palos, an utterly different place, they feel as if guests there. And even if they see an ugly and awful buckthorn, they wouldn't dream of touching it or cutting it or removing it without asking one of the local elders. And so here these people are rediscovering their humanity - they're becoming, in a very real sense, the human beings of the North Branch, and the human beings of the Palos. So you see this happening (Wilhelm, pers. comm.).

4.6. Disturbance management and restoration

Noss and Cooperrider (1994: 29) write "...perhaps management is optimally a set of interim measures that will help ecosystems recover their natural values. The ideal future may be one where management is no longer needed because ecosystems are wild and healthy enough to take care of themselves." However, long term management remains an unavoidable reality of restoration projects. The oldest prairie restoration, at the University of Wisconsin at Madison, began in 1934 but still requires management to control the invasion of woody and exotic species. In fact, it highly unlikely that fire management will ever be unnecessary, as natural fire regimes remain interrupted (Kline, pers. comm.).

Betz (pers. comm.) suggests that there may be an endpoint to a restoration project in the sense that they will ultimately require only a minimal amount of work, which would consist mainly of burning. Restoration is a long term project:

> Rebuilding the prairie will take many years, because you don't put in a prairie all at once. It takes years for each successional stage, and if you come to the last [stage],

> which may take decades and decades, ...unforeseeable problems could occur.... If you have a tract at or near the final stage of succession you don't have a lot of trouble except that you have to continually burn to take care of it. And depending on the size you may lose some species and may have to bring things in (Betz, pers. comm.).

It is difficult, however, to predict what will happen (Kline, pers. comm.). Even the 50 and 60 year old prairie restorations at the UWM Arboretum change continuously and dramatically:

> ...It's just fascinating how much it changes each year. We get explosions of different species - one year I looked out the window and I could see right across the prairies a big patch of purple that had never been there before. I had to go out and see what it was - it was one of the *Liatris* species. There suddenly was enough of it that I could see it from clear across the prairie. Since I've been here we've begun to have an explosion of white baptisia [*Baptisia leucantha*]. I can remember coming here in years past - 20 years ago - and we would wonder why they weren't spreading - there were a dozen plants or two dozen plants. We'd look at the seeds and wonder if the weevils were eating the seeds, and then suddenly we have it wall to wall. I don't know how the natural prairies did this - we don't have any big natural, mesic prairies. I don't know if it's something you see because it's a new prairie - only 60 years old. But I don't expect to just sit back. We'll continue to see big changes and have problems (Kline, pers. comm.).

While management practices are all essentially experiments, some would argue that we need not be overly cautious when approaching active management. While in the past, management was often undertaken with little consideration of the long term consequences, Fitzsimmons and Put (1994: 22) propose that resource managers have swung to the opposite extreme and cite "...an aversion to accepting active management when long-term consequences cannot be predicted accurately." They point out, however, that our ability to predict the consequences of hands-off or status quo management is equally limited. Brown (1994) agrees, and contends that we need to swap attitudes and approaches between the often bold and aggressive introduction of exotic species and game animals (as in reforestation, range management, and fish stocking) and the usually more "timid and scrupulous" restoration of threatened species and habitats. It may be more appropriate for the introductions to be approached with caution and the restorations to be less scrutinized (Brown 1994).

Sieg (pers. comm.) contends that in order to plan a restoration, it is imperative to understand the historical disturbances to that system. She maintains that "...if you can understand what disturbances you had and the frequency of those disturbances and put those back into the system, the system will take care of itself. Because given those disturbances the native flora and fauna adjusted themselves." Hobbs and Huenneke (1992: 324) agree that the preservation of biodiversity and of functioning ecosystems requires "...explicit consideration of disturbance processes." For example:

> Suppression of fires in ecosystems dominated by fire-adapted species can cause severe disruption of community and ecosystem processes, which may have implications for the conservation of native, fire-tolerant species (Hobbs and Huenneke 1992: 327).

At the same time, as already discussed, managed fire schedules can alter dominance patterns within native and restored prairie systems (Howe 1994).

Both the imposition or removal of a grazing regime can act as a disturbance, depending on the grazing history of a place (Hobbs and Huenneke 1992). Prairie plants, for example, have evolved with grazing as well as with fire, and they are both tolerant of and adapted to such pressures. Designing grazing regimes is difficult, however, because different species in the same community will respond differently to various regimes. Grazers influence species competition through their feeding preferences. They can reduce dominance, with the result being that overall diversity is increased. Even the soil disturbance caused by grazers can change community structure. These impacts suggest that an ungrazed grassland area will "...develop differently than comparable grazed areas..." (Howe 1994: 698).

Smaller scale soil disturbances such as those caused by badgers, prairie dogs, and ants also play a role in increasing biodiversity of the overall landscape. In general, disturbances increase landscape heterogeneity and biodiversity (Hobbs and Huenneke 1992). Hobbs and Huenneke (1992) point out, however, that the effects of several disturbances often act "synergistically." They propose that managers should design disturbance regimes that are tailored "...to the landscape, the biotic community, and their specific conservation goals" (Hobbs and Huenneke 1992: 332).

The application of landscape ecology's patch analysis would be useful in this regard. Pavlovic (1994: 181) writes:

> Discordance between anthropogenic disturbance regimes and plant life history results from spatial, temporal, and/or intensity scales of disturbance that differ from those of natural disturbance to which plants are adapted.

Spatially, humans may isolate patches and populations by increasing the distances between them. Human disturbance by fragmentation results in novel habitat patterns to which many species may not be able to adapt. Populations may in turn be extirpated at higher rates than recolonization. Temporally, the frequency of disturbance may be altered by humans (Pavlovic 1994). Plants may not be able "...to reach maturity, produce seed, or establish" under the new regime (Pavlovic 1994: 181). In terms of disturbance intensity, alteration, whether by increasing or decreasing the intensity, "...can cause the disappearance of patches or catastrophic destruction of populations..." (Pavlovic 1994: 181). At the same time, "...the spatial, temporal, and/or intensity aspects of disturbance interact" (Pavlovic 1994: 181).

"Concordance between human disturbance and plant life history results from mimicking the scale of natural disturbance regimes" (Pavlovic 1994: 182). However, restoring the disturbance regime on a landscape or regional scale is difficult where there are a number of different land uses existing, and impossible where the "...original biotic disturbance agent was migratory or has a home range larger than reserve size" (Pavlovic 1994: 184). When an artificial disturbance must be introduced (e.g., cattle or horse grazing) it is critical that it be of appropriate scale.

Because relict habitat patches remain as small islands with artificial boundaries, disturbance regimes must cater to this. Whereas at one time "...many seral stages and community types [were] maintained simultaneously on a regional scale," presently a fire can destroy what may be the last remaining old-growth remnant (Noss 1983: 704). Even where the disturbances are very similar to the historic situation, the response to disturbance may be highly changed due to differences in available invasive or weedy species. Often, then, disturbance involves a trade-off - it may increase native diversity but also invite invasions by exotics. Managers must consider strategies in light of this (Hobbs and Huenneke 1992).

White and Bratton (1980: 245) express concern that in small reserves (relative to the scale of the disturbances) "...the full range of compositional fluctuations may be experienced locally." White and Bratton (1980) argue that it is critical that firm policies be in place to guide managers in terms of intervention in the preserves (or restorations), especially where natural disturbances are a vital part of that system. The dynamic quality of the system must be recognized and management must be guided by the needs of the system, rather than based on a simple, static view of the natural area. Indeed, as Sieg (pers. comm.) points out:

> If you had a one acre prairie remnant, you'd be real nervous about putting a cow out there if you're not sure that that's going to be okay. Well, with 70 000 acres the potential impact of some cows is lower....[So] larger areas are easier to manage in some ways. You can stick your bison out there, torch off half of this pasture this year and half next year. If lightning starts a fire there isn't a house right next to it.... A larger scale certainly takes less attention - you can let nature more take its course. Just put the things back that you thought were there originally and just "let 'er rip." Small areas require more intensive management, more tinkering. If you get a leafy spurge infestation in a five acre plot it could be gone literally in a year. On the Sheyenne National Grassland they've been battling leafy spurge for years, and they've definitely lost in some places but they've still got lots of places where they're winning.

4.7. Summary

The maintenance of ecosystem integrity is the main goal of ecosystem management. A system with integrity is biologically diverse (from the genetic to the regional scale) and exhibits the four properties of natural systems as defined by Laszlo (1972). Integrity, like the systems in which it is measured, is very complex. It is, to a certain extent, unique to each system, while each system may have a number of states that exhibit integrity.

Indicators of integrity may be chosen by identifying the characteristics that appear to be important to the maintenance of the community type being restored, as well as identifying the characteristics of the same community types in a degraded condition (Keddy et al. 1993). It is important that the indicators be practically measurable, as well as sensitive enough to measure degrees of integrity. The monitoring of a wide variety of characteristics is probably the safest approach.

Assessing the monitored characteristics is another complicating factor. The complexity of ecosystem responses to stress make it difficult to determine when a system is exhibiting a loss of integrity or a normal fluctuation. The restoration researchers and field workers that were interviewed relied most heavily on the presence or absence of specified species, with reference to the age of the restoration. They generally accepted changes in the restored system as long as exotics were kept at a relatively low level.

Holistic or ecological restoration aims to restore integrity to a compromised or destroyed ecosystem. In practice, restoration workers tend to focus on measuring species abundance and composition. Published historical materials (if any) and existing native remnants may serve as loose models for the restored communities. Attempts are made to impose a disturbance regime that is appropriate historically and in terms of scale.

Integrity is a concept that is value-laden and restoring integrity involves subjective decision making. As systems theory, landscape ecology, and ecosystem management acknowledge, humans can not possibly perceive the world around them without bias. These approaches, along with the management goal of ecological integrity, challenge societies to define the principles that should guide their interactions with the earth.

Special attention should be given to the societal aspects of restoration projects, namely local support and participation. The effectiveness of and need for certain management practices, such as burning or deer culling, must be demonstrated to the local community.

Employing local residents and incorporating volunteer stewardship in restoration projects encourages local support and in some cases may lead to the evolution of new human / habitat relationships.

In the next chapter, a restoration planning model will be presented that integrates the theoretical, philosophical, and practical issues that arise with the restoration of ecosystems.

5. A RESTORATION PLANNING MODEL

5.1. Introduction

Planning is a necessary step in the restoration process. Is it possible to develop a restoration plan that integrates the consideration of values and beliefs, a wise approach to natural areas conservation, and a consistent scientific and management perspective? One example of a plan for the design and implementation of a natural area restoration is that proposed by Nuzzo and Howell (1990). While only the first step in the restoration process, the plan is intended to significantly increase the restoration's "potential for success." The plan is a five step process:

> (1) conducting a site analysis and gathering background material;
> (2) establishing policy, goals, and objectives for the project;
> (3) creating the restoration design;
> (4) establishing and scheduling the implementation procedures and short-term management program; and
> (5) establishing a monitoring and evaluation program... (Nuzzo and Howell 1990: 202).

Nuzzo and Howell (1990: 208) emphasize that the five steps should not necessarily follow a strict, linear sequence: "Ideally, there is an ongoing feedback process between the implementation procedures, the actual implementation, research, and monitoring."

This is very similar to the adaptive ecosystem management plan presented by Haney and Power (1996). Their plan has six components:

(1) compiling ecological and social information about the site;
(2) establishment of goals and objectives;
(3) model development;
(4) management implementation;
(5) monitoring; and
(6) data analysis and model evaluation.

Haney and Power (1996), like Nuzzo and Powell (1990), stress the importance of adapting the management model as information is gained and as the system itself changes. They advocate developing a management plan that specifically allows for learning while managing.

A notable omission in the above plans is that the process of restoration is not considered in terms of ideological issues and fundamental goals. Thus, a revised restoration planning model is proposed here that incorporates the concepts that have been examined in previous chapters. The model consists of seven steps, each of which will be discussed in turn:

1. Identification of guiding principles
2. Identification of site
3. Identification of purpose
4. Identification of goals
5. Identification of objectives
6. Identification of methods
7. Implementation of plan

5.2. Identification of guiding principles

This step involves the explicit recognition of the values and beliefs that are relevant to the restoration project, i.e., the beliefs that underpin the decision to restore a site. These beliefs can also be referred to as the "guiding principles" and as such serve to inform every aspect of the restoration. Clarifying the rationale for restoration requires the consideration of issues such as those presented in the second chapter of this thesis. For example, it may be stated that value is placed on: positive human involvement in natural areas; maintenance or rehabilitation of ecosystem components and functions; maintenance or rehabilitation of ecological integrity; historically accurate ecosystems and disturbances; and/or management without the use of chemical herbicides. Likewise, beliefs are clarified. Examples include: (1) the belief that indigenous ecosystems will ultimately be protected through the transformation of societal attitudes about indigenous species and spaces; (2) the belief that human bias in decision-making should be acknowledged, while also being informed by scientific understanding; and/or, (3) the belief that ritual is vital to guiding the creation of appropriate ecological citizenry.

The guiding principles should be carefully stated initially and manifest throughout the restoration plan. In this way, they help to focus the direction of the restoration plan as well as inform decision making at more technical levels. When questions arise concerning management techniques or specific objectives, there will be a set of "guiding principles" against which to compare options. The other steps in the plan should be consistent with these guiding principles.

5.3. Identification of site

The next step is to identify and characterize the site in question. Obvious descriptions of the site such as the ownership, physical situation, social situation, and general ecological condition may be identified. Is it a schoolyard in an urban neighbourhood or a residential front yard? Is it a degraded site within a protected area? Is it one site within a proposed system of protected areas across an entire region? The characteristics of the restoration site will dictate to some degree what the restoration itself can or should achieve. For example, a front yard restoration cannot accomplish the re-establishment of a functioning large-scale ecosystem. More detailed ecological and cultural information will be gathered later in the plan. This step allows for the purpose and goals of the restoration to be realistic for or appropriate to the site.

5.4. Identification of purpose

The question "why restore this site?" should be answered. Answering this question identifies the purpose of the restoration project. There are several common reasons for restoring a site. These include:

- *Aesthetics*
Restoration recreates the unique character of a region's landscape (Morrison 1975).

- *Education*
Restoration provides hands on opportunities for learning about the regional flora and fauna.

- *History*
Restoration helps to create a "living museum," illustrating the historical landscape and potentially demonstrating the lifestyles of aboriginal peoples.

- *Scientific understanding*

The restoration process can be framed as an experiment, useful in furthering scientific knowledge.

- *Changing the human-habitat relationship*

Restoration can provide humans with a positive role in the landscape (Jordan 1988a; Jordan 1994a).

- *Providing habitat*

Restoration can provide habitat for endangered plant and animal species.

- *Regaining ecosystem services*

Restoration can help to recover some ecological functions such as erosion control, nutrient cycling, and drainage.

- *Recovering ecological integrity*

Restoration can potentially re-establish an indigenous ecosystem that possesses the characteristics of integrity.

The term restoration is quite general when used to refer to each of these purposes. Qualified terms may be more helpful where projects have a single or specific purpose: native landscaping might describe restorations where aesthetics take precedence; reclamation might refer to the restoration of ecosystem functions; and ecological restoration may describe the re-establishment of entire ecosystems and their functions. It is likely that many restorations will have more than one purpose and be informed by many values and beliefs. A restoration could set out to accommodate all of these purposes and values. The priorities of the stated purposes may need to be clarified, however. For example, shall experimentation be given priority over the restoration of integrity where the two may conflict?

These initial steps (identifying the guiding principles, identifying the site, and clarifying the purpose of the restoration) may be approached in any order. The process may be instigated by a set of values or guiding principles that lead to the search for a site where a restoration that serves a particular purpose could be undertaken. Alternately, a site may be presented and seem appropriate for a restoration of some sort with the guiding principles being considered later. Finally, the reason(s) for restoration may be apparent but the guiding principles need to be examined and a suitable site must be found. What is important is that each of these steps is undertaken, with emphasis on the implications of each on the others. Together these three steps form the "vision" of the restoration project.

5.5. Identification of goals

The fourth step identifies the restoration goals. In terms of a restoration project, goals may be defined as "...qualitative statements that clarify the [purpose] and provide direction for all future planning of the restoration" (Nuzzo and Howell 1990: 203). The goals describe the desired results of the project, "...including anticipated attributes and functions of the site" (Nuzzo and Howell 1990: 203). The goals offer more detailed, expanded descriptions of the purposes.

There are several issues to consider in goal-setting. As discussed in the previous chapter, ecological and social goals must be addressed, and both must be addressed within the context of the subjective nature of goal-setting. First, in terms of ecological elements, is the restoration aiming to restore the ecosystem components or the ecosystem functions and processes, or both (the whole system)? If the goal is to restore the latter, which whole system should serve as the restoration model? Should a system that seems to be historically accurate be used as a model, or should a system that exhibits ecological integrity and contains indigenous plants be used? If ecological integrity is deemed the most important goal the modelers must acknowledge that any given ecosystem may exhibit integrity in a number of different states. Biassed decision making is unavoidable - but how best to make decisions that lead to integrity and conservation of indigenous ecological diversity? Experimentation may be a necessary first stage.

Social goal-setting may address the need for public support of the project and the desired level of public involvement. Provision of opportunities for ecosystem involvement beyond the usual recreation uses may be a goal. Creating opportunities for ritual/spiritual experiences may also be identified as a goal.

Each of the purposes listed in 5.4 would lead to different restoration goals. Table 2 illustrates a variety of potential restoration purposes along with their associated principles and goals. For example, if a restoration were intended to illustrate the beauty of native plants, the goal may be to present well known species in such a way that the "feeling" of prairie is evoked rather than to carefully reproduce a more authentic piece of prairie. Most restoration will have more than one purpose and some will attempt to serve all of those purposes listed in 5.4.

5.6. Identification of objectives

The fifth step in the restoration planning model is to specify the objectives. Objectives are the "...quantifiable measures, or statements about measurable features, that make the goals operational" (Nuzzo and Howell 1990: 203). The objectives are the tasks to be completed in order to reach the goals that have been set. Like goals, objectives describe the desired results of the project, but objectives do so in a more detailed, quantitative fashion. In this way, objectives act to "...provide criteria which will be used to judge the success of the restoration" (Nuzzo and Howell 1990: 203).

Making explicit the criteria by which the restoration success will be judged will "..permit rigorous examination of the [restoration] activity itself and, equally important, identify changes in strategy more likely to reach intended goals" (Cairns and Heckman 1996: 185). In order to develop such objectives one "...requires a clear understanding of how the restoration will take place, and knowledge of the target communities and species, habitat requirements, site conditions, and proposed uses" (Nuzzo and Howell 1990: 204). This step can be broken down into four sub-objectives:

5.6.1. Site description

The first sub-objective involves the description of the historic and current ecological and cultural characteristics of the restoration site and the surrounding area. The ecological

Table 2. Potential restoration purposes along with their associated principles and goals. Most restoration programs will have more than one purpose and some will attempt to serve all of these purposes.

PURPOSE:	AESTHETICS	EDUCATION	HISTORY	SCIENCE	HUMAN ROLE	HABITAT	SERVICES	INTEGRITY
PRINCIPLES:	Value is placed on "natural" beauty and/or the unique character of a region.	Value is placed on knowledge of the regional flora and fauna and/or hands on learning.	Value is placed on knowledge of the historical landscape and/or the practices of aboriginal peoples.	Value is placed on *in situ* experiments and furthering scientific understanding.	Value is placed on giving humans a positive role in the ecosystem and/or creating modern mores to promote conservation.	Value is placed on protecting indigenous species from extinction.	Value is placed on the services provided by the indigenous ecosystem.	Value is placed on the existence of systems that evolved in a place and/or on the ethic of repairing the damage we have done.
GOALS:	To evoke the "feeling" of prairie using well known and beautiful plants	To include a wide assortment of species with different characteristics	To create the look of a prairie landscape and include species with food, spiritual, and medicinal roles	To conduct restoration such that it is an experiment - the restored area is a by-product of the experiment	To reintegrate people into their habitat while at the same time building community and increasing awareness of conservation issues	To establish large populations of endangered indigenous species (rather than authentic densities) and fulfill specific requirements of certain species	To restore ecosystem processes but not necessarily using indigenous species or communities	To restore indigenous biodiversity, ecosystem functions, and disturbance regimes in order to re-establish system integrity

analysis "...consists of identifying and evaluating biotic and abiotic components of the site, and assessing their interactions" (Nuzzo and Howell 1990: 202). Nuzzo and Howell (1990: 202) outline the basic information that should be gathered. Biotic information should include "...an assessment of the abundance, diversity, and distribution of species and communities within and adjacent to the site, with special attention to problem species (both native and exotic) and the status of rare, threatened or endangered species, and identification of the site's presettlement community types." The abiotic information should include "...an assessment of the geology, topography, soils, chemistry, surface and groundwater hydrology, and microclimate of the site. In some restorations, ecosystem functions are identified." The ecological information can be obtained from a combination of on-site data collection and published data, such as soil maps, topographic maps, and climate data (Nuzzo and Howell 1990).

The cultural site analysis "...documents changes in, and impacts on, the natural regime resulting from anthropogenic activity, as well as the current and anticipated human use of the area after restoration. Legal restrictions, including zoning and easements, are also identified" (Nuzzo and Howell 1990: 202). By documenting the impacts of human actions on the site, the restoration can be specifically designed so as to mediate against negative impacts. Furthermore, the consideration of future human use of the area and its environs allows for the incorporation of features such as trails or buildings "...with minimal disruption to the restored communities" (Nuzzo and Howell 1990: 202).

Haney and Power (1996) would add to the inventory process the identification of stakeholders and the collection of information about their concerns. Stakeholder support is vital to sound management, and meetings and surveys can indicate the level of support and understanding among stakeholder groups (Haney and Power 1996). This can point out where extension and education may be needed for the management plan to proceed with stakeholder approval (Haney and Power 1996).

Nuzzo and Howell (1990) stress that the site analysis must extend beyond the site. Factors such as neighbouring vegetation and land use may seriously affect the restoration. It may not be possible to change off-site factors, and alleviating the negative impacts of certain conditions may be expensive (Nuzzo and Howell 1990). These factors may indeed determine the feasibility of the project itself, and will certainly be fundamental considerations in the restoration design.

The third major component of this sub-objective is the gathering of "...information about the structure and functions of the natural communities that serve as models for the restoration" (Nuzzo and Howell 1990: 203), whether from actual remnant sites or from published materials. This information can be used to develop target conditions for the restoration and eventually as "baseline data" against which to compare the restored site (Nuzzo and Howell 1990).

The site analysis will contain information that will be vital to the evaluation process. It provides an account of the initial site conditions, and so can be used as a benchmark against which to measure the success of the project (Nuzzo and Howell 1990).[20]

5.6.2. Restoration design

The second sub-objective, to design the restoration, involves a number of considerations. "The design specifies the desired physical structure of the site, with topographic intervals and hydrologic conditions, and designates the spatial location and composition of the natural communities within the site" (Nuzzo and Howell 1990: 204). Nuzzo and Howell (1990: 204) point to consideration of "...slope, aspect, soil structure, substrate, hydrology..." as

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[20] The detail required in each of the sub-objectives will be a reflection of the restoration goals. For example, where a project is not focussed on restoring ecosystem health, services, integrity, etc., less detailed site analysis would be required.

well as the more obvious subject of vegetation. Vegetation is often modelled on remnant communities in terms of "...species presence, frequency, density, [and] percent cover...," for example (Nuzzo and Howell 1990: 204).

In any case, detailed lists of species to be present in each community type, and their "...desired proportions, patterns, and spatial arrangements," must be carefully described (Nuzzo and Howell 1990: 205). Further, the arrangement of community types in space, the transitions between them, and the relationship between the restored and adjacent landscapes must be considered (Nuzzo and Howell 1990). In restorations that begin with a degraded, rather than destroyed, site, community types and spatial arrangements will perhaps still be discernible. In such cases, the design will be informed by existing vegetation.

Restoration design will benefit from the application of landscape ecology and patch dynamics concepts. Different patches, or vegetation communities, that make up landscapes tend to be accompanied by a particular set of attributes. "The broad vegetation type that would have occurred in any particular area can often be inferred from landform, soil type, or other biophysical attributes" (Hobbs and Norton 1996: 100). The collection of these types of site characteristics can lead, then, to the restoration of appropriate "patches."

Nuzzo and Howell (1990) suggest that restoration design also must take management and recreational needs into consideration. For example, temporary roads may be required during the initial stages to provide access for irrigation, mowing, or weed control. Firebreaks should be incorporated where controlled burns will be part of the long term management of the site. Where visitors are allowed, trails may be designed. Likewise, where human use is to be discouraged, physical means such as fences or signs may be included, as may psychological barriers such as "limited visual access" (Nuzzo and Howell 1990).

Nuzzo and Howell (1990) point out that the design usually goes through a number of transformations as different interest groups add modifications. Also, in the case of large restorations that will be approached in stages, a series of designs should be drawn up to represent each stage. "This ensures that the sequence is realistic, and allows each stage to stand alone yet be sufficiently integrated into the following stage..." (Nuzzo and Howell 1990: 205). Planners may wish to follow Egan's (pers. comm.) suggestion of starting with the least degraded sites first:

> There's a general theory of working from the best to the worst. With a little bit of effort you can get good results and then move on to the other places. You start with the easy stuff, get some results, build up some momentum. It's always good, politically, to get some results and show that the funders are getting some bang for their buck. In a similar way there's an approach called a triage approach, where like in a military situation where you are bringing in wounded, you take the ones that you think you can help, and those who are near gone fall down in the priority scale. This of course is driven by limited funds. If money is no object then that's not a problem. On the other hand if some sites are so degraded and there's a possibility that they'll become even more degraded over time, you might want to put them into a holding pattern until you can get to them. I know that the plains have a lot of trouble with leafy spurge [*Euphorbia esula*], for example, and once that gets into a degraded site it's just more trouble than it's worth. So you may want to tackle that too. You kind of have to balance that out but the basic approach is to work from the best to the worst.

5.6.3. Implementation and management

The third sub-objective is to establish and schedule implementation and management procedures. This step takes the site as it exists immediately prior to the start of the project and clearly describes the procedures necessary to reach the state characterized and specified in the design and objectives. The procedures should be detailed, precise, and realistic, as well as clear enough to be used by a third party to direct the restoration (Nuzzo and Howell 1990: 205).

Implementation consists of "...site preparation, planting rates and procedures, and acceptable conditions and sources of plant and animal materials" (Nuzzo and Howell 1990: 205). Procedures described for site preparation vary between communities, but may specify actions to modify existing topography, remove exotic species, or prepare an area for planting. Certain tools and equipment may be specified (Nuzzo and Howell 1990).

Planting procedures specify the amount and type of propagules to be used. Of course, this should take propagule availability into consideration. Where seed availability is limited, it may be more sensible to either break the project down into smaller areas to be planted over a number of years, or to set up a system whereby the amounts needed to plant the entire area can be propagated (Nuzzo and Howell 1990).

If there is a concern about maintaining local genetic diversity, the definition of "local" should be defined, as should the policy on locally extinct species. It is very common for a "collection radius" to be imposed - that is, a somewhat arbitrary boundary beyond which plant materials are not used. The point of imposing a boundary is to "...ensure local genetic integrity" (Nuzzo and Howell 1990: 205). Nuzzo and Howell (1990) stress, however, that this specification must be very clearly thought out. For example, some species may not be found within the area delineated, but be indigenous to the site. Further, it may be that spatial proximity is a rather poor way to ensure similarity. For example, nearby sites may "...vary substantially in microclimate, elevation, substrate, or other habitat feature."[21]

Other planting specifications include plant size, required condition of plant material (such as lack of disease and container size), cover crop or mulch requirements, and any fertilization or irrigation needs (Nuzzo and Howell 1990).

Standards should also be set in the implementation procedures. For example, "...acceptable soil compaction rates or minimum percent species presence and vegetative cover two years after seeding" may be specified (Nuzzo and Howell 1990: 205), but it is vital that these standards be realistic. Establishment and survival rates vary in time. Further, as survival does not always lead to long term establishment, measurements of "...plant frequency or density, or animal reproduction..." should also be specified (Nuzzo and Howell 1990: 205).

The management of the restoration after planting is vital to the success of the project.

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[21] Nuzzo and Howell (1990: 205) cite Millar and Libby (1989).

Both short term and long term management practices and regimes should be outlined. Procedures to meet short term objectives such as irrigation, weed and erosion control, and replanting or re-seeding where necessary should be proposed. Similarly, long term management regimes should be proposed. One long term effort will be the control of exotic species, likely through mowing or burning and specific herbicide application where necessary (Nuzzo and Howell 1990). Another management element that must be developed is the disturbance regime. Disturbance intensity, frequency, and spatial extent must be proposed, as must disturbance methods. Fire and grazing are the two most common methods.

Brown (1994), like Howe (1994), expresses concern over the paucity of controlled experimentation in restoration ecology. Brown (1994: 360) contends that experimentation must be integrated into restoration projects in order that we can "...separate ecologically sound practices from those motivated by force of habit and conventional wisdom." It may therefore be wise to approach management strategies experimentally as a test of our models and understanding (Fitzsimmons and Put 1994). Where experimentation is to be a part of the restoration project, guidelines in terms of acceptable impacts of the experiments on the restoration should be determined (if indeed the restoration is not itself intended as an experiment).

A schedule that outlines the timing of the implementation procedures is extremely important. The schedule "...provides direction for those implementing the plan, and ensures that each step is conducted in the appropriate time span relative to other steps" (Nuzzo and Howell 1990: 207). However, Fitzsimmons and Put (1994) point out that while many management programs require long term commitments in order that the objectives be met, the reality of inadequate funding and staffing can pose serious obstacles to this end. Dealing with the necessary monetary and personnel requirements is imperative to the ultimate success of conservation management.

The procedures to implement the social goals of the project should not be overlooked. As the non-human considerations are being outlined and scheduled, so too must the implementation and management of social goals be clarified. Specific approaches to community involvement and information dissemination should be proposed. The level of desired community or volunteer involvement should also be determined, and the best methods of achieving those objectives should be established. Procedures must be outlined to meet the desired social endpoints, such as local involvement in the project. For example, if public meetings are to be held, their format must be determined and they must be scheduled. Effective methods of informing local people and encouraging their involvement and support must be established.

5.6.4. Monitoring and evaluation

The final sub-objective is to establish a program to monitor and evaluate the restoration. "Monitoring is a critical and acclaimed (but often neglected) component of natural area restoration" (Nuzzo and Howell 1990: 207). Monitoring serves several purposes: it allows the success of the project to be measured and/or verified; it provides a means to evaluate whether or not the standards have been met; it can point to reasons for the success or failure of the restoration; it highlights the need (when necessary) to undertake remedial procedures; and it documents "...the process, as compared to the results, of restoration" (Nuzzo and Howell 1990: 207).

Like the other aspects of restoration, developing a monitoring and evaluation program requires attention to the social and ecological goals and objectives of the specific project. Even different communities within the same restoration project may have different monitoring requirements (Nuzzo and Howell 1990).

In this step, the procedures by which monitoring will take place should be very clearly described, such as methods of collecting and analysing data. Clarity in the detailing of procedures will help to ensure that different people over years of monitoring can accurately repeat measurements and descriptions. Both quantitative and qualitative procedures are useful. The former can provide "...accurate measurement of restoration success," while the latter can add to this information with "...permanent photographic points and lists of species presence...," for example (Nuzzo and Howell 1990: 207).

In Chapter 4, specific attention was given to monitoring and assessing ecological integrity, as it is perhaps the most important and problematic goal of many restoration projects. While integrity indicators should be developed in reference to the ecosystem in question, several general characteristics of integrity have been proposed. Care must be taken to consider spatial and temporal scales when assessing the importance of the information being monitored, as system responses are often unique to the scale of measurement. Both macro- and micro-scale monitoring is important.

Critical to the usefulness of monitoring is a process whereby the information from the monitoring procedures is fed back into the restoration plan itself. For example, where volunteer programs have been unsuccessful, approaches other than those outlined may be required. Similarly, if non-chemical management cannot adequately remove a particularly invasive weed, planners may be forced to revise their advocacy of a non-chemical approach. Nuzzo and Howell (1990) suggest that it is also important that the knowledge gained about successful or unsuccessful approaches be published in an attempt to further restoration ecology's development as a science.

Monitoring "critical features" should continue on a long term basis. Short term success may be misleading, and long term study of restorations may lead to more efficient and well-directed projects in the future (Nuzzo and Howell 1990).

There are several other important considerations when developing an assessment framework. One of the initial steps must be to consider who will ultimately be using the information and thus, what kind of information is desired (Kay 1993; Munn 1993; Steedman and Haider 1993). Another basic step is to explicitly state the theoretical and methodological approach that will be taken, as well as the personal and cultural biases of the researcher, so that the bias inherent in any approach (and by implication the resulting analysis) can be openly evaluated and accounted for (Kay 1993; King 1993; Steedman and Haider 1993).

Some suggested characteristics of an assessment approach are that it be flexible and able to incorporate new understanding and knowledge (Marshall et al. 1993; Haney and Power 1996) and that it monitor for "...both known and unknown stresses" (Woodley 1993: 166). Another suggestion is that the approach include measures and perspectives from as many theoretical areas as feasible in order to provide as comprehensive an analysis as possible (Karr 1993; King 1993).

Monitoring and evaluation are the least straightforward of the stages in restoration. However, they are extremely important considerations and attempting to address the unknowns should improve understanding of integrity and ecosystem sustainability.

5.7. Identification of methods

The sixth step in the restoration planning model is the outline of the methods to be used in order to meet the objectives. As previously mentioned, the methods chosen should not only meet the objectives that have been established, but should be consistent with the guiding principles. Generally the methods consist of two major components. The first involves compiling information relevant to each objective through field work, surveying published materials, and/or conferring with those who have expertise in the subject in question. The second component involves analysing that information and making it usable in terms of meeting each objective. Methods will not be discussed further here, as they will be specific to each restoration.

5.8. Implementation of plan

The final step is to put the plan into action, that is, to follow the schedules and methods as outlined, as well as to regularly re-assess the plan as conditions change or new information is gained. For further clarification and to illustrate how steps one through five of the model planning process might proceed, a hypothetical restoration plan is presented in Figure 8.

5.9. A process of clarification

Above all, "A restoration plan needs to be realistic, clearly written, based on attainable objectives, and flexible enough to accommodate change without losing effectiveness" (Nuzzo and Howell 1990: 208). The clarity of consideration is of utmost importance; careful consideration of the issues at each stage in this planning process will be more likely to lead to a project that is successful, by the standards set by the planners.

Even the most thorough planning, however, cannot overcome uncertainty about the wisdom of chosen management goals or a manager's ability to meet these goals in the first place. Dealing with ecosystems is highly complicated and a great many of the variables are beyond the manager's control. Planning that recognizes these limitations and attempts to add to ecosystem understanding is the best option.

5.10. Summary

A seven step planning process, suitable to a variety of restoration projects, has been presented. The planning model attempts to integrate the many issues that arise with such a project.

It should be re-emphasized that the steps in this plan should act and be approached as an integrated whole. The purpose, goals, objectives, and methods each grow from the guiding principles and themselves are interconnected. The site is the context in which the planning proceeds, while off-site characteristics are considered in terms of their influence upon the site

STEP 1: GUIDING PRINCIPLES

It is important and desirable to:
- sustain indigenous biodiversity and ecological integrity
- restore indigenous biodiversity and ecological integrity where they have been compromised
- gain knowledge and appreciation of our "home place"
- learn about and understand aboriginal cultures and traditional ecological knowledge
- establish a meaningful and positive role for humans in the landscape

STEP 2: SITE IDENTIFICATION

- 64.8 ha (160 acres) of provincially owned land 20 km northwest of Regina, Saskatchewan, Canada
- contains degraded mixed grass prairie; 16.2 ha (40 acres) have been under cultivation, the remaining 48.6 ha (120 acres) have been overgrazed and contain significant amounts of exotic grass and forb species
- surrounding landscape is predominantly under cultivation

STEP 3: PURPOSES

- to restore indigenous biodiversity (as much as possible) and ecological integrity to the entire site
- to provide ecological and historic learning opportunities
- to integrate people, including Regina residents, into their prairie habitat

STEP 4: GOALS

- to re-establish the indigenous plant species mix and eliminate the non-native species
- to re-establish populations of indigenous fauna where possible
- to re-establish species interactions and ecosystem processes
- to provide information on the native species and on the usefulness and significance of certain plants to aboriginal cultures
- to create opportunities for low impact public activities, such as hiking and skiing, where system integrity will not be compromised
- to establish a volunteer labour corps as a means to integrate people with the ecosystem and to maintain ecosystem integrity
- to provide information about the project to local residents
- to involve local residents in decision making

STEP 5: OBJECTIVES

A: GATHER ECOLOGICAL AND CULTURAL INFORMATION
- document and analyse existing vegetation and vegetation patterns, geology, topography, hydrology, soils, and microclimate both on- and off-site
- collect and analyse any existing historic information regarding the above characteristics
- survey surrounding area for prairie remnants to further inform the desired species mixes
- document and analyse the current and historic land uses of the site and the surrounding areas, including pre-European settlement
- inform local residents of the planned project and hold public meetings to gauge concerns and attitudes
- identify any legal limitations relevant to the site (e.g., zoning, easements)

Figure 8. **Example of a restoration plan (steps 1 - 5) for a hypothetical project.**

B: DESIGN RESTORATION

- design the restoration in terms of species mix, vegetation communities, and any reconstruction of topographical or hydrological features
- map the placement of hiking trails, the information centre, and parking lots
- map the placement of firebreaks

C: ESTABLISH AND SCHEDULE IMPLEMENTATION AND MANAGEMENT PROGRAM

- establish site preparation guidelines, considering any requirements for topographical reconstruction or soil amendment
- determine the methods of weed elimination, both in the degraded prairie and the broken land
- establish guidelines for propagule sources, in terms of a "collection radius"
- determine seed requirements and whether seed sources exist or if they need to be established
- determine the planting procedures
- set standards for desired short term and long term frequency and/or density of species
- if there is insufficient information to complete any of the previous objectives either set up pre-restoration experiments to determine propagule needs and which implementation and management procedures would be most effective, or approach the restoration as a long term experiment using a variety of techniques
- propose a short term management plan
- propose a long term management plan to deal with exotic species and the need for disturbance
- obtain coverage of the project in local media wherever possible
- hold public meetings both to inform and involve local residents
- target local schools and clubs to get involved in the planning and implementation stages
- convey a sense of project ownership to local residents and initiate a volunteer work force with multiple responsibilities
- carefully schedule the implementation of these objectives

D: ESTABLISH MONITORING AND ASSESSMENT

- select the criteria by which ecological success shall be judged, i.e., establish desired frequency, pattern, and mix of plant species and specific indicators of ecological integrity to be regularly measured and evaluated
- establish an evaluation program for the social goals, i.e., conduct an annual review of educational programs and volunteer involvement to ensure that they are effective in meeting the original goals and consistent with the guiding principles
- feed the information from the monitoring and evaluation process back into the restoration plan in order to reform the plan where necessary and to accommodate changing needs of the restoration project and of the people involved

Figure 8. (continued)

and the restoration plan. Each step in the plan may uncover new information that will lead to the amendment of previous steps. In other words, as the planning proceeds, new information should always be fed back through the previous steps which should, in turn, be re-evaluated and modified where necessary. Later, when the plan is operationalized, new information should be used to re-assess the relevance of the plan and to amend components of the plan where appropriate.

By incorporating new information into the entire plan and at the same time assessing the new information in the context of the entire plan, the plan is made as effective as possible. The continued reference to the principles, purpose, goals, objectives, and methods that guide the project helps to integrate the separate steps so that the restoration represents a consistent and well considered approach to a conservation problem.

6. CONCLUSIONS

6.1. Summary and future directions

The steep and rapid decline of natural areas in North America leads to an examination of current conservation approaches. Humans in modern Western cultures tend to view themselves as distinct from nature. In order to achieve conservation objectives, modern industrialist societies need to accept the notion of human belonging in the landscape and learn to live in "dynamic complementarity" with the landscape. Restoration of ecosystems has the potential to integrate humans with their habitat in a meaningful and mutually beneficial way.

Restoring ecosystems requires consideration of whole systems, including the human component. Landscape ecology theory and ecosystem management are two perspectives that approach landscape management holistically and are useful in attempts to restore the ecological integrity of a natural system. Ecological integrity is a value-laden concept, and the influence of human values must be addressed. Likewise, the social aspects of restoration, such as local involvement and support, must be considered as part of the landscape management plan.

The seven step planning process presented in Chapter 5 integrates the variety of issues relevant to restoration, with special emphasis on the definition of the project vision: the guiding principles, the restoration site, and the restoration purpose. The project vision creates a context within which management goals and techniques can be defined and success can be evaluated. This holistic planning process aids in the development of an effective restoration project.

This thesis delimits the philosophical and theoretical issues that are fundamental to ecological restoration by presenting: (1) a comprehensive discussion of the main issues relevant to developing a strategy for restoring ecosystems; and (2) a conceptual model of the steps involved in developing such a strategy. A comprehensive discussion of the many issues that are basic to ecological restoration and a conceptualization of these issues as an integrated whole has been provided. This "whole" acts as the setting for the restoration, to be dissembled only after it emerges as a conceptual framework for a comprehensive approach to restoration.

In retrospect, there are several issues that could add to the discussion if explored more fully. The first is the concept of efficiency in restoration, that is, the economic considerations in restoration planning and implementation. Higgs (1997) pointed to efficiency, in terms of the required inputs of time, labour and resources, as one component that defines a successful restoration. Second, certain of the social implications of restoration as highlighted by Light and Higgs (1996) were not fully discussed. Specifically, the politics of restoration when it is a corporate-sponsored project as compared to a community activity is worthy of further discussion. Third, while reference is made to indigenous cultures and their practices, there has been no discussion of management from the perspective of traditional ecological knowledge. The management theory discussed (i.e., ecosystem management) is based in western science, albeit a new approach in western science.

A final limitation is that in presenting a comprehensive discussion there is an inherent lack of detail. Each component of this thesis warrants the attention of a more extensive study. Many of the topics are already the subject of a great deal of research and discussion. Others, however, are not, pointing to the need for future work in several areas:

(1) Developing templates and measures of meaningful local participation in restoration.

In order to develop recommendations for local participation, it may be necessary to look to restoration projects that involve local people, public participation models, and historic examples of community-scale conservation behaviour. From this, it would be useful to derive social indicators that can be used to measure participation and thus the success of a restoration project with respect to its potential for involving communities in local conservation.

(2) Documenting the storehouse of unpublished knowledge of restoration workers, in order to share information and direct future experimentation.

Restoration workers have a great deal of experiential knowledge that may not be shared in written form or tested for broader application. The subtleties of ecosystems are often internalized by those who spend day after day entangled in them. These intuitions and instincts, though perhaps unsubstantiated by scientific experiment, can be useful pointers for researchers. Ecological integrity is complicated by the absence of benchmark data, and the guidance of those who are directly involved in and observing ecosystem change may prove invaluable. A first step is to document this anecdotal knowledge.

(3) Establishing indicators of ecological integrity and the recovery thereof.

Much research is needed to increase understanding of ecological integrity. In particular, it may be useful to devise indicators of integrity applicable to particular landscape and vegetation types. In Saskatchewan, Canada, the provincial landscape has been subdivided based on ecological characteristics such as soil and geological attributes, landform type, and dominant vegetation (Ecological Land Classification Committee, 1994). The potential for a classification system such as this to provide a framework for associated indicators of ecological integrity should be considered, and research therein should proceed.[22] Special attention should be given to measuring degrees of integrity and trends of improvement or decline.

(4) Designing whole-region / whole-landscape conservation and restoration plans to serve as bases for coordinated, multi-agency conservation efforts.

Efforts should be made to design conservation plans according to ecological regions. By identifying conservation objectives across a landscape, the resulting work should be more likely to achieve long term conservation of biodiversity and ecological processes. As discussed, a site-by-site approach cannot accommodate ecological processes that operate on a larger scale, and

[22] A recent manual (Nernberg 1995) that describes species mixes for grassland restoration in Saskatchewan is subdivided on the basis of this classification system.

this is imperative to conservation. Designing a large-scale plan would allow different agencies and communities to operate in a coordinated way to reach a common goal. Again, an ecological classification system such as Saskatchewan's may serve as a useful framework for identifying landscapes and the appropriate planning scale.

(5) Applying and evaluating holistic restoration plans.

The conceptual model developed in this thesis should be tested in practice. Modifications to the model itself may arise from this process. At the same time, it is vital that restoration work be implemented across landscapes and regions. While serious attention to the theories, concepts, planning, and research designs of restoration are crucial, empirical work on the landscape must begin in earnest.

Continued work in each of these areas will strengthen the usefulness of ecological restoration in the long term conservation of biological and ecological diversity and integrity.

6.2. Recognizing complementarity, restoring integrity

Humans, like all other species on the planet, are products of conditions on Earth. For millennia, earth's species have been evolving to adapt to the conditions presented in a certain geographical place. Soils, micro-organisms, climate, disturbance events and regimes, topography, hydrology, vegetation communities, and the immense variety of animal species, including humans, are linked in an intricate web. When large and sudden alterations in this web occur, or novel introductions are made, systems are not always able to adjust to maintain the pre-existing components and patterns.

In recent history, armed with relatively powerful technologies and a "nature-as-other" ideology, human migrants have imposed adjustments on their surroundings, resisting adjustments to themselves. Many biotic and abiotic components of ecosystems have been substantially altered by human activities.

The latest immigration of humans to North America, that began in the fifteenth century, can be likened to the introduction of other species to environments in which they did not evolve. Leafy spurge is an example of a Eurasian plant that has no natural control agents on the North American continent. The combination of its extremely successful adaptations for propagation, its aggressive nature, and the lack of interdependent relationships with other species (such as natural predators or competitors) results in leafy spurge invading indigenous plant communities to the extent it replaces most of the native herbivory.

Leafy spurge, however, is not "unnatural" in its behaviour. It is simply not native to this place. It is an alien species, lacking the controls that the processes of evolution impose. Likewise, the most recent human immigrants to North America are natural. Humans have also been highly successful at appropriating resources for their own uses and ensuring the propagation of their species. With the assistance of science, technology, and medical advances, they too have evaded natural controls on their numbers. To avoid the results of over-exploitation, rational beings must impose limits on their behaviour. As Forman (in Pollan 1990) suggests, humans must return to the metaphorical pilgrim shore - a return that brings with it the attempt to understand how *humans* can adapt to their habitat.

Conservation, therefore, is not a question of naturalness but of negotiating complementary relationships, acting as one of the interdependent parts within the larger ecosystem. As Grumbine (1994b) proposes, living in harmony with nature really means living in a dynamic complementarity that is continuously redefined. This requires the mediation of behaviour. What should guide this mediation? What interactions, what forms of consumption, and what changes are acceptable?

It is not the magnitude of interference alone that defines unacceptability. Restoration of devastated landscapes is large-scale interference. Neither is it solely the use of advanced science and technology. The judicious use of herbicides may help remove invasive exotic species, while scientific research informs wise management decisions. Likewise, mimicking historical processes is not a simple guide to acceptable behaviour, as our lack of knowledge and the considerable alterations to historical ecosystems may make re-creating historical systems impossible. In fact, to mimic what we believe were the historic ecological processes may ultimately be detrimental. Controlled fires on small parcels of land, with no alternative natural habitat as refuge or re-population source, may be devastating to certain plant, insect, or animal populations. The ecological effects of fire in the absence of free-roaming bison may be entirely different than they were historically.

While reducing the magnitude of interference, minimizing novel actions and introductions, and mimicking historic ecosystem processes are important considerations in conservation, human actions must be guided by whether or not an action is sustainable, or if it is compatible with the maintenance or recovery of ecological integrity and/or diversity. It may not be possible, given the lack of understanding of what characteristics define ecological integrity, to be sure that resource and land management decisions meet these criteria. Yet human decision-making is always and necessarily hindered by built-in limits in perception. The impacts of all land-use decisions are somewhat unknown, and the lack of knowledge increases with the temporal scale.

Uncertainty, however, should not deter conservation or restoration activities. It may be ideal to measure a whole suite of integrity indicators, but not practically feasible. For example, a project may support only the planting of wild-harvested native seed and subsequent management of the site. It may not serve as a benchmark against which to examine restoration techniques, and the only measured indicators of integrity may be the presence or absence of certain species. Nonetheless, the project can be beneficial to biodiversity conservation. Despite uncertainties or unknowns, it is still constructive to attempt to partially restore the abundance and extent of indigenous species and ecosystems. Humans may not be able to distribute species to exactly replicate a system that has evolved under normal successional processes. It may not be possible to take land that has been cultivated for decades and re-create soils that existed under prairie sod for thousands of years. Nonetheless, it is possible to conserve the components of ecosystems, restore assemblages of species, and allow evolutionary processes to operate in a relatively undisturbed fashion.

Humans will never re-create the North America of five hundred years ago. Even if human resource appropriation decreased substantially, too many species have been introduced or eradicated. Humans have altered the evolutionary course of the living and non-living components of this continent. However, it is possible to work towards perpetuating the genetic information that remains, in what may be new systems. It may be possible to sustain and establish ecological integrity at various scales, through conservation and restoration of indigenous ecosystems in combination with the restoration of ecosystem functions across the landscape as a whole. Wise management decisions can perhaps be made from perspectives that respect the wholeness of systems and attempt to understand them in their complexity.

> At first glance, a vision of North America with regained wildness and biodiversity seems unrealistic, even utopian. [But] perhaps recovery is inevitable. The human population cannot grow forever, and must either plateau, decline gradually, or crash. In any case, repairing the damage our culture has done and giving other creatures a fair chance for life is the job of enlightened management today and in the future. This is our chance to pay retribution (Noss and Cooperrider 1994: 27-28).

LITERATURE CITED

Aber, John D. and William R. Jordan, III. 1985. Restoration ecology: an environmental middle ground. *Bioscience* 35(7): 399.

Baldwin, A. Dwight, Jr., Judith de Luce, and Carl Pletsch. 1994a. Conclusion: constructing a new ecological paradigm. In *Beyond Preservation: Restoring and Inventing Landscapes*, eds. A. Dwight Baldwin, Jr., Judith de Luce, and Carl Pletsch, 260-265. Minneapolis, Minnesota: University of Minnesota Press.

_________. 1994b. Introduction: ecological preservation versus restoration and invention. In *Beyond Preservation: Restoring and Inventing Landscapes*, eds. A. Dwight Baldwin, Jr., Judith de Luce, and Carl Pletsch, 3-16. Minneapolis, Minnesota: University of Minnesota Press.

Berger, John J. 1990. Introduction. In *Environmental Restoration: Science and Strategies for Restoring the Earth*, ed. John J. Berger, xv-xxiv. Covelo, California: Island Press.

Birch, Thomas H. 1990. The incarceration of wildness: wilderness areas as prisons. *Environmental Ethics* 12: 3-26.

Block, John. 1984. Evolution of the wilderness concept in the US. In *Wilderness: The Way Ahead*, eds. Vance Martin and Mary Inglis, 74-77. The Park, Forres, Scotland: Findhorn Press and Middleton, Wisconsin: Lorian Press.

Bonnicksen, Thomas M. 1988. Restoration ecology: philosophy, goals, and ethics. *Environmental Professional* 10: 25-35.

Bradshaw, A.D. 1996. Underlying principles of restoration. *Canadian Journal of Fisheries and Aquatic Sciences* 53 (suppl.): 3-9.

Brinck, Per, Lars M. Nilsson, and Uno Svedin. 1988. Ecosystem redevelopment. *Ambio* 17(2): 84-89.

Brown, James H. and Jonathan Roughgarden. 1990. Ecology for a changing earth. *Bulletin of the Ecological Society of America* 71(3): 173-188.

Brown, Joel S. 1994. Restoration ecology: living with the Prime Directive. In *Restoration of Endangered Species: Conceptual Issues, Planning, and Implementation*, eds. Marlin L. Bowles and Christopher J. Whelan, 355-380. New York: University of Cambridge Press.

Brunner, R.D. and T.W. Clark. 1997. A practice based approach to ecosystem management. *Conservation Biology* 11(1): 48-58.

Burch, William. 1971. *Daydreams and Nightmares*. New York: Harper and Row.

Cairns, John Jr. and J.R. Heckman. 1996. Restoration ecology: the state of an emerging field. *Annual Review of Energy and the Environment* 21: 167-189.

Capra, Fritjof. 1982. *The Turning Point: Science, Society, and the Rising Culture*. Toronto: Bantam Books.

Caraher, D. and W.H. Knapp. 1995. Assessing ecosystem health in the Blue Mountains. In *Silvaculture: from the Cradle of Forestry to Ecosystem Management*, (General Technical Report SE-88, Southeast Forest Experimental Station, U.S. Forest Service), 34-41. Hendersonville, North Carolina.

Colwell, Tom. 1987. The ethics of being part of nature. *Environmental Ethics* 9: 99-113.

Cowell, C. Mark. 1993. Ecological restoration and environmental ethics. *Environmental Ethics* 15(1): 19-32.

Curtis, John Thomas. 1959. *The Vegetation of Wisconsin: an Ordination of Plant Communities*. Madison, Wisconsin: University of Wisconsin Press.

Dasmann, Raymond F. 1976. Life-styles and nature conservation. *Oryx* 13(3): 281-286.

Denzin, Norman K. 1970. *The Research Act*. Chicago: Aldine Publishing Company.

Diamond, Jared. 1992. *The Third Chimpanzee: the Evolution and Future of the Human Animal.* New York: Harper Collins.

Dobson, A.P., A.D. Bradshaw, and A.J.M. Baker. 1997. Hopes for the future: restoration ecology and conservation biology. *Science* 277: 515-522.

Ecological Land Classification Committee. 1994. *Ecoregions of Saskatchewan*. Regina, Saskatchewan: Central Survey and Mapping Agency.

Ehrlich, Paul and Anne Ehrlich. 1990. *The Population Explosion*. New York: Simon and Schuster.

Elliot, Robert. 1982. Faking nature. *Inquiry* 25: 81-93.

Elliot, Robert. 1994. Extinction, restoration, naturalness. *Environmental Ethics* 16: 135-144.

Finnamore, Albert T. 1992. Arid grasslands - biodiversity, human society, and climate change. *Canadian Biodiversity* 2(3): 15-23.

Fitzsimmons, Michael and Margaret Put. 1994. Formulating objectives for ecosystem management: Prince Albert National Park. In *Ecological Restoration of National Parks*, ed. N. Lapoukhine, 19-23. Ottawa, Ontario: Minister of Supply and Services

Freedman, Bill. 1989. *Environmental Ecology: The Impacts of Pollution and Other Stresses on Ecosystem Structure and Function*. San Diego, California: Academic Press, Inc.

Forman, Richard T.T. and Michel Godron. 1986. *Landscape Ecology*. Toronto: John Wiley & Sons.

Gomez-Pompa, Arturo and Andrea Kaus. 1992. Taming the wilderness myth. *BioScience* 42(4): 271-279.

Grumbine, R. Edward. 1994a. What is ecosystem management? *Conservation Biology* 8(1): 27-38.

__________. 1994b. Wildness, wise use, and sustainable development. *Environmental Ethics* 16: 227-249.

Gunn, Alastair S. 1991. The restoration of species and natural environments. *Environmental Ethics* 13(4): 291-310.

Haber, Wolfgang. 1990. Using landscape ecology in planning and management. In *Changing Landscapes: An Ecological Perspective*, eds. Isaac S. Zonnefeld and Richard T.T. Forman, 217-232. New York: Springer-Verlag.

Haney, A. and R.L. Power. 1996. Adaptive management for sound ecosystem management. *Environmental Management* 20(6): 879-886.

Harris, Larry. 1984. *The fragmented forest*. Chicago: University of Chicago Press.

Harris, Larry and John Eisenberg. 1989. Enhanced linkages: necessary steps for success in conservation of faunal diversity. In *Conservation for the Twenty-first Century*, eds. David Western and Mary C. Pearl, 166-181. New York: Oxford University Press.

Higgs, E.S. 1997. What is good ecological restoration? *Conservation Biology* 11(2): 338-348.

Hobbs, Richard J. and Laura F. Huenneke. 1992. Disturbance, diversity, and invasion: implications for conservation. *Conservation Biology* 6(3): 324-337.

Hobbs, Richard J. and D.A. Norton. 1996. Towards a conceptual framework for restoration ecology. *Restoration Ecology* 4(2): 93-110.

Howe, Henry F. 1994. Managing species diversity in tallgrass prairie: assumptions and implications. *Conservation Biology* 8(3): 691-704.

Johnson, Darryll R. and James K. Agee, eds. 1988. *Ecosystem Management for Parks and Wilderness*. Seattle, Washington: University of Washington Press.

Jordan, William R. III. 1988a. A double value: ecological restoration and the conservation of biological diversity. *New Alchemy Quarterly* 32: 17-19.

__________. 1988b. Ecological restoration: reflections on a half-century of experience at the University of Wisconsin-Madison Arboretum. In *Biodiversity*, ed. E.O. Wilson, 311-316. Washington, D.C.: National Academy Press.

_________. 1994a. "Sunflower forest": ecological restoration as the basis for a new environmental paradigm. In *Beyond Preservation: Restoring and Inventing Landscapes*, eds. A. Dwight Baldwin, Jr., Judith de Luce, and Carl Pletsch, 17-34. Minneapolis, Minnesota: University of Minnesota Press.

_________. 1994b. Sunflower seeds. In *Beyond Preservation: Restoring and Inventing Landscapes*, eds. A. Dwight Baldwin, Jr., Judith de Luce, and Carl Pletsch, 243-250. Minneapolis, Minnesota: University of Minnesota Press.

Jordan, William R. III, Robert L. Peters II, and Edith B. Allen. 1988. Ecological restoration as a strategy for conserving biological diversity. *Environmental Management* 12(1): 55-72.

Jostad, P.M., L.H. McAvoy, and D. McDonald. 1996. Native American land ethics: implications for natural resource management. *Society and Natural Resources* 9(6): 565-581.

Kane, G. Stanley. 1994. Restoration or preservation? Reflections on a clash of environmental philosophies. In *Beyond Preservation: Restoring and Inventing Landscapes*, eds. A. Dwight Baldwin, Jr., Judith de Luce, and Carl Pletsch, 69-84. Minneapolis, Minnesota: University of Minnesota Press.

Karr, James R. 1993. Measuring biological integrity: lessons from streams. In *Ecological Integrity and the Management of Ecosystems*, eds. Stephen Woodley, James Kay, and George Francis, 83-104. Ottawa: St. Lucie Press.

Katz, Eric. 1993. Artefacts and functions: a note on the value of nature. *Environmental Values* 2(3): 223-232.

Kay, James J. 1991a. A non-equilibrium thermodynamic framework for discussing ecosystem integrity. *Environmental Management* 15(4): 483-495.

_________. 1991b. The concept of ecological integrity, alternative theories of ecology, and implications for decision-support indicators. In *Economic, Ecological, and Decision Theories: Indicators of Ecologically Sustainable Development*, Canadian Environmental Advisory Council, 23-58. Ottawa, Ontario: CEAC.

_________. 1993. On the nature of ecological integrity: some closing comments. In *Ecological Integrity and the Management of Ecosystems*, eds. Stephen Woodley, James Kay, and George Francis, 201-212. Ottawa, Ontario: St. Lucie Press.

Keddy, Paul A. 1991. Biological monitoring and ecological prediction: from nature reserve management to national state of the environment indicators. In *Monitoring for Conservation and Ecology*, ed. Barrie Goldsmith, 249-268. New York: Chapman and Hall.

Keddy, Paul A., Harold T. Lee, and Irene C. Wisheu. 1993. Choosing indicators of ecosystem integrity: wetlands as a model system. In *Ecological Integrity and the Management of Ecosystems*, eds. Stephen Woodley, James Kay, and George Francis, 61-79. Ottawa, Ontario: St. Lucie Press.

Kelly, John R. and Mark A. Harwell. 1990. Indicators of ecosystem recovery. *Environmental Management* 14(5): 527-545.

Keystone Center, The. 1991. *Final Consensus Report of the Keystone Policy Dialogue on Biological Diversity on Federal Lands.* Keystone, Colorado: The Keystone Center.

King, Anthony W. 1993. Considerations of scale and hierarchy. In *Ecological Integrity and the Management of Ecosystems*, eds. Stephen Woodley, James Kay, and George Francis, 19-45. Ottawa, Ontario: St. Lucie Press.

Kirby, Jack Temple. 1994. Gardening with J. Crew: the political economy of restoration ecology. In *Beyond Preservation: Restoring and Inventing Landscapes*, eds. A. Dwight Baldwin, Jr., Judith de Luce, and Carl Pletsch, 234-240. Minneapolis, Minnesota: University of Minnesota Press.

Knight, R.L. 1996. Aldo Leopold, the land ethic, and ecosystem management. *Journal of Wildlife Management* 60(3): 471-474.

Laszlo, Ervin. 1972. *Introduction to Systems Philosophy; Toward a New Paradigm of Contemporary Thought.* New York: Gordon and Breach Science Publishers.

Levin, S.A. 1987. Scale and predictability in ecological modeling. In *Modeling and Management of Resources Under Uncertainty (Lecture Notes in Biomathematics 72)*, eds. T.L. Vincent, Y. Cohen, W.J. Grantham, G.P. Kirkwood, and J.M. Skowronski, 1-8. Berlin: Springer-Verlag.

Light, A. and E.S. Higgs. 1996. The politics of ecological restoration. *Environmental Ethics* 18(3): 227-247.

Lodwick, Dora G. 1994. Changing worldviews and landscape restoration. In *Beyond Preservation: Restoring and Inventing Landscapes*, eds. A. Dwight Baldwin, Jr., Judith de Luce, and Carl Pletsch, 97-110. Minneapolis, Minnesota: University of Minnesota Press.

Looman, J. 1977. Applied phytosociology in the Canadian prairies and parklands. In *Application of Vegetation Science to Grassland Husbandry*, ed. W. Krause, 317-356. The Hague: Dr. W. Junk b.v. Publishers.

Loucks, Orie L. 1994. Art and insight in remnant native ecosystems. In *Beyond Preservation: Restoring and Inventing Landscapes*, eds. A. Dwight Baldwin, Jr., Judith de Luce, and Carl Pletsch, 127-135. Minneapolis, Minnesota: University of Minnesota Press.

Marshall, I.B., H. Hirvonen, and E. Wiken. 1993. National and regional scale measures of Canada's ecosystem health. In *Ecological Integrity and the Management of Ecosystems*, eds. Stephen Woodley, James Kay, and George Francis, 117-129. Ottawa, Ontario: St. Lucie Press.

McNeely, Jeffrey A. 1989. Protected areas and human ecology: how national parks can contribute to sustaining societies of the twenty-first century. In *Conservation for the Twenty-first Century*, eds. David Western and Mary C. Pearl, 150-157. New York: Oxford University Press.

Meier, C.A. 1984. Wilderness and the search for the soul of modern man. In *Wilderness: The Way Ahead*, eds. Vance Martin and Mary Inglis, 152-161. The Park, Forres, Scotland: Findhorn Press and Middleton, Wisconsin: Lorian Press.

Millar, C.I. and W.J. Libby. 1989. Disneyland or native ecosystem: genetics and the restorationist. *Restoration and Management Notes* 7(1): 18-23.

Mitchell, Mark and Janina Jolley. 1988. *Research Design Explained*. Toronto: Holt, Rinehart and Winston, Inc.

Monette, Duane R., Thomas J. Sullivan, and Cornell R. DeJong. 1986. *Applied Social Research*. Toronto: Holt, Rinehart and Winston, Inc.

Morrison, Darrel G. 1975. Restoring the midwestern landscape. *Landscape Architecture* 65: 398-403.

Munn, R.E. 1993. Monitoring for ecosystem integrity. In *Ecological Integrity and the Management of Ecosystems*, eds. Stephen Woodley, James Kay, and George Francis, 105-115. Ottawa, Ontario: St. Lucie Press.

Nernberg, Dean. 1995. *Native Species Mixtures for Restoration in the Prairie and Parkland Ecoregions of Saskatchewan*. Simpson, Saskatchewan: Canadian Wildlife Service, Environment Canada, and Wildlife Habitat Canada.

Neuhols, J.M. and L.F. Ruggerio, eds. 1975. *Ecosystem Processes and Organic Contaminants: Research Needs and Interdisciplinary Perspective*. Washington, D.C.: National Science Foundation.

Noss, Reed F. 1983. A regional landscape approach to maintain diversity. *BioScience* 33(11): 700-706.

__________. 1987. Protecting natural areas in fragmented landscapes. *Natural Areas Journal* 7(1): 2-13.

__________. 1994. *Maintaining ecological integrity in representative reserve networks*. A report to World Wildlife Fund Canada Endangered Spaces Campaign. Unpublished.

Noss, Reed F. and Allen Y. Cooperrider. 1994. *Saving Nature's Legacy: Protecting and Restoring Biodiversity*. Covelo, California: Island Press.

Noss, Reed F. and Larry D. Harris. 1986. Nodes, networks, and MUMs: preserving diversity at all scales. *Environmental Management* 10(3): 299-309.

Nuzzo, Victoria A. and Evelyn A. Howell. 1990. Natural area restoration planning. *Natural Areas Journal* 10(4): 201-209.

Oates, David. 1989. *Earth Rising: Ecological Belief in an Age of Science*. Corvallis, Oregon: Oregon State University Press.

O'Connell, Michael A. and Reed F. Noss. 1992. Private land management for biodiversity conservation. *Environmental Management* 16(4): 435-450.

Odum, Eugene P. 1985. Trends expected in stressed ecosystems. *BioScience* 35(7): 419-422.

Olwig, Kenneth. 1984. *Nature's Ideological Landscape. (London Research Series in Geography 5).* London: George Allen and Unwin.

Paul, David. 1987. *A Primer for Systems Theory and Human Communication*. Seattle, Washington: Antioch University.

Pavlovic, Noel B. 1994. Disturbance-dependent persistence of rare plants: anthropogenic impacts and restoration implications. In *Restoration of Endangered Species: Conceptual Issues, Planning, and Implementation*, eds. Marlin L. Bowles and Christopher J. Whelan, 159-193. New York: University of Cambridge Press.

Peters, R.H. 1991. *A Critique for Ecology*. Cambridge: Cambridge University Press.

Pickett, S.T.A. and John N. Thompson. 1978. Patch dynamics and the design of nature reserves. *Biological Conservation* 13: 27-37.

Pletsch, Carl. 1994. Humans assert sovereignty over nature. In *Beyond Preservation: Restoring and Inventing Landscapes*, eds. A. Dwight Baldwin, Jr., Judith de Luce, and Carl Pletsch, 85-89. Minneapolis, Minnesota: University of Minnesota Press.

Pollan, M. 1990. Only man's presence can save nature. *Journal of Forestry* 88(7): 24-33.

Rapport, David J. 1990. What constitutes ecosystem health? *Perspectives in Biology and Medicine* 33(1): 121-132.

Rapport, David J., H.A. Regier, and T.C. Hutchinson. 1985. Ecosystem behaviour under stress. *American Naturalist* 125(5): 617-640.

Regier, H. A. 1993. The notion of natural and cultural integrity. In *Ecological Integrity and the Management of Ecosystems*, eds. Stephen Woodley, James Kay, and George Francis, 3-18. Ottawa, Ontario: St. Lucie Press.

Reive, Dan, Mirek Sharp, and Bill Stephenson. 1994. Integrating ecological restoration with ecosystem-conservation objectives: Point Pelee National Park. In *Ecological Restoration of National Parks*, ed. N. Lapoukhine, 7-18. Ottawa, Ontario: Minister of Supply and Services.

Richards, J.F. 1986. World environmental history and economic development. In *Sustainable Development of the Biosphere*, eds. W.C. Clark and R.E. Munn, 53-71. New York: Cambridge University Press.

Rigler, F.H. 1982. Recognition of the possible: an advantage of empiricism in ecology. *Canadian Journal of Fisheries and Aquatic Sciences* 39: 1323-1331.

Risser, Paul G. 1990. Landscape pattern and its effects on energy and nutrient distribution. In *Changing Landscapes: An Ecological Perspective*, eds. Isaac S. Zonnefeld and Richard T.T. Forman, 45-56. New York: Springer-Verlag.

Robinson, John, George Francis, Russel Legge, and Sally Lerner. 1990. Defining a sustainable society: values, principles and definitions. *Alternatives* 17(2): 36-46.

Rowe, J. Stan and Robert T. Coupland. 1984. Vegetation of the Canadian Plains. *Prairie Forum* 9(2): 231-248.

Ryder, R.A. 1990. Ecosystem health, a human perception: definition, detection, and the dichotomous key. *Journal of Great Lakes Research* 16(4): 619-624.

Schaeffer, David J., Edwin E. Herricks, and Harold W. Kerster. 1988. Ecosystem health: I. Measuring ecosystem health. *Environmental Management* 12(4): 445-455.

Schindler, D.W. 1987. Detecting ecosystem responses to anthropogenic stress. *Canadian Journal of Fisheries and Aquatic Sciences* 44 (suppl. 1): 6-25.

Schreiber, Karl-Friedrich. 1990. The history of landscape ecology in Europe. In *Changing Landscapes: An Ecological Perspective*, eds. Isaac S. Zonnefeld and Richard T.T. Forman, 21-33. New York: Springer-Verlag.

Selye, H. 1973. The evolution of the stress concept. *American Scientist* 61: 692-699.

Shackell, N.L., B. Freedman, and C. Staicer. 1993. National environmental monitoring: a case study of the Atlantic Maritime region. In *Ecological Integrity and the Management of Ecosystems*, eds. Stephen Woodley, James Kay, and George Francis, 131-153. Ottawa, Ontario: St. Lucie Press.

Soule, Michael. 1991. Conservation: tactics for a constant crisis. *Science* 153: 746.

Spellerberg, Ian F. 1991. *Monitoring Ecological Change*. New York: Cambridge University Press.

Steedman, Robert and Wolfgang Haider. 1993. Applying notions of ecological integrity. In *Ecological Integrity and the Management of Ecosystems*, eds. Stephen Woodley, James Kay, and George Francis, 47-60. Ottawa: St. Lucie Press.

Todd, John. 1988. Restoring diversity: the search for a social and economic context. In *Biodiversity*, ed. E.O. Wilson, 344-352. Washington, D.C.: National Academy Press.

Turner, Frederick. 1985. Cultivating the American garden. *Harper's Magazine* 271: 45-52.

_________. 1988. A field guide to the synthetic landscape. *Harper's Magazine* 276: 49-55.

_________. 1994a. The invented landscape. In *Beyond Preservation: Restoring and Inventing Landscapes*, eds. A. Dwight Baldwin, Jr., Judith de Luce, and Carl Pletsch, 35-66. Minneapolis, Minnesota: University of Minnesota Press.

_________. 1994b. The invented landscape (reprise). In *Beyond Preservation: Restoring and Inventing Landscapes*, eds. A. Dwight Baldwin, Jr., Judith de Luce, and Carl Pletsch, 251-259. Minneapolis, Minnesota: University of Minnesota Press.

Webb, N.R. 1996. Restoration ecology: science, technology and society. *Trends in Ecology and Evolution* 11(10): 396-397.

Western, David. 1989. Conservation without parks: wildlife in the rural landscape. In *Conservation for the Twenty-first Century*, eds. David Western and Mary C. Pearl, 158-165. New York: Oxford University Press.

White, Peter S. and Susan P. Bratton. 1980. After preservation: philosophical and practical problems of change. *Biological Conservation* 18: 241-255.

Willeke, Gene. 1994. Landscape restoration: more than ritual and gardening. In *Beyond Preservation: Restoring and Inventing Landscapes*, eds. A. Dwight Baldwin, Jr., Judith de Luce, and Carl Pletsch, 90-96. Minneapolis, Minnesota: University of Minnesota Press.

Wilson, Edward O. 1989. Conservation: the next hundred years. In *Conservation for the Twenty-first Century*, eds. David Western and Mary C. Pearl, 3-7. New York: Oxford University Press.

Woodley, Stephen. 1993. Monitoring and measuring ecosystem integrity in Canadian national parks. In *Ecological Integrity and the Management of Ecosystems*, eds. Stephen Woodley, James Kay, and George Francis, 155-176. Ottawa, Ontario: St. Lucie Press.

Woodmansee, R.G. 1990. Biogeochemical cycles and ecological hierarchies. In *Changing Landscapes: An Ecological Perspective*, eds. Isaac S. Zonnefeld and Richard T.T. Forman, 57-67. New York: Springer-Verlag.

World Commission on Environment and Development [WCED]. 1987. *Our Common Future*. New York: Oxford University Press.

World Wildlife Fund [WWF]. n.d. (1989?). *Prairie Conservation Action Plan*. Toronto, Ontario: WWF.

Zedler, P.H., M. Josselyn, and C. Onuf. 1982. Restoration techniques, research, and monitoring: vegetation. In *Wetland Restoration and Enhancement in California*, ed. M. Josselyn, 64-72. La Jolla, California: California Sea Grant College Program. University of California.

Zonnefeld, Isaac S. 1990. Scope and concepts of landscape ecology as an emerging science. In *Changing Landscapes: An Ecological Perspective,* eds. Isaac S. Zonnefeld and Richard T.T. Forman, 3-20. New York: Springer-Verlag.

Zonnefeld, Isaac S. and Richard T.T. Forman. 1990. Part IV: Planning and management of landscapes (Introduction). In *Changing Landscapes: An Ecological Perspective,* eds. Isaac S. Zonnefeld and Richard T.T. Forman, 215-216. New York: Springer-Verlag.

APPENDIX 1: LIST OF INTERVIEWEES

Robert Betz - **Biologist - Founder of Fermilab Restoration, Batavia, Illinois**

Interview: June 14, 1994, Fermi National Accelerator Laboratory, Batavia, Illinois

Robert Betz is Professor Emeritus of Biology at Northeastern Illinois University in Chicago. Dr. Betz has been involved in prairie preservation and restoration since the early 1960s, beginning with the documentation and restoration of old cemetery prairie remnants in Indiana and Illinois. Some of these areas are now nature preserves. As well as conducting research into prairie plant composition and soils, Dr. Betz has served as a Research Associate at the Field Museum of Natural History in Chicago and at the Morton Arborteum in Lisle, IL.

Dr. Betz is perhaps best known for founding the restoration work at the Fermi National Accelerator Laboratory in Batavia, where 405 ha (1000 acres) of tallgrass prairie have been re-established at a nuclear accelerator ring research site. Dr. Betz conceived of the project and has overseen the restoration work since its beginning in 1972. He is currently an advisor to the Illinois Chapter of the Nature Conservancy, a consultant to the Nature Preserves Commission in Springfield, IL, and an ecological consultant at the Fermilab Restoration.

Dave Egan - **Private Consultant / Urban Restoration, near Madison, WI**

Interview: June 17, 1994, University of Wisconsin - Madison Arboretum, Madison, Wisconsin

Dave Egan is the Associate Editor of *Restoration and Management Notes*, a publication of the University of Wisconsin-Madison Arboretum and the oldest journal dealing with the topic of ecological restoration. He has written several articles about restoration and served as a chapter editor to *The Tallgrass Restoration Handbook for Prairies, Savannas and Woodlands* (Island Press, 1997). Mr. Egan also consults with local businesses, municipalities, and landowners who are interested in the planning, implementation, and maintenance of their restoration projects.

Michael Foy - **Wildlife Management Private Lands, Dept. of Natural Resources, Madison, WI**

Interview: June 13, 1994, Department of Natural Resources, Madison, Wisconsin

Michael Foy has been a wildlife biologist for the Wisconsin Department of Natural Resources [WDNR] since 1987. He holds a Masters Degree in Wildlife and Fisheries Sciences from Texas A&M University.

Michael has worked on wetland restoration projects for many years, including two projects to restore drained shallow lakes. Most of these projects have been on private land in cooperation with the U.S. Department of Agriculture and U.S. Fish and Wildlife programs. Others have been on WDNR and other public lands or part of wetland mitigation requirements for highway projects. He recently chaired the Wetlands Appraisal committee for the Mendota Priority Lake project.

Virginia Kline - **Ecologist, University of Wisconsin-Madison Arboretum (now retired)**

Interview: June 19, 1994, University of Wisconsin - Madison Arboretum, Madison, Wisconsin

Virginia Kline holds a Ph.D. in Botany (Plant Ecology) from the University of Wisconsin (1976). She served as a UWM lecturer from 1977 to 1992 and as Staff Ecologist and Research Program Manager at the UWM Arboretum from 1976 to 1996. The UWM Arboretum is home to the oldest prairie restoration in North America. Work to restore abandoned farm fields began here in the 1930s.

In addition to conducting research and publishing scientific papers, Dr. Kline was responsible for planning, facilitating, and evaluating restoration and management of the 405 ha (1000 acres) of prairies, savannas, forests, and wetlands in the Arboretum's collection of ecological communities. Dr. Kline was also involved in the Arboretum's education programs.

Mark Martin - **Resident Manager, Goose Pond Sanctuary, Arlington, WI**
Interview: June 12, 1994, Goose Pond Sanctuary, Arlington, Wisconsin

Since 1979, Mark Martin and his wife have been the resident managers for Madison Audubon's Goose Pond Sanctuary, which is the largest tallgrass prairie restoration in Wisconsin. He has been personally involved with three wetland restorations and a 30 ha (75 acre) prairie restoration.

Mark received a B.Sc. in Wildlife Management with a minor in Biology from the University of Wisconsin in 1971. He has served as the Natural Areas Specialist for the Bureau of Endangered Resources (Ecosystem and Diversity Conservation Section) since 1982. His duties include coordination of the Native Plant Seed Program.

David Nilson - **Senior Reclamation Specialist, Glenharold Mine, Stanton, North Dakota**

Interview: June 6, 1994, Glenharold Mine, Stanton, North Dakota

David Nilson is a Reclamation Supervisor at Basin Electric Power Cooperative's Glenharold Mine in west central North Dakota. He received his B.Sc. from North Dakota State University in 1971 majoring in Zoology and Botany and specializing in wildlife and range management. He was employed by the U.S. Fish and Wildlife Service from 1971 to 1974 and was a Biologist for the N.D. State Department of Transportation from 1974 to 1980.

In 1980, he was employed by private industry in North Dakota as a Reclamation Biologist for Consolidation Coal Company. He has been actively involved in mined land reclamation/habitat restoration and has authored or co-authored several publications concerning native grassland and woodland establishment and management.

Joe Nyhoss - Chief Warden, Goose Lake Prairie State Natural Area, IL

Interview: June 16, 1994, Goose Lake Prairie State Natural Area, Illinois

Joe Nyhoss received his B.Sc. in Education, with a major in Field Biology from the Chicago Teacher's College. He has been working at the Goose Lake Prairie State Natural Area since 1971, where he is involved in prairie management, prescribed fire use, and restoration. Approximately 223 ha (550 acres) of abandoned farm fields have been restored to date. His earlier work includes employment at the Sand Ridge Nature Centre in Cook County (Illinois) and involvement in the Morton Arboretum restoration in the mid-1960s.

Joyce Powers - Owner / Operator, Prairie Ridge Nursery, Mt. Horeb, Wisconsin

Interview: June 13, 1994, Prairie Ridge Nursery, Mt. Horeb, Wisconsin

Joyce Powers is a restoration ecologist with over 20 years experience in the restoration and propagation of native plant communities. She holds an M.Sc. in Natural Resources Communications from the University of Wisconsin - Madison. In addition to her work as a consultant and lecturer, Ms. Powers is owner and president of CRM Ecosystems / Prairie Ridge Nursery, which specializes in consulting on the restoration and management of native ecosystems, as well as the production of seeds and plants native to the upper Midwest of the United States.

Carolyn Hull Sieg - Research Wildlife Biologist, USDA Forest Service, Rapid City, South Dakota

Interview: June 8, 1994, USDA Forest Service, Rapid City, South Dakota

Caroyn Hull Sieg received her Ph.D. in Range and Wildlife Management (fire ecology) from Texas Tech University. Her research has focussed on the role of fire in natural areas, including the influence of fire in maintaining wooded coulees, in the ecology of a threatened plant species, and in setting back undesirable plant species. Other research involves determining the historic frequency of fire in the Black Hills through dendrochronology and exploring methods to slow the expansion of alien plant species following a wild fire. Her fire experience includes acting as Fire Boss or crew member on prescribed burns on areas ranging in size from 405 to 4,050 ha (1,000 to 10,000 acres) over a period of three years.

Gerould Wilhelm - Botanist, previously with the Morton Arboretum, Lisle IL

Interview: June 15, 1994, Morton Arboretum, Lisle, Illinois

Gerould Wilhelm received a Ph.D. in Botany from Southern Illinois University, Carbondale, in 1984. He is coauthor of *Plants of the Chicago Region* (Swink and Wilhelm, 4th edition, Indiana Academy of Science, 1994), and a leader in promoting a philosophy of environmentally sustainable, economically sensible land planning, development, and long term management, including the integration of natural landscape treatments and ecological restoration.

Dr. Wilhelm worked at the Morton Arboretum from 1974 to 1996, first as Assistant Curator of the Herbarium and later as a Research Field Taxonomist. The Morton Arboretum is home to the Schulenberg Prairie - a 40 ha (100 acre) tallgrass prairie restoration that began in the early 1960s. He presently is the Principal Environmental Scientist at Conservation Design Forum, Inc. His current work includes research on the assessment and analysis of natural areas and the restoration, rehabilitation, maintenance, and management of natural landscapes.

APPENDIX 2: ETHICS COMMITTEE APPROVAL FORM

UNIVERSITY OF REGINA

OFFICE OF ASSOCIATE VICE-PRESIDENT AND DEAN
FACULTY OF GRADUATE STUDIES AND RESEARCH

DATE: June 27, 1996

TO: Leslie Hall
Canadian Plains Research Center

FROM: G.W. Maslany, Chair
Research Ethics Review Committee

Re: Prairie Restoration: Rationale, Goals, Planning and Management

Please be advised that the committee has considered this proposal and has agreed that it is:

✓ 1. Acceptable as submitted.
(Note: Only those applications designated in this way have ethical approval for the research on which they are based to proceed.)

______ 2. Acceptable subject to the following changes and precautions (see attached):
Note: These changes must be resubmitted to the Committee and deemed acceptable by it prior to the initiation of the research. Once the changes are regarded as acceptable a new approval form will be sent out indicating it is acceptable as submitted.
Please address the concerns raised by the reviewer(s) by means of a supplementary memo.

______ 3. Unacceptable to the Committee as submitted. Please contact the Chair for advise on whether or how the project proposal might be revised to become acceptable (ext. 4161/5186.)

G.W. Maslany

/mm
cc: D. Gauthier, supervisor

(Ethics2.doc)

REGINA, SASKATCHEWAN CANADA S4S 0A2 PHONE (306) 585-4161 FAX (306) 585-4893

APPENDIX 3: CONSENT FORM

I hereby consent to participate in the research conducted by Lesley Hall, under the supervision of Dr. David Gauthier, to consist of the following:

(1) participation in an audiotaped interview with Lesley Hall;
(2) revision/approval of the transcribed interview as provided by Lesley Hall;
(3) inclusion of all or part of the approved transcript contents in the thesis to be written by Lesley Hall and/or in publications related to this study.

I understand the following conditions of the research project:

(1) access to the original data will be limited to Lesley Hall and David Gauthier;
(2) information from the interview will be held in strict confidence - only information from the final approved transcripts will be used and anonymity will be guaranteed if so desired;
(3) the opportunity exists to withdraw my participation at any time during the research process, even after this initial consent has been given.

This project has been approved by the Research Ethics Review Committee of the University of Regina. Any complaints that may arise as a result of this project should be directed to the Chair, Research Ethics Review Committee. Faculty of Graduate Studies. University of Regina, Regina, Sask., Canada, S4S 0A2.

____

Signature of Participant

____

Signature of Researcher

Lesley Hall
Dept. of Geography
University of Regina
Regina, Sask.
Canada S4S 0A2
(306) 536-2804

Dr. David Gauthier, supervisor
(306) 585-4758

APPENDIX 4: INTERVIEW QUESTIONS

1. Rationale

- Why should we restore ecosystems? What are the benefits of restoration?
- What are the most difficult issues that restoration raises (in terms of values)?
- Do you see any conflict between restoring the indigenous diversity and the integrity of an ecosystem and the necessity of managing that ecosystem (with fire, for example)? In other words, can an ecosystem that is restored and managed to resemble a previous state, a state that was a direct result (in part) of the indigenous North American cultures, be anything but a "museum" within a society that otherwise would not create such systems?
- How can we account for the present human cultures in the ecosystem? Do you see this as fundamental to the long term success of restoration projects?

2. Goals

- What exactly is the goal of this project?
- How was this goal decided upon, and who decided (consensus, researchers, locals, government)?
- What and whose values are represented by the project objectives?
- Do local people (landowners, industry) care about the project? Are they involved in any way?
- How do you deal with neighbouring landowners' concerns or objections, i.e., how do you cope when a conflict arises between the ecological objectives of the park and the values of the people who live nearby?
- What do you envision as the endpoint of the project (or is there an endpoint)?
- What are the management implications when the endpoint is reached (or if in fact there is no endpoint)?
- What is the value of restoring biodiversity at the site-specific, small scale level? Do you see these small sites as existing within a matrix that perhaps can allow certain functions of the original prairie ecosystem to be re-established? Are we able to determine which sites are vital to the functioning prairie matrix?
- Is it feasible that we may apply the sort of intensive management practices that you are using at this project scale to a regional conservation / restoration program?
- Do you feel that there would be public support for such a program, or are people content to know that there is a remnant of prairie here where it does not interfere much with their everyday lives?
- In choosing the pre-settlement state as a restoration model, how do you account for the dynamic nature of ecosystems? What is "natural" succession?

3. **Restoration planning and management**

- Do you know what the pre-settlement state of this land was?
- If not, what formed the basis of the restoration model?
- What are your seed sources and how did you establish them?
- If herbicides are used, how is this reconciled with the ecological concerns that drive a project like this?
- Is scientific experimentation one of the project objectives? How does this rank in importance against the objective of (ecosystem health)?
- Is there much interaction between theoretical scientists and restoration managers?
- Are there management and/or scientific committees set up?
- Do you have ties to other projects?
- In what ways have you considered the larger regional ecological context of this project?
- What methods did you use to assess lands / waters in need of restoration?
- On what basis did you assign priorities for restoration?
- How is your progress / success measured, i.e., what indicators are used and who evaluates it?
- What are the obstacles to restoration (social, economic, scientific)?

IMAGE EVALUATION TEST TARGET (QA-3)

150mm

6"

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