Ecological Integrity in Parks

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Abstract

Any successful application of the concept of ecological integrity in parks management needs to incorporate two fundamentals: 1. Ecological processes on the site will be the ultimate judge of integrity. 2. Ecological processes affecting a park are composed of a hierarchical set at several spatial scales. The small-scale set of processes includes the specific interactions among soil, plants and animals on the site (primary production, decomposition, predation, etc.). The intermediate set includes landscape and regional processes (habitat fragmentation, subdivision development, etc.) which significantly affect the site and the processes in the previous set. The largest set includes global processes (climate change, export trade development, etc.) which affect those in the intermediate set. Like other hierarchies, forces become slower but more powerful as the scale increases. In this application to parks management, the pure biology decreases and the social component increases at larger scales. There is only one integrity and it will require attention to all these processes. Successful management of the global processes will be fruitless if the organisms have all disappeared from the park. We may study the abstraction of integrity from various viewpoints such as systems analysis based on thermodynamics, global dynamics based on human impacts on non-human components of the biosphere, or simple assessment of biodiversity by counting loss of species. None of these singular approaches will assure a functional set of processes that will maintain the ecological structures and functions of a park into the future. New parks policy is required if ecological integrity is to be successfully applied to parks.

The Meaning of Ecological Integrity in Parks

Like biodiversity, ecological integrity has gained prominence from incorporation in legislation and treaties. "The notion of ecological integrity has repeatedly appeared in legislation ... ... in the absence of serious consideration as to exactly what the term means." (Ulanowicz, 2000). This is not policy based on science but it does present an opportunity for managers and researchers. The rise of the notion of ecological integrity offers potential public support for managers and could give direction to scientific abstractions. But concepts arising from public concern through the political process, like ecological integrity, lack defined parameters and measurable variables. Starting points for defining these elements may be chosen from the application end of the conceptual spectrum or from the scientific end. The former will give public satisfaction but probably will result in simplified applications which may not work. Defining elements with a bias toward workable scientific research will give satisfying elements for modeling but may not be measurable under real field conditions preventing testing and effective application and if bent to adhere to Newtonian mechanistic ideals, may lose any holistic character.

Ecological integrity is about holism above all else. It is about the integrity of an ecological system — the holon of interest. However, holons and systems occur at several scales in environmental hierarchies. Thus the definitions of ecological integrity range from species-species and species-environment interactions at a single site (Karr 1981) to the Global Integrity Project which is a multi-pronged response to the combined problems of (a) threatened human well-being, (b) degradation of the ecosphere, and (c) unsustainable economies (Miller and Rees 2000). Karr's original definition of ecological integrity was "... the sum of physical, chemical and biological integrity..." (Karr 1981). His updated view is "Biological integrity refers to the condition of places at one end of a continuum of human influence, places that support a biota that is the product of evolutionary and biogeographic processes with little or no influence from industrial society." (Karr 2000, 1991, 1990, Karr and Chu 1995). Clearly Karr uses 'wild nature' as the baseline for measuring integrity just as Noss has done (various). Ulanowicz (2000) elaborates four other bases for integrity: 1) system 'health' - the continuing functioning of the community, 2) capacity to withstand 'stress', 3) undiminished 'optimum capacity' for greatest possible developmental options, and 4) continued ability for ongoing change and development unconstrained by human interruptions. Ulanowicz's view also needs absence of human influence for baseline data. These definitions of ecological integrity are clearly akin to ecosystem health. Although Ulanowicz builds his model from a base in entropy and thermodynamics, his assessment is global and could be applied to questions of degradations of integrity affecting any element of the system, including human communities.

For applications in management of parks and protected areas, baselines measured from large numbers of sites uninfluenced by industrial society may be very difficult. Beyond the lack of such baseline data, it is certain that parks and protected areas will always have to be managed at a reduced state of integrity. The other clear conclusion from definitions of ecological integrity is that if we are to 'measure whole things', we must include a hierarchical set of scales from the individual site up to the global. The large scales, including the global, will include large, slow-acting variables which will be the most powerful in the hierarchy (Allen and Starr 1982) and logically can not be omitted from management strategies.

Parks Problems Related to Integrity

It is widely agreed that Ontario parks are not big enough to be self-sufficient. If available, a lot of technical management would need to be applied repeatedly to make many Ontario parks survive into the future as natural areas. Even very large parks relatively protected from human influence, like Polar Bear, are not clear exceptions to this generality. Smaller parks, exposed to excessive human influence are probably best predicted to be temporary because they will require impossible amounts of technical and integrative management. Pelee's future as a natural area may be limited and its duration may depend mainly on the lag time caused by the inertia of its biomass, not adaptation to its environment. Its extreme ecological isolation in the landscape prevents supplementation from similar habitats to repair the heavy impacts of visitors and management applied to accommodate them. Available information shows that transboundary influences are overpowering the abilities of the ecological processes to adapt. That is: forces coming from the larger scales up the hierarchy are determining the fate of processes and structures on the site. Similarly for Rondeau we know that its isolation at the landscape scale is causing significant impacts on the structures and processes of its ecological system. It also is clear that forces from larger scales are influencing management in Rondeau.

Algonquin once was large but is no longer because regional socio-economic changes have reduced its effective size. Use of selective forest harvesting as a management direction was dictated by regional socio-economic and political forces not by considerations of ecological integrity. Changes in use of surrounding lands has influenced ecological processes within the park. Deer cross the eastern park boundary in winter to fill seasonal needs not met in the park and this causes movement of wolves into contact with human activities. The management of Algonquin wolf futures is not possible by actions solely within the park (Forbes and Theberge 1996). Data confirming such transboundary penetration of forces into parks are available widely e.g. black bears in Riding Mountain and La Mauricie, several species in Banff and Jasper, Rondeau and Pelee, cited above.

Penetration of regional forces into parks is not just a historical mistake. It is ongoing. In Puskaskwa, exotic European plants are moved right up to the park gate by regional road maintenance practices and then are moved along the trails in the park by hikers and probably also by maintenance machines and methods. At the same time, mining activities have pushed right up against the park fence on the east and have imported another stock of exotics as far as the boundary. Almost surely, these exotic herbs will begin a new front of park penetration even in the 'back country'.

Snowmobile trails are being rerouted under the Living Legacy policy which permits them to remain in protected areas. However, moving lake trails onto the land requires rerouting of some land trails. Closure of previous routes to maintain no net increase in trails is known not to work. ATV's use them. They also use all new land routes. So there is actually a net increase in poorly regulated ATV trail in some protected areas. The ecological results are not well known but there are data in the literature on effects of motorized traffic and of elevated noise levels on ecological processes such as successful nesting of songbirds (e.g. Hourdequin 2000, Reijnen 1995). What is clear is that the forces are from outside the site and have proven difficult to manage solely on the site.

Wet sulphate deposition from Sudbury and from the Ohio valley power plants falls on the Frost Centre in Dorset. Although the quantities are somewhat lower than sulphate falling in the Great Lakes Basin, this continental-scale force has decreased the calcium available from decomposition and from the soil at Dorset. The calcium stored in bole wood at Dorset has decreased by about 50% since the 1960's (Loucks 2000). Wet sulphate deposition is a surrogate for many other processes in Ontario's consumer economy. Even Parks Ontario policy reflects the strong influence of consumerism. Ontario parks are 'marketed', their operation 'privatized'. Ontario's tourism agencies promote wilderness destinations in an attempt to elevate tourist densities to ever-increasing levels.

Transportation policy interacts with tourism marketing and has many strong effects on integrity of parks. Parks may be isolated from supporting environments without buffering and without effective consultation in planning. New roads bring other development with little predictability or planning considerations for park integrity. Overuse elicits a response of additional development of transportation creating a positive feedback which leads to increased overuse and inappropriate use if the objective is park integrity. Many of these transportation effects are virtually irreversible.

Tourism and transportation forces also come from the global scale. Promotion of global ecotourism is well known to have drastic impacts on the integrity of reserves. Monte Verde in Costa Rica and many African sites are clear examples of the effect in relatively pristine and inaccessible places. Global tourism effects on Canadian and US National Parks are just as clear even when masked by intense domestic tourism. Ontario has higher quality park destinations than most of Europe and much of the USA, so forces of global tourism unavoidably must be part of integrity management plans.

Tourism is just one example of effects of applying a global macro-economic model without parks managers having any influence on the outcome. Promotion of consumer tendencies as the accepted means of economic competition (and as a measure of success of parks programs) will bring inexorable continental and global forces to affect the ecological processes in parks. Global climate change enters parks from the largest scale and has demonstrable effects on site-level ecological processes.

Applying Ecological Integrity in Parks Management

The ultimate assessment of ecological integrity in parks will be made by the ecological processes in that park but managing those processes requires attention to all the scales: site, landscape, regional, continental and global. For all these scales, the ultimate response variables affecting the integrity of a site will be in the ecological processes operating on that site. Natural selection and adaptive forces have their effects on the organisms of the site but they are driven by constraints that also arise at the landscape or regional scale and at the continental and the global scales.

Responses to changes in integrity that appear as effects on structural elements of the ecosystem, such as species losses, distortion of fauna and flora by losses or invasions, changes in age and sex structure, etc. all are driven by changes in ecological processes. It is these system processes related to: production, system maintenance and evolutionary adaptation that will judge the degree of integrity that is still operating. That is: the wholeness and the functionality of a site will be reflected in the ecological processes operating there; changes in structural components will follow as results.

Processes of production include: primary production, successional changes, immigration, colonization, and demographic maturation. Maintenance processes include: decomposition and nutrient cycling, demographic exchanges in metapopulations, genetic exchanges, replacements of mortality, and annual population regrowth. Adaptive processes include: natural selection, genetic variation, support of population size sufficient for directed selection, support of consistent selective forces, and protection from impacts with rates and intensities too great to allow adaptation by selective forces.

The basic system processes of net primary production, decomposition, nutrient recycling, demography and genetics are foundational to other processes and to structural elements when we consider a scale larger than a single stand or habitat patch. Relationships between processes and functionality of the whole system are better shown at the primary producer level than at the secondary producer level. However, with enough research, good indicators have been found among secondary producers (e.g. Karr 1981).

We probably agree that the objective for parks and protected areas is to manage them so that they will maintain their biodiversity into the future and will be allowed to continue evolving. If we achieve the maintenance of ecological processes in parks, some freedom to evolve will be a by-product. We already know that almost all parks in Ontario are too small to maintain themselves so their maintenance must be a composite of technical supplements and as many self-maintenance processes as we can save or resurrect. If the ratio is bad, we will not be able to supply all the technical supplements required. That seems to be more or less where we are in Ontario parks.

Currently we assume that biodiversity somehow solves the problem of sensing the ecological trajectory of a park. But if we just count species losses, biodiversity is too insensitive. By the time a species has been lost, the environmental support mechanisms have changed so much that restoring them is too costly, too slow and too problematic. We need a sensing system that works earlier in the process. If the sensor is to work on individual species, where we have our best knowledge, it must sense when the species first shows signs of trouble, long before the species has been lost from the park. For many species, parks are population patches. We know from metapopulation dynamics that sensing signs of early troubles means seasonal assessment of a large sample of patch populations spread over a large landscape area surrounding the focal park (Fahrig and Merriam 1994). Rate of local (patch) extinction exceeding the rate of recolonization of those empty patches, will predict regional loss of species with enough lead time for effective management intervention.

This brief analysis shows two things: Information necessary for feedback in parks management must come from ecological processes, not just structures. That information must come from a hierarchical set of spatial (and temporal) scales because the processes in the parks are affected by processes at larger scales. It is from this viewpoint that many have suggested that an area will be protected only if has a nearly fully functional set of ecological processes (e.g. Loucks 2000), is secured within a buffered area, and is highly connected to other similar environments (e.g. Noss and Cooperrider 1994). Place that mental picture in most of Ontario and the other requirement will emerge; the area also must have protection from global forces such as industrial development to promote foreign trade, private power generation and the other social, economic and political forces which enter across the boundaries of protected areas (Merriam, 1999).

Getting impractical? Go back to the objective and the sensor which tells how well we are meeting that objective. If the environment in the park is to be maintained into the future, then the processes of that environment must continue at survival levels. To whatever degree we allow forces to cross into the park and degrade its ecological processes, we must be able to substitute technical alternatives or decrease those forces before the degradation decreases biodiversity.

Parks policy has been slowly changing to include management attention to increasingly large support zones around parks. Political conflict has suppressed attention to the really large and powerful forces of globalizing economies and social systems but forces at intermediate scales are getting attention. 'Big picture' proposals such as Yellowstone to Yukon, Algonquin to Adirondacks, the great northern forest, Carolinian Canada, The Trent-Severn Waterway and others all can serve to put powerful buffers and connecting habitat along the natural land and environmental patterns around and between parks and protected areas. These are real advances over the outdated prescription of doughnut buffers. Such 'big picture' initiatives depend primarily on stewardship programs on private lands combined with more intensive management on nodes of public lands.

Improved land care through stewardship can be extended regionally to add another smaller scale to the buffer among parks. Ontario Stewardship Councils, woodlot owners associations, forest product cooperatives, watershed conservation authorities and other organizations are already in position to enhance care of ecological processes on the land. Parks managers should consider the potential of facilitating better knowledge and cooperation in these groups. Even within the City of Toronto, some buffering capacity for High Park has been achieved simply by encouraging householders to favour native plants in 'naturalized' backyards surrounding the Park. Gaining widespread acceptance by stewardship groups of a general statement of regional goals that would unify conservation priorities and providing a voluntary baseline for stewardship could be an effective first step. Availability of such an agreed-upon, grassroots direction could enlist a significant amount of management aimed at buffering the ecological integrity of parks and protected areas. By contributing intellectual resources in such ways to selected activities outside the parks, managers could begin a smooth entry into the larger scales which they must address for successful future management of the parks and protected areas. Progressive managers are already quietly contributing to such activities. Those activities need to be increased and moved up onto the global scale by contributions to groups already working at that level (see below). Mechanisms and policies are needed for contributions of material resources for management on the land between the parks. Moving outside the fence could be eased by contributions of GIS base data and formulation of natural resource layers for selected activities by the environmental support groups in areas around parks. If Ontario Power Generation and other industries can field programs of 'carbon sequestration' surely parks in Ontario have an even better opportunity to benefit from an updated management scenario. Recent developments of thought such as 'The Natural Step' (a global environmental management prescription — see Hounsell 1999), 'natural capital' (e.g. Hawken *et al.* 1999) and ecological economics (e.g. Di Castri 2000, International Society for Ecological Economics 2000) provide a foundational policy for entry of modern parks management to the global scale. Policy that viewed such involvement as a minefield in the past needs to be changed to see it as an unavoidable field of opportunities.

The impact of the hierarchical pyramid of forces affecting ecological integrity in parks and protected areas will be on the ecological interactions of variables on the site. If the interactions among the organisms and their environmental support system is degraded, restoration of the integrity of the ecological system may take a very long time or even be impossible despite improvements at the regional and global scales. We need to be able to sense, early in the process, any trends in degradation of important ecological processes on the site. This is a tough task because ecological structures on the site depend on a complex system of interacting forces, most of which are non-linear and many may act chaotically. Managers facing such a knotty problem should look for basic elements that affect their objective and should build on any partially workable approach to their problem that is already available.

A Proposal for Applying Ecological Integrity in Park Management

There are approaches in the literature to sensing the state of ecological processes that complex into what we are calling integrity. These are not designed with parks in mind so they will need modification. Modifications for parks should be guided by two questions. What are the absolutely fundamental processes without which this ecological system will degrade? At this scale in the hierarchy, biological processes are dominant so the second question is: how do the fundamental processes of the first question relate to the biology of species on this site?

The first application of the notion of ecological integrity was Karr's (1981) 'index of biological integrity'. This was a multimetric index aimed at a single aquatic site. Clearly Karr's index was related to the idea of ecological 'health' in that it used the 'normal' uninfluenced habitat as the comparative base. This also allies it with many other discussions where 'wild nature' is the assumed objective of management as well as the baseline for comparison. For management of Ontario parks this poses complications. In southern and central Ontario, 'wild nature' is no longer available as a source of regional baseline data. Further, restoring 'wild nature' is not possible because so many strong transboundary forces will continue to impact parks in this region. Some other baseline must be designed by the managers. For the 'near north', 'wild nature' no longer is available but the impacts that removed it may be more subtle. For parks in cottage, mining and timbering country, deviations from 'wild nature' are clear. They are less clear for some 'back country' but effects such as air and water pollutants are significant as are effects of enhanced transportation and mobility by air, snowmobile, ATV and by boat. Both for southern, settled parks and for more northern parks, a baseline must be constructed from fundamental knowledge of ecological processes rather than from assumptions about historical environments.

Miller and Ehnes (2000) have begun this process. Their model is aimed at sustainable harvested forests. The model rests on two response variables: primary production (which measures tree growth very well) and nutrient availability which combines the processes of decomposition and nutrient cycling. They establish their baseline data by widely sampling forest stands within a region. After eliminating outliers, Miller and Ehnes use the scattergram of data points for each variable for the regional sample of stands to mark normal upper and lower values for a particular age of stand for each variable. If harvesting moves either primary production or nutrient availability below those norms, harvest must be adjusted. This certainly is an ecologically sound approach but many parks clients will focus on other response variables. They will want charismatic consumers and other specific species included in the response variables used to sense integrity.

This is a decision point for management strategy. To follow the high values that users place on charismatic consumers is problematic. Clear relationships between particular consumers and system integrity are difficult to establish (Loucks 2000). Reliable indicators can be found, as Karr (1981) did, but the intensive studies to establish the accuracy of indicators are costly and usually lack predictive generality. The strategy of including charismatic consumers as indicators of integrity also is subject to strong influence by the value systems of users. This can be a political advantage but it may be temporary. If the indications of integrity are inaccurate, the ecological system may fail in future and no longer support the indicator consumers.

The greatest assurance of integrity of the future functioning of the ecological system will come from maintaining other fundamental ecological processes in addition to Miller and Ehnes' production and nutrient supply. That is: keep production and nutrient supply within acceptable lower and upper limits, and also safeguard some of the next most important fundamental processes of an ecological system. In the case of parks and protected areas, an important one is habitat supply. If primary production assures the food supply for the rest of the system and decomposition and nutrient cycling assure the feedstocks for primary production, then directing that primary production into the formation and maintenance of characteristic regional habitats is the next priority. Characteristic regional habitats is an important specification because high primary production and good nutrient supply could go to production of exotics, of crops or of other vegetation types. Simply by measuring rates of primary production in habitat-specific categories we can sense production and maintenance in target habitats. If transboundary environmental forces are reducing primary production and nutrient supply in target habitats within the protected area, degradation must be prevented by one of two means. Either management outside the park must reduce the transboundary force or, high cost technical means must supplement and direct the self-maintenance processes within the park. Generally, technical supplements are very costly and difficult to integrate into the system.

Beyond habitat production and maintenance, habitat availability must be managed. By definition, habitat availability in a park will be too low for any species or group that uses an area bigger than the park. That species set includes most of the charismatic consumers. The remaining species, mainly invertebrates, small herbs, fungi and bacteria can survive in habitat within the protected area only if their population there never suffers an event requiring recolonization. Even if these small area users persist in a protected area, their isolation from other populations of their kind may modify genetic exchange so that normal evolutionary adaptation by natural selection may be prevented. Although the dynamic processes of genetics and demography differ, a freely accessible and adequate supply of habitat is the most practical safeguard for the integrity of these processes.

Primal characteristics of the habitat supply were: a nearly continuous distribution of habitats, a mosaic of adjacent patches which changes over time, and the distribution of those patches following natural patterns of the landscape. A modern check list of those characteristics is the 3 C's of landscape ecology: Composition - the qualitative types of habitat in the mosaic, Configuration - the spatial patterning of those types in the mosaic, and Connectivity - the ease with which organisms can move among patches of their habitat in the mosaic. In the primal landscape, both composition and configuration were dictated by site and environmental conditions. Connectivity was determined by the first two; the landscape space was filled with habitats. Now, composition is the reciprocal of what is not taken to satisfy human desiderata. Configuration also is dictated by human activities with an additional random effect and complications from human insertions of novel land uses such as roads and subdivisions. Connectivity is still determined by the other two but has been shifted to very low values of landscape permeability for many organisms in some landscapes.

If parks need enhanced habitat supply and maintenance, and we are forced to generate it outside the parks, we should organize our strategy around those 3 C's and what remains of the original landscape patterns. If remaining habitat in the landscape is a large fraction of the original amount, configuration and connectivity are not likely to be limiting. Composition should be checked for missing critical, species-specific habitat types, remembering that habitat must be available and accessible for all seasons and all phases of the life cycle. If, at the other extreme, only a small amount of the original habitat remains in isolated patches, then all 3 of the C's will likely need attention. The integrity of the park may rest on the buffering support of metapopulations in a severely degraded landscape where changes in human activities could quickly make the buffer dysfunctional. In such a landscape, the transboundary forces impacting the system within the park also are likely to be intense and frequent.

Some form of 'triage' using this range of landscape conditions surrounding a park may be necessary when deciding resource expenditure and management strategy for particular parks. If real additions to the habitat around the park cannot be gained by restoring the regional composition and establishing significant areas of habitats along natural land patterns, such as drainage valleys, alternatives should be considered. It may be necessary to recognize that narrow, arbitrarily placed lines of vegetation will increase connectivity only in the worst circumstances and only for selected organisms. Without real gains in amount of habitat, there will be no long-term support for the park and the transboundary impacts in the park probably are not going to abate. It may be better to put the resources elsewhere.

The same 3 C's checklist is useful in establishing priorities for prevention of losses from the lands surrounding parks. The most efficient use of resources in managing for the integrity of parks will be by protecting existing valuable characteristics of the surrounding landscapes. Enhancement of the natural values of surrounding lands in the perception of the people living on and using those lands is likely the most efficient method of managing for the integrity of parks.

It seems clear that for most parks in Ontario, the ecological integrity of 'wild nature' is no longer possible and to maintain the degree of ecological integrity that still is possible, we must continue some technical management within the parks but it is critical that management be extended into the area between the parks and onto the regional, continental and global scales.

Management of Ontario parks has become a subset of a world problem. It requires a team approach like most other world problems. The problem is multipartite and the management team needs to address all of its facets: ecological, sociological, business, economic, political and cultural.

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