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SOCIETY, CIENCE, AND THE ECONOMY; EXPLORING THE EMERGING NEW ORDER IN WILDLIFE CONSERVATION

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Historical perspectives of the wildlife conservation movement reveal the complex interplay between evolving states of knowledge and evolving societal values and expectations. From its first awakening in the early-to-mid 1800's, and through the formative years of the late 19th and early 20thcenturies, the movement to safeguard North American wildlife reflected the great concerns for population and species depletions that lay strewn in the wake of unbridled slaughter and industrial expansion. Emergent policies and paradigms confronted this excess with a focus on protection and recovery, wilderness set-asides, forestry reform, and game laws. The underpinnings of natural history served these initiatives reasonably well, until moderate successes in recovering some populations but persistent declines in others revealed the vacancy between knowledge and applied policy (Trefethen 1975).

Wildlife science emerged from this tension as a prerequisite to all formalized conservation efforts (Geist et al. 2001, Mahoney 2004), eventually incorporating an explosion of knowledge about species dynamics, habitat requirements, and predator-prey interactions into harvest regimes and refuge designs. Some of this information derived from wildlife studies per se, but much was also borrowed from the broader reach of ecology, the discipline that most purposefully sought understanding of how natural systems behaved and were regulated. This engagement between a science focused on defining the biological imperatives of species important to wildlife management, and that which concerned itself with questions of natural system engineering and persistence, was to prove a long and fruitful one. Continuously, as ecology applied models and quantitative methods to analyze the natural world and predict its response to perturbations, wildlife science would incorporate these insights, improving its ability to more precisely integrate both human harvest and protection policies within the capacities of natural systems. In its turn, wildlife science contributed its detailed expositions of the life history and landscape requirements of certain managed species as baselines to assess the accuracy of ecology's more conceptual approach.

However, it was not only the ratcheting of scientific inquiry that steered the course of wildlife conservation. From its inception the movement had been influenced, founded even, by two recognizably distinct societal views. These focused on either a utilitarian philosophy of nature's worth, or on a belief in the inherent value of the natural world, often represented as the anthropocentric versus biocentric rationale for conserving nature (Hendee and Stankey 1973, Paterson 2006). In truth, these value streams may not be entirely distinct, but certainly they remain the most conceptually instructive dichotomy in conservation focus, and are reflected vividly in the historical legacy of wildlife policy, law, and management (Reiger 1975, Meine 1988). Wildlife science was of value to either approach of course, as both sought to preserve the natural world and required knowledge to do so.

However, the interplay between these philosophical contours and science was, and remains, far more complex than this, for obviously societal emphases help direct the focus of science, and coerce and enjoin its financial support. For these concrete reasons, and for many that are far more subtle, science and society do blend, fraying the lines of demarcation between social and conservation policy. And social policy, of course, is heavily defined by economics, ensuring that conservation approaches and the science attendant to them will never lie beyond the influence of society's valuations of what wildlife is worth. These relationships persist through the cyclic phases of precedence that the intrinsic versus utilitarian conservation agendas assume (Mulder and Coppililo 2005).

Thus, even as the accretion of ecological knowledge continued through the mid-20th century, new and powerful social ideals were to erupt that would alter the course of wildlife conservation and help restructure both the social-scientific and the economic perspectives that had hitherto guided its approach. The environmental awakening of the 1960's, for example, repositioned humans as both dependant entity and custodian within conservation's purpose, while at the same time forecasting the inevitable consequences for human health and economic opportunity that ecological impoverishment would derive. These realities drove a new social awareness that demanded, in its turn, new and improved science that could offer alternative approaches to resource use and extraction, and would identify new bench marks such as bio-diversity on the one hand, and endangered species on the other, as primary indicators of wildlife conservation success. Within this context, wildlife science could no longer be concerned with just ensuring game species were in ready supply. It needed to turn its attention to ecosystems and their dynamics, intellectual arenas ecology called home.

Somewhere in all of this, "game management" (Leopold 1933), the initial driver and raison d'etre for wildlife science (but not ecology), struggled for position and profile, and the economics of conservation in the broadest sense forced the question of who was to pay for the new ideals. In addition to the environmental movement, other structural changes in North American society helped drive this debate and impinged on the nature and focus of wildlife conservation. Many of these social alterations freighted important economic challenges. Thus, the economies surrounding non-hunting engagements with wildlife, such as wildlife viewing and bird feeding, escalated to unheard of proportions (Kellert and Smith 2000, Bolen and Robinson 2003), slowly reformulating valuations for wildlife in general. These trends were coupled with social patterns of increased urbanization, and decreased familiarity with nature in any practical sense. These, in turn, changed societal expectations for wildlife conservation, and increasingly demanded a science that embraced issues of animal overabundance and wildlife-to-human disease transmission, but still, somehow, maintained its broader ecological focus. Farming and ranching of wild animals has recently led to other complex debates, and placed further demands on wildlife science to expand (Geist 1989, Rasker et al. 1992).

It is important to recognize that the trade between economic/social installations and wildlife science is not a one-way street. The new developments and insights revealed by science exerted their own influence on social awareness and priority setting, ensuring a level of symbiotic entanglement between these seemingly independent human endeavors. Furthermore, these tensions between wildlife and other resource interests are destined to intensify as human populations and resource demands rise (Klein 2000). Under such circumstances, wildlife science and ecology will both be called to attest their worth in light of new trends in social priorities, and traffic in similar ideas to remain relevant to their respective audiences. It is in this manner that the ties between ecology, wildlife science, and the economy are repeatedly reinforced over time; and while new paradigms continuously emerge, this pattern of concept introgression and the hybridizing of the science around wildlife and ecosystems remains consistent. As the following discussion illustrates, this integration has led to major advances in wildlife science and helped prepare it to embrace the emerging conservation order.

ECOLOGICAL THEORY AND WILDLIFE SCIENCE

General Background

While ecology had originally been considered a sub-discipline of physiology, its evolution towards a community focused science was well in hand by the latter part of the 19th century. By this time, the broad principles of how natural systems functioned were identified and new insights and discoveries surrounding the complexity of ecological communities could be incorporated into a systematic understanding of how species interacted with one another and their physical environment. Over time, many of these advances (below) were to influence wildlife conservation and science, and critical transformations that would link economics and ecological theory also emerged. The latter have been especially influential in recent decades, when many concepts and theories central to ecology have been revised.

These shifts in thinking have had important implications for resource management and utilization (Pimm 1991, Pickett et al. 1992, Fiedler et al. 1997, Wallington et al. 2005), and have forced significant innovation in wildlife science approaches. In this regard, the most fundamental paradigm shift has been a change in perception of ecosystems as rather static and predictable, to entities that are complex, dynamic, and unpredictable across time and space (Holling 1986, Fiedler et al. 1997, Scoones 1999, Wallington et al. 2005). It is now generally recognized that disturbances (natural and human-caused) are among the most important factors shaping ecosystem health and performance, and that change, rather than being exceptional, is very much the one constant in nature's economy. Furthermore, classical ecology viewed humans as vagrants in ecological systems and there was the general belief that natural systems would balance themselves if the influence of humans was removed. Current ecological approaches recognize that humans are an integral component of most ecosystems, and the world's growing human population is now considered the principal threat to biological diversity and persistence (McKee et al. 2003).

This emergent view of ecological systems has made the job of managing and protecting wildlife far more challenging. Recognition that disturbances are integral components of natural systems means that efforts to manage and conserve wildlife and their habitats must include consideration of disturbance processes, and not just their effects (Hobbs and Huenneke 1992). This new approach increasingly requires "active" management rather than the historical approach which allowed nature to "take care of itself" (Wallington et al. 2005). Human demands and aspirations are now considered implicit to all wildlife management and conservation approaches; and human societies are not just end users of the resource, but shapers and drivers of ecological processes themselves.

These conceptual changes have led to a growing recognition that it is society's responsibility to collaboratively choose possible management and conservation options (Bradshaw and Bekoff 2001, Robertson and Hull 2001). What they have not altered is the responsibility scientists have to ensure that societal decisions around wildlife are based on the best available information. While a growing task for wildlife managers and policy-makers is to determine how to include societal values in decision-making processes, integrating ecological theory has been, and must remain, a consistent and well-attended priority for wildlife science practitioners. In the midst of increasingly rapid change, science capacity becomes ever more relevant and the ability to efficiently integrate new findings from disparate sources, ever more important.

Ecological Concepts and the Wildlife Science Horizon

Ecology is a broad science, and one which has increasingly developed an appreciation of the effects of scale, both in the functioning of natural systems, and as a powerful conceptual lens for elucidating patterns and predictive models. Thus, its hierarchical sub-fields – behavioral, population, community, and landscape – have all contributed to the maturation and substance of understandings regarding wildlife fluctuations, and to our management prescriptions for wildlife conservation. Ecological subfields have also transferred such insights to the role of humans in the world's ecology, helping stimulate a new calibration of the human-nature equation.

Behavioral ecology.-- Behavioral ecology emerged from the field of ethology, which focused mainly on the description of innate and fixed-action patterns of animal behavior. Following the pioneering work of Niko Tinbergen and Konrad Lorenz, there was a focus on understanding the proximate and ultimate causes and functions of individual behaviors. Behavioral ecology expanded on ethology by focusing on both the ecological and evolutionary basis for animal activity, and the role of behavior in enabling an animal to adapt to its environment. For some time, behavioral ecologists have argued that an understanding of individual and group behavior is fundamental to successful wildlife management and conservation efforts. While there is uncertainly as to the degree to which this knowledge is being applied (Harcourt 1999), there is a growing recognition that behavioral ecology has a great deal to offer (Curio 1996, Lima and Zollner 1996, Sutherland 1998, Caro 1999, Anthony and Blumstein 2000). For example, optimal foraging theory is used to predict why and how individuals move through the landscape, and this knowledge is critical to our understanding of habitat selection for species generally and for identifying critical habitat necessary for the protection of species at risk. The theory's predictive capacity also contributes significantly to the development of policies that address the effects of landscape and habitat alteration.

Knowledge of species' reproductive behavior is also practically applied, being vital for both field and captive breeding programs associated with species recovery efforts. It also provides valuable information for predicting demographic and behavioral impacts of ecosystem exploitation (Caro 1999). Models link these specific behavioral responses to population effects, and are thus used to predict the far reaching consequences of resource extraction on conservation efforts (Sutherland and Gill 2001). Furthermore, enhanced understanding of species' social structures and avoidance behavior assists in developing accurate environmental assessment reviews and mitigation efforts for industrial undertakings (Mahoney and Schaefer 2002), and for effective predator-prey management strategies (NRC 1997, Vucetich et al. 1997).

Population and community ecology.-- Population and community ecology have provided insights into how ecological communities and components (individuals, species, and populations) are structured, and how they interact with their environment. Both have provided key insights that have become well established in wildlife science, and in conservation practices around the world. Both have long pedigrees, with Thomas Malthus, it may be said, launching the former with his 1798 *Essay on the Principle of Population*; and community ecology gradually emerging from the great European tradition of plant sociology which flourished throughout the 19th century. The theory of island biogeography (MacArthur and Wilson 1967), and associated concepts of food webs and predator-prey dynamics, all emerged from these trails of inquiry and greatly improved our understanding of species interactions and the mechanisms influencing the distribution and abundance of species within an ecological community. Their combined influence on conservation has been of enormous significance and many of our widely accepted approaches to wildlife exploitation and management are derived from or built directly upon their constructs.

By illustration, the equilibrium theory of island biogeography has had many far-reaching applications. The theory proposes that the number of species on any island reflects an equilibrium between the rate at which new species colonize it and the rate at which populations of established species become extinct. These two processes, in turn, are controlled by the size of the island, and the island's distance from the nearest mainland; smaller islands have larger extinction rates and islands closer to the mainland receive more immigrants. The deep simplicity of island biogeography theory and its immediate accessibility to a wide range of figurative "island" circumstances saw it applied to many kinds of problems, including selecting the minimum area required for nature reserves, selecting wetlands for protection, and predicting changes in the distribution and abundance of wildlife caused by habitat fragmentation (Bolen and Robinson 2003). It also contributed to wildlife science in a still more general sense, by firmly reinforcing the practical importance of considering scale as an independent variable of high resolution when calibrating ecological problems.

Like island biogeography, the concept of food chain (Elton 1927) has also, since its inception, played a critical role in our understanding of how ecological communities function; and has been generally applied to a wide range of ecological and wildlife conservation issues. We now know, of course, that ecosystems are organized in food webs, a theory which extends the food chain concept from a simple linear pathway to a complex network of interactions. Wildlife practitioners have increasingly recognized the importance of food-web structure and dynamics in understanding how ecosystems function, and how scale and system based approaches are required to predict and monitor the response of ecosystems to anthropogenic disturbances such as climate change, over-fishing, pollution, and the introduction of invasive species. Wildlife science has not only logically borrowed from this concept in its studies of predator-prey relationships but has extended the concept to help design and execute broad synecological investigations, culminating in studies such as the Kluane Boreal Forest Ecosystem Project (Krebs et al. 2001), an elaborate experimental and multi-scale study of species interactions in the Canadian north.

Predator-prey theory has contributed to wildlife science and management since the development of the Lotka-Volterra Predator-Prey Model (Lotka 1925, Volterra 1926). The model assumed a certain potential rate of increase for the predator population when the prey population was abundant, and an increase in the prey population when the predator population was low or absent. Like many theoretical constructs, the Lotka-Volterra Model's initial derivation was overly simplistic and assumed that prey populations would continue to increase as long as predators were absent or were removed from the system. However, the decline of numerous game species in North America during the early 20th century, despite heavy predator control practices, challenged the simple cause-and-effect association between few predators and abundant prey, and led to the development of the concept of carrying capacity (Leopold 1933) and density dependence (Andrewartha and Birch 1954), two theories which became central to wildlife management and drove decades of fruitful wildlife research. Collectively these ideas positioned, for the first time in wildlife circles, the notion of overabundance and its inevitable corollaries of disease, death, and decline.

Significantly, it was this science centered on wildlife populations themselves that provided, through broadly applied predator control programs, the long term and large scale "experiments" of predator-prey dynamics that ecological research per se was not positioned to undertake. Of course, these Malthusian principles came to wildlife science through hard and practical lessons, like the now classic irruption and decline of mule deer on the Kaibab Plateau, Arizona (Leopold 1943, cited in Bolen and Robinson 2003). After 20 years of predator control and no-shooting regulations, the mule deer population stomped and chewed its way to forage depletion and 60% of the animals died over two successive winters, eventually collapsing from 100,000 animals to no more than 10,000. Through this and other similar observations, wildlife ecologists realized that prey populations were regulated by factors other than predators, such as competition for food and space, and that predators play an important and valuable role in ecosystem functioning. For some, like Aldo Leopold himself, this insight was an epiphany (Meine 1988), changing fundamentally and forever how predators were viewed and their ecological profession assessed.

Eventually such allowances were incorporated in wildlife and ecological research, and predator-prey models were developed which incorporated logistic self-limitation or carrying capacity components (Rosenzweig and MacArthur 1963). Since then numerous predator-prey models have been developed to predict the effect of the functional and numerical response of predators on the abundance of prey, and outcomes from these models have been used to support always expensive and often controversial predator reintroduction and predator control management strategies. These innovations and the empirical studies that forced their development inevitably focused wildlife science on the broader question of how all populations, predators and prey alike, are regulated; and how human extraction can be managed within such ecological imperatives.

Certainly concepts of population regulation, such as logistic growth and carrying capacity, continue to have significant implications for wildlife conservation. These have been deeply and variously integrated in the management and use of wildlife populations through the application of Maximum Sustainable Yield (*MSY*) theory. The goal of *MSY* is hold population size at a constant level by harvesting the individuals that would be normally added to the population, and, by doing so, avoid driving a population to extinction. Maximum Sustainable Yield is obtained at a harvest rate which is roughly half the carrying capacity. Below this level yield is limited because there are only a few individuals reproducing, and above it density-dependent factors limit breeding until carrying capacity is reached and there are no surplus individuals to be harvested. Therefore medium-sized populations with a high potential for growth produce the highest yields. Although *MSY* has been applied extensively in wildlife management, its utility has been criticized extensively, especially following the collapse of numerous fisheries worldwide managed under the *MSY* approach (reviewed in Ludwig et al. 1993). However, *MSY* still plays an important role in wildlife science and management, and its general principles remain relevant. Indeed *MSY* has re-emerged in the goals and objectives of Sustainable Use and Development, newly emergent paradigms now guiding the international conservation community (see below).

Landscape ecology.-- Developed almost as a hybrid sub-discipline of ecology and geography, landscape ecology was first described by the German geographer Carl Troll, who developed many of the formative concepts for the discipline while applying interpretations of aerial photographs to human altered landscapes in Europe (Troll 1939). Until the emergence of landscape ecology, the influence of spatial scale and pattern on ecological processes was often neglected in wildlife investigations. While other theories also contributed (e.g. island biogeography), landscape ecology exerted unique influence, by emphasizing the importance of landscape diversity at *multiple* scales as a primary factor for predicting and assessing resistance to and recovery from disturbance. Thus, while classical ecology focused on homogeneity in landscapes, landscape ecology emphasized heterogeneity; and while classical ecology stressed and sought to elucidate non-anthropogenic influences as drivers of ecological processes, landscape ecology explicitly included, indeed focused upon, human factors as primary imperatives in real world ecology.

Through its focus on the role of humans as part of the landscape rather than as a force external to it, landscape ecology provided a means to understand impacts of human disturbance on landscape structure and organism abundance (Naveh and Lieberman 1984) and highlighted the importance of considering fragmentation and scale in development of all wildlife conservation or habitat restoration strategies. Furthermore, the expansive geography which landscape ecology embraced allowed it to integrate a wide range of ecological theory arising from other applications. Thus meta-population theory (Levins 1969), while becoming central to landscape ecology, originated from the theory of island biogeography. Because meta-population theory stressed the importance of habitat connectivity and corridors for persistence of wildlife populations in fragmented habitats, its relevance to landscape ecology was predetermined. In a similar fashion these ecological insights are collectively poised to contribute increasingly to conservation as their arena of disrupted and discontinuous landscapes can only expand as human influence on earth's ecology grows.

This new emphasis on managing and protecting landscapes at multiple scales, and the necessity for connectivity between landscapes fractured by anthropogenic forces, has influenced numerous wildlife conservation initiatives and has recently spurred efforts at unprecedented ecosystem scales. For example, the Boreal Forest Conservation Framework (Canadian Boreal Initiative 2003) is a conservation approach which seeks to sustain ecological and cultural integrity of the entire Canadian boreal region (1.4 billion hectares, 58% of Canada's land mass) by protecting at least 50% of the region in a network of large interconnected protected areas, and by managing the remaining landscape through an ecosystem-based resource management approach (see below).

For endangered wildlife species, such as woodland caribou (*Rangifer tarandus spp),* and for large predators generally (Peters 1983), there can be no substitute for such initiatives; space and ecological runway (the response opportunity afforded by habitat heterogeneity) are essential to the behavioral ecology of many large mammals. Large expanses of land will promote biodiversity protection in general, and insure that ecosystem functions are not impaired (Gilbert et al. 1998, Harrison and Bruna 1999).

Flow is essential to nature; as restriction is essential to zoos. In executing such a biome and continent wide application of ecological theory, we realize how much wildlife conservation, and the science it has engendered and depended upon, have borrowed and benefited from ecology's ever broadening reach. Inevitably this very science would itself influence the emergence of new management paradigms that, in their turn, would require not only additional science for wildlife conservation, but arguably, new kinds of science; moving from the reductionist to the integrative, and from the linear to the synthetic.

Ecosystem Management and the Economics of Ecology

Just as the evolving character of wildlife science in the early to mid-20th century was to reshape how we understood the role of predators in ecosystems, so attempts to understand the ecological conditions required to husband wider communities of animals and plants would inevitably lead conservation efforts to embrace ever expanding hierarchies (Mulder and Coppolillo 2005). Thus, as ecology developed and our understanding of the functioning and complexity of ecosystems grew, there emerged a pervading recognition that human beings and their effects on natural systems needed to be considered integral, rather than just disruptive, if the science was to serve conservation in any practical sense. In the applied science that centered on wildlife populations and management this was an easy assumption to integrate, it being at the heart of the discipline's origins; but for ecology it was a more significant re-evaluation. Nevertheless, it has come to increasingly affect both disciplines, and stimulated a new approach to natural resource management and conservation that by definition incorporates human dimensions, and which demands new science ventures in turn.

Termed *Ecosystem Management*, the goal of this new approach is to assure productive, healthy ecosystems by incorporating social, economic, physical, and biological values in management decisions. Unlike many other management approaches, Ecosystem Management is focused on long-term sustainability of resources rather than maximizing short-term yield; and economic gain is not the sole valuation on which management practices are constructed (Christensen et al. 1996). Although the International Union for the Conservation of Nature (IUCN) has developed, through its *Convention on Biological Diversity*, a set of principles that help define the ecosystem management approach, and despite its widespread reference in the conservation literature, critics have suggested that the approach lacks clear, measurable objectives (Sedjo 1996). While this may be true, Ecosystem Management's explicit recognition of diverse values inherent to natural resources and systems, and its codifying of what these values are, represent a conceptual advance over previous approaches that focused on single resource values for specific ecosystems. Furthermore, Ecosystem Management has done a great deal to re-emphasize the inherent reliance of human life and society on the very processes that control and regulate ecosystems themselves, thus bringing wildlife, the habitats they require, and our own human existence, within one holistic framework. To paraphrase Sir Francis Bacon's famous quip concerning justice, Ecosystem Management makes the case that if we maintain natural systems, they will maintain us.

To make its philosophy accessible, the Ecosystem Management movement adopted an economics frame of reference that not only evaluated resources, such as timber and wildlife, in the classic manner, but also evaluated the economics of ecosystem processes themselves. In the new lexicon, these processes were collectively termed *Ecosystem Services*, thus making humans ecosystem clients. Not poetic, certainly, but at least bringing some humility to our position in the natural scheme of things, and forcefully challenging the man-outside-of-nature syndrome. Specifically, these Ecosystem Services are defined as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Daily 1997). In addition to provisioning of goods (food, fresh water, fuel, wood and fiber, medicines), ecosystems also provide a variety of supporting (nutrient cycling, soil formation, primary production, provision of habitat), regulating (climate regulation, flood control, pollination, water purification), and cultural (spiritual, recreation, aesthetic, educational) services which directly affect human well-being (security, health, shelter, good social relations) (Daily et al. 1997, Millennium Ecosystem Assessment 2005, Pereira and Cooper 2006). Ecosystem Services are valuable to humans in that they support our lives, are cheap, and cannot easily be replaced with human-engineered alternatives (Cork 2001).

Explicit recognition that ecosystem functions have value beyond their inherent worth has prompted unprecedented attention from scientists and economists around the world. Their shared focus has been on describing, measuring, and valuating the entire range of ecosystem goods and services (Daily 1997, Constanza et al. 1997, Pimm

1997, Allen and Loomis 2006, Christie et al. 2006), a process sufficiently robust to be now recognized as a distinct field called ecological economics (Constanza 1989). This endeavor is reminiscent of efforts in the 18th and 19th centuries aimed at cataloguing species themselves, and indicates the heightened influence ecological awareness is exerting within mainstream economics. It also provides clear evidence of how economic rationalizations are being used to buttress arguments in support of conservation. Increasingly, international and continental appraisals of the earth's ecological health are persuaded by this highly utilitarian perspective. Thus, while estimates and valuation techniques have met with some criticism (Pimm 1997, Ludwig 2000), the release of the United Nations sponsored Millennium Ecosystem Assessment (2005) has yet again emphasized the dependence of human well-being on ecosystems, the negative state of the world's ecosystems, and the urgent need to better value (ecologically, culturally, and economically) the goods and services they provide.

These new amalgams of ecology and finance are now influencing regional and local conservation initiatives worldwide (Czech 2000), as communities and individuals come to understand the interconnectedness of these phenomena, and the increasingly rapid pace of resource depletion and conflict. Indeed, the curve of knowledge is beginning to bend on itself as increasing numbers of people recognize that ecosystem services are declining because of a loss of biological diversity, which itself is a direct consequence of human actions (World Resources Institute 2000). This, of course, was the very worry that launched North American wildlife (and forestry) science in the first instance; although long before we understood in any detail how ecosystems actually worked. In a fascinating conceptual evolution, we have been forcefully returned to earlier fears of anthropogenic impacts by vastly improved knowledge, gathered largely through ecological studies that were focused on "natural" processes.

Wildlife science marched along through this process keeping an eye on ecology and borrowing from its achievements, while at the same time improving its own capacity to better serve wildlife management. And the latter always maintained human requirements and valuations as central to its mission. Might we say that ecology has, in Ecosystem Management and its attendant science, converged on the focus wildlife science never abandoned? And in seeking an incentive driven paradigm to convince ecological conscience and initiate conservation action, have we not returned to Leopold's "conservation economics" of the 1930's and to George Perkins Marsh's (1864) forewarnings in *Man and Nature*, the root philosophical treatise that may be said to have launched conservation in America?

No matter. We are going to need the best of both, indeed of all our disciplines. Over the past few centuries, humans have increased the extinction rates of species, for all taxonomic groups by as much as 1,000 times historical rates and future extinction rates are projected to be more than 10 times higher than the current rate. The most important drivers of biodiversity loss are habitat and climate change, invasive species, over-exploitation, and pollution. The impact of these factors, all of which are associated with human activity, is predicted to remain constant or increase rapidly (Millennium Assessment 2005). Most experts take the latter view.

Little wonder then, that the global degradation of ecosystem services, and the recognition of the economic and intrinsic value of these services to humans, led to a heightened focus amongst international conservation agencies, and to development of an international protocol for the sustainable use and development of our natural resources. In many ways this protocol reaffirms the principles articulated in the North American wildlife management approach; namely, that vested self interest and regulated harvest can be critical to long term conservation efforts. While far broader than "wildlife" in its focus, this new international protocol has implications for wildlife science. Predictably it will encourage wildlife research to become more integrative and multidisciplinary; it may also lead wildlife research further from its cherished history of ever more detailed studies of animal ecology. In all these regards, it will move wildlife science in many of the same directions promoted by landscape ecology, but this time with the combined force of political and social agendas that are coordinated by some of the world's most powerful organizations. In terms of its North American domain, wildlife science will become influenced by a world order now rapidly defining conservation agendas in terms reminiscent of North America's own first awakenings; incentive based conservation has gone global, and the science required to sustain it, including wildlife science, will become more globalized in turn.

SUSTAINABLE USE AND CONSERVATION: THE NEW ORDER

At the international level, conservation had for many reasons become more preservationist oriented as the mid-20th century approached (Mulder and Coppolillo 2005). However, in time, many social and scientific influences came to challenge this largely protectionist approach, especially as it became clear that policies such as land protection and no development zones were entirely insufficient for preventing further declines in environmental standards. Changing life styles and societal aspirations in the developing world also made it clear that a more comprehensive approach to all lands and resources was required. It was UNESCO's (the United Nations Educational, Scientific, and Cultural Organization) Man and Biosphere program in the 1960's that may have first heralded a new international pragmatism. By proposing that human demands be included within international conservation policy, a new vision for conservation was launched, one in which resource consumption might actually help safeguard, rather than inevitably deplete, natural abundance (Batisse 1982). This was to move us conceptually beyond simply accounting for human influence in the environment, a central premise of Ecosystem Management, to viewing human activities as an important source for conservation itself. Meanwhile, global recognition that the environment was endangered by human activity, while escalating in scientific circles for decades, was cemented politically at the United Nations Conference on the Human Environment held in Stockholm, Sweden in 1972, making it again clear that some new strategy for conserving the planet's environment and resources was desperately required.

Thus, the groundwork was laid to advance a new agenda, and both the motivations and general directions were obvious; however, as with so many conceptual leaps, no knowledge undercarriage existed to launch this new order. The international community was clear in identifying the need for greater understanding of the linkages between the environment and social-economic forces, and thus identified the knowledge gap. But the looming question was how to close the gap. As with Ecosystem Management (and its Ecosystem Services repertoire), a terminology was required for this new conservation strategy, a common language the world could agree upon when discussing the interface of environmental, social, and economic issues.

To address this need, the concept of *Sustainable Development* was derived, and gained near immediate acceptance with the publication in 1987 of *Our Common Future*, a United Nations sponsored report by the World Commission on Environment and Development. Defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs," the concept was quickly adopted at the 1992 United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil. At this *Rio Earth Summit* Sustainable Development was formally identified as the guiding vision for the development efforts of all countries, and led to the adoption of *Agenda 21*, a wide-ranging blueprint for action to achieve Sustainable Development worldwide. Ten years later this plan of action was reviewed at the World Summit on Sustainable Development in Johannesburg, Africa, with disappointing results. Nevertheless, Sustainable Development remains a significant guiding principle, one with sufficient international presence to see governments worldwide agree to a wide array of commitments and cooperative programs under its aegis. Many of these have implications for wildlife conservation and for wildlife science.

For example, one of the agreements adopted at the 1992 Rio de Janeiro meeting was the *Convention on Biological Diversity* (CBD) which concerns itself with conservation of the world's biological diversity and the sustainable use of its components. The CBD defines sustainable use as "the use of components of biological diversity in a way and at a rate that does not lead to long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations." Under this convention, sustainable use of the world's natural diversity was identified as essential to achieving the broader goal of Sustainable Development, leading, as a consequence, to the *Conservation through Sustainable Use Strategy* (CSU), introduced at the 2000 IUCN 2nd World Conservation Congress in Amman, Jordan.

The CSU, in its turn, proposed that wildlife conservation could sometimes be enhanced through harvest of wildlife, and recognized that economic benefit is critical for the success of many conservation plans. The IUCN supports use of resources only when it is sustainable and proceeds in a manner which minimizes losses to biodiversity. Accordingly, an adaptive management approach is considered critical for sustainable use to be effective as a conservation tool. This approach requires continuous monitoring and the ability to modify management practices to take account of risk and uncertainty. Thus, it requires a complimentary stream of relevant science.

In addition to the CBD and the IUCN, the World Wildlife Fund (WWF) International, and the *Convention on the International Trade in Endangered Species of Wild Fauna and Flora* (CITIES) also support the CSU strategy, making it now possibly the most influential conservation paradigm in the world. This international pedigree is an important distinction, as there are numerous conservation approaches around the world that much earlier expressed similar points of view. The century old North American Wildlife Conservation Model for example, has forever incorporated similar philosophies of wise use and vested interest as its foundations for biodiversity protection (Mahoney 2004). However it, like other conservation models around the world, was more regional in its application and effect. Through the CSU, many principles of the North American Model have gone global, most crucially the notion of vested interest or incentive driven conservation as a compelling force for biodiversity protection.

However, despite the growing acceptance of CSU by the international community, not everyone in the field of wildlife conservation appreciates and supports the sustainable use approach. One of the main objections stems from the numerous historical examples where use of wildlife led to over-exploitation and extinction (Ludwig et al. 1993, Lavigne et al. 1996, Ludwig 2001), in contrast to the few well documented examples where extractive use has been shown to have enhanced conservation effects, especially for vulnerable species and populations (Webb 2002). Others view sustainable use as a part of a “new world deception” that has empowered charlatan promoters of the paradigm (Willers 1994), those who would seek, under its aegis and cloak of respectability, to advance pro-development regimes no more ecologically sensitive than previous. Other criticisms address the range of “uses” considered acceptable for conservation, and the lack of clarity in the definition of “sustainability” itself (Taylor and Dunstone 1996, Hutton and Leader-Williams 2003). Of course, some proponents of conservation, as well as animal rights and welfare, are opposed to any use of wildlife purely for ethical reasons, and oppose sustainable use regardless of whether it does or does not lead to conservation benefits (Webb 2002).

Regardless of such reservations, sustainable use *is* the new conservation agenda: a first time global acceptance of vested interest and utilitarianism, although contextualized certainly by reference to a broad range of human values and aspirations. For wildlife science and its game management framework (later expanded to include all biota) as evolved in North America, the international approach is remarkably familiar. A combination of practical conservation and idealistic activism, focused upon ecological diversity, integrity, and continuance, is a long tradition in the shared agenda of Canada and the United States (Mahoney 2004). And at the base of it all, a vital community of restrained self-interest financing supports the very infrastructure of conservation, including the wildlife science programs essential to success. The ark of conservation progress seemingly bends towards such principles, and the paradigms they encompass.

CONCLUSIONS

It is clear that the world's biota and natural systems are under ever increasing strain. Seemingly, whatever advances we have attained in knowledge have been insufficient in themselves to halt biodiversity loss and environmental degradation. Even as ecology and wildlife science have advanced, so too have the scale and diversity of the ecological problems we face. We need a new approach. Sustainable use paradigms reflect this reality, and seek to integrate ecological, social, and economic demands. This international approach represents the most recent realignment in our thinking and is viewed by many as crucial to successful conservation initiatives in the 21st century. In and of itself, however, sustainable use can only provide conceptual guidance; to be effective it will require much of wildlife science and ecology. These will continue to be the beasts of burden, provisioning the new zeitgeist and enabling it to evaluate approaches and opportunities.

From a North American perspective, wildlife science emerged from a cradle of unbridled resource slaughter. It was nourished from its earliest years by a citizen activism that increasingly saw conservation of the continent's wild diversity as a near measure of nationhood and progress itself. This was true of both Canada and the United States, and led eventually to a cultural tradition in both nations for a practical inquiry that would support the continued use of wildlife, yet ensure its valuation as an intergenerational equity. Furthermore, the context for this science embraced a range of human activities and values, including the aesthetic and spiritual. Nevertheless, it was and remains a science in service of a utilitarian ethic, a rationalized insurance of continued supply simultaneous with continued demand, each being promoted by a social and political agenda that sees wildlife as crucial to our lives.

As the historical review shows, this utilitarianism was not a recipe for closeted inquiry. Wildlife science had its focus, of course; and in its earlier years this was primarily the understanding of a specific suite of organisms, those large mammals and game birds sought by the recreational hunter. However, the sinuous path of knowledge acquisition itself and ecology's neighboring status coerced wildlife science, expanding its horizons and raison d'etre. Increasingly, ecosystem dynamics and the full range of biodiversity became the arena of wildlife investigations and the conservation of these its objectives. It could leave to ecology the task of refining theoretical models, but its own work was done with one eye to the intellectual culture; ecology was advancing, and its results were to be evaluated by a dual relevance, to wildlife in the practical sense and to validating and improving ecological insights themselves. In reaching this position it helped clarify other scientific niches, and in concert with the looming biodiversity crisis, helped launch the discipline of conservation biology.

Wildlife science has matured greatly since its first beginnings, but like many other disciplines finds difficulty in striking a balance between its historical focus and the knowledge requirements imposed by current social and ecological realities. Nevertheless, to maintain its relevance in the 21st century our discipline must find this balance. Doing so will mean positioning itself to more effectively engage in interdisciplinary research, especially in the social-economic and human dimensions arenas; and to more efficient communication with policy-makers on issues of sustainability. It will also mean increasing its profile in the international arena and working much harder to inform the public of its contributions to conservation. Even more importantly, however, wildlife science must recommit to its responsibility for educating the public concerning the true nature of ecosystems, and for offering practical, humanity relevant agendas for conservation. At the same time it must recognize and promote the irreplaceable value of practical experience, and the collective intelligence of public discourse in addressing conservation challenges. By doing so, and by exploring the magic and mystery of wildlife, and our shared and inalienable responsibility for its continuance, our science will continue to inform the greatest of human challenges: how to maintain a glorious diversity of life and a civilized future for mankind.

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