Tony Prato

Alleviating Multiple Threats to Protected Areas with Adaptive Ecosystem Management

The Case of Waterton–Glacier International Peace Park

Managing a protected area to achieve the purposes of its organic act is difficult and challenging. In the United States, the National Park Service Organic Act (16 U.S.C. §§ 431–433) requires national parks to be managed so as "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." The ability of national park managers to achieve the dual mandate of conserving resources and providing for public use and enjoyment in perpetuity is stymied by multiple external and internal threats. Cumulative effects of threats are additive over time and/or space, and occur when seemingly minor management actions are made or minor events occur in an ecosystem that eventually have major social, economic and ecological consequences (Meffe et al. 2002). Management actions for alleviating multiple threats are best devised using a long-term, regionally based, stakeholder-inclusive approach known as adaptive ecosystem management (AEM). This article describes an AEM framework for alleviating the multiple threats facing protected areas with special reference to Waterton–Glacier International Peace Park.

Background

In 1932, the American and Canadian governments passed legislation creating Waterton–Glacier International Peace Park, the world's first such park. The peace park symbolizes "peace and goodwill between the United States and Canada" and "represents the need for cooperation and stewardship in a world of shared resources" (Waterton Lakes National Park Resource Guide 2002). The peace park consists of Waterton Lakes National Park in Alberta, Canada, and Glacier National Park across the border in Montana, United States (see Figure 1). Both parks are UNESCO biosphere reserves, and the peace park is a World Heritage site (Flathead Basin Commission 2001; Montana's Flathead Valley 2001). Waterton Lakes is 52,540 ha (129,728 acres) in extent, and Glacier is 410,506 ha (1,013,594 acres). The peace park is the centerpiece of the Crown of the Continent Ecosystem (CCE), which includes the mountainous regions of northwestern Montana, southwestern Alberta, and southeastern British Columbia.

In 1980, the U.S. National Park Service (NPS) reported that national parks in the United States faced 4,300 threats (Dilsaver 1994). More than half of the threats to aesthetic qualities, cultural resources, air and water quality, plants, and wildlife came from

Figure 1. Waterton-Glacier International Peace Park. *Source: National Parks Conservation Association (2002b)*

sources outside the parks. The report documented only about 25% of the threats. Glacier National Park faced an above-average number of threats: 56 for Glacier vs. 13.5 for the 326 park units that existed at the time. The National Parks Conservation Association (NPCA) identified several internal and external threats to the peace park (NPCA 2002b). They are: (a) proposed highway expansion; (b) conversion of working ranches and forests to residential, commercial, and resort developments; (c) clearcut logging; (d) growth in sightseeing air tours; (e) invasions of non-native species into parklands and waters; (f) legalized hunting for gray wolf in Alberta; (g) potential extraction of oil, gas, coal, and hard-rock mineral resources; (h) global warming and airborne chemical pollutants; and (i) shortages of personnel and operating funds for monitoring wildlife populations, completing archeological research, maintaining historic struc-

tures and museum collections, and providing high-quality visitor services. Most of these threats are caused by events and circumstances external to the peace park. On a scale of 0 to 100, NPCA gave the peace park scores of 83 for natural resources, 52 for cultural resources, and 52 for stewardship capacity. Low scores for cultural resources and stewardship capacity indicate that improvements are needed in these areas.

Impacts of threats to the peace park include: (a) fragmented, degraded, and destroyed habitat for several wildlife species; (b) severe limitations on the movement of wide-ranging species such as bears, wolves, deer, and elk; (c) reduced populations of native fish that are unable to compete with invasive non-native species; (d) potential water quality degradation; (e) high likelihood of total absence of glaciers in 30 years; (f) potentially severe impacts to alpine, floodplain, and wetland systems; and (g) degradation and loss of native vegetation. Table 1 lists the threats and impacts, and Figure 2 summarizes the nature, location, and impacts of the threats to the peace park. Other protected areas in North America face similar threats and consequences.

AEM for Protected Areas

Making specific management prescriptions for threats to the peace park and other protected areas requires detailed site-specific socioeconomic and ecological assessments that are beyond the scope of this article. Moreover, socioeconomic and ecolog-

Table 1. List of threats and impacts to Waterton-Glacier International Peace Park and the Crown of the Continent Ecosystem

Threat	Impact
Proposed highway expansion (external)	Fragmented, degraded, and destroyed habitat for several wildlife species
Conversion of working ranch and forests to residential, commercial, and resort developments (external)	Severe limitations on the movement of wide-ranging species such as bears, wolves, deer, and elk
Clearcut logging (external)	Reduced populations of native fish that are unable to compete with invasive non-native species
Growth in sightseeing air tours (external)	Potential water quality degradation
Invasions of non-native species into parklands and water (internal and external)	High likelihood of total absence of glaciers in 30 years and potentially severe impacts to alpine, floodplain, and wetland systems
Legalized hunting for gray wolf in Alberta (external)	Degradation and loss of native vegetation
Potential extraction of oil, gas, coal, and hard-rock mineral resources (external)	
Global warming and airborne chemical pollutants (external)	
Shortage of personnel and operating funds for monitoring wildlife populations, completing archeological research, maintaining historic structures and museum collections, and providing high-quality visitor services (internal)	

Note: There is not necessarily a cause-and-effect relationship between threats and impacts listed in the same row. *Source: National Parks Conservation Association (2002a)*

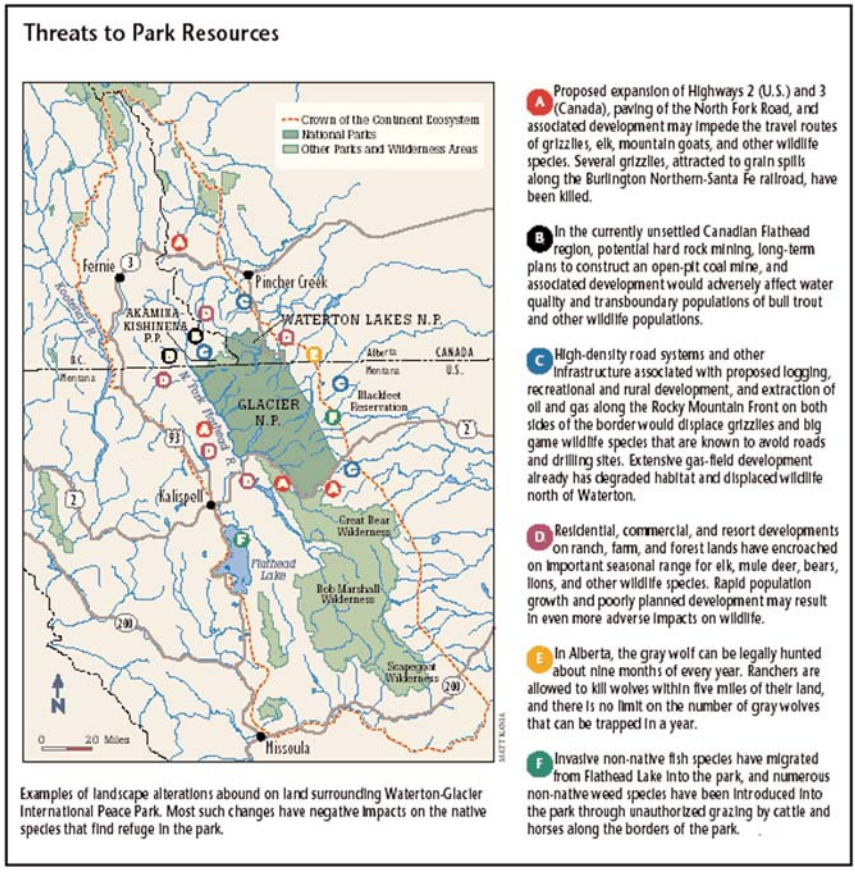

Figure 2. External threats to Waterton-Glacier International Peace Park. *Source: National Parks Conservation Association (2002b)*

ical conditions in protected areas change often enough that management prescriptions have a short shelf life. The proposed AEM approach for alleviating threats to protected areas is based on the following six general principles (see also Table 2).

1. Wide-ranging threats to protected areas cannot be alleviated with a single management action. Actions such as increasing the amount of a park's budget and personnel devoted to monitoring wildlife populations or improving the maintenance of historic structures would do little to reduce landscape fragmentation in the CCE. Therefore, alleviating multiple threats or impacts requires a suite of well-designed and coordinated management actions. This does not mean, however, that management actions aimed at seemingly unrelated problems are totally independent. In the above example, part of the additional budget and personnel used to monitor wildlife populations could be used to monitor and evaluate how wildlife populations respond to habitat loss and degradation from landscape fragmentation.

2. It is easier to alleviate internal threats than external threats. The two national parks that comprise the peace park could make a coordinated

request to their respective agencies (Parks Canada and USNPS) for additional personnel and equipment to monitor threatened and endangered species, complete archeological research, maintain historic structures and museum collections, provide high-quality visitor services, and reduce the spread and adverse ecological impacts of non-native species in the park. By comparison, it is more difficult for managers to alleviate external threats to the peace park from proposed highway expansion, continued fragmentation of working ranches and forests, and logging and mineral extraction on nearby lands. Managers have virtually no control over global warming and airborne chemical pollutants originating in far-off places.

Differences in the ability of park managers to deal with internal versus external threats arise because the environmental, socioeconomic, and demographic drivers of external threats are, for the most part, independent of the mandate to conserve park resources and provide for public enjoyment. These drivers are regional economic development, supply and demand for wood and minerals, global emissions of carbon and chemical pollutants, and other events beyond the control of park managers. This situation does not imply that peace park managers should focus only on reducing internal threats to the exclusion of external threats; quite the contrary. Not only are most threats to the peace park external (see Table 1), but alleviating them is likely to require more planning and collaboration than internal threats.

***3.* Formulating and evaluating management actions in an ecosystem management (EM) framework accounts for interdependencies among social, economic, and ecological values of protected areas.** An EM approach requires integrating science-based ecological knowledge and socioeconomic perspectives and values in a collaborative decision-making framework designed to enhance long-term sustainability of protected areas. EM represents a fundamental shift in the philosophy for managing people and natural resources to incorporate larger spatial scales, longer time periods, and more variables than commodity-based resource management (Thomas 1997) and strives for sustainable productivity of the entire ecosystem (Franklin 1997; Schowalter et al. 1997; Prato 2003; Prato, in press). An EM approach requires threats and impacts to be addressed in a manner that harmonizes social, economic, and ecological values at the CCE scale and accounts for the interdependencies among those values. For example, proposed highway expansion and commercial/resort development in gateway communities would improve the quality of visitor services outside the peace park, but threaten the park's ecological integrity. Similarly, using more of the peace park's limited budget to monitor wildlife populations and complete archeological research and less to reduce habitat loss/fragmentation and controlling the spread of non-native species involves trade-offs.

4. Adaptive management (AM) allows managers to handle uncertainty regarding the likely impacts of alternative management actions on social, economic, and ecological values of protected areas. While outcomes of some management actions are fairly certain, outcomes of other actions are uncertain. Clearcut logging and mineral extraction in areas adjacent to the peace park have a high likelihood of impairing the movement of wide-ranging species, increasing soil erosion and the spread of invasive species, and contaminating water. In contrast, impacts of global warming on

alpine, floodplain, and wetland systems and impacts of legal hunting for gray wolf in Alberta on wolf recovery in the United States are more uncertain. AM is specifically designed for managing natural resource systems under uncertainty (Holling 1978; Walters 1986; Walters and Holling 1990). It rests on the basic tenet that "if human understanding of nature is imperfect, then human interactions with nature [e.g., management actions] should be experimental" (Lee 1993).

There are two forms of AM: passive and active. Passive AM formulates predictive models of ecosystem responses to management actions, makes management decisions based on model predictions, and uses monitoring data to revise model parameters (Walters and Hilborn 1978; Hilborn 1992). While passive AM is relatively simple and inexpensive to implement, it is nonexperimental and, as such, lacks statistical validity and does not provide reliable information for making decisions (Hurlbert 1984; Wilhere 2002). Active AM evaluates management actions using an experimental design (Halbert 1993). Experimental results are used to test hypotheses about whether alternative management actions influence achievement of desired outcomes, such as recovery of threatened and endangered species. Since experiments incorporate replication and randomization of management actions (treatments), active AM yields reliable information about how management actions influence socioeconomic and ecological conditions (Lee 1993).

5. Protected area managers are likely to have greater success in alleviating the impacts of threats by working collaboratively with a broad range of stakeholders to establish and achieve common goals. A stakeholder is defined as "anyone who has an interest in the topic at hand and wishes to participate in decision making" (Meffe et al. 2002). Stakeholders for protected areas include private landowners and businesses, First Nations, community planners, residential and commercial developers, resource extraction firms, public land management agencies, natural resource/environmental interest groups, and the general public. Effective cooperation among stakeholders requires establishing and maintaining collaborative relationships with them, and involving them in a more comprehensive and integrative way than is done in traditional management approaches.

Several organizations have been established to raise stakeholder awareness and understanding and facilitate collaboration on natural resource issues in the CCE. The Crown of the Continent Ecosystem Education Consortium (COCEEC) has as its goals to: (a) encourage and support coordination and cooperation among individuals and organizations that educate about the human and natural resources of the CCE; (b) promote a sense of community among citizens of the region, a comprehensive view of the landscape, and an ethic centered on personal and community stewardship; (c) provide balanced educational leadership on emerging concepts of ecosystem stewardship, biological diversity conservation, and ecosystem sustainability; (d) encourage the development and dissemination of information and educational materials for presentation to diverse audiences in a variety of settings; and (e) cooperatively seek private and public support and partnerships for activities which further its mission (COCEEC 2002).

The goal of NPCA's Glacier Field Office is to build grassroots community support for park conservation among diverse interests in the

Waterton–Glacier region (NPCA 2002a). A collaborative organization whose geographic domain includes the CCE is the Yellowstone to Yukon Conservation Initiative. The goal of this initiative is to ensure that the region's rich and diverse wilderness, wildlife, native plants, and natural processes continue to function as an interconnected web of life, capable of supporting all the natural and human communities within it for present and future generations (Yellowstone to Yukon Conservation Initiative 2003).

Transboundary cooperation between parks is especially important when the political jurisdictions have conflicting natural resource management policies. For example, hunting for gray wolf is not permitted in the United States portion of the CCE because the wolf is a protected species. Hunting for wolf is permitted across the border in Alberta, Canada. Such divergent policies can slow the recovery of gray wolves in the United States.

6. Success in alleviating threats to protected areas is increased by integrating knowledge about (a) cultural, social, economic and ecological values; (b) institutional arrangements influencing management and operations; and (c) state-of-the-art decision-making approaches. Complex dynamic processes operating in natural resource-based protected areas such as the peace park makes these areas difficult and challenging to manage. In order to alleviate threats to the peace park and other protected areas, managers need to continually develop and evaluate management actions that harmonize multiple social, economic, and ecological values. This requires integration of knowledge about the multiple values of the park, the institutional setting in which resource management and other decisions are made, and various approaches for making decisions. Such integration can be accomplished using an AEM approach that incorporates the six principles proposed here.

Designing and Evaluating Management Actions

Well-designed management actions can alleviate one or more threats to the peace park. Management actions are discussed first for external threats and impacts, and then for internal ones. Park management actions aimed at reducing one external threat or impact can influence another such threat or impact, as well as social, economic, and ecological values. For example, a management action that bans clearcut logging in national forests in the CCE might not only increase the movement of wide-ranging species across their home range, but also improve habitat for endangered fish species outside the park by reducing sediment delivery to streams. Banning clearcuts is likely to have a negative impact on regional income and employment in gateway communities if it is more profitable than other forms of logging and the ban causes some timber operations to shift to areas outside the CCE that allow clearcutting. Any reduction in regional income and employment attributable to a management action is a social cost and needs to be weighed against the fish and wildlife benefits of the ban.

Similarly, management actions to reduce internal threats are likely to generate benefits and costs in the regional economy. For example, a management action that reduces congestion in park campgrounds and roads by limiting the number of vehicles admitted to the park would improve the quality of visitor experiences (internal benefit), but reduce gate receipts (internal cost) and decrease regional income and employment in gateway communities (exter-

nal cost). Decreases in regional income and employment have adverse economic consequences on gateway communities. Other examples of management actions aimed at reducing internal threats to the peace park that have external impacts are reconstructing Going-to-the-Sun Road and revising the commercial services plan for Glacier National Park. Both actions ultimately improve the quality of visitor services, but have potentially significant economic impacts on gateway communities.

The preceding discussion illustrates the advantages of evaluating management actions for the peace park using an AEM approach. Such an approach requires protected area managers to consider the long-term impacts of management actions on the CCE, in which the park resides. EM requires managers to consider how a ban on clearcut logging affects not only wildlife species that have a significant portion of their home range in the park, but also water quality in streams outside the park and income and employment in gateway communities. Ecological and economic impacts to the greater ecosystem are just as important to consider as those within the arbitrarily defined boundaries of the park. Evaluating management actions in a long time-frame is just as important to AEM as taking a regional perspective. Hence, the long-term social, economic, and ecological trade-offs involved in, say, replacing clearcut logging (even-aged management) with selective cutting (uneven-aged management) or reconstructing Going-to-the-Sun Road using the quickest, lowest-cost alternative rather than longest, highest-cost alternative need to be considered.

AEM recognizes the uncertainty regarding the social, economic, and ecological consequences of management actions. For example, it is reasonable to expect that disallowing clearcut logging in national forests in the CCE would benefit large carnivores because they are area- and edge-sensitive species. However, this benefit could be partially offset by other factors that influence carnivore populations, such as food supply, natural disasters, weather, and climate change. Not only are ecological effects of logging methods and climate change confounded and hence difficult to separate, but logging releases carbon to the atmosphere, which contributes to climate change.

Implementing AEM

The Crown of the Continent Managers Partnership (CMP) is a group of public and land resource management agencies in the CCE whose goal is to develop "management tools, data management and science (research/inventory/monitoring) at the ecosystem scale in cooperation with academic institutions" (CMP 2002). To illustrate how adaptive ecosystem management might work in the CCE, let us suppose CMP were to be given the authority and responsibility to implement it, and in response created an adaptive management working group (AMWG) for the purpose of developing management actions to alleviate threats to and impacts on the peace park, based on the six principles listed in Table 2.

Membership in the AMWG would best be determined based on the criteria of inclusivity, self-selection, and diversity of representation. *Inclusivity* means that all interested stakeholders or their representatives would be invited to participate in the AMWG. Being inclusive helps "people with different views recognize and understand their common interest in working together" (Meffe et al. 2002). *Self-selection* means AMWG members would be free to choose how involved they

Table 2. Principles for designing management actions to alleviate threats to protected areas

Principle	Management Implication
Wide-ranging threats/impacts cannot be alleviated with a single management action.	Alleviating multiple threats or problems requires a suite of well-designed and coordinated management actions.
It is easier to alleviate internal threats than external threats.	Alleviating external threats is likely to require more planning and engagement with stakeholders than alleviating internal threats. In dealing with external threats, planners and managers should focus on those posing significant risks to ecological integrity.
Formulating and evaluating management actions in an AEM framework accounts for interdependencies among social, economic, and ecological values.	An AEM approach requires integrating scientific-based ecological knowledge and socioeconomic perspectives and values in a collaborative decision-making framework designed to enhance long-term sustainability of natural and cultural resources.
Adaptive management allows managers to handle uncertainty regarding the likely impacts of alternative management actions on social, economic, and ecological values.	Adaptive management requires more planning, research, and coordination than traditional management approaches.
Managers are likely to have greater success in alleviating the impacts of threats by working collaboratively with a broad range of stakeholders to establish and achieve common goals.	Collaboration requires managers to interact with stakeholders in a more comprehensive and interactive way than traditional top-down management.
Success in alleviating threats is increased by integrating knowledge about: (a) cultural, social, economic, and ecological values; (b) institutional arrangements influencing management and operations; and (c) state-of-the-art decision-making approaches, concepts, and methods.	AEM is a suitable integrating framework that allows consideration of these elements.

become in particular issues. The degree of stakeholder involvement in an issue depends on how that issue affects each stakeholder and the manner in which the AMWG would address the issue. In other words, AMWG members would not be equally interested in all threats and impacts. *Diversity of representation* requires that AMWG members would have to reflect a broad spectrum of interests and concerns. Meffe and co-workers (2002) provide an excellent treatment of successful community-based conservation based on these and other principles. Based on these criteria, members of the AMWG would likely include scientists, private landowners, First Nations, businesspersons, developers, community planners, environmental groups, and other stakeholders.

The primary objectives of the AMWG would be to: (a) identify desirable outcomes for the ecosystem and management actions for achieving them; (b) compare the social, economic, and ecological consequences of management actions using AEM; and (c) select preferred management actions. An AMWG should identify management actions that are likely to provide sustainable and efficient social, economic, and ecological outcomes (Prato 2003). For instance, a desirable ecological outcome for carnivores is to have sufficient habitat to sustain viable populations, especially

for threatened and endangered carnivores that have a portion of their home range in the peace park.

One of the principles discussed earlier is that wide-ranging threats and impacts cannot be alleviated with a single management action. Neither can desirable outcomes be achieved with one management action. This does not mean that a single management action influences only a single threat or impact. For instance, buying conservation easements on ranchland might not only alleviate adverse ecological impacts of landscape fragmentation, but also improve movement of carnivores and water quality (ranches generate less sediment and chemical-laden runoff than built-up areas) and reduce losses in native vegetation.

An AMWG should identify alternative management actions to alleviate threats and impacts. Management actions that provide desirable outcomes can be compared and ranked using a multiple-attribute decision-making approach (Prato 2003). For instance, appropriate social, economic, and ecological attributes for management actions designed to alleviate adverse impacts of landscape fragmentation on carnivore populations are: (a) local and regional income and employment, (b) landscape patterns that enhance habitat suitability for carnivores, (c) movement of carnivores, and (d) water quality. Impacts on income and employment can be estimated using the IMPLAN model (Lindall and Olson 1993). Other management actions that an AMWG might consider are land donations, land purchases, cooperation with land trusts, land exchanges, zoning. and so on (Brown 1999).

Selecting preferred management actions using multiple-attribute evaluation requires knowledge of the relative importance to stakeholders of the social, economic, and ecological attributes of the actions being considered. Not all stakeholders will attach the same relative importance to attributes. The ranking of management actions according to stakeholders' preferences requires: (a) calculating stakeholders' utility scores for management actions using a simple additive utility function that combines the values of attributes for management actions and the relative importance (weights) of attributes, (b) ranking management actions based on those scores, and (c) resolving stakeholder disagreements about preferences for management actions using group decision-making techniques.

Suppose an AMWG is able to distinguish between management actions (or elements of them) that have relatively certain outcomes, and those that have relatively uncertain outcomes in terms of alleviating the threats to and impacts on the peace park and CCE. Management actions with relatively certain outcomes should be addressed using passive AM, and, if feasible, management actions with uncertain outcomes should be addressed using active AM.

Two hypothetical management actions may be used to illustrate implementation of passive and active AM. The first is a ban on sightseeing air tours in the peace park. This action would eliminate the visual and auditory disturbances caused by these tours, the option of seeing the park from the air, and the income and employment generated by air tours. While there is some uncertainty regarding the extent to which banning sightseeing air tours would enhance the experiences of on-the-ground visitors, most elements of this management action have relatively certain outcomes. Hence, an AMWG should evaluate the elimination of sightseeing air tours and similar management actions using passive AM.

The second management action is

to have a land trust buy conservation easements on working farms and ranches in the vicinity of the peace park in an effort to reduce further landscape fragmentation. Uncertainty regarding this management action stems from two sources: whether the location and spatial extent of easements will be sufficient to reduce landscape fragmentation, and whether the likely reductions in landscape fragmentation will significantly improve wildlife habitat. Due to these uncertainties, an AMWG should evaluate conservation easements and similar management actions using active AM.

Conclusions

Multiple internal and external threats to protected areas can be alleviated using an AEM approach based on the six general principles enunciated here. AEM establishes desired outcomes or future conditions for a protected area ecosystem, and ranks efficient and sustainable management actions for achieving those outcomes based on stakeholders' expressed preferences for the multiple attributes of actions. Elements of management actions having relatively certain outcomes are evaluated using passive AM and, if feasible, elements of management actions having uncertain outcomes are evaluated using active AM. AEM is best implemented by a working group of stakeholders that is constituted based on inclusivity, self-selection, and diversity of representation of stakeholders.

Application of AEM is challenging because it requires: (a) specification of the number and scale of experimental units (in the case of active AM); (b) spatial replication of certain management actions, which may not be possible when larger-scale environmental processes, such as climate change, affect localized experimental responses; (c) accounting for complex transient responses (delays, sharp increases followed by slow decline, cycles, etc.); and (d) the presence of stakeholders who are willing to accept experiments that could yield unacceptable social and economic outcomes (Walters and Holling 1990). Despite these challenges, AEM holds promise for alleviating internal and external threats to protected areas in general and the Waterton–Glacier International Peace Park in particular.

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Tony Prato, 130 Mumford Hall, University of Missouri–Columbia, Columbia, Missouri 65211; pratoa@missouri.edu