Sustainable Management of the Crown of the Continent Ecosystem

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Introduction

Federal and state programs have been initiated to restore large, degraded ecosystems such as the Great Lakes, Chesapeake Bay, Everglades, Puget Sound, and the Gulf of Mexico. Considerable attention has also been given to sustainable management of large rivers, such as the Columbia, Colorado, and Missouri. Although these areas are deserving of ecological restoration and sustainable management, there is increasing recognition of the need to preserve relatively intact ecosystems and their connectivity in the Rocky Mountain West, such as the Crown of the Continent Ecosystem (CCE) that is shared by Canada and the United States (Mahr 2007; Figure 1).

The CCE shares many of the attributes and faces many of the same threats as the rest of the Rocky Mountain West that includes Arizona, Colorado, Idaho, New Mexico, Montana, Nevada, Utah, and Wyoming in the U.S., and Alberta, British Columbia, and Yukon Territory in Canada. The Rocky Mountain West contains a variety of flora and fauna that occupy a range of ecoregions from the desert grasslands in New Mexico to the prairies in Alberta and the alpine–tundra in the high mountain areas (Elias 2002). The human population of the region occupies both sparsely populated rural areas and densely populated urban areas. Large tracts of federal land account for 46% of the region's total land area (Whitney et al. 2005; World Almanac 2005).

The region is experiencing rapid population growth and economic development because its scenic landscapes and open spaces (i.e., environmental amenities) attract residents and visitors who find it a desirable place to live, work, and play and an escape from the fast-paced, high-pressure, congested environments of metropolitan areas (Rasker et al. 2004; Carruthers and Vias 2005). Between 1990 and 2000, the population of Colorado, Idaho, and Utah increased 23%, and the population of Alberta, British Columbia, Montana, New Mexico, and Yukon Territory increased between 10% and 15% (Travis et al. 2002). During the 1990s, the population of the U.S. portion of the Rocky Mountain West grew more than 25% (Riebsame et al. 1997), and two-thirds of the counties in the region experienced population growth that exceeded the national average (Beyers and Nelson 2000). During the same period, 5 of the 10 fastest-growing states and 9 of the 15 fastest-growing counties in the U.S. were in the Rocky Mountain West (Fagre 2000). From 1982 to 1997, two million acres of agricultural, forested, and open lands in the U.S. portion of the Rocky Mountain West were converted to urban, suburban, and exurban uses, which is the principal form of development

Figure 1. Map of the Crown of the Continent Ecosystem. Source: Prato and Fagre (2007b).

in the region (Carruthers 2000; Esparaza and Carruthers 2000; USDA 2002; Vias and Carruthers 2003).

Rolston (2005) attributes such growth to the way people respond to the natural world. He states: "Those who live in the Rockies find that nature becomes a defining part of our existence, palpably affecting our sense of presence.... The beauty of this landscape is that the human residents thereon are daily set in a world not entirely developed by human artifice for human interests."

Growth in population and changes in economic activity have transformed land use in the Rocky Mountain West from the traditional resource extraction activities that character-

ized the Old West (i.e., agriculture, fishing, logging, and mining) to service-oriented recreation and tourism activities the characterize the New West (Riebsame et al. 1996; Power and Barrett 2001; Shumway and Otterstrom 2001; Travis et al. 2002). New West values emphasize preserving natural resources and the environment, enjoying year-round outdoor recreation and environmental amenities, and maintaining the high quality of life provided by gateway communities for protected areas.

Ironically, the very environmental amenities (Figure 2) that attract people and businesses to the New West, as well as the region's ecological integrity, are being threatened by population growth, economic development, and changes in land use (Turner and Meyer 1994; Solecki 2001). Open space is declining, fish and wildlife habitats are being lost or degraded, conflicts between human activities and the recovery of threatened and endangered species have increased (although a few species have been recovered), pollution of air and water has increased, and road construction and development have dramatically increased the spread of invasive species (Fagre, 2000; Miller and Brown 2001; Baron 2002; Prato and Fagre 2007b). An increasing threat to the ecological integrity of the region is tar sands development in Alberta, coal and coalbed methane extraction in southeast British Columbia, oil and gas development in the Rocky Mountain Front, and global climate change. This paper addresses the desirability and feasibility of sustainable management and the feasibility of adaptive ecosystem management of the CCE, and a recommendation for scaling up current sustainability efforts in the region to the ecosystem level. This paper is based on a book about sustainable management of the CCE to which 39 American and Canadian authors contributed (Prato and Fagre 2007b).

Crown of the Continent Ecosystem

The CCE is a 16,873-square-mile area of the northern Rocky Mountains that straddles northwestern Montana, southwestern Alberta, and southeastern British Columbia (Figures 1 and 3). Approximately 60% of the land area of the CCE is in the United States and 40% is in Canada (Waldt 2004). The CCE extends from the Highwood River south of Banff National Park in Alberta to the Blackfoot River in western Montana. It features many spectacular natural areas, including the Waterton–Glacier International Peace Park (WGIPP) in Alberta and Montana, which includes Waterton Lakes National Park in Alberta and Glacier National Park in Montana, the Castle Rock Wilderness and Elk River Valley in British Columbia, and the Bob Marshall, Great Bear, Scapegoat, Rattlesnake, and Mission Mountains wilderness areas in Montana. Two major Indian reservations overlap the U.S. portion of the CCE: the Blackfeet Indian Reservation, just east of Glacier National Park; and the Confederated Salish and Kootenai Tribes of the Flathead Reservation in the Mission Valley, which is home to the Bitterroot Salish, Kootenai, Pend d'Oreilles, and Chinook tribes (Long 2007). Triple Divide Peak in Glacier National Park and WGIPP is the inspiration for the name "Crown of the Continent." Precipitation on Triple Divide Peak flows into three major rivers: the Columbia to the west; the Mississippi to the east; and the Saskatchewan to the north. Glacier and Waterton Lakes national parks are also designated as biosphere reserves and WGIPP is a World Heritage site and the world's first international peace park (Prato and Fagre 2007b).

The CCE consists of a mosaic of natural, rural, built-up, and cultural landscapes that provide environmental amenities; sustain economic growth and development; and contain rich cultural and biological diversity and abundant and diverse natural resources. Public lands in the CCE, which are managed by multiple agencies, make up 83% of the land area, and protected areas, which account for 32% of the land area, are managed primarily for public enjoyment and natural resource protection (McCool and Adams 2007). National, state, and provincial forests in the CCE are managed for multiple uses, including recreation, biodiversity, water supply, logging, and fish and wildlife habitats. Protected areas are managed for resource protection and are off limits to residential and commercial development, and in some cases, resource extraction and certain forms of recreation.

Figure 2. A typical landscape in the CCE. Source: Prato and Fagre (2007b).

Despite the adverse impacts of rapid economic growth and development on the CCE's unique endowment of natural and cultural resources, the ecosystem harbors one of the most intact assemblages of mammals of any region in southern Canada or the contiguous United States with 65 species of native mammals, 270 species of birds, 27 native fish, and 12 species of reptiles and amphibians. The Flathead River in British Columbia and the North Fork of the Flathead River in Montana, which are located in the northwestern portion of the CCE, has the highest density of inland grizzly bears and the most diverse association of ungulates in North America (Prato and Fagre 2007b).

In 2005, 17 Canadian and 20 American scientists, managers, planners, and policymakers attended a workshop to discuss the CCE. Workshop participants agreed that "the [CCE] region is a globally unique nexus of converging ecosystems and biodiversity," and that it faces two critical issues: (1) "How do you provide access to a priceless resource without compromising the very thing, its pristine attributes, that makes it so valuable?" and (2) "What is needed to protect the natural environment yet facilitate economic prosperity?" (Crown of the Continent Ecosystem Committee 2005). Both issues can be distilled into one overarching issue, which is the primary focus of this paper: How can we achieve sustainable management of the CCE?

Desirability and feasibility of achieving sustainability

Prato and Fagre (2007b) posit four premises or conditions that are germane to sustaining the CCE and other ecosystems:

1. Natural landscapes in the CCE are worth preserving because they supply valuable ecosystem goods and services. Natural landscapes in the CCE contain forests, soil, water, air, and minerals that are used to produce ecosystem goods in the form of timber, forage, and fossil fuels (i.e., coal, crude oil, and natural gas). Ecosystem goods are used in the production of primary goods (e.g., lumber, aluminum, and inorganic fertilizers) and primary goods are used in the production of consumer goods (e.g., homes, automobiles, and clothing). The value of ecosystem goods is derived from the market prices of the primary goods they are used to produce. Natural landscapes also provide ecosystem services in the form of air and water purification, flood and drought mitigation, waste detoxification and decomposition, soil generation and renewal, biodiversity preservation, partial climate stabilization, nutrient cycling and services, pollination, sustaining recreational/tourism activities and aesthetics, and others (Daily 1997). Since ecosystem services are not traded in markets, they lack prices, which make it more difficult to value such services.

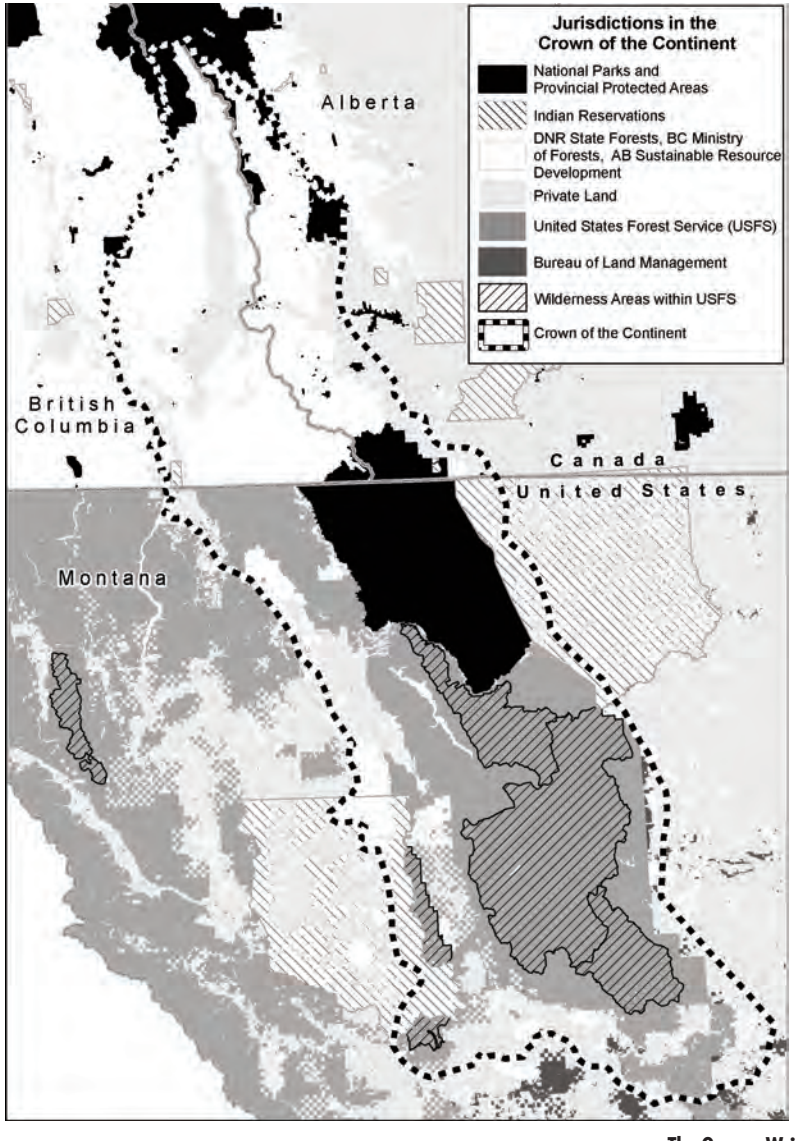
2. Population/economic development and environmental threats are expected to continue in the CCE. Economic growth is expected to continue in the CCE due to increased population and increased demand for outdoor recreation, outdoor tourism, and environmental amenities. The increased demand is fueled by higher per capita disposable income, higher rates of retirement, and larger numbers of urban refugees (i.e., people who move to gateway communities to escape the crime, social problems, and higher cost of living in urban centers). Continued population growth and economic development jeopardize the capacity of the CCE to provide ecosystem goods and services and threaten its ecological integrity. Future growth of some gateway communities could moderate, particularly if the adverse environmental effects of growth discourage people from moving to or visiting those communities.

3. Despite the degradation of natural landscapes from human activities in the CCE, the ecosystem is relatively intact. The CCE is considered one of the most biologically intact ecosystems in the contiguous U.S. and western Canada. The U.S. portion of the CCE has the only viable non-transplanted population of wolves, the largest native population of Rocky Mountain bighorn sheep, one of the largest elk herds, the largest mountain goat population, and the largest and densest population of grizzly bear in the American West (Waldt 2004). Although aquatic ecosystems in the CCE are healthy compared with other regions of the country, aquatic ecosystem health has been significantly degraded from its original condition (Hauer et al. 2007). Other protected landscapes have not fared as well. Air pollution is substantially worse in the Great Smoky Mountains, Sequoia, Kings Canyon, and Shenandoah national parks than in WGIPP (Mansfield 2002).

4. Sustainable management of the CCE is challenging because of its large size and the predominance of public lands. As with other ecosystems in the Rocky Mountain West, the CCE is home to large expanses of public land whose management presents challenges not faced in private land management. Specifically, the allocation of private land to primary and consumer goods is guided by market prices for these goods. In addition, market prices for primary goods influence the use and value of ecosystem goods. In contrast, most ecosystem services provided by public land are not priced due to lack of markets or incomplete markets for these services. In cases where prices do exist for public goods, such as access fees to

national parks, the fees are administratively determined; they do not represent the price for any particular ecosystem service. Moreover, most decisions about the use and management of public land are based on statutory authority, regulations, public policy, and public opinion. Public land management in the CCE is also challenging because of the jurisdictional fragmentation in public land ownership, which results in land being managed by agencies having different statutory mandates (Quinn et al. 2007; Figure 3) and the difficulties encountered in implementing ecosystem management, which is discussed in the next section.

Figure 3. Jurisdictional map of the CCE. Source: Miistakis Institute for the Rockies.



Ecosystem management approach

Liszewski (2004) points out that "the complex nature of ecosystems, and the increasingly complex nature of human stresses and demands on ecosystems, means that simple and narrowly focused approaches are not sufficient to penetrate modern environmental problems." Ecosystem management involves integrated management of human activities and natural resources over larger areas and longer time periods than conventional resource management (Franklin 1997). Ecosystem management is sustainable when it maintains the flow of ecosystem goods without permanently impairing the long-term capacity of the ecosystem to provide ecosystem services (Franklin 1997; Prato 2000). Sustainable management of an ecosystem involves maintaining the human uses (e.g., production of timber and energy and recreational experiences) and intrinsic values (i.e., values not directly related to human uses of an ecosystem) of the ecosystem without impairing its long-term capacity to supply ecosystem goods and services. Ecosystem management of the CCE is challenging because (1) it is large, complex, and dynamic; (2) scientific knowledge about the biophysical and socioeconomic processes operating in the ecosystem is incomplete; (3) data on ecosystem processes are often inadequate and expensive to acquire; and (4) the human and financial resources needed for research and management are limited and, in many cases, inadequate.

Implementation of ecosystem management involves (1) developing a common vision for the ecosystem, (2) identifying whether the current state of the ecosystem is sustainable, (3) selecting best management actions for achieving a sustainable ecosystem state when the current state of the ecosystem is not sustainable, and (4) monitoring and adjusting management actions to maintain a sustainable ecosystem state (Prato and Fagre 2007a). Each of these elements is discussed below in the context of the CCE.

Developing a common vision Efforts to achieve sustainable management of the CCE should be guided by a common or collective vision of the values provided by the ecosystem and why those values are worth preserving. Establishing a common vision does not require stakeholders to reach consensus about the relative importance of the ecosystem goods and services provided by the ecosystem, but rather to enumerate the values and their importance.

It is important to create a common vision for an ecosystem for several reasons. First, it builds stakeholder consensus around the most significant and unique ecosystem values. Second, it provides a basis for determining when human activities are adversely affecting the ecosystem (e.g., when such activities threaten those values). Third, it creates mutual respect among stakeholders that is essential for collaborative decision-making. Fourth, it helps stakeholders to select appropriate indicators of ecosystem integrity and health. For example, coal development in the Canadian Flathead River Basin in southeast British Columbia has been recognized by many stakeholders as a threat to water quality and wildlife habitat in the Flathead River Basin in northwest Montana (Thompson and Thomas 2007).

Stakeholders are already working together to preserve ecosystem values in the CCE. For example, in an effort to protect critical lower-elevation habitat for grizzly bears, trumpeter swans, and other species, conservation easements have been purchased on private land adjacent to Waterton Lakes National Park in Alberta (Quinn and Broberg 2007). The Crown Managers Partnership has brought together federal, aboriginal, provincial, and state agencies or organizations with significant land or resource management responsibility in the CCE for

the purpose of improving regional communication and resource management (Quinn et al. 2007). The Yellowstone to Yukon Conservation Initiative, which encompasses the CCE, has the goal of restoring and maintaining biological diversity and habitat connectivity in a large ecoregion that stretches from the state of Wyoming to the north-central Yukon Territory (Chadwick 2000; Mahr 2007).

A word of caution is in order about creating a common vision for the CCE. Because the CCE is large, it is easier to cobble together visions that are pertinent to different issues or threats facing the CCE (e.g., reducing the environmental impacts of energy production, reducing loss or fragmentation of wildlife habitat from residential development, and curtailing the spread of invasive species). The downside of such a piecemeal approach is that it does not address the cumulative effects of ecosystem threats, which have a direct impact on achieving ecosystem sustainability. For this reason, stakeholders should attempt to create a vision for the entire ecosystem.

Identifying whether the current state of the ecosystem is sustainable Identifying the current state of the CCE is subject to two kinds of errors. First, the decision can be made that the current state is sustainable when it is not, which results in inaction even though action is needed to achieve sustainability. Second, the decision can be made that the current state is unsustainable when it is actually sustainable, which results in the development and implementation of management actions to enhance ecosystem sustainability when none are required. Both decision errors result from uncertainty in determining ecosystem states from indicators of ecosystem conditions. Such decision errors can be minimized by using Bayesian statistical inference to test a set of hypotheses about ecosystem states (Prato 2007b).

Selecting best management actions for achieving a sustainable ecosystem state If it is determined that the current state of the ecosystem is not sustainable, then managers need to implement feasible management actions that have a high likelihood of achieving sustainability. For example, if the natural resources in a backcountry camping area are being negatively impacted by human use, then feasible management actions need to be identified and implemented that reduce those impacts. Feasible management actions are possible management actions that are financially feasible and provide efficient combinations of the attributes of the outcomes of management actions. An efficient combination of attributes of outcomes of management actions is one for which it is not possible to increase a positive attribute, such as human satisfaction from backcountry camping, without increasing a negative attribute, such as the natural resource impacts of backcountry camping.

Multiple attribute evaluation (MAE) can be used to determine the best management actions for achieving a sustainable ecosystem state. This involves using a MAE method to rank feasible management actions based on their multiple social, economic, and ecological attributes and the relative importance of those attributes to the decision-maker. The best management action is the highest-ranked feasible management action. MAE has been used to address a variety of agricultural and natural resource management issues (Strassert and Prato 2002; Mendoza and Martins 2006; Prato and Herath 2007).

Monitoring and adjusting management actions Since *a priori* knowledge about the likely ecosystem impacts of management actions is imperfect or uncertain, there is no guarantee that a sustainable ecosystem state will be achieved by implementing the best manage-

ment actions identified using MAE. Accordingly, it is important to monitor ecosystem responses to implemented management actions to determine whether the ecosystem state is becoming sustainable. If not, it will be necessary to adjust or change management actions.

The process of selecting, implementing, monitoring, assessing, and adjusting management actions is called adaptive ecosystem management (AEM; Holling 1978; Walters 1986; Prato 2003, 2007a). If passive AEM is used, the decision of whether or not to adjust management actions depends on whether the indicators or multiple attributes of the outcomes of management actions imply that the ecosystem is becoming sustainable. If active AEM is used, the decision of whether or not to adjust management actions is determined by testing hypothesis about how the ecosystem state is responding to management actions. Active AEM treats management actions as experiments. Unlike passive adaptive management, active AEM yields statistically reliable information about ecosystem responses to management actions although it is more expensive and difficult to apply than passive AEM and has several prerequisites (Lee 1993; Wilhere 2002) that may not be satisfied (Prato 2005).

Applications of adaptive ecosystem management

Passive and active adaptive management are being used to manage the impacts of human activities on a variety of natural resources. Banff National Park is using passive adaptive management to implement a human use management strategy for the park (Parks Canada 2002). Elk Island National Park in Alberta is using adaptive management in its prescribed burn program (Parks Canada 2003). Federal and state agencies are using passive adaptive management to evaluate management strategies designed to alleviate the risk of brucellosis transmission from bison to cattle outside Yellowstone National Park (Status Review Team 2005). In addition, passive adaptive management is being used in the bison management plan for Yellowstone National Park (National Park Service 2008). Adaptive management was the basis for implementing the final winter use rule for Grand Teton and Yellowstone national parks (National Park Service 2003).

The lower Colorado River, which flows through Grand Canyon National Park, is using active adaptive management to improve understanding of how water releases from Glen Canyon Dam influence sediment, vegetation, fish and wildlife and habitat, and other resources (Glen Canyon Adaptive Management Program 2003). The Comprehensive Everglades Restoration Plan (CERP) gives planners flexibility to refine and revise the plan "as part of (an) adaptive assessment process" (U.S. Army Corps of Engineers and South Florida Water Management District 2000). The Northwest Power and Conservation Council is using an active adaptive management in their salmon recovery program for the Columbia River Basin (Lee 1993, 1995; McLain and Lee 1996). British Columbia is exploring how adaptive management can be used to test alternative silvicultural practices in forest stands, evaluate ecosystem management for entire watersheds or landscape units, and test the effectiveness of land and resource management plans (BC Forest Service 2008). The National Research Council recommended immediate development and implementation of "an [active] adaptive management approach to reverse the ecological decline of the Missouri River" (National Research Council 2002).

Examples of sustainable management in the CCE

This section describes four examples of sustainable ecosystem management in the CCE. All four examples involve rather small areas in the CCE. The first example is in the Nyack floodplain, a 5.6-mile-long by 1.9-mile-wide floodplain on the Middle Fork of the Flathead River about 36 miles upstream from West Glacier, Montana. The Nyack floodplain provides important habitats for elk, moose, deer, mountain lion, black bear, cutthroat trout, bald eagle, and Canada geese, and critical habitats for harlequin ducks, grizzly bear, bull trout, and boreal toads. As long-time floodplain residents, the Dalimata family determined to make their ranch operations compatible with sustaining wildlife species and their habitats. The family's small ranch supports 150 cows, produces hay and grain for winter feed, selectively harvests mature timber, harvests and mills salvage logs from a river corridor, and operates a trout pond; wood products from the sawmill are used to manufacture prefabricated cabins and other value-added products (Stanford 2000). Stanford (2000) observed that "the Dalimatas have not received, nor have they asked for, compensation for avoiding elk calving areas during the spring, for allowing elk to graze in their hay fields year-round or for hazing the occasional grizzly away from their cattle. These and other activities by ranchers do have real monetary value, however, which figure into the decision by families to sell out to development or hang in there with traditional land-use activities that secondarily foster maintenance of natural attributes of the landscape."

The second example is in the Rocky Mountain Front, a 200-mile-long by 50-mile-wide area that forms the eastern boundary of the CCE and stretches from southern Alberta to northern Montana. Due its relatively unfragmented landscapes, the Rocky Mountain Front affords prime habitats for grizzly bear, black bear, wolf, cougar, lynx, wolverine, elk, deer, and moose. It is one of the few places in the Rocky Mountain West where grizzly bear habitat extends into the prairie.

The outstanding native prairie in the Rocky Mountain Front makes it ideal for ranching. The Nature Conservancy's (TNC's) 18,000-acre Pine Butte Swamp Preserve is an example of an area that is operated as a sustainable working ranch. The preserve is located just east of the eastern boundary of Glacier National Park near Choteau, Montana. Ranch management goals include supporting biodiversity and providing seasonal habitat for wildlife, especially prairie habitat for grizzly bear. Local ranchers lease grazing rights to the preserve from TNC. TNC requires leaseholders to use grazing systems that "mimic the buffalo's seasonally intensive use of grass and … integrate into the rancher's agricultural operations" (TNC 2006). According to TNC, the use of sustainable grazing systems in the Rocky Mountain Front is generating local economic benefits and improving the health of native grasslands.

The third example is the Blackfeet Trust, a private, nonprofit land trust for the Blackfeet Indian Reservation located west of Glacier National Park. One of the goals of the trust is to "involve people in the community, educate them about protecting the land and actually regain some of the lands that have been lost to us" (TNC, n.d.). The trust works collaboratively with TNC to reclaim and protect nontribal lands that were once under tribal ownership, and to prevent development in high-quality prairie foothill, prairie pothole, and wetland ecosystems.

The fourth example is the Blackfoot Challenge, a coordinated effort by private landowners to "enhance, conserve and protect the natural resources and rural lifestyle of the Blackfoot River Valley for present and future generations" (Blackfoot Challenge 2007). The Blackfoot River is in the southeastern portion of the CCE. Accomplishments of the Blackfoot Challenge include weed-free grasslands, public access to recreation, restored fisheries, and conservation of scenic vistas by people who live on the land. The Blackfoot Community Project is a land transaction partnership that involves the Blackfoot Challenge, TNC, and Plum Creek Timber Company (Blackfoot Challenge 2007). The project provides an opportunity for local residents to guide the future ownership and management of nearly 88,000 acres of large, intact landscapes that possess critical community, agricultural, and biological values. As part of the Blackfoot Challenge, TNC purchased 42,927 acres from Plum Creek Timber in 2004, 11,155 acres in 2005, and 13,970 acres in 2006, and plans to purchase the remaining 20,000 acres in 2007.

Sustainable ecosystem management is more likely to be practiced in the CCE if landowners: (1) adopt a stewardship ethic (like the Dalimatas, ranchers in the Pine Butte Swamp Preserve, Native Americans in the Blackfeet Nation, and private landowners in the Blackfoot River valley), (2) become knowledgeable about sustainable landscape-management practices, and (3) demonstrate a willingness and ability to implement such practices. A stewardship ethic has a greater chance of developing if the economic and environmental benefits of sustainable landscape management exceed the environmental costs of unsustainable landscape management.

Feasibility of adaptive ecosystem management

For the most part, current management decisions in the CCE are made in much the same manner as in the rest of the U.S. and Canada. These decisions occur in an adversarial setting in which stakeholders file lawsuits to "get their way," work the political system to outwit their "opponents," and impose their preferences for management actions on their opponents regardless of social and economic consequences. In such an adversarial approach, individuals and organizations use the political system to achieve self-serving management outcomes (e.g., the rent-seeking behavior described in Anderson 2005). In particular, private commercial interests exert political influence through the actions of corporate entities and executive leaders, and lobbying activities. Environmental groups exert political influence by lobbying for actions and legislation that support their position and filing lawsuits to get their way. Federal and state agencies manage natural resources under their jurisdiction based on statutory authority, policies, and court decrees. Scientific and professional organizations influence natural resource policy and legislation by issuing position statements and lobbying government officials. The adversarial approach is not only contentious and divisive, but also costly and often counterproductive. It generally produces win–lose outcomes (i.e., the welfare of one stakeholder group increases at the expense of the welfare of another stakeholder group). In contrast, an AEM approach cultivates mutual respect among stakeholders who work together to develop and implement a common vision of ecosystem values and sustainability, and resolve conflicts using collaborative decision-making approaches. The AEM approach has the potential to produce win–win outcomes.

The current institutional framework (i.e., laws, rules, regulations, and norms) for managing public lands in the CCE and other ecosystems in the U.S. is undergirded by a myriad of statutes, including the National Environmental Policy Act of 1969, the Clean Air Act of 1970, the Clean Water Act of 1972, the Endangered Species Act of 1973, the National Forest Management Act of 1976, and other statutes. Although these statutes have noble purposes, they can run counter to AEM. For example, AEM is susceptible to being challenged for nonconformance with the planning requirements of the National Environmental Policy Act. Also, collaborative decision-making can be stifled by the Federal Advisory Committee Act of 1972. In contrast, a 1998 amendment to Canada's National Parks Act seems compatible with AEM because it establishes maintenance of ecological integrity through the protection of natural resources as the first management priority in Canadian national parks (Dearden and Rollins 2002). The AEM approach proposed here is not predicated on abandoning the suite of well-intentioned U.S. environmental statues mentioned above. Rather, Congress should consider amending these statutes and supporting regulations in a manner that supports and facilitates AEM in cases where the existing statutes and AEM are conflict in one another.

Perhaps the biggest boost for AEM in the CCE would be for stakeholders to adopt and implement collaborative decision-making approaches to AEM. Collaborative approaches have been successful in resolving public land management conflicts (Wondolleck and Yaffee 2000). For example, the Keystone Center for Science and Public Policy (2005) has assisted numerous stakeholders in gathering the scientific, economic, and political information necessary to reach consensus-driven decisions, plans, and agreements related to energy, environment, health, and social policy. Additionally, consensus-building or collaborative decision-making processes have been successfully employed in resolving public land-management conflicts in California, Montana, and North Dakota.

Several geospatial technologies, notably geographic information systems, remote sensing, and Interactive Map Server, can aid stakeholders in implementing ecosystem management. In particular, these technologies can be used to create a decision support tool for AEM that would help users to (1) identify whether the current state of an ecosystem is sustainable, (2) select best management actions for achieving a sustainable ecosystem state, and (3) monitor and adjust management actions as needed.

Recommendation for scaling up AEM to the CCE

The two previous sections describe sustainable management efforts and the feasibility of implementing AEM in the CCE. Although AEM of the CCE would be challenging, the approach represents a potentially viable alternative to the current adversarial approach to resolving resource conflicts. In contrast to the adversarial approach, the proposed AEM approach attempts to draw stakeholders together rather than pull them apart and uses a collaborative approach to resolve inter-stakeholder conflicts in the preferences for ecosystem values and/or management actions. Admittedly, implementing AEM in the CCE does not guarantee the CCE would achieve a sustainable ecosystem state.

Given the mounting threats to the CCE and the breakdown of communication and polarization that often accompanies an adversarial approach to decision-making, we recommend that serious consideration be given to implementing a proactive, collaborative, and

adaptive approach to sustainable management of the CCE. One way to act on this recommendation is to scale up to the CCE level one or more of the current, successful, collaborative resource management efforts underway in the ecosystem, such as sustainably managing the Rocky Mountain Front and the Blackfoot River Valley. These particular efforts focus on natural resource use and management in rural areas of the CCE. The scaling-up approach must also consider sustainable ways to develop urban centers and surrounding areas. AEM at the scale of the CCE will require designing institutions that facilitate a proactive, collaborative, and adaptive approach to sustainable management of the CCE in a manner that protects private property rights and acknowledges legal mandates governing the management of public lands.

References

Anderson, T.L. 2005. From the Old West to the New West and back again. In *2005 State of the Rockies Report Card*. Economics and Business Department, Colorado College State of the Rockies Project. Colorado Springs, Colo.: Colorado College, 15–20.

Beyers, W.B., and P.B. Nelson. 2000. Contemporary development forces in the nonmetropolitan West: New insights from rapidly growing communities. *Journal of Rural Studies* 16, 459–474.

BC [British Columbia] Forest Service. 2008. *Adaptive Management Initiatives in the BC Forest Service. Ministry of Forests and Range, British Columbia*. On-line at www.for.gov.bc.ca/hfp/amhome/amhome.htm. (Accessed March 11, 2008.)

Blackfoot Challenge. 2007. *Better Communities through Conservation.* On-line at www.blackfootchallenge.org/am/publish/. (Accessed October 25, 2007.)

Carruthers, J.I. 2003. Growth at the fringe: The influence of political fragmentation in the United States metropolitan areas. *Papers in Regional Science* 84, 475–499.

Carruthers, J.I., and A.C. Viaz. 2005. Urban, suburban, and exurban sprawl in the Rocky Mountain West: Evidence from regional adjustment models. *Journal of Regional Science* 45, 21–48.

Chadwick, D.H. 2000. *Yellowstone to Yukon*. Washington, D.C.: National Geographic Society.

Crown of the Continent Committee. 2005. Transboundary synthesis workshop for the Crown of the Continent Ecosystem. *Flathead Lake Journal.* On-line at www.umt.edu/flbs/Help/FLJournals/FLJ%2019-1%20Final%206-9-05.pdf. (Accessed October 2, 2007.)

Daily, G.C. 1997. Introduction: What are ecosystem services? In *Nature's Services: Societal Dependence on Natural Ecosystems,* G.C. Daily, ed. Washington, D.C.: Island Press, 3–6.

Dearden, P., and R. Rollins. 2002. *Parks and Protected Areas in Canada: Planning and Management.* 2nd ed. Don Mills, Ont.: Oxford University Press.

Elias, S.A. 2002. *Rocky Mountains.* Washington, D.C.: Smithsonian Institution.

Esparza, A.X., and J.I. Carruthers. 2000. Land use planning and exurbanization in the rural Mountain West: Evidence from Arizona. *Journal of Planning Education and Research* 20, 26–39.

Fagre, D.B. 2000. Changing mountain landscapes in a changing climate: Looking into the future. *Changing Landscapes* 2, 1–39.

Franklin, J.F. 1997. Ecosystem management: An overview. In *Ecosystem Management: Appli-*

cations for Sustainable Forest and Wildlife Resources, M.S. Boyce and A. Haney, eds. New Haven, Conn.: Yale University Press, 21–53.

Glen Canyon Adaptive Management Program. 2003. *Adaptive Management Work Group.* On-line at www.gcdamp.gov/. (Accessed March 11, 2008.)

Hauer, R., J.A. Stanford, M.S. Lorang, B.K. Ellis, and J.A. Craft. 2007. Aquatic ecosystem health. In *Sustaining Rocky Mountain Landscapes: Science, Policy and Management of the Crown of the Continent Ecosystem*, T. Prato and D.B. Fagre, eds. Washington, D.C.: RFF Press, 117–134.

Holling, C.S. 1978. *Adaptive Environmental Assessment and Management.* Chichester, U.K.: John Wiley & Sons.

Keystone Center for Science and Public Policy. 2005. Introduction. On-line at www.keystone.org/spp/index.html. (Accessed October 23, 2007.)

Lee, K.N. 1993. *Compass and Gyroscope: Integrating Science and Politics for the Environment*. Washington, D.C.: Island Press.

———. 1995. Deliberately seeking sustainability in the Columbia River Basin. In *Barriers and Bridges to the Renewal of Regional Ecosystems and Institutions,* L.H. Gunderson, C.S. Holling and S.S. Light, eds. New York: Columbia University Press, 214–238.

Liszewski, M.J. 2004. The Glen Canyon Dam adaptive management program. *Water Resources Impact* 6, 10–13.

Long, B. 2007. The Crown of the Continent Ecosystem: Profile of a treasured landscape. In *Sustaining Rocky Mountain Landscapes: Science, Policy and Management of the Crown of the Continent Ecosystem*, T. Prato and D.B. Fagre, eds. Washington, D.C.: RFF Press, 17–35.

Mahr, M. 2007. Transboundary conservation and the Yellowstone to Yukon Conservation Initiative. In *Sustaining Rocky Mountain Landscapes: Science, Policy and Management of the Crown of the Continent Ecosystem*, T. Prato and D.B. Fagre, eds. Washington, D.C.: RFF Press, 229–248.

Mansfield, D. 2002. Smokies the nation's most polluted park, says study. *WRAP Sheet* 12:10 (November/December). On-line at www.cis.tennessee.edu/publications/wrap_archive/wrap_novdec2002.shtml. (Accessed October 22, 2007.)

McCool, S.F., and J.C. Adams. 2007. Sustaining wildland recreation: Issues, challenges, and opportunities. In *Sustaining Rocky Mountain Landscapes: Science, Policy and Management of the Crown of the Continent Ecosystem*, T. Prato and D.B. Fagre, eds. Washington, D.C.: RFF Press, 67–82.

McLain, R.J., and R.G. Lee. 1996. Adaptive management: Promises and pitfalls. *Environmental Management* 20, 437–448.

Mendoza, G.A., and H. Martins. 2006. Multi-criteria decision analysis in natural resource management: A critical review of methods and new modelling paradigms. *Forest Ecology and Management* 230, 1–22.

Miller, H., and L. Brown. 2001. Losing ground to urban sprawl: Is progress costing us our natural resources? *Missouri Conservationist* 62, 19–23.

National Park Service. 2003. Final winter use rule for Grand Teton and Yellowstone published in Federal Register. On-line at www.nps.gov/yell/parknews/07106.htm.

(Accessed March 11, 2008.)

———. 2008. Bison management operations continue near Gardiner. On-line at www.nps.gov/yell/parknews/0808.htm. (Accessed March 11, 2008.)

National Research Council. 2002. Ecological dynamics on Yellowstone's Northern Range: The report of the National Academy of Sciences. Chapter 5: Conclusions and recommendations. *Yellowstone Science* 10, 3–11.

Parks Canada. 2002. *A Review of the Implementation of the Banff National Park Management Plan.* Report of 2002 Forum, Banff Centre, November 29–30. Banff, Alberta: Parks Canada, Banff National Park. On-line at www.pc.gc.ca/pn-np/ab/banff/plan/plan7_E.asp. (Accessed March 11, 2008.)

———. 2003. *Elk Island National Park of Canada, Natural Wonders & Cultural Treasures.* On-line at www2.parcscanada.gc.ca/pn-np/ab/elkisland/natcul/natcul1di_E.asp. (Accessed March 11, 2008.)

Power, T., and R. Barrett. 2001. *Post-Cowboy Economics: Pay and Prosperity in the New American West*. Washington, D.C.: Island Press.

Prato, T. 2000. Multiple attribute evaluation of landscape management. *Journal of Environmental Management* 60, 325–337.

_____. 2003. Alleviating multiple threats to protected areas with adaptive ecosystem management: The case of Waterton–Glacier International Peace Park. *The George Wright Forum* 20:4, 41–52.

_____. 2005. Ecosystem management. In *National Parks and Protected Areas: Approaches for Balancing Social, Economic and Ecological Values,* T. Prato and D. Fagre, eds. Ames, Iowa: Blackwell Publishers, 109–153.

_____. 2007a. Adaptive ecosystem management. In *Sustaining Rocky Mountain Landscapes: Science, Policy and Management of the Crown of the Continent Ecosystem*, T. Prato and D.B. Fagre, eds. Washington, D.C.: RFF Press, 249–259.

_____. 2007b. Selection and evaluation of project to conserve ecosystem services. *Ecological Modelling* 203, 290–296.

Prato, T., and D. Fagre. 2007a. Achieving ecosystem sustainability. In *Sustaining Rocky Mountain Landscapes: Science, Policy and Management of the Crown of the Continent Ecosystem*, T. Prato and D.B. Fagre, eds. Washington, D.C.: RFF Press, 302–311.

Prato, T., and D. Fagre, eds. 2007b. *Sustaining Rocky Mountain Landscapes: Science, Policy and Management of the Crown of the Continent Ecosystem*. Washington, D.C.: RFF Press.

Prato, T., and D. Fagre. 2007c. The Crown of the Continent: Striving for ecosystem sustainability. In *Sustaining Rocky Mountain Landscapes: Science, Policy and Management of the Crown of the Continent Ecosystem*, T. Prato and D.B. Fagre, eds. Washington, D.C.: RFF Press, 3–16.

Prato, T., and G. Herath. 2007. Multiple-criteria decision analysis for integrated catchment management. *Ecological Economics* 63, 627–632.

Quinn, M., and L. Broberg. 2007. Conserving biodiversity. In *Sustaining Rocky Mountain Landscapes: Science, Policy and Management of the Crown of the Continent Ecosystem*, T. Prato and D.B. Fagre, eds. Washington, D.C.: RFF Press, 102–116.

Quinn, M., D. Duke, and G. Greenaway. 2007. Cumulative effects analysis and the Crown Managers Partnership. In *Sustaining Rocky Mountain Landscapes: Science, Policy and Management of the Crown of the Continent Ecosystem*, T. Prato and D.B. Fagre, eds. Washington, D.C.: RFF Press, 215–228.

Rasker, R., B. Alexander, J. van den Noort, and R. Carter. 2004. *Prosperity in the 21st Century West: The Role of Protected Public Lands*. Bozeman, Mont.: Sonoran Institute.

Riebsame, W.E., H. Gosnell, and D.M. Theobald, eds. 1997. *Atlas of the New West*. New York: W.W. Norton.

Rolston, H., III. 2005. Mountain majesties above fruited plains: Culture, nature, and Rocky Mountain aesthetics. Manuscript submitted for publication.

Shimek, C. 2003. Water wizardry station pioneers new river flood plain model. *Vision* (University of Montana). On-line at www.umt.edu/urelations/vision/2003/12wizardry.htm. (Accessed October 23, 2007.)

Shumway, J.M., and S.M. Otterstrom. 2001. Spatial patterns of migration and income change in the Mountain West: The dominance of service-based, amenity-rich counties. *Professional Geographer* 53, 492–502.

Solecki, W.D. 2001. The role of global-to-local linkages in land use/land cover changes in South Florida. *Ecological Economics* 37, 339–356.

Stanford, J.A. 2000. Family stewardship of a river floodplain: A demonstration project. Unpublished paper. Flathead Lake Biological Station, University of Montana, Missoula.

Status Review Team. (National Park Service; U.S. Department of Agriculture–Animal and Plant Health Inspection Service; U.S. Department of Agriculture–Forest Service; Montana Department of Livestock; and Montana Department of Fish, Wildlife and Parks.) 2005. *Interagency Bison Management Plan: A Status Review of Adaptive Management Elements, 2000 to 2005.* On-line at www.nps.gov/yell/naturescience/upload/bmpstatusreview.pdf. (Accessed January 17, 2008.)

Strassert, G., and T. Prato. 2002. Selecting farming systems using a new multiple attributes decision model: The balancing and ranking method. *Ecological Economics* 40, 269–277.

The Nature Conservancy (TNC). N.d. Blackfeet Land Trust names its first property "Sokeeps-kim" Ranch. On-line at www.nature.org/wherewework/northamerica/states/montana/news/news750.html. (Accessed October 23, 2007.)

_____. 2006. *Land Stewardship on the Front.* On-line at www.nature.org/wherewework/northamerica/states/montana/science/art15847.html. (Accessed October 19, 2007.)

_____. 2007. *Pine Butte Swamp Preserve, Montana. The Nature Conservancy.* On-line at www.leo.lehigh.edu/fen/profiles/pine_butte_swamp_preserve/. (Accessed October 25, 2007.)

Thompson, S., and D. Thomas. 2007. Resolving transboundary conflicts: The role of community-based advocacy. In *Sustaining Rocky Mountain Landscapes: Science, Policy and Management of the Crown of the Continent Ecosystem*, T. Prato and D.B. Fagre, eds. Washington, D.C.: RFF Press, 285–301.

Travis, W.R., D.M. Theobald, and D. Fagre. 2002. Transforming the Rockies: human forces, settlement patterns, and ecosystem effects. In *Rocky Mountain Futures: An Ecological Perspective,* J.S. Baron, ed. Washington, D.C.: Island Press, 1–26.

Turner, B.L., and W.B. Meyer. 1994. In *Global Land-use and Land-cover Change: An Overview. Changes in Land Use and Land Cover: A Global Perspective*, W.B. Meyer and B.L. Turner, eds. Cambridge, U.K.: Cambridge University Press, 3–10.

U.S. Army Corps of Engineers and South Florida Water Management District. 2000. *Master Program Management Plan, Comprehensive Everglades Restoration Plan.* West Palm Beach, Fla.: South Florida Water Management District.

U.S. Department of Agriculture. 2002. *1997 National Resources Inventory.* Machine readable data available on CD-ROM. Fort Worth Tex.: National Cartography and Geospatial Center.

Vias, A.C., and J.I. Carruthers. 2003. The highest and best use? The outcome of land use change in the Rocky Mountain West, 1982–1997. Working paper. Storrs, Conn.: Department of Geography, University of Connecticut.

Waldt, R. 2004. *Crown of the Continent: The Last Great Wilderness of the Rocky Mountains*. Helena, Mont.: Riverbend Publishing.

Walters, C. 1986. *Adaptive Management of Renewable Resources*. New York: Macmillan.

Whitney, C., B. Hurlbutt, and F.P. Holmes. 2005. Rockies energy futures. In *2005 State of the Rockies Report Card*. Economics and Business Department, Colorado College State of the Rockies Project. Colorado Springs, Colo.: Colorado College.

Wilhere, G.F. 2002. Adaptive management in habitat conservation plans. *Conservation Biology* 16, 20–29.

Wondolleck, J.M., and S.L. Yaffee. 2000. *Making Collaboration Work: Lessons from Innovation in Natural Resource Management*. Washington, D.C.: Island Press.

World Almanac Education Group. 2005. *World Almanac.* New York: World Almanac Education Group.

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