Nature reserves as catalysts for landscape change

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Scientists have called repeatedly for a broader conservation agenda that emphasizes not only protected areas but also the landscapes in which those areas are embedded. We describe key advances in the science and practice of engaging private landowners in biodiversity conservation and propose a conceptual model for integrating conservation management on reserves and privately owned lands. The overall goal of our model is to blur the distinction between land management on reserves and the surrounding landscapes in a way that fosters widespread implementation of conservation practices. Reserves assume a new role as natural laboratories where alternative land-use practices, designed to achieve conservation objectives, can be explored. We articulate the details of the model using a case study from the North American tallgrass prairie ecoregion.

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Nature reserves have long served as the foundation of biodiversity conservation, yet reserves alone are insufficient to solve the problem of biodiversity loss (Mora and Sale 2011). This realization has engendered repeated calls for a broader conservation agenda that emphasizes not only reserves but also the working landscapes in which they are embedded (Folke *et al.* 1996; Daily 2001; Prugh *et al.* 2008; Franklin and Lindenmayer 2009).

Achieving conservation goals on private lands has traditionally involved top-down controls on individual action through regulation. More recently, incentives to elicit beneficial actions have been emphasized over regulations that merely prohibit harmful actions (Wilcove *et al.* 2004). Yet incentive-based programs may result in piecemeal conservation efforts at landscape or regional scales (Brown *et al.* 2009), and participation varies depending on prevailing policy and market conditions (Wallace and Palmer 2007; Fargione *et al.* 2009). Clearly there is a need for alternatives that are politically viable, equitable, and effective in achieving conservation objectives (Freyfogle 2006).

In a nutshell:

- Scientists have been challenged to become more active in engaging the public and effecting the conservation actions that they recommend
- Opportunities for such engagement can be found in performance-based environmental management, a grassroots community-building framework aimed at achieving conservation goals on private lands
- Tools derived from this framework have the potential to improve habitat for biodiversity over broad scales
- One such tool, the Reserves-As-Catalysts model, expands the role of protected areas and blurs the distinction between reserves and working lands in ways that enhance conditions for biodiversity while conveying multiple benefits to private landowners

Here, we propose a conceptual model for implementing collaborative conservation that considers multiple benefits to landowners and envisions a new role for protected areas in catalyzing change on private lands. Reserve managers are often involved in mitigating adverse effects on biodiversity resulting from human activities in the surrounding landscape (Saunders *et al.* 1991). Conversely, private landowners may be worried about undesirable impacts emanating from conservation lands (Buckley and Crone 2008). Our model represents a decided shift from "fortress" conservation (Berkes 2004) to a scenario in which (1) nature reserves become an integral part of the landscapes in which they occur and (2) the contrast with the matrix of private ownerships becomes less distinct. We draw upon our research in the North American tallgrass prairie ecoregion to illustrate the steps of the model, underscoring the promise and challenge of implementing the cultural changes needed to achieve conservation goals at landscape scales.

The Reserves-As-Catalysts model

The fundamental objective of our model is to build grassroots support for landscape-scale conservation. In formulating this model, we incorporated several key elements of performance-based environmental management, a community-building process initially developed to help improve water-quality standards in agricultural watersheds (Panel 1). We rely on a group effect to develop collective goals for private landowners in managing natural

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Panel 1. Performance-based environmental management

Farmers are skilled at routinely tracking indicators of agricultural production (eg crop yields, tons of hay produced, livestock weight gain) and adjusting their practices accordingly. Yet they seldom monitor on-farm or broad-scale indicators of the environmental impacts of their practices. To avoid environmental degradation and subsequent regulatory action, Cooperative Extension Service specialists at Iowa State University devised a framework known as performance-based environmental management (Morton and McGuire 2011).

Performance-based management has been a hallmark of industry for decades, with the goal of improving manufacturing processes while adhering to safety and environmental regulations. The agro-environmental counterpart to this strategy similarly aims at continual improvement in land-use practices through ongoing assessments and adaptive management. At the heart of performance-based environmental management is a group process (Figure 1) involving farmers and technical specialists. Farmers must first recognize a problem (*awareness*) and use a data-driven approach to understand the contribution of their land-use practices to the situation (*assessment*). These data are shared among group members and extrapolated to the watershed, thereby informing participants of the effect of their decisions not only on their own land but also on the natural resource base beyond their property. The assessment phase provides the basis for determining how best to improve ecosystem resilience while maintaining profitability in agricultural operations (*goals–plans*). The group then develops specific objectives (*targeting*) and initiates a cycle of adapting their practices to meet objectives (*performance*) and measuring their success in doing so (*evaluation*).

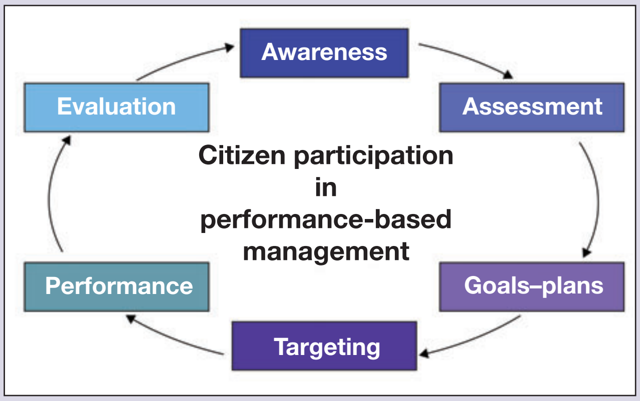

Figure 1. Model for performance-based environmental management (adapted from Morton and McGuire 2011). The model initiates with "awareness" but otherwise the process is iterative and non-linear, and any two boxes could be linked in any direction. For the sake of simplicity, we present this version.

Since 2001, performance-based environmental management has been implemented by farmer-led groups in northeast Iowa to reduce sediment loss and nutrient runoff in five watersheds (Morton and McGuire 2011). In the Hewitt Creek watershed, farmers reduced commercial nitrogen use by 30–110 kg ha^{-1}, with an average reduction of 22% and no decrease in crop yield. This not only has mitigated non-point-source pollution but, when extrapolated to the entire watershed, has also reduced nitrogen application by 200 000 kg, valued at $240 000.

resources (Morton 2011). Our approach is transdisciplinary in its emphasis on the collection and free exchange of data among landowners, natural resource managers, and scientists. Furthermore, landowners are afforded opportunities to explore new technologies while avoiding reinforcement of local norms that resist innovation and change.

The first step (Figure 2) is identifying key processes driving ecosystem change and establishing the linkages between these processes and land-use practices. Reserves serve as natural laboratories in which fundamental aspects of these processes can be examined. To understand the factors driving these practices, we suggest that a dialogue should be initiated with landowners – one that continues through all subsequent interactions. Scientists and natural resource professionals often make overly simplistic assumptions about the nature of such drivers (eg the profit motive) when, in reality, motivations underlying land-use practices tend to be complex and sometimes counterintuitive (McCown 2005).

The dialogue continues in the form of surveys and interviews intended to document landowner understanding of key processes driving ecosystem change, how this understanding influences management decisions, and the presence of barriers that may prevent the adoption of new practices. Landowner knowledge, experience, beliefs, prevailing social perceptions, and management norms collectively provide the foundation to which landowners add new information and form the basis for adopting new land-use practices (Fischer 2000; Wood and Doan 2003). Data collected through participatory methods are also useful in identifying key landowners who may be willing to implement conservation practices on their properties.

The initial transfer of practices (represented by the first open-ended circle in Figure 2) emphasizes the development of shared values and a regional vision among key landowners. Underpinnings of this process are rooted in individual and collective elements (Triandis and Gelfand 1998; Burton and Wilson 2006) that either reinforce or challenge personal and social identities – for example, what a good landowner does (Burke 2004; Burton 2004; Burton and Wilson 2006). The civic and social relationships among landowners influence how they engage one another and the social expectations and normative behaviors that occur (Putnam 1993; Morton 2008). This model step involves the development of an informal landowner group that focuses on a shared problem and engages in performance-based environmental management. Three key assumptions underlie this progression. First, current management practices can always be improved by developing a continuous information–action feedback loop. Second, peer-to-peer information exchange enhances learning and provides mutual support for improving current norms of practice (Weber 2000). Third, exposure to activities on reserves provides oppor-

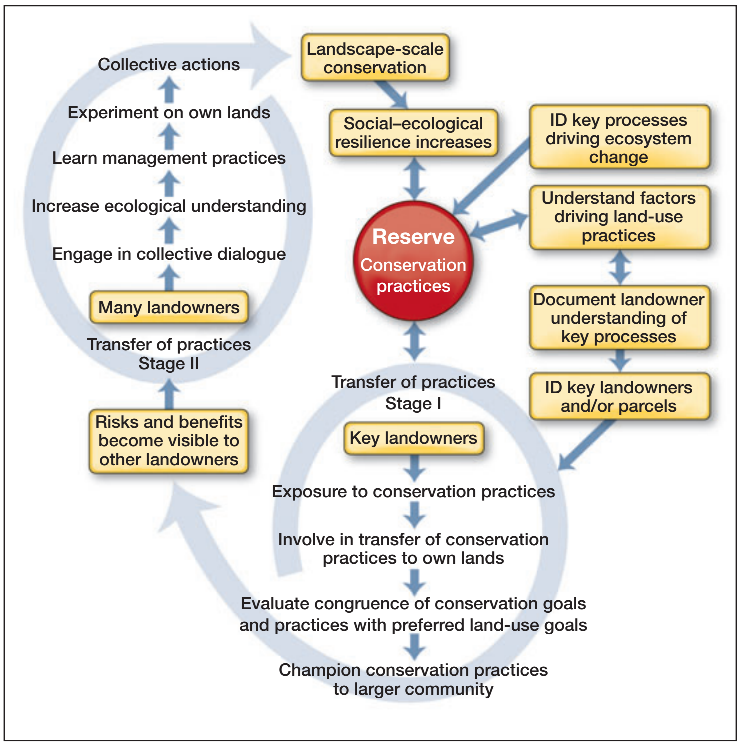

Figure 2. *The Reserves-As-Catalysts model, in which conservation actions on reserves serve as catalysts for change on surrounding private lands.*

tunities to integrate scientific advances with current practices. Thus, reserves serve to catalyze change in the broader landscape. Landowners evaluate conservation practices in light of their own land-use goals, yet are influenced by the group in forming their regional vision and making management decisions.

The second open-ended circle entails the transfer of conservation practices, from reserves and properties of key landowners to those of their neighbors. This transfer hinges on key landowners assuming leadership roles and becoming champions for these practices. Peer-to-peer exchange of personal experiences and enhanced ecological awareness provide the motivation and collective support to "risk" undertaking actions that are not the current normative practice. As in the model's first circle, we are leveraging a group effect whereby landowners learn from each other, collectively refine their vision for the land, and adopt those practices that meet individual goals and community expectations. It is in this model step that landscape-scale conservation can become the norm.

Case study: the Grand River Grasslands

The areal extent of the North American tallgrass prairie has been reduced by about 96% since the advent of European-style agriculture in the region during the 1830s (Samson and Knopf 1994). Much of the grassland habitat in the tallgrass ecoregion now consists of privately owned pastures and hay fields (Herkert *et al.* 1995; Askins *et al.* 2007). In the heart of this region is the Grand River Grasslands, comprising 30 000 ha on the Iowa–Missouri border. The Grand River Grasslands has been identified as the best-known opportunity to restore a functional tallgrass prairie system in the entire ecoregion (TNC 2008), largely because of the sizeable percentage (nearly 15%) that is protected and the large area (>80%) in native and non-native grasses.

The distinction between land-use practices on reserves and on private lands in the Grand River Grasslands (Figure 3) typifies much of the ecoregion. Livestock grazing is the dominant enterprise on ownerships that have characterized the region historically (hereafter, traditional ownerships), whereas wildlife biologists have long promoted the exclusion of livestock from protected areas (Kirby *et al.* 1992; Kruse and Bowen 1996). Fire is used as a management tool on many grassland reserves but is largely absent from private lands – the region-wide exception being the Flint Hills of Kansas and Oklahoma, where most private grasslands are burned annually. A crucial consequence of fire exclusion has been rapid encroachment by fire-intolerant woody plants, particularly eastern redcedar (*Juniperus virginiana*; Briggs *et al.* 2002). Eastern redcedar encroachment is especially acute on private lands where livestock grazing is also absent (hereafter, non-traditional ownerships). When sold, properties in the region are most often purchased by non-residents who are more interested in recreational pursuits than livestock production (Duffy 2007). For this reason, non-traditional ownerships are increasing with a concomitant decrease in traditional ownerships.

Conserving grassland biodiversity in the region cannot be accomplished by conservation management on reserves only. The challenge, then, is to devise strategies that will be embraced by landowners and improve conditions for native grassland species.

First steps

Grasslands in the eastern Great Plains and Prairie Peninsula (a segment of prairie that extends from western Iowa to western Indiana) have a long evolutionary history of disturbance from grazing and fire (Milchunas *et al.* 1988). The lack of disturbance on non-traditional ownerships, intensive grazing on traditional ownerships, and use of prescribed fire as a management tool on reserves are the *key processes driving ecosystem change* in the Grand River Grasslands. We therefore initiated a replicated pasture-level experiment in 2007 to examine the utility of a fire–grazing interaction as a management framework. This approach relies on the application of discrete fires and focal grazing by large ungulates (known as "patch-burn grazing") to promote habitat heterogeneity (Fuhlendorf and Engle 2004).

Our research in the Grand River Grasslands has shown that the diversity of grassland-dependent wildlife in-

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Figure 3. *Principal land uses in the Grand River Grasslands. (a) Livestock production is the dominant enterprise on traditional ownerships. These properties are characterized by high stocking rates of cattle, lack of vegetation structure due to heavy grazing, and exclusion of fire. (b) Prescribed fire is applied on reserves, but grazing is typically excluded and herbaceous vegetation is often dominated by grasses. (c) Habitat heterogeneity on reserved lands tends to be low. (d) Both grazing and fire are usually absent on non-traditional ownerships; as a result, woody plants, particularly eastern redcedar (*Juniperus virginiana*), are common.*

creases with the use of patch-burn grazing (Pillsbury *et al.* 2011), similar to findings in Oklahoma on birds (Fuhlendorf *et al.* 2006), invertebrates (Engle *et al.* 2008), and small mammals (Fuhlendorf *et al.* 2010). Livestock weight gain and body condition score are at least as good under patch-burn grazing as under traditional management (Limb *et al.* 2011). Yet prescribed fire and moderate grazing of livestock are conservation strategies that run counter to regional norms. The next three steps of the model are intended to lay the foundation for change.

Changing norms of practice must be predicated on understanding motivations. Toward this end, we initiated the second step of the model, *understanding factors driving land-use practices*, with a landowner survey (Morton *et al.* 2010). Survey results highlight the disparity between the two dominant landowner groups; most traditional owners have a commodity production perspective on livestock grazing, whereas non-traditional owners place a high value on wildlife habitat, native species, and grassland restoration. The survey also revealed that agricultural production and conservation of native species are viewed as competing goals, and that the relationship between fire suppression and encroachment of woody plant species is not widely appreciated (Morton *et al.* 2010). This latter result poses a particularly vexing challenge in terms of motivating an effective response to a threat that will fundamentally alter the system in a decade or two if left unchecked (Figure 4).

Our efforts to understand the motivations behind land-use practices proceeded iteratively with the next two model steps. We held a series of landowner field days on our study sites to discuss the results of our experiments with fire and grazing, and to raise awareness of grassland ecology. We conducted face-to-face interviews with individual landowners, which revealed that even those who had not attended field days were aware of our work in the area. On the basis of these interactions, we began identifying a group of key landowners (Panel 2). These individuals were convened to talk about the survey and to participate in a concept-mapping exercise (Trochim 1989) intended to document their beliefs, management practices, social networks, and understanding of grassland ecosystems. Dominant recurring themes associated with barriers to implementing prescribed fire and grazing practices were emotional responses to fire use, profitability concerns, and lack of a collective vision for the grassland ecosystem.

Figure 4. *Four stages of invasion by eastern redcedar (*Juniperus virginiana*) in the absence of fire: (a) 2–3-year-old seedlings, (b) 5–6-year-old saplings, (c) 6–8-year-old saplings, (d) mature woodland.*

Key landowners – transfer of conservation practices

Model implementation is currently focused on further interactions with key landowners. We continue to foster a deeper understanding of grassland ecology for participating landowners on our study areas, and are providing training in methods for characterizing vegetation structure and identifying native plant and animal species. Habitat assessments are conducted jointly by landowners and project staff to develop mutual trust and provide opportunities for information exchange. Data are subsequently aggregated and shared with the group to promote dialogue about the impacts of management practices and to connect landowners with the methods of ecological research. Relationships formed here foster a willingness to collaborate and to continue sharing results as landowners begin to experiment with conservation practices on their properties.

In the transfer of conservation practices to the properties of key landowners, our initial emphasis is on the use of prescribed fire. Burning is the most economical method for controlling the encroachment of eastern redcedar (Bernardo *et al.* 1988), which over 75% of the

Panel 2. Identifying a core group of key landowners

In the Reserves-As-Catalysts model, a crucial step in implementing conservation actions on private lands is enlisting the participation of a core group of landowners willing to experiment with new management techniques. In the Grand River Grasslands, individuals in this group belong to one or more of the following groups:

- Those who graze cattle on our experimental pastures.
- Non-traditional owners who do not stock cattle but use their land for hunting and other recreational pursuits.
- Those who own relatively large parcels of land adjacent to reserves.
- Cattle producers who are community leaders, innovators, and early adopters of management practices, who other owners listen to and trust, and who have the potential to champion restoration practices.

Although some of the wording in these descriptions is specific to our study, the general categories are relevant to a wide range of situations in which the objective is adoption of conservation practices on private lands.

landowners in the region consider a problem (Morton *et al.* 2010). Our survey results also indicated that more than half of the landowners in the region view fire as a legitimate management tool, but apprehension and lack of skills pose major barriers to its use (Morton *et al.* 2010). Having provided examples of successful burns on reserves and private lands, we are now seeing indications from key landowners that these barriers are far from insurmountable. We recently held a "burn school" for the core group, led by an individual who has organized more than 25 burning cooperatives (Weir and Bidwell 2011) across the central US. This workshop included training and active participation of landowners in conducting a prescribed burn. Several months later, landowners again convened to conduct a burn on one of their properties.

As individuals continue to experiment with implementing conservation practices on their lands, conversations will shift to evaluating the congruence between their land-use goals and the broader vision for the region. These discussions encourage group learning, reinforce the value of experimentation and data collection on the owners' own lands, and heighten awareness of the effects of their actions beyond the boundaries of their individual properties. Intermediate success in the Reserves-As-Catalysts model will be manifest when key landowners champion a broader vision for the region and advocate conservation practices to the larger community.

■ From the few to the many

A group effect will serve to extend conservation action from reserves and the properties of key landowners to the broader community. Although not all landowners will attend field days or even attempt to learn about natural grassland habitat and species, they will be influenced by neighbors talking about grassland restoration goals and practices. Our survey revealed that when making decisions about their properties, landowners place the highest trust in other landowners, followed by family and friends (Morton *et al.* 2008). Input from natural resource agency personnel and scientists may help, but will not substitute.

Our findings indicate that non-traditional owners are more amenable to implementing conservation practices (Morton *et al.* 2010). These individuals can derive a variety of benefits – including habitat improvement for wildlife species (Schroeder 1985; Bareiss *et al.* 1986; Spears *et al.* 1993; Bidwell *et al.* 2004; Masters *et al.* 2005) that they highly value (Table 1; Morton *et al.* 2010) – through the adoption of burning and grazing.

Traditional owners may be slower to adopt conservation practices. Yet numerous benefits will accrue to them from putting such practices into effect on reserves and on non-traditional ownerships as those landowners become aware of the utility of grazing as a management tool (Table 1). Although benefits can also be derived by traditional owners from implementing conservation action on their own lands, it remains to be seen how many will be willing to reduce their stocking rate of cattle to do so. That said, there is no shortage of traditional owners interested in stocking cattle on reserves, presumably because of lower rental fees and a reduced need to provide supplemental forage late in the grazing season. This is also likely to be the case on non-traditional properties opened to grazing.

■ Alternative futures

If current trends continue in the Grand River Grasslands, we envision a landscape in which none of the dominant land uses are thriving (Figure 5). Each of the three scenarios, especially non-traditional ownerships, will experience a substantial increase in eastern redcedar. Habitats will accommodate fewer grassland-dependent and game

Table 1. Benefits accruing to private landowners derived from conservation practices, such as prescribed fire and moderate grazing, implemented on grasslands in nearby nature reserves and on their own property

Location of practice	*Benefit*
Nearby reserve	Additional source of forage Forage buffer in drought Learning environment for new practices Improved habitat for native fauna, including game species, with potential spillover benefits
Traditional ownerships[1]	Forage buffer in drought Reduced encroachment of woody vegetation Reduced reliance on supplemental livestock forage (eg hay) More diversified sources of income or landowner uses (eg fee-based hunting)
Non-traditional ownerships[2]	Additional source of forage Forage buffer in drought Reduced encroachment of woody vegetation Improved habitat for native fauna, including game species, with potential spillover benefits More diversified sources of income or landowner uses (eg fee-based hunting)

Sources: Cummings *et al.* (2007); Weir *et al.* (2007).
Notes: [1]Livestock grazing is the dominant enterprise on traditional ownerships. [2]Non-traditional landowners typically live outside the region, do not stock cattle, and – as compared with traditional owners – place a higher value on wildlife and habitat restoration.

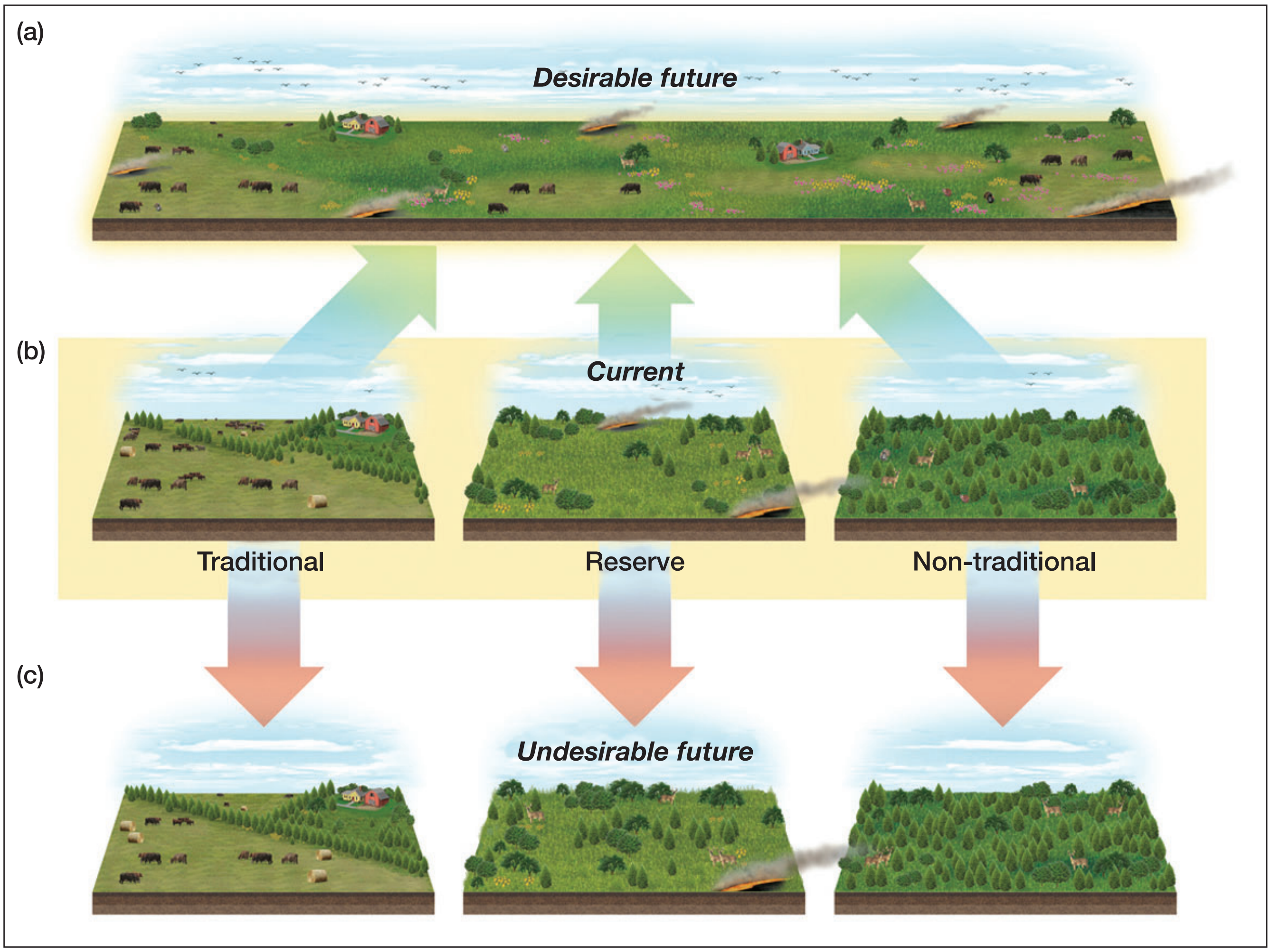

Figure 5. *Two potential future scenarios for the Grand River Grasslands. The undesirable scenario (c) results from the continuation of current practices (b). Woodlands are the dominant land cover on many properties, leading to declines in grassland biodiversity. Alternatively, as implementation of prescribed fire and moderate grazing become widespread, a more desirable scenario unfolds (a). Woodlands decrease, habitat heterogeneity increases for grassland and open-country fauna, and traditional owners benefit from an expanded array of economic opportunities.*

species. Indeed, if patterns established elsewhere in the central US unfold here, a threshold may be passed wherein grass-based enterprises are no longer tenable and woodland becomes the dominant land cover.

Alternatively, if the Reserves-As-Catalysts model proves viable, a more prosperous future is possible (Figure 5). Implementation of moderate grazing and periodic prescribed fire on reserves and non-traditional ownerships both expands and enhances habitat for grassland biodiversity and open-country game species alike. Opening these lands to cattle grazing at stocking rates compatible with habitat improvement (about an 80% reduction from typical stocking rates in the region) can also translate to similar reductions on at least 5% of grazable land in traditional ownership without any change in overall livestock herd sizes. Such reductions could be required of producers who wish to acquire grazing leases on these properties.

Collectively, these actions would double the amount of habitat currently existing in set-asides. If the real estate market maintains its current trajectory, this amount could increase by 5% annually as more properties are transferred to non-traditional owners. As the landscape is transformed, additional opportunities for income generation on private lands will be created and prospects for future grass-based enterprises will become more secure. Even incremental change has the potential to be amplified as new norms of land-use practice evolve throughout the region.

■ Conclusions

Scientists have been challenged to assume active roles in engaging the public and effecting the conservation actions they are recommending (Arlettaz *et al.* 2010; Groffman *et al.* 2010). The Reserves-As-Catalysts model is an attempt to do both. The general approach outlined in the model is applicable to a range of landscape types, from forested regions to metropolitan areas. Successful implementation requires that four essential conditions be met. First, there must be ecological potential in the landscape that would allow the transfer of conservation practices to private lands.

Second, natural resource agencies or non-governmental organizations with jurisdiction in the region of interest must adopt a broad-scale focus that extends beyond reserve borders, and they must be willing to engage neighboring landowners. Third, there must be some level of social readiness for change. At the very least, a core group of landowners must value conservation objectives and be amenable to modifying their land-use practices accordingly. These individuals must also recognize problems stemming from current land-use practices and be willing to engage in a search for solutions. Finally, social readiness must be achieved in a timeframe that will allow the landscape's ecological potential to be maintained or improved.

Although we believe that the notion of reserves as catalysts for conservation action on private lands has relevance across the range of reserve sizes, relatively small reserves may be particularly well-suited to this role. The conservation value of smaller set-asides remains under scrutiny (Fuller *et al.* 2010; Kareiva 2010). Yet there is often greater flexibility regarding management options on smaller reserves (Schwartz and van Mantgem 1997), and managers are therefore able to experiment with innovative practices. Smaller protected areas are also more accessible to the public because they are more evenly distributed than large holdings and typically occur in human-dominated landscapes (Miller 2006). Managers of these reserves, particularly in rural areas, likely have strong ties to the local community. Taken together, these qualities may make it easier to engage local landowners in a dialogue about land-use practices.

There have been numerous calls for a conservation agenda that extends beyond reserves to include working landscapes, as noted above. These calls typically provide general rationales for doing so, but rarely offer detailed guidance for implementing such an agenda. The Reserves-As-Catalysts model is intended to serve as an explicit roadmap for engaging private landowners in the adoption of conservation practices. This model is also intended to stimulate new ways of thinking about the role of reserves in conservation.

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