The Future of Restoration and Management of Prairie-Oak Ecosystems in the Pacific Northwest

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Source: Northwest Science, 85(2) : 83-92

Published By: Northwest Scientific Association

URL: https://doi.org/10.3955/046.085.0201

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Abstract

The 24 papers in this issue of *Northwest Science* summarize research and management presented at a 2010 meeting convened by the Cascadia Prairie-Oak Partnership, a collaboration focusing on the prairie/oak ecosystems of the Willamette Valley-Puget Trough-Georgia Basin ecoregion. We present an overview that builds on these papers to consider future threats and conservation priorities in these systems. Human population growth, encroachment by woody vegetation, the spread of invasive non-native organisms, and climatic changes all will provide future challenges. Developing and implementing techniques to abate these threats will require effective collaboration, creative research, and innovative management of natural areas. One priority will be the restoration of highly degraded habitats to increase acreage of native ecosystems, create buffers, and enhance connectivity. Other priorities will focus on detecting and eradicating newly-arrived invasives, enhancing species diversity and habitat heterogeneity, and increasing ecological resilience. Long-term commitments and investments are critical. Developing realistic restoration goals will be particularly challenging, especially when assembling new communities from the ground up, and in a world with a rapidly changing climate. To assist with goal development, we propose a system for conceptualizing restoration goals so that their relative merits can be more easily compared when deciding amongst them. We suggest evaluating goals along two continua, one related to management intensity (ecological goals) and the other to ecological impacts (cultural goals). We conclude by suggesting some specific restoration and management principles that may help to further guide conservation action, and that point toward critical information needs for future research.

Introduction

A single species of oak was among the numerous collections made by David Douglas during his botanical wanderings through the Columbia River watershed in the early 1800s. He observed it growing individually and in groves around the broad grasslands west of the Cascade Mountains. Douglas named the tree *Quercus garryana* to honor the secretary of the Hudson's Bay Company, under whose protective auspices he carried out much of his work (Nisbet 2009). Depending on your geographic proclivities, this iconic species is commonly known as Garry oak or Oregon white oak. An even wider range of names—prairies, grasslands, meadows, woodlands, savannas—refer to the grass and oak-dominated landscapes of the Willamette Valley-Puget Trough-Georgia Basin (WPG) ecoregion in British Columbia, Washington, and Oregon. Here, we refer to them jointly as prairie/oak ecosystems.

The treeless grasslands and productive soils of the WPG ecoregion were enticing to the agriculturally-inclined settlers who began to arrive soon after Douglas, and the WPG has continued to be a focus of much agriculture ever since. Furthermore, although it accounts for < 4% of the regional land area, three quarters of the regional population reside in counties (WA, OR) or regional districts (BC) that contain the WPG ecoregion in whole or in part. As a result, the prairie/oak ecosystems are one of the most endangered systems in the region (Floberg et al. 2004).

Over the last two decades, conservation, management, and research in these landscapes have progressed rapidly. Energetic partnerships and collaborations have sprung up to protect these endangered systems, identify key research and management needs, facilitate the exchange of information, generate new methods for restoring and managing rare species and communities, and sustain their long-term viability and ecological health. Regionally, groups that have been key facilitators of these interactions include the Garry Oak Ecosystems Recovery Team (http://www.goert.ca), South Puget Sound Prairie Landscape Working Group (http://www.southsoundprairies.org), North Puget Sound Prairie Working Group (http://www.northsoundprairies.org), and the Oregon Oak Communities Working Group (http://www.oregonoaks.org).

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In 2010, the Cascadia Prairie-Oak Partnership (CPOP) was organized as an international collaboration to link these regionally-based groups more closely, and to encourage greater cross-fertilization of ideas and effort. In March 2010, CPOP convened a meeting in association with the Northwest Scientific Association to summarize the current understanding of prairie/oak ecosystem ecology, management, and conservation across the region. The results of these presentations are published as 24 papers in this special issue of *Northwest Science*, the journal of the Northwest Scientific Association. In many ways, this special issue provides an update to the 1997 publication edited by Dunn and Ewing (1997), which focused on the south Puget Sound prairies. It differs from the earlier work, however, by bringing together papers from across the ecoregion, reflecting the greater collaborations and broader perspective that underpin many current research and conservation efforts.

Our objective in this paper is to provide a context for the papers in this special issue. To do so, we review the historical context of prairie/oak systems, summarize current conservation efforts, and identify future challenges to their management. We close by discussing the importance of defining restoration goals and suggesting some ways to use these to select among alternative actions.

Historical Context

The prairie/oak ecosystems of the WPG ecoregion spanned 600 km latitudinally from central Vancouver Island in the north to the Willamette Valley in the south. They occurred at low elevations (0 to 150 m) across a broad range of substrates and hydrologic conditions. Grass-dominated vegetation – called meadows or prairies – occurred on rocky balds, coastal bluffs, gravelly and mounded outwash plains, and alluvial floodplains in valley bottoms characterized by deep, rich soils. Some of these sites experienced extensive summer droughts, while others had standing water for several months during the winter. Garry oak similarly occurred on dry hillslopes and along creeks.

Burning by indigenous peoples was a major factor that maintained prairie/oak ecosystems in many parts of the ecoregion (Boyd 1999), and fire is increasingly being reintroduced to these systems. However, harvesting of plant materials such as camas (*Camassia* spp.) bulbs, chocolate lily (*Fritillaria affinis*) corms, and bracken (*Pteridium aquilinum*) rhizomes also occurred extensively in these systems (Turner 1999) and likely resulted in significant soil disturbance. These processes, along with edaphic breaks and differences in soils, were important factors in maintaining these systems and the ecotones between them and the surrounding matrix forests.

However they are defined and by any measure of status, these systems have suffered extensive losses since Douglas explored the area. Throughout the ecoregion, prairie/oak ecosystems now occupy only a fraction of their original area. Various approaches have been used to quantify their historical extent and changes in area and condition since Euro-American settlement; these approaches include 19th century land survey records and maps, documentation of historical place names, photographs, diaries and other accounts, maps of soil types, detailed soil analyses, and current vegetation maps. On Vancouver Island, Lea (2006) concluded that there were ca. 15,250 ha of Garry oak ecosystems historically; he did not estimate the acreage of prairies that did not contain Garry oak. These oak ecosystems have been reduced to < 10% of their original extent, with < 5% of the remaining habitat in a natural condition (Lea 2006). In the islands of the Georgia Basin and northern Puget Sound, most remnants are found on rocky outcrops, shallow soils, and small islets that were impractical for agriculture. Southern Puget Sound historically contained some of the largest prairie/oak ecosystems north of the Willamette Valley. The largest remaining grasslands in south Puget Sound occur on Joint Base Lewis-McChord. Overall in western Washington, the ca. 73,000 ha of historical grasslands have been reduced by about 91%, and only 2 - 3% are still dominated by native species (Crawford and Hall 1997, Chappell et al. 2001), though these numbers are more than a decade old and should be updated. Oregon's Willamette Valley contained vast acreages dominated by prairie and oak vegetation types in the 1850s; as in areas to the north, only a fraction of these remain (Noss et al. 1995, Christy and Alverson 2011).

In all of these areas, the surviving remnants tend to be small and highly fragmented, having lost the functional connectivity that once allowed everything from butterflies to prairie fires to move across the landscape with little interruption. Crawford and Hall (1997), for example, noted that only a handful of the 30 prairies that once exceeded 200 ha in south Puget Sound remain. Nor are these losses evenly distributed across the historical sites. Deep soil prairies were disproportionately impacted, having been the most highly prized for agriculture (Lea 2006). Similarly, the historical extent and composition of wet prairies is very poorly understood due to the virtual absence of extant examples. Draining, plowing, grazing, and invasion by non-native species have been particularly devastating in these habitats. Thus, the examples of prairie/oak communities that remain today are highly skewed towards sites on the poorest soils that were least-suited for agriculture.

The biota in these remnants is often highly degraded as well, both by losses of native taxa and by the invasion of non-native species. In a study of 15 of the largest prairie remnants in south Puget Sound, Dunwiddie et al. (2006) found that 40% of the native plant species occurred in only 1 or 2 prairies, and a similar percentage occurred (currently or in the past) only in nearby sites, and today are absent from all of the study sites. Native annuals are a notable example of a group of species that is now uncommon in many prairies, likely due to the lack of frequent disturbances that historically would have provided areas for them to establish in (Dunwiddie et al. 2006). It probably is no coincidence, therefore, that this loss has had cascading effects: some of these species (e.g., *Collinsia parviflora, Collinsia grandiflora, Plectritis congesta,* and *Triphysaria pusilla*) are host plants for rare butterfly species (Schultz et al. 2011). Thus, in addition to the losses of plant species, most prairie/oak ecosystems have almost certainly also suffered significant losses of mammals (Stinson 2005), birds (Altman 2011), butterflies (Schultz et al. 2011), and other invertebrates (Fazzino et al. 2011). The remaining populations occupy smaller, degraded habitats and are increasingly vulnerable to extirpation. The list of threatened and endangered species continues to grow. In British Columbia, over 100 plants and animals associated with the Garry oak ecosystems are considered 'At Risk' (GOERT 2005). As we write, four animals discussed by authors in this Special Issue (Taylor's checkerspot [*Euphydryas editha taylori*], Mardon skipper [*Polites mardon*], streaked horned lark [*Eremophila alpestris strigata*], and Mazama pocket gopher [*Thomomys mazama*]) are being evaluated for possible listing as threatened or endangered under the Endangered Species Act (USFWS 2011).

These losses in native species are mirrored by, and to some extent caused by, increases in non-native plants (Dennehy et al. 2011). Dunwiddie et al. (2006) found that ca. 40% (range: 33-48% among sites) of the flora in major south Puget Sound prairies is introduced from other continents. In many smaller sites, this proportion is much higher in terms of both number of species and abundance.

Current Conservation Efforts

Conservation of prairie/oak ecosystems is increasingly approached from a broader, ecosystem perspective. Fire, one of the key historical processes that shaped and maintained prairie/oak ecosystems, is becoming widespread as managers strive to re-establish important ecological functions (Hamman et al. 2011). Invasive species management is increasingly being addressed using more coordinated, collaborative approaches (Dennehy et al. 2011). As restoration efforts focus on larger acreages and more highly degraded sites, they are also growing in scale and impact as innovative restoration techniques are developed (Nuckols et al. 2011, Stanley et al. 2011). Furthermore, the diversity and quantity of native species available for seeding and outplanting is increasing through the efforts of groups such as the Native Seed Network (Ward et al. 2008).

Losses of individual native species, which have been occurring since the arrival of Euro-American settlers in the 19th century, are being countered by aggressive conservation measures as well. Slater and Altman (2011) describe encouraging efforts to reintroduce breeding populations of Western bluebirds to areas where they have been extirpated, and Schultz et al. (2011) highlight recent actions to bring Taylor's checkerspot butterflies and other rare lepidopterans back into sites where they have been lost. Successes in conserving and restoring plant species in these habitats also are increasing, aided by extensive support from various state and federal agencies. For example, since golden paintbrush (*Castilleja levisecta*) was listed as a threatened species in 1997, the U.S. Fish and Wildlife Service has awarded nearly $1 million (US) in grants directed towards recovering viable populations, and $5.5 million (US) to acquire land on which this recovery can occur (Ted Thomas, U.S. Fish and Wildlife Service, personal communication).

Land managers are also working closely with scientists to understand the complexities of these ecological systems and their component species. Several papers in this Special Issue examine the history of the oak-dominated systems (Dunwiddie et al. 2011, Gilligan and Muir 2011, Hegarty et al. 2011, Sprenger and Dunwiddie 2011), while others consider topics that relate to the development of more effective approaches to restoring the diversity and function of prairie/oak ecosystems (Elliott et al. 2011, Kirkpatrick and Lubetkin 2011, Mitchell and Bakker 2011, Nuckols et al. 2011, Rook et al. 2011, Russell et al. 2011, Wold et al. 2011). Investigators are also increasingly directing attention towards other, less-studied taxa, including pollinators (Fazzino et al. 2011) and mycorrhizae (Smith 2007).

Future Threats and Conservation Priorities

The information compiled in this Special Issue provides a useful platform on which to contemplate the future of prairie/oak ecosystems, and to identify where important contributions by researchers and managers are most needed.

Threats

The most pressing future threats are likely to come from four main directions. First, population and economic growth across the region will continue. Current state (WA, OR) and provincial (BC) government projections are that the WPG ecoregion will increase in population by 28% between 2010 and 2030. This growth will increase the development pressure on our remaining open spaces. Although existing preserves may be at relatively low risk of conversion, currently undeveloped buffer areas and potential restoration sites will be irrevocably lost if they are not the subject of future protection efforts. This development would further fragment the landscape, reducing the connectivity among prairie/oak ecosystems, likely adding greater stress to small populations of species and further compromising many ecosystem functions.

Second, trees and shrubs will almost certainly continue to invade extant prairies, and to infill savannas and woodlands (Foster and Shaff 2003). This threat will be most readily contained where managers can develop and maintain an active prescribed burning program. Where such actions are precluded, and in unmanaged sites, future losses can only be mitigated by regular mowing and costly, on-going manual and mechanical removal of woody vegetation.

Third, invasive non-native species will forever pose a threat to the composition and structure of prairie/oak ecosystems. A large number of non-native species are already present in the region (Dunwiddie et al. 2006) and are the focus of active management (Dennehy et al. 2011). However, we also expect that new taxa – plants, animals, pathogens –will arrive in the future. The proximity of many prairie/oak sites to roads and other transportation corridors make them especially vulnerable to invasion.

Fourth, climate change is projected to have relatively large effects in terms of the magnitude and rate of change (Bachelet et al. 2011). These changes are likely to result in significant stochastic losses of native species from many sites, particularly those that are small and isolated. While such changes inevitably result in both winners and losers, those most likely to benefit will be able to rapidly disperse and establish. Unfortunately, these characteristics are also possessed by many invasive species.

Conservation Priorities

Conservation priorities in the future will need to focus on abating these critical threats. Traditional strategies will remain relevant, but will have to be modified to accommodate the changing ecological, economic, and sociological landscape. For example, land protection efforts have tended to focus on parcels that contain assemblages of native prairie plant species, but there are relatively few unprotected fragments of significant area that still contain such assemblages. In the future, we suggest that protection efforts be directed towards parcels where active, large-scale restoration efforts can be undertaken. Often, these areas will be former prairie habitat that was tilled, converted to non-native pasture grasses, or overgrown by conifers. This change in acquisition priorities would provide an opportunity to begin restoring habitat types that are poorly represented in current conservation portfolios, such as deep soil grasslands and wet prairies. This change would also foster the creation of larger management units where fire and other ecosystem processes can be maintained at ecologically meaningful scales, and where a greater range and quality of ecosystem services may be provided by prairie/oak ecosystems. However, it may be challenging to convince potential donors and funders that the purchase of a cornfield or thicket of reed canarygrass (*Phalaris arundinacea*) is a strategic conservation priority.

Oak savannas and woodlands present a somewhat different picture with regard to protection. Mature oak trees provide key structural components of these systems that take decades or more to develop. Many oak stands still exist on private property throughout the region, but have been highly altered in the absence of fire by the ingrowth of Douglas-fir (*Pseudotsuga menziesii*), Scotch broom (*Cytisus scoparius*), and other shrubs. Future protection of significant oak-dominated habitats requires the identification of key parcels where the current extent, composition, and proximity to other priority habitats may collectively increase the overall conservation value of the site. Protection will also require a long-term perspective on oak regeneration within these sites to ensure that seedling establishment, survival, and growth is adequate to provide a continuing supply of saplings, mature trees, and snags long into the future (Clements et al. 2011, Gould et al. 2011, Michalak 2011).

Management of existing sites will need to counter the twin threats of invasive species and encroaching woody vegetation. Although future climate change may influence the relative importance of these threats, both will remain management issues. It will be critical that managers remain flexible and attentive as novel climatic conditions may alter the suite of species that may appear. Early detection of these new invasive species, combined with rapid and effective control actions before they become extensive and difficult to eradicate, is already a widely embraced strategy (Dennehy et al. 2011) and will become increasingly urgent in years to come. Prairie managers will constantly be challenged to control encroaching woody vegetation using tools that are effective, economical, and do not compound other threats.

The small size and high degree of fragmentation of many prairie/oak sites will present formidable challenges for maintaining and increasing their ecological integrity. Strategies such as increasing overall species diversity, enhancing habitat heterogeneity, and building functional redundancy (Dunwiddie et al. 2009, Thorpe and Stanley 2011) may increase the resistance of individual sites to environmental changes and enable them to recover more quickly when disturbances do occur (i.e., increase ecological resilience). These strategies need to be tested using practical methods and statistically rigorous experimental designs.

Establishing and enhancing connectivity between sites will also become increasingly important. This will place a high priority on identifying and protecting parcels that occupy critical locations to provide essential linkages. These parcels may not contain prairie/oak ecosystems at present, and may not even have supported them in the past. Invasive species may be rampant, and the soil structure, nutrients, and microfauna may be very different from that in a prairie/oak ecosystem. Restoration of these types of sites has scarcely been attempted in this region, and presents enormous challenges in terms of both cost and feasibility.

Many of these conservation priorities cross jurisdictional and site boundaries. Increased collaboration among researchers, managers, agencies, and funders, as demonstrated by the establishment of CPOP and the compilation of this Special Issue, is critical. Greater cooperation will significantly enhance the exchange of information, address issues such as invasive species at scales that may be more ecologically meaningful, and help to catalyze synergistic projects with greater impacts.

Future Challenges

The active management of prairie/oak ecosystems requires long-term commitments and investments. Although quantitative data are lacking, our experience is that the attention required to properly manage this type of ecosystem is significantly higher than for many other native ecosystems. Prescribed burning requires ongoing investments in infrastructure to supply equipment and trained personnel (Hamman et al. 2011). Invasive species control in grasslands frequently requires greater and more consistent investments than in many forested systems. Similarly, newly restored prairies may require considerable intervention over many years before they attain a reasonably stable composition of native species. Conservation organizations and agencies have struggled for decades to maintain both the institutional commitment to ensure uninterrupted and ongoing stewardship of natural areas, and to devise means for adequately funding these efforts year after year. The organizations that are central to the conservation of prairie/oak ecosystems will change over time, as evidenced by the recent consolidation of Ft. Lewis and McChord Air Force Base into Joint Base Lewis-McChord, and by The Nature Conservancy's decision to reduce its role in long-term, on-the-ground management of prairie/oak ecosystems in south Puget Sound (Olympian 2011). Practitioners will need flexibility and ingenuity to ensure continuity in management and a commitment to ongoing, long-term success. CPOP may be valuable in this context by providing an opportunity for systematic assessments of actions across the ecoregion, as well as providing a prominent, unified voice for conservation of prairie/oak ecosystems.

The development of restoration goals is a fundamental challenge for restoring and managing ecosystems, though defining such goals for imperiled communities and species is not easy (Thorpe and Stanley 2011). Sites exist within ecological and cultural contexts that, as we discuss below, can be contradictory and leave managers with difficult choices. Furthermore, spatial and temporal variation can constrain restoration options and outcomes in ways that may not be easy to discern *a priori*. For example, intact sites on different substrates present unique combinations of composition, history, and context, as do sites that have been significantly degraded in different ways, or sites where restoration is starting from different conditions. Our ability to predict the effectiveness of restoration and management actions would be enhanced if we could incorporate this variation into our planning. For this to occur, however, we need to understand the sources and implications of this variation. One way to do so is through carefully designed experiments that are replicated across many sites (e.g., Stanley et al. 2011).

Defining restoration goals in the WPG ecoregion is also challenging due to a notable lack of high quality reference sites. Even the most pristine natural areas have been extensively altered by the loss of native species and the invasion of non-native species. Key ecological processes, such as Native American harvesting and burning, have been absent for well over 100 years. Fragmentation has broken up the connectivity among sites so that we have few examples of how organisms might move or respond within large, contiguous prairie/oak ecosystems.

In addition, it may be difficult or impossible to restore some of these key processes at ecologically meaningful scales. Burning is likely to become increasingly difficult as human populations grow, wildland/urban interface issues mount, and air pollution issues increase (Hamman et al. 2011). Reintroducing harvesting, or replicating its ecological effects, would be a challenge that no managers of natural areas have seriously experimented with to date. Compounding this is the ecological uncertainty of how these and other disturbances might interact with a changing suite of invasive species.

Finally, articulating clear restoration goals is complicated by the uncertainty that surrounds the geographic ranges of native species under future climate scenarios. Restoration efforts may be most successful in creating habitats that are viable into the future if they include those species that are best adapted to future climatic scenarios at a site (Dunwiddie et al. 2009, Lawler et al. 2010). However, the necessary models and data to inform these decisions have not been developed for most species that occupy prairie/oak ecosystems. For example, scientists are just beginning to use distribution models to predict which species will be able to survive where they currently exist, which will be able to disperse successfully to other suitable habitats, and which will not survive without active intervention (Lawler et al. 2009).

Given these uncertainties, we suggest that it is necessary to rethink the process of setting site-specific restoration goals. The standard practice has been to set restoration goals by choosing a target that falls within some presumed historical range of variability with respect to structure, composition, or function (SER 2004). While identifying such historical precedents will continue to be important, these precedents do not adequately anticipate the many constraints imposed by highly altered future conditions, and by novel pools of potential species (Ravenscroft et al. 2010). We propose here a system for conceptualizing multiple restoration goals so that their relative merits can be more easily compared when deciding amongst them. We define goals in terms of two continua, one related to ecological goals and the other to cultural goals.

The first continuum is one of management intensity (Figure 1). Management intensity can range from a conservative 'hands-off" posture in which there is little or no human intervention to alter community composition or ecological function, to a highly interactive extreme where the composition, structure, and ecological functions of a site are actively manipulated to achieve defined conditions or states. Between these extremes are a wide range of potential alternative levels of activity on a site. These might include, for example, re-establishing key historical processes, controlling invasive species, or introducing species extirpated from a site. Examples of other alternatives that could be considered include deliberately managing the composition and distribution of species on a site to enhance ecosystem resilience, or assisting in the dispersal of species from more distant sites that may be threatened in their current home range, but are expected to be adapted to future climates at a site.

The second continuum relates to how sites are used by humans (Figure 2). Incorporating human activities as fundamental components of ecological restoration has increasingly been advocated by restoration practitioners (Dunwiddie 1992, Higgs 2003). We suggest that these usages should be explicitly articulated as cultural goals, and be considered in terms of their associated ecological impacts. Cultural goals may have relatively low ecological impacts, such as bird watching and management for aesthetic values, or may have high impacts, such as creation of novel species assemblages or some types of military training. In between these extremes again lie a plethora of alternatives that may include such things as Native American harvesting of plants, reintroduction of fire, and the preservation of rare species.

As we have defined them, these continua are not independent, orthogonal axes that mutually determine restoration space. Rather, they each provide a framework for viewing the range of human activities that might be carried out within natural areas, and which conceivably could be articulated as management goals. Viewing restoration alternatives along these continua does not make a decision regarding the goals for a site any less subjective; no choice is ecologically unambiguous or devoid of personal preference. But, we suggest that these continua may help clarify the

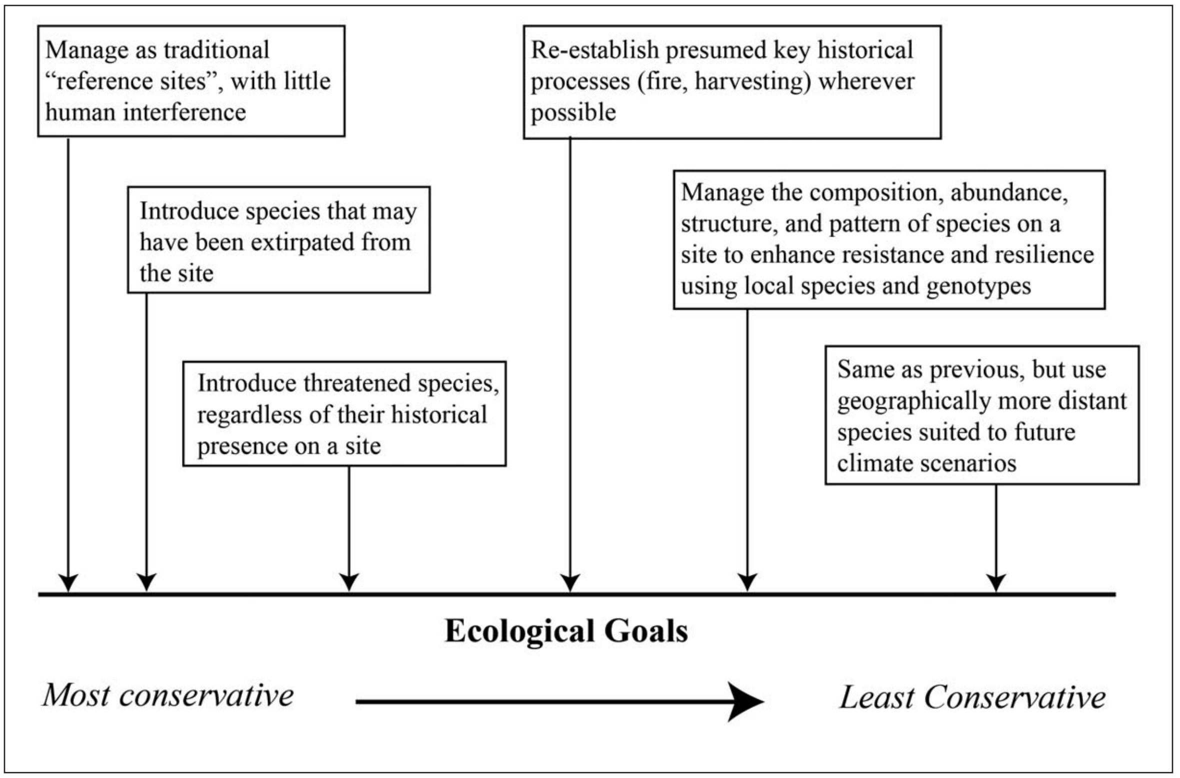

Figure 1. Examples of ecological site management goals along a continuum of management intensity.

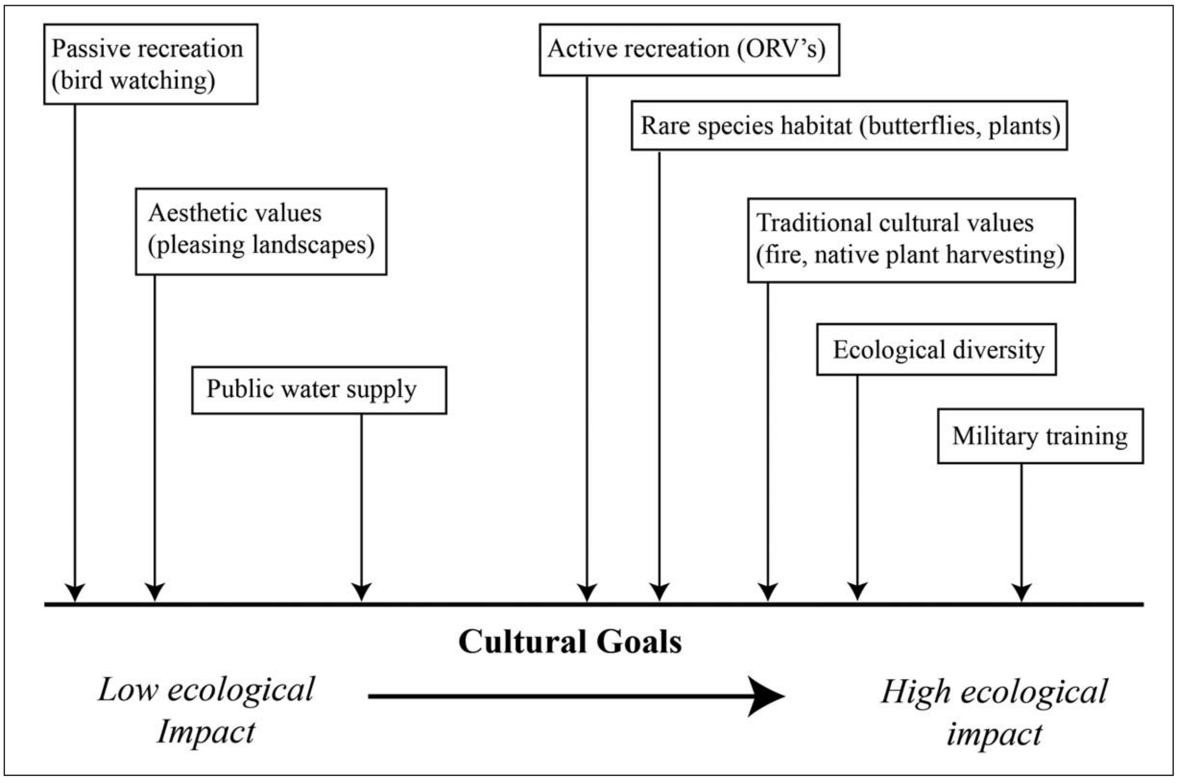

Figure 2. Examples of cultural site management goals along a continuum of ecological impacts

philosophical positions, management biases, and implicit assumptions that underlie the various choices. By doing so, they may help identify potential conflicts and contradictory goals.

Three examples may illustrate how using these continua can clarify decisions about restoration goals. First, imagine the creation of a new prairie ecosystem on a site that is currently forested. Options on the more conservative end of the ecological continuum would not even be possible at this site, yet the full range of cultural goals may be possible. Second, explicitly articulating a cultural goal of incorporating Native American harvesting would set a framework of appropriate site practices within which ecological goals could be defined and potential conflicts reconciled. Third, identifying a culturally defined goal of maximizing species diversity on a site would underscore potential incompatibilities with an ecological goal as an untouched, semi-pristine reference site.

Concluding Thoughts

The wide range of ecological conditions that prairie/oak ecosystems encompass is one of the reasons people are fascinated by this system. However, this variation also complicates the job of land managers in preserving native species and communities. Prairie/oak ecosystems have been harmed in the past and face daunting threats in the future. Thinking about actions in terms of management intensity (ecological goals) and ecological impact (cultural goals) may enhance on-the-ground success by highlighting both types of goals, thereby enabling managers to minimize conflicts among them. We conclude by suggesting some specific restoration and management principles that may help to further guide conservation action, and that point toward critical information needs for future research.

Restoration should be particularly directed towards retaining and enhancing native species diversity, habitat heterogeneity, and ecological functionality. Depending on the site and context, this may be achieved through actions that mimic historical processes and conditions, or that create novel conditions, processes, and assemblages. Given the spatial and temporal variability in these systems, however, we largely lack the capability to predict how these systems will respond to management actions. Research should be directed to enhancing our predictive capacity.

In general, it is preferable that restored systems be as self-sustaining and resilient as possible. However, processes such as fire, which is important for the survival of many species in this system, may have to be sustained through deliberate and ongoing intervention. Similarly, enhancing resiliency may at times require periods of greater intervention within systems. We need a better understanding of what it means for a prairie/oak ecosystem to be self-sustaining and resilient, both now and in the future.

While the focus of restoration must remain on preserving the native biota, this must be done with an eye toward a changing and uncertain future. Such uncertainty needs to be met with an open mind that considers alternative definitions of "native" and "indigenous." We need to consider and discuss the possibility that species that do not currently occur on a given site may be valuable components of future ecosystems.

Restoration and management must be carried out with species movements in mind, with attention paid towards landscape context, connectivity, and dispersal of organisms across fragmented habitats. We lack fine-scale distribution models that could describe such movements of plants and animals, particularly in a system like this with many intentional human activities.

Practitioners need to adopt more holistic views of restoration that embrace the often subtle interactions between flora and fauna on, above, and below ground, from genotypes to metapopulations, from the scale of microplots to landscapes. A greater understanding of these interactions must be interwoven with a similar knowledge of the complexities of community structure and ecological processes.

Over 180 years after David Douglas made his pioneering observations on the biota of this region, our understanding of the natural history of prairie/oak ecosystems remains incomplete. Even the most comprehensive restoration effort will only begin to address the status of restored vascular plants, a few of the more charismatic invertebrates, and the most easily recognized vertebrates. From toads to nematodes, uncertainties will remain. If we build it, will they come? If they come, will they survive without our assistance? Although we may not discover the answers to many of these questions, the spirit of inquiry that led Douglas to his first encounter with a Garry oak continues to motivate new generations, as evidenced by the papers in this Special Issue. Through these efforts, as well as the future work of both expert biologists and dedicated naturalists, we can ensure that oaks and camas lilies, checkerspot butterflies and bluebirds, will continue to thrive.

Acknowledgements

This Special Issue of *Northwest Science* would not have come together without the assistance and cooperation of numerous partners. We especially thank the Legacy program of the U.S. Department of Defense for providing funding that supported the Cascadia Prairie-Oak Partnership special session at the 2010 Northwest Scientific Association meeting, as well as production of this issue of *Northwest Science*. Particular thanks are also due to Hannah Anderson for her tremendous efforts to get CPOP up and running, and for her efforts, together with Pat Pringle, to organize the meeting. Rob Fimbel generously assisted as a special editor for several of the manuscripts. And of course, this could not have been accomplished without the efforts of the many authors, reviewers, and the overall editor, Jeff Duda, who worked to assemble and polish this collection of papers.

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Received 24 February 2011
Accepted for publication 21 April 2011

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