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Traditional and Local Ecological Knowledge About Forest Biodiversity in the Pacific Northwest

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Abstract

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This paper synthesizes the existing literature about traditional and local ecological knowledge relating to biodiversity in Pacific Northwest forests in order to assess what is needed to apply this knowledge to forest biodiversity conservation efforts. We address four topics: (1) views and values people have relating to biodiversity, (2) the resource use and management practices of local forest users and their effects on biodiversity, (3) methods and models for integrating traditional and local ecological knowledge into biodiversity conservation on public and private lands, and (4) challenges to applying traditional and local ecological knowledge for biodiversity conservation. We focus on the ecological knowledge of three groups who inhabit the region: American Indians, family forest owners, and commercial nontimber forest product (NTFP) harvesters.

Integrating traditional and local ecological knowledge into forest biodiversity conservation is most likely to be successful if the knowledge holders are directly engaged with forest managers and western scientists in on-the-ground projects in which interaction and knowledge sharing occur. Three things important to the success of such efforts are understanding the communication styles of knowledge holders, establishing a foundation of trust to work from, and identifying mutual benefits from knowledge sharing that create an incentive to collaborate for biodiversity conservation. Although several promising models exist for how to integrate traditional and local ecological knowledge into forest management, a number of social, economic, and policy constraints have prevented this knowledge from flourishing and being applied. These constraints should be addressed alongside any strategy for knowledge integration.

Keywords: Traditional ecological knowledge, forest management, biodiversity conservation, American Indians, family forest owners, nontimber forest product harvesters, Pacific Northwest.

Summary

In 2004, the U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station launched a Biodiversity Initiative to provide information tools and products to help resource managers in Oregon and Washington address management challenges relating to biodiversity conservation in the region's forests (Molina and White 2007). Stakeholders who are clients of this information expressed an interest in learning more about traditional ecological knowledge and how it might be integrated into forest biodiversity conservation (Nelson et al. 2006). This report is a response to that request.

The report synthesizes the existing literature on traditional and local ecological knowledge (TEK and LEK) pertaining to biodiversity conservation in Pacific Northwest forests for forest practitioners (people with strong social, cultural, and economic ties to forests) belonging to three groups that inhabit the region: American Indians, family forest owners, and commercial nontimber forest product (NTFP) harvesters. We focus on Washington, Oregon, and northern California, but our findings are broadly applicable for integrating TEK and LEK into biodiversity conservation elsewhere.

The report addresses four topics that we believe are relevant for forest biodiversity conservation. First we consider the views and values people have relating to biodiversity, and how they intersect with western scientific concepts of biodiversity. Second, we examine the resource use and management practices of local forest users, and their effects on forest biodiversity. Third, we explore how TEK and LEK can be shared and integrated into biodiversity conservation efforts. Finally, we discuss challenges associated with using TEK and LEK for forest biodiversity conservation, and how they might be overcome.

American Indians

According to the literature, people and the biophysical world are viewed by American Indians as being interconnected and forming part of one integrated system in which each thing (e.g., plant, animal, mineral) affects everything else. Generally speaking, it is important to maintain the balance of the system. The spiritual and sacred values associated with forests are also held to be extremely important, and there is a belief in respecting and caring for the natural world. Many American Indians view active manipulation as necessary for maintaining the ecological integrity of forests.

Most of the literature about American Indian TEK relating to forest management in the Pacific Northwest characterizes how they managed forest resources

in prehistoric and historical times. Fire was an environmental management tool commonly used by indigenous peoples in California and the Pacific Northwest in the past, although not all tribes used fire and not all environments were shaped by it (Blackburn and Anderson 1993, Boyd 1999a, Gottesfeld 1994). The most common use of fire prehistorically and historically related to food production. Fire was used for other purposes as well, such as increasing the abundance and quality of materials used in basketry. Today, burning by American Indians occurs on a much reduced scale, for example in collaboration with federal land managers trying to reintroduce prescribed fire into the landscape (Anderson 2005).

Other techniques used to enhance desirable plant species included planting or broadcasting seeds; transplanting bulbs and other propagules, shrubs, and small trees to make them more abundant and accessible; modifying soils and digging to enhance the growth of root vegetables; removing undesirable plants that competed with valued plants; selective harvesting; pruning or coppicing berry bushes and other shrubs to enhance their productivity and to encourage certain patterns of growth; pruning trees and shrubs near desired plants to reduce competition; rotating harvesting locations; and diverting water for irrigation and to reduce erosion (Anderson 2005, Blackburn and Anderson 1993, Deur and Turner 2005b). Although such practices are not as widespread today, many of them persist on a much reduced scale (Anderson 2005, Deur and Turner 2005b, Senos et al. 2006).

By regulating the size, intensity, frequency, and location of anthropogenic disturbances, American Indians and Canadian First Nations are believed to have manipulated biodiversity (Peacock and Turner 2000). Burning practices of Indians influenced forest composition, and the distribution and abundance of many tree and shrub species (Kimmerer and Lake 2001). These practices set back succession and promoted habitat heterogeneity by maintaining mosaics of vegetation types in different stages of succession. Burning and other vegetation management practices also multiplied the presence of ecotones (Turner et al. 2003). Several researchers believe that habitat and species diversity were maintained as a result.

It is unclear from the literature what role TEK and LEK have played in Indian forest management for timber production. The federal government has dominated Indian forestry since its inception. Nevertheless, there has been a major transition over the past decade from U.S. Department of the Interior, Bureau of Indian Affairs (BIA) to tribal control of, and responsibility for, forest management. According to the Indian Forest Management Assessment Team (IFMAT 2003), American Indian groups having a greater degree of control have forests and forest management practices that are better aligned with their own management goals and values.

One of the biggest challenges to applying the TEK of American Indians to forest biodiversity conservation is the fact that this knowledge is rapidly eroding. Loss of access to traditional land and resource use areas and the prohibition of traditional forest management practices assumed to be destructive (like burning) have reduced opportunities to implement TEK (Anderson 2005). Ecological change resulting from the cessation of traditional forest management practices, habitat conversion, commercial timber production, and grazing have meant that the forest resources upon which many social, economic, and cultural practices were based have declined (Anderson 2005, Deur and Turner 2005b, London 2002). As forest resources, access to them, and rights to manage them diminish, so does the TEK associated with these resources.

We identified four models of knowledge integration from the literature on American Indian TEK that are currently being implemented: collaborative species-specific management, co-management for landscape-scale ecological restoration, integrated scientific panels, and formal institutional liaisons.

Family Forest Owners

Family forest owners are private individuals and families who own forest land but do not own wood processing infrastructure (Birch 1996). Our understanding of family forest owners' views of biodiversity in the Pacific Northwest is sparse. There are a few studies that explore Pacific Northwest owners' views on topics that can be considered surrogates for biodiversity—for example, wildlife habitat, forest health, riparian quality, and ecosystem management. These and studies conducted elsewhere in the United States suggest that family forest owners are aware of aspects of biodiversity—including species diversity, structural diversity, ecological time scales, and landscape context—and may be predisposed to developing LEK. It is important to understand the context of owners' LEK; owners that manage production forests may operate with different assumptions about biodiversity than owners managing for mature native forests that provide aesthetic enjoyment.

As with American Indians, family forest owners do not believe that management interferes with the "naturalness" of their forests; rather, they believe their forests are better off because of their interventions. Family forest owners use their LEK to manage biodiversity in several ways. They experiment with planting patterns to foster favored wildlife species and view qualities and to explore new species arrangements. For many, diversity indicates a healthy forest. To achieve this diversity, they cultivate a variety of native species in addition to the primary commercial species on their tree farms (Fischer and Bliss 2006a, 2006b). Owners are also known to set aside stands of hardwoods, brushy areas, and wide riparian corridors instead of converting them to plantations (Dutcher et al. 2004, Fischer and Bliss 2006a, Jacobson 2002a). In Oregon, some owners have used prescribed fire to reduce fuels and control invasive species, mimicking historical disturbance processes (Fischer 2005, Stanfield et al. 2003). Although little research has been done on the direct impacts of family forestry on biodiversity, one landscape analysis conducted in Oregon suggests that family forest owners may maintain forest habitat diversity (Stanfield et al. 2003).

Few prominent examples of cooperation between family forest owners, scientists, and other land managers exist to serve as models for integrating their LEK in biodiversity conservation efforts (Knight and Landres 1998, Rickenbach and Reed 2002). Although recent research suggests that cooperatives may provide an appropriate infrastructure for cooperation based on owners' values (Campbell and Kittredge 1996; Rickenbach et al. 2005, 2006), it is too early to tell whether they could serve as models for knowledge integration because factors underlying owners' decisions to participate are still not well understood. Family forest interest groups currently serve as forums for cooperation and knowledge-sharing among family forest owners. Watershed councils have brought owners, scientists, environmentalists, and other public and private land managers together in ecosystem management efforts. Conservation efforts facilitated by land grant university extension programs hold the potential to serve as models for cooperation and sharing LEK.

Tenure security among family forest owners provides an opportunity for them to develop and apply experiential knowledge by experimenting with different practices and conditions in their forests. Nevertheless, family forest owners are subject to regulations and policy requirements, and are the targets of mixed messages about how they should be managing their forests (Sampson and DeCoster 1997), which affect their ability to use LEK. Their management practices are also influenced by the economic context in which they operate. It must be recognized that although family forest owners are motivated to conserve biodiversity, they do so at the expense of other land uses, and risk incurring future regulatory restrictions. As a result, compensation—such as payments for ecosystem services—and policy protections may be important.

Nontimber Forest Product Harvesters

There is little literature that documents commercial NTFP harvester views of biodiversity, and not many commercial harvesters use the term. The general attitude among many harvesters is that more species richness and abundance is better when it comes to commercial needs (Jones et al. 2004). Often the household economy of commercial harvesters includes the harvest of a diversity of NTFPs (Emery 2001).

Thus, harvesters have a vested interest in diversity and view managing forests to support a diversity of NTFP species as important.

Commercial harvesters have an economic incentive to investigate, understand, and practice sustainable harvesting (Jones and Lynch 2002, Love and Jones 2001). There is clearly a strong interest among many harvesters in learning about how resource stewardship can sustain their livelihoods. Many harvesters attempt to steward the resources they harvest through behaviors such as (1) engaging in productivity experiments by trying different harvest techniques, spreading seeds and relocating plants, and watering; (2) monitoring environmental change through observation, writing, photography, mapping, and videotaping; (3) treading lightly in harvest areas; and (4) imposing harvest level restrictions on themselves (Jones and Lynch 2002, Love et al. 1998).

Very few studies have been conducted on the ecological effects of commercial NTFP harvest practices. Harvesting is nonmechanized for most NTFPs, and is generally considered low impact for many species. An exception might be mosses, some of which have longer regeneration rates than most other NTFP species (Peck 2006). Nonetheless, unlike nearly all forms of timber extraction, NTFP extraction impacts are often confined to the species being harvested, with seemingly low impact to other elements of the ecosystem. Thus, commercial NTFP harvest activities at a minimum are apt to maintain species richness of target species at the local level, and some management practices—such as productivity experiments—may increase it.

Harvesters are highly dependent on federal and state lands and large private lands, although it is difficult to negotiate access to the latter. Consequently, harvesters are limited in how much they are allowed to manage, and how much experimentation they can conduct on lands they do not own. With insecure tenure, the management practices they do implement may be rendered ineffective by others who also harvest NTFPs in the same locations.

There has been little research on how harvesters acquire and share LEK. With few written guides and virtually no formal training, harvesters have had to figure out where to harvest, what the optimal harvesting times are, what quantities can be removed sustainably, and what techniques to employ. It is clear that harvesters are having contact with one another in many ways, but it is unclear what level of information exchange takes place and how this affects harvest practices. In the last decade, a movement has begun to promote more participatory approaches in forestry. In participatory research and monitoring, western scientists, land managers, and harvesters work together to gather data about NTFPs and their ecological relationships, and management impacts on them. The participants offer their own interpretations of the data, theories relating to findings and trends, and management solutions. Through direct interaction in the research and monitoring process, LEK is shared and integrated into forest management. Participatory research and monitoring projects hold promise as models for knowledge sharing and integration between commercial NTFP harvesters and others.

Key Findings

- Many different people use and manage forests—be it on private lands they own or have access to, reservation lands, or public lands. It is worth identifying who is actively engaged in local forest use and investigating the ecological knowledge they hold.
- Different groups conceptualize biodiversity differently. There are some areas of overlap, however, between western forest managers' notions of biodiversity and those of American Indians, family forest owners, and NTFP harvesters. For example, all of the groups studied appear to favor forest management to support species/population and community/ecosystem-level diversity, and the composition dimension of biodiversity, although the composition desired by each group differs depending on what they value. In addition, all care about and have an interest in forest conservation.
- American Indians, family forest owners, and NTFP harvesters are applying TEK and LEK as they use and manage Pacific Northwest forests. The extent of this knowledge and its use is not well known, however, because research documenting their contemporary forest management practices is limited. Even more limited is documentation of the ecological outcomes of these practices, which are often assumed to maintain biodiversity despite a lack of scientific evidence, and without careful scrutiny of issues like scale and which components of biodiversity are being maintained (e.g., ecosystem structure, function, and composition; genes, populations, species, communities, ecosystems). Although the causal relationship between culturally-diverse forest management practices and biodiversity may well be a positive one, this relationship has not yet been adequately assessed in the Pacific Northwest.
- Regarding the application of TEK and LEK to biodiversity conservation efforts, what most of the models described here share in common is an approach that actively engages forest practitioners, western scientists, and forest managers in on-the-ground projects that encourage interaction and knowledge sharing in the process of identifying goals, designing approaches, and implementing projects for forest management to conserve

biodiversity. Knowledge sharing may occur in formal or informal ways, but by working together and sharing ideas, management approaches emerge that integrate different forms of knowledge. Two things needed to make such efforts successful are understanding the communication and operating styles of the people that hold TEK and LEK, and establishing a foundation of trust to work from.

- TEK and LEK persist, develop, and flourish through application. Yet many knowledge holders lack access to and some control over forest resources, or face economic and policy constraints that inhibit their use. Thus, serious efforts to integrate other knowledge systems for biodiversity conservation must address the fundamental structural issues—such as land tenure, the imposition of unfavorable forest management practices and policies, and market conditions—that threaten to undermine the viability of these knowledge systems and their implementation in diverse forest landscapes.
- It is important to assess how well the kinds of models for integrating TEK and LEK into forest management discussed here are working, and to continue experimenting with new models, being sensitive to which are best suited for different groups. Few models and examples exist for groups other than American Indians, and those described in the literature lack assessments of how well TEK and LEK were actually integrated in forest management; what made for success or lack thereof in knowledge sharing and application; and what difference including TEK and LEK made on the ground.
- Knowledge integration is impossible unless forest practitioners are willing to share their knowledge with western scientists and forest managers. They are unlikely to do so unless it is in their interest; thus, identifying incentives for, and mutual benefits from, knowledge sharing are important.
- Research to improve understanding and documentation of TEK and LEK for forest management is needed for the three groups discussed in this paper, as well as others. Such research should do more than describe ecological knowledge systems; it should examine how this knowledge is being actively implemented and with what ecological outcomes. Equally important is to expand efforts to engage local forest practitioners in joint forest management, for it is through practical application that this knowledge emerges and comes to life, and can be shared in an ongoing, interactive, and meaningful way.

Contents

Introduction

The potential for traditional and local ecological knowledge (TEK and LEK) to contribute to biodiversity conservation has been widely recognized. For example, at the international level, Article 8(j) of the United Nations Convention on Biological Diversity states that the knowledge and practices of indigenous and local communities that are relevant for the conservation and sustainable use of biodiversity should be respected, preserved, and applied. At the local level, in 2004 the U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station launched a Biodiversity Initiative to provide information tools and products to help resource managers in Oregon and Washington address management challenges relating to biodiversity conservation in the region's forests (Molina and White 2007). Stakeholders who are clients of this information expressed an interest in learning more about TEK and how it might be integrated into forest biodiversity conservation (Nelson et al. 2006). This report is a response to that request.

The report synthesizes the existing literature on TEK and LEK pertaining to biodiversity conservation in Pacific Northwest forests for three groups who inhabit the region: American Indians, family forest owners, and commercial nontimber forest product (NTFP) harvesters. American Indian peoples have lived in the Pacific Northwest the longest and have developed a rich body of TEK as a result, some of which has been documented. Family forest owners—whose parcels typically change hands every 10 to 49 years (Butler 2006)—are likely to develop LEK about their forest lands regardless of the length of their tenure. Commercial NTFP harvesters make at least part of their living from forests and consequently spend considerable time there. As a result, they too develop LEK. This literature synthesis focuses on Washington, Oregon, and northern California, but our findings are broadly applicable for integrating TEK and LEK into biodiversity conservation elsewhere.

We focus on four topics that we believe are relevant for forest biodiversity conservation. First we consider the views and values people have relating to biodiversity, and how they intersect with western scientific concepts of biodiversity. Second, we examine the resource use and management practices of local forest users, and their effects on forest biodiversity. Third, we explore how TEK and LEK can be shared and integrated into biodiversity conservation efforts. Finally, we discuss challenges associated with using TEK and LEK for forest biodiversity conservation and how they might be overcome. Our hope is that by synthesizing this information and making it more accessible, it will be easier for those who use and manage forests to collaborate in biodiversity conservation across ownerships and landscapes, and to draw on and integrate the knowledge of others.

Definitions

Many definitions of biodiversity exist in the literature. The definition adopted here follows Marcot (2007) and is based on Noss's (1990) conceptual framework. That framework incorporates three biological levels of organization—genes, populations/species, and communities/ecosystems—and three dimensions: composition, structure, and function. But biodiversity may be perceived and conceptualized differently by different people. These different views have implications for biodiversity conservation efforts, and we examine them here.

Traditional ecological knowledge can be defined as a cumulative body of knowledge about the relationships living things (including people) have with each other and with their environment, that is handed down across generations through cultural transmission.

Traditional ecological knowledge can be defined as a cumulative body of knowledge about the relationships living things (including people) have with each other and with their environment, that is handed down across generations through cultural transmission (Berkes 1999). Traditional ecological knowledge is a more-or-less integrated system of knowledge, practices, and beliefs. It is dynamic and evolves as people build on their experiences and observations, experiment, interact with other knowledge systems, and adapt to changing environmental conditions over time. Traditional ecological knowledge is grounded in place, and is most often found among societies that have engaged in natural resource use in a particular place over a long period, such as indigenous or traditional peoples (Berkes 1999).

However, new knowledge is created all the time. This more recent LEK is defined here as knowledge, practices, and beliefs regarding ecological relationships that are gained through extensive personal observation of and interaction with local ecosystems, and shared among local resource users. Local ecological knowledge may eventually become TEK. In this paper we discuss both TEK and LEK, recognizing that peoples' ecological knowledge can have value for biodiversity conservation whether it was developed over a decade or over millennia.

Local ecological knowledge is defined here as knowledge, practices, and beliefs regarding ecological relationships that are gained through extensive personal observation of and interaction with local ecosystems, and shared among local resource users.

There is a debate in the literature about what makes TEK and LEK different from western scientific knowledge, and whether the criteria used to distinguish them are valid (Agrawal 1995, Ellen and Harris 2000). We agree that separating "traditional" from "western scientific" knowledge creates a false dichotomy, but recognize some general distinguishing characteristics. Western scientific knowledge tends to be driven by theoretical models and hypothesis testing, and generated using the scientific method; not necessarily utilitarian; often generalizable and not always local; generated by research institutions; and documented and widely disseminated in written form. Traditional and local ecological knowledge tend to be driven by a desire for utilitarian information that will help people survive and maintain a natural resource-based livelihood; generated through practical experience with the natural world in the course of everyday life; locally based and specific; and transmitted orally or through demonstration (less true for commercial harvesters) (Ellen and Harris 2000).

We use the term "forest practitioners" in referring to the people whose ecological knowledge we discuss here. By forest practitioners we mean people who spend time in forests and derive a portion of their economic livelihood from them, have social or cultural ties to forests, operate at a small, nonindustrial scale, and hold TEK or LEK about the forests they spend time in. Not all American Indians, family forest owners, and commercial NTFP harvesters can be considered forest practitioners given this definition, and the depth of TEK and LEK held by individual practitioners differs, as do their individual behaviors. Forest practitioners also possess varying degrees of western scientific knowledge; these knowledge systems are not mutually exclusive. Furthermore, there is a great deal of cultural diversity within the three groups. In the interest of covering three groups we do not examine variation within them, but rather speak in general terms about them. Finally, there is some overlap between groups. For example, American Indians and family forest owners may also be NTFP harvesters; and American Indians may be family forest owners. Forest practitioners also belong to other forest user groups in the Pacific Northwest, such as loggers and tree planters. We focus on American Indians, commercial NTFP harvesters, and family forest owners because we found the most literature about them.

The Relevance of Traditional and Local Ecological Knowledge for Biodiversity Conservation

Why consider TEK and LEK in biodiversity conservation efforts? Forest practitioners spend a great deal of time in forests observing, experiencing, experimenting, working, and tinkering. In the process, they learn things that could be of value to western scientists and other forest managers; they are a potential source of experimental, anecdotal, and/or observational data on forest ecosystems. A main proposal of this report is that partnerships in which forest practitioners, western scientists, and forest managers share their knowledge are likely to provide a better understanding of the natural environment and how to conserve biodiversity than these groups could achieve alone.

Partnerships in which forest practitioners, western scientists, and forest managers share their knowledge are likely to provide a better understanding of the natural environment and how to conserve biodiversity than these groups could achieve alone.

Another reason to consider TEK and LEK in biodiversity conservation stems from the observation that commercial timber production on private industrial and public lands in the Pacific Northwest—based on western science, belief, and value systems—have emphasized the production of a small number of commercially valuable species on short rotations in plantations using even-age management techniques, with negative effects on the structure, composition, and function of forest ecosystems (Carey 2006, Wilson and Puettmann 2007). In contrast, many forest practitioners have an interest in managing forests for a broad set of species and values, often with an emphasis on the forest understory or on ecosystem services. For example, over 200 species of NTFPs are known to be harvested on private and public lands in the region (Alexander and Fight 2003), and this number could be much higher because 370 commercial NTFP species are known to occur in Oregon alone (Weigand 2006). Indigenous peoples of the Pacific Northwest coast traditionally used about 300 plant species for food, medicine, materials, and other purposes, and some of these uses persist today (Deur and Turner 2005b). And, family forest owners are known to manage their forests for a diversity of values. Forest management for a diversity of products, uses, and values is more likely to maintain biodiversity than forest management for commercial timber production based on short rotations and a small number of species (Carey 2006, Carnus et al. 2006).

Since the 1990s, there has been a surge of interest in ecological restoration in the Pacific Northwest (Apostol and Sinclair 2006). Some land managers have called for restoring forests to the conditions that prevailed prior to European settlement, or to conditions and processes within their historical range of variability (Apostol 2006, Kenna et al. 1999). The forests encountered by early nonnative settlers were shaped by both biological and cultural forces over thousands of years; they were not “wilderness” (Anderson 2005; Deur and Turner 2005a, 2005b; Maffi 2004). If presettlement forests are the reference ecosystems that are the goal of restoration and biodiversity conservation, understanding how past forest use and management practices based on TEK influenced biodiversity in forest ecosystems could provide valuable information about how to re-create these reference ecosystems today (Anderson 2005, Kimmerer 2000).

Traditional and local ecological knowledge emerge through processes of cultural adaptation to the environment. It is in the self-interest of forest practitioners to use resources sustainably to ensure their long-term survival in specific locations. Numerous resource use and management practices based on TEK and LEK that contribute to conservation—either intentionally or unintentionally—have been documented from around the world (Anderson 2005; Berkes et al. 1994, 2000; Carlson and Maffi 2004; Minnis and Elisens 2000; Peacock and Turner 2000). And there is a notable geographic overlap between the world’s biological and cultural diversity “hotspots” (Maffi 2005). Learning if and how TEK and LEK maintain and restore forest biodiversity can contribute to biodiversity conservation efforts.

Forest practitioners work with and shape biodiversity. Their forest use and management practices may have significant effects because they use and/or control substantial areas of forest land. Family forest owners own roughly one-fifth of all forest land in the Pacific Northwest, much of it in low-elevation areas that provide important habitat not often protected as part of public lands, which lie mostly at higher elevations (Creighton et al. 2002, Johnson et al. 1999). Indian lands cover nearly 1.6 million hectares (4 million acres) in Washington, Oregon, and California (USDA FS 1997), and many western tribes have off-reservation rights reserved by treaty to use and harvest on federal forest lands at customary locations. Commercial NTFP harvesters make extensive use of public lands and large private forest lands. To be successful at conserving forest biodiversity, it is necessary to work at large scales and across ownerships with those whose activities influence it.

To be successful at conserving forest biodiversity, it is necessary to work at large scales and across ownerships with those whose activities influence it.

Report Organization

This report has four main sections. The first three sections focus on American Indians, family forest owners, and NTFP harvesters, respectively. For each group, in turn, we discuss views of biodiversity, forest management practices and their ecological effects, models for knowledge integration, and challenges to applying TEK and LEK to biodiversity conservation. We conclude by presenting our findings from this synthesis about how to integrate TEK and LEK into forest biodiversity conservation more effectively.

Traditional Ecological Knowledge of American Indians

According to U.S. census figures, the American Indian population of Washington, Oregon, and California totaled 471,858 in 2000 (93,301 in Washington, 45,211 in Oregon, and 333,346 in California), or between 1.0 and 1.6 percent of the population of each state. There are 28 federally recognized tribes in Washington, 10 in Oregon, and 107 in California (USDI BIA 2005). Tribal landholdings range widely in size. In the mid-1800s, American Indians in California were unable to gain control of large reservation lands, and as a result many California tribes either lack land or control small rancherias, most of which are 121 hectares (300 acres) or less (Anderson 2005).[1] This situation makes American Indians in California more dependent on public or private lands for natural resources than on tribal land holdings.

In contrast, some of the largest reservations in the United States are located in Washington and Oregon. For example, the Yakama reservation in Washington is 457 411 hectares (1,130,262 acres) in size, and the Warm Springs reservation in Oregon is 260 417 hectares (643,491 acres) (USDA FS 1997). Reservation lands

[1] There are exceptions, however, such as the Hoopa Valley Reservation (36 349 hectares or 89,572 acres) and the Yurok Reservation (25 510 hectares or 63,035 acres) in northern California.

include a combination of tribal trust lands (land held collectively by tribes for which the Secretary of the Interior has a trust responsibility to manage for their benefit); allotted lands (reservation lands divided into individual parcels of 160 or 80 acres [65 to 32 hectares] and allotted to individual tribal members under the General Allotment Act of 1887, over which the Secretary of the Interior has trust responsibility); and U.S. Department of the Interior, Bureau of Indian Affairs (BIA)-owned lands (lands within reservations reserved by the federal government for schools, agency buildings, etc.). Although the majority of reservation lands in the Pacific Northwest and California are tribal trust lands, substantial acreage is also held under individual allotments, which poses challenges for forest management.

In addition, many tribes have off-reservation treaty ceded rights to federal forest lands and natural resources occurring there. These rights may include grazing rights, hunting and fishing rights, gathering rights and interests, water rights, and subsistence rights (USDA FS 1997). Treaty rights may also pertain to how natural resources are managed on federal forests.

Views of Biodiversity

Little has been published about how American Indians in the Pacific Northwest perceive biodiversity or identify it as a value to be managed for. Kimmerer (2000) characterized American Indian views of biodiversity as encompassing not just species diversity, but the web of reciprocal relations that exist between the community of human and nonhuman beings, including their spiritual consciousness. There is a larger body of information on American Indian views of the natural world. According to this literature, people and the biophysical world are viewed as being interconnected and forming part of one integrated system in which each thing (e.g., plant, animal, mineral) affects everything else. Generally speaking, it is important to maintain the balance of the system. This perspective is similar in several respects to systems theory in modern ecology (Pierotti and Wildcat 2000). In addition, the spiritual and sacred values associated with forests are held to be extremely important, and there is a belief in respecting and caring for the natural world.

For example, a nationwide analysis of news articles about natural resource management written by American Indians and published in American Indian newspapers and magazines revealed an emphasis on the spiritual and sacred values of forests (Bengston 2004). It also found a holistic, ecosystem-based view of how forests should be managed that has long prevailed, and that is consistent with the ecosystems approach to forest management that emerged in the 1990s. Another study of land ethics held by a sample of American Indians that included some tribes from the Pacific Northwest identified four main belief areas: (1) everything is sacred and has a spiritual dimension; (2) all living and nonliving things are interconnected and affect each other; (3) the Earth is like a mother, providing the gift of life and creation, and should be respected, thanked, and cared for; and (4) people should act in ways that maintain the balance of the system (Jostad et al. 1996). In addition to a systemic view of nature, the view of active human manipulation as necessary for maintaining the ecological integrity of forests is held by many American Indians. For example, the idea that human use of plants ensures their abundance and quality is pervasive, creating a reciprocal relationship between plants and people (Anderson 1993, 2005). In many cases there is a related belief that natural resources should be used or they might not return (Jostad et al. 1996). Sustainable use is a way of honoring the Earth's gifts; if these gifts are not used, they might not be offered again.

Forest Management Practices and Their Ecological Effects

The importance of forest resources to the economy and culture of American Indians is emphasized throughout the literature on American Indian forest management and TEK. This literature falls into three general categories discussed here. The first category consists of ethnoecological research; the second documents forest management practices for a wide range of species that have cultural and economic uses, and to some extent, their ecological effects; and the third pertains specifically to forest management for timber production.

Ethnoecology—

Ethnoecological research investigates topics such as which plants and animals indigenous peoples used prehistorically, historically, and today, and for what purposes; people's knowledge about the natural history of these species; native names for species; descriptions of the plants and animals used and the habitats in which they occur; how they were prepared; and beliefs, rituals, stories, and songs associated with each species (see for example, Marles et al. 2000; Minnis 2004; Turner 1980, 1995, 1998). The plants and animals described include those used for food, medicine, materials, and religious purposes. American Indians and Canadian First Nations who lived along the Pacific Northwest coast used roughly 300 plant species (Deur and Turner 2005b). Hundreds to thousands of plant species occurred within each California Indian tribal territory, and many of these species had a use (Anderson 2005). It is undocumented, however, how many species are still used by Pacific Northwest tribes today.

One important purpose of ethnoecological research is to document what species were used and how by indigenous peoples so that this knowledge is not lost. Ethnoecological information provides a window into the cultural heritage, classification systems, and identity of indigenous peoples. It has also been used to explore the potential for developing commercial uses of plants, a possible economic development and diversification strategy for indigenous communities. With regard to biodiversity conservation, ethnoecological information reveals which forest species were and are important to indigenous peoples, and their role in supporting different cultural practices. This information can be used to identify what species should be protected and restored to facilitate the continuation of these practices. Ethnoecological research does not, by itself, reveal how people's use and management of plant and animal species affects biodiversity, but it does indicate which species were likely favored through forest management practices.

Forest management practices—

The second category of literature about American Indian TEK relating to forest management in the Pacific Northwest characterizes how they managed forest resources in prehistoric and historical times. Although there is also information on contemporary forest management practices, this is much more sparse. The same is true for Canadian First Nations, for whom a fair amount of literature is also available. Authors who write about these past practices believe that they did maintain some components of biodiversity (Anderson 2005; Boyd 1999a, 1999b; Deur and Turner 2005a, 2005b; Peacock and Turner 2000; Turner et al. 2003). Moreover, some assert that biodiversity was dependent on active environmental management by indigenous peoples, and has declined locally with the disappearance of indigenous management practices (Anderson 2005, Peacock and Turner 2000).

Fire was an environmental management tool commonly used by indigenous peoples in California and the Pacific Northwest in the past, although not all tribes used fire and not all environments were shaped by it (Blackburn and Anderson 1993, Boyd 1999a, Gottesfeld 1994). There is substantial historical and ethnographic evidence that prescribed fire was widespread in historical and prehistoric times, but there is little physical evidence of past anthropogenic fire (Lepofsky 2004). Burning was not limited to California and the Pacific Northwest; indigenous peoples throughout the United States used fire to manipulate and manage the environment (Stewart et al. 2002, Vale 2002, Williams 2003).

The most common use of fire prehistorically and historically related to food production. Burning disrupted forest succession and reduced the dominance of coniferous forests (which were relatively poor in food plant species), maintaining open habitat (such as prairie in coastal forests) where desirable food plants grew (Kimmerer and Lake 2001). It also created a mosaic of habitat patches in different successional stages, which increased food security by enhancing the diversity of food resources, and creating a buffer against fluctuations in the abundance of individual food species. Burning also increased the abundance and productivity of food plants such as camas (*Camassia* spp. Lindl.), other bulb and root species, and berries, such as huckleberries (*Vaccinium* spp.) (Boyd 1999b, Gottesfeld 1994). Fire controlled insects and diseases that damaged important foods like acorns (Anderson 2005, Boyd 1999b, Peacock and Turner 2000). In addition, game such as elk and deer were drawn to burned areas for forage, improving hunting opportunities. Fire was also used to drive game animals during a hunt, for gathering grasshoppers, and for improving access to hunting areas (Boyd 1999b, Stewart et al. 2002).

American Indians and First Nations used fire for other purposes as well. For example, burning increased the abundance and quality of materials used in basketry, such as beargrass (*Xerophyllum tenax* (Pursh) Nutt.), willow (*Salix* spp. L.), hazel (*Corylus cornuta* Marsh.), and redbud (*Cercis occidentalis* L.) (Anderson 1993, Boyd 1999b, Ortiz 1993). Straight rhizomes and stems without lateral branching are preferable for basketmaking, and burning enhances these features (Anderson 1993). Burning also prevented the accumulation of fuel that could lead to catastrophic fires, and was done to create fuel breaks (Boyd 1999b, Stewart et al. 2002).

By the early 1900s, anthropogenic fire had virtually disappeared from the forests of the Western Untied States because nonnative settlers believed it was destructive and unsafe, and policies enforced its suppression (Kimmerer and Lake 2001). Today, burning by Native Americans occurs on a much reduced scale, for example in collaboration with federal land managers trying to reintroduce prescribed fire into the landscape (Anderson 2005).

Burning was not the only forest management practice indigenous peoples employed in the Pacific Northwest. Other techniques they used to enhance desirable plant species included planting or broadcasting seeds; transplanting bulbs and other propagules, shrubs, and small trees to make them more abundant and accessible; modifying soils and digging to enhance the growth of root vegetables; removing undesirable plants that competed with valued plants; selective harvesting; pruning or coppicing berry bushes and other shrubs to enhance their productivity and to encourage certain patterns of growth; pruning trees and shrubs near desired plants to reduce competition; rotating harvesting locations; and diverting water for irrigation and to reduce erosion (Anderson 2005, Blackburn and Anderson 1993, Deur and Turner 2005b). Although such practices are not as widespread today, many of them persist on a much reduced scale (Anderson 2005, Deur and Turner 2005b, Senos et al. 2006).

By regulating the size, intensity, frequency, and location of anthropogenic disturbances, American Indians and Canadian First Nations are believed to have manipulated biodiversity.

By regulating the size, intensity, frequency, and location of anthropogenic disturbances, American Indians and Canadian First Nations are believed to have manipulated biodiversity (Peacock and Turner 2000). Burning practices by American Indians influenced forest composition, and the distribution and abundance of many tree and shrub species (Kimmerer and Lake 2001). These practices set back succession and promoted habitat heterogeneity by maintaining mosaics of vegetation types in different stages of succession. Burning and other vegetation management practices also multiplied the presence of ecotones (Turner et al. 2003). Several researchers believe that habitat and species diversity were maintained as a result (Anderson 2005; Boyd 1999a, 1999b; Deur and Turner 2005a, 2005b; Peacock and Turner 2000; Turner et al. 2003). Others note that the effects of indigenous burning must be understood within the context of how climate and natural disturbance processes affected vegetation conditions, which may not be distinguishable, at least for prehistoric times (Whitlock and Knox 2002).

Timber management—

The third category of literature regarding forest management by American Indians in the Pacific Northwest focuses on historical and contemporary timber management practices. Commercial timber production by American Indians is a relatively recent phenomenon. Although trees were used for materials and construction in historical and prehistoric times, commercial timber production did not take hold on Indian lands until the late 1800s (McQuillan 2001). Since the General Allotment Act of 1887, the BIA has had trust responsibility for the management of Indian lands, and has been responsible for protecting Indian forests. The BIA interpreted this responsibility to mean that it should prevent logging there, except where needed to clear land for agriculture or obtain wood for personal use (e.g., building purposes) (McQuillan 2001).

Demand for lumber was high in the early 1900s, however (McQuillan 2001). Therefore, in 1910, an act was passed that allowed regulated timber sales from Indian lands following principles of sustained yield, using selective logging practices (rather than clearcuts). The Indian Reorganization Act of 1934 mandated that Indian forest lands be managed according to principles of sustained yield. However, selective logging was not practical in the Pacific Northwest at the time, and by the end of World War II the main harvest method was to clearcut small blocks of forest roughly 16 hectares (40 acres) in size in a checkerboard pattern that enabled natural reseeding and regeneration to take place. By the late 1950s, timber had become so valuable that slash was burned on harvested sites, and monocultures of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) were planted (McQuillan 2001).

Throughout most of the 20th century, timber production on reservation lands in the Pacific Northwest was largely controlled by the Department of the Interior, BIA. Thus, it was governed by federal laws and regulations, influenced by evolving concepts of professional forestry, and mirrored forestry practices on public lands.

There was little unique or culturally distinct about it (IFMAT 1993, McQuillan 2001).

Following the Indian Self-Determination and Education Assistance Act of 1975, many tribes established their own forestry operations and natural resource management staffs, becoming more independent of the BIA in forest management functions. Tribes now manage their forest programs and associated budgets themselves. Currently, Indian reservations in the United States contain about 2.3 million hectares (5.7 million acres) of commercial timber land. About 35 percent of this land is in the Northwest region[2] (IFMAT 2003). The Northwest region accounts for 55 percent of the standing timber volume on Indian lands, and most domestic commercial timber production from Indian lands occurs there. For example, in 2001 the Northwest region produced nearly 435 million board feet of timber, accounting for over 70 percent of the harvest volume nationwide from reservations. Although timber production from Indian lands represents only a small percentage of the national wood supply, and was about 2 percent of the total harvested volume across ownerships in the Northwest region in the mid-1990s, this volume is important at the local and regional levels (IFMAT 2003). Douglas-fir, true firs (*Abies* spp. P. Mill.), ponderosa pine (*Pinus ponderosa* P.& C. Lawson), and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) are the dominant species harvested (IFMAT 1993).

The National Indian Forest Resource Management Act of 1990 mandated that an independent assessment of Indian forest lands be undertaken every 10 years. Two assessments have been conducted to date (IFMAT 1993, 2003). They summarize Indian forestry goals and practices, and the condition of commercial timber lands on reservations, and offer recommendations for improving Indian forestry. The data used in the assessments come from the Sustainable Forestry Initiative and Forest Stewardship Council certification assessment processes, tribal visits to conduct interviews, focus groups, and questionnaires sent to 30 tribes. Over half of the tribes sampled were located in the Northwest (including California).

The Indian forests and forest management assessment (IFMAT 1993) characterizes timber management practices on Indian lands as follows. Uneven-age management was the primary means of harvesting historically, and still plays an important role east of the Cascades. Clearcutting is the primary regeneration harvest method and is used extensively on the west side of the Cascades. A move toward selective harvesting has been taking place to protect scenic quality. Natural regeneration is the primary means of reforestation. Prescribed burning for thinning or manipulating species distribution is limited and is used mainly for fuels management and

[2] The Northwest region includes the Rocky Mountain, Northwest, and Pacific Regional Offices of the Bureau of Indian Affairs.

site preparation. Mechanical means are most commonly used for site preparation and control of competing vegetation. Use of herbicides is limited. Forest growth is enhanced by controlling density, generally with the use of a chainsaw or brushsaw to reduce competition from undesirable vegetation. Commercial thinning programs are limited, in part because of uneven-age management, and in part because of a focus on regeneration harvest of slow-growing, old-growth stands. Pruning and fertilization are limited. There is a move toward ecosystem management, with a shift from commodity production to maintaining ecological processes and functions. In essence, Indian forestry has employed the same techniques used in forestry on national forest lands, although some of these practices are more widespread on national forest lands, whereas others are used more frequently on Indian lands. A backlog of thinning exists in the Northwest in mixed-conifer forests in particular as a result of fire suppression and harvest practices. The fact that reservation lands are partially composed of allotments interspersed with tribal trust lands makes tribal timber management complex. Allotments are owned by individuals or groups of individuals who may have different management objectives than the tribe. It has been difficult for tribal forest managers to get allottees to engage in coordinated forest management (IFMAT 1993).

Knowledge about the effects of timber management on forest biodiversity on Indian lands is limited by a lack of monitoring. Ecological conditions on Indian forest lands west of the Cascade crest in the early 1990s were mixed (IFMAT 1993). Regeneration following logging activities has been effective in most places, although some areas are understocked or nonstocked owing to regeneration failures. Harvest in coastal forests has simplified the structure and composition of stands, with clearcutting eliminating older trees, large snags, down logs, and large woody debris in watercourses. Road systems developed to support timber harvesting and other forest management actions have had a major impact on water quality, causing stream sedimentation and negatively affecting fish populations. There has been a simplification of stand structure and loss of species resulting from even-age harvest practices, and old-growth forest habitat has been lost from some landscapes, with negative ecological effects. Fire suppression and past forest management practices have resulted in overstocked stands and insect epidemics.

Forest management practices had improved by 2003, although their quality varied across reservations (IFMAT 2003). Between 1993 and 2003 wildfire, insects, and disease played a major role in shaping Indian forests and their management. Forest health issues are a major challenge, with many reservations in 2003 affected by large-scale pest outbreaks, fires, invasive species, and disease. Fuels reduction activites have increased, however, and much greater investment is occurring to address wildfire risk. Many tribes have begun aggressive management programs to reduce hazardous fuels and to salvage stands damaged by fire, insects, and disease (IFMAT 2003).

Although American Indian tribes have their own individual goals for forest management, common themes that emerged from the assessments include a priority on protecting forest resources including water quality and quantity, valuing the scenic beauty of forests, and a desire to pursue sustainable forest management in an integrated way that supports multiple uses and values (IFMAT 1993, 2003). Employment and timber production were found to have secondary importance as forest management goals. Actual forest management practices were inconsistent with these goals, however, although they became more aligned between 1993 and 2003. For example, the Yakama—who produce a substantial amount of timber revenue from their reservation—have a policy that calls for adhering to tribal values and holistic forest management goals when conducting sustained-yield timber production to protect the ecological and cultural values of forests (WG-CIFM 1998). Tribes like the Confederated Tribes of Warm Springs in Oregon have received Forest Stewardship Council certification, signifying socially, economically, and ecologically sustainable forestry practices.

It is unclear from the literature what role TEK and LEK have played in Indian forest management for timber production. The federal government has dominated Indian forestry since its inception. Nevertheless, there has been a major transition over the past decade from BIA to tribal control of, and responsibility for, forest management. Some tribes now administer forest management programs through their own forestry departments; others still rely on the BIA for nearly all forest management functions. A blend of tribal and BIA responsibility is most common (IFMAT 2003). According to IFMAT (2003), American Indian groups having a greater degree of control have forests and forest management practices that are better aligned with their own management goals and values.

Integrating Traditional Ecological Knowledge Into Biodiversity Conservation

Some researchers assert that because TEK is valuable and in some cases, eroding, it should be recorded, documented, and stored (see Agrawal 1995). Some people are reluctant to share their knowledge, however, because of concern that others will not use it responsibly or in a manner that benefits the knowledge holders. Moreover, those who attempt to record it may not take responsibility for returning it to the local people or place from which it was acquired. There are also concerns over intellectual property rights (Posey and Dutfield 1996). It takes time to understand the knowledge, practices, and beliefs that make up the systems of ecological knowledge maintained by others in order to represent it adequately, requiring long-term research (Sillitoe 1998). Moreover, such accounts are rarely framed in a manner that addresses scientific questions relating to forest management. Also problematic are the facts that by nature, TEK is (a) dynamic and changes over time, (b) locally specific, and (c) dependent on a specific cultural context that gives it meaning (Agrawal 1995, Sillitoe 1998). Consequently, documenting this knowledge, storing it, and relying on it as a data source for forest biodiversity conservation may be problematic because it can become stagnant and irrelevant over time, and lose meaning out of context.

Traditional ecological knowledge is applied by combining the knowledge and skills that are a product of a person's cultural history and learning, and expressing them in the context of prevailing environmental circumstances currently affecting resource use and management.

Furthermore, TEK is not easy to generalize at different scales or at widely varying locations (Agrawal 1995, Sillitoe 1998). Trying to gain access to it in written form and treating it as a set of technical facts to be applied to forest management problems elsewhere is inappropriate. Traditional ecological knowledge is more than an empirical stock of information, procedures, and blueprints that can be inventoried, packaged, and transferred from one place or group to another (Ellen and Harris 2000, Ingold 2004). It includes the skills and range of strategies people draw on to address the environmental circumstances they find themselves in—which may call for adjusting procedures and adapting knowledge—because resource management is an interactive process. Traditional ecological knowledge is applied by combining the knowledge and skills that are a product of a person's cultural history and learning, and expressing them in the context of prevailing environmental circumstances currently affecting resource use and management (Ingold 2004). There is value in recording and documenting this knowledge to capture and help restore the cultural heritage of American Indians, but there may be limitations on applying the TEK found in scientific journal articles, books, newsletters, and other written formats on the ground.

Integrating TEK into forest biodiversity conservation is more likely to be successful if tribes are directly engaged as active participants in these efforts.

Integrating TEK into forest biodiversity conservation is more likely to be successful if tribes are directly engaged as active participants in these efforts. The form that this engagement takes may vary considerably, and is subject to negotiation (Sillitoe 1998). It will also depend on how tribal members prefer to share and communicate their knowledge. Traditional ecological knowledge is typically transmitted through oral rather than written communication, through demonstrations, and through shared experiences.

We identified four models of knowledge integration from the literature on American Indian TEK: collaborative species-specific management, co-management for landscape-scale ecological restoration, integrated scientific panels, and formal institutional liaisons. For additional models and examples that demonstrate the use of TEK in ecological restoration projects in the Pacific Northwest, see Senos et al. (2006).

Collaborative species-specific management—

Collaborative species-specific management between indigenous peoples and other forest managers occurs when they work together to actively integrate TEK into forest management practices to protect or enhance certain species that have cultural or economic value. In most of the cases from the Pacific Northwest, this kind of collaboration has occurred between tribal members, western scientists, and forest managers who work together and combine their knowledge to manage species on public lands. This is the most common model for knowledge integration found in the literature.

Beargrass restoration on the Olympic Peninsula provides one example of collaborative, species-specific management. Beargrass is valued by many Pacific Northwest tribes as a basketry material, and some also use it in burial ceremonies (Shebitz 2005). Historically, burning practices by American Indians maintained open-canopied beargrass habitat (Shebitz 2005, Wray and Anderson 2003). This habitat has declined, in part because burning by American Indians on much of the peninsula stopped around the turn of the 20th century, and successional processes have disfavored beargrass. As a result, beargrass has decreased in quality and quantity.

In 1995 the Olympic National Forest began a restoration project in an area that was historically Skokomish territory to restore beargrass and other shade-intolerant species (Shebitz 2005). American Indians, forest managers, and University of Washington scientists collaborated to design the project and implement treatments. Traditional land management practices based on TEK about historical landscape structure and burning techniques (e.g., the season, frequency, and intensity of the burn) have been reintroduced. Over 13 hectares (32 acres) of Douglas-fir forest has been thinned, burned, and revegetated. Additional periodic burns are planned at 3- to 5-year intervals, and adjacent plots have also been treated with prescribed fire and vegetation removal. Plots have been set up in several places to monitor the effects of different fire and thinning treatments on beargrass. In 2004, one of the beargrass restoration treatments performed on the Olympic National Forest was replicated on the Quinault Indian Reservation (Shebitz 2005).

Similarly, the Olympic National Park is considering working with the Makah Tribe to revive historical burning practices of American Indians to restore prairie ecosystems that have declined inside the park (Wray and Anderson 2003). And elsewhere, fuel specialists, timber planners, and cultural resource managers have collaborated with California Indian basket weavers to design prescribed burns that enhance beargrass and other important basketry plants on national forests in northern California (Anderson 2005, Ortiz 1993). These projects have been motivated by a desire to restore species having cultural value to tribes, and in the process restore habitat types and associated species that have declined in the absence of fires.

To date, most collaborative species-specific management projects have been implemented on a very small scale. Nevertheless, they have the potential to restore biodiversity locally or more widely. Collaborative species-specific management may be particularly effective when applied to "cultural keystone species"—species that play a key role in the diet, material culture, or belief system of a group and as a result, help shape their cultural identity (Garibaldi and Turner 2004). Focusing on the conservation and restoration of such species can be important for maintaining the identity and cultural traditions of American Indians, and provide incentive for them to participate.

Co-management for ecological restoration—

Co-management occurs when local resource users establish a formal, power-sharing partnership with the state that enables them to assume an active role in, and share responsibility for, resource management and decisionmaking (Stevenson 2006). One example of a co-management project for ecological restoration is the Maidu Stewardship Project in northern California.

The Maidu Stewardship Project is being implemented through the Maidu Cultural and Development Group on 619 hectares (1,530 acres) of the Plumas National Forest and 202 hectares (500 acres) of the Lassen National Forest in northern California (Thompson 2006). In 1998, the group was awarded a 10-year stewardship contract[3] on these forests, making this the first place in the United States where an American Indian tribe has been given authority to apply traditional resource management practices to national forest lands for forest restoration (Little 2005). The project combines land management, cultural education, and economic development objectives in the context of forest stewardship (London 2002). The Maidu are using TEK—including techniques like burning, tilling, pruning, and selective harvesting—to restore ecosystem health throughout the project area, with an emphasis on NTFPs. They hope to return the forest to pre-European settlement conditions (Anderson 2005, Little 2002). Traditional ecological knowledge is supposed to be used in the analysis, planning, and implementation of forest management projects (London 2002). Project work began in 2004 with Maidu crews

[3] A stewardship contract is a contract or agreement entered into by the Forest Service or the Bureau of Land management for services to achieve land management goals and meet local and rural community needs, consistent with section 323 of public law 108-7.

thinning trees, removing noxious weeds, transplanting gray willows (*Salix cinerea* L.), and managing for beargrass. They hope to use fire as a management tool, and also plan to restore watershed health, build a fuelbreak, and incorporate a public education component by building a nature trail that identifies plants having cultural significance, and labeling them with both scientific and Maidu names (Little 2002). The Maidu will monitor sites with their partners to assess progress in meeting restoration goals.

Benefits of the project include the opportunity to apply and enhance TEK, maintenance and restoration of culturally-important plants and their habitats, reduced fire risk, economic opportunities for the Maidu, tribal empowerment in forest management, improved communication, and building awareness of Maidu cultural traditions (Anderson 2005, Thompson 2006). Challenges to co-management have revolved around trust and communication between the Maidu and the Forest Service. These may be rooted, in particular, in different notions of what co-management means and how it is politically and legally recognized. In addition, it has been difficult for the Maidu to comply with the bureaucratic processes required by the Forest Service, such as contracting and reporting requirements, timelines, budgets, and business plans (Little 2005). There is some debate about the extent to which TEK has been used in the project stemming from differing perceptions of what TEK is, how it should be implemented, and what it looks like on the ground (Thompson 2006). And there appears to be little in the way of knowledge transfer from the Maidu to scientists and managers because the Forest Service has not been directly involved in project implementation.

Integrated scientific panels—

Integrated scientific panels are formal panels having a mix of western scientists and indigenous peoples holding TEK who work together to jointly address specific resource management problems by undertaking activities like analyzing existing data, and developing recommendations for how to manage natural resources. The Scientific Panel for Sustainable Forest Practices in Clayoquot Sound, Canada, provides one example of this kind of mechanism for sharing TEK (Mabee and Hoberg 2006, Ministry of Sustainable Resource Management 2004).

The Clayoquot Sound Panel, established in 1993 and together until 1995, was charged with reviewing existing forest management standards in Clayoquot Sound (located off the west coast of Vancouver Island in British Columbia), and developing new standards for sustainable forest management in the region based on a combination of traditional ecological and western scientific knowledge (Ministry of Sustainable Resource Management 2004). The Clayoquot Sound area, roughly 350 000 hectares (864,869 acres) in size, has vast expanses of old-growth forest, which was the subject of a major land-use debate in the early 1990s. The panel was established to address the conflict. It included scientific experts in ecology and biodiversity, one chief and three elders from the Nuu-Chah-Nulth Nation who are experts on traditional land and resource use in the area, engineers, foresters, earth scientists, biologists, a recreation planner, and an ethnobotanist. It developed new standards and recommendations for sustainable forest management in the region based on a combination of traditional ecological and western scientific knowledge, which were subsequently adopted, including creation of a co-management body composed of the Province of British Columbia and Nuu-Chah-Nulth for natural resources.

Although this panel was heavily dominated by western scientists, other kinds of integrated scientific panels exist. The Alaska Beluga Whale Committee comprises Native Alaskans who hunt beluga whales (*Delphinapterus leucas*) and government agency biologists and managers (Huntington 2000). Together, committee members discuss conservation issues, information needs, the biology of belugas, and management policy. They identify research priorities and research methods for gathering information on the whales, with committee members conducting most of the research and hunters contributing TEK. This research and knowledge forms a basis for developing management policy (Huntington 2000). Although this example does not come from forestry, it does serve as a model that could be applied in the forest management context.

Formal institutional liaisons—

Formal institutional liaisons are institutions that serve as intermediaries between indigenous peoples and others who are interested in their TEK, and would like to learn more about it and its potential for application in natural resource management. These institutions are typically composed of people who represent indigenous groups, who may or may not be members of those groups. They work to transfer TEK and integrate it into natural resource management in socially and culturally appropriate ways.

One example is the Indigenous Peoples Restoration Network. The network is a working group of the Society for Ecological Restoration, and is international in scope (IPRN 2006). Its members work with ecological restorationists and indigenous nongovernmental organizations to promote the appropriate use of TEK in ecological restoration in a range of ecosystems. The network supports indigenous communities that need technical assistance for ecological restoration on their own lands. It also provides assistance to other resource managers who wish to apply TEK in their restoration efforts, and integrate it into models of sustainable ecosystem management. In addition, the network helps promote the co-management of public lands by indigenous peoples and government agencies to facilitate the integration of TEK into environmental management (IPRN 2006). Although the network is not based in the Pacific Northwest or solely focused on forest management, it is a model that could be replicated regionally, or that could develop local, place-based chapters.

Challenges to Using Traditional Ecological Knowledge for Biodiversity Conservation

One of the biggest challenges to applying the TEK of American Indians to forest biodiversity conservation is the fact that this knowledge is rapidly eroding. As evidenced by the literature, considerably more information is available about TEK for forest management from historical and prehistoric times than for contemporary TEK. Loss of access to traditional land and resource use areas, and the prohibition of traditional forest management practices assumed to be destructive (like burning) have reduced opportunities to implement TEK (Anderson 2005). Tribes having reservation lands are in a stronger position in this regard, but many tribes do not have a land base, and therefore depend on public and other private lands to obtain the forest resources they need. Ecological change resulting from the cessation of traditional forest management practices, habitat conversion, commercial timber production, and grazing have meant that the forest resources upon which many tribal social, economic, and cultural practices were based have declined (Anderson 2005, Deur and Turner 2005b, London 2002). As forest resources, access to them, and rights to manage them diminish, so does the TEK associated with these resources. When TEK dies out, culturally-important species also decline, reducing biodiversity and making it difficult for the cultural traditions they once supported to continue.

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Concluding Remarks

The literature describing the TEK relating to forest management held by indigenous peoples in the Pacific Northwest is relatively extensive. However, much of it focuses on past management practices that have declined because of the dramatic social and ecological changes that followed nonnative settlement in the region. And, most focuses on forest management for nontimber species; little has been written about the application of TEK and LEK for timber production on reservation lands. Attempts to revive some of this knowledge, and to apply it to forest management for biodiversity conservation, have been occurring on public lands in the last few decades using the models described here. There are few examples in the literature of comparable efforts on reservation lands. Little information is available that evaluates the success of these models, however, e.g., how effectively they have used and integrated TEK for forest management, with what results. Key to knowledge integration is to have American Indians participate actively in the knowledge transfer and application process on the ground.

Family forest owners are private individuals and families who own forest land but do not own wood processing infrastructure.

Local Ecological Knowledge of Family Forest Owners

Family forest owners are private individuals and families who own forest land but do not own wood processing infrastructure (Birch 1996). Once assumed to be small versions of industrial timber companies, family forest owners are now understood to be a diverse group of educated and often professionally employed landowners whose environmental values are more similar to those of the general public. They are neither as land-connected and private property rights-oriented as once thought, nor do they all hold vested resource interests or utilitarian values (Bourke and Luloff 1994, Jones et al. 1995). Consistent with national trends (Birch 1996), most family forest owners in Oregon are older than 40 years and earn their income from sources other than timber production (Johnson et al. 1997). Two-fifths have a university degree and most are either employed in white-collar jobs, self-employed, or retired (Johnson et al. 1999). Many owners are former urbanites or urban-based nonresident landowners (Jones et al. 1995), although others are descendents of families who have lived on the same piece of forest land in rural communities for multiple generations.

Family forest owners are a significant force in forest management because they control a large land base. Nationally, they hold 47 percent of forest land ownership (Birch 1996). In the Pacific Northwest, they hold about 20 percent of all forest land (Creighton et al. 2002, Johnson et al. 1999). The ownerships themselves are held in relatively small units. For example, in Oregon 67 percent of private forest-land owners hold parcels of less than 202 hectares (500 acres) and 75 percent of private forest acreage is held in parcels of less than 202 hectares (500 acres) (Birch 1996). The majority of family forest parcels change hands after 10 to 49 years of ownership (Butler 2006).

The ecological importance of family forests stems from their extent and location. Unlike national forests and wilderness areas, family forests are often located in low-elevation valley and riparian areas that provide rich habitat (Johnson et al. 1999). These are the areas that nonnatives first settled and developed for agriculture, forestry, and towns, and as a result, they have been significantly altered (Bliss 2003). Thus, they contain many threatened habitats such as oak woodlands and savannas, prairies, and bottomland hardwood forests (Oregon Biodiversity Project 1998).

Views of Biodiversity

Our understanding of family forest owners' views of biodiversity in the Pacific Northwest is sparse. With the exception of Fischer and Bliss's (2006a, 2006b) investigation of owners in the oak ecotype of Oregon, no studies address biodiversity per se. There are a few studies that explore Pacific Northwest owners' views on topics that can be considered surrogates for biodiversity—for example, wildlife habitat, forest health, riparian quality, and ecosystem management. These and studies conducted elsewhere in the United States suggest that family forest owners are aware of aspects of biodiversity—including species diversity, structural diversity, ecological time scales, and landscape context—and may be predisposed to developing local knowledge. For example, in their survey of family forest owners in Washington, Creighton et al. (2002) found that owners were sensitive to the unique habitats and features on their properties, employed a long-term vision about the ramifications of their land use practices, and were aware that their property fit into a larger ecosystem. The Oregon Small Woodlands Association is a family forest interest group that claims that its members recognize the importance of biological diversity, and often manage for wildlife habitat (OSWA 2003).

Hairston-Strang and Adams (1997) and Wright (2000) looked specifically at riparian quality. Their studies found that owners, especially watershed council members, are interested in and concerned about riparian health. However, while they manage their land according to their conceptions of healthy conditions, they are not well informed about the technical and scientific aspects of stream ecology (Hairston-Strang and Adams 1997, Wright 2000).

In a study of family forest owners in one watershed in the Willamette Valley, Oregon, Fischer and Bliss (2006a) found that the owners in their sample were knowledgeable about the concept of biodiversity and believed that they should steward the biodiversity of their forests through management. However, their notion of biodiversity appeared to be quite generic, rather than specific to the native oak ecotype of their lands. Some owners, for example, saw diversity in brush-filled regenerating clearcuts, while others saw diversity in mature stands of mixed conifers and hardwoods. Insofar as they recognized diversity of species, structures, and scales, the owners in the study viewed biodiversity in much the same way as conservation biologists. However, they implemented their knowledge of biodiversity differently. They promoted species richness at the expense of evenness, marginalizing ecotype-associated forms of biodiversity. The Fisher and Bliss (2006a) study illustrates the importance of understanding the context of owners' LEK; owners that manage production forests may operate with different assumptions about biodiversity than owners managing for mature native forests that provide aesthetic enjoyment.

As with American Indians, family forest owners do not believe that management interferes with the "naturalness" of their forests; rather, they believe their forests are better off because of their interventions. In their view, management is not an interruption to the course that forests follow in their evolution; it is a helpful, guiding force.

Studies from other parts of the United States and other countries provide further evidence of how family forest owners conceptualize elements of biodiversity. These studies indicate that they recognize and manage for riparian habitat and water quality (Dutcher et al. 2004, Jacobson 2002b), presettlement reference conditions (Hull et al. 2001), landscape conditions and processes (Rickenbach et al. 1988), unique, small-scale ecological features such as rare species and wetlands (Belin et al. 2005, Campbell and Kittredge 1996), and to some extent, endangered species (Brunson et al. 1996) and game species (Haymond 1990).

Family forest owners commonly hold multiple management objectives for their forest lands ranging from wildlife habitat, scenic views, and recreation to long-term investment and timber income.

Forest Management Practices and Their Ecological Effects

Family forest owners commonly hold multiple management objectives for their forest lands ranging from wildlife habitat, scenic views, and recreation to long-term investment and timber income (Bliss and Martin 1989, Clawson 1989, Huntsinger and Fortmann 1990, Johnson et al. 1997). Their objectives vary with ownership size (Huntsinger and Fortmann 1990, Sampson and DeCoster 1997), length of tenure, age, income level, and residence on the property (Ostrum 1985). They typically prioritize amenity objectives over timber production (Brunson et al. 1996, Huntsinger and Fortmann 1990, Jones et al. 1995), yet the opportunity to harvest timber for income remains important (Johnson et al. 1999). Past research has indicated that most commercial timber on family forest lands eventually is harvested because of changes in ownership, market prices, and owner objectives (Carpenter 1985, Lettman 2002). However, the effects of recent trends in owner objectives on harvest practices have not been explored in the literature. A survey of family forest owners in Washington state characterized the management practices of over 50 percent of owners as agroforestry (a combination of livestock grazing, windbreaks, special forest product harvesting, forage production, and orchard intercropping) that many said increases biological diversity (Lawrence et al. 1992). Managing forests for multiple goals likely enhances biodiversity relative to forest management practices that emphasize timber production.

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Family forest owners use their LEK to manage biodiversity in several ways. They experiment with planting patterns to foster favored wildlife species and view qualities, and to explore new species arrangements. For many, diversity indicates a healthy forest. To achieve this diversity, they cultivate a variety of native species in addition to the primary commercial species on their tree farms (Fischer and Bliss 2006a, 2006b). Owners are also known to set aside stands of hardwoods, brushy areas, and wide riparian corridors instead of converting them to plantations (Dutcher et al. 2004, Fischer and Bliss 2006a, Jacobson 2002a). In Oregon, some owners have used prescribed fire to reduce fuels and control invasive species, mimicking historical disturbance processes (Fischer 2005, Stanfield et al. 2003).

Although little research has been done on the direct impacts of family forestry on biodiversity, one landscape analysis conducted in Oregon suggests that family forest owners may maintain forest habitat diversity (Stanfield et al. 2003). The study found that nonindustrial private ownerships provide a mixture of young to medium-aged conifer stands, extensive hardwood stands, and a high proportion of nonforest land including meadows and fallow fields. This mixture contributes ecological diversity to landscapes otherwise dominated by conifer plantations on private industrial forest lands, and maturing stands of Douglas-fir on public lands (Bliss 2003).

Integrating Family Forest Owners' Knowledge Into Biodiversity Conservation

Family forest owners may not be familiar with the terms "traditional ecological knowledge" or "local ecological knowledge," but they do distinguish between experiential knowledge and scientific knowledge. There is a tension in the way owners value these two kinds of knowledge. While many owners think scientific research and expert information are necessary to improve their ability to manage for habitat and ecological processes, some distrust scientific knowledge, seeing it as tentative and impractical (Fischer and Bliss 2006a). Some owners develop their own knowledge by experimenting with different practices and conditions in their forests. Successful capacity-building programs such as the Oregon State University Extension Services Master Woodland Manager Program have built on this dualism in owners' knowledge preferences by disseminating both information produced through academic research and information gained from personal experience. Interpersonal communication has been recognized as an important channel of management advice to owners in the past, in part because of their tendency to be independent and skeptical (Rogers 1983, West et al. 1988). The importance of trusted peer-to-peer communication has also been emphasized in studies of landowner attitudes and behaviors about conservation (Brook et al. 2003). The new wave of exurban forest owners will rely to a greater extent on nongovernmental organizations and private sector consultants for guidance than other owners did in the past (Rickenbach et al. 2005).

Few prominent examples of cooperation between family forest owners, scientists, and other land managers exist to serve as models for integrating their LEK in biodiversity conservation efforts (Knight and Landres 1998, Rickenbach and Reed 2002). Although recent research suggests that cooperatives may provide an appropriate infrastructure for cooperation based on owners' values (Campbell and Kittredge 1996; Rickenbach et al. 2005, 2006), it is too early to tell whether they could serve as models for knowledge integration because factors underlying owners' decisions to participate are still not well understood. Family forest interest groups such as the Oregon Small Woodlands Association currently serve as forums for cooperation and knowledge-sharing among family forest owners. Unfortunately, studies have not examined the utility of such forums for cooperation between owners and other groups. Nor have studies examined factors in owners' willingness to participate.

Watershed councils have brought owners, scientists, environmentalists, and other public and private land managers together in ecosystem management efforts, most notably in Oregon as a result of the Oregon Plan for Salmon and Watersheds (Rickenbach and Reed 2002). Studies suggest a number of factors in watershed councils' ability to engage family forest owners. Habron (1999) found that owners' perceptions of watershed councils' ability to reduce bureaucracy, enhance communication and understanding, and build local capacity are central factors in their attitudes toward watershed councils. Cheng (1999) suggested the perception that other members share owners' sense of place is important. Rickenbach and Reed (2002) asserted that owners' perceptions that other members share their stewardship ethics, concerns about property rights, and preferences for an action orientation determine their willingness to join watershed councils. However, the newness of watershed councils has limited owners' willingness to participate, and, in turn, researchers' abilities to assess their usefulness for knowledge sharing.

Conservation efforts facilitated by land grant university extension programs hold the potential to serve as models for cooperation and sharing LEK. For example, the Willamette Valley Ponderosa Pine Conservation Association (WVPPCA)—founded in 1994 by a land-grant university forestry extension program, timber companies, and family forest owners—has helped to reestablish the historical range and genetic diversity of the Willamette Valley race of the ponderosa pine by planting millions of seedlings each year for conservation and timber production. Local ecological knowledge is developed through experiential learning based on landowner trials with growing the pine. Their knowledge of what works and what does not is shared with other members of the organization. The WVPPCA has not focused on re-creating the range of conditions that were characteristic of the habitat type; instead it has worked with family forest owners to integrate ponderosa pines into their individual management approaches (Fletcher 2006). As a result, the program's value for biodiversity conservation remains to be seen. Nevertheless, the WVPPCA provides an important lesson for the integration of LEK. It has encouraged owners to plant an unfamiliar species having almost no present market value for long-term conservation and economic gain, building on the dual goals family forest owners have of biodiversity protection in a manner that incorporates utilitarian production values. Organizers attribute the project's success to two things: its peer-to-peer approach of linking forest owners with each other through tours, experimental trials, and meetings; and its flexibility to work within the framework of owners' existing goals and practices (Fletcher 2006).

Although cooperatives, interest groups, watershed councils, and efforts such as the WVPPCA can serve as examples for cooperation, their utility for integrating LEK into biodiversity conservation is unclear. More research is needed on the factors in owners' willingness to participate and share knowledge before these examples should be viewed as models for knowledge integration. The current scarcity of models for cooperative knowledge sharing may be explained by owners' history of engaging in independent decisionmaking (Sample 1994); managing and marketing their products independently (Rickenbach et al. 2005); prioritizing privacy (Finley et al. 2006); and practicing forestry by themselves or with neighbors rather than outsiders, even in planning efforts that cross ownership boundaries (Jacobson 2002a). Nevertheless, some family forest owners are willing to cooperate with each other (Jacobson 2002a, Finley et al. 2006). Although these characteristics may reveal a tendency to not get involved in collaborative groups (which can work against knowledge sharing), they may also be indicative of other constraining factors. For example, Rickenbach et al. (2006) suggested that the reason owners manage and market their products independently is that other alternatives are largely absent.

Challenges to Using Local Ecological Knowledge for Biodiversity Conservation

Family forest owners own the forest lands they manage. Tenure security provides an opportunity for them to develop and apply experiential knowledge by experimenting with different practices and conditions in their forests. Nevertheless, family forest owners are subject to regulations and policy requirements, and are the targets of mixed messages about how they should be managing their forests (Sampson and DeCoster 1997), which affect their ability to use LEK. Their management practices are also influenced by the economic context in which they operate.

Family forest owners' generic conceptions of biodiversity may limit opportunities for biodiversity conservation. Without more advanced and sophisticated understandings of habitat associations, owners may compromise ecotype-associated diversity in their management practices. It is important to note, however, that owners' beliefs about biodiversity may in part be attributable to their economic and policy context. For example, it may seem contradictory for owners to underplant native Oregon oak savanna (a declining habitat) with commercial conifer species in the name of biodiversity conservation (Fischer and Bliss 2006a). The psychology literature attributes such discrepancies in part to contexts where situational constraints overpower beliefs and values (Kaiser and Fuhrer 2003). In the Pacific Northwest, where Douglas-fir production has been a cornerstone of the economy and conflict over species conservation has made the concept of biodiversity politically volatile, owners may have no choice but to treat commercial conifer production as compatible with diversity in their notions about stewardship (Fischer and Bliss 2006a).

Economic pressures also affect family forest owners' management practices. In particular, the decline of large-dimension timber harvesting from federal lands and the globalization of the forest products industry have caused processors to retool for smaller diameter timber (Best and Wayburn 2001, Bliss 2003). Family forest owners now face limited markets for small quantities of logs of diverse sizes and species. As a result, they are under more pressure to grow timber in plantations on short rotations, which are less biodiverse.

The complex policy environment in which owners operate further complicates opportunities for biodiversity conservation on their lands (Bliss and Martin 1989), and affects their ability to use LEK. In their dual roles as timber plantations and natural areas, family forests face public expectations and policy requirements on both ends of the spectrum (National Research Council 1998). Like all productive forest lands, family forests are subject to forest practices regulations. And because family forest lands occupy large areas of lowland valleys and riparian ecosystems, they are also becoming increasingly subject to riparian-zone and other regulations, such as the Endangered Species Act and the Clean Water Act (Johnson et al. 1999). Although owners feel obligated to provide habitat for endangered species, they also fear attracting these species, thereby subjecting themselves to restrictions under the Endangered Species Act.

In addition to facing economic and policy constraints on their land management practices, family forest owners have been the targets of conflicting assistance programs. In an attempt to increase production, programs such as the Forestry Incentives Program have sought to help family forest owners reforest and improve the stands on their properties (Sampson and DeCoster 1997). Because of the ecological importance of family forests, programs have also tried to help owners improve habitat and ecological processes through financial and technical assistance, as in the Forest Stewardship Program and companion Stewardship Incentives Program (Sampson and DeCoster 1997). At the same time, land-grant university extension foresters, agency foresters, and family forest interest groups often promote Douglas-fir plantation management through their programs (Best and Wayburn 2001, Sampson and DeCoster 1997), sometimes at the expense of native biodiversity (Fischer and Bliss 2006a). All of these programs try to influence the way in which family forest owners manage their forests. How these influences affect the use of LEK is unknown.

Concluding Remarks

The literature provides evidence that family forest owners are knowledgeable and concerned about biodiversity. Through daily forest management, owners have acquired intimate knowledge of their forests. They hold information about forest biodiversity that is unavailable from industrial or public land managers. The literature provides direction on how to integrate family forest owners and their knowledge in conservation efforts. Owners' independence and self-determination, and their vulnerability to economic influences from the industrial forestry sector, make their participation as equal partners an essential component of any conservation strategy. It must be recognized that although family forest owners are motivated to conserve biodiversity, they do so at the expense of other land uses, and risk incurring future regulatory restrictions. As a result, compensation—such as payments for ecosystem services—and policy protections may be important.

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Local Ecological Knowledge of Commercial Nontimber Forest Product Harvesters

Nontimber forest products include wild foods such as mushrooms, fruits, nuts, and honey; medicinal plants; floral greenery and horticultural stock; native seeds; fiber and dye plants; and oils, resins, and saps like maple syrup. The Forest Service also considers small-diameter poles, posts, and firewood to be NTFPs. Nontimber forest products comprise a significant part of the biological diversity of forest ecosystems. Given the small amount of western scientific research that has been done about them, it is not surprising that the largest reserve of knowledge about NTFPs is with harvesters (Emery 2001, Love et al. 1998).

Researchers have identified eight different types of harvesters, categorized by what motivates them to harvest. These include commercial, subsistence, recreational, educational, and scientific motivations, as well as healing and spiritual reasons (Jones and Lynch 2002). Most harvesters belong to multiple categories. While all harvesters may have LEK of value for forest management, we focus on commercial harvesters for the following reasons: (1) they generally spend more time in the forest and harvest larger quantities and varieties of products than other harvester types, (2) they generally have a wider geographic range than other types of harvesters, and (3) they are ideally positioned to become involved in participatory research projects that provide an opportunity to share cultural and ecological knowledge with forest managers.

Harvesting occurs in every forested ecological zone in the United States. In the past, even landscapes like the arid areas of southeast Oregon that have dispersed plant populations supported subsistence gathering by indigenous inhabitants (Fowler 1986). Today, such environments still support commercial seed gathering, nursery stock removal, and other commercial NTFP activities. The greatest concentration of commercial harvesting in the Pacific Northwest, however, is in the temperate forests that lie between the crest of the Cascade mountain range and the Pacific Ocean. This area has more dense populations of economically important NTFP species, more people, and more infrastructure for access than most other Pacific Northwest forests. Commercial harvesters remove hundreds of NTFP species every year in the Pacific Northwest, but at what levels is not well known.

Commercial harvesters in the Pacific Northwest can be found across a diversity of lands under different private and public ownerships. Federal lands including those managed by the Forest Service and the U.S. Department of the Interior (Bureau of Land Management), state forests, and large private lands are important resource areas for many harvesters. A few commercial harvesters own their own forest land, but most do not. If they do own or rent land, it is typically not enough to sustain commercial harvesting. Some farmers and small woodlot owners have areas on their lands that have wild native and invasive NTFPs that they nurture. Examples include wild berries and edible greens, plants for medicinal uses, mushrooms, seeds, and Christmas trees and transplants. Although some landowners manage for NTFP productivity, most harvesting in their case is probably for incidental use, and most plants are simply left alone rather than actively managed. A few commercial harvesters have reported negotiating relationships with private landowners to extract NTFPs. Few timberland companies issue permits or provide leases, and occasionally harvesters have been confronted by law enforcement for harvesting on private lands without permission. Although agency permit data are inconsistent and sometimes unreliable, they do show that harvesters regularly use state and federal public forests (McLain and Jones 2005). Additionally, some commercial harvesting occurs on military reservations. Commercial harvesting also takes place on some national parks and game refuges, although harvesting is officially not allowed there. Lastly, many American Indian tribes report commercial harvesting activities by both tribal members and nontribal members on their reservations, and in areas subject to treaty rights.

Views of Biodiversity

There is little in the way of literature that documents commercial NTFP harvester views of biodiversity, and not many commercial harvesters use the term. The general attitude among many harvesters is that more species richness and abundance is better when it comes to commercial needs (Jones et al. 2004). Few if any forest industry sectors depend on as many species or have such a diversified economy as that of commercial NTFP harvesting. Often the household economy of commercial harvesters includes the harvest of a diversity of NTFPs (Emery 2001). Although most harvest at least a few species, many harvest dozens throughout the year. For example, some harvesters specializing in fungi may pick as many as 15 edible commercial species throughout the Pacific Northwest (Jones and Lynch 2007). In the case of wild seed harvesters, the number of species collected can reach into the hundreds (Jones et al. 2004).

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With some notable exceptions such as morel (*Morchella* spp.) mushroom productivity the year following a forest fire, in general, few commercial NTFP species do well in the immediate wake of major landscape disturbances like fire, clearcutting, road building, and grazing. Although some species can ultimately benefit from disturbance (Kerns et al. 2003), the short-term disruption to harvest patterns can impact both knowledge systems and a harvester's household economy. Many commercial harvesters voice frustration with land managers over their disregard for the diversity of NTFPs being harvested. Such disregard is demonstrated by the destruction of species-rich gathering sites by activities such as timber removal, as well as how natural events like catastrophic wildfires are planned for and managed. Although some commercial harvesters are interested in a few species, many have a vested interest in harvesting sites not being destroyed, many of which are areas of NTFP species richness. Given both the value of harvester knowledge about NTFP habitat, and the potential impacts of management on their livelihoods, greater effort needs to be taken to include harvesters in forest planning and decisionmaking processes.

Forest Management Practices and Their Ecological Effects

Many harvesters attempt to steward the resources they harvest through behaviors such as (1) engaging in productivity experiments by trying different harvest techniques, spreading seeds and relocating plants, and watering; (2) monitoring environmental change through observation, writing, photography, mapping, and videotaping; (3) treading lightly in harvest areas; and (4) imposing harvest level restrictions on themselves.

Commercial harvesters have an economic incentive to investigate, understand, and practice sustainable harvesting (Jones and Lynch 2002, Love and Jones 2001). Harvesters are limited in how much they are allowed to manage or how much experimentation they can conduct on lands they do not own. Nonetheless, there is clearly a strong interest among many harvesters in learning about how resource stewardship can sustain their livelihoods. Many harvesters attempt to steward the resources they harvest through behaviors such as (1) engaging in productivity experiments by trying different harvest techniques, spreading seeds and relocating plants, and watering; (2) monitoring environmental change through observation, writing, photography, mapping, and videotaping; (3) treading lightly in harvest areas; and (4) imposing harvest level restrictions on themselves (Jones and Lynch 2002, Love et al. 1998).

One example of how harvesters use their knowledge for biodiversity conservation and stewardship comes from the wild mushroom arena. Although studies suggest harvesting mushrooms is generally akin to picking fruit and unlikely to negatively impact productivity (Arora 1999, Pilz et al. 2004), many harvesters nonetheless observe a number of informal rules about how to harvest. For example, harvesters who regularly return to patches of mycorrhizal mushrooms like chanterelles (*Cantharellus formosus*) and boletes (*Boletus edulis*) often visit their patches numerous times before, during, and after a season to check their conditions and the conditions of the surrounding habitat (Love and Jones 2001, McLain 2000). Although they lack the knowledge and power to stop clearcuts, thinnings, burning, and spraying, which can harm or destroy their patches, they often exercise restraint in harvesting until they feel the conditions are suitable. For instance, small mushrooms will be left to grow larger, and some large mushrooms may be left in a patch on the chance they may increase productivity (Love et al. 1998).

Among floral green harvesters on the Olympic Peninsula, Ballard (2004) and Ballard and Huntsinger (2006) found that inexperienced harvesters described more intensive harvest practices than experienced harvesters. Furthermore, experienced harvesters managed their patches for multiple species to maintain year-round harvesting options and a diversified income. Experienced harvesters also practiced resource rotation, leaving some areas to lie fallow and recover for future harvests. Lastly, Ballard found that some harvesters showed understanding of and interest in the concept of succession management, whereby silvicultural practices are implemented that simultaneously achieve timber production goals while producing quality harvestable salal and other floral greens at various stages.

In comparison to other sectors such as timber and recreation, very few studies have been conducted on the ecological effects of commercial NTFP harvest practices. Even fewer studies have examined the impacts of management activities like logging on NTFP habitats and culture. Harvesting is nonmechanized for most NTFPs, and is generally considered low impact for many species. An exception might be mosses, some of which have longer regeneration rates than most other NTFP species (Peck 2006). Nonetheless, unlike nearly all forms of timber extraction, NTFP extraction impacts are often confined to the species being harvested, with seemingly low impact to other elements of the ecosystem. Thus, commercial NTFP harvest activities at a minimum are apt to maintain species richness of target species at the local level, and some management practices—such as productivity experiments—may increase it.

Integrating Harvester Knowledge Into Biodiversity Conservation

There has been little research on how harvesters acquire and share LEK. With few written guides and virtually no formal training, harvesters have had to figure out where to harvest, what the optimal harvesting times are, what quantities can be removed sustainably, and what techniques to employ. How much of this information has been learned by individuals through trial and error versus social learning is an area in need of research. Although LEK is an academic construct that few harvesters are likely to be familiar with, they regularly express conceptually similar ideas such as "having farmer's knowledge," "learning by doing," and "I learned how to harvest through the school of hard knocks." These expressions reflect the experiential learning that is a key aspect of LEK. Many commercial harvesters enjoy the process of discovery.

To survive as commercial harvesters, individuals probably learn all they can on their own and learn from others. Within the commercial arena there are a number of places where commercial harvesters can find one another and potentially exchange knowledge. One such place is at commercial buying stations. In small communities throughout Oregon and Washington, buying stations can often be found where harvesters come into contact with one another and the buying station owner as they sell their product at the end of the day. This creates an opportunity for informally exchanging information, although the degree to which information is shared depends on many factors such as trust and language. For some products like mushrooms, harvesters may seasonally camp. In central Oregon a number of Southeast Asian ethnic groups, Latino harvesters, and Caucasians camp in proximity to one another for months during the fall matsutake mushroom harvest, creating another opportunity for information exchange.

Although folklore about patch secrecy is legendary in the mushroom arena, in reality most commercial harvesters learn by accompanying a mentor into the woods, and quite often end up teaching others the same way. Many harvesters also exchange information over the Internet because the cost is low, it allows for immediate news sharing (e.g., what prices are being offered for products), and it allows harvesters to exchange tools such as digital maps.

It is clear that harvesters are having contact with one another in many ways, but it is unclear what level of information exchange takes place, and how this affects harvest practices. A better understanding of the nodes and processes of communication would be helpful for structuring management and policy such that it advances LEK.

In the last decade, a movement has begun to promote more participatory approaches in forestry. Participatory research, citizen science, and collaborative conservation are participatory approaches that have had excellent success in other sectors such as fisheries and water quality monitoring (Pilz et al. 2006). As workshops and research indicate, commercial NTFP harvesters are in many ways an ideal group to involve in participatory research such as biological inventory and monitoring (Ballard et al. 2005, Ballard and Huntsinger 2006, Lynch et al. 2004). They often visit the same forests regularly, scout new optimal harvest areas, and are competent at navigating off-trail and in challenging terrain. Not only could they assist in gathering information about NTFPs, they could also collect data about other species, biological and ecosystem processes, vegetation associations as they relate to elevation, aspect and slope, soil characteristics, stand conditions, and management impacts on NTFP species and habitats. Minimally, harvesters could be trained to carry portable data entry devices, but there is also significant potential to involve them in other aspects of scientific research.

Participatory research and monitoring projects hold promise as models for knowledge sharing and integration between commercial NTFP harvesters and others. In participatory research and monitoring, western scientists, land managers, and harvesters work together to gather data about NTFPs and their ecological relationships, and management impacts on them. The participants offer their own interpretations of the data, theories relating to findings and trends, and management solutions. Through direct interaction in the research and monitoring process, LEK is shared and integrated into forest management.

An example of a participatory research project that facilitated knowledge exchange comes from Ballard (2004) and Ballard and Huntsinger (2006) who conducted a 2-year study of salal (*Gaultheria shallon* Pursh) harvesting impacts on the

Olympic Peninsula in Washington state. Ballard started by developing relationships with local harvesters, who helped define the research question: How do different harvest intensities affect salal regrowth and sustainability? The harvesters helped select the study site, develop methods for measuring plant regrowth in relation to commercial harvest, and collect, weigh, measure, and record the data with the researcher. The harvesters were Latino, many with limited English, and many of whom were migrant workers. Harvesters were paid $10 to $12 per hour, an amount slightly higher than they made picking salal. They spent from 2 to 8 hours per day, for a varying number of days, collecting and recording data with the ecologist. Several Forest Service technicians from the Olympic National Forest were also trained to collect data, often in teams with the harvesters, facilitating cooperation and co-learning between participants.

Harvesters had neither the expertise nor the desire to conduct a statistical analysis of the data, so the researcher compiled the results. Harvesters did meet with the researcher to offer their interpretations of the data, which were presented as large bar graphs showing harvest yield results. With instructions on how to read bar graphs, and harvesters who served as Spanish translators, harvesters discussed in small groups why some results differed from their hypotheses, why sites responded differently to the same harvest treatments, and how the results could be used for management recommendations. This participatory process resulted in a project that both integrated western scientific knowledge and LEK, and addressed management questions important to harvesters and land managers, an outcome that could not have been achieved by ecologists alone (Ballard et al. 2005, Ballard and Huntsinger 2006). As this case demonstrates, participatory monitoring could also involve harvesters in project design, data collection, and analysis.

For harvesters to participate in such projects and share their LEK they must see a clear benefit, such as increased resource access or financial compensation. A number of benefits could serve as incentives. For example, many harvesters would welcome the opportunity to have sustained access to resources, especially forms of access that afford some protection such as zoning, stewardship contracts, or small leases that would allow them to steward a harvest area for an extended period. Institutionalizing commercial harvester relationships with forest management could help facilitate interactions and trust building that would lay the foundation for sharing knowledge.

Most scientists and managers lack the formal training to facilitate participatory research and monitoring processes. People trained in ethnographic methods, facilitation, and conducting focus groups, and who have established relationships with harvesters, would be well equipped to help out. A number of publications and tools have recently emerged to aid in this process (see Ballard et al. 2005, Lynch et al. 2004, Pilz et al. 2006).

Challenges to Using Local Ecological Knowledge for Biodiversity Conservation

Incorporating harvester knowledge into biodiversity conservation presents several challenges. For one, the lack of basic research on harvester demographics and behavior means that management and science can barely move beyond speculation about many aspects of commercial NTFP harvesters. Yet one only has to look around to see in nearly every store, restaurant, and airport evidence of hundreds of products made from NTFP species that occur in the Pacific Northwest. Some of these products are imported from other countries where the same species occur, but many are undoubtedly wild-harvested in the Pacific Northwest. Without a thorough understanding of who NTFP harvesters are, their motivations, and their issues, it is unlikely that much of their knowledge will find its way into science or management.

For those harvesters that are visible, a lack of trust between commercial harvesters and other stakeholders has built up over years, and it will take a sincere commitment of time and resources to remedy the situation before harvesters will willingly share their knowledge. Part of this lack of trust comes from the fact that commercial harvesters rarely feel any support from other stakeholders. Instead, they face constant forces that work to make their livelihoods more difficult, but without the organization and power to object in any significant way (Love and Jones 1997, Lynch and McLain 2003). The consequence is that many harvesters choose to maintain a low profile and avoid forest managers and scientists, making them appear secretive and unapproachable.

A few commercial harvesters own their own forest land, but most do not. If they do own or rent land, it is rarely enough to sustain commercial harvesting. Thus, harvesters are highly dependent on federal and state lands and large private lands, although it is difficult to negotiate access to the latter. Consequently, harvesters are limited in how much they are allowed to manage, and how much experimentation they can conduct on lands they do not own. With insecure tenure, the management practices they do implement may be rendered ineffective by others who also harvest NTFPs in the same locations.

A management trend over the last decade that is most likely affecting harvester populations and their ability to use LEK is that both public and private lands have been decreasing harvester access through gates, permits, and other means (Lynch and McLain 2003, McLain 2000). This can have the effect of concentrating harvesters into smaller areas of forests, and cause harvesters to abandon stewardship and conservation practices intended to improve harvest levels. Those harvesters who do not wish to abandon these practices will settle for smaller product quantities, or simply stop harvesting in an area altogether if it is not economically possible to sustain themselves. In fact, although no economic monitoring is done on the status of NTFP industries in the Pacific Northwest, many NTFP businesses have collapsed over the years resulting in fewer commercial harvesters, less diversity of products, and smaller quantities of NTFPs being removed. Such conditions make it difficult to implement LEK for managing NTFPs. However, interest in NTFPs remains strong, and management for their productivity, together with the creation of more economically favorable harvesting conditions, would likely see this trend reversed.

Ethnographic research shows that many commercial harvesters display an interest in the science and management of forest resources. Furthermore, research shows that under mutually beneficial circumstances, many harvesters would willingly share their knowledge with other stakeholders (Jones et al. 2004). Knowing this, managers should be especially careful not to undermine existing commercial harvester stewardship attitudes and behaviors through misinformed or hasty actions. For example, it might well be counterproductive to set permit prices so high that harvesters cannot afford them, or to consolidate harvesters into small areas such that it increases competition for scare resources. Managers and scientists need to bring harvesters into the scientific process, but that may mean sharing decision-making about what questions should be tested, and how.

Concluding Remarks

Few if any forest industry sectors depend on as many species or have such a diversified economy as that of commercial NTFP harvesting. Commercial harvesters are often in the forest on a regular basis making observations of, and interacting with, forest ecology in the course of their harvesting activities. The greater their knowledge and skill levels, the more successful they will be at harvesting. Thus, NTFP harvesters are an important source of local knowledge about forests. Participatory research studies have begun to show how western scientists can enter into mutually beneficial relationships with NTFP harvesters. Nontimber forest products make up a significant subset of biodiversity in the Pacific Northwest, with hundreds of NTFP species being commercially harvested in the region. Yet very little money has been invested in NTFP research and management, with even basic inventories lacking on most forests, and virtually no monitoring of the impacts of harvesting. Furthermore, commercial harvesters have voiced frustration with land managers over their

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disregard for the diversity of NTFPs being harvested, often demonstrated by the destruction of species-rich gathering sites resulting from activities such as logging. Attention to these issues would contribute to the conservation of NTFP species.

Conclusions

By defining the scope of our synthesis to include both TEK and LEK, and forest practitioners from three different groups, we emphasize the point that many different people use and manage forests—be it on private lands they own or have access to, reservation lands, or public lands. It is worth identifying who is actively engaged in local forest use and investigating the ecological knowledge they hold. To date, most of the literature on TEK and LEK from around the world has focused on indigenous peoples and farmers. Their ecological knowledge is valuable, but so too is that of other forest practitioners, who should not be overlooked.

Regarding views of biodiversity, we find that different groups conceptualize biodiversity differently. There are some clear areas of overlap, however, between western forest managers' notions of biodiversity, and those of forest practitioners who are American Indians, family forest owners, and NTFP harvesters in the Pacific Northwest. For example, all appear to favor forest management to support species/population and community/ecosystem-level diversity, and the composition dimension of biodiversity, though the composition desired by each group differs depending on what they value. In addition, all care about and have an interest in forest conservation.

Forest practitioners from the three groups actively use and manipulate forest resources to meet their needs and values. Nontimber forest product harvesters generally do not view their harvest activities as being detrimental, and many American Indians and family forest owners hold a belief that forests are better off because of their interventions, and in the case of American Indians, that forests need these interventions to maintain biodiversity. These views contrast sharply with those advocated by some conservation biologists who believe that biodiversity must be protected through preservationist approaches that prohibit resource use and remove humans from the landscape (e.g., Kramer et al. 1997, Oates 1999, Terborgh 1999, Terborgh and van Schaik 2002). These contrasting views imply very different strategies for biodiversity conservation. Where views about biodiversity and how to approach its conservation diverge, it is important to understand how differences can be reconciled to find common biodiversity conservation goals that people are willing to collaborate to achieve.

Regarding forest management practices and their ecological effects, we find that forest practitioners are applying TEK and LEK as they use and manage Pacific

Northwest forests. The extent of this knowledge and its use is not well known, however, because research documenting the contemporary forest management practices of forest practitioners is limited. Even more limited is documentation of the ecological outcomes of these practices, which are often assumed to maintain biodiversity despite a lack of scientific evidence and without careful scrutiny of issues, such as scale and which components of biodiversity are being maintained (e.g., genes, populations; species; communities; ecosystems; ecosystem structure, function, and composition). Although the causal relationship between culturally diverse forest management practices and biodiversity may well be a positive one, this relationship has not yet been adequately assessed in the Pacific Northwest.

Regarding the application of TEK and LEK to biodiversity conservation efforts, what most of the models described here share in common is an approach that actively engages forest practitioners, western scientists, and forest managers in on-the-ground projects that encourage interaction and knowledge sharing in the process of identifying goals, designing approaches, and implementing projects for forest management to conserve biodiversity. Knowledge sharing may occur in formal or informal ways, but by working together and sharing ideas, management approaches emerge that integrate different forms of knowledge. Two things needed to make such efforts successful are understanding the communication and operating styles of the people that hold TEK and LEK, and establishing a foundation of trust to work from. The communication and operating styles of forest practitioners may be quite different from those of western scientists and agency forest managers, with lack of sociocultural understanding between groups creating a potential barrier to understanding these different styles. Respecting others' knowledge and using it in appropriate ways is critical for trust-building. People trained in ethnographic methods, facilitation, and who have established relationships with the forest practitioners involved in such efforts may be well equipped to help out.

Both TEK and LEK persist, develop, and flourish through application. Yet they cannot be implemented if forest practitioners lack access to and some control over forest resources, or face economic and policy constraints that inhibit their use. Thus, serious efforts to integrate other knowledge systems for biodiversity conservation must be about more than finding the right or best methods and models for knowledge sharing and application. They must also address the fundamental structural issues—such as land tenure, the imposition of unfavorable forest management practices and policies, and market conditions—that threaten to undermine the viability of these knowledge systems and their implementation in diverse forest landscapes.

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It is also important to assess how well the kinds of models for integrating TEK and LEK into forest management discussed here are working, and to continue experimenting with new models, being sensitive to which are best suited for different groups. Few models and examples exist for groups other than American Indians, and those described in the literature lack assessments of how well TEK and LEK were actually integrated in forest management; what made for success or lack thereof in knowledge sharing and application; and what difference including TEK and LEK made on the ground.

Knowledge integration is impossible unless forest practitioners are willing to share their knowledge with western scientists and forest managers. They are unlikely to do so unless it is in their interest; thus, identifying incentives for, and mutual benefits from, knowledge sharing are important. For example, many harvesters would welcome the opportunity to have sustained access to resources, especially forms of access that afford some protection such as zoning, stewardship contracts, or small leases allowing them to steward a harvest area for an extended period. Institutionalizing commercial harvester relationships with forest management could help facilitate interactions and trust building that would lay the foundation for sharing knowledge. For family forest owners, working with scientists, natural resource agencies, and other landowners may help protect species before they become threatened or endangered, safeguarding owners from future regulation under the Endangered Species Act. And owners may be able to make biodiversity conservation efforts more sensitive to their own interests by working with other stakeholders and participating in these efforts. For American Indians, engaging in forest management on federal lands provides an opportunity to manage for and enhance the nontimber forest species and habitat types that have economic and cultural importance to them.

Several researchers assert that cultural diversity and biodiversity are linked, and that these links provide an opportunity for conservation. Biodiversity supports a broad range of cultural practices and adaptations, which in turn create demand for, and forest management to maintain, a broad range of species.

Active forest management for diverse objectives and products may maintain and restore biodiversity. Several researchers (see Maffi 2005 for a review) assert that cultural diversity and biodiversity are linked, and that these links provide an opportunity for conservation. Biodiversity supports a broad range of cultural practices and adaptations, which in turn create demand for, and forest management to maintain, a broad range of species. This synthesis obscures the cultural diversity that lies within broad categories of forest practitioners. To fully understand and appreciate the links between cultural diversity and biodiversity, it is necessary to look at the multiplicity of knowledge, practice, and belief systems held within cultural groups, and how they are expressed on the landscape. It is also necessary to examine their outcomes to address the question of whether active forest management for a broad range of species having economic and cultural value to a diverse group of forest practitioners can do more for biodiversity conservation than a hands-off, preservationist approach that seeks to re-create "natural" forest landscapes, as opposed to biocultural forest landscapes.

Research to improve understanding and documentation of TEK and LEK for forest management is needed for the three groups discussed in this paper, as well as others. Such research should do more than describe ecological knowledge systems; it should examine how this knowledge is being actively implemented and with what ecological outcomes, to understand how it might contribute to biodiversity conservation. Equally important is to expand efforts to engage local forest practitioners in joint forest management, for it is through practical application that this knowledge emerges and comes to life, and can be shared in an ongoing, interactive, and meaningful way.

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