LANDSCAPES IN TRANSITION:

PRIVATE LANDS OAK WOODLAND MANAGEMENT IN THE KLAMATH-SISKIYOU BIOREGION

By

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ABSTRACT

Oak woodland restoration is increasingly prioritized in the Klamath-Siskiyou bioregion of northern California and southern Oregon. More than 80% of oak woodlands (genus *Quercus)* in this region occur on private lands, and they are unique from a restoration perspective in that they require regular disturbance regimes and active management in order to sustain them. Few studies have systematically evaluated the methods by which land managers and owners plan for and implement oak woodland restoration at the landscape scale and individual parcel scales, and the constraints that each of these stakeholders face in the management process. The objectives of this study were to determine the extent of management of private oak woodlands in the Klamath-Siskiyou bioregion and the regional management needs of these ecosystems according to resource managers. This research attempted to identify factors likely to predict landowner engagement with oak woodland management, and the principle barriers to oak management according to both landowners and land managers. This study employed a combination of social science and GIS methodologies to survey 400 landowners and 150 professional resource managers regarding their perceptions of and management activities in oak woodlands. Survey respondents were mailed or emailed questionnaires comprised of ~70 questions regarding land stewardship and oak woodland management. The response rates were 25% (n=98) for landowners, and 44% (n=66) for land managers. Survey responses revealed that most landowners were not managing the oak trees on their properties to the extent that land managers perceived as necessary for long-term persistence of oak woodlands at the landscape scale. The survey responses indicated that

significant predictors for landowner engagement in oak woodland conservation may be parcel size, participation in conservation organizations and programs, perceptions of natural and prescribed fire, occupation, and amenity-based ownership values. Landowners and land managers identified a number of impediments to oak woodland management, including: lack of awareness of restoration needs, lack of resources available for restoration, competing land uses, shifting ownership trends, unclear oak woodland policies, lack of institutional support for prescribed fire, and unrefined methods and monitoring in oak woodland restoration. These findings can inform managers' and landowners' abilities to plan for and implement oak woodland management in the future at both parcel and landscape scales.

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LIST OF ABBREVIATIONS

BLM RAC: Bureau of Land Management Resource Advisory Council

CALFIRE: California Department of Forestry and Fire Protection

CCPI: Cooperative Conservation Partnership Initiative

CEQA: California Environmental Quality Act

EQIP: Environmental Quality Incentives Program

ESA: Endangered Species Act

FET: Fisher's Exact Test

FRI: Fire Return Interval

GIS: Geographic Information Systems

IRB: Institutional Review Board

KSB: Klamath-Siskiyou Bioregion

KWI: Klamath Watershed Institute

LEK: Local ecological knowledge

LiDAR: Light Detection and Range

NAD: North American Datum

NRCS: Natural Resources Conservation Service

Rx fire: Prescribed fire

TEK: Traditional ecological knowledge

TPZ: Timber Protection Zone

USFWS: United States Fish and Wildlife Service

WHIP: Wildlife habitat improvement program

WQIP: Water Quality Incentives Program

WUI: Wildland urban interface

INTRODUCTION

The implementation of ecological restoration on private lands is an increasingly prioritized objective amongst the conservation community (e.g. Lepczyk et al. 2004, Newburn et al. 2005, Collier et al. 2010). Conservation policies intended to provide protection for ecosystems have traditionally been designed with public lands and larger ownerships in mind and do not characterize most private ownership regimes (Franklin and Lindenmeyer 2002). Certain habitats exist primarily under private land ownership, and thus the conventional mechanisms for their conservation and restoration may be inadequate. More than 80% of the oak woodlands (genus *Quercus)* of the Klamath-Siskiyou bioregion of northern California and southern Oregon (hereafter: KSB) occur on private ownership (Oregon Biodiversity Project 2008). Due to the great diversity and degree of threat that characterize them, the oak woodlands of the KSB are increasingly analyzed by ecologists (Fisher and Bliss 2008). Oak woodlands are considered to be among the most productive, biodiverse, and threatened ecosystems in the United States (Noss et al. 1995), and have been designated as a conservation priority by multiple public agencies and private conservation groups in the KSB (Oregon Department of Forestry 2001, McCreary et al. 2011).

Few studies have systematically evaluated the barriers and opportunities that are presented to landowners and land managers who are planning for and implementing oak woodland restoration both at the landscape and at the individual parcel scales. Individuals who are attempting to implement oak woodland management goals across the KSB's landscape of multiple uses and ownerships are constrained by many ecological and social

factors. Furthermore, almost no monitoring of the efficacy of these restoration efforts has been conducted, nor has the knowledge derived from these previous efforts been incorporated into mechanisms for managing biodiversity at the landscape scale (Hosten et al. 2006).

Oak ecosystems are unique from a restoration perspective in that they require both active management and periodic disturbance regimes to regenerate; in the absence of both of these interactions, their ability to persist is greatly diminished (Agee 1993, Fisher and Bliss 2008). A changing eco-cultural context, combined with morphological characteristics unique to the genus *Quercus* have resulted in a drastic reduction of their range. More than 90% of the oak woodlands in the KSB have been removed for agriculture, grazing, and other human development, or have been replaced by other habitat types due to successional ecological processes (NRCS 2011).

For millennia, indigenous people managed oak woodlands throughout the KSB via pruning, coppicing, and episodic burning for the provision of food, resources, safety, and a multitude of cultural functions (Anderson 2005). By contrast, land use regimes over the past two centuries have emphasized intense grazing and farming practices, management of forests for production of coniferous species suitable for timber, and fire suppression at the landscape scale (Agee 1993, Huff et al. 2005, Morton et al. 2010).

As conservation practitioners progressively emphasize maintaining under-represented ecosystems and re-introducing natural disturbance regimes to the landscape (Lindenmeyer 2004), oak woodland restoration has become a highlighted conservation issue in the KSB (Noss et al. 1995, Fischer and Bliss 2008). Because a high proportion of oak woodlands are coincident with private ownership (NRCS 2011), landowners are in

a highly influential position to determine their management. However, the lack of standardized methods for restoring oak woodlands and the unique challenges of implementing conservation on private lands make achieving landscape-scale restoration of oaks throughout the KSB a notably complex goal.

Social research in restoration

In order to address the unique challenges of private lands' conservation, ecologists are increasingly proposing the implementation of more extensive sociological research that investigates the relationships between landowner profiles and the management regimes landowners practice on their properties (e.g. Hilty and Merenlender 2003, Lepczyk et al. 2004, Rickenbach et al. 2011). Long term monitoring data may highlight important correlations between specific landowner ecosystem management practices and the species assemblages and ecosystem integrity observed on their properties over time (Hostetler 1999). However, place-based sociological data are necessary in order to explain why landowners are most likely to utilize specific management practices (Habron 2004). Research to provide linkage between biological and social occurrences entails gathering data that reveal what activities landowners are engaged with on their land and their reasons for doing so. Results from such research may reveal not only valuable data on what activities are taking place on private lands, but also whether there may be specific explanatory variables associated with landowners who engage in conservation

activities on their properties, as opposed to those who do not. The opportunity to collect qualitative data derived from landowner surveys and questionnaires could yield new and valuable insight to a long-standing socio-ecological question of how to best engage private landowners for the public goods of ecological conservation and restoration. Social research may be more effectively applied to ecological restoration if it also encompasses the significant insight and perspectives of the land managers and professionals who are often responsible for implementing the decisions of land owners. These professionals tend to view and implement ecosystem management across multiple spatial scales, ranging from individual parcels to large management units.

Surveys are the most commonly-implemented tool used in sociology for data collection (Dillman 2000). They are useful largely because they "produce information that is inherently statistical in nature," and are generally designed to question "behavior, attitudes/beliefs/opinions, characteristics, expectations, self-classification, and knowledge" (Groves 2004). Sociological data gained from surveys are increasingly recognized as being fundamental to addressing conservation issues, and this is particularly the case in cases of private land management, where there is generally less available information or systematic collaboration in land management practices than on public lands (Newburn et al. 2005). Survey questionnaires should be designed to be as uniformly understandable and interpretable as possible by their respondents. Respondents of different backgrounds and socio-demographic profiles will not always interpret questions the same way; therefore survey design must be highly attentive to the wording and syntax in order to attempt to maximize the uniform comprehension of questions (Dillman 2000). A principle objective of surveys is often to achieve the highest response

rate possible. When response rate is high, self-selection is less likely to influence the responses, which means that the sample more accurately represents the population (Huntsinger 1990).

The significant knowledge embodied by both landowners and land managers is a critical contribution to the greater effort towards oak woodland management across the KSB. As remaining oak woodlands continue to become fragmented and compromised by human development and habitation, an evaluation of the social processes underlying these impacts is an essential aspect of the conservation planning process. Articulating the current status and the future of oak woodlands in the KSB requires more in-depth knowledge of specific activities and characteristics of the individuals who are interacting most closely with these habitats, which are in most cases the landowners and resource managers (Kendra 2003). The implementation of upland watershed restoration efforts across the matrix of the KSB's land ownerships remains a critical challenge facing its stakeholders. Conserving its oak woodland habitats, the biodiversity they support, and the important ecological and cultural functions they contribute to the watershed system as a whole is an imperative, although understudied, component of the current ecological restoration discussion occurring among the region's stakeholders.

Collecting first-hand information about how people interact with the landscapes that they inhabit is an often-overlooked aspect of the conservation process (Hilty and Merenlender 2003). Yet when conducting ecological monitoring across a mixed land use landscape, data about landowners may be indispensable. Landowners who elect to practice conservation and restoration on their properties confer myriad benefits to themselves and their properties, to the watersheds and ecosystems in which they live, and

to society as a whole. Aldo Leopold wrote in *The Land Ethic* (1934) that "conservation will ultimately boil down to rewarding the private landowner who conserves the public interest." Nearly a century later, these words can be directly applied to the oak woodlands of the KSB.

The objectives of this research are to:

1. Describe the extent and nature of oak woodland management on private lands in the KSB, as well as the management goals of the region's professional resource managers.

2. Identify characteristics of participating and non-participating landowners in oak woodland conservation practices in the KSB.

3. Determine the motivations for and barriers to implementing oak woodland restoration at both the individual parcel and the landscape scale, according to both landowners and professional land managers.

LITERATURE REVIEW

Study Area: the Klamath-Siskiyou Bioregion

The KSB is an approximately 12,000 square mile, hourglass-shaped watershed straddling southern Oregon and northern California (Figure 1), delineated by the Klamath River and the associated sub-basins that drain into it[1]. The KSB encompasses a dense network of mountain ranges and is widely recognized for its unique geomorphic composition and correspondingly diverse range of flora and fauna (Wallace 1983). The Klamath River originates in the Cascade mountains of central Oregon, and then passes through the Upper Basin comprised of agricultural and rangelands, Upper and Lower Klamath Lakes, and vast wetland systems. From here, the Klamath River crosses into California and descends into the Lower Basin, dropping steeply through Klamath Gorge, ultimately flowing through mixed coniferous forest to its mouth on the Pacific coast (Doremus and Tarlock 2008).

[1] The spatial definition of the Klamath-Siskiyou Bioregion differs according to various sources. . The definition used for this study is derived from Klamath Watershed Institute's boundary layer (Klamath Watershed Institute, 2009).

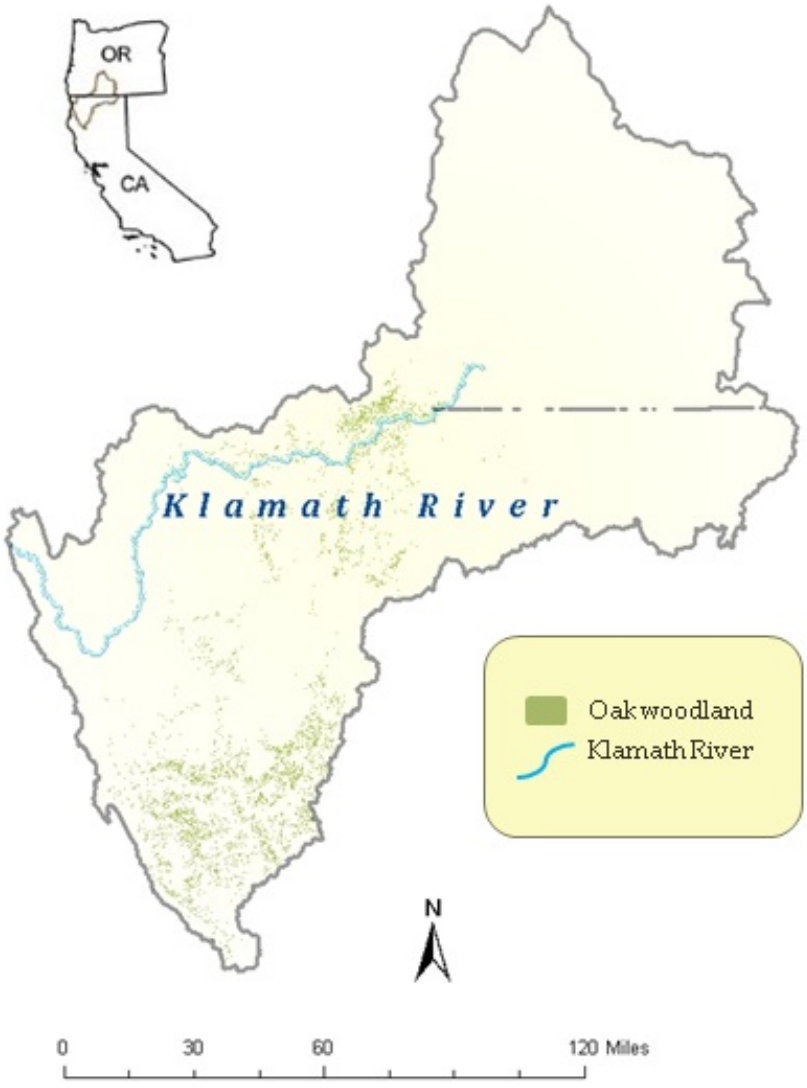

Figure1. Study Area: Oak woodlands of the Klamath-Siskiyou Bioregion.

Of the KSB's approximately 10 million acres, 6.2 million acres are public, 3.7 million acres are private, and 90,000 acres are tribal (NRCS 2004). When represented geographically, both land ownership and land use appear as a patchwork quilt (Figure 2). The KSB contains land use patterns that are variable both spatially and temporally. Many rural areas of the western United States, including the KSB, are undergoing profound shifts in ownership as large landholdings are divided into smaller parcels and greater numbers of people move from urban areas into these rural, less densely-populated landscapes (Gosnell et al. 2009). These smaller parcels contain increasingly fragmented segments of ecosystems that provide critical wildlife habitat and repositories of biodiversity, such as oak woodlands (NRCS 2011).

Oak woodlands are considered by the state of Oregon's Department of Fish and Wildlife to be a *strategy habitat*, by which the state identifies at-risk habitats and species (ODFW 2001). Oak habitats of the KSB have diverse vegetative and structural compositions and occur at multiple seral stages (Oregon Biodiversity Project 1998). These woodlands were once prominent ecosystems throughout the KSB, but have been diminished during the last two centuries to less than 10% of their original range (NRCS 2011). Currently, the majority of forest management plans in the KSB are written with timber-producing, coniferous forests in mind, and few protections are afforded to oak habitats via forest practice regulations (Giusti and Merenlender 2002).

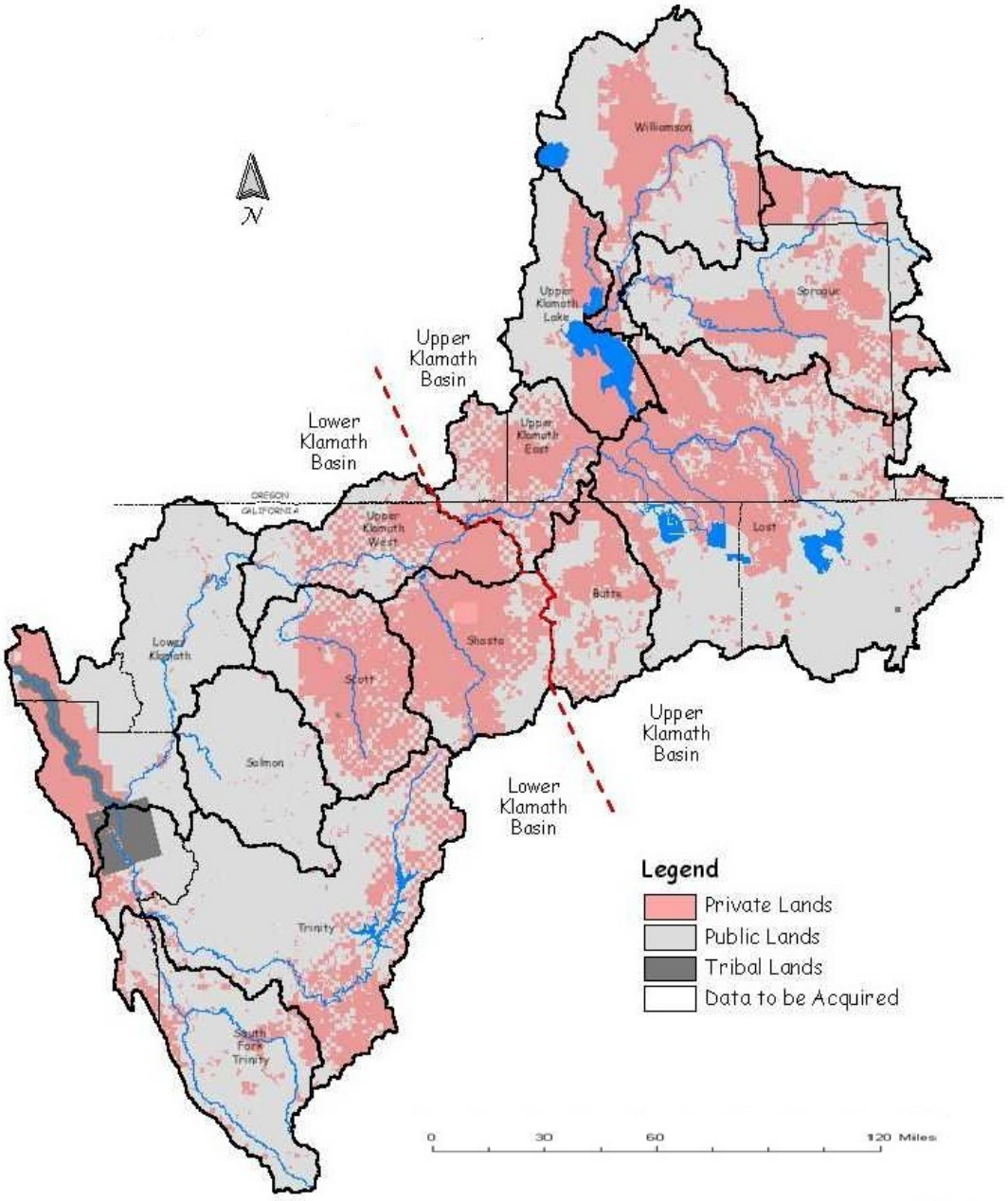

Figure 2. Land Ownership in the Klamath Basin. Dashed line indicates border between Upper and Lower Basins. Map from NRCS Work Plan for Adaptive Management, 2004.

Humans and Oak Woodlands

Humans around the world have long associated closely with oak woodlands and continue to do so, utilizing them for food, fuel, building material, and habitat for themselves and their livestock (Pavlick 1991). Anthropological data suggest that oak woodlands and savannas are intrinsically attractive to humans, providing open space with high visibility, safety, and aesthetic appeal (Logan 2005). In the KSB, indigenous people have concentrated in and near oak woodlands for millennia, maintaining and altering them for optimal forage, hunting and living conditions (Anderson 2005). Oaks have been managed by humans through processes of traditional ecological knowledge (TEK) and local ecological knowledge (LEK), which can be thought of as a "cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes et al 2000). TEK and LEK tend to be informally disseminated and transferred through generations and among those who utilize and inhabit ecosystems (Berkes et al. 2000).

Ecologists and ethnobotanists suggest that forests stewarded with TEK or LEK tend to be managed in "steady-state shifting mosaics" of adjacent successional stages (Martinez 2003). Creation of landscape patchiness, which has more recently become a central objective in forest management schema (Lindenmeyer 1999), is used commonly by people for the purpose of resource harvesting, which enhances biodiversity and provides variable patches from which to gather resources. Patch creation also reduces vulnerability to exogenic disturbance events such as pest outbreaks, catastrophic fire, and

drought (Anderson 2005). Patchiness tends to confer resilience to an ecosystem, or its "capacity to recover after disturbance, absorb stress, internalize it, and transcend it" (Berkes et al. 2000).

Fire scar, tree ring, and pollen records indicate that oak distributions are diverging drastically from pre-European contact oak habitats as human perturbations alter their historic trajectories (Hosten et al. 2006). These biological records are corroborated with cultural literature and resources, as well as site descriptions from arriving settlers and explorers (Sugihara and Reed 1987). Historical data and current land use patterns in the KSB reveal complex land use regimes of routine burning, logging, livestock grazing, fire suppression, agricultural conversion, introduction of non-native grasses and other annuals, and residential development (Fisher and Bliss 2008). Due to its high wood density and unique structural composition, oaks make superior firewood and have been harvested extensively in order to fuel these developments, at the rate of tens of thousands of cords per year (Pavlick 2001). Contemporary settlement patterns in the KSB continue to favor oak woodland sites for residence, recreation, agriculture, and grazing (Garmon 2006).

Human communities around the world have long relied upon the high productivity associated with oak ecosystems to support many aspects of their lives. Their extremely nutritious acorns were dietary staples of many of the indigenous people throughout the KSB (Anderson 2005). Various species of acorns were harvested, and each tribe had different methods for preparing and storing them. Land claims and distributions amongst different tribes were often delineated based upon the spatial distribution of the oak woodlands in each area (Pavlick 1991). Indigenous fire regimes enhanced the production

of scores of edible species such as camas lily (*Camassia quamash*), and maintained productive grazing land for game animals such as deer and elk (Hosten et al 2006).

European immigrants, many accustomed to oak woodland habitats that they had left behind in their native countries, were also heavily drawn towards the oak-covered regions of the KSB. . A previous study of rural, family forest owners in Oregon found that landowners had developed a strong sense of stewardship over the ecological and cultural heritage of their properties and the oak trees therein (Fisher and Bliss 2008). Communities (e.g. Oakland and Oakridge) were simultaneously named after oaks as oaks were removed to clear land for farms, orchards, vineyards, and levees. Hundreds of thousands of acres have been cleared for livestock production, agriculture, residences, and firewood to fuel these developments, at a tremendous cost to the region's oaks (Pavlick 1991).

Oak Woodland Ecology

The genus *Quercus* is capable of exploiting an extremely diverse range of habitats and environmental conditions, with more than 600 species throughout the world (Logan 2005). The oaks of the KSB take no exception to these global occurrences, growing at many elevations and in highly variable edaphic compositions (McShea and Healy 1999). Within-species variation is notably high in many oaks, producing individuals ranging from large and decadent to dwarfed and shrubby, depending upon site characteristics and disturbance history (Johnson and O'Neil 2001).

Four dominant oak species are native to the KSB: Oregon white oak (*Quercus garryana),* California black oak, (*Q. kelloggii),* canyon live oak, (*Q. agrifolia),* and blue oak (*Quercus douglasii*) (Johnson and O'Neil 2001). Additionally, the tanoak, (*Lithocarpus densiflorus),* is commonly classified into the oak family and was included in this research. Although it is not a true oak, tanoak is a regionally distinctive forest type in many parts of the KSB, and fulfills a functionally similar role in the ecosystem, producing a massive acorn crop that has been a staple food of wildlife and humans alike (Hosten et al. 2006) .

Of these five species, *Q. garryana* is the most ubiquitous and wide-ranging in the KSB, occurring at elevations ranging from sea level to 7,500 feet (Hanna and Dunn 1997). *Quercus garryana* is well-adapted to a hot and dry climate, and can thrive in summer drought that inhibits the growth of many other tree species. Oregon white oak woodlands and savannas[2] are hallmarks of the KSB's landscape. These classically recognized ecosystems exhibit open stands of statuesque, mature specimens with understories comprised of grasses, forbs, and shrubs (Wallace 1983). Tan oak, live oak, and black oak often grow in dense, multi-layered canopies of mixed composition, which were also considered oak woodlands in this research.

Oak woodland communities are considered to be among the most diverse and productive in the KSB (Johnson and O'Neil 2001). Much of this floristic diversity is due to the high level of disturbance required to maintain them, and the mosaics of habitats

[2] Within oak communities, there is a great diversity of oak sub-habitats, such as woodlands, savannas, and mixed oak forests. Oak woodlands and savannas are distinguished by the percent canopy closure they maintain and by the composition of their understories. Savannas are open, grass-dominated expanses with less than 30 % canopy cover, whereas woodlands have between 30 and 60 % canopy closure (Hanna and Dunn 1997).

that are created as a result of these disturbance processes (Agee 1993). Oak woodlands frequently host rare or endangered plant communities, diverse forb and perennial bunchgrass understories, and many species of hardwoods, conifers, and shrubs. Oaks commonly occur amongst mixed-conifer forests, and can be found interspersed with Ponderosa pine (*Pinus ponderosa),* Douglas fir (*Pseudotsuga menziesii*), Western hemlock (*Tsuga heterophylla*), Western redcedar (*Thuja plicata),* Pacific madrone (*Arbutus menziesii*), and many other trees. Common understory shrub associations include snowberry (*Symphoricarpos albus),* various species of *Ceanothus*, Oregon grape (*Mahonia nervosa),* serviceberry (*Amelanchier alnifolia*), and dozens of others (Johnson and O'Neil 2001). They also provide habitat for numerous rare mosses and lichens, such as *Sulcaria badia,* which grows primarily on *Q. garryana* and has been extirpated in parts of its ranges, presumably due to loss of oak habitat (Oregon Biodiversity Project 1998).

Oak woodlands and savannas are among the most important habitat for fauna in the KSB, hosting over 200 species of terrestrial vertebrates, an abundance of amphibians, reptiles, and insects, and also serve as corridors for numerous species of anadramous and resident fish (NRCS 2011). More than 110 bird species occupy oak woodlands during the breeding season, and 35% of the KSB's terrestrial mammals utilize them during their lifetimes (McCreary et al. 2011). Structural elements such as variable overstory, large, complex branches and trunks, snags and cavities, and litter and course debris on the ground provide critical habitat for wildlife. Oak trees form a trophic base of energy for a large and complex food web. Acorns and their young sprouts and shoots, which are extremely caloric and nutritious, are a principle food for bear, deer, squirrels, and numerous other mammals, who heavily utilize oak woodland areas. They are also relied

upon by domestic livestock, who browse acorns in the understory, supplementing their grass and hay-based diets with much-needed fats, minerals, and vitamins (Pavlick 1991).

Many animals are dependent upon structural attributes provided only by oak trees of particular stature or age class. Dead oaks, both standing and downed, are critical structures for the wildlife of the oak woodland community. Standing, large-diameter snags are essential nesting locations for many birds and mammals (Johnson and O'Neil 2001). Oaks are unique among trees in that older, living oaks often contain large sections of dead wood or branches that provide habitat and foraging material for wildlife (Marcot et. al 2010). Some wildlife are dependent upon structural attributes provided only by oak trees of particular stature or age class. Mature "legacy" oaks are crucial for nesting and roosting sites for raptors, woodpeckers, and many mammals (Johnson and O'Neil 2001). Mature oaks have highly complex bark surfaces that host rich plant communities, such as mistletoe, epiphytes, and lichen, and are used by many species for foraging and nest-building material (McShea and Healy 2002).

Oak habitats of the KSB are considered to be obligate for several songbird species, such as Lewis' woodpecker (*Melanerpes lewis),* Western bluebird (*Sialia mexicana),* acorn woodpecker (*Melanerpes formicivorus*), oak titmouse (*Baeolophus inornatus*), and white-breasted nuthatch (*Sitta carolinensis*) (Hosten et al 2006). Just as wildlife are dependent upon oak trees for their survival, oaks also benefit from particular functions and services that wildlife provide to them. Jays, for example, are known to promote oak regeneration through their behavior of caching acorns across their territories, dispersing oak genetic material (McShea and Healy 2002). Oak habitats contain more species of foliage-feeding Lepidoptera than any habitat in North America, which are the

major food source for gleaning species such as warblers and vireos. These birds in turn keep Lepidoptera densities from becoming so high that they excessively defoliate the oaks (Marquis and Whelan 1994).

The presence of even just one isolated legacy oak tree can have profound effects upon the diversity in the area surrounding it, which may translate to greater biodiversity at the landscape level. One mature oak tree within an agricultural matrix has been shown to support 47 species of birds, 16 of which are associated specifically with oak woodlands and savannas (DeMars et al. 2010). Other studies about remnant trees have demonstrated that older legacy trees support greater faunal diversity and usage than less mature or sizeable trees, and can provide ecosystem benefits that are disproportionally greater than their area on the landscape (Mazurek and Zielinski 2004). Endangered species such as Pacific fisher (*Martes pennant pacifica)* and Northern spotted owl (*Strix occidentalis)* have also been observed utilizing legacy oaks (NRCS 2011).

Fire and Oak Woodlands

The diverse range of flora and fauna of the KSB have co-evolved with fire for millennia (Martinez 2003). By contrast, the twentieth century and onward have been characterized by an absence of low-intensity, frequent fires that were once ubiquitous on the landscape (Reed and Sugihara 1987, Agee 1993). Modern forest management practices, along with increased human habitation in the wildland urban interface (WUI), have favored fire suppression, and as a result these ecosystems have undergone succession towards less fire-dependent species compositions, such as Douglas fir and

Western juniper, and tend to exhibit high stand density, heavy fuel loads, and enclosed canopies (Agee 1993).

Although the ecological implications of fire suppression are only beginning to be understood, it is thought to be one of the major factors contributing to the decline of oak health and regeneration (McCreary 2004). Ecological and ethnobotanical data indicate that fire return intervals prior to Euro-American settlement were significantly shorter than they are now, and that much of the fire on the landscape in the KSB occurred due to indigenous practices of managing various ecosystem types (Anderson 2005). These frequent, mild fires were combined with intermittent and more severe naturally-occurring fire events. The combination of anthropogenic and natural fires produced conditions that were optimal for the persistence of oak trees throughout the region (Hosten et al. 2006). Historic fire intervals promoted cohorts of mature oak trees with perennial grass understories, which formed mosaics of habitats at different successional stages and promoted diversity of flora and fauna at the landscape scale (McCreary 2004).

Oaks are morphologically adapted to and dependent upon short and non-catastrophic fire return intervals (Reed and Sugihara 1987). They are able to withstand episodic burning due to physical characteristics such as flame-retardant bark, sap that is less flammable than many coniferous species, and ability to re-sprout from the base after a fire (Johnson and O'Neil 2001). Regeneration of oak seedlings has been found to be greatly improved post-fire, producing a seedbed that is more conducive to germination, creating less favorable conditions for wildlife that predate upon acorns and seedlings, reducing competition, and increasing recruitment by clearing accumulated litter and ground fuels (Hanna and Dunn 1997). However, the hotter temperatures and prolonged

burning times that are characteristic of contemporary fire regimes tend to destroy topsoil, making oak recovery far more difficult and time-consuming (McCreary 2004).

In the absence of regular burning to maintain them at lower densities, fuel loads and ladder fuels have amassed to unprecedented levels, resulting in greater likelihood of catastrophic crown fires rather than the historically-prevalent low-intensity fires that do little damage to mature trees (Reed and Sugihara 1987). Fire suppression has more severely affected ecosystems such as oak woodlands and savannas where fires were more frequent and less severe than in those ecosystems where fires occurred less often (Huff et al. 2005). Thirty-five years ago, Reed and Sugihara (1987) predicted that conifer encroachment would cause the white oak woodlands in their KSB study sites in to disappear or become severely degraded within 30 years. These predictions have been widely confirmed. Many oak stands have succeeded to even-aged, densely-populated "dog-hair" thickets that are competing for space and sunlight and, as such, cannot achieve the decadent, open crown structure characteristic of historical oak woodlands (Hanna and Dunn 1997). Under dense conifer understories, shade-intolerant oak seedlings have little chance of survival, and many of the oaks that remain are of reduced health and vigor. The forests that have resulted from over a century of fire suppression lack age-class heterogeneity that is crucial for the supporting many kinds of wildlife (Huff et al. 2005). The increasing isolation of remaining oak stands reduces connectivity and the ability of oak obligate species to move between stands. This decreases genetic variability and resilience, and renders species more vulnerable to stochastic events and population sink (Noss et al. 1995).

Oak Woodland Management and Restoration Pathways

The oak forests of the KSB are threatened by poor regeneration in some species, habitat loss, fragmentation, soil compaction and erosion, overgrazing, invasive species, overharvesting, and loss of vital ecological processes such as fire (Hosten et al. 2006, Noss et al. 1995). Oaks tend to grow slowly in comparison with most other tree species, taking decades to reach maturity. It takes about 150 years to grow an oak tree that can support cavity nesting (McShea and Healy 2002). Because of this slow turnaround time, many restoration ecologists recommend conserving and restoring existing habitats in favor of attempting to create new ones (Hanna and Dunn 1997).

Because they are shade-intolerant and fire-dependent, most oak woodlands require a comparatively high level of sustained, active management, making their restoration labor-intensive, costly, and prolonged (Hosten et al. 2006). Oak restoration tends to be highly site-specific, meaning that techniques successfully employed on one property may not be effective on another (Lomakatsi Restoration Project 2009). The site-specific nature of oak woodland restoration highlights the importance of close cooperation between land owners, who are often most familiar with nuanced site characteristics and disturbance histories, and resource managers, who can provide the technical expertise and experience to plan and implement such projects. In many cases restoration requires removal of conifers via either mechanical thinning or localized controlled burns[3] (Mid-Klamath Watershed Council 2008).

[3] In this research, controlled burn, prescribed fire, and Rx fire are used interchangeably. They all refer to the process of intentional fire ignition under specified conditions in order to produce specific management objectives (Agee 1993).

The Society for Ecological Restoration defines ecological restoration as "the process of assisting the recovery and management of ecological integrity. Ecological integrity includes a critical range of variability in biodiversity, ecological processes and structures, regional and historic context, and sustainable cultural practices" (SER Publication 2004). When deciding upon a reference ecosystem by which to gauge the restoration process, there are many important ecological, economic, and aesthetic considerations for landowners and land managers. A more holistic restoration method accounts for the effects both at the stand and the landscape level by envisioning a "reference landscape". A reference landscape consists of a mosaic of seral stages, vegetation assemblages, patches, and linkages between these features (Martinez 2003). Landscape-scale factors such as stand fragmentation, adjacent habitats, and edge-to-interior ratios are critical considerations when planning for oak restoration. The adjacent habitats to oak woodlands will greatly impact the community structure within the stands, and how those stands interact and maintain dispersal pathways with surrounding habitats (Noss et al. 1995).

Oak woodland restoration requires a considerable amount of preparatory labor. Dennis Martinez (2003) recommends the following work schedule. Prior to a restorative burn, forest thinning and removal of invasive plants can be conducted through middle to late spring, until bird nesting season begins. The recommended pattern for pre-restoration thinning is to maintain uneven-aged, variable density stands, commonly referred to as skips and gaps, with varying levels of canopy closure. Thinning should ideally be conducted in five to ten year intervals so as to not drastically alter the forest at one time,

although this may not always be entirely feasible given time or financial constraints (Lomakatsi Restoration Project 2009).

The future herbaceous, shrub, and tree stock to be planted after a restorative burn can often be gathered and propagated from the very same site, and, for optimal site fitness, ideally should be. Acorns and native plant seeds should be collected as they mature during the summer and early fall. Ideally acorns are from no further than 100 miles away in order to ensure that they are adapted to a site, but should also be taken from a variety of elevations, to promote resistance to both freezing and drought in future forest gene pool (Martinez 2003). Re-seeding with annuals is generally not supported by ecological restoration practitioners, as it does not necessarily prevent erosion on a denuded landscape. It also produces significant amounts of dry, hot fuel that is likely to contribute to a high-intensity fire the subsequent year (McCreary 2004). Instead, replanted areas are best reseeded and replanted with native perennials. Plant species that are not present in the current assemblage but are desired in the reference system can be directly seeded into the ashes after a burn (Martinez 2003). As serotinous species, only around 30% of *Quercus* seedlings are killed during a burn, while nearly all conifer seedlings are killed (Hanna and Dunn 1997).

Any remaining fire preparations should be made after the first fall rains, and slash piles burned. When burning slash, burn piles should be placed far away from legacy trees or sensitive areas in order to prevent scorching, and some piles should be left for wildlife habitat. Snags and nurse logs would ideally be maintained, and course woody debris placed perpendicular to slope to catch upslope erosion and build soil (Lomakatsi Restoration Project 2009). Just before the first major rains of the season, if the

preparatory work has been conducted sufficiently, the burn window begins and burning may be applied if conditions allow.

The temporal nature of restoration activities should be considered when using fire as a restoration tool. While natural wildfires predominantly occur in summer (June through September) in the KSB (Agee 1993), this is also a time of higher potential for fire escape, and poses potential risks to humans and their properties. In order to prevent fire escape, therefore, some controlled burns are administered in spring, which is potentially detrimental to many species of wildlife, which are entering their breeding seasons. Alternatively, when fires are ignited during late summer and early fall, they may coincide with the acorn mast, destroying this vital food source upon which wildlife heavily depend (McCreary 2004). The effects of seasonally variable burns upon the fauna of oak woodlands and their behavior have not been thoroughly investigated (Huff et al. 2005). The intricacies of planning for prescribed burns when considering appropriate ignition conditions, human property and safety, effects upon wildlife, and other ecological impacts can introduce significant complexity to the oak woodland restoration process.

After a burn is complete, newly planted trees and plants require a great deal of care and maintenance. Seedling mortality is often high, particularly during the first year (McCreary et al. 2011). Oaks regenerate more effectively on north-facing slopes, where temperatures are lower and precipitation is greater than on southern aspects (Martinez 2003). Oak seedlings must be planted in areas that provide adequate water and protection from deer, livestock, and other forms of predation and trampling. Installing enclosures and vaca cages is highly recommended if they have been planted in active rangelands

(Giusti 2008). Range managers have found that grazing seasonally, allowing livestock to graze in oaks during winter and spring, when more green material is available to them, and excluding them during summer, when there is less available forage, can significantly reduce seedling and sapling damage (McCreary 2004).

Land Fragmentation and In-Migration

The number of family forest owners in the United States is increasing by about 150,000 owners per year as larger landholdings are parcelized and sold (White and Mazza 2008). The land owned by family forest owners changes hands an average of every 10-49 years, and average land tenures are declining significantly (Rickenbach et al. 2011) Although the trends are complex and poorly understood, surveys of these landowners demonstrate that owners of smaller parcels of forestland are less likely to manage their forests than are owners of larger parcels or those with longer land tenure (Birch 1996). Recent in-migrants tend to own their properties for a host of reasons that are somewhat distinct from landowners who have resided in the region for long periods of time (Gosnell and Abrams 2009). The land use patterns in the KSB are reflective of these nationwide trends, resulting in more landowners on rural, residential properties across the landscape (Charnley et al. 2008). The declining agriculture, ranching and forestry bases of the KSB have decreased landowners' ability to earn their livelihoods from these traditional economic staples. Many of the remaining large landholders in the KSB are of advanced age, and when they pass away and leave their properties to their children, the inheritors decide to subdivide and sell the land. At the same time, the

demand for rural residential properties is increasing (Charnley et al. 2008).

Much of this increased demand is due a process of "rural restructuring," in which significant amounts of people from out of the area relocate to rural communities because they are drawn to the natural or cultural amenities available there (Gosnell and Abrams 2009). According to the amenity-based model of migration, rural areas are increasing in population because they have desirable attributes such as attractive surroundings, small communities, and open space. These attractions bring new residents, often from more urban areas, who carry with them both financial and human capital, and significantly influence the character of the rural community to which they relocate (Charnley et al. 2008). The majority of these in-migrants are less financially dependent upon the management of their land, and they tend to be employed in professional, post-industrial sectors (Gosnell and Abrams 2009). Due to population increases, westward migration, evolving economic bases, and changing patterns in how and where people choose to live, thousands of acres per year are being converted from large, contiguous landholdings to smaller "ranchette" parcels; thus median parcel size is diminishing (Pincetl 1999). Charnley et al. (2008) attribute much of the in-migration and parcelization currently taking place in the KSB to "inexpensive real estate, low cost of living, recreation opportunities, and scenic beauty." The increased number of developments on ranchette parcels is considered to be one of the biggest threats to oak woodlands in the KSB (NRCS, 2011).

Recent in-migrants often have different land management objectives than the traditional landowner base, and value non-utilitarian aspects of their property such as scenic value, seclusion, and conservation of biodiversity more highly (Gosnell and

Abrams 2009). While in-migrants tend to own smaller parcels, the cumulative amount of land they own is substantial, resulting in the fragmentation of biodiverse and threatened habitats. Although parcelization is a well-documented phenomenon in the United States, the ecological effects of the resulting fragmentation, and the social dynamics that underlie it, remain poorly understood (Gosnell and Abrams 2009).

METHODS

Site Selection and Sampling Design

The sampling units for this study were selected using Geographic Information Systems (GIS), based upon the coincidence of privately-owned properties and oak woodland habitats within the KSB. All spatial layers used for the analysis are shown in Table 2. The initial boundaries of the KSB, as well as the sub-basins and physical properties therein, were defined using the parameters set by the Klamath Watershed Institute (KWI) based out of Humboldt State University (accessible via www.klamathinstitute.org). All subsequent layers were clipped and re-projected in order to be consistent with KWI boundaries and projections (UTM Zone 10 N, NAD 83). Multiple base layers were overlaid in the process of site selection. Oak woodland habitats were identified using three vegetation layers. Vegetation classification in oak habitats has been noted to be particularly difficult in the context of predicting oak distribution. One of the most challenging aspects of mapping oak habitats is that individual oaks are rapidly being overtopped by taller conifers, which makes them increasingly difficult to identify via remotely sensed imagery (Keane et al. 2007). Mixed oak woodlands tend to be extremely diverse in terms of their floristic composition, which can confound habitat classification. Previous oak woodland classifications have experienced an average of at least ten percent error (Byrd et al. 2009). In order to optimize efforts to sample only the desired habitat types in this analysis, two raster vegetation layers and one 5 meter resolution LiDAR layer were overlaid.

Table 1. Spatial data used in sampling design and parcel selection

Data Layer	Source	Format	Use
Klamath Basin boundary	Klamath Watershed Institute	Polygon	Klamath Basin Delineation
Klamath Sub-Basins	Klamath Watershed Institute	Polygon	Major sub-basins of Klamath Basin
Klamath watercourses	Klamath Watershed Institute	Polyline	Klamath River and Major Klamath tributaries
LANDFIRE 2008 REFRESH	US Forest Service, US Department of Interior	Raster	Landscape fire and resource management planning
LULC	US Geological Survey	Raster	Land Use Land Cover, Vegetation change
Oregon Explorer	Oregon State University	LiDAR	Light detection and ranging aerial imagery
Humboldt	County of Humboldt, CA	Polygon	County and parcel boundaries
Trinity	County of Trinty, CA	Polygon	County and parcel boundaries
Siskiyou	County of Siskiyou, CA	Polygon	County and parcel boundaries
Klamath	County of Klamath, OR	Polygon	County and parcel boundaries
Jackson	County of Jackson, OR	Polygon	County and parcel boundaries

Oak woodland habitats were classified by pairing two separate raster layers. The first was the 2008 Refresh Regional Coverage of the LANDFIRE dataset. LANDFIRE was developed by national fire management agencies as an ordinal index of landscape change. This dataset is intended to provide fuels, fire regime, vegetation class, and ecosystem restoration data for the entire country, but has a particular focus on the fire-prone western United States. LANDFIRE was developed using a succession model that predicts how far the current landcover has shifted from its historical trajectory, and divides these into ordinal categories (Keane et al 2007). The Klamath Basin area was then re-classified using the USGS LULC (Land Use Land Cover) GAP Analysis remote sensing data set. GAP is a Landsat-based dataset that describes land uses and vegetative covers for the entire United States, grouping them into thematic classes (Stockenberg 2008). An error checking process was applied to the LANDFIRE and GAP datasets using the Raster Calculator function of ArcGIS (Version 10.0). The two raster datasets were classified into "oak" or "non-oak." Those that contained oak were re-classified into oak habitat types, some comprised of homogenous oak stands, and others of mixed oak alliances (Figure 1).

Once oak habitats for the entire KSB were classified, parcel boundaries and ownership information were obtained via county planning and tax assessor records for each individual county within the KSB. Five counties were in the study area: Humboldt, Siskiyou, and Trinity (California) and Jackson and Klamath (Oregon), (Table 1). Each county maintains its own unique policies and procedures for storing and releasing its tax lot data, and complete tax parcel layers for each county were eventually obtained. All counties were merged into one layer so that their attributes could be analyzed

simultaneously. Each parcel that agreed in its classification of oak habitat by 75% or greater between the LANDFIRE and GAP 30 x 30 meter pixels was included in the analysis, and those that did not agree were excluded. Each remaining parcel was classified into public or private; all public parcels were eliminated from the analysis. Next, any private parcels that were categorized as industrial or commercial were removed. In order to emphasize the tracts of land that are contiguous blocks of similar habitat type, parcels that were less than 20 acres were excluded from the analysis. A threshold was set so that only parcels that contained at least 15% oak habitat according to the imagery sources were included in the study. Using the Random Number Generator function in ArcGIS, 400 parcels that met all of the above criteria were selected for inclusion in this survey. If a landowner owned multiple parcels and was selected more than once, the second parcel was removed and a new parcel with a different landowner was selected.

Survey Methodology

This study was conducted using a randomly drawn spatial sample of landowners who inhabit oak woodland landscapes. A written questionnaire format was selected for this study. This method has benefits and drawbacks. The benefits are that they produce statistical information about which it is easy to maintain privacy, and it is relatively inexpensive. The drawbacks are that turnaround can be slow (it sometimes takes several weeks for surveys to be returned) and response rate tends to be lower than in other methods (Dillman 2000). Owner names and addresses for each property were obtained

from each county's tax lot parcel layer, and 400 of these parcels were selected via a random number generator function in ArcGIS to be sent a survey questionnaire regarding oak woodland management on their properties (Appendix B).

Pre-survey postcards announcing the upcoming arrival and providing a brief explanation of the survey were mailed to selected landowners. The following week, the actual survey questionnaires arrived, along with a cover letter, statement of consent and privacy, and self-addressed, stamped envelope. The cover letter provided a thorough description of the purpose of the survey and the role that the survey recipients were playing in it. All recipients were notified that their willingness to contribute to the research was signified by their returning the survey.

Each survey questionnaire was four pages, contained 72 questions, and was designed to take around 20 minutes to complete. A combination of check-box, fill-in-the-blank, open-ended, and Likert-scale matrices was used. The questionnaire provided a space at the end to provide any additional thoughts, concerns, or questions. See Appendix B for a copy of the survey instrument, pre-survey postcard, and letter of introduction and consent to participate.

A second, similarly structured survey questionnaire was sent to a selected group of professional resource managers who work in the KSB. These managers were selected to participate in the questionnaire based upon their involvement in land and resource management and planning in the Klamath-Siskiyou bioregion, particularly those occupations that might directly involve oak management and restoration. The intent was to importune responses from a wide range of professions and locations throughout the KSB. This survey differed from the previous survey in a number of ways. The survey was

not a random sample, but was a targeted group of people. Participants were identified via the snowball method, meaning that additional contacts were identified via the previous contacts (Esterberg 2002). The questionnaire was administered via email using the program Survey Monkey. Some of the questions asked in the resource manager survey were identical to the landowner survey so that responses could be directly compared, and some were unique to this focus group. Managers were only contacted once; no follow up attempts were made to garner additional responses. See Appendix C for a copy of the survey instrument.

All of the above research methods were approved via the Humboldt State University IRB (Institutional Review Board) process (HSU IRB # 11-119). The IRB requires that all research projects involving human subjects to submit an application to the HSU Committee for the Protection of Human Subjects in Research and receive board approval before surveys are mailed. This research met IRB approval, and ensured that all responses remained anonymous, incurred minimal risk upon the respondents, and were not used for anything beyond research purposes at this research institution as per the IRB guidelines set forth by Chadwick et al. (1996).

Analysis and Interpretation

The responses to the landowner and resource manager questionnaires were analyzed using a combination of quantitative and qualitative methods. All surveys were entered into a database and analyzed using SPSS 19 (Statistical Package for the Social Sciences, 2011, Chicago, Illinois). The responses were analyzed for correlations and trends to

explore the variables likely influence both landowners' and land managers' motivations and barriers to managing oak woodlands on their properties or in their management areas.

Indices were created in order to assign "scores" to each landowner regarding several key facets of their management. The principal index against which most other parameters were measured was called the landowners' management "score." A list of 12 different management actions was compiled, emerging from the literature on the most critical practices for oak woodland conservation and restoration (e.g. Martinez 2003, McCreary et al. 2004, Hosten et al. 2006, and Giusti 2008). Management actions were assessed on a temporal rating scale indicating how often landowners conduct a given activity on their property. Landowners were asked to select if they performed each management action "never," "rarely," (every nine to 20 years) "sometimes," (every three to eight years) or "often" (every one to two years). Based upon the general consensus from the literature of how imperative each individual management action is considered to be to oak conservation, each action was assigned a weight. Activities that are intended specifically to regenerate oaks or are highly labor intensive, such as planting oak seedlings or conducting a prescribed burn received a weight of three, whereas more general land maintenance activities such as burning brush piles received a one. Superscripts denote the weights assigned to each given management activity.

After accounting for weights, all management actions were summed, resulting in an overall score for each landowner. This management score indicated how much active management each landowner performed on their oak woodlands, which was then correlated against other themes addressed within the questionnaire. In the second questionnaire, land managers were asked a parallel set of questions regarding the relative

importance of each management action and a similar index was developed, allowing for a comparison between what resource managers and landowners believed to be the most essential management actions for oak conservation.

Based on a matrix of Likert-scale questions, each landowner was assigned a "concern" score reflecting how concerned or interested they were in conserving and restoring oak trees on their own properties and on the landscape more generally. Using natural breaks in the data set, these scores were grouped into "high, medium, and low" categories for categorical analysis. Similarly, indices were created to assess how concerned landowners were about health and regeneration of their oak trees, and how landowners regarded disturbance regimes such as fire.

Following index development, contingency tables were created in order to compare various predicting variables to landowners in different meaningful groups. The principle grouping mechanism selected for this analysis was parcel size. Numerous previous studies of private landowner management practices have found that parcel size frequently predicts management behavior (e.g. Huntsinger 1990, Habron 2004). Using natural breaks in the data set, landowners were grouped into the following parcel size blocks: small (20-40 acres), medium (41-300 acres) and large (>300 acres) (see: Huntsinger et al. 2011). Pearson's Chi-square analysis was used to identify levels of association between a variety of categorical predictor variables, blocked by parcel size. In some cases, there were multiple categories with less than five responses, so Fisher's Exact Test was used in place of Pearson's Chi-square test. Fisher's exact test is useful for assessing the association between two variables in small sample sizes, or if the data are not evenly distributed, although the test is also meaningful for larger data sets (Field 2009).

Independent-samples *t*-tests were used to analyze continuous, parametric data. The Kruskal-Wallace multiple comparisons test was used to analyze continuous, non-parametric data. For all tests, statistical significance was determined at $\alpha = 0.05$.

Following statistical analysis, the open-ended questionnaire responses and comments were transcribed, organized, and analyzed thematically. The most commonly-occurring themes were distilled out of the surveys after numerous passes through the data. These comments highlighted issues that were not necessarily addressed in the rest of the questionnaire, and gave landowners and land managers an opportunity to contribute their own unique perspectives and experiences to the research. They also underscored issues and sentiments from the survey that appeared to be of particular importance to stakeholders. These comments were useful in determining what aspects of oak woodland conservation were most significant to the individuals surveyed, and were factored heavily into the analyses performed on the data. The open-ended comments are analyzed in the discussion section of this research.

RESULTS

Landowner Profiles and Ownership Values

Of the 400 surveys mailed out and received by the addressee, 135 were returned. Of the 135 returned surveys, eight were not filled out at all, 15 were incomplete, and 12 were unusable because the respondents indicated that there was no oak habitat on their property, leaving 98 usable and complete surveys to include in the analysis, and an adjusted response rate of 25%.

Landowners across all parcel sizes were asked to indicate the single most important purpose of their property besides residential use. The most common uses were agriculture/grazing (25%), private forestry (22%) and biodiversity conservation (20%) (Table 2). Other important functions of the land were recreation and investment.

Table 2. Principle non-residential uses of surveyed parcels in the Klamath-Siskiyou Bioregion, grouped by parcel size (n=98). All numbers are percentages.

	1-40 acres n=42	41-300 acres n=43	> 300 acres n=13	All parcels n=98
Agriculture/livestock	15	22	44	25
Private forestry	33	16	12	22
Biodiversity	22	22	11	20
Recreation	19	28	11	17
Investment	4	6	0	5
Other	7	6	22	11

Responses about landowner demographics found that they were primarily male (70%), with a mean age of 61 years, and an average land tenure of 24 years. Median parcel size was 386 acres. Owners of the smallest parcels had owned their properties for an average of 17 years, medium parcels had owned for 24 years, and large parcels had owned for 27 years. Fifty-seven percent of the landowners of parcels 40 acres or less had owned their land for less than 15 years, compared with 40% of all other landowners. Twelve percent of landowners indicated that they made their living farming or ranching on their properties. Twenty-three percent were classified as professionals, 24% were employed in various trades sectors, 21% were retired, and 16% were environmental professionals (n=90).

Table 3. Landowner values for their properties across parcel sizes. (n=98). Bold values were significantly different as determined by a Pearson's Chi-square analysis. Bolded p values without a common superscript are significantly different within each at α = 0.05.Numbers are expressed as percentages.

Parcel is Valued for…..		Small [a] (1-40 acres) n=41	Medium [b] (41-300 acres) n=43	Large [c] (> 300 acres) n=14
(Bolded *p* values without a common superscript are significantly different among parcel sizes at α =0.05*.)*				
Family heritage	**Not important**	29	14	0
(*p*=0.086)	**Somewhat important**	25	37	11
	Important	46	49	89
Quality of Life	**Not important**	11	0	0
*(p=0.*175*)*	**Somewhat important**	4	9	0
	Important	85	91	100
Escaping from the city	**Not important**	11	9	0
(*p*=0.643)	**Somewhat important**	11	14	0
	Important	78	77	100
Preserving land from development	**Not important**	25	6	0
(*p*=0.126)	**Somewhat important**	14	21	11
	Important	61	73	89
Grazing livestock	**Not important**	**75[cb]**	**54[ac]**	**22[ab]**
(*p*=0.002)	**Somewhat important**	**21[c]**	**20[c]**	**11[ab]**
	Important	**11[cb]**	**26[ac]**	**67[ab]**
Agriculture	**Not important**	**75[c]**	**64[c]**	**22[ab]**
(*p*=0.015)	**Somewhat important**	**14[c]**	**21**	**33[a]**
	Important	**11[c]**	**15[c]**	**44[ab]**
Forestry	**Not important**	**46[bc]**	**25[ac]**	**0[ab]**
(*p*=0.015)	**Somewhat important**	**36**	**49**	**33**
	Important	**18[c]**	**26[c]**	**67[ab]**
Economic value	**Not important**	29	23	0
(*p*=0.497)	**Somewhat important**	21	35	22
	Important	50	57	78

Survey respondents evaluated the economic and amenity-based values that they placed on their properties (Table 3). Eighty-nine percent of owners of the largest parcels strongly agreed that their property was an important part of their family heritage, compared to 46% and 49% of the small and medium parcel sizes, respectively. The majority of respondents from all parcel groups agreed or strongly agreed that their land was important for quality of life, for escaping from the city, and for preserving the land from development. Respondents who owned more than 300 acres were significantly more likely to consider their land to be very important for livestock grazing (p=0.002), and forestry (p=0.015) than parcels less than 300 acres (Pearson's Chi-Square analysis). Seventy-eight percent of large parcel owners considered their properties to be very important for economic purposes, compared with 50% and 57% of small and medium parcel owners, respectively.

Sixty percent of landowners surveyed lived on their properties full-time, while 30% did not live on their properties at all and 10% lived on their properties for part of the year. Landowners from each of the three parcel size categories were about equally likely to live on their property full time. Only 6% of landowners had a conservation easement of some kind on their property. Due to this low occurrence, participation in conservation easements was not used as a parameter for further analysis in this study. Most landowners (87%) earned less than 25% of their income from their properties. Confirming findings from previous studies about rural property owners (e.g. Huntsinger 1990), owners of larger landholdings earned a significantly greater portion of their income from their properties than did owners of smaller landholdings (p=0.003, Pearson's Chi-Square analysis).

Landowner Oak Woodland Management and Priorities

An index of oak woodland management developed in this study in to quantify the amount of management being conducted upon the KSB's private oak woodlands (Table 4). The mean landowner management score was 9.5, with a minimum score of 0 (which was also the mode score) and a maximum score of 42. The most commonly-implemented oak management activities were burning brush piles, removing competing vegetation, pruning limbs, and monitoring for diseases and pests. The least commonly-implemented activities were planting new oak seedlings, installing vaca[4] cages or exclosures, fencing off oaks, and conducting prescribed burns in oak trees.

Overall responses to the management portion of the survey indicate that landowners more commonly implemented activities that require less technical expertise or equipment than activities that require more specialized knowledge, equipment, or time. Only 25% of all landowners had ever consulted an advisory agency or forester about the trees on their property. Landowners were asked to rate the health of the existing oaks as well as the regeneration of oak seedlings on their properties. Sixty-eight percent of all landowners rated the health of their mature oaks as good. By contrast, only the regeneration rate of oak seedlings was rated as good by just 33% of landowners.

[4] *Vaca* is Spanish for cow; vaca cages are exclosures placed around oak seedlings to reduce livestock browse damage (Giusti 2008).

Table 4. Landowner oak woodland management index indicating different oak management actions and how often each management action was implemented. Results are presented as percentages of all landowners (n=98).

	Management occurrence interval			
Management action	**Never**	**Rarely (9-20 years)**	**Sometimes (3-8 years)**	**Often (1-2 years)**
Plant new oak seedlings	87	6	4	3
Fence oaks to protect from livestock	78	12	3	7
Thin conifers to reduce competition with oaks	61	7	19	12
Install vaca cages or tree shelters for protection	93	3	1	3
Remove competing vegetation	46	15	15	24
Conduct a controlled burn in understory under oaks	72	10	13	4
Burn brush piles	18	9	20	51
Re-seed with native grasses	65	14	12	8
Collect acorns for propogation	80	8	8	4
Consult an advisory agency, forester, or other professional	74	10	9	6
Monitor for diseases/pests	62	9	8	21
Prune limbs above deer/livestock browse line	62	9	15	14

Landowners' management scores were examined with respect to a number of different parameters identified in the literature review as potential indicators of their management levels (Table 5). As parcel sizes increased, mean management scores increased significantly. The mean management score in the small parcel size was 6.9, as opposed to a mean management score of 12.2 in the highest parcel size (Table 5). The amount of time spent on the property also correlated significantly with management scores. Landowners who lived on their properties full time had a mean management score of 11.4, as opposed to a mean score of 3.3 for those who do not live on their properties, and 6.3 for those who spent part of the year there.

Thirty-two percent of all landowners participated, in some capacity, in at least one conservation program, organization, or watershed or fire safe council. Landowners who

participated in at least one conservation organization had significantly higher management scores than those who did not participate (p=0.021). Some of the most common programs, organizations, agencies, or associations cited were BLM Resource Advisory Council (RAC), NRCS (Natural Resources Conservation Service), US Fish and Wildlife Service, Natural Resources Defense Council (NRDC), Soil Conservation Service (SCS), various small woodlands associations, Mid-Klamath Watershed Council, Trinity River Watershed Council, Hayfork Watershed Research and Training Center, Trinity Resource Conservation District, and others.

Landowners with certain occupations had significantly higher management scores than others. Environmental professionals, who were 16% of the survey population, had mean management scores of 17.4, nearly twice as high as the overall mean scores. Landowners whose occupations were in the “professional” sector, who were 24% of the survey population, had the lowest management scores, with a mean of 6.2.

Table 5. Landowner characteristics and correlations to management scores, determined by a Kruskal-Wallis non-parametric test (n=98). Bolded p values and mean scores without a common superscript are significantly different within each landowner characteristic at $\alpha = 0.05$.

Landowner Characteristics		%	Mean Score
Parcel Size	1-40 acres [a]	40	**6.9[bc]**
(*p*= 0.024)	41-300 acres [b]	45	**11.6[a]**
	>300 acres [c]	15	**12.2[a]**
Lives on Property Full-Time	Yes [a]	60	**11.4[bc]**
(*p*= 0.002)	No [b]	30	**3.3[a]**
	Part of Year [c]	10	**6.3[a]**
Main Use for Property (besides residential)	Agriculture/Grazing [a]	25	**9.5[bde]**
(p= 0.029)	Private Forestry [b]	22	**10.9[ade]**
	Biodiversity [c]	20	**13.6[de]**
	Recreation [d]	17	**5.8[ac]**
	Investment [e]	5	**5[abc]**
	Other [f]	11	**8.1**
Gender	Male	70	10.2
(*p*= 0.32)	Female	30	8
Level of Education	High school or below	14	3.9
(*p*= 0.054)	JC or trade school	25	9.3
	4-year college	34	11.2
	Graduate school	24	10.5
Amount of Income Earned from Property	None	61	8.1
(*p*= 0.066)	<25%	26	13.7
	26-50%	3	10.7
	51-75%	4	6.3
	76-100%	6	7.5
Occupation	Ranching/Agriculture[a]	12	**8.6[ed]**
(p= 0.029)	Professional [b]	23	**6.2[e]**
	Trades [c]	24	**8.1[ed]**
	Retired [d]	21	**8.8[be]**
	Enviro professional [e]	16	**17.4[abcd]**
Level of Concern for Oak Trees	Not concerned	13	7.3
(*p*= 0.191)	Somewhat concerned	53	8.2
	Very concerned	34	12.4
Participates in conservation organization, fire safe council	Yes [a]	32	**12.9[b]**
(*p*= 0.021)	No [b]	68	**7.9[a]**
Grazes Livestock on Property	Yes	21	11.5
(*p*= 0.232)	No	79	9.1
Likelihood of Creating Oak Management plan	Not at all likely [a]	18	**6.2[c]**
(*p*= 0.004)	Somewhat likely [b]	46	**7.2[c]**
	Likely [c]	35	**14.1[ab]**
Fire Concern/Acceptance	Low [a]	10	**2.3[bc]**
(*p*= 0.001)	Medium [b]	49	**8.6[ac]**
	High [c]	38	**12.8[ab]**

There was a wide range of management attitudes, motivations, and constraints that landowners perceived regarding oak woodland management on their properties (Table 6). Nearly all landowners highly regarded oak trees as important ecological and cultural resources, however far fewer landowners indicated that they were highly concerned about or inclined to manage their oak trees. Nearly all landowners (94%) agreed that oak trees are an important ecological and cultural resource. Thirty-five percent of the landowners surveyed expressed that they would be likely to create an oak management plan for their properties if they had the opportunity. Thirty-nine percent of landowners would consider restoring oak trees if they had more time, 37% would do so if they had access to labor and equipment, and 44% of landowners would do so if they had more money or knowledge on how to do so. Twenty-eight percent of landowners preferred to manage for other trees on their properties because they are more economically valuable.

Table 6. Landowner values and concerns about oak woodlands (n=98).

	% Disagree	% Somewhat Agree	% Agree
Oak trees are an important ecological and cultural resource.	1	5	94
The amount of oak trees on my property is declining over time.	38	48	14
The oak regeneration/replacement on my property is not adequate.	37	41	22
Maintaining and restoring oak trees on my property is a high priority in my property management.	18	31	51
I would like to develop an oak management plan for my property.	18	46	36
I am interested in collaborating with an agency and/or a local conservation organization in order to restore the oaks on my property.	24	40	36
If I had more time, I would be more inclined to restore the oaks on my property.	27	34	39
If I had more money, I would be more inclined to restore the oaks on my property.	27	29	44
If I had more knowledge/training on how to do so, I would be more likely to do restoration on the oaks on my property.	26	30	44
If I had access to labor/ equipment, I would be more likely to do restoration on the oaks on my property.	27	36	37
There are other tree species besides oaks on my property that I prefer to manage for because they are more important or economically valuable to me.	34	38	28
Oak trees on private lands should be regulated by public agencies.	81	12	7

Landowner Perceptions of Natural and Prescribed Fire

As a significant component of oak woodland management, the questionnaire also contained a matrix of questions regarding landowners' perceptions of fire on the landscape more generally and their attitudes towards management and preparation for fire on their properties (Table 7). Survey results indicated that landowners generally acknowledged fire as a necessary ecological function.

Landowners felt a high degree of responsibility to plan and manage for fire events on their properties. Seventy-three percent agreed or strongly agreed that it is their responsibility to do so. Twenty percent of landowners had experienced some kind of wildfire on their properties during the time that they had owned it.

Landowners expressed an interest in applying prescribed fire on their properties as a means to greater fire safety and improved ecological integrity (Table 7). Forty-two percent of landowners believed that their properties would be ecologically healthier if there were some sort of natural fire regime present, and 47% believed that prescribed fire could benefit both the safety and ecological condition of their properties. Forty-five percent would implement prescribed fire if they had financial or technical assistance to do so, but 30% viewed the permitting process as an obstacle to the prescribed fire process.

Significant correlation was found between attitudes towards fire and amount of management implemented. Landowners who felt most favorably about prescribed fire and about fire as a natural landscape process had significantly higher oak management scores (Table 5) (p= 0.001).

Table 7. Landowner attitudes towards natural and prescribed fire. Results expressed in percentage of all landowners (n=98).

Owners believe that…..	% Disagree	% Somewhat agree	% Agree
Property would be healthier with a fire regime	22	36	42
It is owner's responsibility to plan for fire	3	24	73
Prescribed fire could benefit their property	21	32	47
Would be interested in conducting prescribed fire on property	28	27	45
Fire is a threat to property and safety	37	13	51
Fire is a threat to ecological condition of property	42	16	42
Permitting for prescribed fire is an obstacle	9	61	30

Professional Resource Manager Profiles and Priorities

The outreach effort towards professional resource managers regarding oak woodland conservation and restoration yielded 66 complete, usable surveys out of 150 distributed, for an overall response rate of 44%. Resource managers held an average of 14.5 years of professional natural resources experience in the KSB. Their management areas represented all of the counties in the KSB (Table 8). They held a wide variety of professional duties and worked for a broad representation of agencies, organizations, and businesses. The largest group represented was the non-profit sector (31%) followed by federal employees (20%) and private consulting (14%). Other participants worked for universities, state and county agencies, tribes, and other sectors.

Table 8. KSB Resource professional management descriptions. Results presented as percentage of all respondents (n=66).

Resource professional		%
Works for….	Non-profit	31
	Federal	20
	Private consulting	14
	State	8
	University	8
	Other government/district	7
	Tribe	6
	County	3
	Timberland owner	3
Manages land/works in…..	Humboldt	62
	Trinity	50
	Del Norte	47
	Siskiyou	41
	Klamath	24
	Jackson	30
	Douglas	14
Communicates with landowners about oaks…	> 25 times/year	18
	> 10 times/year	21
	< 10 times/year	46
	Never	15
Attends trainings/workshops about oaks…	> 10 times/year	5
	5-10 times/year	9
	< 5 times/year	61
	Never	25

Table 9. Resource professional beliefs and attitudes about oak woodland management, expressed in percentage of all professionals surveyed (n=66).

Resource managers believe that……	%
Oaks are an important ecological/cultural resource	93
They are highly concerned about oak conservation in their management area	81
Oaks have economic potential that could be utilized	35
They are satisfied with amount of oak management in their management area	10
There are higher conservation priorities than oak trees in their management duties	58
Oak conservation should be a higher priority than it currently is	64
Amount of protected oak woodlands in their management area should be increased	70
Landowner participation in conservation and management should be increased	93
Economic potential of private properties could be enhanced through conservation implementation	74

Resource managers held a wide variety of conservation responsibilities and priorities within their job descriptions. The survey responses indicate that these professionals had considerable experience working with oak woodlands and private landowners in the KSB. Eighteen percent of professionals communicated with landowners more than 25 times per year about oak woodlands on their properties, and 21% of them did so more than 10 times per year. Most professionals (46%) communicated with landowners about oaks less than 10 times per year, and 15% of them never communicated with landowners about oak trees.

Only 10% of resource managers were satisfied with the amount of oak woodland management that they were able to implement, and with the amount of oak management that generally occurs in their professional jurisdictions (Table 9). Eighty-one percent of resource managers were highly concerned about the oak woodlands in their management areas, but 58% had higher conservation priorities than oak woodlands in their professional duties. Just 35% of managers felt that oaks could be utilized economically,

but 74% believed that the economic potential of private lands could be enhanced through the implementation of conservation measures.

Managers were asked to rate the importance of the same suite of oak management activities that was sent to the landowners (Table 10). Resource managers rated a mean score of 25.24 on the index of recommended oak management out of a possible 90 (SE=15.68), $t(70)=-2.77$, which was significantly higher than the man score of 9.5 that landowners reported on their index of actual management performed ($p=0.007$, Table 5).

Table 10. Land manager recommended oak woodland management intervals (n=66).

	Never[0]	Rarely[1] (9-20 years)	Sometimes [2] (3-8 years)	Often [3] (1-2 years)
Plant oak seedlings[3]	33	15	39	13
Fence off oaks to protect from livestock[2]	29	15	30	27
Thin conifers to release oaks from competition[3]	12	17	36	35
Install shelters/vaca cages[1]	33	16	31	20
Remove competing vegetation[2]	17	9	47	27
Conduct Rx burn in understory[3]	8	14	46	33
Burn brush piles[1]	---	---	---	---
Re-seed with native grasses[2]	19	11	42	29
Collect acorns for propogation[1]	---	---	---	---
Consult advisory agency [2]	12	9	40	39
Monitor for diseases or pests[2]	9	3	36	52

[3,2] Superscript denotes value that each management action was weighted. Actions that were never performed were multiplied by zero, "rarely by one, "sometimes" by two, and "often" by three, resulting in an overall management "score" for each landowner.

---Question was asked to landowners but not to land managers

Overall, managers regarded all of the management activities as important to conduct at least some of the time. For ideal oak woodland management, managers recommended that most of these activities occur periodically (every three to eight years) to often (every one to two years).

The regulation of oak trees appeared to be a highly divisive subject among resource managers (Table 11). The federal regulation of oaks on private lands was highly unpopular, with only six percent in support of it; nor was regulation by state agency strongly supported (29%).

Table 11. Resource professionals' beliefs about oak conservation mechanisms (n=66).

Resource professionals believe….		**%**
Oak woodlands on private lands should be regulated by:	Federal agencies	6
	State agencies	29
	No public agencies	35
	Choose not to answer	30
The most effective way to help landowners implement oak woodland conservation is to provide:	Access to monetary support/tax breaks	15
	Trainings/workshops	18
	On-site labor and equipment	24
	Assistance creating management plans	43

Thirty-five percent of managers did not believe that any public agencies should regulate oaks on private lands, and another 30% chose not to answer the question. Most managers (43%) believed that the most effective way to encourage landowners to manage and restore oaks on their properties is to assist them in writing management plans and creating conservation easements. Twenty-four percent felt that the best way to facilitate oak management is to provide onsite labor and equipment to landowners.

Because prescribed fire commonly accompanies oak woodland management and restoration, land managers were also asked a series of questions about their perceptions of both natural and prescribed fires. The land managers of the KSB were strongly in favor of facilitating both natural and prescribed fire on the landscape. Seventy-two percent disagreed that fire is a threat to landowner property and safety, and 85% disagreed that fire is a threat to the health of forest ecosystems. Land managers were highly aware of the use of prescribed fire for the purposes of oak woodland restoration, as a moderator of fire

risk, as well as for a host of other ecological purposes. One hundred percent of resource professionals agreed that prescribed fire could benefit landowners' safety and property if planned for and managed properly. Fifty-eight percent believed that it is property owners' responsibility to plan for and manage fire on their properties.

DISCUSSION

The KSB's oak woodlands are dependent upon the values and priorities of its stewards: the landowners and land managers who inhabit them. The analysis of these surveys reveals a number of significant findings about how the characteristics and values of stakeholders may be incorporated into resource management policy and practice. Perhaps the foremost conclusion is that landowners recognize the significance of oak woodlands as ecological and cultural resources, and that there exists a collective desire among landowners to contribute to conservation at the landscape scale via their individual property management regimes. However, the survey responses also indicated that landowners may lack awareness of the potential benefits of restoration on their land, technical expertise regarding restoration methods, funding and equipment to implement these methods, and trust in the "experts" who may be able to facilitate these fundamentals. An increased understanding of individual ownership profiles, therefore, appears to be a key factor in successfully implementing restoration on private lands. The results of this study clarify the temporal variation in management activities that are implemented by landowners across the KSB, and underscore the fact that landowners are not currently managing their oak woodlands to an extent that meets the minimum threshold that land managers set forth for their continued existence.

Previous studies of rural landowners have demonstrated that they tend to adopt conservation practices in stages. These stages proceed from: awareness of innovation, motivations to implement the innovation, deciding to implement the innovation, implementing the innovation, and deciding upon the success of the innovation (Habron

2004). The specific motivations, rates and mechanisms by which these innovations diffuse into and are implemented by the rural landowner population are of great interest to many conservation biologists, and should be strong considerations for land managers who view the engagement of private landowners as a crucial component to oak woodland restoration success. The rural landowner population of any given area represents a tremendous repository of local ecological knowledge (Charnley et al. 2008). Numerous barriers are encountered by private landowners who consider undertaking conservation measures on their properties. Nonetheless, their potential to gain considerably from such efforts is significant, in the form of enhanced biodiversity and wildlife habitat, aesthetically improved surroundings, improved fire safety, income generation, and increased knowledge, skills, and self-determination regarding their land management (Fisher and Bliss 2008).

Resource professionals who are striving to realize habitat conservation goals across their management areas are challenged by a variety of ecological, institutional, and social constraints. They must work at various spatial scales to link conservation objectives with management realities across individual parcels. The KSB encompasses two states and numerous counties, each with their own specific policies, or lack thereof, regarding the conservation and management of oak woodlands (NRCS 2011). Funding from agencies and institutions to carry out such projects may be limited in favor of a myriad of other conservation priorities. Lack of consensus about the most effective restoration methods, and of monitoring efforts to evaluate these methods, are also serious impediments to restoration success identified in this research. Attaining such landscape-scale results is challenging amidst an increasingly complex matrix of public and private

ownerships and requires both spatial and temporal foresight. It also requires familiarity with the cultural context in which the landscape is embedded, and with the different landowner characteristics that may be encountered within this landscape (SER 2004).

This research revealed disparities in the management of oak woodlands by landowners and the management requirements perceived by resource managers, which is not surprising given the lack of consensus on what management techniques are most effective, and the significant constraints that both landowners and managers face in implementing these activities. The questionnaires and open-ended responses demonstrated that landowners and land managers perceived a number of significant constraints to oak woodland conservation, including: lack of awareness about restoration requirements, lack of resources to perform restoration, shifting land ownership trends, inconsistent policies regarding oak trees, and a lack of monitoring of previous restoration efforts. The following sections discuss these constraints, as well as the landowner characteristics that appear most likely to correlate with engagement in oak woodland management, interpreted from the survey data. These sections incorporate the open-ended responses from landowners and land managers into the analysis in order to further clarify the most critical concerns held by both of these stakeholder groups.

Awareness of Restoration Requirements

The initial and perhaps most critical barriers to ecological restoration for landowners and managers alike are the lack of realization that restoration is needed, and the lack of resolve to implement restoration (Fisher and Bliss 2008). For restoration to

occur, compelling motivations must be apparent to landowners. Landowners are unlikely to engage in conservation practices unless there are recognizable benefits of participation, practices can be easily integrated into their pre-existing land management regimes, and practices have been previously demonstrated to work (Habron 2004).

These survey data demonstrate that as landowners' level of awareness and concern increased, their management of their oak trees increased accordingly (Table 5). Lack of concern and awareness appeared to be a major impediment to landowners' management scores. For example, while 68% of landowners perceived that their existing oak trees were in good health, only 33% perceived a good rate of regeneration of oak seedlings on their properties. Despite the fact that inadequate oak regeneration was apparent to around 66% of landowners, 86% of landowners never planted new oak seedlings. A number of landowners noted that they were interested in replanting oak trees, but had encountered difficulty in acquiring native oak seedlings available for sale locally. This lack of availability of native oak stock was a restoration impediment also noted by several land managers in the survey.

Landowners' occupations significantly influenced their management scores, indicating that those landowners who had extensive experience and contact working on the land, for example environmental professionals or farmers and ranchers, tended to be more aware of the management needs of their properties (Figure 5). The landowners whose occupations are unlikely to bring them into contact with the land (i.e. the "professional" group, by contrast, received the lowest management scores, indicating overall lower levels of experience and awareness of the ecosystem management needs of their properties.

The survey responses revealed that management activities that were most commonly implemented by landowners, such as burning brush piles, conducting prescribed burns, or thinning conifers (Table 4), were not necessarily being conducted with the specific intent to improve or release the oaks from competition. Landowners may have been implementing these activities for other reasons, such as opening the canopies of the forests around their houses or reducing fire risk, but in doing so were providing secondary benefits that created far more favorable conditions for their oaks (Garmon 2006). Because landowners tend to be more amendable to implementing conservation practices with which they are already familiar (Fisher and Bliss 2008), land managers may be able to optimize their participation in oak woodland management by positively reinforcing these activities in conjunction with promoting other possible management actions.

While awareness of specific management requirements of certain ecosystems may be uneven among landowners, it should be noted that a high level of desire to contribute towards landscape-scale conservation was observed among the landowners in this survey, and has been well-documented in other surveys (e.g. Birch 1996, Habron 2004). The desire on the part of landowners to contribute positively to the overall ecosystem via their own individual property management represents a significant conservation opportunity, the importance of which should not be underestimated by resource managers.

Lack of Trust Between Landowners and "Experts"

Landowners in this study did not appear to trust all aspects of the conservation process, even if they did acknowledge the restoration needs for oak woodlands on their properties. Some landowners, used to troubleshooting and solving their land management issues themselves by relying on the considerable LEK that they have developed about their properties, did not welcome the top-down recommendations from "experts" of ecosystem management. While almost all landowners (96%) regarded oak trees as important cultural and ecological resources, only 36% were interested in developing a written oak management plan for their properties, and only 36% would consider collaborating with an agency or organization to do so. The fact that landowners who were likely to create oak management plans also had the highest management scores (p=0.004) confirms the efficacy of organized, thought-out ecosystem management. Resource professionals both in this survey (43%) and in the literature recommended individual management plans as the initial and perhaps most important step of the conservation process (Giusti 2008, Lomakatsi Restoration Project 2009). Such management plans can lead to more effective implementation of conservation goals by landowners by clearly delineating their management objectives while simultaneously preserving their autonomy and unique visions for their properties.

Sixty-four percent of landowners were either not interested or only slightly interested in developing management plans for their properties; the management scores for these groups were significantly lower than those who were interested. These scores indicate that while landowners valued their oaks, they were either unconcerned or

unaware that input or restoration may be necessary to sustain them, or they lacked trust in partnering with an agency or an organization via conservation agreements or management plans. Therefore, resource managers may need to consider outreach approaches that address landowner reluctance to create management plans or enter into formal restoration agreements, and ways to incentivize the management plan process to make it more appealing to landowners. These landowners may regard such official management plans as potential threats to their property values or liberties, or they may have concerns that creating or enhancing habitat will increase their likelihood of regulation or otherwise impede their use of their property (Fisher and Bliss 2008).

Other landowners believed, and perhaps rightly so, that their current management regimes would not necessarily benefit by entering into formalized conservation agreements with agencies or "experts." One rancher noted that the "perceptions held by most urbanites and academics are not a real reflection of what landowners do to protect lands and habitat… Agriculturalists are real conservationists." This statement reflects the independent and individualistic nature of many rural landowners, who are accustomed to applying LEK to their land, and see little utility in recommendations from the "experts" of agencies or academia.

Lack of Restoration Resources

Even if landowners recognized the imperative to restore oaks on their properties, there was agreement among most landowners and land managers that oak woodland restoration can incur significant and oftentimes prohibitive costs, labor, and time. Costs

can be high both at the front end of a restoration project and over time, as oaks require sustained, active management. Both landowners and managers cited financial burden as the principal consideration of whether or not they would be able to effectively implement a restoration project. For 50% of landowners, oak restoration was a stated property management goal; however they felt constrained by lack of funds, labor, and equipment. One landowner remarked, "I am doing my best and have spent over 500 hours managing, but could use technical assistance, equipment, and labor." Another said, "I treasure the black oaks, live oaks, and tan oaks on my property and it pains me to see conifers invading and displacing…My desire to improve and restore is hampered by inability to pay for expensive tree removal."

With significant costs and little guarantee of financial return for restoration, some land managers empathized with landowners who were not prioritizing oak restoration on their properties: "My sense is that programs to engage the private sector must demonstrate how the landowner benefits either financially upfront or long-term," noted one restoration practitioner. Even if landowners obtain funding for one round of restoration, they may not obtain funding to conduct restoration over the long term (Fisher and Bliss 2008). A land manager corroborated this issue, remarking that: "I do not think landowners can be fairly or realistically expected to shoulder the burden of stemming ongoing ecological processes- conifer encroachment and stand succession, deer grazing, etc."

Landowners were constrained not only lack of resources to address the ecological processes occurring on their properties, but by activities and management considerations on adjacent lands that significantly impacted them. Grazing livestock and open range was

a concern addressed by a number of landowners and land managers. One property owner observed, "Approximately 15 head of cattle trample through forest and neighborhood impacting young trees and water sources." Another noted, "[My property is] open range. I have spent hundreds of hours fencing out range cattle. Cattle grazing over time ensure that oaks will disappear….open range laws in the western states need to be repealed." Others critiqued the practices of industrial forest owners on adjacent lands. In the words of one landowner, "We live in an area that is surrounded by SPI[5]. They do their best to kill every oak tree they can. You can see sections of their land where they have poisoned the oaks and there [are] stands of dead and dying oak trees." Thus, land managers wishing to facilitate restoration on specific parcels may need to consider activities on adjacent parcels that may impede landowners' efforts (Rickenbach et al. 2011).

Competing Land Uses

Both landowners and land managers cited that other management activities and forest types competed for their abilities and desires to prioritize oak management. There is a strong culture in the KSB of managing forests for economically profitable, timber-producing species. The KSB is a primarily coniferous region, and has a long and deeply rooted connection to logging and forestry-based practices. Almost all of the existing federal and state forest management plans are designed to maximize the growth of coniferous forests (Giusti and Merenlender 2002).

While 81% of professional resource managers considered oak woodland management to be highly important in their management areas, 58% of them also noted

[5] Sierra Pacific Industries, one of the largest industrial timberland owners in the KSB.

that they had higher conservation priorities than oak woodlands. Such are the realities faced by conservation managers, who must balance many conservation and economic management concerns. On private lands, foresters from university extensions, agencies, and family forest alliances have promoted fast-growing and profitable Douglas fir production, often at the cost of stand complexity and wildlife habitat (Fisher and Bliss 2008).

Historically, oaks and other hardwoods have been cleared because they are perceived to be of little commercial value outside of firewood. This research confirmed that oaks were not generally regarded to have strong economic value by landowners; 28% strongly agreed and 38% somewhat agreed that there are other tree species on their properties that they preferred to manage for because they were more economically valuable, while just 35% of land managers believed that oak trees have significant economic potential. A landowner acknowledged, "I have never really thought of the oaks on my property as being commercially valuable or even a very significant component of the ecological health of the property."

As confirmed by one rancher, "Oak is secondary to conifers on the ranch and is used primarily as a source of firewood." There are almost no mills in the KSB that will process oaks or hardwoods, and thus there are few commercial markets for it (Fisher and Bliss 2008). Oaks have been frequently clearcut, girdled or sprayed with herbicide to make way for more valuable commercial species. One landowner remarked that "…in most cases, we consider oak trees weeds." A professional forester concurred that "Oaks are considered secondary to pine and fir, which are commercial species."

Clearing profitable conifers in order to restore oaks is an opportunity cost that

appears to be too great. Particularly among landowners whose economic base lies in forestry, or who hope to one day harvest lumber from their properties, restoring an area of encroached former oak woodland is not only an expensive undertaking, but it can mean that a significant amount of an owner's property is taken out of production that could otherwise generate revenues. One non-profit restoration practitioner noted that while some landowners in his management area do favor their oaks through fuels reduction treatments, "others prefer to maximize DF [Douglas fir] growth for future timber value." A landowner's thoughts on this subject captured the sentiment well: "We would think your time, energy, and education at a historically forestry school could be better spent on a more important cause, such as maintaining healthy evergreen forests that have value in more ways."

Landowners were frequently concerned not only by the costs and potential loss of income associated with oak restoration, but with the loss of future land uses or depreciation of development potential due to the presence of high-quality habitat created by the restoration process. A restoration project that creates high-quality habitat might then host species listed at the state or federal levels, and could result in increased regulation on their properties or limitations upon future property uses and developments, rendering land less economically valuable and more difficult to sell.

Shifting Ownership Trends

The reasons for which landowners are motivated to manage and steward their land originate in their beliefs and values (Fisher and Bliss 2008). The results of this and other

surveys about rural landowners (e.g., Ferranto et al. 2011, Birch 1996) revealed that median parcel size is decreasing, and landowners of these smaller parcels are increasingly prioritizing the amenity-based values of their properties such as aesthetic quality, living away from urban areas, recreation, and wildlife or biodiversity (Table 4) . The landowner base is significantly shifting from those who practice agriculture, forestry, and other resource-based activities to those who primarily value their properties for non-utilitarian reasons. Increasing numbers of landowners in the KSB are relatively recent in-migrants who moved to small, rural communities for amenity-based, non-economic reasons (Charnley et al. 2008). These survey data reveal that as parcel size increases, so does overall management of the oak woodlands therein (Table 5). Given the increasing trend towards parcelization in the KSB, land managers may need to consider the corresponding decrease in ecological management that may accompany this trend.

The oak management scores across income blocks suggested that overall, landowners who are less economically tied to their properties may be less concerned or aware of the management needs of the oak trees on their property than those with strong economic ties to their land (Table 5). Landowners who depend upon the condition of their properties for economic reasons may have extensive, nuanced contact with their land that provides them with frequent opportunities to observe its ecological condition. Conversely, landowners who have less economic imperative to assess their properties on a regular basis do not necessarily observe aspects of their properties that may require their attention. Even if these landowners are concerned about restoration needs of their properties, they may possess fewer land management skills or equipment to do so than owners who more often work on their land for a livelihood.

The results of these surveys indicate that amenity-based values were more important to landowners in smaller parcel blocks. Seventy-three percent of landowners in this survey who owned 40 acres or less responded that escaping from the city was an important reason that they bought or lived on their property, indicating their desires to embrace rural lifestyles and the ways of life associated with exurban living. Half of all landowners earned less than 25% of their income from their properties, and just one percent received all of their income from their property (Table 5).

Biodiversity was cited as the most important non-residential value by 22 % of the landowners of the small and medium parcels, but only 11 % of those with the largest parcels (Table 3). This is a notable finding, given that owners of the largest parcels would presumably have the ability to support the most biodiversity and wildlife habitat. Similarly, recreation was the most important value for 19 % of the smallest parcel block, 28 % of the medium block, and only 11% of the largest block. Overall, the landowners with the largest properties were foremost committed to economic uses; 44 % of them primarily owned their land for livestock/agriculture, and 11 % primarily for private forestry. Seventy-eight percent of the largest landowners considered their property's economic value to be very important, compared with 50 % and 57 % of small and medium parcels, respectively.

Thirty percent of the landowners in this survey did not live on their properties at all. One respondent noted that "the biggest hazard to oaks on our property has been the fact that we are absentee landowners." A considerable portion of landowners in the KSB overall may be absentee landowners who are constrained primarily by the fact that they are not present to either notice that their property needs restoration, or to conduct the

restoration. Another former absentee landowner who had recently decided to live full-time on his property remarked, “While employed and living 400 miles from properties we were not in a position to make property improvements.” Land managers may want to consider the fact that landowners in this survey who lived on their properties full time were significantly more likely to be concerned about oak conservation than those who did not live on their properties full-time (p=0 .003), and to identify ways to address the restoration needs of properties owned by absentee landowners.

A considerable portion of the respondents to this survey did not actively manage their properties at all or did so very minimally not because they didn’t care about their land, but because they believed that to care for it is to refrain from manipulating or changing it. The responses to this survey revealed a strong desire among many landowners to maintain their land in “wild,” “pristine,” “secluded,” or “untouched” states, operating under the assumption that “nature knows best.” One respondent had “elected to allow [oaks] to recover by leaving them alone,” while another believed that “nature plants plenty.” A landowner noted that she preferred her property “in its natural state without human imposition or ‘management.’” Many landowners believed, in other words, that they were benefitting their properties by managing them as little as possible. Considerable education of landowners may be necessary, therefore, in order to communicate the specific management requirements of certain habitat types such as oak woodlands that may not benefit from laissez faire stewardship. These responses further suggest that novel approaches are required in order to effectively communicate with landowners of varying land use goals and values about the restoration needs of their properties. In order to instill in landowners a desire to restore habitat on their properties,

the amenities that they value and the land management practices that might have negative connotations must be identified and addressed.

After decades of public scrutiny of logging practices in the KSB, some of the management practices that accompany oak restoration, such as removal of mature conifers, particularly by topping or girdling them, may have very negative connotations for landowners (Fisher and Bliss 2008). While topping and girdling creates snags, which are essential habitat components for wildlife, these practices may initially not be perceived as restorative to individuals who have generally thought of the felling of mature trees as destructive or ecologically detrimental. Considerable education of landowners may be necessary in order to overcome landowners' perceptions of certain restoration processes as unsightly or ecologically unsound. Landowners may be more amendable to managing their oaks if the aesthetics or recreational opportunities on their properties are improved by restoration. Removal of young conifers, for example, can greatly enhance owners' viewsheds by converting dense doghair thickets to open woodlands.

Landowners from all parcel sizes frequently mentioned the importance of creating wildlife habitat on their properties in the open-ended section of the survey. These landowners widely expressed interest in enhancing wildlife habitat on their properties, although some remarked that they lacked knowledge about to do so. Given that oak woodlands are among the most productive wildlife habitat in the KSB (Johnson and O'Neil 2001), pairing wildlife habitat creation and oak woodland conservation may be an effective way to engage landowners who are interested in oak conservation but unsure of the benefits.

Land managers may be increasingly challenged by the diverse needs and viewpoints of private landowners as more landowners come to inhabit formerly large, intact landholdings. The average forested landholding is now 10 % smaller than it was 25 years ago (Rickenbach et al. 2011). The increased parcelization of the landscape creates highly challenging management scenarios, both logistically and ecologically, for land managers. As in-migration occurs and properties are divided, family forest owners are decreasingly likely to actively manage their forests (Birch 1996). Properties that are separated into smaller units cause formerly contiguous tracts of habitat to become isolated, altering vital ecosystem processes and connectivity (Noss et al. 1995).

A considerable amount of the owners of these smaller parcels may be interested in exploring oak conservation mechanisms for their properties, however most of these educational and assistance programs are traditionally designed with landowners with large properties who use their property for extractive purpose such as agriculture or livestock grazing (Huntsinger 1990). Although the cumulative amount of land that they own and the oak woodlands on their properties are substantial, owners of smaller parcels are considerably overlooked by oak woodland restoration incentive efforts (Ferranto et al. 2011). Greater contact with and outreach from land managers and other agents of conservation have been shown to improve landowner participation in conservation (Habron 2004). In order to conduct outreach to these lesser-contacted populations, alternative forms of outreach could be developed with smaller, amenity-based landowners in mind. However, as noted by a number of land managers, the current capacity and knowledge of effective landowner outreach approaches are limited.

While such changing land uses were largely indicative of increased uncertainty

for the future management of oak woodlands, these surveys did reveal a few interesting ways in which these changes may represent conservation opportunities. One landowner noted, for example, “As irrigation pumping costs increase 12 times what they once were, the amount of my property dedicated to agriculture will decrease, and I would like to establish oak woodland on the marginal ag/idled land.” The decreased amount of land in agricultural production may, in other words, provide landowners with more space (and time) with which to practice oak management or even increase the amount of oak woodlands present. A resource manager noted that “as the economy sags and the prices of agricultural land continue to fall, more and more agricultural landowners are putting conservation easements on their lands as a way to lower their tax burdens.” Thus, changing economic times and shifting land uses, although they introduce complexity to the conservation process, may lead to novel opportunities for the conservation and restoration of oak woodlands.

Lack of Institutional Support for Prescribed Fire

Given that oaks thrive in the presence of a regular fire regime, and that the KSB has experienced increasingly severe wildfire conditions in the past century (Agee 1993, Mid-Klamath Watershed Council 2008), some landowners regard the application of prescribed fire on their properties with fear or doubt. Landowners who have observed escaped prescribed fires, in particular, may be leery of such activities occurring on their own properties, even if the restoration process results in greatly reduced fuel loads, lower

potential for fire to spread to infrastructure and structures, and reduced risk of stand-replacing fires on their property. Multiple landowners cited or implied that escaped government "controlled" burning had burned or affected their properties. Although some landowners considered prescribed fire to be an important tool, others had legitimate reasons to avoid it. Nonetheless, 79% of landowners in this survey expressed partial or full support of the use of this practice on private lands. Prescribed fire is a more common practice within many communities throughout the KSB than in other areas in the United States (Mid-Klamath Watershed Council 2008). Due to a variety of social and ecological factors, prescribed fire is implemented with relative frequency in the KSB, and residents have developed a pervading culture of fire awareness.

The high correlation between acceptance of natural and prescribed fire and extent of oak management ($p = 0.001$) in this study suggest a natural pairing between the two management practices. Many landowners in this region already use prescribed fire as a fuels-reduction practice foremost, which produces the secondary benefit of releasing their oak woodlands from competition, and enhancing the habitat of wildlife associated with them (Hosten et al 2006). Therefore, the processes of prescribed burning and oak woodland restoration may be complementary practices that appeal to landowners, provided that they are able to overcome the significant impediments to prescribed fire that currently deter them from implementing it. Mechanisms that pair landowners' interest in prescribed fire with their interest in restoring the oaks on their properties may have symbiotic results for both management objectives.

The results of the landowner and land manager surveys in this study confirm that residents and natural resource professionals in the KSB widely perceived beneficial

ecological and economic applications for prescribed fire. Twenty-nine percent of landowners had conducted a controlled burn at some point on their properties, and 72 % expressed some level of interest in implementing a prescribed burn for the purpose of oak woodland restoration. A landowner confirmed his belief in the restorative effects of fire upon oaks, “We annually Rx burn the oak trees on our property, and they continue to be very healthy.”

Land managers suggested that institutional factors greatly hinder landowners’ ability and motivation to conduct restorative burns on their property. Although controlled burning is a demonstrably effective method for curtailing conifer encroachment and releasing oaks from competition, it is subject to many bureaucratic hurdles and constraints. Due to regulatory considerations, a burn plan must be prepared, burns must be conducted with the notification and at times participation of state or local fire agencies, and permits obtained from state Air Quality Control Boards. Obtaining air quality permits can be a complicated bureaucratic process; private landowners must often compete with industry for a limited number of permits, and are liable for prescribed burns should they escape from their property (Mid-Klamath Watershed Council 2008). For owners of smaller parcels, prescribed fires may be less practical from a logistical standpoint due to smaller distances between homesites and buildings, limited road ingress and egress, and greater considerations of adjacent property uses. Risk of escaped fires can clearly incur greater safety and economic risks amidst a populated, rural-residential area in the WUI (wildland-urban interface) than on a large parcel of contiguous acreage (McCreary 2004).

Seemingly insurmountable regulation combined with potential for high financial

or legal risk create strong disincentives for landowners to practice restorative burns on their properties, even if they recognize the need to do so. Lack of management leads to higher fuel loading and increased chances of a catastrophic burn (Agee 1993). Over time, this feedback loop is difficult for landowners to escape, and makes restoration through prescribed fire a daunting prospect. Aptly put by one survey respondent, "Landowners, particularly in California, are already OVERREGULATED! We are losing employment opportunities and our forests are wildfires waiting to happen." Therefore, in order to increase oak woodland restoration across private lands, the facilitation of the prescribed fire process therein appears to be a necessary accompaniment.

Inconsistent Oak Woodland Policies and Regulations

One of the major impediments to oak woodland conservation and restoration identified in this research is the lack of clear overarching policy addressing it. The KSB spans two states and five or more counties, with a multitude of federal, state, county, municipal, and tribal agencies operating within it. Examination of environmental laws and policies reveals frequent inconsistencies between landowners of conifer-dominated sites, and landowners of oak-dominated sites (Giusti and Merelender 2002). In both Oregon and California, oaks are addressed infrequently and inconsistently by forest practice laws and management plans, and are subject to unreliable interpretation and implementation. Although oak woodlands are habitat for at least 45 species that are listed as 'at risk' by various agencies or organizations, the habitats themselves have no formal, systematic protection (NRCS 2011).

California and Oregon each have their own Forest Practices Acts, and both acts address oaks infrequently, instead emphasizing commercial species for which there is far greater economic imperative for regulation (Giusti and Merenlender 2002, Fisher and Bliss 2008). Although oak trees are subject to mitigation requirements under state laws if trees are removed that have a "significant impact" (as determined under regulatory statutes such as NEPA or CEQA), mandatory requirements are sparse for maintaining or restoring oak habitats that are dying or succeeding to different habitats due to "natural" succession. No mandatory policies require landowners to plant new oaks if they are found to be regenerating inadequately or dying of "natural causes."

The regulation of the harvesting and conservation of oak trees is highly decentralized, with most responsibility for oak management falling under the jurisdictions of individual counties. Activities associated with oak woodland restoration can be formidable undertakings to counties and municipalities tasked with designing and implementing oak woodland conservation plans. Counties are generally not equipped to sufficiently evaluate and mitigate for the impacts that different land use practices have on oak trees (Giusti and Merenlender 2002). Despite the lack of protection and planning for oak woodlands, regulation of these habitats on private lands by public agencies is highly unpopular with both landowners and land managers. Only 7 % of landowners and 35 % of land managers believe that oaks on private lands should be subject from any kind of public regulation. Many land managers noted in the comments section that regulation of oaks on private lands would be most effective if done so at the county or municipal levels.

Numerous state and federal forest management laws appear to ignore or disregard

the unique characteristics and ecological requirements of oak woodlands, perhaps because their complex needs seem simply too constraining or expensive to consider. Most oak trees are not covered by the Forest Practice Act, administered by CALFIRE, which regulates logging and forest practices on private lands. Unless a property is in a TPZ (Timber Production Zone), oaks on their property may have no formal protection (Giusti and Merenlender 2002).

Other forest practice laws contain inconsistencies that make oak woodland restoration efforts challenging. Oregon Forest Practices have re-stocking rules that require landowners to plant new trees of the same species after they are removed (Fisher and Bliss 2008). As conifer thinning and removal tend to be requisite practices for oak woodland restoration, as well as for fuels reduction and fire safety efforts, landowners wishing to conduct restoration via selective conifer thinning may then be in violation of Forest Practices replanting requirements (Fisher and Bliss 2008).

A number of resource professionals in this survey mentioned that conservation and restoration efforts might be most effective if implemented in conjunction with local capacity-building organizations based in the KSB such as the Lomakatsi Restoration Project, the Mid-Klamath Watershed Council, or the Hayfork Watershed and Training Center. Such locally-based organizations employ restoration practitioners with the place-based LEK and TEK to effectively oversee restoration. Most managers agree, however, that the funding for such efforts would still need to obtained from federal and state programs such as Natural Resources Conservation Service (NRCS) or United States Fish and Wildlife Service (USFWS). A cost-share approach is currently being piloted in the KSB, linking funding from the NRCS and USFWS with technical expertise and

TEK/LEK from the Lomakatsi Restoration Project to restore oaks on private lands (NRCS 2011). The Klamath Bird Observatory is participating by monitoring the sites before and after restoration activities take place, using birds as indicators of restoration success (Lomakatsi Restoration Project 2009). There are a variety of incentive programs through which landowners can potentially obtain funds to conduct restoration work on their properties, however navigating such programs can be highly complex. Despite the variety of existing programs, most landowners do not formally take advantage of them (Huntsinger, 1990). Programs designed specifically with the general tendencies and goals characteristic of contemporary landowners, many of whom own their land for non-extractive purposes, would likely increase their inclination to take advantage of such programs.

Lack of Monitoring in Restoration

Monitoring the performance of ecological restoration can be a complex and highly costly process, as many projects require years of repeated study across multiple sites to demonstrate the effectiveness of a restoration effort (Hanna and Dunn 1997). While practitioners can recommend general guidelines for conserving, restoring, or encouraging the regeneration of new oaks, very little monitoring has been conducted to quantify the success of these previous efforts (Hosten et al. 2006). Restoration practitioners emphasized the importance of communicating oak woodland restoration outcomes, successes, and shortcomings between agencies, organizations, landowners, and all restoration practitioners. A tribal restoration practitioner suggested that oak woodland

managers should observe past projects and then “adapt future projects based on project outcomes.”

While isolated oak woodland restoration efforts are occurring across the KSB, land managers noted that the successes and failures of such efforts are not frequently shared between organizations and agencies. Restoration practitioners are left to repeat easily avoidable mistakes and miss opportunities to gain valuable LEK from previous efforts. One manager summarized the complicated nature of oak woodland regulation and policy: “Organizations and agencies need to collaborate to answer important questions about conserving and managing oak ecosystems and also to find ways to bring in resources to get work done. It’s all about communication and initiative within organizations.”

Restoration practitioners widely cited a lack of monitoring by which to gauge the success of projects as a major impediment to improving the efficacy of the process (Garmon 2006). The long time span required in order to see and evaluate results surely contributes to this scarcity of restoration guidelines and monitoring feedback available to land managers. When they set out to prioritize projects and conduct restoration, they must work with the best available knowledge and resources to optimize results. A non-profit land manager who frequently consults with landowners about oak restoration noted that they, “would like to see monitoring, esp[ecially] vegetation monitoring as an important part of oak restoration as I feel we don't quite know what we're doing in this region or the long term impacts of various treatments.” To complicate an already complex process, each site presents its own suite of ecological and social nuances that are best evaluated by an individual who possesses the LEK to be able to assess a site over time (Martinez

2003).

A lack of concrete assurance as to the outcomes of a restoration project may be unappealing to landowners, who have limited resources and would like to see clear picture of what the restoration outcomes will be (Habron 2004). Some landowners may require education about the successional nature of forests, and given a framework in which to envision how the post-restoration landscape may develop. Particularly if they have not been on the land for a long time to observe its change over time, landowners may tend to view their properties as a "snapshot" rather than a shifting mosaic over time.

Some organizations are monitoring the success of oak woodland restoration by pairing landowners' desire to manage for wildlife habitat with the use of indicator species (e.g. Lomakatsi 2009). Birds, for example, can serve as effective indicators by which to evaluate restoration attainment due to their higher position in the food chain, their wide distribution across various habitats, and the relative ease and cost-effectiveness by which they can be monitored (Lindenmayer 1999). Landowners may be engaged to participate in oak woodland restoration monitoring via their widely-cited interest in creating songbird habitat on their properties (Hilty and Merenlender 2003, Lepczyk et al. 2004). Bird are ubiquitous, visible, audible, and highly charismatic to landowners across many parcel sizes, ages, incomes, and management styles. Therefore, the monitoring of future of oak habitats and the bird assemblages they support depend largely upon the participation and education of private landowners on whose properties they are most likely to occur.

As mentioned by multiple resource professionals in this survey, oak woodland monitoring efforts are also confounded by a lack of concrete knowledge of the exact

spatial extent of remaining oak woodlands. Assigning conservation priorities to habitats on a landscape scale may be difficult if their extents are unknown or are improperly classified. While a wealth of GIS models are available that attempt to quantify the amount and nature of remaining oak woodlands, ground-truthing efforts have demonstrated that much of these spatial data are somewhat to wildly inaccurate (Newburn et al 2005). Spatial mapping errors are due to a suite of compounding errors, such as rapid conifer over-topping in some locations and oak die-off in others, that confound oak mapping efforts. Therefore, in order to be able to quantify where oak woodland restoration is taking place, where it is needed, and if this process is providing adequate results, further effort should be put forth into improving and synthesizing these data.

Recommendations

Several recommendations emerged from this research suggesting key components that are necessary to increase engagement with oak woodland restoration by both landowners and land managers. Existing policies and practices surrounding oak woodlands must be modified to reflect unique management needs and threatened conservation status. The roles of natural and prescribed fire should be re-examined in order to facilitate landowners' ability to implement prescribed fire on their properties.

A principal recommendation derived from this study is to increase communication between land managers and landowners about the needs of oak habitats. In order to address the challenges of shifting ownership trends within the KSB, land managers will

require a greater awareness of the landowners who inhabit and own the private landscape. As the landowner base changes and landowners increasingly prioritize amenity-based, non-economic values on their properties, the traditional methods of outreach from agencies and capacity building organizations should be tailored to these landowner values. New forms of landowner outreach and education must be developed that are relevant to the contemporary land base, such as instructional pamphlets, workshops or webinars, and family forest associations, among many other possible forms of outreach. Incentives, both economic and symbolic, should be identified that appeal to landowners of different ownership profiles in order to further engage their participation in oak management. Greater communication should be established among restoration practitioners in agencies, universities, tribes, private sectors, and other spheres dealing with oak woodland management in order to optimize future restoration efforts.

Given the apparent lack of trust of state and federal agencies by landowners, local, capacity-building organizations can play a more prominent role in increasing the management of private oak woodlands by implementing cost-share approaches that apply available public funding to locally based restoration projects, which also include funding for post-restoration monitoring. Finally, increased knowledge of the spatial extent of remaining oak woodlands by improved geospatial data would allow for greater optimization of future restoration and management efforts.

CONCLUSION

Oak woodlands are challenging to restore both ecologically and socially despite a long-standing human affiliation with these ecosystems. Oak woodlands are disturbance-dependent ecosystems situated in a matrix of land uses that is increasingly sensitive to such disturbances. The survival of oak woodlands at the landscape scale is dependent upon endogenous factors, such as each individual land owners' management regimes, and exogenous factors, such as land fragmentation and suppression of natural disturbance regimes.

Some ecologists suggest that the oak woodlands of the KSB, although beautiful and biodiverse, are a remnant of the past. The considerable time, energy, and funding required to restore and maintain these ecosystems at their historic extents may be a cost that society ultimately decides is too high to bear in the face of other important conservation priorities. Unless conservation organizations and agencies, along with the landowners on whose properties these ecosystems predominantly occur, make a collective commitment to their conservation and restoration, such a recovery appears improbable. A complete ecological regime shift may be imminent, one from which the oak woodlands of the KSB are unlikely to make a significant comeback, unless society commits to prioritizing their conservation and restoration. Existing policies and regulations regarding oak woodlands, along with current management priorities and capacities of the landowners and land managers, indicate that novel conservation strategies must be implemented at the landscape-scale in order to ensure the perseverance of these diminishing habitats. The fact that oak woodlands have been historically maintained by humans, and that they occur

primarily on private lands, further underscore the imperative to consider the social factors that determine the restoration process. This research has attempted to identify some of these emergent factors. By exploring the management characteristics that may impede or promote engagement with oak conservation and restoration across the KSB, a more informed trajectory by which to proceed may be available to the stewards of these unique socio-ecological systems.

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APPENDIX A. LANDOWNER CONSENT FORM

Humboldt State University
Department of Environmental Science and Management
1 Harpst Street
Arcata, CA 95521

9 January, 2012

Dear landowner,

My name is Iris Koski and I am a graduate student in the department of Environmental Science and Management at Humboldt State University. I am participating in a research project whose goal is to assist landowners in improving the health of oak woodlands on their properties. This project is researching ways to assist private landowners to better access the resources required for improved stewardship of oak trees. Such resources include funding, labor, equipment, trainings, and workshops.

As you may be aware, our oak woodlands are in precipitous decline in this region, and you as a landowner may be able to contribute to a solution. You were selected to participate in this study because you own one or more parcels in the Klamath region of northern California/southern Oregon that occur within a known area of oak habitat. Because most oak woodlands occur on private lands, it is essential that private landowners are included within this study. I have enclosed a questionnaire that will allow you to provide your valuable insight regarding the important topic of oak woodland conservation. In the questionnaire, you will be asked to give your thoughts and opinions about land management, oak restoration and conservation, and prescribed fire.

Your participation in this study is completely voluntary and would be most appreciated. All that you would need to do is complete the enclosed questionnaire, and then return it with the addressed, stamped envelope provided. The survey should take 15-20 minutes to complete. I am interested in your opinions and expertise about land management, conservation, oak woodland restoration, and your local knowledge about this region. The purpose of this study is to determine what oak woodland conservation or restoration practices are being practiced, and how private landowners might be better assisted in the restoration process. This could result in more funding or tax incentives for doing restoration on private lands, and greater opportunities for landowners to receive training or technical assistance with oak restoration. With this information, we may be able to come up with viable solutions and alternatives that benefit both private landowners as well as our region's oaks. **The completion and return of this survey**

signifies your willingness to participate in this research, and assures that your participation will be entirely confidential.

Important Statement of Your Privacy

Your anonymity is an extremely high priority in this study. This research necessitates the collection of data in the form of your opinions gathered from this questionnaire, but all information given by survey participants will be kept completely confidential and classified. All data will be kept and analyzed in a secure location at Humboldt State University. The results of this questionnaire will be aggregated such that no individual names, parcels or responses will be displayed. Survey responses will only be used for the purposes of data analysis for this master's thesis. This research is in fulfillment of a Master of Science in the Environmental Science and Management Program at Humboldt State University under the supervision of Dr. Alison O'Dowd. For more information about Humboldt State's privacy statement, please contact Chris Hopper, Associate Dean, College of Professional Studies, cah3@humboldt.edu, (707)826-3853

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If you have any questions about this project and/or your participation you can contact me (Iris Koski) at (707)-535-9323 or, iek1@humboldt.edu, or my faculty advisor, Alison O'Dowd, at (707)-826-3438 or ap73@humboldt.edu . If there are any further questions regarding your rights as a participant, any concerns regarding this project, or any dissatisfaction with any part of this study, you may report them—confidentially, if you wish—to the Dean for Research & Sponsored Programs, Dr. Rhea Williamson at Rhea.Williamson@humboldt.edu or (707)-826-4189.

Best regards,

Iris Koski

Humboldt State University
Department of Environmental Science and Management

APPENDIX B: LANDOWNER SURVEY INSTRUMENT

LANDOWNER QUESTIONNAIRE: OAK WOODLAND MANAGEMENT

Section 1: Property Information.

1. Do you own this parcel? ☐ Yes ☐ No _____ # acres total you own
2. For how many years have you owned it? _____
3. For how many generations has this property been in your family? _____
4. Do you live on this property?
   ☐ Yes ☐ No ☐ Part of the year (_____# months/year)

5. **Not including residential use**, what would you describe as the **main use** for this property? **Please choose one answer only**

- ☐ Livestock/Grazing
- ☐ Farming/Agriculture
- ☐ Private forestry
- ☐ Ecotourism
- ☐ Biodiversity
- ☐ Recreation
- ☐ Commercial production
- ☐ Mixed use, specify: _____|_____
- ☐ Non-timber forest products: _____
- ☐ Other: _____

6. Do you currently have a conservation easement on your property?
   ☐ Yes ☐ No
7. If **Yes**, how many acres are protected under the conservation easement? _____
8. Through which organization (s) do you have the conservation easement?
   _____
9. Are you involved with any other conservation organizations, agencies, watershed councils? If yes, please list them below:
   _____

10. What does your land mean to you? Please rate the following values you place on your land:	Very important	Important	Somewhat important	Slightly important	Not important at all	Not sure/ don't know
An important part of your family heritage						
A place that provides personal satisfaction or improved quality of life						
A place to live rurally or to escape from the city						
A place to preserve the land from development						
A place for grazing livestock						
A place for commercial agriculture						
A place for practicing forestry/timber production						
A source of economic value to you and your family						

LANDOWNER QUESTIONNAIRE: OAK WOODLAND MANAGEMENT

Section 2: Oak Woodland Ecology and Management .

11. How do you rate the health of the oak trees on your property overall?

☐ Very healthy ☐ Healthy ☐ Moderately healthy ☐ Poor ☐ Very Poor ☐ Don't know

12. How do you rate the regeneration of oak seedlings and saplings on your property?

☐ Good ☐ Adequate ☐ Poor ☐ Not Sure

14. Do you fell any living oaks on your property?

☐ Yes ☐ No

15. Do you graze livestock in the oaks on your property?

☐ Yes ☐ No

16. Please rate the following statements about oak trees.	Strongly Agree	Agree	Neither Agree nor disagree	Disagree	Strongly Disagree	Not sure/ don't know
Oak trees are an important ecological and cultural resource.						
The amount of oak trees on my property is **declining** over time.						
The oak regeneration/replacement on my property is **not adequate.**						
Maintaining and restoring oak trees on my property is a high priority in my property management.						
I would like to develop an oak management plan for my property.						
I am interested in collaborating with an agency and/or a local conservation organization in order to restore the oaks on my property.						
If I had more **time,** I would be more inclined to restore the oaks on my property.						
If I had more **money,** I would be more inclined to restore the oaks on my property.						
If I had more **knowledge/training on how to do so,** I would be more likely to do restoration on the oaks on my property.						
If I had access to **labor/ equipment,** I would be more likely to do restoration on the oaks on my property.						
Oak trees have significant economic value.						
There are **other** tree species besides oaks on my property that I prefer to manage for because they are more important or economically valuable to me.						
Oak trees on private lands should be regulated by public agencies.						

LANDOWNER QUESTIONNAIRE: OAK WOODLAND MANAGEMENT

17. How often do you implement the following activities on the oaks on your property?	**Often (1-2 years)**	**Sometimes (3-8 years)**	**Rarely (9-20 years)**	**Never/ NA**
Plant new oak seedlings				
Fence off oaks to protect from livestock				
Thin conifers to reduce competition with oaks				
Install vaca cages or tree shelters around young oaks for protection				
Remove competing vegetation (brush, weeds, grasses) around young oaks				
Conduct a controlled burn in understory around your oak trees				
Burn brush piles				
Re-seed with native grasses				
Collect acorns for propagation				
Consult an advisory agency, land trust, forester, or other professional about oaks on your property				
Monitor for diseases/pests				
Prune limbs above deer/livestock browse line				
Other activities intended to benefit your oak trees (specify) :				

18. Please rate the degree to which you agree or disagree with the following statements about wildfire safety and ecology.	**Strongly Agree**	**Agree**	**Neither Agree nor disagree**	**Disagree**	**Strongly Disagree**	**Not sure/ don't know**
Fire of any kind poses a threat to my property and safety.						
Fire of any kind is a threat to the ecological condition of my property.						
My property would be ecologically healthier with a regular fire regime.						
Prescribed fire could be a benefit to the safety and ecology of my property.						
It is my responsibility to plan and manage for fire on my property.						
I would be interested in conducting prescribed burning on my property if there were more financial resources and/or technical assistance available.						
The permitting process required for prescribed fire is an obstacle.						
Fire a required process for maintaining oak health on the landscape.						

LANDOWNER QUESTIONNAIRE: OAK WOODLAND MANAGEMENT

19. Has any portion of your property burnt during a wildfire since you have owned it? ☐ Yes ☐ No ☐ Don't know

20. Have you ever conducted a controlled burn on your property? ☐ Yes ☐ No

21. **If YES**, did the portion of your property that burned contain oak trees? ☐ Yes ☐ No ☐ Don't know

22. Do you participate in a local fire-safe council? ☐ Yes ☐ No ☐ Never heard of one

Section Three: Landowner information:

22. Zip code _____

23. What is your age? _____

24. Are you: ☐ Male ☐ Female

25. What is your occupation? _____

26. About what percent of your income comes from your land?

☐ None ☐ Less than 25% ☐ 26-50% ☐ 51-75% ☐ 76-100%

27. What is the highest level of education you have **completed**?

☐ High school or below ☐ Community college or trade school

☐ 4-year college or university ☐ Graduate degree or beyond

28. Would you like a copy of the results?

☐ No ☐ Yes (If Yes, write address here:) _____

_____

_____

29. Is there anything else that you would like to tell us? Any additional thoughts are appreciated; please comment in the space below:

Thank you for participating in this survey! Your opinions are a valuable contribution to this project.

4

APPENDIX C. LAND MANAGER SURVEY INSTRUMENT

1. What type of organization or agency do you work for?

- What type of organization or agency do you work for? Federal
- State
- County
- University
- Non-profit
- Other (please specify)
- Private consulting
- Private forester
- Tribe
- Fire Agency
- Fire Non-profit

2. How long have you worked with your agency or organization?

3. How long have you worked in the field of conservation/land management in the Klamath Basin?

4. Check all the counties that are within your professional management areas

- Del Norte (CA)
- Trinity (CA)
- Siskiyou (CA)
- Klamath (OR)
- Douglas (OR)
- Jackson (OR)

Other (please specify)

*****

5. In an average year, how often do you communicate with land owners about oak woodland management or restoration, for any reason?

25 or more times per year

- 10 or more times per year

- Less than 10 times per year
- Never

*

6. As a part of your professional duties, how often do you attend trainings, workshops, or meetings that address oak woodland conservation or restoration?

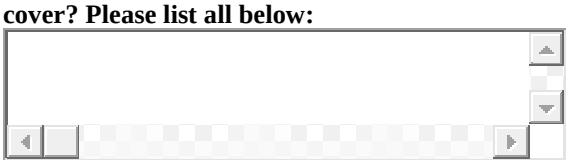
- More than ten times per year
- Five to ten times per year
- Less than five times per year
- Never

*

7. Are you aware of any regional oak woodland management plans in your management area?

- Are you aware of any regional oak woodland management plans in your management area? Yes
- No
- Don't know

8. If so, through which organizations or agencies are the management plans, and what areas do they cover? Please list all below:



If so, through which organizations or agencies are the management plans, and what areas do they cover? Please list all below:

*

9. Rate the degree to which you agree or disagree with the following statements about oak woodland conservation:

	Strongly Agree	Agree	Neither Agree nor disagree	Disagree	Strongly Disagree	Not sure/ don't know
Oak trees are an important ecological and cultural resource.						
I am highly concerned about conserving/restoring oak woodlands in my management area.						
Oak trees have economic potential that should be utilized.						
I am satisfied with the amount of oak						

	Strongly Agree	Agree	Neither Agree nor disagree	Disagree	Strongly Disagree	Not sure/ don't know
woodland management in my management area.						
There are other conservation issues besides oaks that are higher priorities in my conservation duties.						
Oak woodland management should be a higher priority than it currently is in my management area.						

*****

11. Do you think that oak trees on private lands should be regulated by (check all that apply):

- ☐ Don't know/ Choose not to answer
- ☐ State agencies
- ☐ Federal agencies
- ☐ No public agencies

*****

12. Please rate the degree to which you agree or disagree with the following statements about fire safety and ecology.

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree	Not sure/ don't know
Fire of any kind poses a threat to landowner property and safety.						
Fire of any kind is a threat to the ecological health to forest ecosystems.						
Fire is an important naturally-occurring event at the landscape scale.						
Private property would						

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree	Not sure/ don't know
be ecologically healthier with application of a regular fire regime.						
If managed and planned for properly, prescribed fire could be a benefit to landowner safety and property.						
It is the property owners' responsibility to plan and manage for fire.						
Fire is a critical natural process for maintaining oak health on the landscape.						

13. How important are the following facets of ecological conservation to you?

	Very important	Important	Somewhat important	Slightly important	Not at all important	Not sure/don't know
Protecting under-represented ecosystems or species						
Providing and enhancing habitat for native fauna/flora						
Increasing the area protected/managed oak woodlands						
Increasing landowner participation in land management and conservation						
Enhancing economic potential of private properties through land improvements or conservation measures						

*****

14. Which of the following strategies would be the most effective method for resource professionals to assist landowners in implementing oak woodland conservation and restoration?

Providing information about monetary incentives or tax breaks

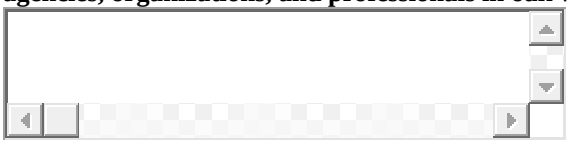
- Providing trainings/workshops about oak woodland restoration
- Providing on-site labor and equipment for implementing restoration
- Helping landowners implement oak management plans or conservation easements

*

15. If you had the opportunity to attend trainings or workshops on oak woodland restoration as part of your job, how likely would you be to participate?

- If you had the opportunity to attend trainings or workshops on oak woodland restoration as part of your job, how likely would you be to participate? Extremely likely
- Very likely
- Moderately likely
- Slightly likely
- Not at all likely

16. Please add any additional comments or ideas about how to engage participation from landowners, agencies, organizations, and professionals in oak woodland conservation and restoration.



17. Would you like a copy of the results?

- Yes
- No

18. If you would like a copy of the results, please enter your email address below: