CONSERVING THREATENED HABITAT TYPES IN RURAL LANDSCAPES THROUGH LAND USE PLANNING: A CASE STUDY IN WASCO COUNTY, OREGON

by

PATRICK T. HURLEY

A THESIS

Presented to the Environmental Studies Program
and the Graduate School of the University of Oregon
in partial fulfillment of the requirements
for the degree of
Master of Science

June 2001

"Conserving Threatened Habitat Types in Rural Landscapes Through Land Use Planning: A Case Study in Wasco County, Oregon," a thesis prepared by Patrick T. Hurley in partial fulfillment of the requirements for the Master of Science degree in the Environmental Studies Program. This thesis has been approved and accepted by:

[redacted]

Dr. Bart R. Johnson, Chair of the Examining Committee

June 5, 2001

Date

Committee in charge: Dr. Bart R. Johnson, Chair
Dr. Peter Walker
Robert Parker

Accepted by:

[redacted]

Vice Provost and Dean of the Graduate School

An Abstract of the Thesis of

Patrick T. Hurley for the degree of Master of Science

in the Environmental Studies Program to be taken June 2001

Title: CONSERVING THREATENED HABITAT TYPES IN RURAL LANDSCAPES THROUGH LAND USE PLANNING: A CASE STUDY IN WASCO COUNTY, OREGON

Approved: [redacted]

Dr. Bart R. Johnson

Land use planning has evolved multiple approaches for promoting conservation on private lands. However, in rural areas where conversion of native habitat is increasing, a methodology for systematically identifying important native habitat elements is needed, particularly at scales smaller than current vegetation mapping efforts undertaken by state Gap Analysis Projects. Inventories need to target the chief units of land use planning: parcels.

Using the watershed assessment approach utilized by watershed councils in Oregon as a model, I developed a methodology to facilitate citizen-involvement in habitat inventories and the subsequent delineation of local habitat types of concern. I tested these methods in a 24,000-acre area in North-central Oregon. Results suggest that the methodology produces higher resolution habitat maps that can be used to create overlay

zones for the application of appropriate ordinances by local land use planners to meet biodiversity conservation goals.

CURRICULUM VITA

NAME OF AUTHOR: Patrick T. Hurley

PLACE OF BIRTH: Baltimore, Maryland

DATE OF BIRTH: March 19, 1971

GRADUATE AND UNDERGRADUATE SCHOOLS ATTENDED:

University of Oregon
University of Maryland

DEGREES AWARDED:

Master of Science in Environmental Studies, 2000, University of Oregon
Bachelor of Arts in German Language, 1994, University of Maryland
Bachelor of Arts in Government and Politics, 1994, University of Maryland

AREAS OF SPECIAL INTEREST:

Biodiversity conservation and land use planning

PROFESSIONAL EXPERIENCE:

Graduate Teaching Fellow, Environmental Studies Program, University of Oregon, 1998-2001

Research Writer, Global 200 Campaign, World Wildlife Fund, Washington, DC, 1998-2000

Research Assistant, Conservation Science Program, World Wildlife Fund, Washington, DC, 1997-98

Teaching Assistant, Department of Germanic and Slavic Languages, University of Maryland, 1994

AWARDS AND HONORS:

Donald R. Barker Foundation Scholarship Fund in Environmental Studies Research Award, Winter 1999

Donald R. Barker Foundation Scholarship Fund in Environmental Studies Research Award, Summer 1999

Donald R. Barker Foundation Scholarship Fund in Environmental Studies Research Award, Spring 2000

Donald R. Barker Foundation Scholarship Fund in Environmental Studies Research Award, Fall 2000

Donald R. Barker Foundation Scholarship Fund in Environmental Studies Research Award, Spring 2001

Graduate Student Research Award, University of Oregon Graduate School, Spring 2001

PUBLICATIONS:

Hurley, P.T. 2001. Swimming in the shadow of salmon: Nongame fishes and the freshwater biodiversity of Oregon. *The Ecotone* Spring. University of Oregon Environmental Studies Program, Eugene, OR.

Hurley, P.T. 2000. Contradictions in Oregon's land use planning. *The Ecotone* Fall. University of Oregon Environmental Studies Program, Eugene, OR.

Abell, R., D.M. Olson, E. Dinerstein, P.T. Hurley, J.T. Diggs, W. Eichbaum, S. Walters, W. Wettengel, T. Allnutt, C.J. Loucks, and P. Hedao. 2000. Freshwater Ecoregions of North America: A conservation assessment. Island Press, Washington, DC.

Ricketts, T.R., E. Dinerstein, D. Olson, C. Loucks, W. Eichbaum, D. DellaSala, K. Kavanagh, P. Hedao, P.T. Hurley, K Carney, R. Abell, and S. Walters. 1999. The terrestrial ecoregions of North America: A conservation assessment. Island Press, Washington, DC.

Olson, D.M., E. Dinerstein, and P. Hurley. 1998. The big picture: The biodiversity of Maryland in a global and continental context. Pages 85 – 88 *in* Therres, G.D. (editor). Conservation of biological diversity: A key to the restoration of the Chesapeake Bay ecosystem and beyond. Maryland Department of Natural Resources, Annapolis, MD.

ACKNOWLEDGEMENTS

I express my sincere gratitude to Dr. Bart R. Johnson, Dr. Peter Walker, and Robert Parker for assisting me with my thesis research and the completion of this project. In particular, I am indebted to Dr. Johnson for planting the seed that became this thesis and for unwaveringly attending to its successful maturation. His enthusiastic mentoring, as well as the many discussions we had about planning and conservation, contributed greatly to my desire to continue in academia. Dr. Walker's ability to guide me in clearly defining questions during the research design phase was tremendously helpful. His encouragement throughout the project cannot be overstated. Bob Parker's commitment to pragmatic planning solutions helped keep me grounded in planning realities and focused on fitting this work within Oregon's land use planning system. I also express my appreciation to Nicole Maggiulli, Matt Visser, and Eric Anderson for their help with completion of the field work.

Completing a project of this magnitude cannot be accomplished, let alone completed successfully, without the support and love of family and friends. A heartfelt thank you goes to my parents, who have always believed in me and who have fostered my lifetime love of learning. Numerous people provided me encouragement along the way. I can never fully thank them all. However, a few special people stand out. I can never fully appreciate Loren McClenachan's patience and support during the past two years. Julie Polhemus, Steph Tuxill, Chris Jones, Chandra LeGue, and Jean Jancaitis made sure the stress never fully got to me. Heartfelt thanks go to Robin Abell, for believing in me at a time when I was unsure of my abilities.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF ILLUSTRATIONS

Illustration Page

CHAPTER I

DESIGNING CONSERVATION LANDSCAPES IN RURAL AREAS UNDERGOING RESIDENTIAL DEVELOPMENT

> We need a new conservation paradigm—one using more proactive, bolder, and larger-scale conservation strategies. This new agenda must focus on land use planning as well as on redefining the role of cities and communities in protecting and preserving biodiversity.
>
> (Beatley 2000: 5)

> An ever-increasing population and the realization that private land inevitably will be developed necessitate a response from conservation biologists.
>
> (Knight 1999: 224)

Efforts to conserve biodiversity in rural areas of the western United States cannot rely solely on a system of nature preserves. We need not, nor should we, abandon reserve strategies in growing rural communities of the American West, but rather we must broaden our efforts by designing conservation landscapes in which native habitats are embedded. I propose an approach for designing a conservation landscape that uses land use planning tools to rework the direction of current development in a rural county in Oregon. This approach, and the specific methods I discuss, are designed to supplement the traditional reserve network strategy advocated by many conservation biologists; in effect, implementing a form of matrix management (Franklin 1993).

Conservation planners have paid little attention to issues of how to place houses or develop portions of the landscape in a way that may support native elements of biodiversity and contribute to the wider landscape-level conservation goals. Moving beyond the limitations of this thinking opens the door for land use planning to direct development to specific sites that are already degraded or do not meet selection criteria for inclusion within the traditional reserve strategy and to implement more habitat-friendly forms of development. This form of matrix management allows new housing construction, while working to encourage development patterns and activities that minimize impact on native plant communities and habitats.

Designing a conservation landscape in rural communities requires the systematic identification and evaluation of key habitat elements. Combining information on the distribution of natural habitats with data on their quality lays the groundwork for directing the location of new residential development to less important areas while controlling the intensity of that development. Pursuing such an approach is particularly important in areas where relatively large tracts of native habitats are experiencing conversion to housing or other land uses. It marks a departure from the "prevailing low-density, scattered development patterns and the belief that all that is needed to preserve biodiversity is to set a side a few areas of protected habitat" (Beatley 2000: 8).

To be successful at creating more biodiversity-friendly land use patterns, planners must implement methods for systematically mapping and assessing the quantity and quality of current habitat. These methods need to apply lessons garnered from current conservation planning efforts, and to incorporate principles of conservation biology and landscape ecology. More importantly, in areas experiencing conversion of natural habitats to rural residential use, mapping efforts must facilitate the application of land use planning tools, paying particular attention to linking parcel-scale habitat issues with wider landscape level conservation issues.

I use a case study in north-central Oregon to develop and evaluate procedures for the mapping and assessment of natural habitat. The site is a 24,000-acre study area in Wasco County that lies within a larger expanse of natural vegetation identified by the Oregon Biodiversity Project (1998) for its importance in conserving native biodiversity. The procedures I detail in Chapter Two are designed specifically to aid land use planners in applying the tools of their trade to habitat conservation in rural areas undergoing development.

I set out to answer a number of important questions that frame the broader topic of how land use planners can work to conserve important areas of relatively intact native habitats. In essence, I seek to move beyond the approaches prevalent in conservation planning literature published to date, uniting a number of divergent themes in contemporary natural resource management. Specifically, this paper explores the following questions:

1. What are the critical principles from conservation biology and landscape ecology that inform how we map habitats at an appropriate scale for land use planning?
2. How do we inventory habitats and determine their significance? In particular, what are the important habitat elements to include in this mapping effort?
3. How do we facilitate the application of flexible planning tools to habitats undergoing development using an overlay zone approach?
4. What does a methodology that relies on local citizens to identify and assess habitats look like?
5. What are the strengths and weaknesses of employing this type of citizen-based inventory?

My research provides a number of important and interesting answers to these questions, as well as general lessons for planners who are developing inventories of natural resources. Moreover, the data collected plus the analytical methods and results illuminate a wide range of conservation planning issues while raising several new questions. I discuss these issues and answers in the final chapter.

Several important components of habitat protection and land use planning are not explicitly considered in this paper. These topics fall outside the scope of my work. In particular, the practical aspects of developing the appropriate language for ordinances that are included in comprehensive plans are not explored. In addition, I do not examine the local politics of planning commissions that often shape the comprehensive plan development process. Instead, the focus of my work is largely on the technical aspects of creating a robust map to facilitate the application of any ordinances created to address the loss of native habitat.

I begin my discussion by providing background on habitat loss and its effects on biodiversity in context of the western United States. Next, I discuss the general nature of conservation planning and its relevance before explaining its limitations for dealing with landscapes undergoing development and suggest a strategy for moving beyond these limitations. Finally, I discuss the specifics of my study area as well as relevant information on land use planning in Oregon. These factors strongly influenced my proposed methods for inventorying remaining areas of intact habitat and protecting them from unfettered development. I turn my attention first to habitat loss and the role for land use planning in stemming the tide of biodiversity decline.

Habitat Loss and Biodiversity Decline: A Role for Land Use Planning

Land conversion for housing necessarily sets up a conflict between native biodiversity and humans and their land use practices (Wilcove et al. 1997; Duerksen et al. 1997, 2000; Theobald et al. 2000; Abell et al. 2000; Beatley 2000; Berke and Conroy 2000; Stein et al. 2000). Habitat loss and the associated fragmentation that development engenders pose major threats to the persistence of many species (Noss and Cooperrider 1994, Karr and Chu, 1995, Kiester et al. 1996, Wilcove et al. 1998, Beatley 2000). In the United States, millions of acres containing native ecosystems—and their attendant biodiversity—have already been degraded or destroyed (Wilcove et al. 1998, Stein et al.

2000). Indeed, large areas of the United States and their biotas are perceived as endangered, given the proportion of their native habitats or species that have been modified or destroyed (Master et al. 1998, Ricketts et al. 1999, Stein et al. 2000, Abell et al. 2000).

Regions and localities in the western United States, in particular, are experiencing conversion of land to meet growing housing needs (Meffe et al. 1997, Ricketts et al. 1999, Abell et al. 2000, Stein et al. 2000). Many of these landscapes still contain important native plant communities and their associated biodiversity. Ensuring the continued persistence of biodiversity in developing landscapes requires comprehensive efforts to protect important physical and biological components at multiple scales—site, landscape, regional, and global (Noss and Cooperrider 1994, Olson and Dinerstein 1998, Oregon Biodiversity Project 1998, Soulé and Terborgh 1999, Stein et al. 2000).

All species depend on their habitat—the physical and biotic components of ecosystems. These conditions provide the requirements for their survival (Morrison et al. 1998). Habitats exhibit a wide range of structural and functional characteristics across space and time (Noss and Cooperrider 1994, Peck 1998, Morrison et al. 1998, Johnson and O'Neil 2001). Human alteration of landscapes, such as logging, farming, and housing developments, lead to the loss, fragmentation, and simplification of important natural habitats (Noss and Cooperrider 1994, Meffe et al. 1997, Peck 1998, Ricketts et al. 1999, Abell et al. 2000, Stein et al. 2000, Johnson and O'Neil 2001).

Allowing further species and habitat loss by not mitigating the problems associated with current land use practices, particularly conversion of rural areas for housing, represents a failure by policymakers and land use planners to adequately address the inherent conflict of modern development with the preservation or conservation[1] of native habitats. This failure is, at the very least, partially responsible for the endangerment of habitats and their biotas across the United States in general, and in the American West in particular. I echo the sentiments posed by Beatley (2000) with which I began this chapter: Planners must play a role in the conservation of biodiversity.

The Role for Land Use Planning

Land use planning is concerned with effecting long-term development patterns that reflect the relationship between the objectives of local communities and regional goals, taking into consideration the social and economic well being of the community and region (Cullingworth 1993). More specifically, planners work directly on issues that determine the conversion of natural or semi-natural habitats[2] to landscapes utilized by humans, whether they be for agricultural, fuel, or fiber production; to fulfill recreational desires; or to meet housing demand (Noss and Cooperrider 1994, Karr and Chu 1995, Vitousek et al. 1997).

---

[1] There is a long-standing debate among scholars in a variety of disciplines about the meanings of the words conservation and protection. See Foreman (2000) for an in-depth discussion. In this paper, I use the terms interchangeably to mean the maintenance of natural habitats in their current form, both in terms of species composition and ecological structure, as well as the maintenance of ecological processes that create, maintain, and modify conditions over time.

[2] Natural and semi-natural habitats can be defined in a number of different ways. For my purpose here, they refer to areas whose floral and faunal components are comprised overwhelmingly of species that existed prior to the emergence of modern industrial society. These species arrived in a given geographic area by means of self-dispersal or were carried chiefly by non-human agents. These basic criteria are loosely based on the framework suggested by Anderson (1991).

Land use planners are uniquely poised to address biodiversity conservation (Pienkowski 1996, Duerksen et al. 1997, Theobald 2000, Beatley 2000). Historically, however, land use planners have generally focused on urban areas and occupied themselves with important social issues (Platt 1996). Consequently, they have largely ignored the issue of native habitat conversion and of mitigating its impact on biodiversity (Knight 1999, Beatley 2000). Environmental planning has focused largely on resource protection; policies and regulations addressing important areas for timber production or watersheds that provide local drinking water are not uncommon in the United States (Platt 1996, DLCD 1996). Alternatively, some efforts have focused on reducing the risk of environmental hazards, such as floods and landslides (Platt 1996).

Only recently have planners addressed habitat protection, most notably that of wetlands. For example, the City of Eugene, Oregon recently completed a comprehensive planning process to facilitate the purchase of large blocks of high quality wetlands (Bjorklund 1999). With the help of the Bureau of Land Management and a number of other federal, state, and non-profit entities as well as financial assistance from Congress, they have been successful at piecing together a protected system of wetland habitats within a developing area of the city.

Planners in the United States employ varying approaches to influence land use and land use patterns. Chief among these is zoning, whose purpose lies in encouraging the orderly and efficient transition from one use to another to avoid potential conflicts (Cullingworth 1993). This approach relies on the use of districts within which certain uses are either permitted outright, permitted conditionally, or are not permitted in each zone. For example, industries may not locate in districts that are zoned for residential uses. A zoning ordinance, usually part of a comprehensive plan, will also outline the specifics residential housing. Ordinances may specify requirements related to the use of a parcel, such as where a structure is situated on the parcel, how large the structure may be, and even the number of occupants residing in a house. Overlay zones, a type of supplemental zone, are typically used to apply specific requirements related to environmental issues. For example, flood overlay zones may be used to determine specific elevation requirements when constructing a new house.

In the rural American West, land development for new houses and other human uses will likely occur in the form of lower density housing (Duerksen et al. 1997). Because most development is tied to a rectilinear parcel pattern, and zoning and building requirements generally relate to this pattern, little attention is given to natural vegetation patterns across parcels or sometimes within parcels (Meffe et al. 1997, Duerksen et al. 1997). Development that ignores these habitat patterns contributes to overall habitat loss, while also fragmenting larger blocks of habitat (Meffe et al. 1997, Ricketts et al. 1999). Guiding development so that it encouraged patterns and activities that minimized habitat loss and fragmentation would strengthen land use planning (Beatley 2000, Mackenzie and Merenlender 2000).

For land use planners to effectively address habitat conservation issues, they must actively incorporate principles of conservation biology into their planning efforts (Smith 1998, Beatley 2000). Beatley suggests their efforts

> must be intentionally multispecies in emphasis and [they] must
> seek to protect the integrity and health of the broader habitats and

> ecosystems that support biodiversity—those species that are endangered and threatened and *ones that are not.* We need more integrated, comprehensive biodiversity conservation strategies that are long range, proactive, and preventive in nature. (page 7; my emphasis)

I argue that pursuing a habitat-based inventory approach that is used to develop a habitat-based zoning overlay provides a robust means for addressing habitat conservation and mitigating some of the major impacts rural development may have on native biodiversity. Constructing these overlay zones is one avenue for the integration of lessons from conservation biology and landscape ecology with land use planning tools.

Conservation Planning and Lessons for Land Use Planners

Not only have land use planners failed to adequately address conservation, but conservation biologists have failed to apply their work to land use planning issues (Knight 1999). The explicit mission of conservation biology and its practitioners is the protection of habitat, species, and ecological processes (Noss et al. 1997, Peck 1998) Similarly, landscape ecologists study the spatial and temporal relationships among ecological components and patterns (Peck 1998, Foreman 1998). Both disciplines may play an important role in assisting the land use planner, who must address the conflict between development and biodiversity conservation (Burke 2000). To understand the failure of both disciplines to address land use planning issues, we must explore the literature on conservation planning and the implicit, if not explicit, assumptions about humans and protection of biodiversity.

Conservation Planning

Conservationists have not completely ignored land use issues, but rather have largely concerned themselves with planning strategies that have remained outside of the traditional land use planning arena. There is a rich literature on conservation planning that addresses the selection of conservation areas (Table 1), which are then supposed to be managed for their biodiversity value alone. Notably, planners such as Frederick Steiner in his *The Living Landscape* and William Marsh in his *Landscape Planning* text, among others, have addressed the issue of how to designate particular portions of the landscape as conservation targets (Peck 1998). Peck, herself, builds on the previous work of these authors, laying out the key ecological issues involved in prioritizing portions of the landscapes for protection in her 1998 book "Planning for Biodiversity."

The major assumption of priority-setting exercises is that the selected area will designated as a park or nature preserve along the lines initially described by Hough (1988) for biosphere reserves (Noss and Cooperrider 1994, Peck 1998). The major feature of this design is a central core area where human intrusions are kept to a minimum. Surrounding the core area is a buffer area, to reduce potential impacts of neighboring anthropogenic activities. Ideally core areas will be connected functionally (Meffe et al. 1997) to other important habitats through the use of habitat corridors or stepping stone islands (Noss and Cooperrider 1994, Forman 1995, Peck 1998). Only outside of these two zones do human settlements enter the picture.

TABLE 1: Guidelines for addressing biodiversity (things to include) through planning and land management. (Three scales are highlighted in this summary table and should be viewed as a nested hierarchy.)

Author	Noss and Cooperrider 1994, *Noss et al. 1997	Duerksen et al. 1997
Principles	Regional Scale 1. Represent all native ecosystem types and seral stages across their natural range of variation 2. Maintain viable populations of all native species in natural patterns of abundance and distribution 3. Maintain ecological and evolutionary processes, including disturbance regimes and hydrologic processes as well as biotic interactions 4. Manage landscapes and communities so that they are responsive to short-term and long-term environmental variation 5. *Encourage human uses that are compatible with ecological goals; discourage uses that are not compatible	Landscape Scale 1. Maintain large, intact patches of native vegetation 2. Establish priorities for species and habitat protection 3. Protect rare landscape elements 4. Maintain connectivity 5. Maintain ecological processes 6. Contribute to regional persistence of rare species 7. Balance the opportunity for public recreation with habitat needs Site Scale 1. Maintain buffers 2. Facilitate wildlife movement 3. Minimize human contact 4. Control numbers of midsize predators 5. Mimic features of the local natural landscape

TABLE 1 (continued): Guidelines for addressing biodiversity (things to include) through planning and land management.

Author	Oregon Biodiversity Project 1998	Peck 1998	Noss et al. 1999
Principles	1. Promote more biodiversity-friendly management. 2. Expand existing preserve network. 3. Focus action on best opportunities. 4. Provide tools and incentives. 5. Coordinate data collection and management. 6. Apply principles of adaptive management.	Landscape Scale 1. Represent all communities and community types. 2. Recognize unusual abiotic factors and gradients. 3. Acquire extensive blocks of open space. 4. Maintain connections between natural areas. 5. Be attentive of overall landscape pattern. 6. Maintain disturbance and hydrologic processes. Community Scale 1. Understand Vegetation structure. 2. Habitat resources (Water, shelter, etc.). Population Scale 1. Recognize minimum population sizes. 2. Be aware of isolated populations. 3. Understand dispersal and migration.	1. Map rare species occurrences, endangered ecosystems, critical watersheds, roadless areas, and other high value sites. 2. Classify habitats within region and map species occurrences to understand distributions. 3. Identify area-dependent species found in the region; conduct population viability analyses for these elements. 4. Overlay above information and compare against established protected areas to identify gaps. 5. Consider hydrologic processes and disturbance regimes. 6. Ensure connectivity. 7. Provide buffers against human uses.

TABLE 1 (continued): Guidelines for addressing biodiversity (things to include) through planning and land management

Author	Askins 2000	Dale et al. 2000
	1. List key sites for endangered or rare species.	1. Examine impacts of local decisions in a regional context.
	2. Estimate minimum territory size to maintain a breeding pair.	2. Plan for long-term change.
	3. Describe precise habitat needs of those species.	3. Preserve rare landscape elements and associated species.
	4. Protect core areas, and harvest buffering areas sustainably.	4. Avoid land uses that deplete natural resources.
		5. Retain large contiguous or connected areas.
		6. Minimize the introduction and spread of nonnative species.
		7. Avoid or compensate for effects of development on ecological processes.
		8. Implement land-use and management practices compatible with the natural potential of an area.

Conservation planners employ two major strategies to select priority areas known as the 'coarse filter' and 'fine filter' approaches (Noss and Cooperrider 1994, Baydack et al. 1999, Anderson et al. 1999a, Stein et al. 2000). The "coarse filter" approach focuses on using vegetation as the major means for delineating habitat types and thus, priority areas are based on expanses of habitat that do not currently receive any form of protection (Noss and Cooperrider 1994, Anderson et al. 1999a, Stein et al. 2000). In contrast, 'fine filter' approaches look to identify biological hotspots, or areas that have high levels of species richness or areas with concentrations of endemics (Noss and Cooperrider 1994, Peck 1998, Stein et al. 2000, Wall 1999, Johnson and O'Neil 2001).

Work by the National Gap Analysis Program (hereafter GAP), initiated by the U.S. Fish and Wildlife Service (USFWS) and carried out by individual states, uses the 'coarse filter' approach to map vegetation. It employs Landsat Thematic Mapper satellite images to classify vegetation types based on an iterative process whereby remotely sensed data are classified according to their spectral images and then compared with known field data (Kagan et al. 1999). These maps are "produced with [the] intended application at the state, or ecoregional level with an accuracy in detail and precision based on USGS 1:100,000 map" (Kagan et al. 1999).

Because our National Parks and Wilderness Areas, as well as other public lands were not explicitly chosen for ecological reasons, they do not capture a full range of biodiversity in terms of vegetation types or plant associations (Noss and Cooperrider 1994, Stein et al. 2000). Comparing vegetation maps generated by statewide GAP analysis projects with the distribution current protected areas highlights habitat types that have not received any form of protection. Identified areas represent 'gaps' in the current protected reserve network, and are by definition priorities for land acquisition or, more generally, are the targets of conservation efforts (Noss and Cooperrider 1994, Kagan et al. 1999).

Because the minimum mapping units used by GAP exercises are generally quite large, often 100 hectares (247 acres)(Kagan et al. 1999, Stevenson 2001), these maps are not particularly helpful for zoning purposes, as they lump large areas—and consequently privately owned parcels—together into one general class. These coarse scale maps do not address structural variation within small areas such as rural residential lots or parcels very well, nor do they adequately capture habitat quality. In some cases, GAP data are available at smaller scales. However, there are relatively few data that address this finer scale issue (Theobald et al. 2000, Shaughnessy and O'Neil 2001).

In contrast to the coarse filter approach, the idea behind hotspots is that some limited areas of the planet, ranging from local sites (e.g., a spring) to larger regions (e.g., tropical rain forests), support high numbers of species ("species rich areas") or concentrations of endemic species that are not found elsewhere (Meffe et al. 1997, Olson and Dinerstein 1998, Mittermeier et al. 1998). Conservation efforts that focus on these biological hotspots employ the 'fine filter' approach by limiting their efforts to these aggregations of species or to the specific range of targeted endemic species (Noss and Cooperrider 1994, Anderson et al. 1999a).

Regions or sites high in species richness thus offer an opportunity to conserve a larger subset of biodiversity in a smaller area (Olson and Dinerstein 1998). Alternatively, areas that support locally endemic species represent what is most likely the only opportunity to protect these species. Failure to ensure local protection for such species may lead directly to their extinction—particularly in the face of known threats such as habitat loss (Olson and Dinerstein 1998, Mittermeier et al. 1998, Rickets et al. 1999). Through exercises to delineate these areas, conservation planners can focus scarce conservation resources on the most biologically rich or distinct areas. In essence, these conservationists attempt to get the biggest bang for their conservation dollar.

Data on restricted-range species, as well as concentrations of species, are another part of the GAP planning process, thus combining the coarse-filter and fine-filter approaches. These data are usually available for many taxa from state heritage networks[3], or state wildlife agencies (Stein et al. 2000) and are readily available for land use planners. Such areas are usually the highest priority sites for the creation of reserves. In some instances, land use planners consult these databases to see if sensitive species occur on proposed development sites prior to making building decisions (City of Eugene 2001). However, short of using these individual species as a habitat proxy, natural vegetation is not generally considered in development decisions except for regulated areas, such as wetlands and floodplains.

A number of organizations nationwide, such as private land trusts and government agencies, actively pursue the purchase of lands to support conservation goals. They use a

[3] All 50 states, and at least one Native American reservation, maintain natural heritage programs that serve as clearinghouses for data on the distribution of native species, including endemic and imperiled species (Stein et al. 2000).

variety of selection criteria (Stein et al. 2000). Besides targeting biological hotspots, habitats, or vegetation types that are not already represented in protected areas (e.g., National Parks or nature preserves), many of these not-for-profits have begun to target large areas of intact natural habitat—or large expanses of land free of major human infrastructure (e.g., roads, houses, power lines)(Ricketts et al. 1999, Tietje and Berlund 2000). This approach may often be a used in conjunction with one of the other strategies described above, but the underlying assumption is that areas free of human infrastructure are likely to support high numbers of native species (Butler 1992, Noss and Cooperrider 1994, Ricketts et al. 1999, Stein et al. 2000, Tietje and Berlund 2000, Mackenzie and Merenlender 2000).

Each of the approaches outlined above is generally designed to facilitate the establishment of conservation reserves. Except for situations where pending development threatens to destroy habitat for endemic species and Natural Heritage Network records provide guidance on critical habitat for these species, sufficient data typically do not exist at the proper scale to aid planners with parcel-level decisions. More broadly, the reserve approach writes off large portions of the rural landscape that may support natural vegetation. The assumption is that these areas are not large enough to provide the full suite of ecological functions associated with these habitats and that areas under development are unlikely to support important components of native habitats.

Peck and others seem largely to pursue an "either-or" strategy when confronting the question of preserving biodiversity in rural lands subject to conversion: either it will be protected in a reserve or it will be converted to another use. In short, there appears to be little discussion of how to place houses or develop portions of the landscape so as to support native elements of biodiversity and contribute to the wider landscape-level conservation goals.

Integrating Conservation Planning Approaches with Land Use Planning: Moving Beyond Reserves and Involving Citizens

The conservation planning principles highlighted in Table 1 exhibit several common themes: 1) represent all native ecosystem types in some form of protected area, 2) maintain large intact patches of native vegetation with the assumption that viable populations of native species will also be retained, and 3) maintain evolutionary and ecological processes, while 4) managing landscapes for short-term and long-term change. Despite their emphasis on nature reserves, these four goals can form the basis for efforts by land use planners to address biodiversity conservation. They suggest that site-, or parcel-scale efforts to address conservation must also relate to regional- or landscape-level considerations.

Recent recommendations by the Ecological Society of America (Dale et al. 2000: 663) further attest to the interest of the scientific community in influencing traditional land use planning efforts. Dale and coauthors strongly urge principles of ecology be used to "shape municipal ordinances for land use practices" and by extension county planners. This call strongly resembles Beatley's comments, highlighted at the outset of this chapter, that land use planners take proactive steps towards habitat protection. The assertions made by both Beatley and Dale et al., however, ignore the geography of wealth generation involved in rural development (Hulse and Ribe 2000). Their insights regarding a traditional conflict between habitat conservation and economic opportunity should not be overlooked. Failure to find a balance between applying strong ecological principles and allowing development may well doom the former (Hulse and Ribe 2000).

I propose developing an inventory of local habitats, one that classifies relatively small areas according to structural differences and assesses the quality of these areas. This inventory can provide the basis for a zoning overlay to guide planning efforts. Rating delineated habitats based on their quality and then overlaying information on buildings and their distribution within the habitat facilitates prioritization of discrete areas.

By prioritizing specific habitat types, a wide range of land use tools can be used to conserve the biodiversity value of affected properties. The zoning overlay would differentiate among habitat priority ranks facilitating the application of specific ordinances, including regulations, standards, and incentives for new development. Additionally, linking alternative strategies with traditional land use management (Vickerman 1998), overlay zone designations provide a wider range of policy alternatives and incentives. The key is that a number of strategies can be targeted to address the needs of different landowners and how they use their lands, and that these strategies are tied to the particular portions of the landscape identified in the inventory for their habitat value.

Duerksen et al. (1997, 2000) provide a means for applying land use planning tools to conservation landscapes at both the site and landscape scales (Shaughnessy and O'Neil 2001). The approaches that Duerksen and his colleagues posit largely rest on specific data outputs from the Colorado High Priority Habitat System (Theobald et al. 2000, Shaughnessy and O'Neil 2001) and, as will be seen shortly, have been hampered by certain limitations. However, I argue the land conservation tools they outline are critical components of any land use planning strategy. The matrix presented in Table 2 applies a three-tiered framework for the approaches and tools advocated by Duerksen and his coauthors. It provides the critical link between the map of priority areas, or specific zones, my methods produce and specific tools that land use planners can use to mitigate development impacts on habitat.

Using a Citizen-Based Approach

To deal with the conflict between conservation and development Theobald et al. (2000) suggest using a citizen-based approach. Their efforts address habitat loss related to rapid development in Colorado and were explicitly designed to provide the requisite for the land use planning tools designed by Duerksen et al (1997). Working with developers, planners, politicians, landowners, and environmental activists they created a natural resources database system to support planning decisions. The database consisted of potential habitat suitability maps for all vertebrates using a standard grid cell, a map of large intact patches, and a map of important corridors for large vertebrates. The authors used the resulting data to map the probability of finding certain species. These data can then be "accessed by county planners interested in identifying and protecting habitats for economically important species in their county" (Shaughnessy and O'Neil 2001: 160).

TABLE 2: Suggested framework for applying land use planning tools and approaches to discrete habitat units as part of an overlay zone. (Priority rank refers to evaluation of the quality of a habitat unit compared with current degree of development. Priority one areas have high quality habitat with basically no human infrastructure present. Suggested approaches are based partially on recommendations found in Duerksen et al. (1997, 2000)).

Priority Rank	Protection	Light Development	Heavy Development
I	• Acquisition by Land Trust or directly by local government.	• Conservation easement on portions of parcels with structures. • Sending area for TDRs • Development agreements	• Conservation easements associated with development on affected portions of a parcel.
II	• Sending area for Transfer of Development Rights (TDRs)[4] • Development agreements	• Conservation easement associated with future development. • Use of special zoning standards.	• Use of special zoning standards
III	• Conservation easement associated with future development. • Use of special zoning standards	• Use of special zoning standards. • Receiving zone for TDRs	• Receiving area for density bonuses. • Full Development, no restrictions
IV	• Development on parcels not already developed. • Density bonuses for development • Receiving zone for TDRs	• Receiving area for density bonuses.	• Receiving area for density bonuses. • Full Development, no restrictions

[4] Transfer of Development Rights (TDRs) involve the sale, or transfer, of a property owners rights to develop to an owner in another area. The key to the process is the designation of 'sending zones,' or areas that planners deem as unsuitable for development (either outright, or at limited intensities). 'Receiving zones' refer to areas deemed to be better suited for development, including at higher intensities than might have been previously allowed.

Theobald and his coauthors (2000) caution, however, that the maps and the resulting data provided important information, but there "remains a disparity between the information that scientists produce and the information needed in local land use planning" (page 63). In particular, data and the analyses they inform must accurately portray the very lands they serve to evaluate. The uncertainties reflected in the data should be fully conveyed to the public and interested stakeholders. Finally the authors state, "probably the most important of these [lessons] is the idea that ecological data and analysis must be understood by those who will be affected by the decisions" (page 43).

Engaging affected local citizens in the planning process, Theobald et al. argue, is a key factor for successful outcomes. There has been much debate in recent years, however, about collaborative approaches to natural resource management (Western and Wright 1994, Daggett 1995, Daniels and Walker 1995). Communities in Oregon and California have attempted to develop ecologically based forest management plans (KenCairn 1995). In fact, citizen based environmental inventories are becoming more common. For instance, watershed councils in Oregon perform assessments of channel sensitivity and classify habitat types using a standardized manual (Watershed Professionals Network 1999).

The case study I present builds on the citizen involvement approaches embodied in the Oregon Watershed Assessment Manual (Watershed Professionals Network 1999) by developing what is essentially a terrestrial assessment modeled after the channel habitat classification procedure. Accordingly, I strive to develop a methodology that is based on sound ecological principles, but that can also be carried out by the general public and is still be scientifically meaningful. In essence, I propose readdressing the concerns raised by Theobald and his coauthors (2000).

I use principles garnered from conservation biology and landscape ecology to develop a methodology for classifying and analyzing data gathered by citizen volunteers. The data these citizens generate are specifically designed to assist mapping efforts of priority habitats. My research highlights potential problems and pitfalls involved with the data collection used to develop a final map of priority habitats using this type of approach and the particular methodology I propose.

Developing an Inventorying (Mapping) Process

Efforts to map habitat units for land use planning should meet two fundamental criteria. First, they must apply the lessons from conservation biology and landscape ecology. More specifically, they need to systematically identify and assess important structural and functional habitat characteristics in areas of concern. Second, given the nature of citizen involvement, they must elucidate clear procedures for assessing selected habitat characteristics and develop clear indices for evaluating habitat elements. Meeting these criteria will hopefully provide clear guidance for citizens who carry out scientifically sound mapping and evaluation procedures and whose results planners in their area will use.

While citizen involvement is a key premise underlying the methods I outline in subsequent chapters, it is not fully clear whether citizens in all jurisdictions will embrace the planning process. Indeed, evidence from certain parts of the country suggests that some local citizens may openly, and actively, work to oppose any effort to address habitat concerns (Walker and Fortmann 2001). Nevertheless, many county and municipal planning departments encourage collaborative efforts, underscoring the role for the methods I describe.

Mapping and Classifying Habitat Units

Different habitat types exhibit different species' composition, spatial patterns, and structural characteristics (Morrison et al. 1998, McComb 2001). For example, annual grasslands differ substantially from perennial grasslands. More dramatically, the open canopy of hardwood-dominated savannas is a striking contrast to closed-canopy conifer forests. The spatial and functional relationship of each habitat patch to others of the same type and to those of different types is also important. Capturing the variability within and among habitats, as well as the role these differences play for a wide array of animals and plants, is key to conserving biodiversity (McComb 2001). Even if any one organism's particular view of the world is overlooked, the delineation of habitat types based on important life cycle requirements of targeted species, or a suite of species, is likely to go a long way in efforts to conserve biodiversity.

Evaluating Habitat Quality

Evaluating habitat is a complicated process; different organisms have very different requirements and home ranges based on differences in physiological size and life history strategies (Johnson and O'Neil 2001). One way to reduce the complexity of multiple species is to look for a functional guild, or assemblage of organisms that depend on the same structural requirement within a habitat type. Removal of this structural, or functional, element would result in the disappearance or decline in the abundance of the associated species (Meffe et al. 1997, Johnson and O'Neil 2001). Ensuring the persistence of such elements, along with efforts to represent the full species composition and structural complexity of the associated habitats, may go a long way to providing habitat needs for a wide range of native species within a given area (Meffe et al. 1997, Morrison et al. 1998, Johnson and O'Neil 2001).

Snags—standing dead trees—are a well-recognized functional element in many habitats (Columbia Gorge Audubon 1990, Ryan and Carey 1995, Askins 2000). Their presence and distribution can be measured. In numerous forest types, snags play a critical role for a number of different taxa, including many cavity nesters (Columbia Audubon 1990). Similarly, legacy trees—defined as large, living old trees—also represent an important element for consideration in the American West. Most of these trees probably established themselves prior to Euro-American settlement and are larger and structurally different than younger trees. Consequently, they provide a structural element that cannot simply be measured by identifying the species composition of the habitat. Moreover, they are likely to become important snags in the future and provide not only an indication of current habitat conditions, but also of future habitat conditions.

Another important factor in evaluating habitat is the extent to which vegetation composition appears to be changing. Identifying dominant or characteristic plant species tells us which trees are currently major players in an area. In some places, one can see changes in the density of a habitat, by observing the number of saplings emerging. Species not represented in the canopy suggest a shift in the habitat type. Including these variables in an assessment of habitat allows us to capture, to some extent, the dynamic nature of the landscape.

The groundlayer is another critical consideration when trying to assess habitat quality. The groundlayer is composed of several different components. They usually include herbaceous species that are generally less than one meter high, particularly grasses, sedges, rushes, and forbs as well as low shrubs. Assessment of these components is a complicated process; in fact, evaluating groundlayer species is perhaps the most difficult part of the mapping efforts I propose. Species identification can be difficult and time consuming, but it is a critical component for any exercise that purports to tackle the conservation of native species.

The importance of native grasses as a component of a groundlayer analysis should not be understated. Throughout much of the western United States, landscapes once comprised primarily of perennial bunchgrasses are disappearing (Noss and Cooperrider 1994, Fleischner 1994, Oregon Biodiversity Project 1998, Ricketts et al. 1999). More than a century of exotic species introductions, combined with grazing pressures, has converted many native grasslands and savannas to systems dominated by annuals (Noss and Cooperrider 1994, Fleischner 1994, Ricketts et al. 1999). Native grasses are in and of themselves important targets for conservation. Because of their general rarity, the relative presence of native grasses serves as an important indicator of habitat quality.

Native grasses are important for diversity of food types and as cover for different species. They also are critical in carrying fire. Similarly, shrub cover and composition comprise a necessary component for evaluating the quality of habitat available within different habitat types. Besides affecting fire dynamics in ecosystems, many shrubs bear fruit, not to mention browse, that is important a food source for native species. Wildflowers can also be important food component. Besides providing diversity in their own right, they are a source of pollen and nectar for many arthropods, birds, and mammals.

The Influence of Human Infrastructure

A final criterion in evaluating habitat is to ask the question: what human influences are present within the habitat? Determining the presence of human infrastructure, such as houses, barns, and roads, and their distribution across habitat units is a critical element. Other indicators of human influence include the presence of borrow pits or ponds, fences, and other smaller structures.

The presence of human infrastructure should not preclude a habitat unit's designation for some sort of conservation attention. The intensity as well as quality of surrounding land uses may well be compatible with the persistence of some native biodiversity in the area. Recognizing the importance and reality of some forms of rural residential development and uses within native habitats is critical to a new conservation landscape in rural areas. However, it is important to note that not all forms of rural development are compatible with native biodiversity. I do not argue for the elimination of reserve strategies, but rather propose patterns of development in areas targeted for conversion that supplement biodiversity conservation at the landscape scale.

Testing A New Approach to Conservation in Northern Wasco, County

In 1998, the Oregon Biodiversity Project (OBP) identified northern Wasco County, Oregon as a "Conservation Opportunity Area." The designation highlights the fact that the area's large expanse of important habitat, plus the fact the area is home to a number of at-risk species. Essentially a statewide Gap Analysis Approach to conservation planning, the report went beyond the standard calls for a system of protected areas and recognized the need for a suite of approaches to conserve biodiversity (Oregon Biodiversity Project 1998, Shaughnessy and O'Neil 2001). A range of strategies, from regulatory to incentive-based, were recommended to protect threatened habitat types. These strategies were spelled out in greater detail in a separate but related document (Vickerman 1998).

OBP emphasized the importance of Oregon white oak (*Quercus garryana*) habitats for biodiversity in Wasco County. Oregon white oak occurs from southern California to British Columbia, including the eastern half of Vancouver Island (Agee 1993, Ryan and Carey 1995). Such a wide range implies that the tree survives under different environmental conditions, albeit within certain tolerances. The wide distribution should not be seen, however, as an indication of conservation status. These trees were once a dominant feature of western Oregon's Willamette Valley (Johannessen et al. 1970, Oregon Biodiversity Project 1998, Ricketts et al. 1999). They are still common there today, although under much different circumstances (Oregon Biodiversity Project 1998). Ryan and Carey (1995) describe the importance of the habitats that include Oregon white oak:

> In Washington, over 321 species of wildlife may use Oregon white oak communities... At least 25 wildlife species are closely tied to the oak-prairie-conifer-wetland mosaic but are not common in strictly coniferous forests. Several components of oak woodlands [and savannas] are especially valuable to wildlife, including the mast-producing trees, cavity trees [and snags], perches, riparian areas, and habitat corridors. (page 20)

In 1993, Wasco County's planning department initiated a process to address citizen concerns about development patterns in the 24,000-acre Transition Lands Study Area (hereafter referred to as TLSA)(Hahn 1997), an unincorporated part of Wasco County between the cities of Mosier and The Dalles (Figure 1) comprised entirely of privately owned lands (Illustration 1). This area falls within the larger OBP conservation opportunity area, recognized for the value of its oak habitat. At the time the study was initiated, only 301 out of 799 parcels zoned for rural residential housing had been developed (Figure 2). Of these, the majority are 10 acres in size, although there are a number

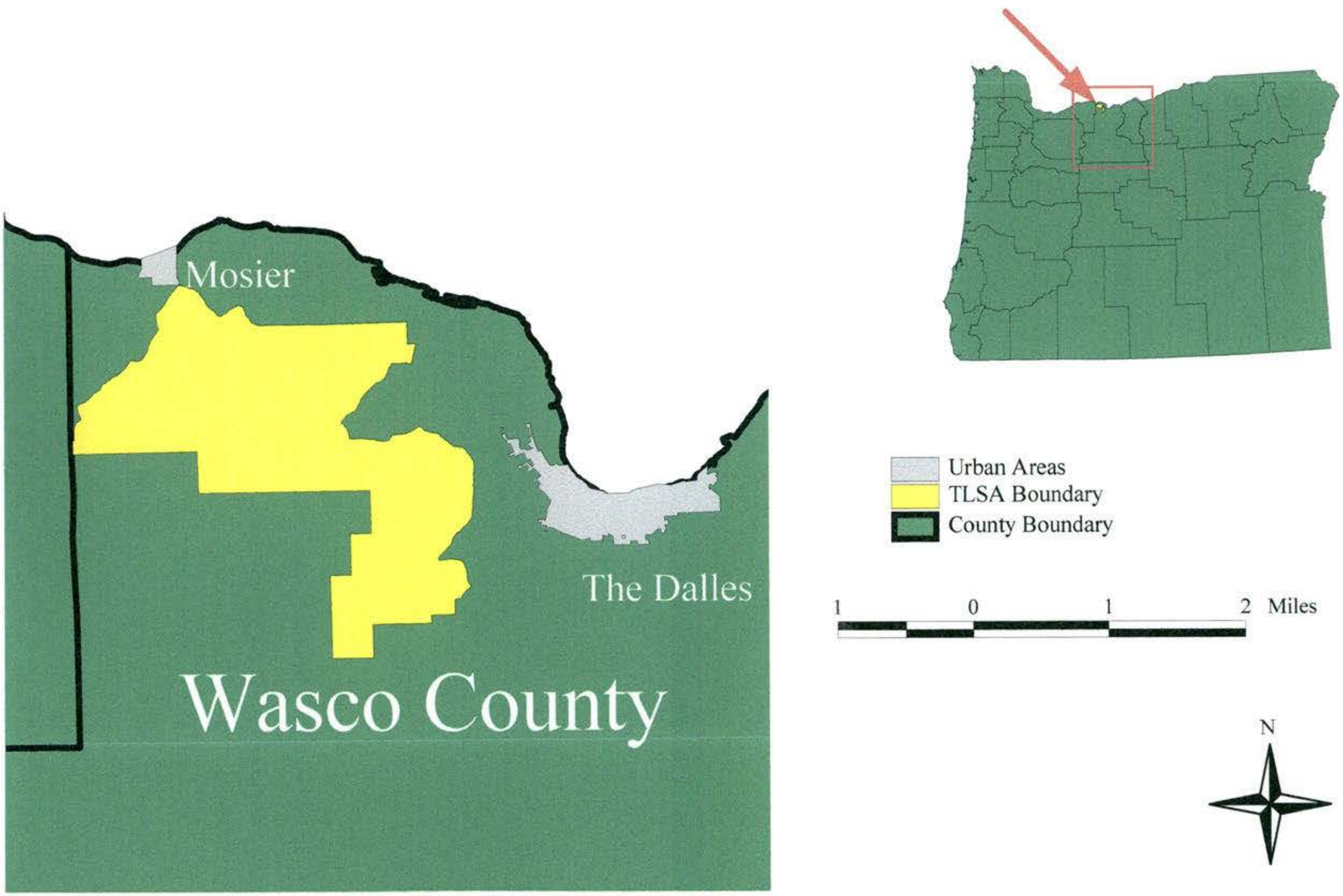
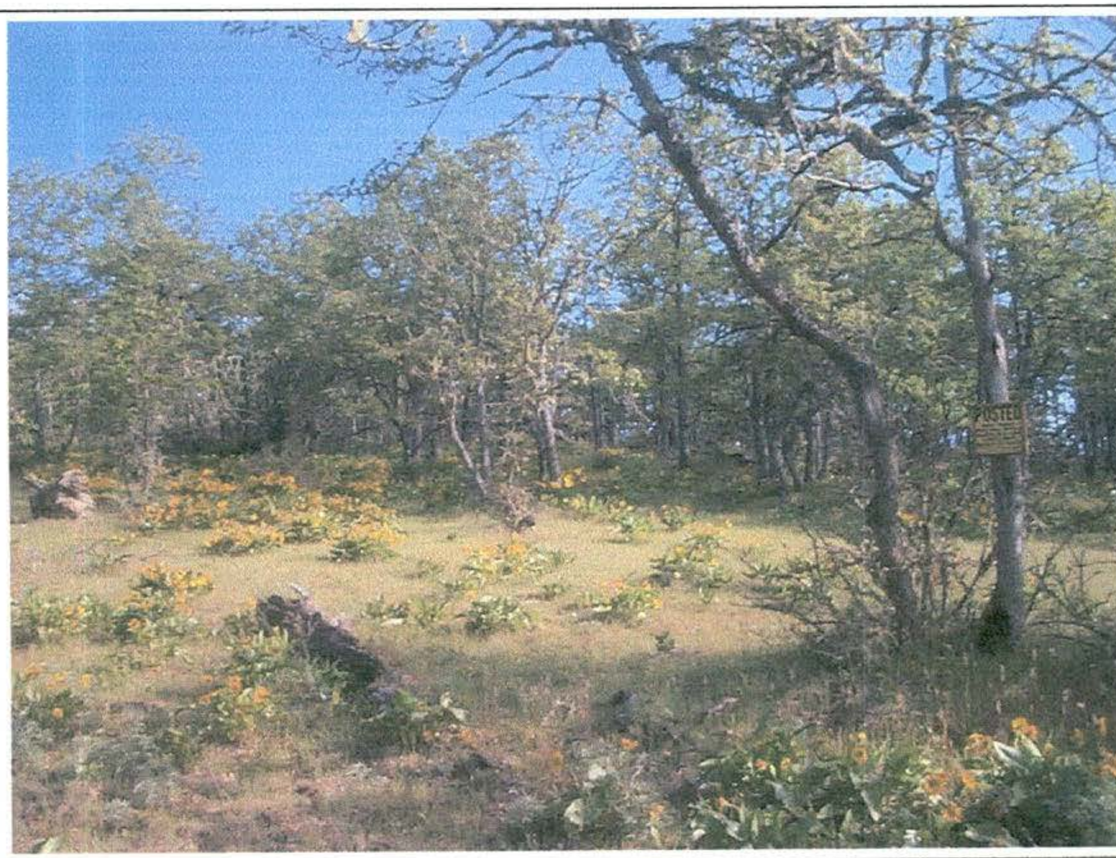


FIGURE 1: Location of the Transition Lands Study Area in Wasco County, Oregon.



ILLLUSTRATION 1: Oak woodland in the Transition Lands Study Area. Note the 'Posted No Trespassing' sign in the foreground as well as the downed wood. Balsamroot (*Balsamorhiza* spp.)

of five-acre lots as well. The analysis had a number of purposes, ranging from studying the appropriateness of current zoning in relation to development patterns, to building a citizen-based monitoring program that would allow local residents to track the impacts of land use decisions.

A common theme throughout the report is an emphasis on understanding and limiting detrimental land use patterns, whether by reducing densities, drawing new lot boundaries, or restricting construction in certain areas. However, it should be noted that a

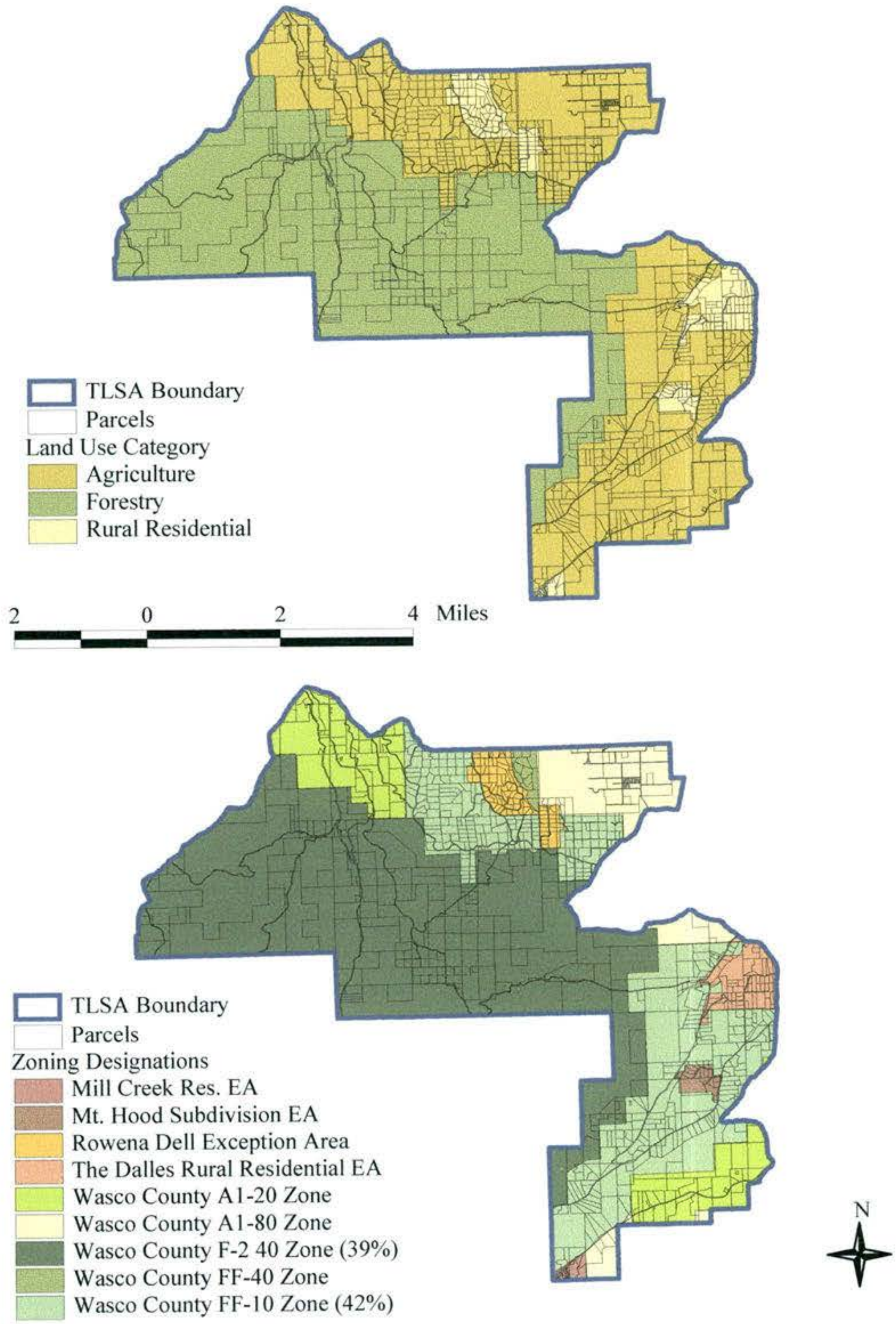


FIGURE 2: a) Land use categories in TLSA. b) Zoning categories in TLSA.

secondary goal was for the county to maintain the overall number of housing opportunities while making best use of all lands within the study area for all stakeholders. Thus, the challenge inherent to protecting habitat in this area is to identify suitable areas for development while shifting construction away from high-quality habitats.

As part of the process, Wasco County carried out an inventorying process to identify problem areas, and to facilitate changes to the comprehensive plan that would help deal with development. The inventory process looked at a number of key data layers, including fire districts, zoning, parcels, developed parcels, and potential development zones.

Although the county also looked at big game winter range as delineated by the Oregon Department of Fisheries and Wildlife (ODFW), agricultural lands (according to soil classes), and forest site classes, the process did not inventory the extent and quality of native habitats. An analysis of "pine-oak woodland habitats [were] discussed at length as a resource suitability consideration" (Hahn 1997:7). However, no definitive mapping of these habitats was available at the time.

The intersection of interest by the county planning office to actively plan for habitat and biodiversity values, coupled with the explicit recognition of this value by OBP, makes this area a strong case study for answering critical questions related to how planners can design a new conservation landscape. The case study, however, should also be understood within the specifics of Oregon's planning system. In this way, my work not only addresses limitations of current conservation planning and land use planning efforts elsewhere, but also speaks to limitations of current state policy in Oregon.

Land Use Planning In Oregon

In contrast to Colorado, Oregon does not have a statewide or state-sponsored program that identifies or maps habitats with important conservation value (Shaughnessy and O'Neil 2001). The Oregon Biodiversity Project has, in essence, provided the coarse filter for identifying relatively large areas for planning attention. The challenge lies in developing the detailed procedures needed to delineate high quality habitat areas of the habitat types highlighted by OBP, such as those dominated by Oregon white oak in northern Wasco County.

Oregon has a unique statewide planning system whose policies are specifically determined by the state legislature and articulated by the Land Conservation and Development Commission (LCDC) and its administrative arm, the Department of Land Conservation and Development (DLCD)(Cullingworth 1993, DLCD 1996, Rohse Pers. Comm.). DLCD plays a major role in shaping land use regulation and incentives in counties and local municipalities. In particular, Oregon's planning system functions around 19 statewide goals.

Understanding the general nature of the Oregon system underscores the importance of the work I present within the context of state policy. Moreover, it provides clarification of the ways state planners deal with the conservation of areas with important habitat value. In Oregon, each county and most cities (over 2,500 inhabitants) are required to write a comprehensive plan that outlines how the jurisdiction will implement each of the 19 goals, where relevant. In this way, local communities are given some latitude to create their own policies, but plans are subject to recognition by DLCD for their conformance with each of the 19 goals. Of the 19 statewide planning goals, I argue that two are particularly important in directly addressing biodiversity conservation issues statewide.

Goal 5 deals with open space, scenic areas, and natural resources and requires local jurisdictions to develop inventories of these resources. The goal is comprised of a five-step process for cities and counties: 1) Inventory local occurrences of resources, 2) Identify potential land uses on or near these resources, 3) Analyze economic, social, and environmental, and energy consequences of such conflicts, 4) Decide whether the resources should be fully or partially protected, and justify the decision, and 5) Adopt measures such as zoning to put policy in effect (DLCD 2000). While the state explicitly directs jurisdictions establish significance criteria for developing an inventory of riparian areas, wetlands, wildlife habitat, natural areas, among others, the goal does not provide significant guidance for resolving the question of how to inventory lands with natural resource value.

The Goal 5 inventorying criteria outlined in the states administrative rules (OAR 600-016-0000) direct jurisdictions to use not only data available for imperiled species maintained by the Oregon Natural Heritage Program, but also to determine the quantity and quality of each resource site. The rule is relatively silent, however, on criteria to use in weighing the value of habitats in areas where extensive natural vegetation remains. The statute allows local jurisdictions to apply a 'safe harbor' approach in which they determine habitat for a threatened or endangered species listed by the state of the federal government, or where a species specifically addressed in state statute, is involved (OAR 660-023-0110). Thus, the inventorying methods I outline serve to fill in the gap in state policy by elaborating new criteria for identifying habitats with significant conservation value in areas neglected by the current inventory process. Further, I suggest a framework for applying planning tools that address the other steps of the Goal 5 planning process.

The Transition Lands Study Area is comprised of over 1,150 parcels that include each of the three major land uses—agriculture, rural residential, and forestry—found outside of Oregon cities (Figure 3a). The work I present provides an opportunity to examine not only how well inventorying methods work in different rural zoning categories (Figure 3b) but how planners might apply different policies to these land uses using overlay zones based on patterns of habitat quality and change.

Within the broader context of Oregon's planning system, the methods I propose seek to allow citizens to carry out the inventorying process. Goal 1 explicitly advocates citizen participation in all phases of the planning process (DLCD 1996). While this goal is clearly stated in the state's administrative rules (OAR 660-015-0000(1)), it is not clear that citizen involvement has always been a major component of policy formulation and land use planning activities. However, recent efforts by local citizens in the Eugene-Springfield metropolitan area of western Oregon suggest citizens are working to link Goal 1 and Goal 5 and underscore the potential for linking Goal 5 inventories with citizen participation.

At the Confluence: Oregon Planning, Watershed Councils, and a Conservation Landscape

The final maps of priority habitat I presented in Chapter Four do not simply serve as an additional layer for consideration by the Wasco County planning department in implementing development in the Transition Lands Study Area. Rather, the methods I detail are meant to complement the citizen-based efforts at resource management embodied in the watershed assessments conducted by watershed councils and to expand public participation in the Oregon planning system.

Moreover, the framework I suggest serves to improve upon statewide planning policy and the general philosophy of conservation planning by using an overlay zone that integrates the land use controls/incentives with conservation and development. In particular, I allow for three levels of involvement that range from the more conservation-minded approaches rooted in the philosophy of reserve design to more development-oriented strategies exemplified by increased densities in the form of clustering or multifamily rural residential housing.

This overlay zone is specifically designed to marry the site-specific principles of conservation biology and landscape ecology in a way that helps further the regional scale goals of conservation planning as presented in Noss et al. (1997) and echoed by the other authors in Table 1. My methods identify local habitat patterns in an effort to alter development trajectories in those areas, thereby contributing to the protection of the full range of native ecosystem types. It protects habitat and connectivity that may otherwise be lost, and thus facilitates the maintenance of viable populations of native species. This, in turn, contributes to the maintenance of ecological and evolutionary processes while bolstering efforts to manage landscapes for short-term and long-term environmental change. Finally, my approach explicitly works to design human land uses that are more compatible with ecological goals. In the next chapter, I present methods for inventorying habitats that go well beyond simply categorizing existing vegetation patterns and classifying habitat types; I lay out specific procedures for assessing quality based on the key elements discussed above. I further link measures of quality with observed infrastructure to prioritize habitat units for conservation action.

CHAPTER II

METHODS FOR DELINEATING AND ASSESSING HABITATS

Vegetation maps currently available for planning processes often do not differentiate vegetation or habitat types at a fine enough resolution to classify parcels for zoning (Figure 3). Moreover, they do not generally provide an indication of habitat quality or the variation in structural conditions that facilitate prioritization among areas where extensive native vegetation remains. This fact is particularly important in areas where development—whether the construction of houses or roads and other associated infrastructure—threatens native vegetation, or where native habitats may have been already partially converted. Thus, a first major step in designing a conservation landscape in areas slated for development is to develop a detailed map of habitat types and their current quality.

In this chapter I begin by describing the necessary components and steps used to delineate habitat polygons and classify the delimited habitat polygons. I suggest a means for evaluating habitat quality before outlining the process of prioritizing important habitats using a human infrastructure screen. In addition, I provide guidance on how to use supplementary wildflower data to facilitate this prioritization process and consider greater representation of biodiversity in a final map for planners.

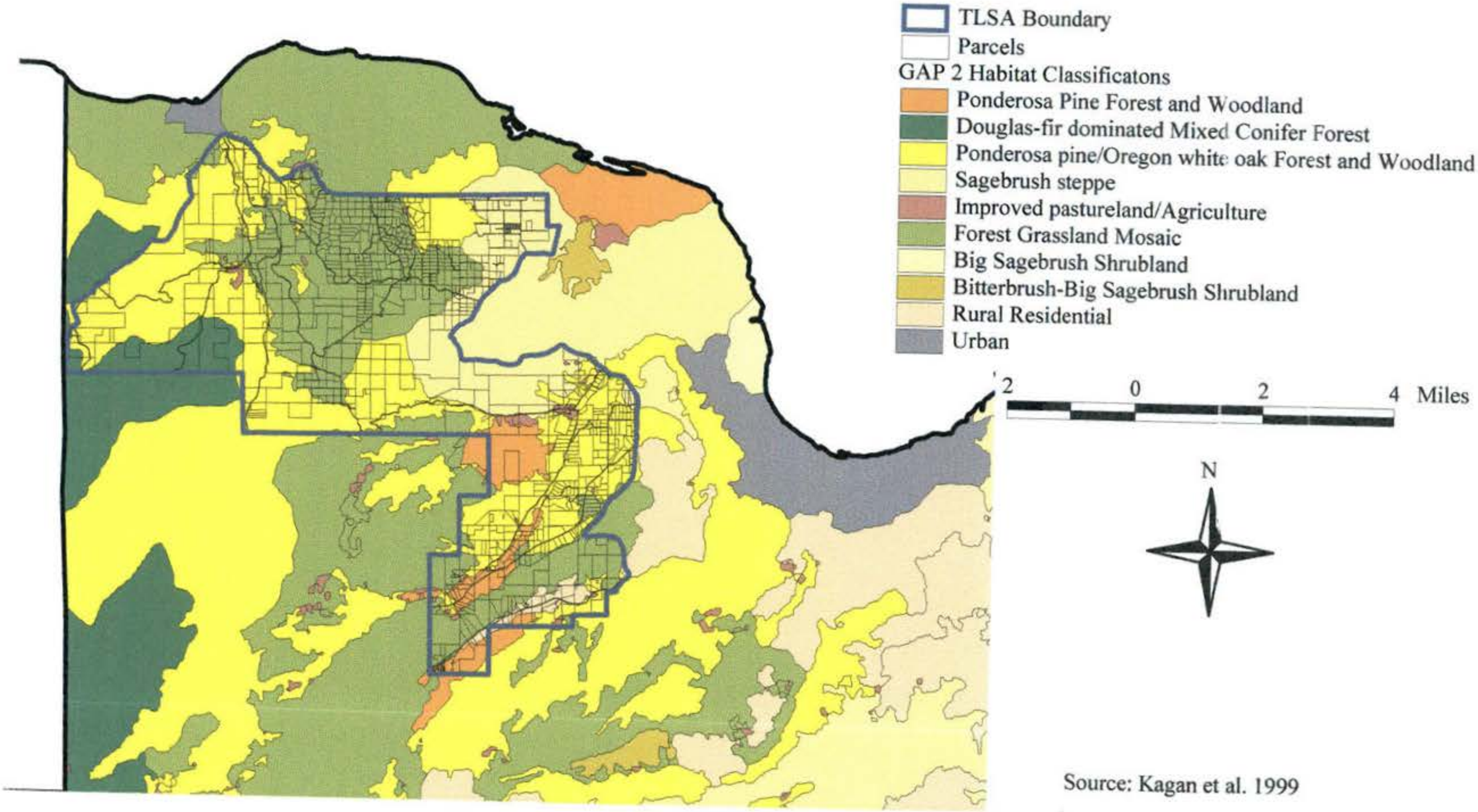


Figure 3. Map of habitat types, as delineated by Oregon Gap Analysis Project, overlain with parcel boundaries for the Transition Lands Study Area in Wasco County, Oregon.

General Approach

Developing a zoning overlay can be divided into two parts: 1) data collection and 2) analysis. In the data collection phase, the actual inventorying and mapping of habitat areas is undertaken. This process consists of using air photos to delineate habitat boundaries and field work to determine species composition and the quality habitat within each resulting habitat unit.

In the analysis phase, data are integrated into a map that can be used as the basis for a zoning overlay that differentiates among habitats ranked according to their habitat quality and biodiversity value. Ranking habitat units considers the relative abundance of different habitat types across the entire TLSA, as well as the quality of each unit, including consideration of wildflower data and measures of human infrastructure. County planners can begin articulating policies and ordinances that direct appropriate land uses, their densities, or even building placement within parcels in ways that minimize impacts on native habitats and associated biodiversity. The resulting map also has the potential to focus conservation work by non-governmental organizations such as land trusts.

A brief discussion of terminology used in this and following chapters is important to clarify their specific meanings. *Delineation* refers to the process of establishing boundaries around patches of homogenous habitat as viewed on air photos. Closely related is the process of *designation* of structural types based on the percentage of canopy cover. In reality, these two processes are done together. However, structural types are assigned in a secondary step, after all polygons have been delineated. *Classification* is the process of surveying each polygon for its tree species composition, which is then used to determine the habitat type. *Evaluation* describes the process of assessing the quality of observed habitats based on the indices I outline below. Combining this information into a final map provides the means for *prioritizing*, or designating a subset of polygons for special attention.

The delineation, designation, classification, and evaluation of habitat polygons involve lab work using a computer and GIS software as well as field work. Figure 4 outlines an idealized process for carrying out the necessary components of a habitat inventory and prioritizing exercise.

Normally, wildflower data should be assessed at the same time as the other elements of habitat polygons are being evaluated. Because I did not obtain air photos in time to delineate habitat polygons, I was unable to sample wildflowers simultaneously with habitat evaluation and assessments. Consequently, I developed an alternative car-based rapid assessment methodology. These methods represent a departure from the idealized inventory process (Figure 5).

The general approach suggested here as well as specific methods are likely to be useful in other regions of the United States. However, specific classification schemes in addition to the variables used as indicators of habitat quality described below are likely to vary according to the type of vegetation and the goals of subsequent mapping efforts. In particular, areas with more homogenous cover types, or those vegetation types with more complex species assemblages, are likely to require alternative methods for differentiating habitat polygons.

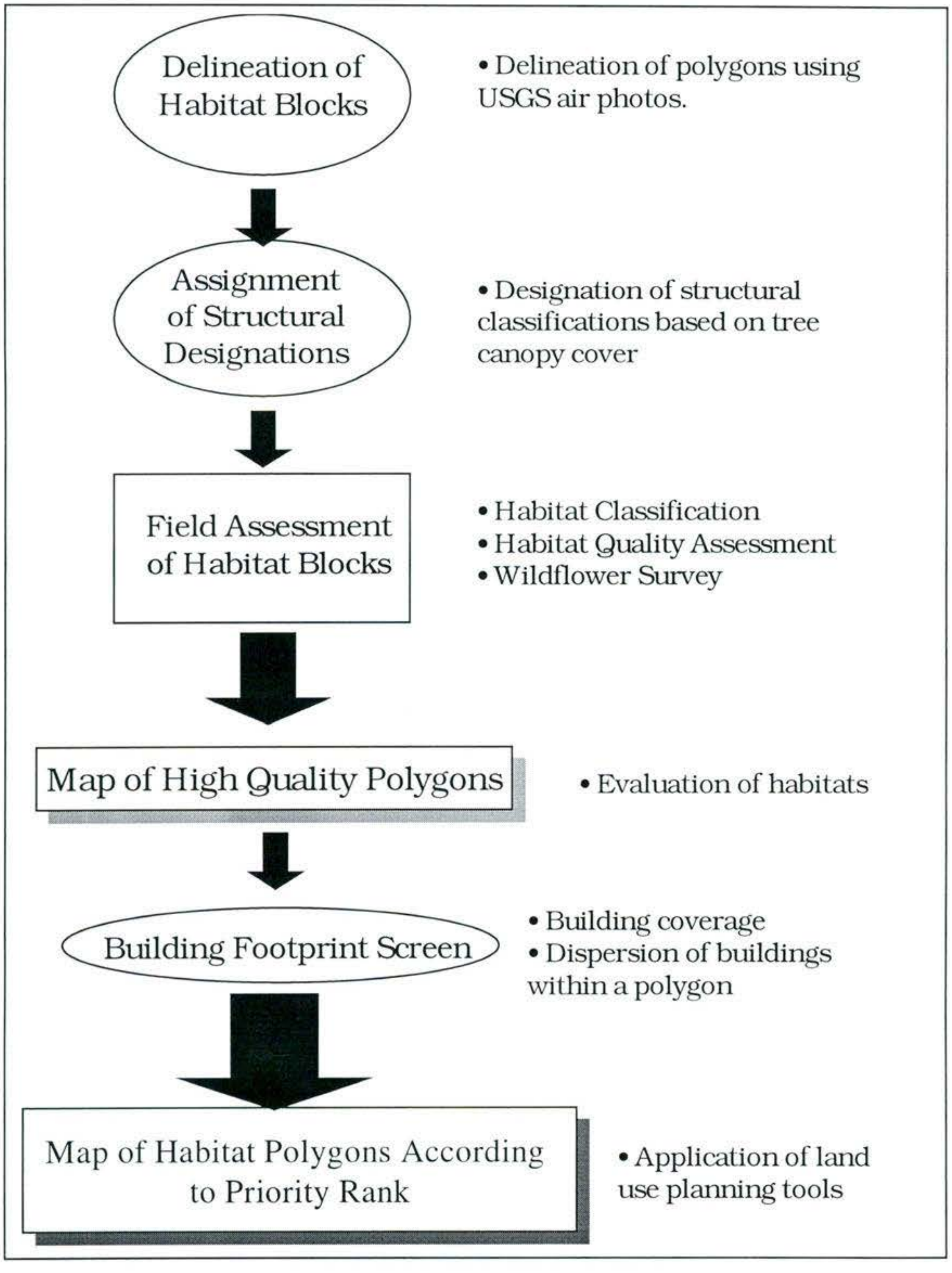


FIGURE 4: Idealized conceptual model of inventory process for delineating, classifying, and evaluating habitat types.

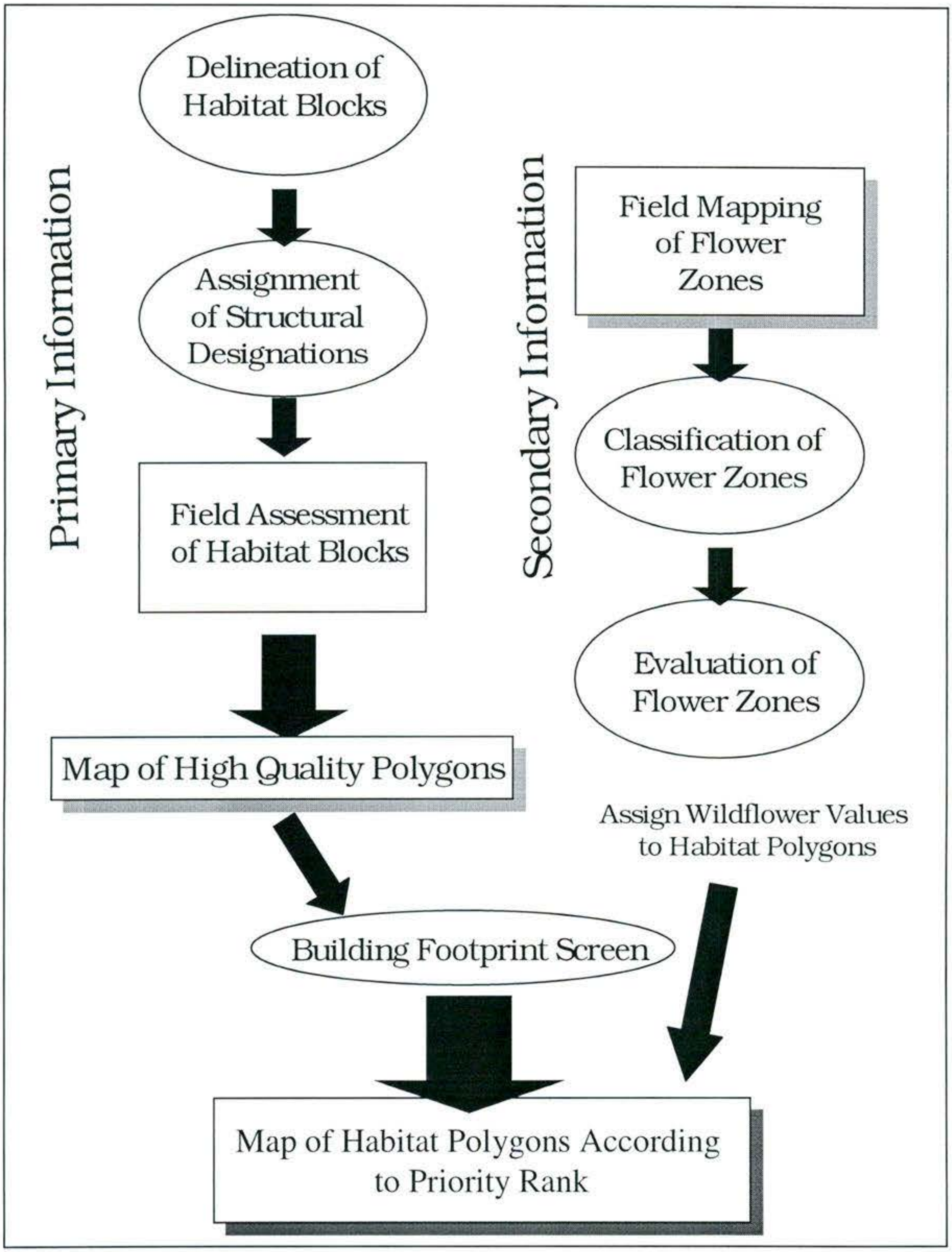


FIGURE 5: Diagram of the actual analysis approach taken in the study.

Phase I: Building a Habitat Inventory

My methods build upon prior efforts to map meaningful vegetation or habitat polygons in the Transition Lands Study Area (TLSA) of Wasco County, Oregon initially proposed by Dr. Bart Johnson[1]—an approach that facilitates on-the-ground classification and evaluation of habitat characteristics. The objective of the mapping exercise is to delineate polygons that represent relatively homogenous blocks or areas of vegetation as viewed on an air photo and verified through field checks. Fieldwork establishes a more detailed assessment of the polygon based on the species composition and characteristics of the vegetation found there. This approach not only offers the opportunity to describe the polygon in terms of its composition (species makeup) and structure (vertical and spatial nature of vegetation elements), but also a way to assess some indication of habitat quality by detailing functional elements known to be important to native species.

My work refines the earlier approach in two ways. First, previous mapping efforts were conducted during the early fall to fit the academic calendar year, so the nature of wildflowers and other important groundlayer elements could not fully be assessed. Second, I expand the characterization of polygons to include the nature of buildings and other anthropogenic structures. Taken together, both the information on groundlayer species composition and the nature of human disturbance within each polygon provide a more meaningful way to evaluate and prioritize areas for special conservation attention.

---

[1] A University of Oregon Department of Landscape architecture class considered the question of identifying lands sensitive to development in a small portion of TLSA during the Fall of 1999 (Johnson and Girling 2000). My thesis work grew out of this initial exposure to the issue.

Delineating Habitat Polygons

Delineating relatively discrete units is the crucial first step in developing a geographically referenced habitat inventory. For this assessment, I delineated habitat polygons in ArcView 3.1 using 1996 National Air Photo Program (NAPP) black and white air photos flown at 40,000 feet and provided in digital format by Wasco County's GIS program. Actual boundaries between polygons were drawn using the decision tree displayed in Figure 6 and the decision rules enumerated in Table 3. Following an established set of rules is designed to map relatively discrete areas of land cover while minimizing the potential error caused when multiple technicians are involved.

I set the minimum mapping unit set at two acres, reflecting a desire to minimize the overall amount of polygons for analysis while recognizing the need to allow some portion of a five-acre lot to be developed. Five acres is the minimum lot size for construction of a home within TLSA.[2] In reality, few polygons were drawn this small. This issue will be discussed in Chapter Three. The decision rules are designed to initially separate natural vegetation patterns from the primary agricultural land use, orchards. Orchards, with their evenly spaced trees, are clearly visible on the air photos and were separated out using two structural classifications: relatively open (<50% canopy cover for a polygon) and closed (> 50% canopy cover).

[2] Not all zones allow houses on parcels this small. Certain zones do not permit the construction of houses without meeting certain economic tests or strict review standards.

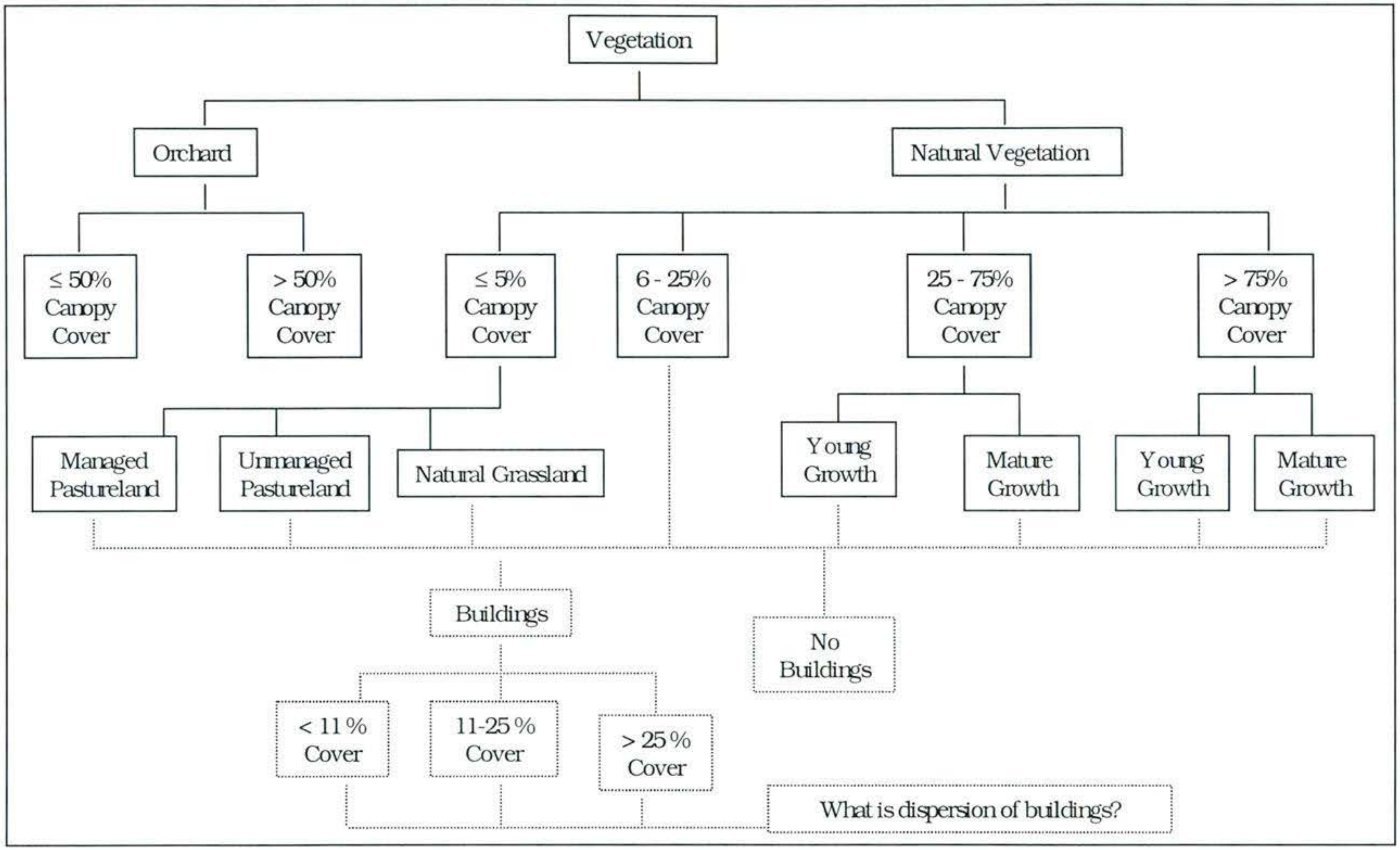


FIGURE 6. Decision tree used to delineate habitat polygons from USGS Air Photos. The dotted lines denote the footprint analysis described in the bottom center of the figure and carried out for all polygons.

TABLE 3. Decision rules (guidelines) for delineating habitat polygons

1. Delineate blocks according to dominant structure: closed canopy, moderate cover, relatively open, or open. Separate out orchards, differentiating among orchards and abutting fields. Orchards and other agricultural land uses may not provide many of the habitat requirements for native species.

2. Maintain a minimum mapping unit of roughly 2 acres. Patches smaller than 2 should be included into the larger block. Two acres theoretically allows some development on a five acre parcel. A smaller minimum mapping unit was not used in an effort to minimize the overall number of polygons.

3. Separate areas of similar structure were split into distinct blocks when bisected by large roads (county roads appearing in the GIS system, relatively wide driveways, or logging roads). This rule attempts to account for fragmentation effects from anthropogenic features that are linear in nature.

4. Delineate areas in forest or woodland that appear to be replanted or areas that exhibit noticeable differences in structure according to their 'signature.'* Forest structure, such as differences in age (young growth vs. mature growth), provides different habitats for native species.

5. Differentiate among habitats using escarpments or natural breaks in elevation or aspect. Natural barriers can impede the movement of some animals. These barriers often mark natural boundaries between habitat types, or even, ecological processes such as fire.

6. Separate open meadows from large yards or areas surrounding houses. These grassland areas are likely to have different management that create important structural differences for native wildlife.

7. Discriminate among other contiguous grassland areas—managed pastureland, unmanaged pastureland, and natural grassland—according to the general 'signature' exhibited in the photo.

*Signature refers generally to the recognizable appearance of a land cover type on the air photo. Different cover types may have unique signatures. Gradation in the shading on the photo can indicate subtle differences in the actual vegetation on the ground.

Natural vegetation polygons were delineated using vegetation patterns—primarily canopy cover—based on the four categories suggested by Anderson et al (1999b): open, relatively open, moderate, and closed (Table 4, Figure 7). The first two categories reflect grassland and savanna habitat conditions while the third category loosely captures what have often been described as woodlands (Anderson 1999a, Anderson et al. 1999b). The fourth category designates closed canopy forest.

TABLE 4: Canopy cover classes and corresponding habitat types

PERCENT COVER	CANOPY DESCRIPTION	COVER CLASS
0-5%	Open	Grasslands/Meadows (possible scattered trees)
6-25%	Relatively Open	Savanna
25-75%	Moderate	Woodlands
75-100%	Closed Canopy	Forest

Within each of the canopy cover categories, the horizontal structure of the vegetation was used to further delineate polygons. Every effort was made to separate areas of woodland or forest that exhibited different tree heights (mature vs. new growth) or clustering from surrounding areas. Adjacent grassland areas that suggested different management regimes (mowed, unmowed, or natural) were delineated separately.

Examining the 'signature' of the air photo, or the texture of the pattern in open areas facilitated this differentiation.

Because of the coarseness of scale and the use of black and white photos, neither tree canopy type (i.e. conifer versus hardwood) nor species composition (i.e. *Quercus garryanna*, *Acer macrophyllum*, etc.) was determined using the air photos. Ideally, color air photos could be used in conjunction with stereo pairs to make, at the very least, a first attempt at identifying whether hardwoods or conifers dominate polygons. Instead, the identification of polygon species composition was carried out exclusively through field work.

In areas where county roads, major logging roads, or agricultural access roads intersected contiguous natural habitats, I started new polygons. However, I did not generally subdivide all habitat areas where smaller roads were present. This fact is particularly true within portions of the study area zoned for forestry and in some of the orchard areas.

Figures 7 displays an example of the polygon delineation process. In particular, the figure shows the delineation and designation of polygons (heavier black lines) for habitat mapping purposes using the structural types and decision rules discussed above. Note that the upper portion of the photo, just to the right of Howe Road, falls outside of the study area, hence no delineation among vegetation structural types is evident.

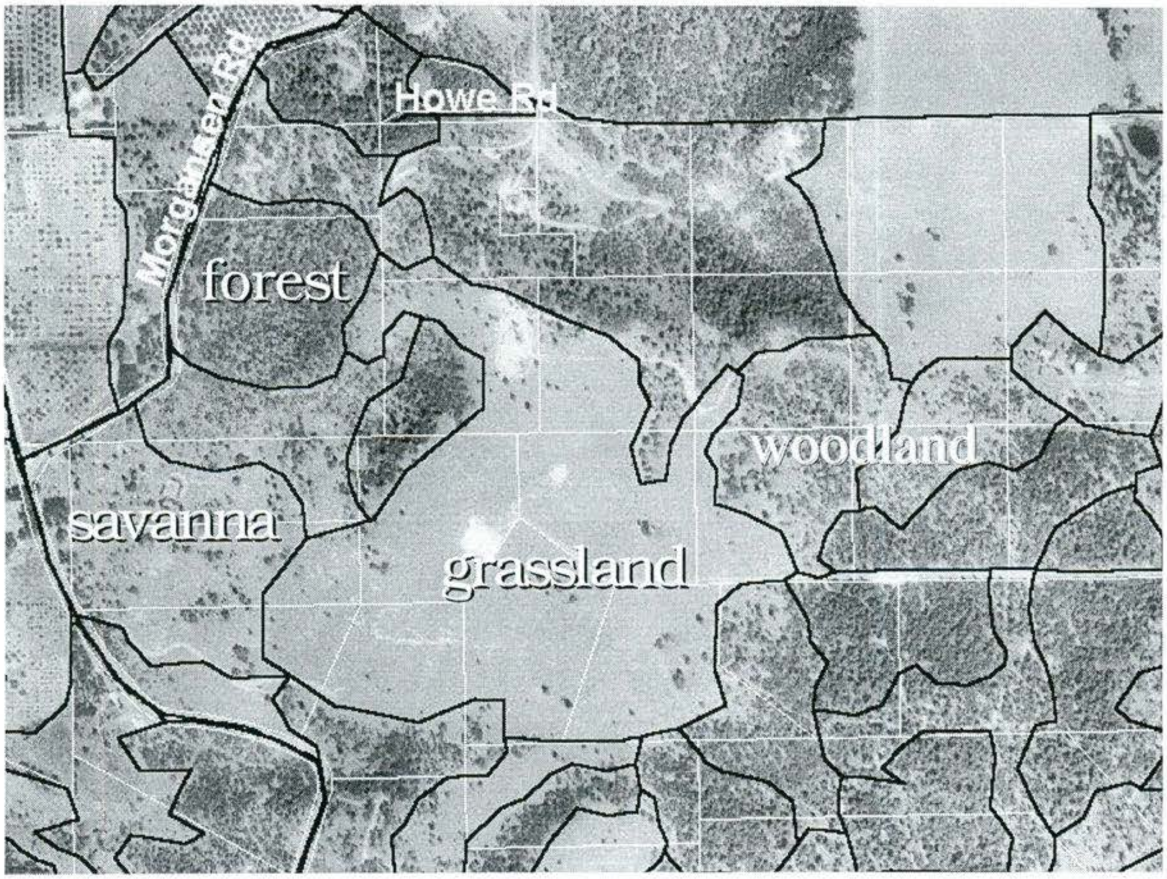


FIGURE 7: Habitat polygons (black lines) as delineated according to the four categories of canopy cover suggested by Andersen et al. (1999) and the decision rules discussed above. Also shown are county roads (thick black lines) and parcel boundaries according to the county planning office (white lines). The two types of orchard are also visible in the upper left corner of the photo: relatively open orchard along the left margin and closed in the corner and along the top margin.

Classifying Habitats and Evaluating Quality

I visited by car, on bicycle, and in some cases on foot, as many of the delineated habitat polygons as possible to determine their species composition as well as the vertical structure of the habitat, and thereby classify them according to habitat type. Moreover, I obtained information on their habitat quality to facilitate prioritization of blocks

Determining Species Composition

As part of the determining habitat type, it is important to document both the relative abundance of selected species within each polygon and the vertical layering of trees and shrubs. I asked five relatively straightforward questions about the nature of each polygon's vegetation:

- What is the dominant tree species found in the polygon?
- What is the subdominant tree species?
- What is the tertiary tree species, if any?
- What is the approximate extent of shrub cover/density?
- What species comprise the shrub layer?

Table 5 summarizes each category and the parameters used to determine the value for each.

TABLE 5: Summary of attributes used to classify the vegetation of mapped polygons

ATTRIBUTE	DESCRIPTION OF MEASUREMENT
Dominant Tree	The tree species most common within a polygon or comprises the majority of the canopy.
Subdominant Tree	Second most common tree species within the polygon or whose canopy makes up a sizeable portion of the canopy.
Tertiary Tree Species	The third most common trees species found in a polygon
Shrub Composition	Identification of shrub species found in the understory of each polygon.
Shrub Level	Rating of the level of shrub cover based on canopy cover: high (> 50%), medium (20 – 50%), or low (< 20%)

Assessing Habitat Quality

I recorded indicators of habitat quality as well as of the polygons' expected trajectory over time (Table 6). Certain functional elements on the landscape are important to a host of organisms and may meet one or more of their needs for shelter and food. Snags, defined as the number of standing dead trees or large downed wood, were rated because of their importance for cavity nesters such as Lewis' woodpecker (*Melanerpes lewis*)(Vierling 1997) or acorn woodpecker (*M. formicivorus*)(Ligon and Stacey 1996, Hooge et al. 1999)—both listed as sensitive species in the State of Oregon (ODFW 1997)—and many other animals (Johnson and O'Neil 2001). Legacy trees, defined as large, living old trees, most of which probably established themselves

TABLE 6: Summary of indicators used to determine habitat quality

INDEX	RANKING	DESCRIPTION
Snags	High	Greater than five per acre.
	Medium	Between one and five per acre.
	Low	Less than one per acre.
Legacy Trees	High	Greater than five per acre.
	Medium	Between one and five per acre.
	Low	Less than one per acre.
Native Grasses	Natives Dominate	Native grass species predominate within the polygon.
	Natives Present	Native grass species are present within the polygon, but do not dominate.
	Natives Nonexistent	No natives present.
Saplings	Low	Less than one sapling per ten trees.
	Medium	Roughly one sapling for every five to ten adult trees.
	High	One sapling for every one to four established trees.

prior to Euro-American settlement were censused also as to their abundance within a habitat block. These trees are likely to be important for acorn mast, for additional cavity sites, as roosting and perching sites for birds and bats, and future snags (Johnson and O'Neil 2001).

To determine the expected possible future trajectory of a habitat polygon in the absence of natural or anthropogenic disturbance, I attempted to rank the level of saplings found within each block. Again, rankings of high, medium, and low were used. In their respective order, each of these corresponded roughly to the ratio of saplings to established trees, where established trees were considered those greater than six feet tall for conifers and three feet tall for deciduous species. In this way, I assured that each structure type was assessed relative to the structural classification and irrespective of the size of the polygon.

The final measure of habitat quality was intended to identify any areas that support native perennial grasses. Three classes were used: non-existent, some present, and dominant. I rated blocks according to the presence of native species, relative to the total grassy understory. The first two categories reflect a 50 percent threshold of relative cover. If the block had greater than 50 percent cover by native grasses it would earn a score of 'dominant.' Blocks with less than 50 percent of its groundlayer covered by natives, received a 'some present' score.

Assigning Habitat Types

Habitat types are the aggregation of individual species and their structural characteristics. Combining the information on structure (e.g., grassland) assigned during the initial mapping exercise outlined above with the species composition information—dominant, subdominant, and tertiary trees—collected in the field provided the necessary information for classifying the habitat type for each polygon. This process is the first major step in comparing polygons within and among habitat types. In turn, the evaluation of the habitat quality of polygons allows land use planners to begin prioritizing areas for conservation or development based on a standardized set of criteria.

For the State of Oregon in particular, and in the United States in general, one of the most commonly accepted maps of habitat types are those produced by state Gap Analysis Projects (GAP, Kagan et al. 1999). By dissecting the GAP classification scheme, it is possible to build an aggregation matrix for the data collected in this assessment. My goal was to compare and contrast the results obtained from these two systems in light of need to develop habitat overlay zones. If the results were comparable, it might be possible to use the Oregon Gap Analysis Project's (ORGAP) map of current vegetation (Table 7, Figure 3) as a foundation for assigning habitat types to the 799 polygons delineated for this analysis.

Oregon GAP uses slightly different terminology in addition to the coarser scale of resolution, compared with this analysis. *Diagnostic trees* correspond roughly to both the 'dominant tree' and 'subdominant tree' categories used here. Similarly, the category

TABLE 7: Summary of Oregon Gap Analysis Project (ORGAP) habitat types (Kagan et al. 1999)

GAP DESIGNATION	DESCRIPTION	DIAGNOSTIC TREES	OTHER TREES
Agricultural Cropland and Improved Pastureland	Agricultural fields in which nonnative grasses dominate. Includes orchards.	None	None
Oregon White Oak-Ponderosa Pine Forest and Woodland	Open woodland to closed-canopied forest.	• Oregon white oak • Ponderosa pine - locally common or scattered	• Douglas-fir
Ponderosa Pine Forest and Woodland	Ranges from open woodlands to closed-canopied forest.	• Ponderosa pine is the only dominant tree species found here.	• Douglas-fir • Oregon white oak
Douglas-Fir Dominant Mixed Conifer Forest	Mixed forests and woodlands in which Douglas fir predominates.	• Douglas-fir	• Ponderosa pine • Oregon white oak
Forest Grassland Mosaic	Open communities of perennial grasslands with scattered trees and sparse stands.	• Ponderosa pine • Oregon white oak • Douglas-fir	• Any combination of Oregon white oak, Ponderosa pine, or Doug-fir
Sagebrush Steppe/ Grassland	Low shrub community dominated by native bunchgrasses and sagebrush	None	None

other trees includes aspects of both the 'subdominant' and 'tertiary tree' categories described above.

Table 8 details how data on species composition (see Table 9 for list of tree species and their abbreviations), along with the designation of different structural classes, were used to classify each polygon's habitat type. It should be noted that ORGAP did not specifically map riparian woodlands in the TLSA, so this category is an addition. To classify the habitat polygons according to ORGAP designations, I needed to collapse the woodland and forest structural categories together. Some readers may ask the obvious whether it is necessary to different between woodland and forest structural types in the first place. I return to this issue in Chapters Five.

TABLE 8: Aggregation of habitat types using the ORGAP classification scheme (See Table 2.7 for a list of abbreviations and corresponding common and scientific names. Combinations presented here reflect actual field survey results)

GAP Classification	Habitat Type	Structure	Dominant Tree	Subdominant Tree	Tertiary Tree
Doug-fir Dominated Mixed Conifer Forest	Doug-fir Dominated Mixed Woodland	Woodland	*PSME*	*PIPO*	*QUGA*
			PSME	*QUGA*	*PIPO*
	Doug-fir Dominated Mixed Forest	Forest	*PSME*	*PIPO*	*QUGA*
			PSME	*QUGA*	*PIPO*
			QUGA	*PSME*	*PIPO*
Forest Grassland Mosaic	Oregon White Oak Savanna	Savanna	*QUGA*	None	None
	Ponderosa Pine Savanna	Savanna	*PIPO*	None	None
	Ponderosa Pine/ White Oak Savanna	Savanna	*PIPO*	*QUGA*	Any
			QUGA	*PIPO*	Any
	Doug-fir Dominated Savanna	Savanna	*PSME*	*QUGA*	Any
	Oregon White Oak Savanna (Nonnatives)	Savanna	*QUGA*	Nonnatives	Non-natives
	Ponderosa Pine Savanna (Nonnatives)	Savanna	*PIPO*	Nonnatives	Nonnatives

TABLE 8 (continued): Aggregation of habitat types using the ORGAP classification scheme (See Table 2.7 for a list of abbreviations and corresponding common and scientific names.)

GAP CLASSIFICATION	HABITAT TYPE	STRUCTURE	DOMINANT TREE	SUB-DOMINANT TREE	TERTIARY TREE
Ponderosa Pine Forest and Woodland	Ponderosa Pine Woodland	Woodland	*PIPO*	*PSME*	*QUGA*
			PIPO	*QUGA*	Any
	Ponderosa Pine Forest	Forest	*PIPO*	*PSME*	Any
			PIPO	*QUGA*	Any
Ponderosa Pine/White Oak Forest and Woodland	Oak Woodland	Woodland	*QUGA*	*None*	None
	Oak Forest	Forest	*QUGA*	*None*	None
	Ponderosa Pine/Oak Woodland	Woodland	*QUGA*	*PIPO*	Any
	Ponderosa Pine/Oak Forest	Forest	*QUGA*	*PIPO*	Any
	Pine Oak Woodland with Nonnatives	Woodland	*QUGA*	*PIPO*	Nonnatives

TABLE 8. (continued): Aggregation of habitat types using the ORGAP classification scheme (See Table 2.7 for a list of abbreviations and corresponding common and scientific names.). ORGAP does not consider riparian areas in their analysis.)

GAP CLASSIFICATION	HABITAT TYPE	STRUCTURE	DOMINANT TREE	SUB-DOMINANT TREE	TERTIARY TREE
Riparian Woodland	Riparian Woodland	Savanna	*QUGA*	*ACMA*	*SASP*
			QUGA	*ACMA*	*PSME*
			PIPO	*POTR*	*PSME*
		Woodland	*POTR*	*ACMA*	*QUGA*
				FRLA	*QUGA*
			ACMA	*POTR*	*QUGA*
				FRLA	*QUGA*
		Forest	*PIPO*	*POTR*	Any
			POTR	*QUGA*	Any
			QUGA	*POTR*	Acma
Sagebrush Steppe	Bunchgrass Grassland	Grassland	Any	Any	Any

TABLE 8 (continued): Aggregation of habitat types using the ORGAP classification scheme (See Table 2.7 for a list of abbreviations and corresponding common and scientific names.)

GAP CLASSIFICATION	EVALUATION CLASSIFICATION	STRUCTURE	DOMINANT TREE	SUB-DOMINANT TREE	TERTIARY TREE
Agricultural Cropland and Improved Pastureland	Grassland with Nonnatives	Grassland	Any	Any	Any
	Orchard	Open	Not applicable	Any	Any
		Closed	Not applicable	Any	Any

TABLE 9: Trees used for habitat classification and their abbreviations (listed alphabetically by common name)

Tree Classification	Abbreviation
Big leaf maple (*Acer macrophyllum*)	*ACMA*
Black cottonwood (*Populus trichocarpa*)	*POTR*
Douglas-fir (*Pseudotsuga menziesii*)	*PSME*
Oregon ash (*Fraxinus latifolia*)	*FRLA*
Oregon white oak (*Quercus garryana*)	*QUGA*
Ponderosa pine (*Pinus ponderosa*)	*PIPO*
Willow (*Salix* spp.)	*SASP*

Comparing Classification Schemes

A natural question to ask is how well the classification system used in the current study matches up with the ORGAP map of habitat types. A simple comparison of total areas classified using the two different schemes is not very meaningful because it does not directly assess whether the same portions of the landscape were identified as the same habitat type. I used the intersection function in ArcView to overlay the two maps. The resulting map is a combination of polygons delineated for both analysis, plus their attendant attributes. Comparison of the habitat type attributes in each new polygon revealed whether there were discrepancies between classifications. I summed the total area of congruence and incongruence between the two classification systems and for each of the habitat types. I also calculate the degree of congruence by summing the total area for polygons that had the same habitat type values and dividing that value by the total amount of area for a given habitat type, as assigned in this study.

Delineating and Assessing Wildflower Zones

Information on wildflowers and their distribution within habitats provides an important consideration, particularly in northern Wasco County where several range-restricted species (local endemics) are found. Furthermore, wildflowers may play an important role in conserving particular elements of the native invertebrate fauna (Peck 1998). Additionally, they potentially may be sensitive indicators of land use degradation.

In Chapter Four, I discuss the particular problems with integrating the wildflower data with individual habitat polygons. For this reason, I not only discuss the methods for mapping and evaluating wildflowers, but I also describe the process I use to assign wildflower values to mapped habitat polygons. I now turn my attention to the specific methods I used to delineate wildflower zones.

Mapping Zones

Because I did not have the air photos in time for the spring field season, I was unable to census wildflowers as part of the habitat assessment for each polygon. Instead, I had to develop a rapid assessment methodology for independently mapping the distribution of wildflowers across the study areas. I provide details methods for this rapid assessment, but stress that ideally wildflower data should be collected at the same time that habitats are being evaluated for quality.

Wildflower surveys were conducted in late April over two weekends, for a total of five days, so as to optimize the total number of spring flowers in bloom. I identified zones with similar species composition at a much broader scale than was eventually delineated for habitat polygons. I drove the major roads of the study area with the help of a field assistant, noting the presence of wildflower species (Table 10). As we drove, I kept track of species totals in the areas alongside our route. Where marked species turnover was noticeable (roughly equal to more than 25% of a zone's total species), or county roads separated areas, new zones were identified and mapped.

TABLE 10: Decision rules (guidelines) for delineating wildflower zones

1. Delineate zones according to characteristic widespread species.
2. Establish zones where marked breaks in characteristics species occur, or where 25% of species change from adjacent area.
3. Separate, where applicable, areas with concentrations of housing and noticeable associated habitat conversion.

I drew the zones on simple paper maps produced using ArcView. The Wasco County Planning and Economic Development GIS specialist provided data on the parcels and roads, in the form of basic shapefiles, prior to my field work. I used these to divide the TLSA area with an overlaid grid and print out the maps for completing the fieldwork.

Detailed notes on location for the general patterns of zones as well as that of isolated species, including local topography and relationship to landmarks likely to be visible from air photos were described. To reiterate, the basic idea was to use a rapid assessment approach that would capture relatively homogenous wildflower zones by including the most characteristic species for each.

For each species seen under "wild" conditions (i.e. it did not appear to be part of a garden or lawn or maintained by other human inputs), we attempted to identify the species using field guides available for the Pacific Northwest (Hitchcock and Cronquist 1973, Pojar and MaKinnon 1994) and one specific to the Columbia River Gorge (Jolley 1988). Besides tallying the species within the zone, I estimated the extent and density of cover within the zone (Figure 8) as well as any other pertinent information.

Identifications in the field proved to be difficult, particularly given the constraints of private property and property rights' issues. All wildflowers were observed from the road, and only where we saw what appeared to be other individuals of the same species in sites farther from the road, did we note the species. In a number of cases, species could not be identified in the field with confidence. For these situations, we took digital photos of the species for later identification. Of these, an even smaller subset of cases required consultation with an expert.

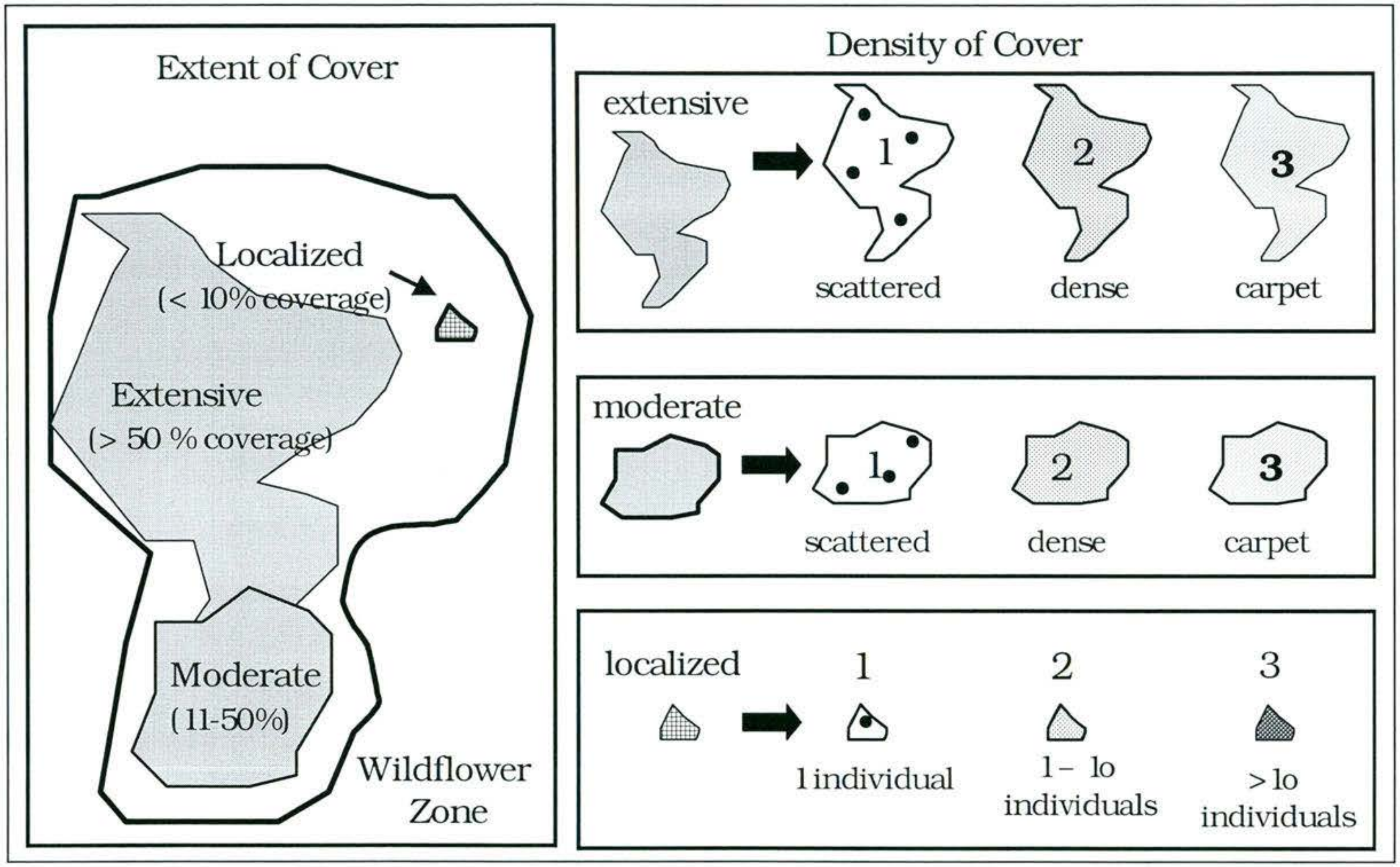


FIGURE 8: Rankings for cover extent and density of wildflower species within wildflower zones in the TLSA.

Checking the Methodology

In one portion of the study area, I had permission to perform transects as a partial check on the car-based rapid assessment methodology. I sampled two transects using slightly different methods (Figure 9) in two relatively small areas. The first transect began at the stream margin of an ephemeral drainage and proceeded 25 meters up a southwest facing slope. At each meter interval, I recorded all the species found within one meter (right angles) of the transect. The second transect passed through a block of woodland with Oregon white oak and Ponderosa pine. It proceeded diagonally along a west-facing slope approximately 250 meters, beginning in the woodland and crossing into an area of open savanna. At each 10-meter interval, I noted all of the species found within a three-meter radius as well as the structural characteristics of that point in relation to the surrounding vegetation. Discussion of the results and the methodological issues raised by this field check are detailed in the results section and discussed in the final chapter.

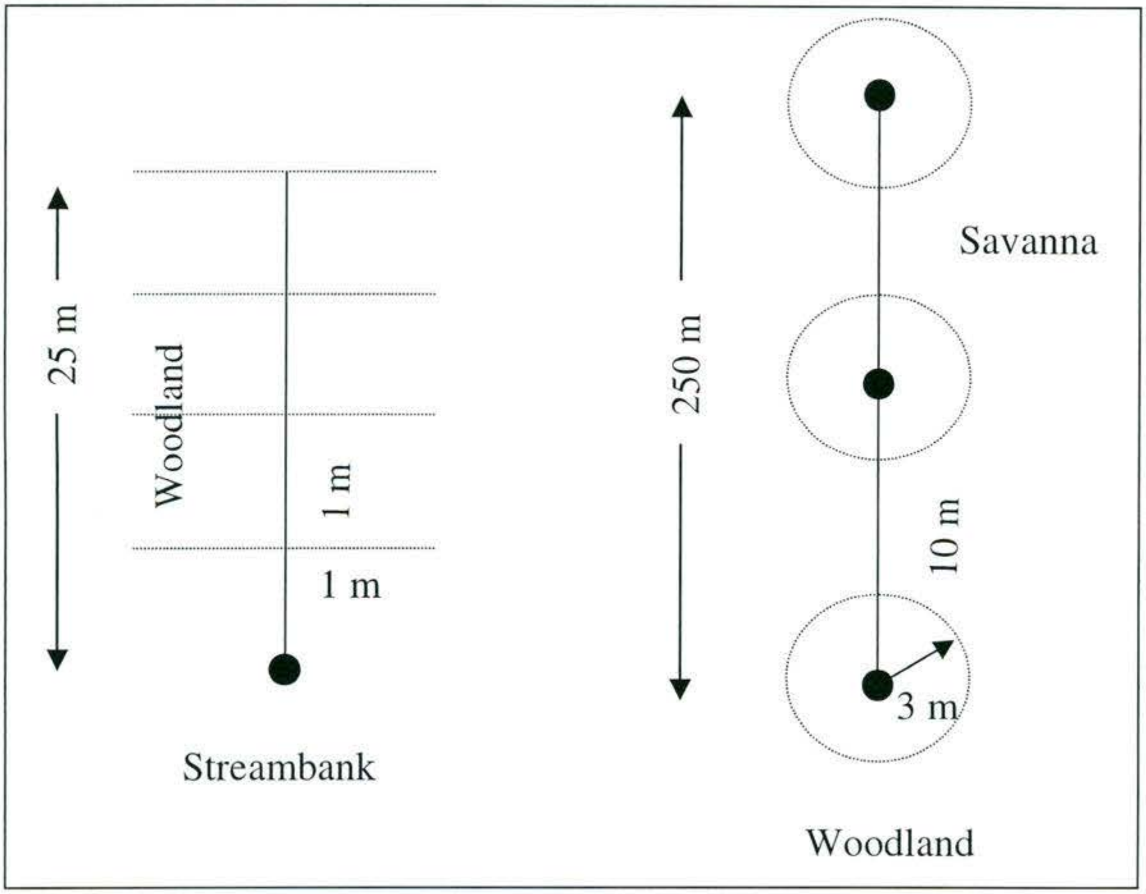


FIGURE 9: Two transect methods used as partial checks for the car-based rapid assessment wildflower methodology.

Characterizing Wildflower Zones

After identifying and cataloging wildflower zones, I used the results to determine wildflower cover types, based on habitat characteristics observed in the field. Given the mix of land uses and the nature of habitats, the cover types that emerged reflect a gradient from more natural environmental conditions to those caused by human land uses. Besides classifying wildflowers according to habitat conditions, a process that indicates areas where common species are likely to be found, this classification has the potential to highlight areas where landowners have maintained native wildflower cover.

Five categories were identified: open canopy woodland wildflower, closed canopy forest wildflower, riparian wildflower, rural residential, and orchard. Because we were unable to reach several areas within the TLSA, I later used air photos to assign wildflower cover types to 'holes' in the wildflower zones based on the general nature of the surrounding canopy.

There are numerous ways to evaluate species diversity in ecology. However, many of the more commonly used indexes, such as the Shannon-Weaver index are not, applicable to categorical data. I was interested in evaluating wildflower zones based on the relationship of the species to their overall range. In essence, I not only wanted to know how many species were found in each zone, but also the rarity of the species.

I began by calculating a series of simple measures to assess the information collected on wildflowers found in zones in TLSA. Three of these measures are relatively straightforward. *Species richness* is a simple number that reflects the total number of species found within a zone. This number does not include nonnative species. The second measure, *total species endemism*, is the sum of all species that are restricted to the eastern part of the Columbia River Gorge and surrounding slopes. A third indicator. *percent nonnatives*, is a measure of the number of nonnative species compared to the natives and is the number of nonnative species, divided by the total number of species.

A fourth measure was designed to assess the proportion of species within a zone that have relatively narrow distributions and may be uncommon in TLSA. This *weighted* *flower score* factors out the effect of species richness and incorporates endemism plus the rarity of the flower in the area. It is calculated as follows:

$$\frac{\sum (\textit{distribution score})}{\textit{species richness}}$$

The *distribution score* is based on a matrix that assigns higher point totals to species that are not widely distributed at the global scale and are relatively uncommon within TLSA; they are rare at two scales (Table 11). At one extreme are species that have continental, or even global, distributions and are relatively common in the study area. At the other extremes are local species are endemics found only in the eastern Columbia River Gorge or within the ecoregion. Regional wildflowers are species that occur only in the Pacific Northwest or on the West Coast. Continental species are those found across North America.

TABLE 11: Distribution score matrix for wildflower species within TLSA

		DISTRIBUTION WITHIN NORTH AMERICA		
		Local (Endemic)	Regional	Continental
DISTRIBUTION WITHIN TLSA	Narrow	10	7	4
	Moderate	9	5	2
	Wide	8	4	1

Table 11 assigns points for the intersection of a species' local distribution with its global distribution. The local distribution column indicates how widespread the species is in TLSA. Categories were calculated by plotting the frequency of species occurrences versus the number of zones and then looking for natural breaks in the slope of the plot of the graph (Figure 10). Widely distributed species were those found in greater than 1o zones, 'moderate' were those species found in five to nine zones, and 'narrow' refers to species found in fewer than five zones.

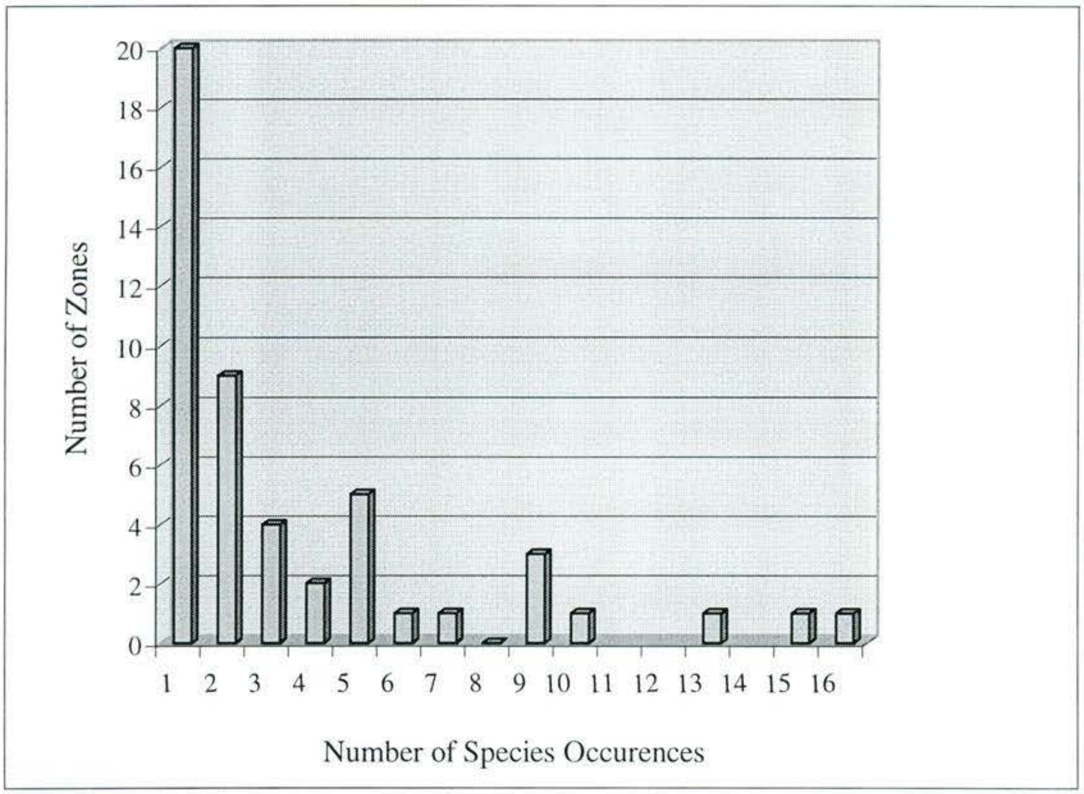


FIGURE 10: Plot of wildflower occurrences and number of zones. Species that are found in only a few zones are not widely distributed within the study area, regardless of their overall distribution in North America.

Once distribution scores have been assigned to each species in the zone, then the *weighted flower score* for the zone is calculated. In theory, values for the *weighted flower score* assigned to a zone can range from 1-10. A one signifies that all species within the zone are widely distributed at the TLSA and global scales. A score of 10 represents a zone where all species are narrowly distributed at both scales.

Phase II: Identifying Priority Areas for Planning Attention

In this section, I outline the process for integrating the data from the habitat evaluations to prioritize habitat blocks for planning. In essence, this part of the analysis establishes what planning tools will be applied to each habitat unit by creating four ranked categories into which each habitat block will be assigned. The resulting prioritization facilitates the four different levels of planning ordinances or standards outlined in Table 2, as discussed in the first chapter.

The methodology presented here is adapted from the conservation status approach put forth by Ricketts et al (1999). The habitat quality scores for each polygon are summed before a footprint analysis considers the footprint of buildings found within to assign a priority rank to each polygon. Information from the wildflower assessment is used to ensure representation of all habitat types. After priority ranks have been assigned to each polygon, a range of planning tools can be applied across the four ranks. The framework consists of three levels of conservation attention and facilitates the application of land use planning controls, primarily at the landscape level. Site level strategies are suggested, but not detailed.

Scoring Habitat Quality

Using the four indices for snags, legacy trees, native grasses, and saplings I assigned habitat quality values to polygons from the field assessment (Table 12). For the first three indicators, a ranking of 'high' received a score of 10 points, 'medium' earned five points, and 'low' received only one point, with the exception of grasses, for which a 'low' ranking received zero points.

TABLE 12: Points assigned to habitat indicators to score habitat quality

INDICE	RANKING	SCORE
Snags	High	10
	Medium	5
	Low	1
Legacy Trees	High	10
	Medium	5
	Low	1
Native Grasses	Dominant	10
	Present	5
	Non existent	0
Saplings	Low	10
	Medium	5
	High	1

For a number of reasons specific to the case study, saplings are scored on a reversed scale. Field assessments showed that in many cases the species composition of saplings was different from that of the dominant or subdominant trees in the block. In other areas, sapling levels indicate that certain habitat structures favored by wildlife of interest may be shifting to denser stands (e.g., savanna conditions to woodland). An ancillary concern relates to fire danger, a major concern for the county and its residents. Many new houses are built in areas that have high fire danger, such as on ridge tops or with poor emergency access. Consequently, a high sapling level received the lowest score while a block that had only a few saplings scored a rank of 'high' and the associated ten points.

The points are totaled to arrive at a habitat quality score for each polygon. Quality rankings are based on the breakdowns shown in Table 13. This breakdown favors blocks that score high in all of the categories or blocks that score high in one of the indices and moderately well in the rest. Point breakdowns can be adjusted to reflect different objectives for separate analyses in other areas.

TABLE 13: Point totals for assigning habitat quality scores

High Quality Habitats	25-40
Medium Quality Habitats	14-24
Low Quality Habitats	1-13

Using Footprint Analysis to Rank Polygons

In addition to classifying and evaluating habitat quality, I determined the presence and extent of building footprints within each habitat polygon using the 1996 air photos. Given the nature of polygons with partially closed or completely closed canopies, I was unable to assess a number of the polygons. In these cases, a score of unknown was noted with the assumption that field assessments would provide this information.

In addition to identifying polygons with buildings or structures present, the footprint extent was determined by calculating the percent of the block taken up by the building or footprint (Table 14). Low values represent areas where less than ten percent of the building footprint covered the polygon. Medium scores were given for the 11-25 percent range and a high value for anything greater than 25 percent. Finally, I described the spatial distribution of buildings within the polygon as either clustered or dispersed to provide a qualitative descriptor of the footprint's relationship to the entire polygon. All designations were subsequently verified in the field, and amended where necessary.

I used the footprint of existing buildings as an indication of the conservation status for each delineated habitat polygon. Humans and their infrastructure are typically used as one means of identifying conservation status. Human activities are the source of many wildlife conflicts, encompassing disturbances such as noise from cars and people; hunting; land conversion activities such as gardens; the use of pesticides, herbicides, and pesticides; the construction of auxiliary buildings; and the presences of domestic animals, including cats and dogs (Meffe et al. 1997, Peck 1998) In theory then, high

TABLE 14: Values assigned for buildings and their footprints

CLASSIFICATION	LEVEL	DISPERSION
None	No building	Not applicable
Low	< 10% coverage of block	Concentrated
		Dispersed
Medium	11-25% coverage of block	Concentrated
		Dispersed
High	> 25% coverage of block	Concentrated
		Dispersed
Unknown	Not observable	Unknown

concentrations of human infrastructure, such as houses and other buildings or structures, should be considered as a threat to the integrity of habitats. However, two important points should be made here. First, concentrating human structures and activities may reduce pressures on wildlife across the greater area. Second, it is possible for high quality habitat conditions to exist in situations where human structures (houses, barns, etc) are present, or are in relatively close proximity. These habitats are quite likely to have important value for some components of native biodiversity, although they may not be the most sensitive of these species. For these reasons, I suggest overlaying habitat quality classifications with a footprint analysis to assign a priority rank.

The priority ranks are designed to stratify habitat units to reflect the degree of quality habitat in conjunction with the degree of intactness (lack of human footprint)(Table 15). This unique combination facilitates the application of a wide range of land use planning tools, from zoning standards to tax-based management incentives. The highest priority habitats (Priority I) represent areas where land use planners should direct the most intense efforts at conservation. At the opposite end of the spectrum, low priority areas (Priority IV) represent areas where development may be best suited, all else being equal.

TABLE 15: Building filter used to assign final priority ranks

		LEVEL OF BUILDINGS AND THEIR FOOTPRINT				
		None	Low Concentrated	Low Dispersed	Medium Concentrated	Medium Dispersed
QUALITY	High	I	I	II	II	III
	Medium	I	II	III	III	III
	Low	II	III	IV	IV	IV

Representing All Habitat Types

As described in Chapter One, a key premise of conservation biology is the inclusion of all native ecosystem types in any reserve network. Similarly, conservation efforts that do not employ a reserve strategy should protect a full range of habitat types, structural variation, and species within the area of interest. This goal suggests that when there are habitat types for which no polygons are ranked in the highest priority category, all level II polygons in that habitat type should be reevaluated for possible elevation to level I status. Thus, a logical next step was to assess the distribution of priority classes for each block according to habitat types, including the different species compositions possible within each.

For this prioritization effort, I used the information on wildflower distributions to meet representation goals. Where certain habitat types have no top priority candidates, level II representatives of these areas that are rich wildflower species, support endemics, or whose weighted wildflower scores are above one standard deviation have their priority rank elevated to priority I status. In order to ensure that all native habitats, including plants are incorporated within the highest level of land use attention, an analysis of gaps in priority classes established according to habitat quality and conservation status and representation of the suite plants is necessary. Under the recommended methods, where simultaneous wildflowers censusing should occur, this aspect would be automatically included within the habitat quality scoring process.

CHAPTER III

RESULTS: CLASSIFICATION OF HABITAT TYPES

During the spring of 2000 I completed the initial delineation of habitat units and designation of structural types using a GIS software package. In July 2000, I attempted to classify each polygon by habitat type and evaluate its. In this chapter I summarize the findings for the habitat polygon delineation and designation process, describe the results from field work regarding species composition, and use these data to assign habitat types. I conclude the chapter by comparing the habitat classifications generated using these methods with the Oregon Gap Analysis Project's version 2 map of Oregon habitats. Results on habitat quality are reported in Chapter Four, as are results from the wildflower mapping. I begin by discussing the initial structural designations before considering results from field investigations.

Delineation and Classification of Habitat Polygons

Using the procedures and materials outlined in the previous chapter, I delineated 799 discrete habitat polygons based on structural attributes. The polygons encompass the entire 24,000 acre Transition Lands Study Area (TLSA) including each of the 1,158 parcels recognized by Wasco County. I included all land uses and ownership types found within the study area. Parcel sizes in the study area range from under one acre to 682 acres while habitat polygons range from two acres to 880 acres, reflecting the full range of land uses (Figure 2a) and many of the county zoning categories (Figure 2b). Throughout the discussion of results that follows I refer to what I consider two relatively distinct portions of the study area. For convenience I refer to the lower right southeastern portion as the lower part of the study area. Conversely, I call the wider main body located to the north and west, the upper part of the study area.

Structural Classifications

The majority of polygons, both in terms of number and total acreage, in TLSA were classified as forest, that is, with canopy cover greater than 75% (Table 16, Figure 11). Thirty-two percent of the study area was classified as woodlands. While fewer grassland polygons were delineated (just 14% of the total number) compared with savanna, the total area of grassland (19%) exceeds that of savanna by almost 1,500 acres. Roughly one-half of this difference is accounted for by just one polygon; the largest polygon delineated in the TLSA is a grassland area measuring 880 acres.

On average grassland areas and closed orchards are the largest polygons across all types. These factors may reflect the general nature of some agricultural practices in TLSA, or may reflect a combination of factors. The small total area for open orchards is likely influenced by the amount of new orchards planted within the past few years, in addition to associated open spaces within larger orchard polygons. Even added together, orchards as a land use account for the fewest acres of any structural type.

TABLE 16: Summary statistics for polygons according to structural classes (all sizes are given in number of acres)

Structure	Number of Blocks	Total Acreage (in acres)	% Area	Size Range	Avg. Size	Std Error
Grassland	108	4,479.5	19%	3-880	41.49	9.20
Savanna	111	2,838.1	12%	2-448	25.58	4.28
Woodland	254	7,660.1	32%	2-245	30.16	2.23
Forest	294	7,995.0	32%	3-217	27.20	1.79
Open Orchard	8	105.5	4%	5-29	13.31	2.78
Closed Orchard	24	922.9	3%	4-148	38.45	7.73
Total	799	24,001	100%	2-880	30.05	1.71

With the exception of the open orchards, the four other structural categories exhibit rather wide ranges in polygon size. Grasslands have the widest range, followed by savannas because of a small number of very large polygons. The general picture that emerges from these numbers is of a heterogeneous landscape, both in terms of the relative proportion of structural types as well as the patchy nature of those types.

The heterogeneity is likely not only indicative of the ecotonal nature of the area—reflecting gradients in elevation and moisture at both the local and regional scales—but also influenced by the way a few major roads bisect the landscape and increase

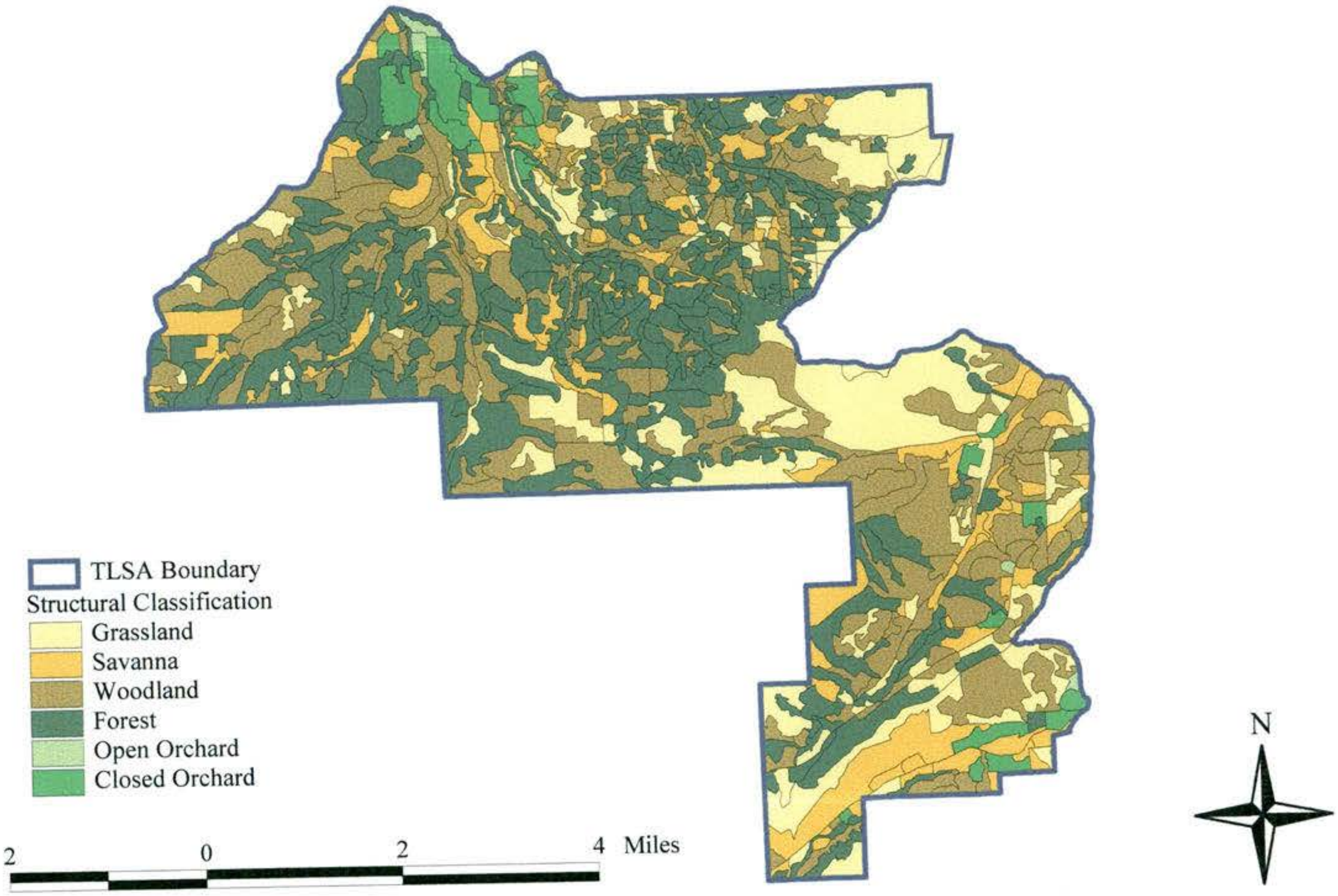


FIGURE 11: Map of structural types in TLSA.

fragmentation. Varied land uses and ownership patterns are also assuredly a contributing factor to the resulting mosaic of structural types. More than one polygon boundary roughly tracks the overlying parcel boundary.

Species Composition

Field observations not only confirmed the heterogeneous nature of the landscape observed from the air photos, but verified most structural designations assigned in the lab. Contrary to expectations, I had to adjust fewer than ten structural classifications. Similarly, I needed to redraw polygon boundaries in only a very small number of cases. I lumped roughly five polygons together and split fewer than five into smaller units. This confirmed that air photo analysis can reliably be used for structural classifications.

Extent of Data Collection

Given the sheer size of the study area plus the limited access to certain areas within TLSA, I was not able to gather complete information for all 799 polygons. In many cases I was only able to gather partial information for habitat classification or habitat quality indicators. Overall, I collected information regarding the canopy species composition for 583 of the 799 polygons (73%), representing 18,356 (76%) of the 24,000 acres (Table 17).

Table 17 contains five categories that describe the completeness of habitat quality data for each polygon, including the number of polygons where I was able to collect

TABLE 17: Summary statistics for the extent of habitat quality data collected in acres (number of polygons)

STRUCTURE	COMPLETE	1 VARIABLE MISSING	>1 VARIABLE MISSING	NO INFORMATION	MISSED
Grassland	1,752 (58)	1,360 (6)	436 (17)	664 (20)	269 (7)
Savanna	1,862 (57)	115 (9)	326 (17)	482 (24)	55 (4)
Woodland	3,587 (118)	599 (21)	1,557 (47)	1,461 (57)	458 (11)
Forest	2,751 (92)	696 (27)	2,213 (84)	1,835 (79)	497 (12)
Open Orchard	102 (7)	0 (0)	0 (0)	5 (1)	0 (0)
Closed Orchard	811 (21)	10 (1)	79 (1)	0 (0)	23 (1)
Total	10,865 (353)	2,780 (64)	4,611 (166)	4,442 (181)	1,302 (35)

information on all variables. The categories, '1 Variable Missing' and '>1 Variable Missing' describe polygons where information on one or more of the quality indicators was lacking. 'No information' includes all polygons that were not visible or accessible by car or bike. They were, in a sense, landlocked or blocked by other polygons that prohibited me from assessing them. The final category, 'missed' refers to all polygons that were inadvertently left out of the field analysis. Because of the number of variables required, and the need for more detailed observation than just canopy composition, over one-half the area lacks data on one or more quality variables.

I choose to include these missed areas as a rough estimate of how many polygons one might expect to be left out of an analysis that is dependent upon volunteer field assessments. Similarly, areas that were not visited demonstrate the extent to which methods to assess or prioritize habitats in a landscape dominated by private lands are constrained by multiple factors, including the degree of road coverage in the area under study. I return to the issue of missing information later in the next chapter.

In particular, I had to assess many of the forest and woodland polygons that are included in these totals from a distance, often by looking across a valley or other intervening landform with the aid of binoculars. Fortunately, the tree species present in the region are relatively easy to differentiate from a distance; ponderosa pines with their distinctive crowns and long needles stand out compared to the pointed top and short needles of Douglas-fir. Similarly, Oregon white oak is practically the only deciduous tree species, except in areas located in general proximity to a stream.

When only polygons with complete information are considered, there is a wide range in the extent to which habitats in individual zones are assessed (Figure 12). The discrepancies appear to be driven primarily by the density of roads in the zone and secondarily by whether those roads are accessible to the public. Not surprisingly, the forest areas zoned for parcels with a minimum of 240 acres has the lowest percentage of area with complete data. The low value (28%) for the 'Wasco County A1-80 Zone' exhibits the same pattern. But this area also exemplifies the issue of private road accessibility, as the road visible in the Northeast corner of the upper study area is actually not open to public use. The lower percentages that appear on the map to have high road density also tend to reflect this problem. In general, clusters of polygons not assessed are often found in areas not reachable by public roads.

The implications of the missing information will be presented throughout this chapter and discussed in more depth in the next. For now, I turn to a discussion of the results in areas for which I was able to collect data. Subsequent tables and figures continue to include information on those areas that lack data to assist the reader in sorting out the relative proportion of area assessed within each category.

Trees

I identified a total of ten native trees in different portions of the study area (Table 18). These species reflect the full complement of species found in literature for this region and for the vegetation types sampled. I also encountered a number of exotic tree species. Of

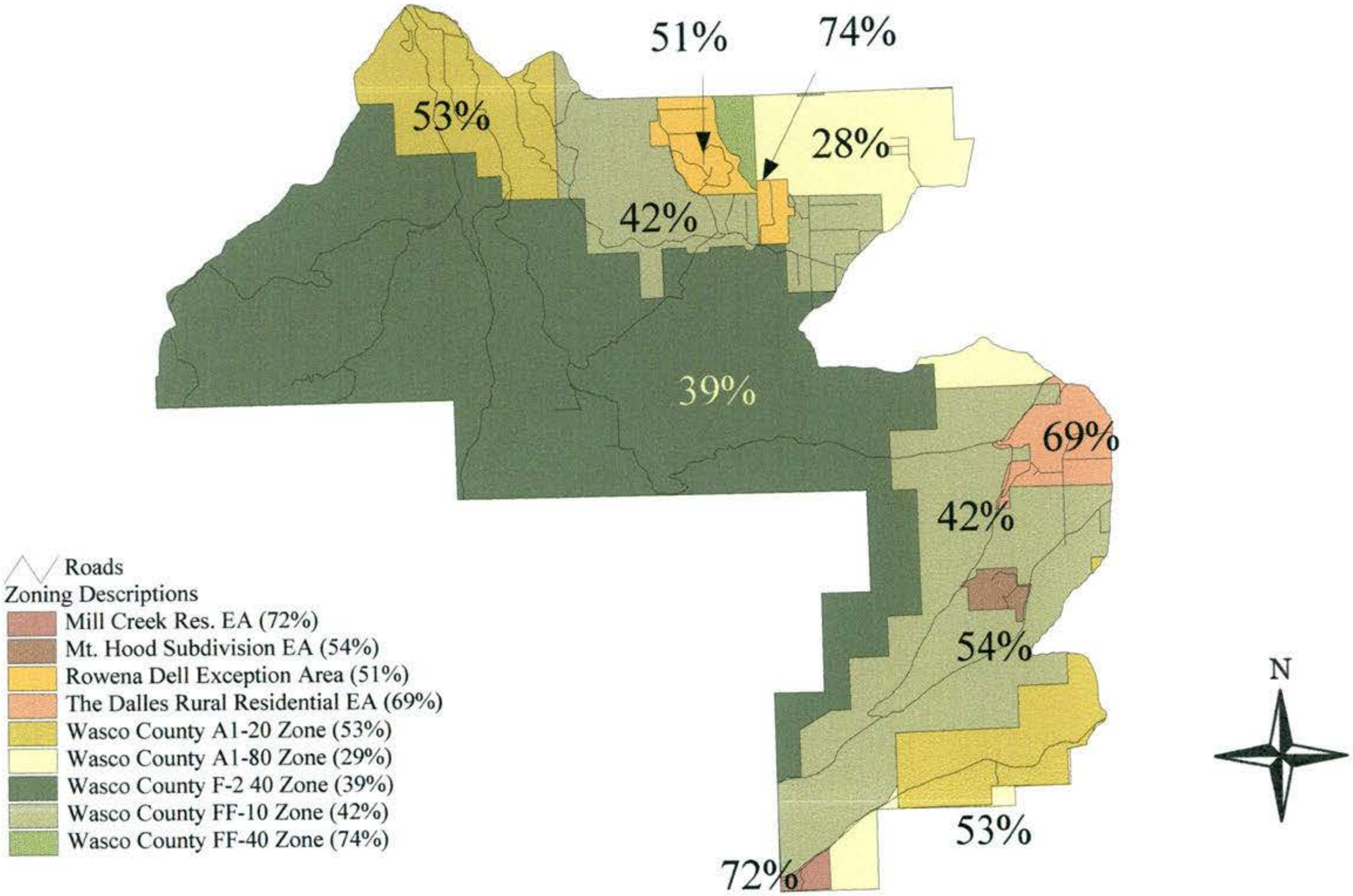


FIGURE 12: Extent of habitat classification within TLSA planning zones.

these, fruit-bearing species important to orchard growers were the most abundant. In addition, I observed several ornamental species—generally in close proximity to dwellings or within well-defined yard areas. I did not record these individual species, but rather determined their abundance relative to the flora within a polygon. Initial habitat classifications presented below denote where nonnative species are a significant portion of a polygon's species composition.

TABLE 18: Native trees of the TLSA (listed alphabetically by common name).

DOMINANT TREES	OTHER TREES
Big leaf maple (*Acer macrophyllum*)	Grand fir (*Abies grandis*)
Black cottonwood (*Populus trichocarpa*)	Oregon ash (*Fraxinus latifolia*)
Douglas-fir (*Pseudotsuga menziesii*)	Pacific dogwood (*Cornus nuttallii*)
Oregon white oak (*Quercus garryana*)	Vine maple (*Acer circinatum*)
Ponderosa pine (*Pinus ponderosa*)	Willow (*Salix* spp.)

Of the greater than 17,000 acres where dominant tree species were identified, 69% were dominated by Oregon white oak, more than the total area of the remaining species combined (Figure 13). Ponderosa pine is the second most common dominant tree (16% of the assessed area), followed by Douglas-fir (12%). Interestingly, only 0.6% (102 acres) of the assessed area lacks trees. This number is partially explained by the fact that the grassland category includes grassy areas that may contain widely scattered trees.

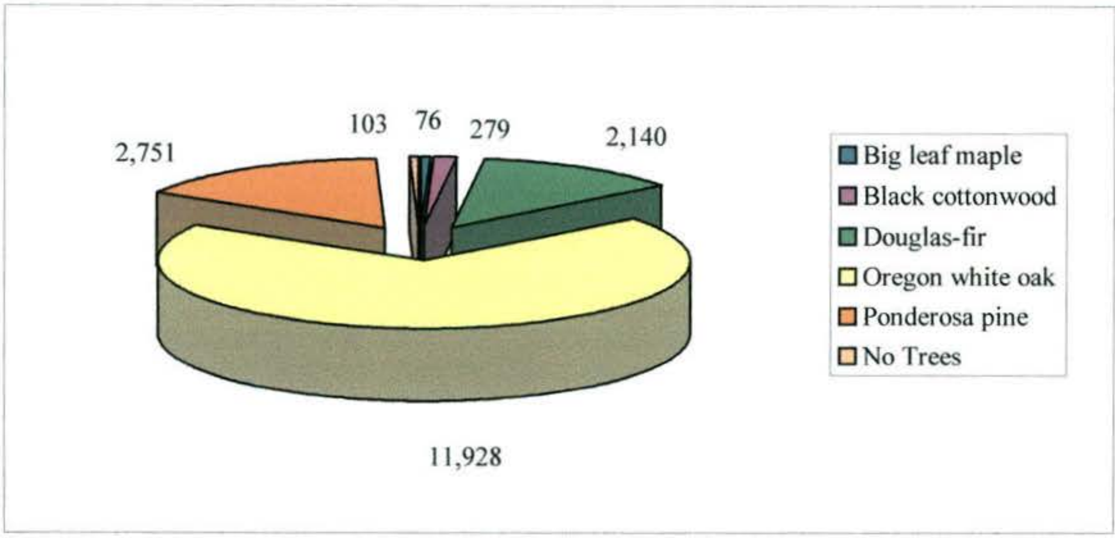


FIGURE 13: Summary of dominant trees by area.

Not only does Oregon white oak appear to be the most dominant species, but its dominance is also widespread across the study area. Only in the southwestern corner does Oregon white oak drop out in dominance; this area is the heart of the industrial forest zone, and not surprisingly is dominated by Douglas-fir. Orchard areas are clustered in the northern and extreme southeaster portions of the assessment. Otherwise, few distinctive clusters emerge; polygons dominated by ponderosa pine are widely distributed while polygons dominated by riparian or more mesic species, such as black cottonwood and big leaf maple, are found in close proximity to perennial streams.

Consideration of subdominant trees reveals a preponderance of ponderosa pine, covering an area of just under 11,000 acres (63% of the assessed area). It too is widespread and overlaps extensively with areas dominated heavily by Doug-fir. Oregon white oak is virtually absent as a subdominant, largely explained by its widespread dominance. More interestingly, two new native trees emerge as components of the vegetation—Oregon ash and willow—while we see nonnative components not related to to agricultural practices for the first time. Twelve polygons covering a total of 178 acres (1% of the total assessed) have nonnative tree species.

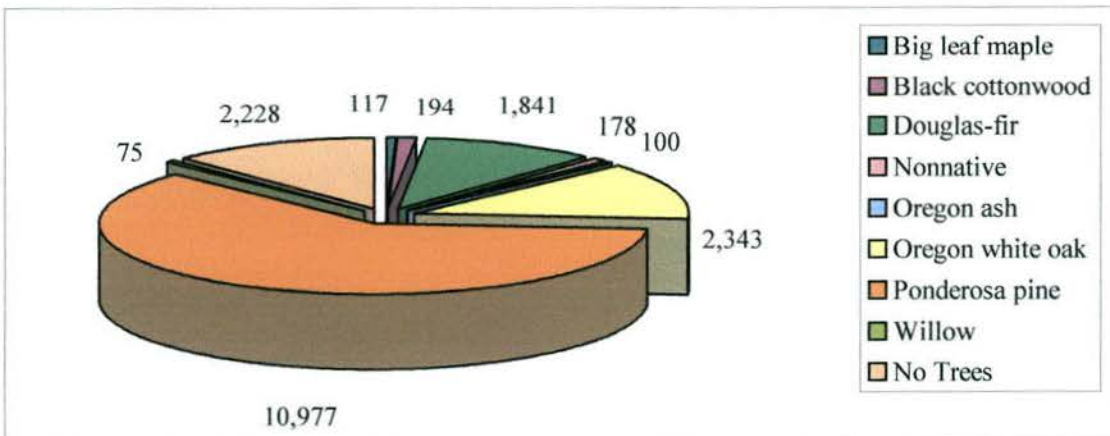


FIGURE 14: Summary of subdominant trees by area.

Examination of tertiary tree composition reveals that close to 50% of polygons are comprised of only two species: Oregon white oak and ponderosa pine. The remainder are characterized by a wide range of species, led by Douglas-fir. Grand fir, vine maple, and Pacific dogwood appear at this level, rounding out the list of native trees. Only nine polygons include nonnative elements at this level.

Shrubs

I collected data on the extent and species composition of shrubs for each polygon. However, because these data were not used explicitly to assign habitat types, I only briefly discuss the nature of shrub cover across the study area in addition to shrub species surveyed. I identified a total of eight shrubs during my surveys (Table 19). Interestingly, the range of shrub species include a number of species that are typical of the drier portions of Oregon.

TABLE 19: Native shrub species observed in TLSA

Dominant Trees	Other Trees
Bitterbrush (*Purshia tridentata*)	Poison oak (*Rhus diversiloba*)
Chokecherry (*Prunus virginiana*)	Serviceberry (*Amelanchier alnifolia*)
Deerbrush (*Ceanothus integerrimus*)	Snowberry (*Symphoricarpos albus*)
Ocean spray (*Holodiscus discolor*)	Vine maple (*Acer circinatum*)

Overall, it would appear that the vast majority of TLSA habitats do not contain areas with extensive shrub cover (Table 20). In fact, a greater area of habitat has relatively little or no shrub cover than do areas with moderate to high shrub cover. Looking at the acreage in Table 20 for each structural type an interesting pattern emerges. The more open the canopy, generally the lower the shrub cover. Similarly, the greater the canopy cover by trees, the more shrub cover. The deviation from this pattern seems to be in the large area of woodlands that have exhibit low shrub cover.

TABLE 20: Level of shrub cover by structural type (in acres)

STRUCTURE	NO SHRUB COVER	LOW	MEDIUM	HIGH	NO OBSERVATION	MISSED
Grassland	1,339	1,751	59	9	390	269
Savanna	1,183	645	220	68	198	55
Woodland	433	2,454	1,392	536	927	458
Forest	372	1,340	1,139	1,287	1,526	497
Total	3,329	6,189	2,810	1,900	3,041	1,279

Native Grasses and Wildflowers

Native grasses, which serve both a component of species composition (particularly within grasslands) and an indicator of quality, are discussed in Chapter Four. Similarly, because data on wildflowers are used in this methodology to facilitate representation goals, they also are discussed within the context of prioritizing habitat units in the next chapter.

Assigning Habitat Types

Combining structural type designations with classifications based on tree species composition (primary, secondary, and tertiary)(Figure 15) facilitates classification of the four native habitat types identified by the Oregon Gap Analysis Project (ORGAP). ORGAP uses two additional categories to classify non-native cover types: agriculture and rural residential areas.[1] Because riparian woodlands are distinctive landscape features, do not fit neatly within ORGAP categories given its degree of resolution in this assessment, and are important conservation targets, I leave them in as a separate category in all remaining tables and figures.

I used the aggregation matrix described in Chapter Two (Table 8), to assign habitat types to each of the polygons with sufficient data. After classifying polygons according to the ORGAP scheme—except for riparian woodlands—a total of 514 polygons covering 14,918 acres (or roughly 62%) emerge (Figure 16, Table 21, Figure 17).

---

[1] Investigation of the actual area measurements for rural area mapped by ORGAP in TLSA using a GIS demonstrates that they are considerably smaller in size than would be expected given the large minimum mapping unit.

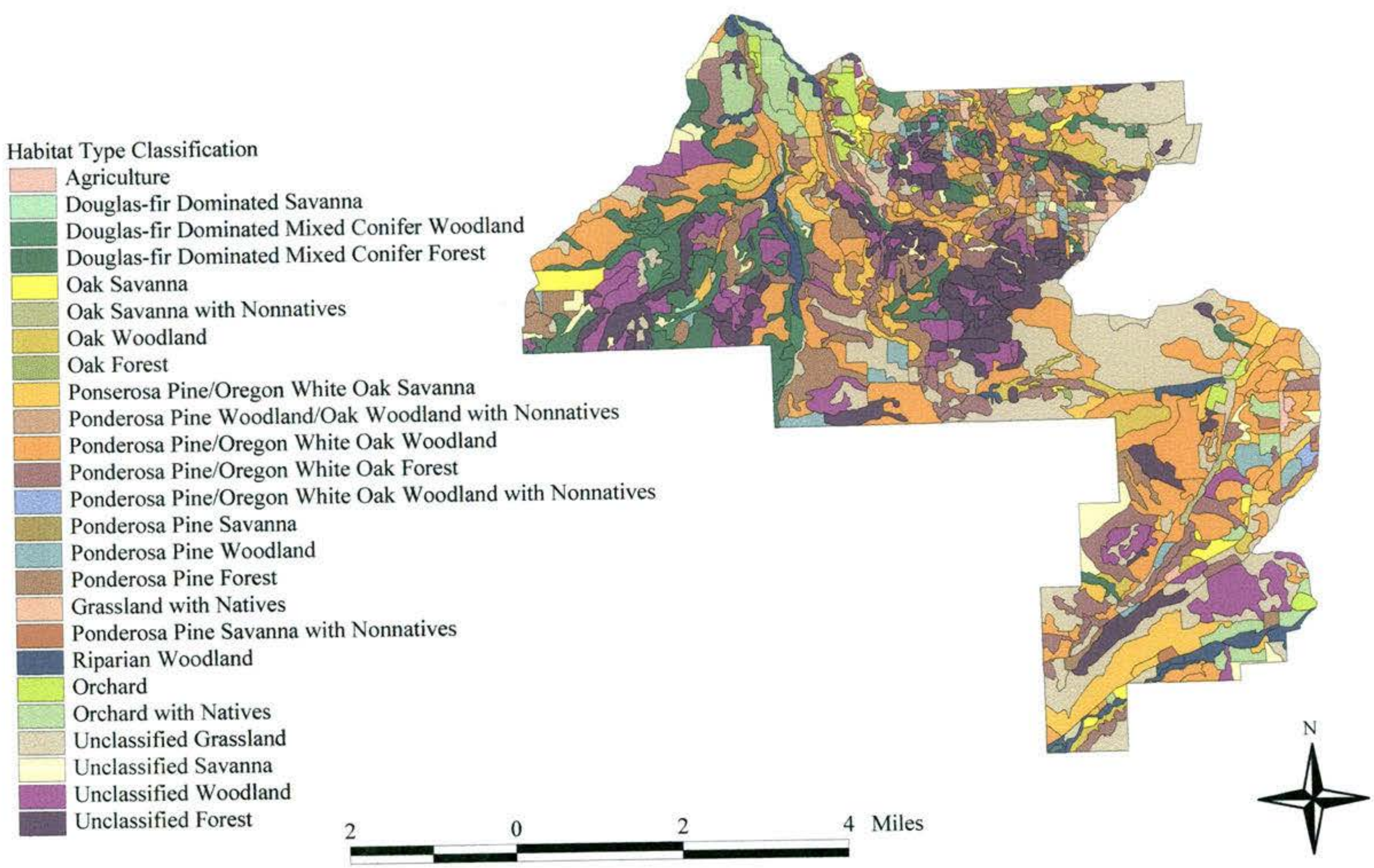


FIGURE 15: Classification of habitat types using structural type and species composition.

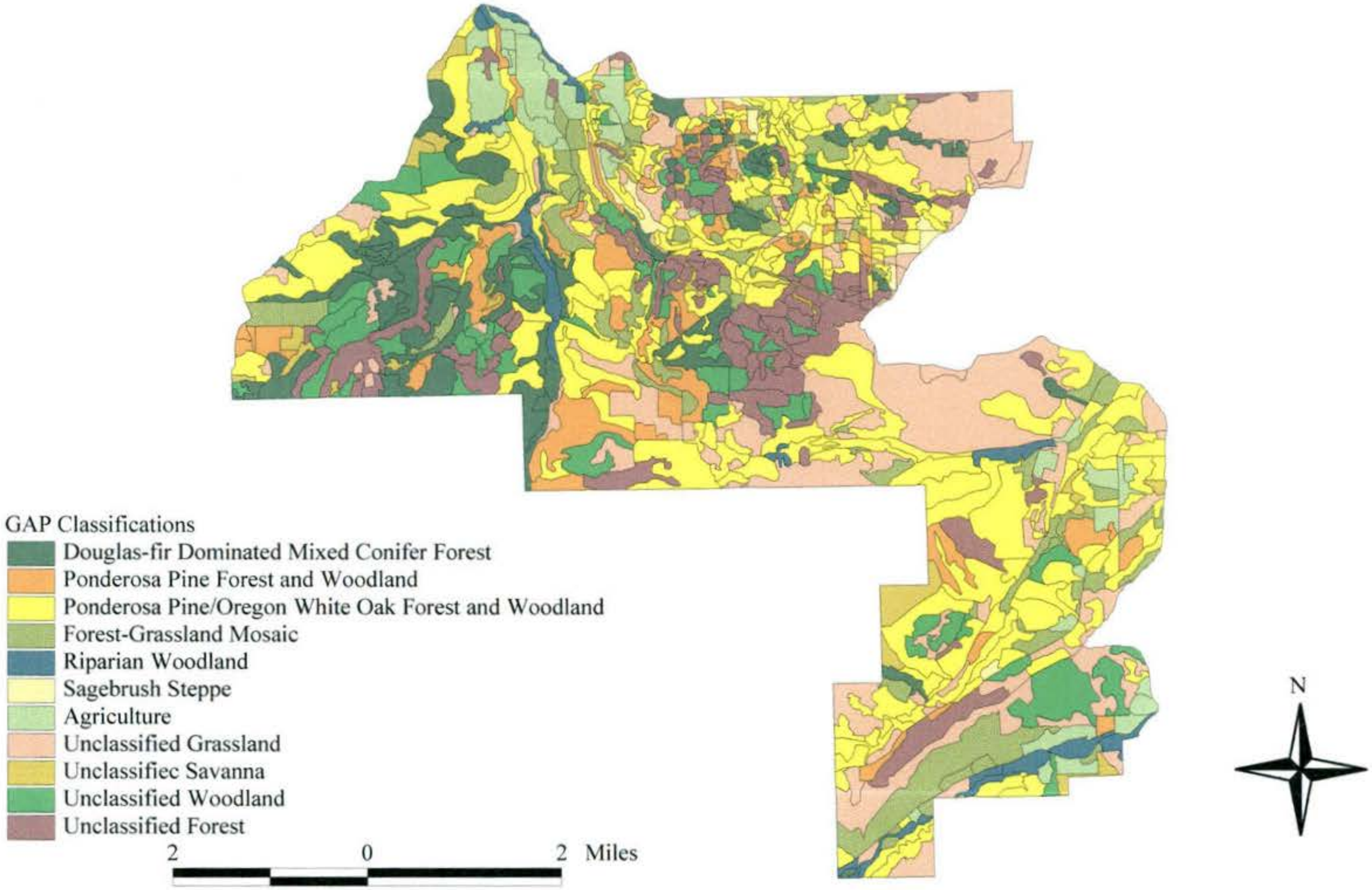


FIGURE 16: Habitat types using the Oregon GAP classification scheme.

TABLE 21: Summary of habitat types using the Oregon Gap Analysis Project classification scheme

HABITAT TYPE	NUMBER OF BLOCKS	Total Acreage	% AREA	SIZE RANGE	AVG. SIZE	STD ERROR
Sagebrush Steppe	10	175	1%	3.1-64.9	18.3	5.4
Forest Grassland Mosaic	76	2,054	14%	2.5-447.7	27.0	6
Ponderosa Pine/Oregon White Oak Forest and Woodland	246	7,318	49%	2.5-241.2	29.7	2.2
Ponderosa Pine Forest and Woodland	58	1,562	10%	3.1-213.5	26.9	4.5
Douglas-fir Dominated Mixed-Conifer Forest	70	2,172	15%	3.1-153	31.02	3.7
Riparian Woodland	19	523	4%	4.6-63.4	27.5	4.0
Agriculture/Rural Residential	35	1,114	7%	4.1-148.8	31.8	5.6
Total	514	14,918	100%	2.5-447.7	29.0	1.6

Of the classified areas, Ponderosa Pine/Oregon White Oak Woodland and forest is the most common habitat type using the ORGAP scheme. Douglas-fir Dominated Mixed Conifer Forest constitutes the second largest habitat type by area, followed by Forest-Grassland Mosaic and Ponderosa Pine Forest and Woodland. By far the rarest of all habitat types are areas classified as Sagebrush Steppe; they comprise a meager 1% of the total TLSA. Only ten polygons, which together cover 175 acres, exhibit species compositions similar to the native grasslands described by ORGAP.

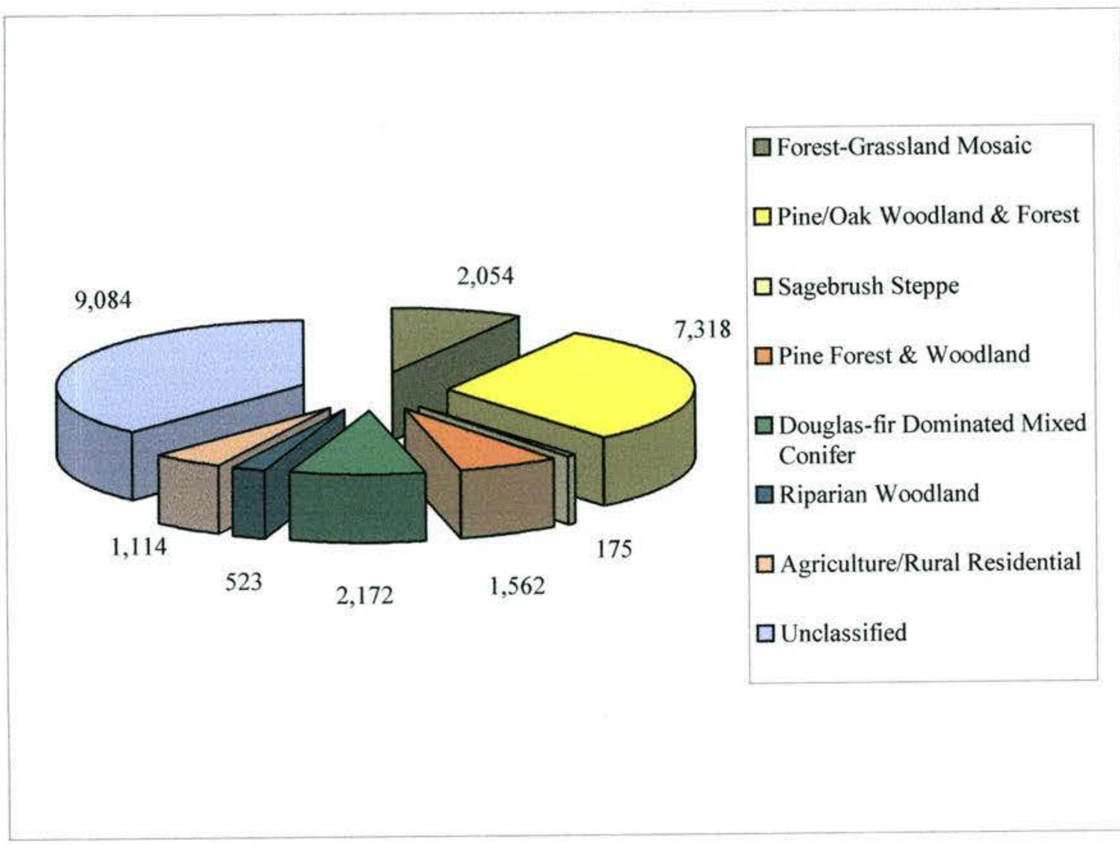


FIGURE 17: Area (in acres) classified according to GAP classifications. (Note that Riparian Woodlands are not included in the GAP Classification.)

Degree of Congruence with GAP Classifications

Comparing the results of the habitat type mapping I completed with the Oregon GAP 2 map provides a means to directly assess whether the same portions of the landscape were classified in the same way by the two schemes (Table 22). In this section I report on the degree of congruence between the two maps.

There is surprisingly little congruence between the two mapping exercises (Table 23, Figure 18). Only areas classified as Douglas-fir Dominated Mixed Conifer Forest and Agricultural/Rural Residential showed similarities when both classification schemes are compared. There was no congruence in areas identified as Ponderosa Pine Forest & Woodland—a rather surprising result. Also surprising, only 50% of Ponderosa Pine/Oregon White Oak areas were classified in the same manner.

However, in many respects the degree of incongruence is to be fully expected. The resolution of the current analysis is much finer than that conducted by Oregon GAP. For example, by using a minimum mapping unit of two acres, most clusters of forest found within relatively open grassy areas—the forest elements of polygons of Forest Grassland Mosaic—are separated out and treated differently by the procedures outline in this paper.

TABLE 22: Comparison of polygon classifications with the Oregon Gap Analysis Project (GAP) by acreage

STRUCTURE	TOTAL ACRES CLASSIFIED IN THIS STUDY	TOTAL ACRES CLASSIFIED BY GAP
Sagebrush Steppe	175.1	3,060.4
Forest Grassland Mosaic	2,054.0	7,624.
Ponderosa Pine/Oregon White Oak Forest and Woodland	7,318.1	10,441.8
Ponderosa Pine Forest and Woodland	1,561.8	1,211.5
Douglas-fir Dominated Mixed-Conifer Forest	2,171.6	1,051.8
Riparian Woodland	523.1	Not Classified
Agriculture/Rural Residential	1,114.0	786.5
Unclassified Grassland	4,258.8	Not Applicable
Unclassified Forest Grassland Mosaic	537.1	Not Applicable
Unclassified Forest and Woodland	4288.5	Not Applicable
Total Across Habitats (unclassified)	14,917.7 (9,084.4)	Not Applicable

TABLE 23: Congruence between the habitat type classifications using the study methods and classifications according to the Oregon Gap Analysis Project (GAP)

STRUCTURE	TOTAL CONGRUENCE	TOTAL INCONGRUENCE	PERCENT CONGRUENCE
Sagebrush Steppe	58.1	690.9	7.8%
Forest Grassland Mosaic	1,201.3	3,456.3	25.8%
Ponderosa Pine/Oregon White Oak Forest and Woodland	3,834.9	3724.2	50.7%
Ponderosa Pine Forest and Woodland	0	906.7	0%
Douglas-fir Dominated Mixed-Conifer Forest	291.9	153.2	65.6%
Riparian Woodland	Not Applicable	Not Applicable	Not Applicable
Agriculture/Rural Residential	112.3	374.2	23.1%
Total Across Habitats	5,498.5	8498.8	37.1%

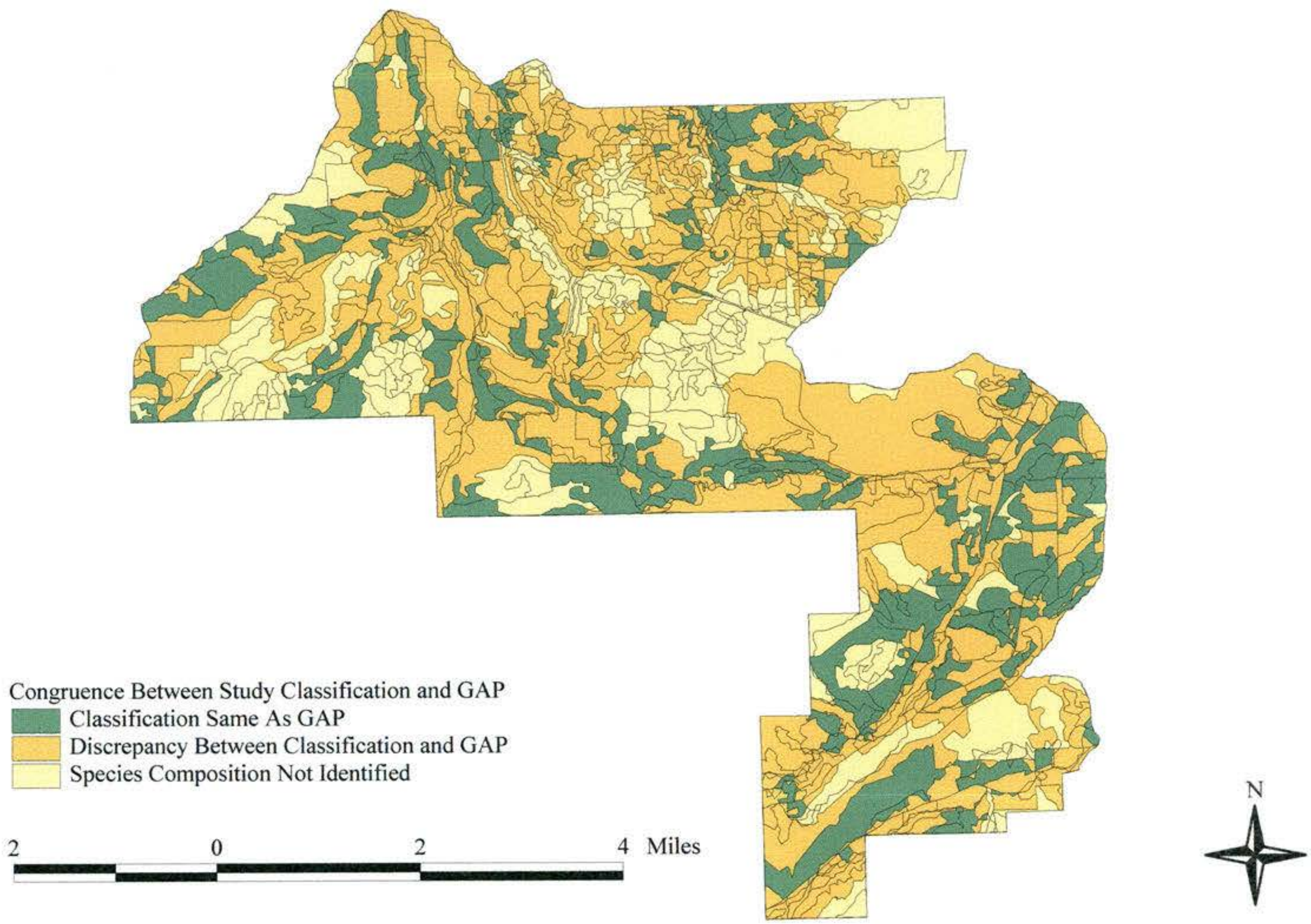


FIGURE 18: Distribution of congruence between habitat types classified using the methods outlined in this paper and the system used by ORGAP.

With increasing resolution, or the use of smaller mapping units, variation in species composition not evident over larger areas stands out. These variations are typically 'smoothed over' by analysis techniques used with satellite imagery and different from those discussed in this paper. Patches of oak-dominated stands within a larger area of ponderosa pine are unlikely to stand out in coarse-scale analyses. Oregon GAP neglects to separate out certain types of agriculture, namely orchards. Instead these very different 'woodlands' are lumped in with the surrounding matrix of native habitat types. Consequently, the current analysis identifies large chunks of agriculture within areas identified by ORGAP as native forest or woodlands. The large tracts of orchard evident from air photos do not appear in the Oregon GAP map. This issue is discussed in further detail in the final chapter.

CHAPTER IV

RESULTS OF PRORITIZING HABITATS FOR PROTECTION

I begin by summarizing habitat quality data collected during July 2000, exploring the patterns that emerged within each of the four indices as well as the overall patterns of quality. Results of the footprint analysis, and the subsequent priority ranks that result from using this filter, are presented. As one means of ensuring greater representation of native biodiversity within areas identified for priority action, I present the findings of the wildflower mapping and evaluation exercise. These data are used to generate a final map of habitat polygons that have been prioritized for application of the land use planning mechanisms suggested in Chapter One. Throughout the chapter, the Oregon GAP habitat classifications[1] discussed in Chapter Three are used as the organizing unit for presenting these findings.

Assessment of Habitat Quality

As discussed in Chapter Three, data could not be collected for each of the four quality variables in all 799 polygons. A small subset of polygons was missed during fieldwork and others could not be assessed. In particular, some structural types (e.g.,

[1] Note I continue to evaluate Riparian Woodlands as a separate category. They are not mapped in the version 2 Oregon GAP map.

forests) do not lend themselves to the assessment methods. The lack of data for these indices, however, varies according to individual polygons. Consequently, all figures and tables presented below include a category entitled 'not assessed,' denoting the lack of data for that particular category.

Evaluation of Functional Elements

A major premise of this study is that mapping habitat quality can be mapped by evaluating structural or functional elements important to native biodiversity. To this end four surrogates for habitat quality—snags, legacy trees, native grasses, and saplings—were used to evaluate individual polygons.

Snags

Contrary to my expectations, habitats in Transition Lands Study Area (TLSA) are not overly dominated by high concentrations of snags. However, 45 polygons contain high concentrations of snags; together they cover 1,286 acres, equivalent to five percent of the study area (Figure 19). With the exception of a cluster of polygons in the northeastern section of the upper part of the study area, habitats with high snag densities are widely dispersed (Figure 20). Of these, the vast majority was classified as Ponderosa Pine/Oregon White Oak Woodland and Forest.

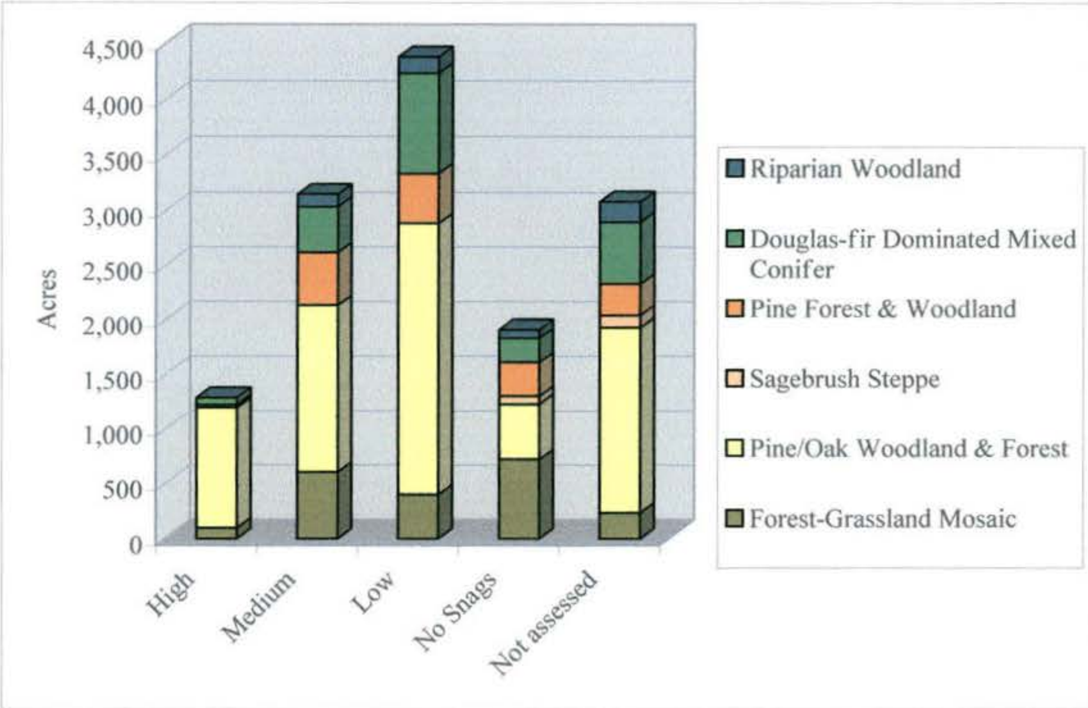


FIGURE 19: Summary of scores for snags. Bars show the total area covered by each quality class and the relative area for each habitat type using the Oregon GAP habitat classification scheme.

Consideration of polygons that support medium concentrations of snags reveals small clusters in the southern portion of the lower study area. Moreover, these areas are also interspersed with habitats that scored high on this index. Over 3,100 acres of habitat, or approximately 13% of TLSA contains moderate levels of snags. Within this category the proportions among habitats are more evenly spread, but still dominated by habitats classified as Ponderosa Pine/Oregon White Oak habitat types. In particular, Douglas-fir dominated and ponderosa pine dominated areas each encompass four hundred acres of moderate snags.

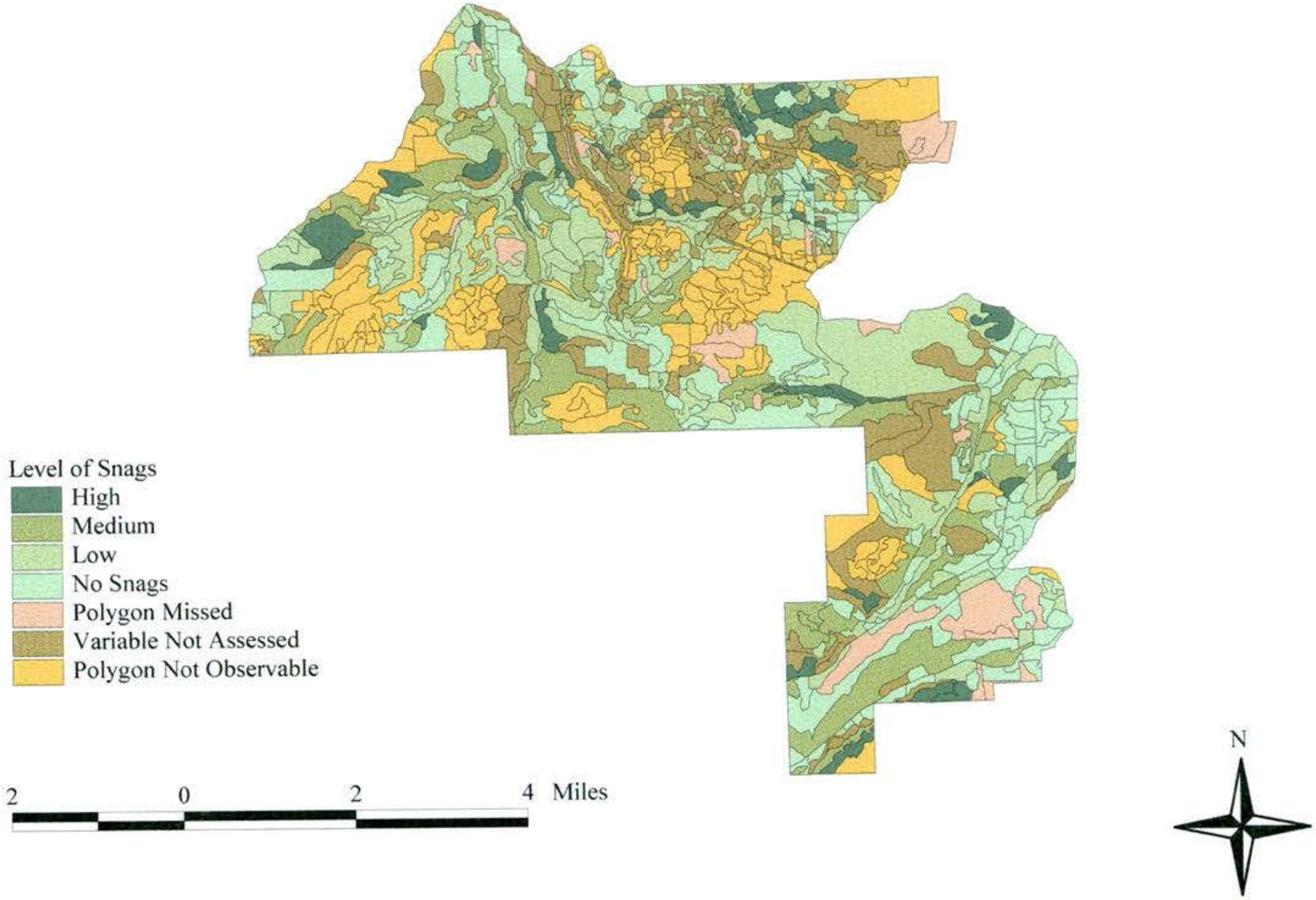


FIGURE 20: Distribution of snag levels.

The high proportion of areas dominated by Oregon white oak that scored high on this index is not particularly surprising, given the large extent of oak habitats. The importance of snags within other habitats should not be overlooked, however, as differences in tree species performing the same functional role may have subtle or not-so-subtle consequences for an array of native species. Factoring in the sheer number of oaks on the landscape, as evidenced by the maps of dominant, subdominant, and tertiary trees suggests that habitat types where oak is not dominant may still score well on this indicator due to a high 'background level' of oaks. Unfortunately, I did not collect data on the species composition of snags, thus my ability to detect different habitat nuances related to snag type are limited.

Legacy Trees

Surprisingly few areas within the study area support high levels of legacy trees; fewer than 200 acres spread across six polygons exhibit these characteristics (Figure 21, Figure 22). Of these, two are contiguous and the remaining four habitat polygons are dispersed throughout TLSA. Slightly over 50% of these acres are classified as Ponderosa Pine/Oregon White Oak Forest and Woodland. Forest-Grassland Mosaic and Ponderosa Pine Forest and Woodland habitats comprise the remaining area.

Consideration of habitats supporting moderate levels of legacy trees does not do much to increase the overall acreage where legacy trees can be found. Polygons in this class do exhibit a greater degree of clustering, with several polygons in the central portion of the study area. The proportion of habitat types represented within this category are similar to those exhibited by polygons with moderate levels of snags. However, one difference worthy of mention is the abundance of riparian woodland habitats with moderate concentrations of legacy trees. This fact largely reflects the presence of black cottonwood trees adjacent to Mosier, Chenoweth, and Mill creeks.

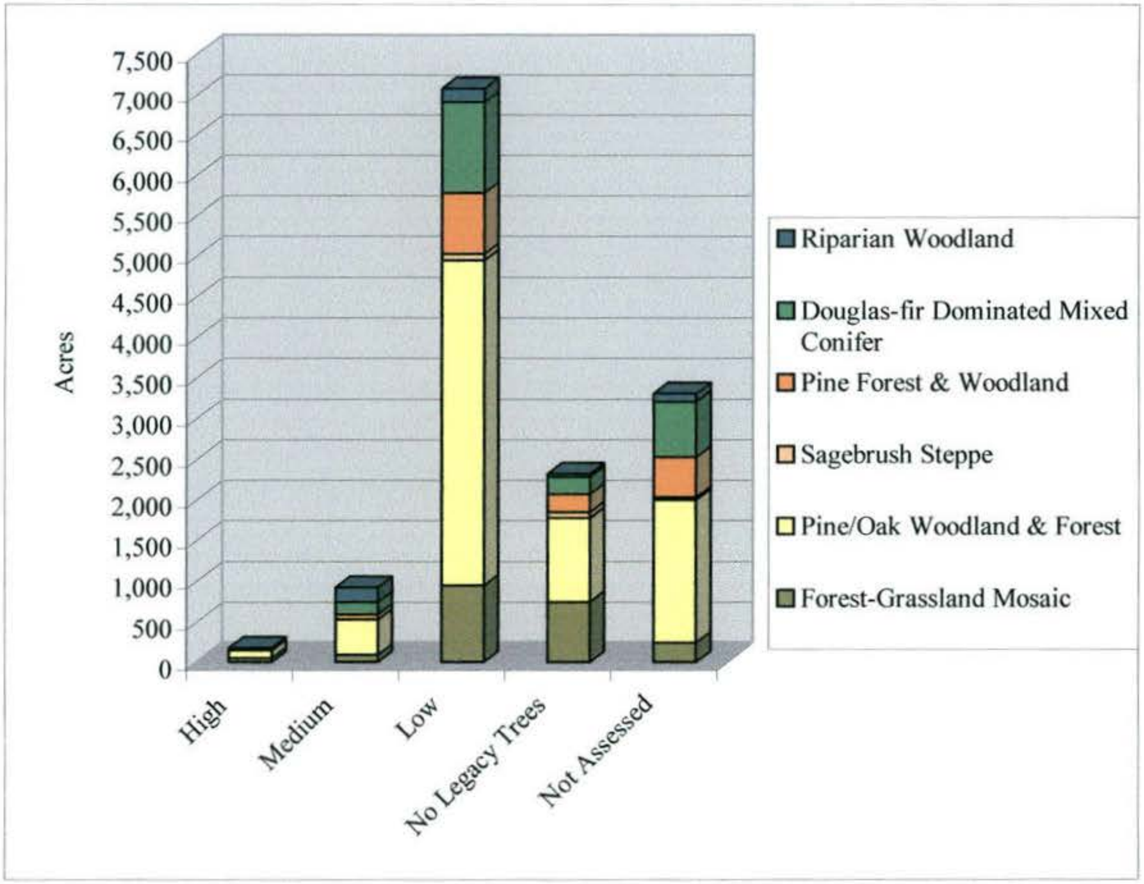


FIGURE 21: Summary of scores for legacy trees. Bars show the total area covered by each quality class and the relative area for each habitat type using the Oregon GAP habitat classification scheme.

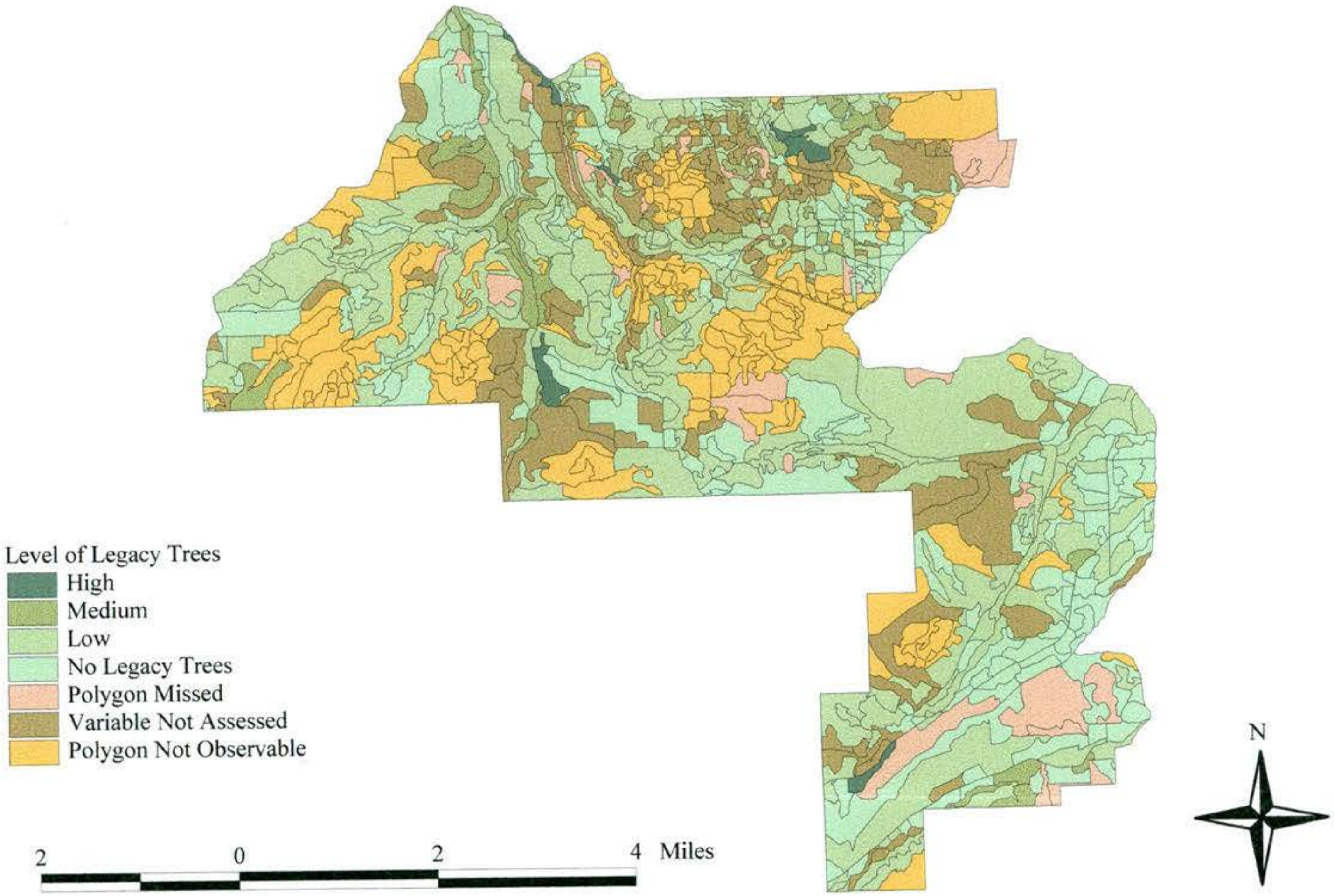


FIGURE 22: Distribution of legacy tree levels.

Native Grasses

Observations of native grasses in TLSA appear to reflect wider trends found in the western United States (Noss and Cooperrider 1994). No habitats were dominated by native species. Moreover, few polygons exhibited grass composition where native species were present. In fact, only 47 of 334 polygons (14%) assessed received a 'natives present' ranking. Together these polygons encompass just 11% of the total area assessed (Figure 23).

Data on native grasses were used as both the means for classifying grassland habitats (Sagebrush Steppe) as well as an indicator of quality. Two points are important in this regard: 1) polygons classified as Sagebrush Steppe are somewhat deceptive, as they are only partially indicative of this habitat type and 2) all Sagebrush Steppe polygons are included within the high quality category because so few grassland habitats contained any native species. In all, I identified 10 polygons, covering 183 acres, which supported native grasses.

A total of 544 acres within 24 polygons were identified for presence of native grasses. The largest areas containing native grasses actually occur in polygons classified as Ponderosa Pine/Oregon White Oak Woodlands And Forest. These areas occur predominantly within two portions of the study area: in the northeastern section of both the upper and lower portions of the study area (Figure 24). Native grasses occur across several contiguous units in this upper section.

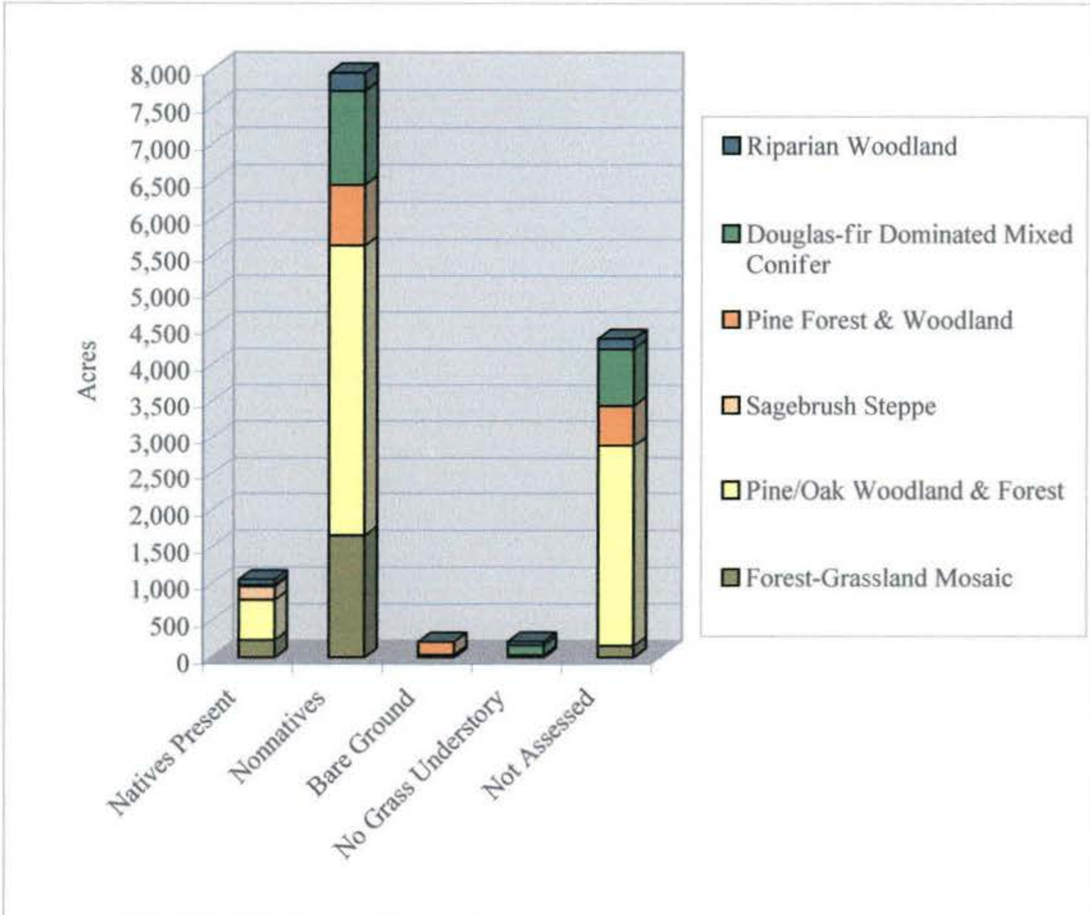


FIGURE 23: Summary of scores for native grasses. Bars show the total area covered by each grass category and the relative area for each habitat type using the Oregon GAP habitat classification scheme. Note: native grasses dominated none of the habitat units assessed in the study area (See discussion in text regarding this issue).

Areas of Forest-Grassland Mosaic have the second largest area of native grass coverage, with 236 acres in just 10 polygons. One polygon of Douglas-fir dominated Mixed Conifer and Ponderosa Pine Woodland and Forest each contained at least one native grass species.

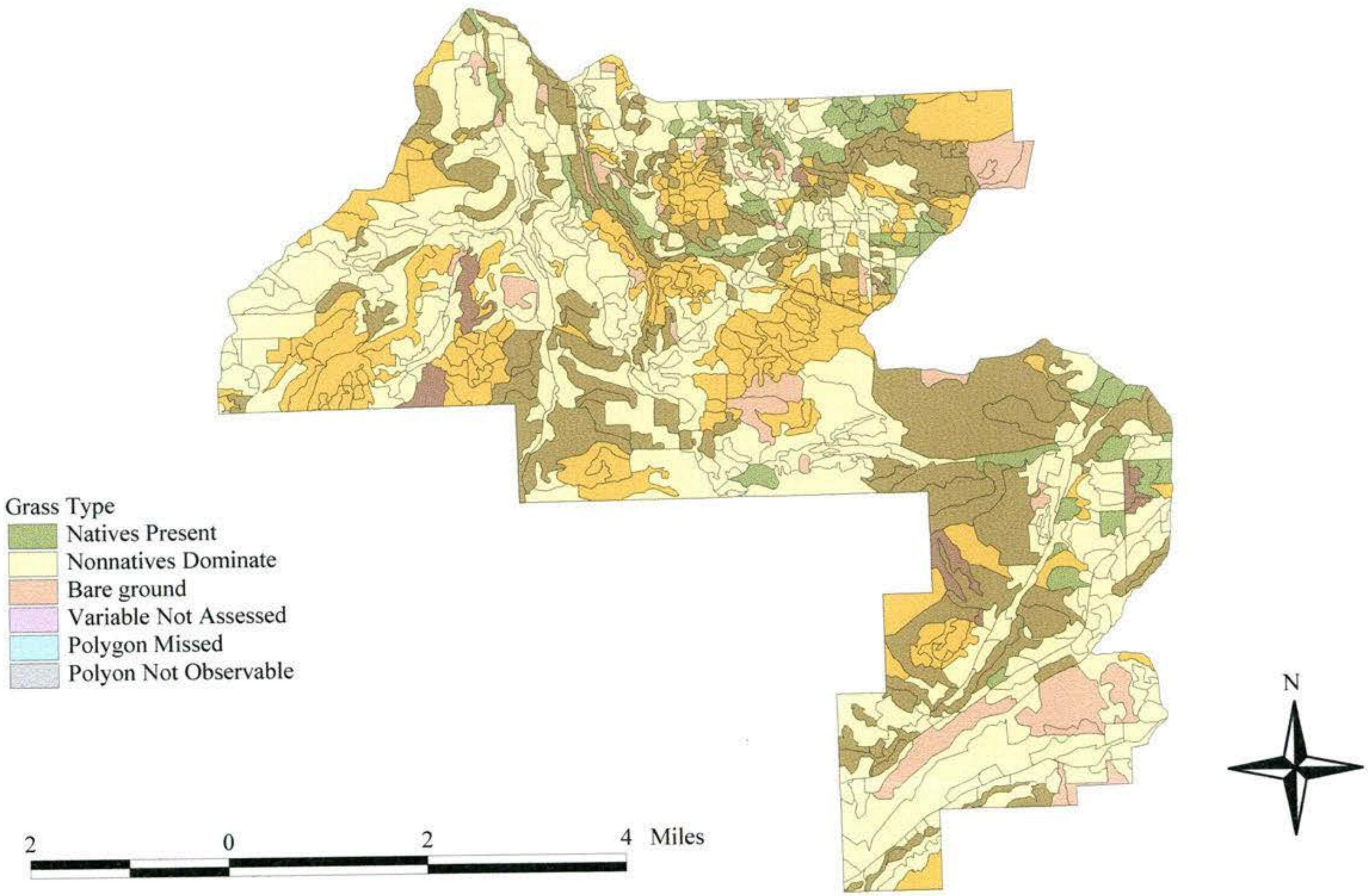


FIGURE 24: Distribution of grass types. (Note: native grasses dominated none of the habitat units assessed in the study area. See discussion in text regarding this issue).

By far, the majority of habitats in TLSA do not harbor native grasses. Most polygons assessed had an understory with at least some grasses sparsely interwoven with other ground species. However, five polygons encompassing 213 acres were devoid of groundcover. In most cases, these habitat units were visibly associated with certain types of land use, such as horses or cattle.

Saplings

Over 5,000 acres of habitat in TLSA appear to have low sapling levels. Similarly, fewer than 1,000 acres of habitat appear to contain no saplings of any kind. Relative proportions according to habitat type closely mirror the proportions of habitat types as a whole within the study area. Taken together, these findings suggest stability of habitat types, based on structure, over short to middle-terms (decades to 100 years). However, these data potentially raise questions about whether certain species of tree may be having difficulty regenerating. For example, scientists in the Willamette Valley are concerned with ability of individuals of Oregon white oak to establish. My results suggest oak habitats are showing less regeneration than Douglas-fir.

The distribution of sapling levels across the landscape reveal wide areas with low levels (Figure 25, Figure 26). A few clusters of polygons with high levels do occur (Figure 26). Three of these fall within the area zoned for forestry and most assuredly reflect replanting following logging activities. A second cluster exists within the rural residential zone along the northern boundary of the study area. Field observations show

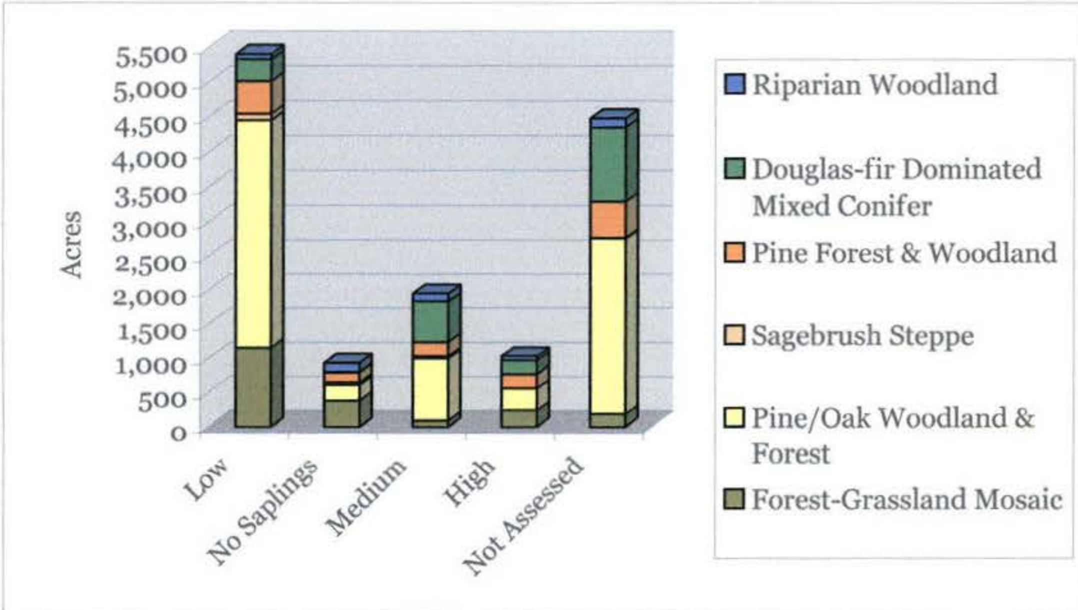


FIGURE 25: Summary of scores for saplings. Bars show the total area covered by each quality class and the relative area for each habitat type using the Oregon GAP habitat classification scheme.

that several of these areas represent parcels where landowners have planted ponderosa pine, as evidenced by even spacing and the presence of sprinklers for irrigation.

Data on areas where sapling levels are high potentially show dramatic increases in tree density within certain habitat types, notably Forest-Grassland Mosaics and Ponderosa Pine/Oak Woodlands. Consistent and reliable data regarding the species composition of these saplings were not recorded; therefore a clear picture on how species composition may be changing within these habitats is unavailable. Casual observations suggest that in many ponderosa pine and Oregon white oak habitats, sapling composition is generally comprised of ponderosa pine, and in some instances, Douglas-fir.

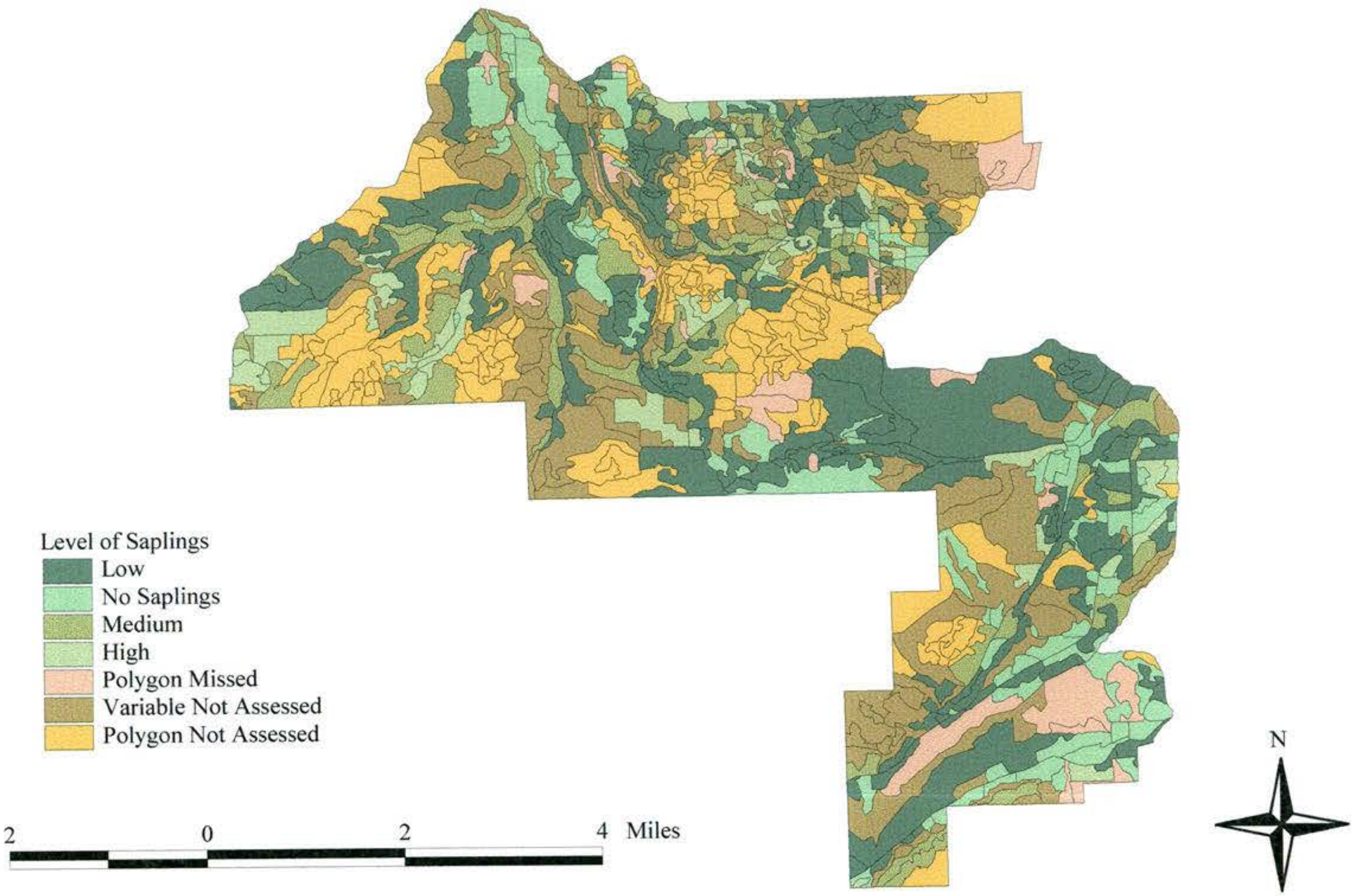


FIGURE 26: Distribution of sapling levels.

Summing Scores To Assign Habitat Quality Values

Combining individual scores from each of the four indices provides an indication of habitat quality. This tallied score serves as an initial rating of a polygon's habitat importance. In essence, high quality habitats are a top priority for conservation attention by land use planners. Problems with this step of the priority setting require discussion at this point.

Given the fact that each habitat quality indicator could not be assessed for all polygons where habitat types were assigned, it stands to reason that a number of polygons lack information for multiple indices. Consequently, I only considered polygons in the final evaluation that had complete information or only one variable missing. In all, 327 polygons spread throughout the study area and covering 9,669 acres (just 40% of the TLSA total) comprise the habitat assessed for its quality (Figure 27). Thus, the results underestimate the true extent of quality habitat found in Transition Lands Study Area of Wasco County.

The results of summing individual habitat quality scores explicitly identify, for the first time, conservation targets using the methods I have outlined. These designations were the basis to create final priority ranks by applying the building footprint filter and representation exercises discussed in the next few sections. They are in effect the anchors for a new conservation landscape. Folding these data into a combined score reveals

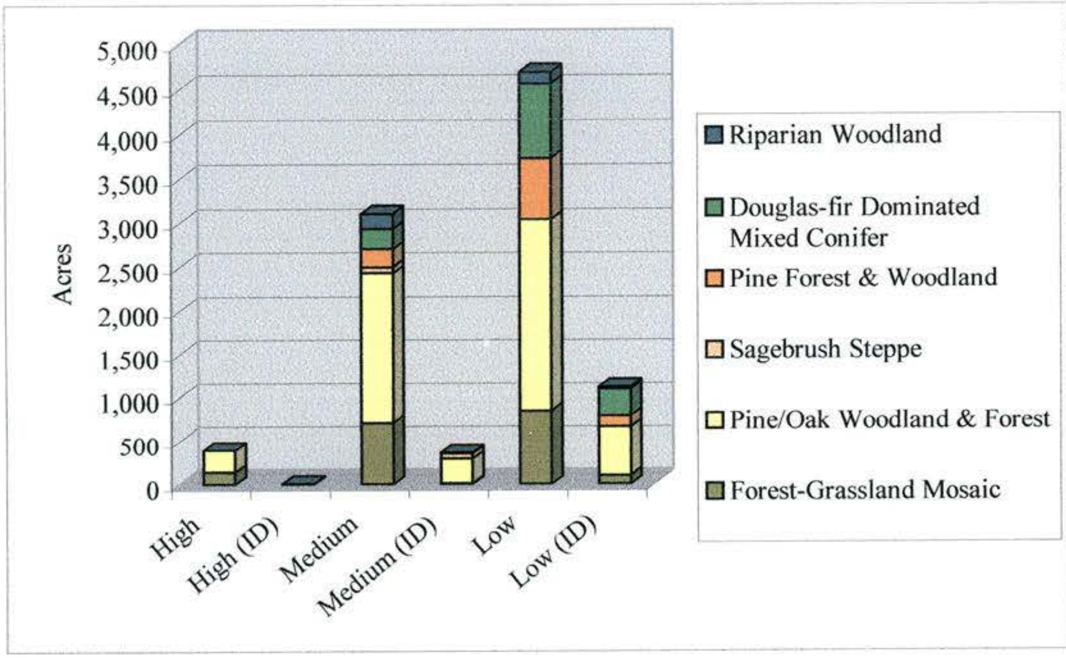


FIGURE 27: Summary of habitat quality using ORGAP habitat classifications. Bars show total acres covered by each habitat quality class. 'ID' indicates data for one of the variables is missing.

that only 13 total polygons, covering 389 acres (a scant 2%) of the study area, exhibit habitat that rates as high quality. Nine polygons (250 acres) of Ponderosa Pine/Oregon White Oak Forest and Woodland habitats and four (139) polygons classified as Forest-Grassland Mosaic comprise this total. An additional polygon falls into the category 'high-insufficient data.' This polygon exhibits high values for the indices, snags, legacy trees, and saplings but its understory could not be evaluated.

A far greater amount of habitat received a quality score of 'medium.' Slightly more than 3,000 acres distributed in 92 polygons and representing each of the six habitat types make up this acreage. Again, the Ponderosa Pine/Oregon White Oak classifcation predominates, but a fair amount of this total includes 704 acres of Forest-Grassland Mosaic polygons. Douglas-fir Dominated Mixed Conifer (225 acres), Ponderosa Pine Forest and Woodland (205 acres), Riparian Woodland (181 acres), Sagebrush Steppe (71) make up the remainder. A slightly smaller area, or 358 acres split between four habitat classifications, constitutes polygons scored as 'medium' but have insufficient data to assign a definitive score.

Within habitat types a few interesting patterns emerge. First and foremost, all Sagebrush Steppe habitats are either rated as 'medium' or 'medium (insufficient data)' for their quality. The heavy emphasis on trees as indicators of quality (i.e. snags and legacy trees) may well preclude these polygons from scoring 'high' for summed habitat quality scores. This realization points further to the need to evaluate other aspects of species composition and quality, such as wildflowers that are not considered at this stage of my analysis.

Given the emphasis on trees as component pieces of the habitat quality assessment, one might assume Forest-Grassland Mosaic polygons would fair poorly in the final habitat quality rating. Yet it is the only other habitat type represented in the 'high' category. Closer investigation reveals that area-wise only seven percent of these Forest-Grassland Mosaic areas were assessed as high quality habitat, again suggesting the need to fine tune indices of quality if we are to adequately capture these unique habitats in priority-setting assessments.

Prioritization of Habitat Polygons

Integrating scores summed for habitat quality with information from the footprint analysis on the extent and nature of building coverage within polygons functions as the primary means to prioritize the habitat units delineated in this paper. The absence of data that I have already discussed precludes a full assessment of habitat quality and thus limits the geographic extent of subsequent prioritization efforts. Consequently, I present the results for polygons whose habitat quality was determined with fewer than two of the four variables left unanswered. Similarly, uncertain or unknown information regarding building footprints limits the reliability of some priority ranks. These cases are identified in the results I provide below. Priority ranks followed by a lower case 'i' indicate habitat units where data for one of the habitat quality indicators is missing or the presence of buildings is unknown.

Rankings Across Habitat Types

A total of 63 polygons (2,385 acres) receive a Priority I ranking (highest priority) (Figure 28, Figure 29). Eleven polygons, rated as high using only the habitat quality indicator, contained no human infrastructure; they are a top priority for conservation attention. Two polygons that scored high for their habitat quality, but they contained low levels of infrastructure that was concentrated and consequently remained in the highest priority category. The remaining 50 polygons are made up by medium quality habitats that were 'elevated' in the final priority ranking because they do not contain any human

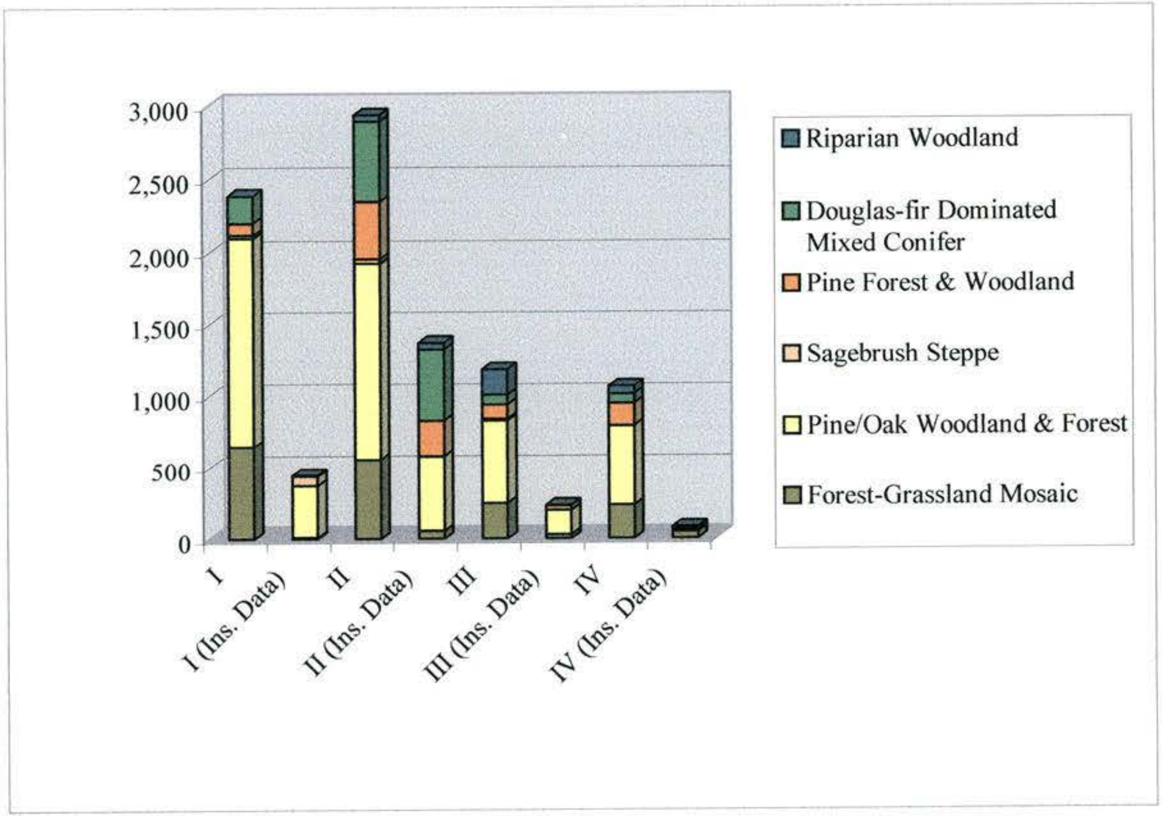


FIGURE 28: Area (in acres) covered by priority ranks according to GAP habitat type classifications.

infrastructure. An additional 11 polygons (440 acres) were tentatively rated as top priority areas, but require further investigation to determine the extent to which human infrastructure is present.

Of the highest priority areas, the Ponderosa Pine/Oregon White Oak habitat type comprises 1,457 acres (61%) of the total. Forest-Grassland Mosaic habitat polygons encompass 639 acres (27%). Less than 300 acres make up the remaining high priority areas representing three of the remaining habitat types. Interestingly, no Riparian Woodlands receive priority I status. Similar patterns emerge when looking at priority II

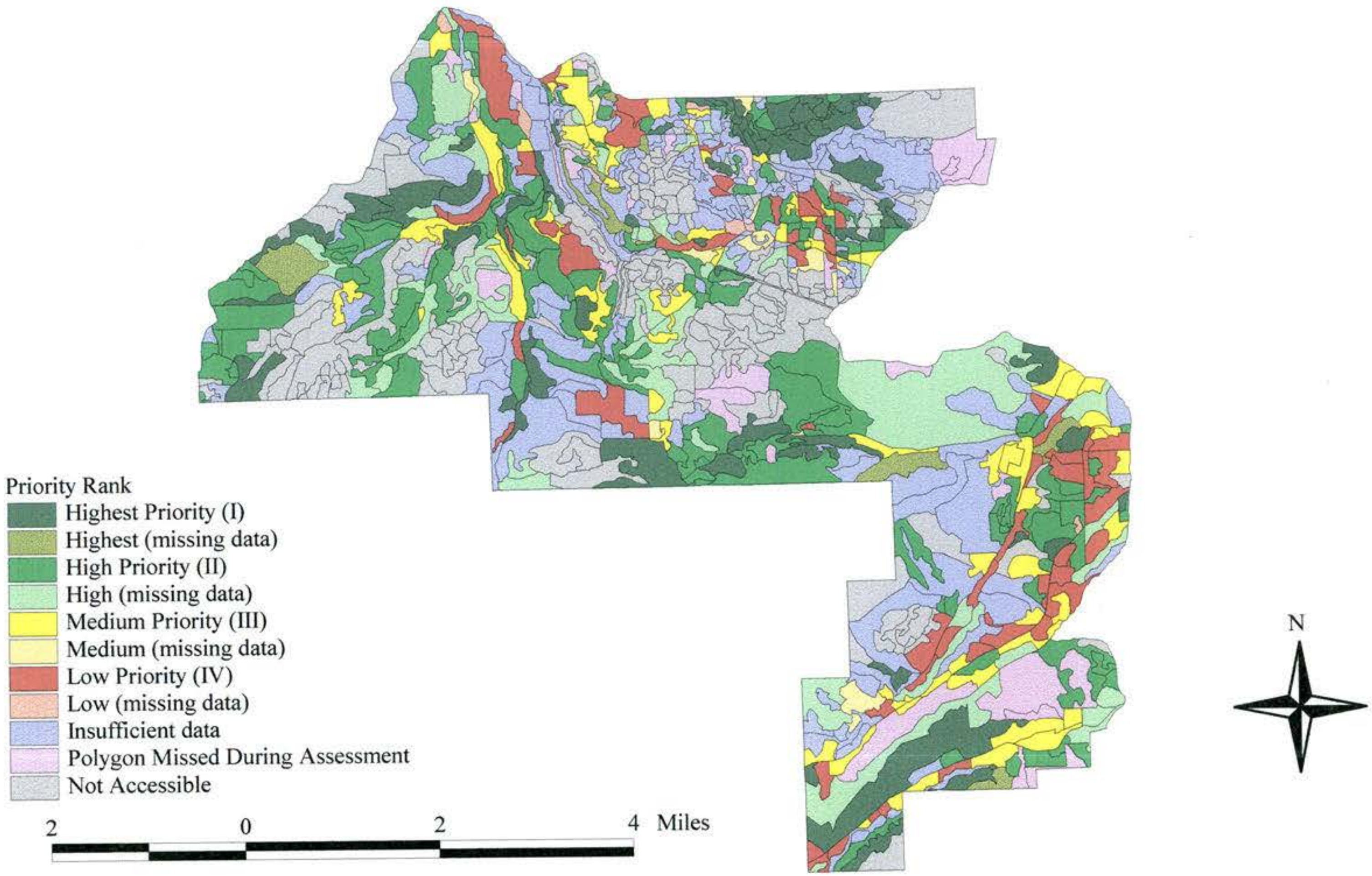


FIGURE 29: Map of priority rankings for habitat polygons in TLSA.

(high priority) habitat polygons. Fewer than 3,000 acres (77 polygons) scored a 'high' with regard to priority rank (Figure 29). Again, pine/oak habitat areas dominate the acreage (47%), followed by forest-grassland areas (19%) and Douglas-fir dominated habitats (19%). Ponderosa Pine Forest and Woodland habitats make up thirteen percent (394 acres) of the 'high priority' area. In contrast to the highest priority polygons, 45 acres (2%) of riparian woodland habitats receive a 'high' score.

A larger proportion of priority two habitats fall into the insufficient data category than for any of the other priority rankings. In all, the status of 1,365 acres (48 polygons) is uncertain. More than likely, some percentage of these do not contain buildings or other elements of human infrastructure and would be elevated to the highest priority rank. Combining each of the top two priority categories, including those with insufficient data, results in over 29% of the assessed acreage (2,825) receiving high priority scores.

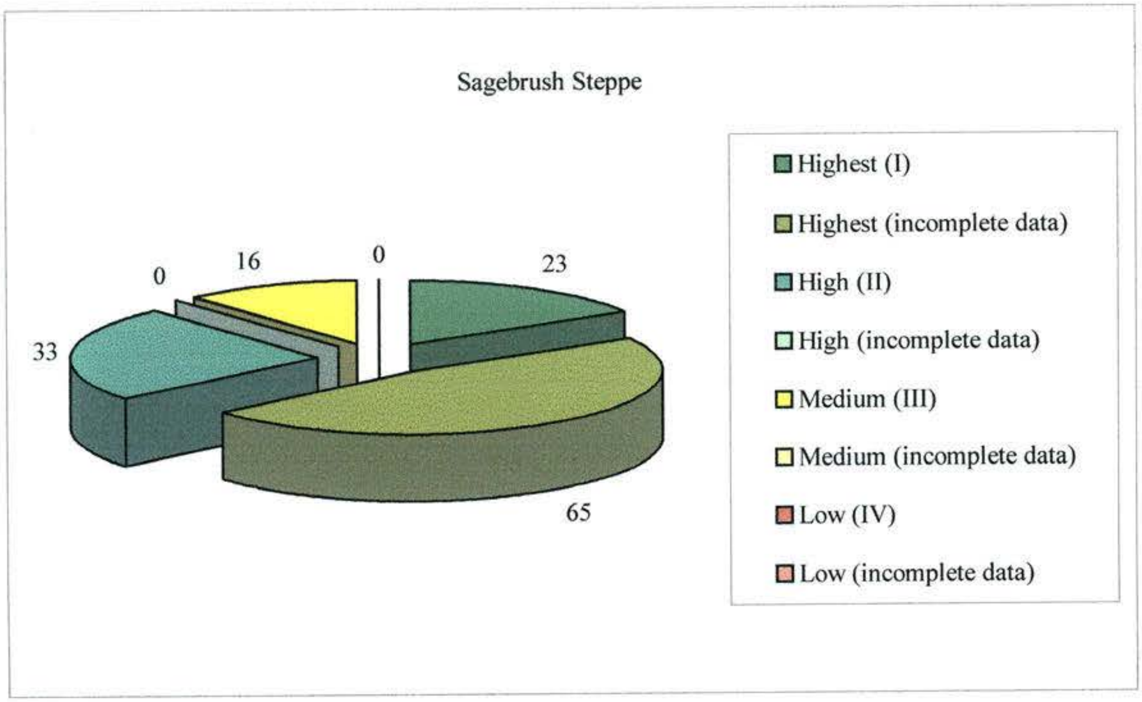
Twenty-three polygons covering 590 acres had their priority ranks effectively reduced because they were the site of low but dispersed buildings or medium levels of residential-related infrastructure. These areas obviously contain important habitat elements, but those elements are in close proximity to houses.

Over 3,500 acres (118 polygons) of habitat received a 'low' score as a result of the habitat evaluation. However, these areas remain free of buildings. Consequently, their priority status was elevated, similar to polygons that scored 'medium' and were elevated to areas with the highest priority for planning attention. Such areas are comprised primarily of native vegetation, but they do not support high levels of the habitat elements assessed in this study. Their undeveloped status, however, remains an important feature to be captured by efforts to conserve biodiversity in this region. It is important to remember here, that habitat polygons are not synonymous with parcels, so the large number of undeveloped polygons elevated in status does not directly translate into reduced development opportunities.

Within Habitat Types

Understanding the distribution of priority rankings within each of the six habitat types offers a different perspective on the question of important areas for conservation. It allows the planner to ask the question, are certain habitats relatively rare with regard to their quality or degree of development. Habitat types that do not contain significant acreage within one of the two higher priority rankings suggest that alternative means may be necessary to ensure inclusion within conservation efforts. In conservation parlance, these areas may be underrepresented in the final analysis.

The preponderance of priority I Sagebrush Steppe polygons (including those lacking data) reflects the fact that the presence of native grass species was used both as a classification variable and evaluation factor (Figure 30). That is, grasslands that do not contain native species and thus indicators of poor habitat quality were not included.



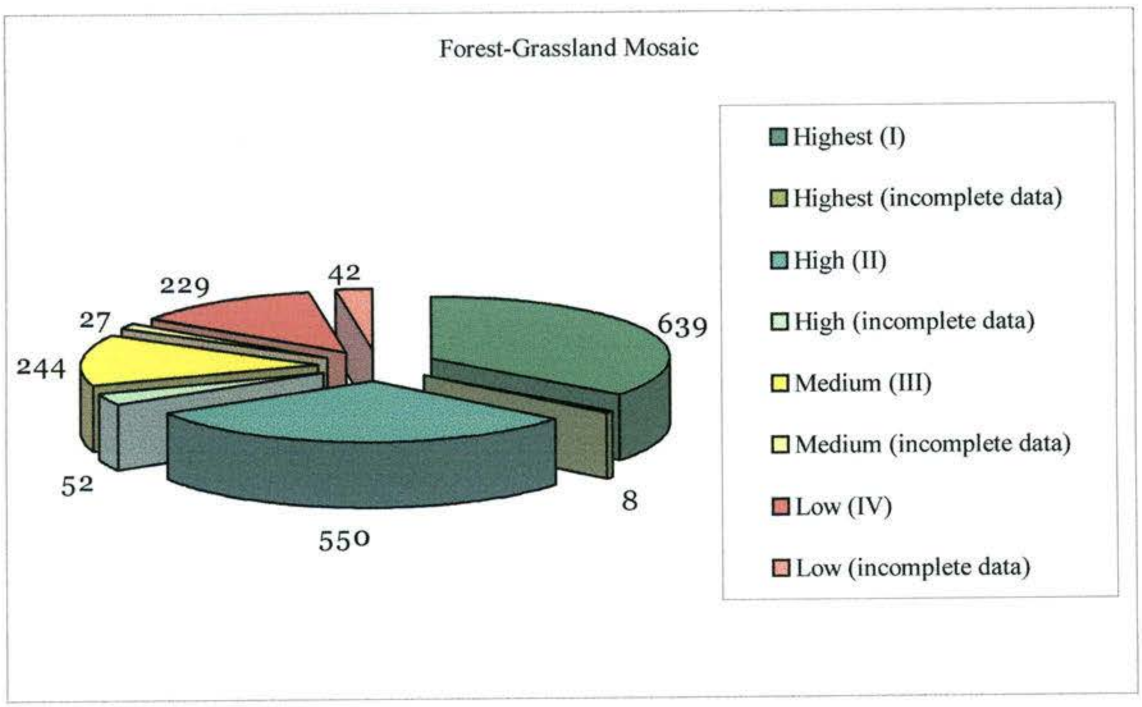
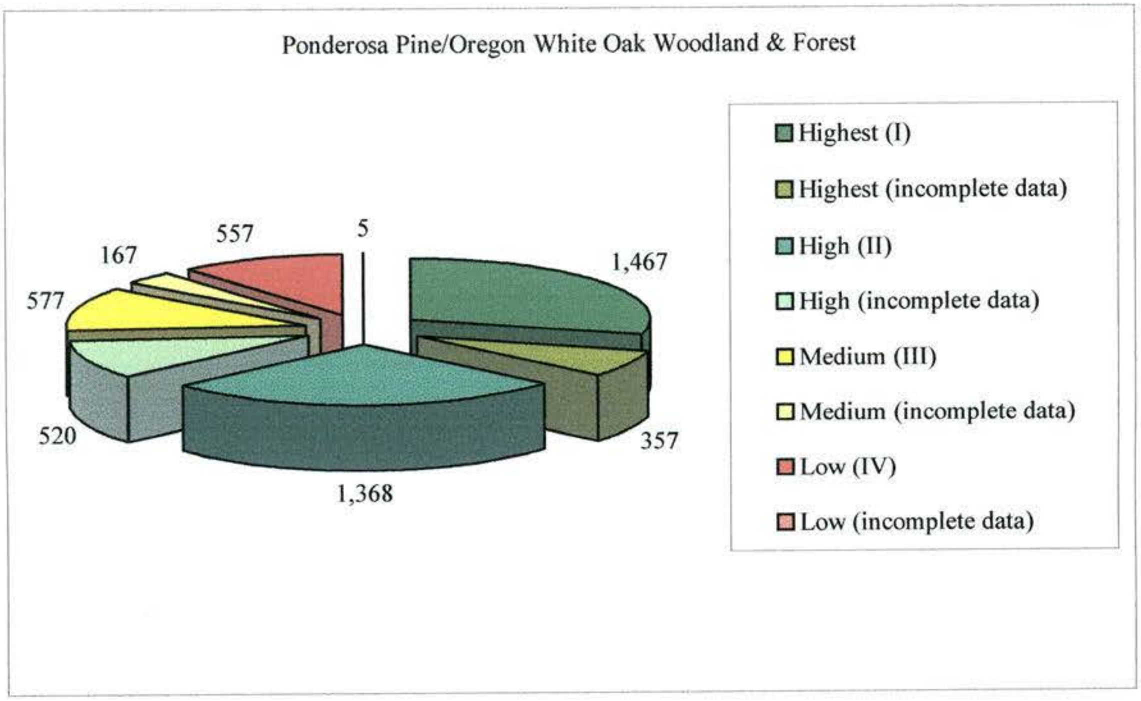


FIGURE 30: Distribution of priority rankings within individual habitat types. Numbers indicate total acres.



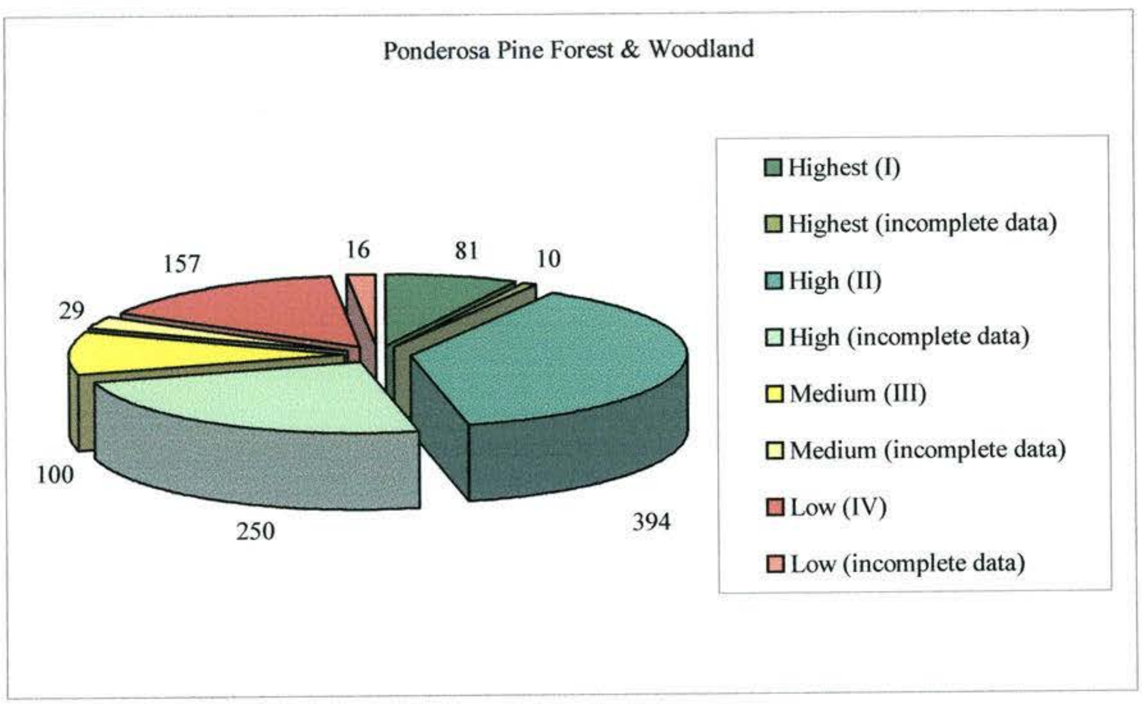
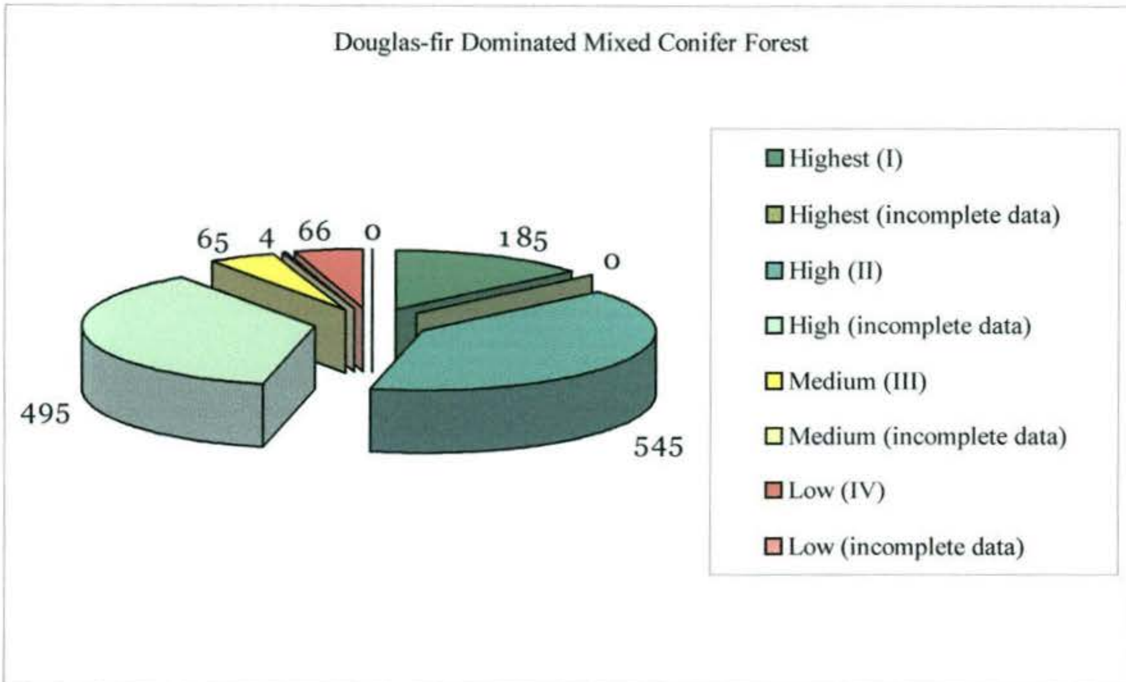


FIGURE 30 (continued): Distribution of priority rankings within individual habitat types. Numbers indicate total acres.



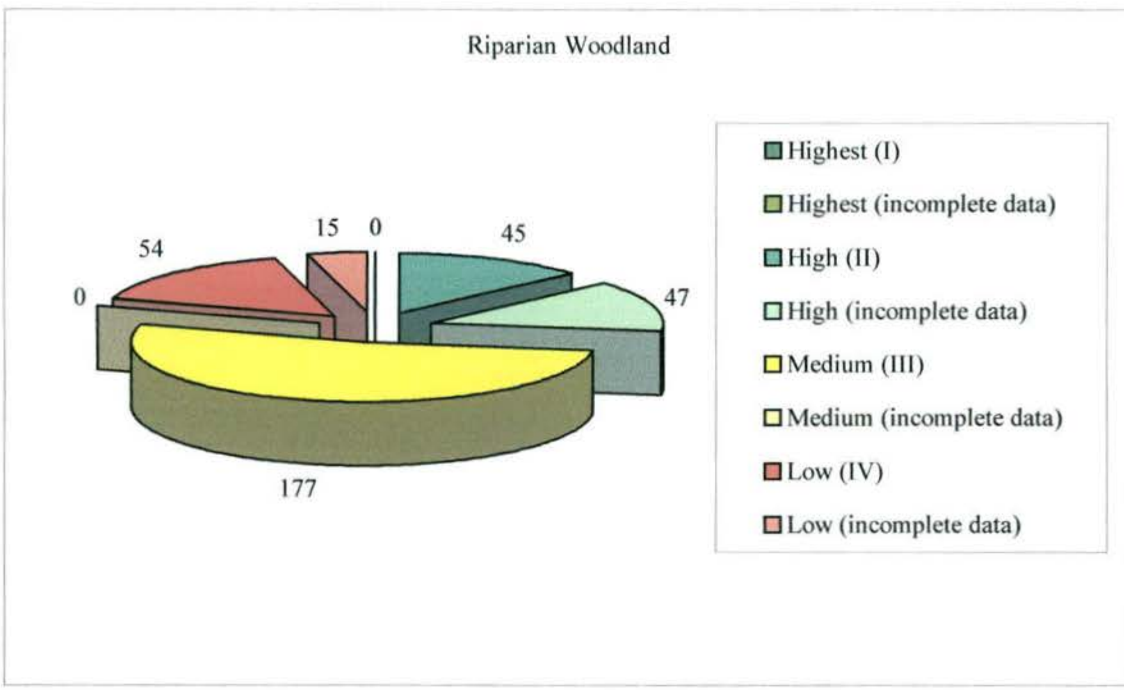


FIGURE 30 (continued): Distribution of priority rankings within individual habitat types. Numbers indicate total acres.

Examining patterns among the remaining habitat types reinforces the fact that all of the habitat types, except for Riparian Woodlands, are represented within the highest ranked polygons (Figure 30). In fact, riparian areas appear to be the only habitat type where the total of medium and low ranked acres predominate. It is important to note again, that these patterns describe only a portion of the entire 24,000 acre Transition Lands Study Area.

Interestingly, these results indicate substantial acreage across habitats would remain available for some type of development, all things being equal. Excluding Sagebrush habitat types for the reasons discussed above, only Douglas-fir dominated habitats show a relatively minor amount of habitat in the lower priority categories. This fact may be a reflection of factors that constrained full assessment of habitats within portions of the study area. In particular, polygons in the area zoned for industrial forestry were among the most difficult to census.

Wildflower Zones

Using the rapid assessment (car-based) methodology outlined in Chapter Two, I mapped 31 separate wildflower zones directly and inferred the boundaries for an additional 22 areas. I summarize the species totals and general patterns that emerge, discuss issues regarding the methodology, highlight species rich areas, highlight areas with endemic species, and discuss the relative rarity of species found within the 31 zones. Finally, I outline how this information can be used to further identify important habitat polygons for planning attention through the proposed framework outlined in Chapter One.

With the help of a field assistant I identified 48 separate wildflower species in the delineated wildflower zones. Wildflower collection, unlike other portions of the procedures I have outlined, required more extensive effort to identify specific species. In particular, we observed lupine in some zones, for which two separate species were possible. We consulted with an expert to try and identify these, but separating the two proved to be rather difficult. Four species were completely unidentifiable, and for this reason, they are left out of subsequent species totals. The general nature of the rapid assessment approach, along with these difficulties, implies that we likely underestimate the species richness of the mapped wildflower zones.

Species Richness Patterns

Species richness records the total number of species found within a geographically defined area; it is one of many measures of biodiversity and of the importance of an area for conservation purposes. The highest species totals recorded for individual zones were 23 and 18 species in two adjacent zones in the central portion of the upper study area (Figure 31a). One zone supports 14 species while two zones recorded 13. Several zones support a few native species.

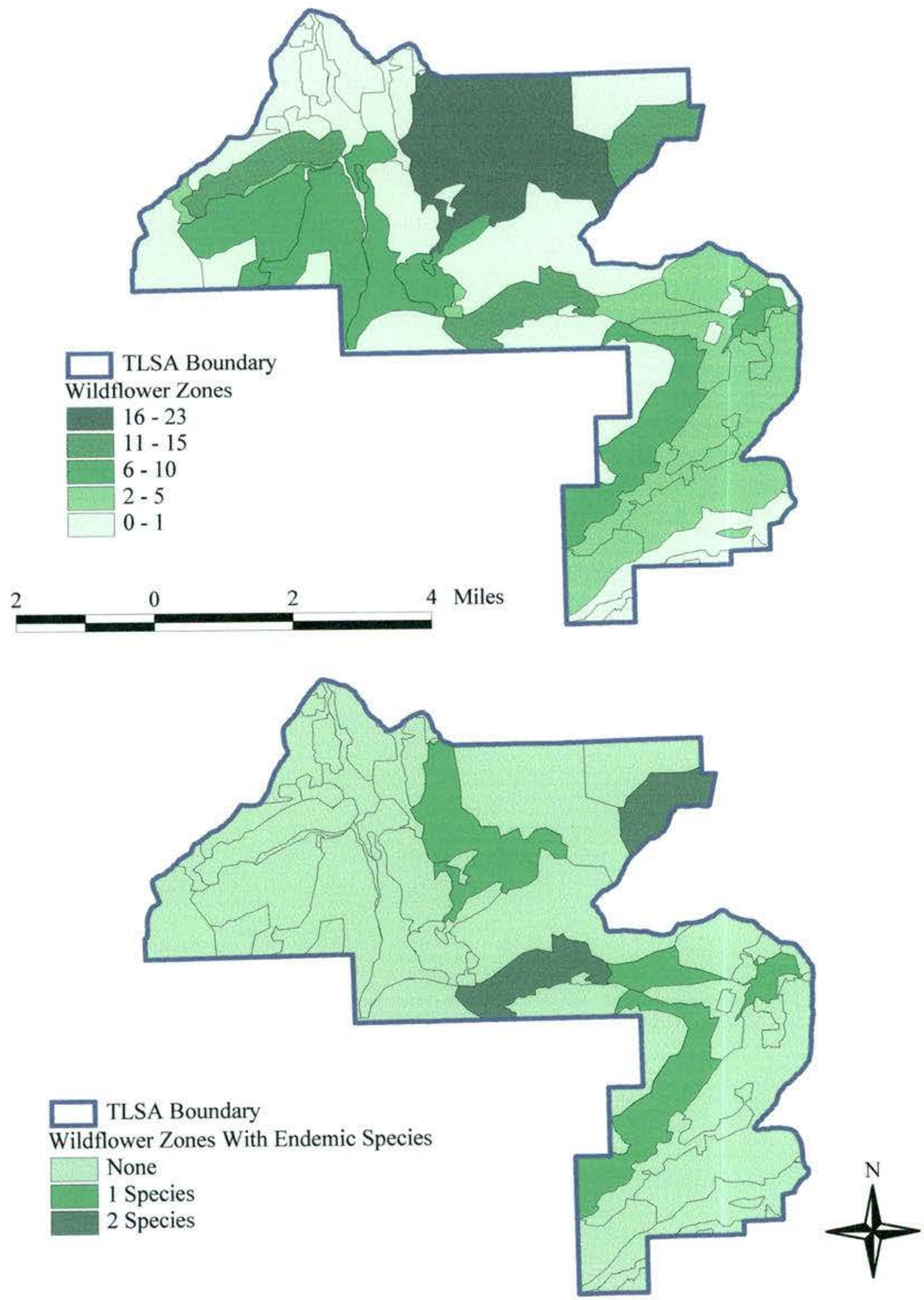


FIGURE 31: Map of wildflower zones. a) According to species richness, and b) According to species endemism patterns.

Four nonnatives species were observed under 'wild' conditions. Of the 31 zones that were mapped, two zones had wildflower assemblages whose species composition was comprised of greater than 30% exotics. In both cases, each zone had very few overall species (< 5) and one of these was classified as rural residential using the five wildflower cover types.

Methodological Issues

In one portion of the study area—more specifically, the zone with the highest total for species richness—I had permission from landowners to lay out two transects to 'collect' specimens at a finer scale using the procedures explained in Chapter Two. My goal was to use these findings to check the car-based rapid assessment methodology and see what might be overlooked or missing. I used the procedures explained in Chapter 2, but do not report the detailed results of my findings here. Instead, I briefly compare the numbers of species I found using each method. The car-based sweep of the zone uncovered 17 total species. In contrast, 21 species were tallied along the two transects. Comparing the composition of the two datasets shows an overlap of 15 species: two species seen from the car were not observed walking the transects. Perhaps more importantly, six species seen along the transect were not observed from the car.

Of the six species recorded using a more detailed transect approach to surveying wildflower composition, four of these were small in stature, standing less than three inches tall. These revelations are not surprising, as they serve to confirm potential limitations of the rapid assessment methodology used to map wildflowers in this assessment. Smaller species are likely to be missed in wildflower surveys conducted in a rapid fashion and in the absence of identification procedures that are wedded to transect or quadrats.

These issues do not, however, mean to the data are not useful. Quite the contrary, I maintain that these data substantially enrich the broader efforts to prioritize habitat polygons. With this in mind, I report the specific findings for species richness, species endemism, percent nonnatives, and weighted flower scores.

Patterns of Endemism

Five species of the 48 identified are endemic to this area; they are found in the eastern end of the Columbia River Gorge in Oregon or across the Columbia River in Washington and no where else in the world (Table 24). All of the species are uncommon within the study area; only two of the species are found in more than one zone. The distribution of these endemics is relatively scattered across the study area; however, no localized species seem to be present on the western or southern margins (Figure 31b).

TABLE 24: Endemic species found in the Transition Lands Study Area

Endemic Species	Distribution Within TLSA
Astragalus hoodianus (Hood River milk vetch)	1 zone
Erigonium compositum (heart-leaf buckwheat)	2 zones
Lomatium columbianum (Columbia desert parsley)	1 zone
Lomatium suksdorfii (Suksdorf's desert parsley)	3 zones
Dodecatheon poeticum (poet's shooting star)	1 zone

The occurrences of these wildflowers offer the only opportunity to conserve their distribution within the TLSA. They are, therefore, important targets for planning attention in and of themselves. Using these data to select out habitat polygons that potentially support populations of these species, regardless of priority rank, provides one means to increase the representativeness of a final conservation landscape.

Weighted Flower Scores

Based on species occurrence data for each zone (Figure 32) I determined whether a given wildflower species was widespread in extent throughout out the study area, medium in extent, or narrow in its extent. Using the natural breaks evident in Figure 32, I determined that species occurring in fewer than three zones were narrow in their extent, or relatively uncommon within the study area. A total of 21 species are found solely in 1 zone. This information drives the local distribution scores needed to derive the overall *weighted flower score* At the other end of the spectrum one species is found in sixteen separate zones, while another is found in a total of 15.

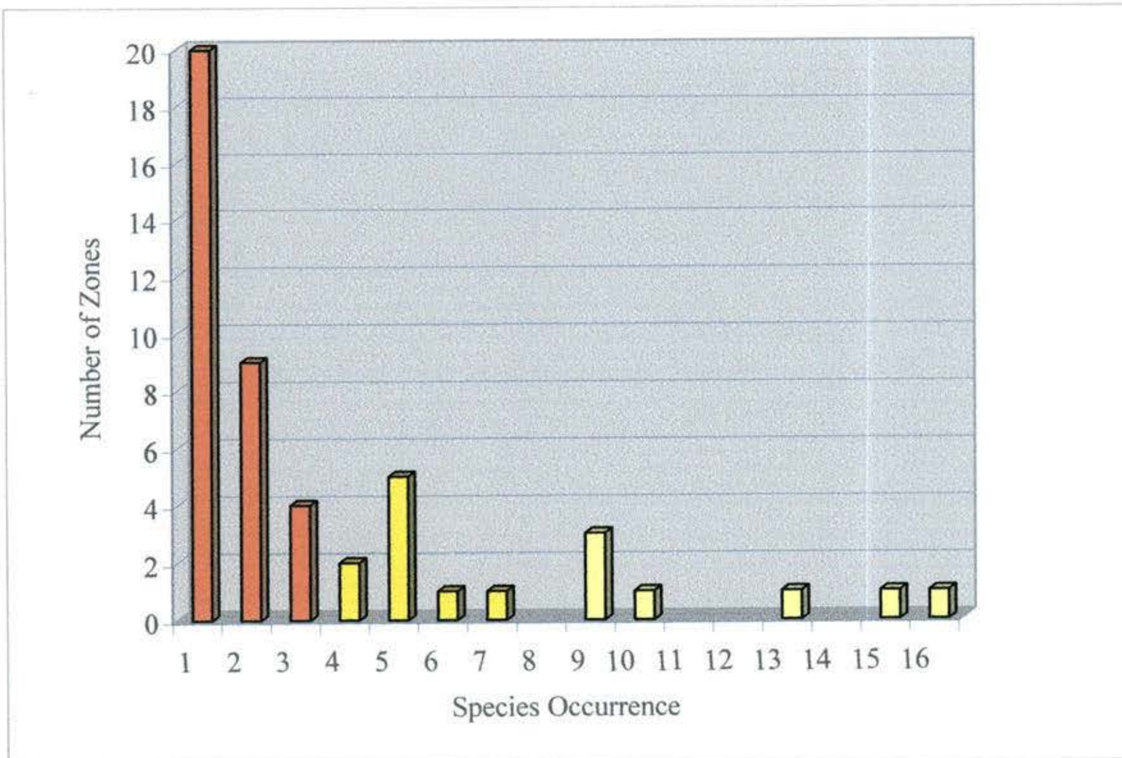


FIGURE 32: Species occurrences plotted by zone. Bars indicate how many zones a given number of species occurrences. For example, 20 species are found in one zone only while only one species is found in sixteen zones. Dark orange bars denote species with narrow distributions, the lighter orange refers to species with medium distributions, and the yellow are the most commonly distributed across the TLSA.

Evaluating wildflower zones using the matrix above, I assigned distribution scores to each species within each zone and calculated *weighted flower scores* for all thirty zones. Because six zones contained no native species, these areas received a zero for the weighted wildflower scoring process and were thrown out of the subsequent analysis. Next, I plotted the frequency distribution to understand how zone values compared to one another and mapped the zones according to their standard deviation scores (Figure 33a).

Comparison of the distribution scores map with the map of richness and the map of endemism shows that one of the zones—in the western portion of the upper study area—stands out neither for high richness values, nor does it support any endemic species yet its *weighted flower score* is greater than one standard deviation from the mean score. This result suggest the polygon contains a unique assemblage of species that may be common within the TLSA, but are not widespread.

Finalizing a Map of Priority Blocks

Combing information on wildflower species composition with information on habitat quality provides an important consideration regarding the conservation value of any given habitat unit, particularly in northern Wasco County where several range-restricted species (endemics) are found. Additionally, herbaceous species may potentially be more sensitive indicators of land use degradation and serve as an additional indicator of habitat quality. Integrating these data with priority ranks emerges as a one way to elevate habitat areas that scored lower in the quality assessment based on their score summed across all functional elements. In this manner, I work to address the issue of

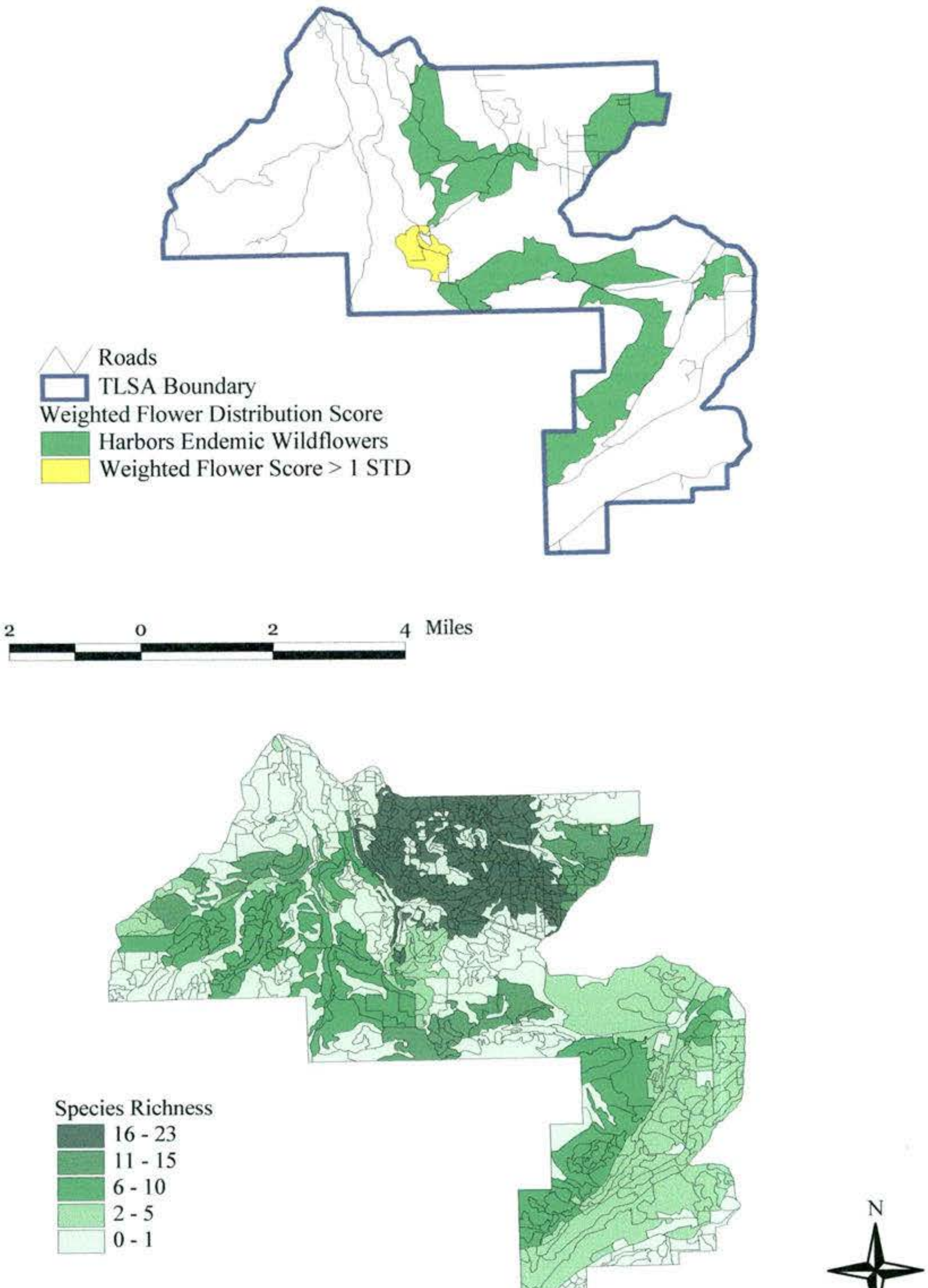


FIGURE 33: a) Weighted flower scores for wildflower zones in terms of standard deviation, and b) Wildflower distributions by habitat polygon.

grasslands that may not have had snags, but may support high numbers of wildflowers species or unique assemblages that are dominated by regionally rare or uncommon species. Simply put, considerations of the groundlayer increase the overall assessment of biodiversity value for any of the delineated habitat units. Polygons that exhibit high species richness, support endemic species, or unique assemblages become candidates for priority attention. As a result I use this information to elevate the priority rankings of these habitat polygons.

The process of integrating data from the wildflower mapping effort with habitat maps involves two logistical steps: 1) assigning wildflower values to the finer-scale habitat polygons and 2) selecting the candidate areas for elevation, assigning a new priority rank. Both steps can be accomplished through use of a GIS. However, the first step is plagued by two inherent problems. First, identification of four broad wildflower cover types at a different spatial scale than the delineation of habitat polygons means there is the likelihood for discrepancies among habitat conditions (e.g., open wildflower zones that include closed canopy forest habitat polygons) that support the wildflower species of interest.

Second, distributions of some species within a defined wildflower zone may not be found in each of the corresponding habitat polygons. Data collected during the rapid assessment wildflower mapping exercise was at a much coarser scale and the resulting boundaries have little correspondence with those delineated for the habitat units. Therefore, assigning wildflower values to each habitat unit is subject to certain limitations as well as a degree of error associated with incongruent boundaries.

Figure 33b shows the distribution of habitat polygons expected to contain environmental characteristics that would support individuals or populations of the targeted wildflower species (i.e. endemics). The limitations of the data collected at the larger wildflower zone mapping effort and then assigned to the smaller habitat units mean that not all habitat units within an overlaying wildflower zone are expected to contain the habitat characteristics that would support some of these unique species.

After integrating the wildflower data, a total of 35 polygons (1,140) have their priority status elevated level II to level I for the presence of endemics while 19 polygons have their priority status elevated for their *weighted flower score* (Figure 34, Figure 35). A total of 15 polygons overlap. In other words, a total of 15 habit units would have their priority status elevated using either of the two scores. Four polygons (130 acres) whose *weighted flower score* is greater than one standard deviation above the mean come from wildflower zones that do not harbor any endemic species, confirming the value of including information on rarity at different spatial scales. Similarly, 20 polygons contain endemic species but their *weighted flower scores* are driven by the presence of species that are likely common at local and wider scales. It should be noted that 19 polygons (691 acres) that were ranked as priority I based solely on habitat quality and the footprint analysis were distributed in wildflower zones that harbor endemic wildflowers.

Taken together, elevating priority II polygons because they harbor endemic species or an important assemblage of species that may be rare at local and regional scales adds an additional 1,270 acres to the highest category of land use planning attention. The resulting priority I polygons now capture a total of 32 wildflower species

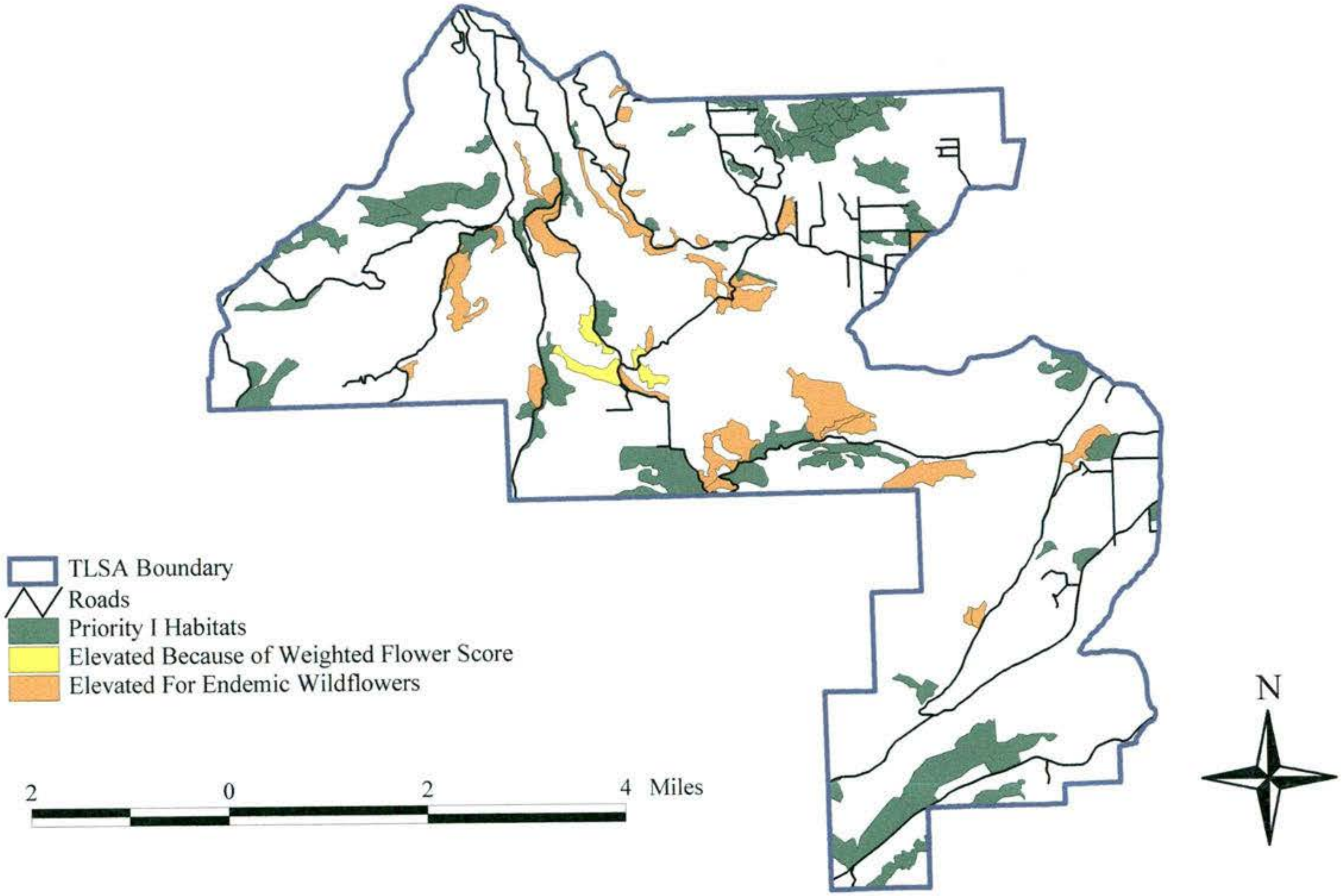


FIGURE 34: Map of habitat polygons that had their priority status elevated to Priority I using wildflower data.

(67% of the species surveyed), including multiple occurrences of many species. Of the sixteen species of wildflower not captured by these two measures, at least ten wildflower species are found within the initial priority I habitat polygons. Thus, focusing attention on all priority I habitats would include 42 of the 48 (87%) wildflower species surveyed.

Consideration of shrub species reveals that focusing attention on priority I habitats alone covers seven of the shrub species identified during field surveys. However, including polygons elevated based on wildflower data adds the final shrub species to the total, meaning that 100% of the shrub species found in the study area are contained in the total represented by Figure 34.

Figure 35 represents a suggested final map of the highest priority habitat polygons, those that are the best candidates using the methods I have outlined for some form of strict protection using the planning mechanisms provided in the Chapter One framework. The remaining priority areas suggest a wide range of possible conservation and planning strategies. Moreover, this map also identifies areas within the Transition Lands Study Area that might be good locations to direct future development, given the ecological and conservation considerations investigated in this study, and within current uses as outlined in the county's comprehensive plan (Note: some of these areas are currently zoned for forestry and are unlikely to be the site of future development).

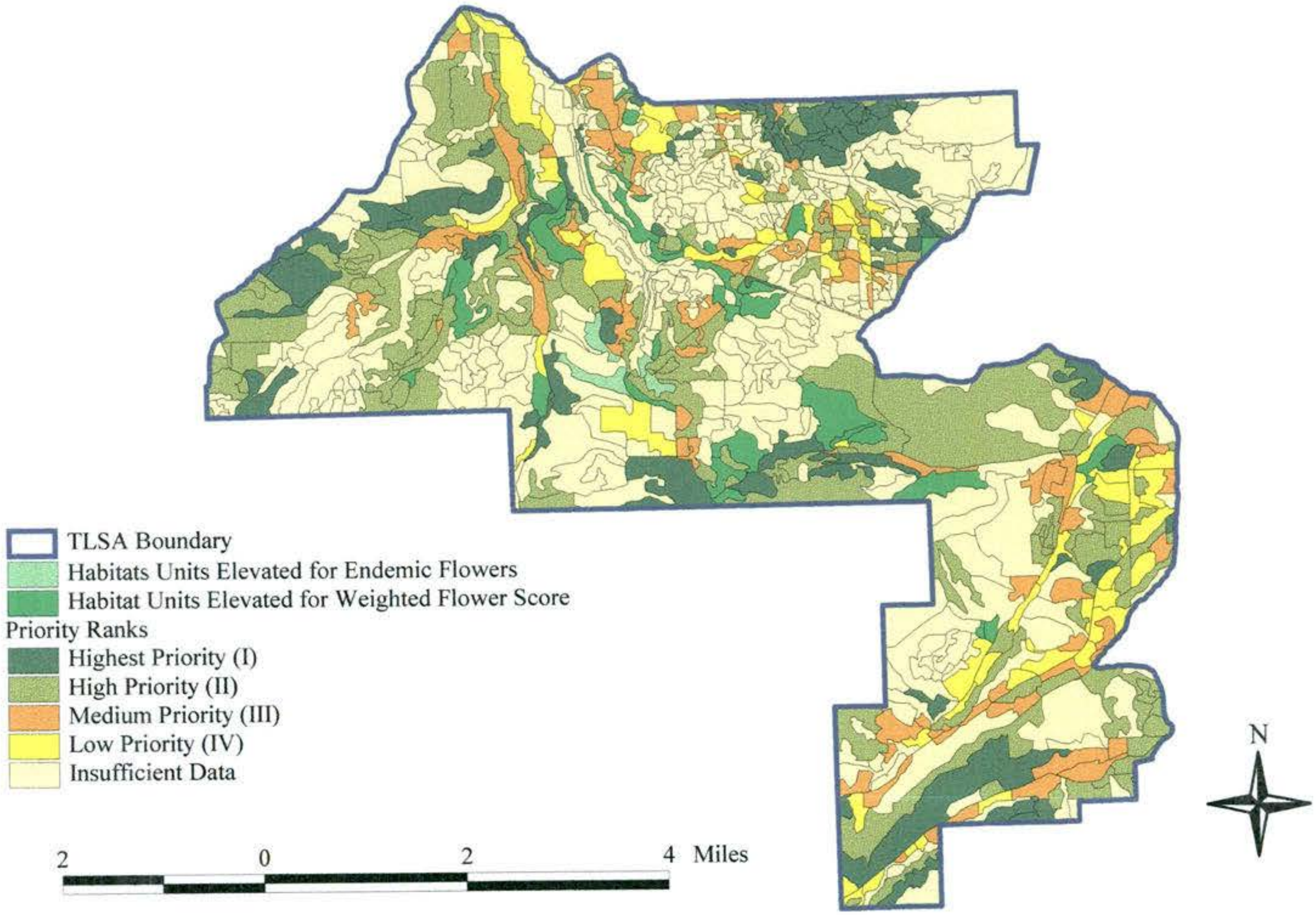


FIGURE 35: Final map of priority areas for planning attention, including information on habitat quality, building footprints, and wildflower data.

CHAPTER V

DISCUSSION AND CONCLUSIONS

> Certainly we must strive to make sure the activities pursued primarily for human ends do not undermine the integrity of the non-human world. If we aspire to a vision of the future in which people treat the rest of nature with the respect and care it deserves, our use of land must surely become more attentive to ecology... and history as well.
>
> Cronon (2000: 673)

Fueled by growing housing demands, many regions and localities in the western United States are experiencing conversion of landscapes that contain important native plant communities and their associated biological diversity. Given the low density of much rural development, this type of land conversion stands to contribute not only to the loss of important habitats but also to their fragmentation. Both effects pose serious threats to the persistence of native species. Current conservation strategies do not adequately address development impacts while also allowing for housing opportunities. Conversely, land use planning should address conservation needs, but it is not currently designed to do so (Duerksen et al. 1997, 2000; Theobald 2000; Beatley 2000). The work I have presented serves not only to resolve multiple issues over how to design a conservation landscape by bridging the gap between traditional conservation planning and land use planning, but also provide a set of methods for accomplishing these objectives. This approach does so by working to create the future vision so eloquently outlined by William Cronon.

The methods I have detailed are not without problems, and most assuredly not without critics, ranging from conservation biologists and land use planners to the most ardent defenders of private property rights or housing developers. In this final section I discuss some of the issues that may be targeted by such critics, and address the merits as well as the problems with the methods I have proposed. Many of these became evident during my field work and the subsequent analysis.

Before discussing the specific concerns about my methods and the results they revealed, I begin by examining the conceptual underpinnings of my work. I address these within the constraints of working in Knight's 'neglected geography' of private lands. Working in areas dominated primarily, or even entirely, by private property owners presents challenges for land use planners attempting to conserve threatened habitat types on private lands. I conclude this chapter by outlining how my work stands to influence the conservation of oak-dominated habitats in northern Wasco County as well as how it might be used in Oregon to redirect land use policy toward rural lands and natural habitats.

Reevaluating Conceptual Underpinnings

I argued in Chapter One that current conservation strategies often employ an either/or approach to conservation on rural lands. Conservationists target important areas for inclusion in a network of preserves, such as large areas of intact habitat or concentrations of rare species, while neglecting landscapes that either are associated with human settlements or do not support rare species. Admittedly, many conservation organizations are acting to ensure the biggest return for their time and money. However, it is clear that this approach neglects large portions of the western United States. By integrating principles of conservation biology and landscape ecology into current land use planning practices—in this case, within Oregon's unique land use planning system—I have suggested planners design a conservation landscape that includes development for housing needs by explicitly considering both habitat patterns and quality relative to the placement of new houses. This should occur at both the parcel scale and across multiple parcels, or within a habitat overlay zone.

Some critics may argue the approach I take will lead to increased habitat loss and fragmentation if it serves as a replacement strategy for protected reserves. I do not believe the reserve strategy should be abandoned. Rather, native habitats that may not fit well within the three traditional models of conservation planning and priority-setting described in the first chapter need to be included in some other form of conservation effort. I suggest, as have other authors, that land use planners have an important role in designing new conservation landscapes in which the more traditional developed landscape of the rural West is embedded. The conservation landscapes I envision act to support as many elements of an area's native biota as feasible across the entire landscape, aid in the protection of species within reserves by providing possible connective corridors for migration or sources for genetic exchange, and ideally, create or preserve a landscape that engenders greater support for and appreciation of local biodiversity within rural communities.

The degree to which local communities may embrace a biodiversity vision of their local landscapes, many researchers will argue, will vary greatly. Indeed, some landowners may view the entire idea as a violation of their private property rights and actively resist such efforts (Walker and Fortmann 2001), while others may actively participate in the inventorying process and welcome planning efforts to protect these open spaces. For example, at least one local landowner in the City of Eugene actively pursued inclusion of his property on the city's natural resource inventory of important natural habitats (Adam Novick, Pers. Comm.). As Walker and Fortmann (2001) point out, however, conflicts clearly reflect differing visions of the landscape, and ideological differences among neighbors are likely to result in conflicts both between neighbors and with planners. However, planners routinely work to balance a multitude of often conflicting community values (Duane 1998).

Regardless of whether citizens support mapping efforts, attempts at collaborative resource management have been made in the West. However, they have met with varied success (Wondolleck and Yaffee 2000). Initially greeted with enthusiasm in the early 1990s, collaborative approaches today are met with suspicion by many (McClosky 1996). Detractors are not limited to private property owners in rural areas. Environmentalists who initially championed such attempts to manage local resources have become skeptical, and resource managers often fear they may lose control of management decisions (Selin et al. 1997, Selin et al. 2000).

The citizen-based assessments advocated in the Oregon Watershed Assessment Manual (Watershed Professionals Network 1999), much like the approach I suggest here, are not explicitly collaborative in the sense that citizens do not define the variables or elements to be measured. I have suggested that scientists define the structural conditions and indicators of quality to measure while citizens provide the person-power to complete the inventory. This is exactly the process for assessing watersheds outlined in the watershed manual used by Oregon's local watershed councils. Moreover, planners retain control (within the context of state and local politics and the democratic process) over the application of regulations, standards, incentives, and the like. This form of citizen-participation is different than many of the collaborative approaches pursued elsewhere.

Issues regarding participation in the process, including determining which parties control the aspects of habitat to be measured and how they are evaluated, obviously still remain. These issues are common to much policy formation, and are not absent from the natural resource management debate (Western and Wright 1994, Ribot 1996). Efforts to map and protect habitat must be sensitive these issues, but dealing with them should not preclude conducting inventories and pursuing conservation of areas with high habitat value.

While issues of participation are important, perhaps the more pressing issue is how this effort fits into broader conservation goals. Critics of my approach may argue that it is not very different from current conservation strategies. Limiting the placement of houses on portions of parcels where development is currently allowed, or limiting certain land uses, amounts to de facto 'reserve status.' In addition to the fact that what I suggest may be implemented in a voluntary fashion, or as an option within broader planning schemes, I argue that there are at least two fundamental differences from current conservation planning strategies. First, the methods I outline identify both lands that should be protected while also highlighting areas that from a habitat standpoint constitute more appropriate building sites. Certainly, conflicts will arise between areas desired both by humans for houses and as the best habitat for species of interest, but the flexibility of the tools I advocate potentially minimize the intensity of such conflicts even as they highlight areas where conflicts may occur. They propose areas where landowners or developers may voluntarily choose to recognize and respond to areas with high habitat value. Second, I suggest using established mechanisms for compensating landowners whose development rights may be affected by the resulting habitat-based overlay zone.

Integrating information on habitat quality with the degree and extent of building footprints, and using wildflowers to ensure representation of all habitat types provides the planner with a map of the landscape that has been systematically classified and evaluated. The resulting map is at the parcel-scale for land use planning decisions, but also is linked to larger landscape issues important to conservation planner. Because the final map details polygons prioritized according to their conservation value based on sound ecological science, planners can apply a wide range of tools and policies. Moreover, the prioritization scheme perhaps can link ecological science to the particulars of place discussed by Hulse and Ribe (2000), by providing planners with a means to address the inherent habitat conversion associated with local development. Using the methods I propose allows planners and developers to provide housing opportunities for the local citizenry while considering specific aspects of local biodiversity.

Methodological Issues

Beyond the general approach and conceptual underpinnings of the work I have presented, there are a number of methodological issues—both practical and conceptual—that I would like to discuss. These issues serve to outline the limitations of the methods I have proposed while also detailing possible improvements. Moreover, illuminating these weaknesses helps to reframe our understanding of conservation on private lands and the challenges these areas impose.

By far the greatest weakness of this study is the rather large data gaps for areas that could not be accessed. I have partially discussed the multiple factors that contributed to these gaps in earlier chapters, but a more detailed look at the causes behind them is appropriate. It is safe to say the lack of data precluded a full assessment of habitat quality and thus, limits the geographic extent of subsequent prioritization efforts. Similarly, uncertain or unknown information regarding building footprints limits the reliability of some priority ranks.

Among the myriad factors limiting the analysis is the extent to which public roads provide access to delineated polygons. This factor represents somewhat of a paradox for conservation planning. Roadless areas are generally de facto priority areas. Therefore, areas lacking roads tend to reflect portions of the landscape that would be captured by prioritization efforts that focused on large blocks of intact or undeveloped habitat.

However, many areas in TLSA contain private roads that have controlled access, including roads designed to provide entry to areas scheduled for timber harvest as well as private residences and agricultural operations. Therefore, many of these data gaps include areas that may or may not be high priority targets for immediate conservation effort.

Given the focus of this study on rural areas undergoing residential development, I argue that the lack of data for particular portions of the TLSA may limit overall conclusions about larger landscape patterns, but does not diminish the importance of rural habitats within the context of conservation design, nor the overall utility of these methods. While several portions of the study area were not fully surveyed—mostly in areas that are not currently targeted for development—areas with higher road density had a larger proportion of their total area assessed. In this respect, the areas that stand to face the highest conversion rates have enough data and have been mapped to a sufficient extent to facilitate efforts by county planners to mitigate the impacts of impending development.

A number of concerns regarding the spatial extent of the data should be considered. First, the participation of local citizens in the actual analysis would, in theory, increase the total amount of area surveyed. Because local citizens may have greater access to private areas, ensuring broader participation would likely result in increased coverage. Most assuredly, not all citizens would support mapping efforts, but evidence from other inventories conducted in Oregon suggest that these types of mapping efforts elicit support from a local citizens, often across the geographic extent of the area being studied (City of Eugene 2001).

Another possible way to increase the total area assessed would be to make use of color air photos taken from lower altitudes. More detailed photos would definitely aid in the classification of habitat types for many polygons, as many tree species can be identified from such photos. Interpolation from existing data, using statistical software and analyses, might be used to infer conditions in interior areas that cannot be accessed.

Limitations to the methods I have presented should not be seen as evidence to avoid their use, but rather as a means for improving the existing maps and to assist in improving future inventory efforts in other locations. With this in mind, I would like to turn my attention to specific problems that arose during the field work and subsequent analysis phase.

Delineating and Classifying Habitat Polygons

The most pronounced and confounding aspect of the process I have detailed lies with the need to pursue what became two separate field inventories. I set out to build on previous work done in TLSA by expanding its geographic as well as ecological scope. The latter meant including information on wildflower distributions. Initially I planned to census flower distributions as part of the larger habitat classification and evaluation. However, I did not receive air photos in time to delineate habitat polygons prior to the spring field season, so I was forced to develop an alternative rapid assessment approach to survey wildflowers.

While using a rapid assessment approach strongly bolstered what I can say about the distribution of wildflowers, my ability to speak confidently about the presence or absence of any particular species within a habitat polygon is relatively low. The other confounding factor reflects the confidence level involved in identifying wildflowers from a distance. Many species easily visible on the side of the road or by using binoculars—and that lend themselves to rather easy identification—were also clearly present in the remaining areas of portions of the delineated zone. However, some species observed from afar could not be identified, and as the two transects showed, there are a number of species that simply cannot be seen using the rapid assessment methods.

Attempts to comprehensively map wildflower distributions using more traditional ecological methods in the TLSA, however, are unlikely to be successful given the sheer number of landowners and the time required to perform such work. While wildflower mapping exercises that do not include more traditional transects at randomly selected points will underestimate the total number of species found in TLSA, a rapid assessment approach that focuses on a few showy or highly visible species (e.g.,balsamroot) can be used to identify indicators of good wildflower habitat (Illustration 2).

The rapid assessment approach I outlined offers one alternative, but given the low confidence of applying those data to individual polygons I strongly recommend that future analyses undertake habitat evaluations and wildflower surveys simultaneously. The general limitations of sampling wildflowers on private property than cannot be accessed, in addition to the limited extent of all habitat assessment work, will constrain the overall coverage of these exercises. The result will represent an improvement over the wildflower map I have presented because it will better document the presence of wildflower species within each assessed polygon.

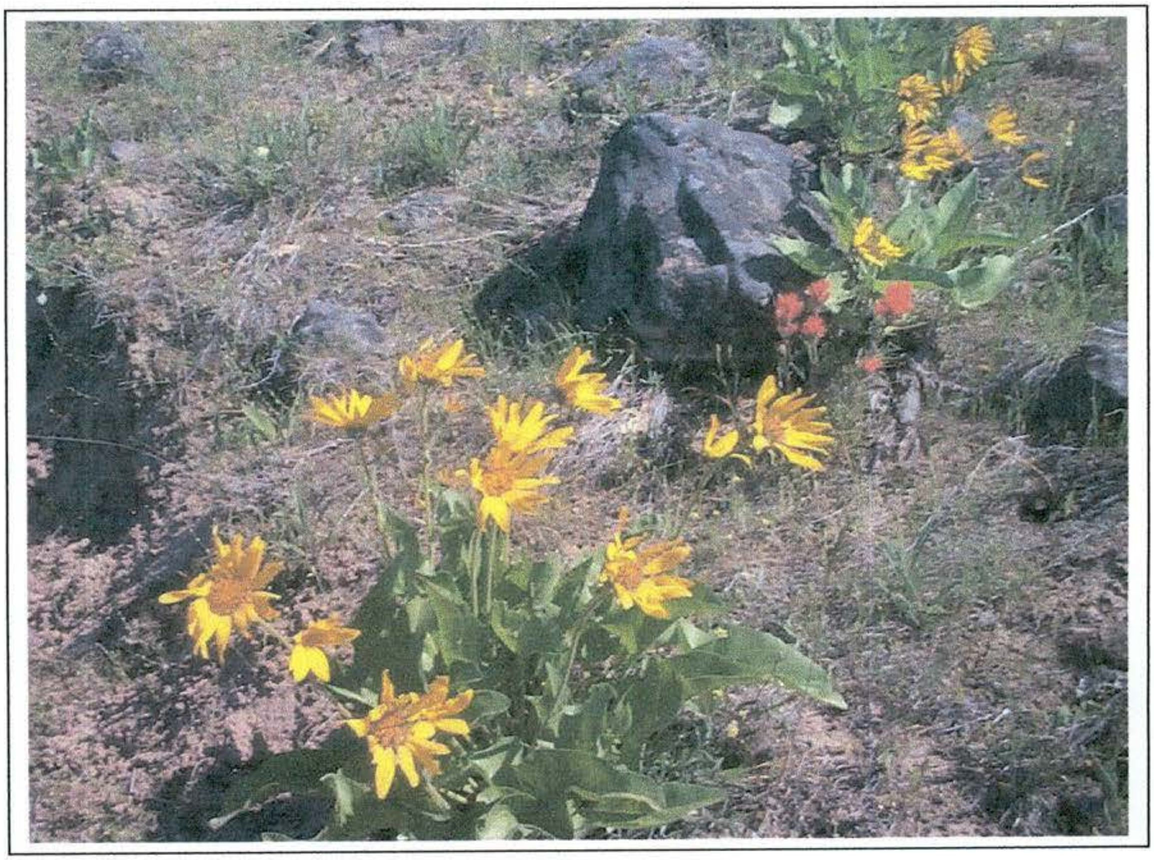


ILLUSTRATION 2: Balsamroot in TLSA. Showy species, such as *Balsamorhiza* spp. may indicate the presence of good wildflower habitat for several species that are not as easily observed from a distance.

The second major mapping issue revolves around the rather dramatic discrepancy between my habitat type classifications and the designations assigned by the Oregon Gap Analysis Program (ORGAP). Two major differences between the methodology I have outlined and the ORGAP system should be noted. First, the minimum mapping unit for native vegetation in the version-two map of Oregon was 100 hectares (247 acres). This structural types I delineate: forest and woodlands. The former contributes largely to the incongruence between my habitat type classifications and those assigned by ORGAP. The latter limits the ability of planners to capture structural variation in habitats using ORGAP.

The large minimum mapping unit used by ORGAP limits the resolution of their habitat maps. In essence, it smoothes the variation in both vegetation structure and composition over wider areas. As a result, small habitat units are lost in the larger scale pattern. Thus, my use of a much smaller unit of analysis more effectively captured the variation in structure and species composition lost in the ORGAP version-two map.

Two examples clearly highlight the influence of resolution on habitat type classifications: 1) The ORGAP map does not identify riparian woodlands, thus guaranteeing that any area classified as such using my system would contribute to the degree of incongruence and 2) ORGAP does not consider differences among savanna types, nor does it delineate smaller areas of forest within these areas. Under ORGAP areas with very different species composition are lumped together within the 'Forest Grassland Mosaic' category. Taken together, these factors explain why more habitat types are presented in Table 25, and also why the congruence between classification schemes was so low.

The discrepancy in areas classified as Forest-Grassland Mosaic in the upper portion of the study area, contributed to the low agreement between the two maps. Additionally, my methods differentiated among areas of pure grassland, scattered trees or savanna, and those with higher levels of canopy cover. In short, I detected the smaller

TABLE 25: Summary Statistics by Acreage for Classification Habitat Types.

HABITAT TYPE	NUMBER OF BLOCKS	TOTAL ACREAGE	PERCENT TOTAL	SIZE RANGE
Doug-fir Dominated Savanna	3	27	0.2%	5-11
Doug-fir Dominated Mixed Conifer Woodland	11	278	2.0%	9-47
Doug-fir Dominated Mixed Conifer Forest	59	1,893	13.9%	3-153
Oregon White Oak Savanna	15	313	2.3%	2-125
Oregon White Oak Woodland	17	510	3.7%	2-101
Oregon White Oak Forest	6	98	0.7%	4-42
Ponderosa Pine Savanna	1	28	0.2%	NA
Ponderosa Pine Woodland	22	402	2.9%	3-74
Ponderosa Pine Forest	40	1,261	9.3%	5-216
Ponderosa Pine Pine/ Oregon White Oak Savanna	49	1,535	11.3%	3-447
Ponderosa Pine Pine/ Oregon White Oak Woodland	125	4,263	31.3%	2-241
Ponderosa Pine Pine/ Oregon White Oak Forest	93	2,317	17.0%	3-164
Grassland with Natives	10	182	1.3%	3-64
Riparian Woodland	19	523	3.8%	4-63
Total	471	13,630	100%	2-447

clusters of forest within these broader grassland-savanna mosaics. The large minimum mapping unit also prohibited ORGAP from capturing finer-scale differences within similar habitat types. By using the ORGAP habitat type classification system to organize habitat polygons and prioritize them, I did not explicitly consider the structural variation within each of the six habitat types. Consideration of the differences between grassland, savannas, woodlands and closed canopy forest however, should not be ignored and I turn now to a brief discussion of the issues involved in selecting individual polygons to ensure representation of the full range of structural types.

Representing Structural Variation in Habitat Types

The practical consequence of smoothing out structural variation and small-scale differences in species composition meant that I had to collapse woodland and forest structural categories together to facilitate the comparison with the ORGAP map. Some readers may wonder why I bother differentiating woodland and forest structural types during the initial delineation of habitat polygons. The answer, I believe, lies in the process of selecting areas for representation of all ecosystems types, and of improving mapping efforts by directly addressing the low resolution of ORGAP maps and their consequences for conservation strategies.

Many conservation planners assert that conservation efforts must represent all native ecosystem types within a network of protected areas (see Table 1). I used this principle to help guide the development of methods for inventorying habitats and for prioritizing where designated land use planning tools should be targeted. The focus on representation is evident in the inventorying process. By identifying multiple structural types, I attempted to evaluate them separately, recognizing differences between habitats provided by woodlands and those associated with closed canopy forest. Moreover, during the prioritization phase, I used information on wildflower distributions to further assess the importance of habitat polygons relative to broader measures of biodiversity, with the aim of designating individual polygons, or clusters of polygons, as the highest priority areas for land use planners to protect through multiple tools. However, I have not explicitly dealt with the issue of ensuring representation of the full array of habitat types, that is the numerous different species combinations that occur within each of the four structural types.

The methods I have detailed facilitate the consideration of different structural conditions within habitat types as well as particular species composition. Table 25 demonstrates how the aggregation matrix (Table 8) can be used to analyze the relative proportions of certain structural types in relation to their species composition. Whereas ORGAP considers Ponderosa Pine/Oregon White Oak Woodland and Forest one single habitat type, my methods suggest that there are multiple important sub-types (Table 25, Illustration 3). Many species respond to these structural differences. For example, habitat suitability studies have determined that Lewis' woodpecker does not fare well in closed canopy hardwood habitats (principally oaks). Instead, the species prefers semi-closed hardwood areas (woodlands in this study) and seems to thrive in open hardwood landscapes (savannas)(Pacific Northwest Ecosystem Research Consortium 2001). It seems clear that planners should consider these more specific aspects of habitat to bolster full representation of Priority One habitats.

Analysis of the relative proportions of certain structural and species combinations suggests that some are relatively rare. For example, only one polygon in the entire assessed area was classified as Ponderosa pine savanna (Illustration 3); it covers an area of 28 acres, comprising just 0.2% of the study area and 1% of all assessed savannas (In the ORGAP analysis, this area was lumped into the Forest-Grassland Mosaic category). Douglas-fir dominated savannas occur in only 3 blocks and occupy a scant 0.2% of the total area classified. Moreover, they represent just 1% of all savannas. Similarly, few areas appear to be comprised of pure stands of oaks. Within forests, oak dominated forests also represent a relatively uncommon type. Forty-two acres, consisting of six separate blocks, comprise 0.7% of the study area assessed and 2% of all forests assessed.

While some of these habitat types may not be common historically, the fact that these conditions are rare today suggests they may have increased importance for certain native species. Accordingly, inclusion of such polygons to ensure broader representation of native ecosystems—specifically targeting the broader spectrum of structural variation—would bolster the resulting conservation landscape design.

A secondary representation consideration involves looking too narrowly at habitat variation. Comparing the ORGAP categories with the narrower structural categories I consider here might mean that the broader category of Forest-Grassland Mosaics was neglected, save through inclusion of polygons identified as savannas. Ostensibly, the aggregation of habitats into the broader Forest-Grassland Mosaic category assumes some

ILLUSTRATION 3: Ponderosa pine savannas were a relatively rare habitat type found in TLSA.

neglected, save through inclusion of polygons identified as savannas. Ostensibly, the aggregation of habitats into the broader Forest-Grassland Mosaic category assumes some functional relationship between areas of open grassland, grasslands with scattered canopy cover, and small enclaves of forest. For instance, Lewis' woodpeckers feed both on acorn mast from oaks, but also rely on flycatching, typically in more open woodlands or fields Vierling (1997). Consequently, some planners may want to use the broader ORGAP designations to guide planning that treats adjacent polygons with the three different grassland in the Forest-Grassland Mosaic area and then treat the adjacent savanna and forest area as one entire unit in an attempt to consider them as one major habitat unit.

Efforts to address biodiversity through habitat inventories obviously must balance multiple objectives, capturing vegetation patterns at multiple scales. The preceding discussion touches only partially on many of the issues involved. However, I believe that the methods I have developed provide appropriate units of analysis that can be evaluated individually, or in aggregations that scale up to facilitate considerations at the larger landscape level. For this fact to be true, evaluations of individual habitat polygons must effectively capture the availability of important habitat elements. I now turn to a discussion of the broad indicators I used to assess habitat quality.

Improving Habitat Quality Assessments

The four indicators of habitat quality initially were chosen based on their role as functional elements in oak habitats and the specific species they support because the original habitat assessments focused on a smaller area dominated by oaks. In particular, the snag and legacy tree indicators were more or less designed to capture important oaks or standing dead oak trees that provided habitat for cavity nesters. However, the field work suggested that many areas contained snags of different species, something I had not explicitly planned to capture. Similarly, the species composition of legacy trees differed across the study area. While the species composition of snags or legacy trees may not make a difference for some organisms, others are most assuredly species specific. For this reason, future assessments should include both the level of snags or legacy trees within a polygon, plus the species composition of these snags and legacy trees.

Field observations also revealed that many habitats did not just contain standing dead trees, but were also comprised of downed wood or fallen trees both in small clusters or widely dispersed across polygons. Like standing dead trees, fallen logs provide habitat for native species, but for different suites of animals, which I had not considered in the initial design of the project. Addition of a category to capture the density of large downed wood would provide important information on the type of habitat available within polygons.

While I have highlighted some shortcomings in the basic methods, I reiterate that the maps I have presented represent an important inventory of habitats in the TLSA. They provide land use planners in the county with valuable information that is needed to facilitate planning across the 24,000 acre area.

Implications for Current Conservation Strategies

Targeting large blocks of intact habitat for acquisition, likely the most appropriate strategy for conserving Wasco oaks, may well preserve significant and functioning portions of landscape, but in northern Wasco County that approach would really only work in areas currently zoned for forestry. In zones where rural residential development is concentrated, or is targeted for future development, the high number of owners combined with the extent of roads, would most likely preclude effective acquisition. My research, while limited in the geographic extent of its treatment, indicates that precisely these areas have some of the best habitat across the TLSA. One of the main strengths of the implementation scheme (Table 2) is that it offers multiple action strategies for each priority level, of which acquisition is only one!

Pursuing a purely fine-filter approach to a habitat analysis—focusing solely on rare species—could easily work in Wasco County. However, such an approach would miss capturing larger habitat complexes whose value within an ecoregional conservation strategy were explicitly recognized by the Oregon Biodiversity Project (1998). The fine-filter approach would also most likely ignore particular functional elements necessary for many species that inhabit oak and pine woodlands and forests, focusing more narrowly on restricted range species, of which there are relatively few in the study area.

I provided a framework for applying established tools used by land use planners to conserve natural areas and open space (Table 2). The matrix builds on the impressive work done by Duerksen et al. (1997, 2000) in Colorado, and incorporates suggestions made by Vickerman (1998). The framework suggests three broad approaches to conservation that reflect the spectrum of attitudes toward conservation: ranging from the no-use tactic embodied by traditional reserve strategies to the full-development options often supported by developers. In this respect, the matrix incorporates site-level considerations, such as alternative building and landscaping techniques, as well as mechanisms for relocating development to other sites within the planning area.

My framework departs from Duerksen and his colleagues' work by providing a specific map of the Wasco County case that ranks habitat polygons according to their conservation value. In short, the framework I propose is not radically new. It builds on the work done by others by outlining specific inventorying methods for rural areas where sufficient data for making parcel-scale decisions about habitat do not exist. In essence, I am providing an alternative means for getting to the same point: a rural landscape that conserves elements of native biodiversity.

I sound one cautionary note: the approach I propose does leave out one key consideration explicitly addressed by Duerksen et al. (1997, 2000), namely, defining clear goals for the persistence of viable populations of native species. It should be noted, however, that Duerksen and coauthors suggest that meeting this goal in rural areas slated for development can be partially accomplished by zoning that sets minimum lot sizes for housing at 40 acres. The Wasco County case study does not fit that scenario because of pre-existing smaller lots sizes and thus demands an alternate strategy. I believe that my methods work to meet this need, but further research would be need to evaluate this aspect with regard to the multitude of species under consideration in TLSA.

Because maintaining viable populations within a conservation area is not explicitly addressed in the approaches I outline, such efforts should not replace any larger efforts to build a system of protective areas, but rather should complement those approaches. Lands identified by the means I describe may serve as another form of corridor to facilitate the movement of native species across the landscape. More than that, they are, in essence, an example of Franklin's (1993) matrix management. First, they supplement overall habitat by keeping blocks of habitat together. Second, even though these habitats might act as population sinks, they are likely to be less hostile forms of matrix vegetation than would be expected with conventional development. They may support greater numbers of individuals from source areas, resulting overall in substantially higher populations in the landscape (Pulliam 1988, 1991).

Within a broader policy context, however, my work provides a sound basis for jurisdictions in Oregon to link efforts to protect natural habitats in developing rural areas with the primary goal of most jurisdictions: low housing densities. Because Oregon does not generally permit high densities in rural areas (Einsweiler and Howe 1994), but instead generally encourages low density housing spread out evenly across the landscape—a situation that explicitly fosters landscape fragmentation—the work I have presented serves to build the case for altering that traditional approach while building in more flexibility than is currently afforded county planning departments. It seeks to link goals in the Oregon planning system that have not been considered simultaneously.

Table 2 presents a number of general approaches to conserving land, including such mechanisms as Transfer of Development Rights (TDRs). Planners in Oregon have largely ignored using TDRs (Rohse 2001). Thus, some of the mechanisms I outline for conserving habitats as prioritized in the resulting overlay zone remain largely untested in Oregon. Many questions about how to carry out these tools on the ground, as well as how to develop specific policies at the state and county level to operationalize my suggestions, remain unanswered. For example, specifics about how to operate a natural resources inventory process where citizens gather data for subsequent analysis by planners remains to be clarified and standardized.

Despite the fact that planners in Oregon have little experience with TDRs and there appears to be no clear process for executing a citizen-based inventory process, implementation of my methods would mark a dramatic improvement over the current 'safe harbor' approach pursued by most counties. Safe harbor allows counties to consult the Oregon Natural Heritage Program database on sensitive species prior to approving development on rural lands. In essence, the safe harbor strategy employs a fine-filter to see whether development will destroy habitat for sensitive species. Instituting a county-wide habitat survey would appear to be rather cumbersome and time-consuming for planning departments whose budgets and staff are strained by current requirements. However, counties could use the Wasco County approach of targeting the areas where rural residential development is focused, and then inventory these areas. Application of the larger framework (Table 2) suggests that taking such an approach may allow planners flexibility to influence resulting development patterns and deal with multiple issues simultaneously.

Failure of county planners to address habitat issues through broader and more innovative approaches will contribute to continued habitat loss and fragmentation. Over time, the slow decline in suitable habitat for certain species is likely to result in possible endangered species listings, and the associated regulation that comes with these listings. In the end, efforts expended now to address biodiversity conservation in a manner that considers habitat and its constituent parts alongside development will likely avoid potential regulation and litigation in the future. Meeting habitat needs while also allowing development—development that creates added amenity value—in rural landscapes would appear to be a wise investment of time and energy.

Conserving Oak Habitats in Wasco County and Oregon

At present, Wasco County is still working to address the preservation of oak habitats within the Transition Lands Study Area. The work I have presented here will likely serve as the beginnings of a broader habitat inventory. However, how the county specifically builds upon the citizen-based methods I have outlined, and how they incorporate my results into their comprehensive plan remain unresolved. It is unclear whether the habitat inventory I have created can be used for the purposes of actual policy decisions. Because the state has given so little direction to jurisdictions for conducting Goal 5 inventorying, my research does provide the county with methods to facilitate addressing Goal 5 concerns.

The map of prioritized habitats plus the methods I have detailed provide the county with a fundamental base from which to pursue protecting wildlife and habitat, as outlined in the 1997 Transitional Lands study, even if the methods or maps are not incorporated into the county's comprehensive plan. While the strategies presented in Table 2 suggest how a number of regulatory-based and incentive-based tools could be applied to a habitat inventory, such strategies still need to negotiate the process of conformance with the county's comprehensive plan. Tools for acquiring, or otherwise conserving land with important biodiversity value ultimately will have to be adapted to fit the specific goals and socio-political realities of planning in Wasco County, and within the constraints of state planning policies and goals.

In addition to specific zoning and planning tools, the county has expressed interest in working with one or more land trusts to secure protection for important native habitat. The Columbia Land Trust, based in Vancouver, Washington, has designated northern Wasco County as one of its priority areas for land acquisition, both through full purchase as well as the use of conservation easements. In essence, the land trust would serve to pursue the more stringent acquisition and protective mechanisms outlined in the framework I have proposed.

The land trust has expressed interest in using the habitat inventory I have completed as well as using these methods to assess the remaining extent of habitats dominated by Oregon white oak in the northern part of the county. The limitations of these methods must be taken into consideration if the trust's efforts are to be successful. Quite likely, procedures for extrapolating from habitat polygons where field surveys successfully assessed the full complement of quality indicators to areas that are not accessible but have good air photo coverage (preferably color photos flown at lower elevations) will need to be employed. Combining this type of habitat delineation and assessment with other available datalayers, such as those available from the Oregon Natural Heritage Program or the Oregon Department of Fish and Wildlife, would go a long way to assist the trust in targeting its acquisition strategies.

Two important considerations regarding land acquisition in the oak habitats deserve brief consideration. First, it is unclear whether the Columbia Land Trust, or perhaps another land trust, is explicitly interested in acquiring extensive property in areas currently zoned for industrial forestry. Much of the oak habitats in Wasco County do fall within these areas, as evidenced by the percentage of habitats within TLSA zoned for logging.

Second, regardless of what habitats are acquired, comprehensive management and monitoring plans will be required to maintain the biodiversity value of these oak habitats, particularly in areas where fir or pine encroachment may alter the structure of open habitats currently dominated by oak. In these cases, as with parcels zoned for forestry, management plans will likely call for the use of logging as a habitat maintenance or restoration tool. Complying with the multitude of state regulations and policies that deal with replanting activities that follow logging in forestry zones—that currently do not recognize the value of managing for oak habitats—will likely complicate such efforts.

Fire has also played an important role in shaping the ecosystems of northern Wasco County (Agee 1993). This natural disturbance is a major sculptor in many western North American ecosystems. Fire suppression over the last hundred years has led to increases in the tree density and canopy cover of many forest types throughout the West. Thus, open habitat conditions, such as savannas, that are naturally maintained by fire regimes may be lost over time.

Habitat restoration and maintenance activities will need to investigate the effects that fire, as well as its absence, have had in influencing the composition and structure of oak habitats. Fire is increasingly used as a management tool, but this approach may prove rather difficult in rural areas that are often characterized by hazardous fire conditions.

Nevertheless, planners and land managers are likely to encourage landowners of all types to manage their lands for fire protection, including considering where to site houses and how to manage vegetation surrounding buildings. In some situations, fire in the form of prescribed burning may be used to accomplish fire protection goals. In this way, practical steps to create safer residential environments could provide opportunities to create or maintain important savanna habitats.

Moving Beyond Reserves: Conservation Through Land Use Planning

Efforts to conserve biodiversity in rural areas of the western United States cannot rely solely on a system of nature preserves. I have argued that we should not abandon reserve strategies, but like Beatley (2000) and Knight (1999), assert that we must broaden the scope and strategic framework of our efforts in landscapes where private lands dominate. Designing conservation landscapes in these areas requires inventorying native habitats and employing the tools of land use planning to ensure that native biodiversity is embedded within rural areas—not just separate areas of land fenced off from the community. I have proposed one approach for designing these conservation landscapes using new tools for land use planning. My hope is that this effort will provide planners in general, and in Wasco County in particular, the knowledge to rework the direction of current development in the rural West.

WORKS CITED

Agee, J. 1993. Northwest woodlands. Pages 351-370 *in* Fire ecology of the Pacific Northwest forests. Island Press, Washington, DC.

Askins, R. 2000. Restoring North America's birds: Lessons from landscape ecology. Yale University Press, New Haven, CT.

Abell. R., D.M. Olson, E. Dinerstein, P.T. Hurley, J.T. Diggs, W. Eichbaum, S. Walters, W. Wettengel, T. Allnutt, C.J. Loucks, and P. Hedao. 2000. Freshwater Ecoregions of North America: A conservation assessment. Island Press, Washington, DC.

Anderson, J.E. 1991. A conceptual framework for evaluating and quantifying naturalness. *Conservation Biology* 5(1): 347-352.

Anderson, M., P. Comer, D. Grossman, C. Groves, K. Poiani, M. Reid, R. Schneider, B. Vickery, and A. Weakley. 1999a. Guidelines for representing ecological communities in conservation plans. The Nature Conservancy, Arlington, VA.

Anderson, R.C., J.S. Fralish, and J.M. Baskin. 1999b. Savannas, barrens, and rock outcrop plant communities of North America.

Baydack, R.K., H.C. Ill, and J.B. Haufler (editors). 1999. Practical approaches to the conservation of biological diversity. Island Press, Washington, DC.

Beatley, T. 2000. Preserving biodiversity: Challenges for planners. *Journal of the American Planning Association* 66(1):5-19.

Berke, P. and M.M. 2000. Conroy. Are we planning for sustainable development?: An evaluation of 30 comprehensive plans. *Journal of the American Planning Association* 66(1):21-34.

Bjorklund, N. 1999. West Eugene Wetlands Program. City of Eugene. Online. Available: http://www.ci.eugene.or.us/wewetlands/default.htm. 20 May 2001.

Burke, V.J. 2000. Landscape ecology and species conservation. *Landscape Ecology* 15:1-3.

Butler, T. (editor). 1992. The Wildlands Project: Plotting a North American wilderness recovery strategy. Cenozoic Society, Canton, NY.

Callicott, J.B., and K. Mumford. 1997. Ecological sustainability as a conservation concept. *Conservation Biology* 11(1):32-40.

City of Eugene. 2001. Metropolitan natural resources study. Online. Available: http://www.ci.eugene.or.us/nrs/documents.htm. 20 May 2001.

Columbia Gorge Audubon. 1990. A plan for managing the oak forests of Washington State. Hood River, OR.

Cronon, W. 2000. Resisting monoliths and tabulae rasae. *Ecological Applications* 10(3):673-675.

Cullingworth, J.B. 1993. The political culture of planning: American land use planning in comparative perspectives. Routledge, New York, NY.

Dagget, D. 1995. Beyond the rangeland conflict: Toward a West that works. Gibbs Smith, Layton, UT.

Daniels, S.E., and G.B. Walker. 1995. Searching for effective natural-resources policy: The special challenges of ecosystem management. *Natural Resources and Environmental Issues* 5:29-35.

Dale, V.H., S. Brown, R.A. Haeuber, N.T. Hobbs,, N. Huntly, R.J. Naiman, W.E. Riebsame, M.G. Turner, and T.J. Valone. 2000. Ecological principles and guidelines for managing the use of land. *Ecological Applications* 10(3):639-670.

Department of Land Conservation and Development. 1996. Oregon's statewide planning goals and guidelines. Online. Available: http://darkwing.uoregon.edu/~pppm/landuse/ INTRO.html. 15 July 2000.

Department of Land Conservation and Development. 2000. LCDC's Goal 5 rule on planning for natural and historic resources. Online. Available:

Duane, T. 1998. Shaping the Sierra: Nature, culture, and conflict in the changing West. University of California Press, Berkeley, CA.

Duerksen, C.J., D.L. Elliott, N.T. Hobbs, E. Johnson, and J.R. Miller. 1997. Habitat protection planning: Where the wild things are. American Planning Association, Planning Advisory Service Report Number 470/471. Washington, DC.

Duerksen, C.J., N.T. Hobbs, D.L. Elliott, E. Johnson, and J.R. Miller. 2000. Managing development for people and wildlife: A handbook for habitat protection by local governments. Online. Available: http://www.ndis.nrel.colostate.edu/escop/handbook/ handbook.html. 15 June 2000.

Einsweiler, R.C., and D.A. Howe. 1994. Managing "the land between": A rural development paradigm. Pages 246-273 *in* Abbott, C. and D.A. Howe (editors). Planning the Oregon way: A twenty year evaluation. Oregon State University Press, Corvallis, OR.

Fleischner, T. 1994. Ecological costs of livestock grazing in western North America. *Conservation Biology* 8(3):629-644.

Franklin, J. 1993. Preserving biodiversity. *Ecological Applications* 3(2):202-220.

Foreman, D. 2000. Resourcism vs. will of the land. *Wild Earth* Summer:1-4.

Griffin, C.B. 1999. Watershed councils: An emerging form of public participation in natural resource management. *Journal of the American Water Resources Association* 35(3):505-518.

Hahn, C. 1997. Wasco County Transition Lands Study Area (TLSA). A report prepared for Wasco County by SRI/Shapiro/AGCO, Inc. Project #7961032. Portland, OR.

Hitchcock, C. L. and A. Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press, Seattle, WA.

Hooge, P.N., M.T. Stankback, and W.D. Koenig. 1999. Nest-site selection in the acorn woodpecker. *The Auk* 116(1):5-54.

Hough, J. 1988. Biopshere reserves: Myth and reality. *Endangered Species Update* 6(1/2):1-4.

Hulse, D. and R. Ribe. 2000. Land conversion and the production of wealth. *Ecological Applications* 10(3):679-682.

Johannessen, C.J., W.A. Davenport, A. Millet, and S. McWilliams. 1970. The vegetation of the Willamette Valley. *Annals of the Association of American Geographers* 61: 286-302

Johnson, B.R. and C. Girling (editors). 2000. Rowena Wilds ecological planning and design studio: Innovative approaches for ecologically sensitive rural development. Department of Landscape Architecture, University of Oregon, Eugene, OR.

Johnson, D.H. and T.A. O'Neil (managing editors). 2001. Wildlife-habitat relationships in Oregon and Washington. Oregon State University Press, Corvallis, OR.

Jolley, R. 1988. Wildflowers of the Columbia Gorge: A comprehensive field guide. Oregon Historical Society Press, Portland, OR.

Kagan, J.S., J.C. Hak, B. Csuti, C.W. Kiilsgaard, and E.P. Gaines. 1999. Oregon Gap Analysis Project final report: A geographic approach to planning for biological diversity. Oregon Natural Heritage Program, Portland, OR.

Karr, J.R. and E.W. Chu. 1995. Embracing Complexity: The Challenge of the Ecosystem Approach. Pages 49-59 *in* Westra, L. and J. Lemons (editors). Perspectives on ecological integrity. Kluwer, Boston, MA.

Kiester, A., M. Scott, B. Csuti, R. Noss, B. Butterfield, K. Sahr, and D. White. 1996. Conservation prioritization using GAP data.*Conservation Biology*. 10(5):1332-1342

KenCairn, B. 1995. A community-based approach to forest management in the Pacific Northwest: A profile of the Applegate partnership. *Natural Resources and Environmental Issues* 5:43-52.

Knight, R.L. 1999. Private lands: The neglected geography. *Conservation Biology* 13(2):223-224.

Mackenzie, A. and A. Merenlender. 2000. Sonoma County Acquisition Plan 2000: A tool for conserving oak woodlands. Oaks 'n' folks Online. Available: http://danr.ucop.edu/ ihrmp/oak101.htm. 20 May 2001.

Ligon, J.D. and P.B. Stacey. 1995. Land use, lag times and the detection of demographic change: The case of the acorn woodpecker. *Conservation Biology* 10(3):840-846.

Maser, C. (editor). 1999. Ecological diversity in sustainable development: The vital and forgotten dimension. Lewis Publishers, Boca Raton, FL.

Master, L.L., S.R. Flack, and B.A. Stein (editors). 1998. Rivers of life: Critical watersheds for protecting freshwater biodiversity. The Nature Conservancy, Arlington, VA.

McClosky, M. 1996. The limits of collaboration. *Harper's Magazine* November:34-36.

McComb, W.C. 2001. Management of within-stand forest habitat features. Pages 140 - 153 *in* Johnson, D.H. and T.A. O'Neil (managing editors). Wildlife-habitat relationships in Oregon and Washington. Oregon State University Press, Corvallis, OR.

Meffe, G.K., C.R. Carroll, And Contributors. 1997. Principles Of Conservation Biology. Second Edition. Sunderland, MA: Sinauer Associates.

Mittermeier, R.A., N. Myers, J.B. Thomsen, G.A.B. da Fonseca, and S. Olivieri. 1998. Biodiversity hotspots and major tropical wilderness areas: Approaches to setting conservation priorities. *Conservation Biology* 12(3):516-520.

Morrison, M.L., B.G. Marcot, and R.W. Mannan. 1998. Wildlife-habitat relationships: Concepts, and applications. University of Wisconsin Press, Madison, WI.

Noss, R.F., and A.Y. Cooperrider. 1994. Saving Nature's Legacy: Protecting and restoring biodiversity. Island Press, Washington, DC.

Noss, R.F., M.A. O'Connell, and D. Murphy. 1997. The science of conservation planning: Habitat conservation under the Endangered Species Act. Island Press, Washington, DC.

Novick, A. Personal Communication. Private landowner in Eugene, Oregon. 17 March 2001.

Olson, D.M. and E. Dinerstein. 1998. The Global 200: A representation approach to conserving the Earth's most biologically valuable ecoregions. *Conservation Biology* 12(3):502-515.

Oregon Biodiversity Project. 1998. Oregon's living landscapes: Strategies and opportunities to conserve biodiversity. Defenders of Wildlife, Portland, OR.

Oregon Department of Fish and Wildlife. 1997. Oregon Department of Fish and Wildlife, sensitive species. Portland, OR.

Pacific Northwest Ecosystem Research Consortium. 2001. Habitat suitability data for birds of the Willamette Valley. Unpublished data. Online. Available: http://www.fsl.orst.edu/ pnwerc/wrb/access.html. 20 May 2001.

Peck, S. 1998. Planning for biodiversity: Issues and examples. Island Press, Washington, DC.

Pienkowski, M.W., E.M. Bignal, C.A. Galbraith, D.I. McCracken, R.A. Stillman, and MG. Boobyer. 1996. A simplified classification of land-type zones to assist the integration of biodiversity objectives in land-use policies. *Biological Conservation* 75:11-25.

Platt, R.H. 1996. Land use and society: Geography, law, and public policy. Island Press, Washington, DC.

Pojar, J., and A. MacKinnon (editors). 1994. Plants of the Pacific Northwest coast: Washington, Oregon, British Columbia and Alaska. Lone Pine Publishing, Vancouver, WA.

Pulliam, H.R. 1988. Sources, sinks and population regulation. *The American Naturalist* 135: 652-661.

Pulliam, H. R. and B. J. Danielson. 1991. Sources, sinks and habitat selection: a landscape perspective on population dynamics. *The American Naturalist* 137: 550-566.

Ribot, J. 1996. Participation without representation: chiefs, councils, and forestry law in the West African Sahel. *Cultural Survival Quarterly* 30(3):40-44.

Ricketts, T., E. Dinerstein, D. Olson, C. Loucks, W. Eichbaum, D. DellaSala, K. Kavanagh, P. Hedao, P.T. Hurley, K Carney, R. Abell, and S. Walters. 1999. The terrestrial ecoregions of North America: A conservation assessment. Island Press, Washington, DC.

Rohse, M. Personal Communication. Policy Development Specialist, Department of Land Conservation and Development, Salem, OR. 11 July 2000.

Rohse, M. 2001. Personal Communication. May 19, electronic mail.

Ryan, L.A. and A.B. Carey. 1995. Biology and management of the western gray squirrel and Oregon white oak woodlands: With emphasis on the Puget Trough. U.S. Forest Service General Technical Report, PNW-GTR-348.

Selin, S.W., M.A. Schuett, and D. Carr. 1997. Has collaborative planning taken root in the national forests? *Journal of Forestry* 95(4):25-28.

Selin, S.W., M.A. Schuett, and D. Carr. 2000. Modeling stakeholder perceptions of collaborative initiative effectiveness. *Society and Natural Resources* 13:735-745.

Shaughnessy, M.M. and T. O'Neill. 2001. Conservation of biodiversity: Considerations and methods for identifying and prioritizing areas and habitats. Pages 154 – 167 *in* Johnson, D.H. and T.A. O'Neil (managing editors). 2001. Wildlife-habitat relationships in Oregon and Washington. Oregon State University Press, Corvallis, OR.

Smith, P. 1998. Regional conservation planning: Protection of regional natural areas and resource lands. Pages 221-229 in Schoolmaster, F.A. (editor). Papers and Proceedings: Applied Geography Conferences, Vol. 21, Denton, Texas.

Soulé and Terborgh 1999. Continental conservation: Scientific foundations of regional reserve networks. Island Press, Washington, DC.

Stein, B.A., L.S. Kutner, and J.S. Adams. 2000. Precious heritage: The status of biodiversity in the United States. Oxford University Press, New York, NY.

Stevenson, M.R. Applying Gap Analysis to county and regional land use planning. 2001. Pages 555 – 561 *in* Johnson, D.H. and T.A. O'Neil (managing editors). Wildlife-habitat relationships in Oregon and Washington. Oregon State University Press, Corvallis, OR.

Theobald, D.M., N.T. Hobbs, T. Bearly, J.A. Zack, T. Shenk, and W.E. Riebsame. Incorporating biological information in local land-use decision making: Designing a system for conservation planning. *Landscape Ecology* 15:35-45.

Thiebold, D.M., N.T. Hobbs, T. Bearly, J.A. Zack, T. Shenk, and W.E. Riebsame. 2000. Incorporating biological information in local land-use decision making: Designing a system for conservation planning. *Landscape Ecology* 15:35-45.

Tietje, W., and T. Berlund. 1996. Land-use planning in oak woodlands: Applying the concepts of landscape ecology using GIS technology and the CDF oak woodlands maps. Integrated Hardwood Range Management Program, UC Berkelye. Online. Available: http://danr.ucop.edu/ihrmp/policy.html. 13 May 2001.

Vickerman, S. 1998. Stewardship incentives: Conservation strategies for Oregon's working landscapes. Defenders of Wildlife, Lake Oswego, OR.

Vierling, K.T. 1997. Habitat selection of Lewis' woodpeckers in southeastern Colorado. *Wilson Bulletin* 109(1):121-130.

Vitousek, P.M., H.A. Mooney, J. Lubchenco, and J.M. Melillo. 1997. Human domination of Earth's ecosystems. *Science* 277:494-499.

Walker, P., and L. Fortmann. 2001. Struggles over Meanings, Struggles over Landscape: A Political Ecology of the 'Exuban' Sierra. Paper Presented at the Annual Conference of the Association of American Geographers, New York, NY.

Wall, W.A. 1999. Maintaining biodiversity in an intensively managed forest: A habitat-based planning process linked with a fine-filter adaptive management process. Pages 127 – 140w *in* Baydack, R.K., H.C. Ill, and J.B. Haufler (editors). Practical approaches to the conservation of biological diversity. Island Press, Washington, DC.

Watershed Professionals Network. 1999. Oregon watershed assessment manual. Governor's Watershed Enhancement Board, Salem, OR.

Western, D. and M.R. Wright. 1994. Natural Connections: Perspectives in community-based conservation. Island Press, Washington, DC.

Wilson, E.O. 1992. The diversity of life. W.W. Norton & Co., New York, NY.

Wondolleck, J.M. and S.L. Yaffee. 2000. Making collaboration work: Lessons from innovation in natural resource management. Washington, D.C.: Island Press.