prepared for THE TRUST FOR PUBLIC LAND
by the CONSERVATION BIOLOGY INSTITUTE

SCIENCE ASSESSMENT FOR THE

SIERRA CHECKERBOARD INITIATIVE





THE TRUST *for* PUBLIC LAND

CONSERVING LAND FOR PEOPLE

The *Science Assessment for the Sierra Checkerboard Initiative* was undertaken and produced with funds from the Richard & Rhoda Goldman Fund and the Bella Vista Foundation. The Trust for Public Land is grateful for their generous support.

SCIENCE ASSESSMENT
for the
SIERRA CHECKERBOARD INITIATIVE

Prepared by

Michael D. White, Ph.D.
Gerald E. Heilman, Jr., M.S.
Jerre Ann Stallcup, M.A.

CONSERVATION
BIOLOGY
INSTITUTE

Prepared for

The Trust for Public Land
San Francisco, California

July 2005

The Conservation Biology Institute provides scientific expertise to support conservation and recovery of biological diversity in its natural state through applied research, education, planning, and community service.

Dedication

This assessment—and the conservation of the Sierra that it will lead to—is dedicated to **Michael Killigrew**, whose vision, resolve, and leadership were instrumental to the launching of the *Sierra Checkerboard Initiativ*e. Michael was a good and noble man, an inspiring presence to all who knew him, who lived in and cared deeply for the land, the water, and the people of the Sierra Nevada.

The Range of Light

Making your way through the mazes of the Coast Range to the summit of any of the inner peaks or passes opposite San Francisco, in the clear springtime, the grandest and most telling of all California landscapes is outspread before you. At your feet lies the great Central Valley glowing golden in the sunshine, extending north and south farther than the eye can reach, one smooth, flowery, lake-like bed of fertile soil. Along its eastern margin rises the mighty Sierra, miles in height, reposing like a smooth, cumulous cloud in the sunny sky, and so gloriously colored, and so luminous, it seems to be not clothed with light, but wholly composed of it, like the wall of some celestial city. Along the top, and extending a good way down, you see a pale, pearl-gray belt of snow; and below it a belt of blue and dark purple, marking the extension of the forests; and along the base of the range a broad belt of rose-purple and yellow, where lie the miner's gold-fields and the foot-hill gardens. All these colored belts blending smoothly make a wall of light ineffably fine, and as beautiful as a rainbow, yet firm as adamant.

When I first enjoyed this superb view, one glowing April day, from the summit of the Pacheco Pass, the Central Valley, but little trampled or plowed as yet, was one furred, rich sheet of golden compositae, and the luminous wall of the mountains shone in all its glory. Then it seemed to me the Sierra should be called not the Nevada, or Snowy Range, but the Range of Light. And after ten years spent in the heart of it, rejoicing and wondering, bathing in its glorious floods of light, seeing the sunbursts of morning among the icy peaks, the noonday radiance on the trees and rocks and snow, the flush of the alpenglow, and a thousand dashing waterfalls with their marvelous abundance of irised spray, it still seems to me above all others the Range of Light, the most divinely beautiful of all the mountain-chains I have ever seen.

-John Muir
The Mountains of California

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

We would like to thank the members of our Science Advisory Panel—Michael Barbour, Frank Davis, Don Erman, Dave Graber, Bob Heald, and Bill Zielinski. Their invaluable input and advice was integral to conducting the assessment, and we greatly appreciate their time and contributions.

We would like to acknowledge the contributions of numerous individuals that provided data, contact information or leads, and input on various project-related issues—John Babin, Klaus Barber, Amber Beckler, Eric Beckwitt, Steve Beckwitt, Steve Benner, Jerry Bloom, Carol Clark, Jose Crummett, Brian Domsic, Roger Ewers, JoAnn Fites-Kaufman, Lynn Frederico, Shawn Garvey, Evan Girvetz, Jerry Henry, Cheryl L. Hickam, Robert Johnston, Vivian Kee, Tanya Kohlerr, Lester Lubetkin, Diane Macfarlane, Tina Mark, Shawn Saving, Frieder Schurr, Brian Schwind, Denise Spanos, Bill Stewart, Nathan Strout, Debra Tatman, Mike Taylor, Kurt Teuber, Tony Valdes, Linda Wright, and Evan Wolf.

Keith Reynolds provided invaluable assistance with EMDS and Netweaver software and reviewed the draft report.

John Moore and Eric Gerstung provided maps depicting their views of lands valuable for natural resources and recreation.

We relied on the extensive and well-documented public data sets available from the California Resources Agency, California Department of Forestry Fire and Resource Assessment Program, and the U.S. Forest Service Region 5 Remote Sensing Laboratory for many of our analyses. We also made use of many data sets provided by the Tahoe and Eldorado National Forests.

Thanks to a number of CBI staff that contributed to this project—Wayne Spencer, Nancy Staus, and Jim Strittholt.

The Science Assessment for the *Sierra Checkerboard Initiative* was undertaken and produced with funds from the Richard and Rhoda Goldman Fund, the Bella Vista Foundation, and The Sierra Fund. We are grateful for their generous support.

We particularly want to thank the *Sierra Checkerboard Initiative* project team—David Sutton, Elise Holland, and Carl Somers (The Trust for Public Land), Sue Britting (Sierra Nevada Forest Protection Campaign), Pete Nichols (California Wilderness Coalition), and Nancy Budge (QB Consulting). Your passion, knowledge, and assistance were indispensable, and we look forward to continuing our collaboration with you on future phases of the *Sierra Checkerboard Initiative*.

EXECUTIVE SUMMARY

The Sierra Nevada, John Muir's *Range of Light*, is a state and national treasure, valued for its scenic beauty, rich biodiversity, ancient forests, unparalleled recreational opportunities, and commercial timber and water resources. The Sierra Nevada supports over 60% of California's vertebrate species and over half of its plant species. For its size, it is the most floristically diverse area in North America. The Sierra supports 50 million recreational visitor days each year, and its watersheds deliver 65% of the water supply for California residents.

But human society's love affair with the Sierra is also threatening these same values, as a result of ownership patterns that challenge the effectiveness of regional land management efforts, ever expanding residential development, and the threat of catastrophic fires. These threats are particularly evident in the central Sierra Nevada, where the ownership pattern is a *checkerboard* of public and private lands. Land management practices often differ on public and private lands with respect to land use, public access, road construction and maintenance, fuel and fire management, and vegetation restoration. This results in fragmented habitats, irregular access for public recreation, and conflicts over timber harvest. The growing human population and continued expansion of residential development in the central Sierra will further diminish resource values and complicate sustainable resource management.

In recognition of these threats to the legacy of the Sierra Nevada, The Trust for Public Land (TPL), in partnership with the Sierra Nevada Forest Protection Campaign, California Wilderness Coalition, and others, commissioned this Science Assessment to initiate development of a vision for a more sustainable landscape in the central Sierra. This vision—the *Sierra Checkerboard Initiative*—is based on the belief that strategies for land conservation and management must rely on a sound scientific foundation. The Science Assessment identifies areas of high biodiversity, mature forest connectivity, and passive recreation values, as well as areas threatened by development, unnatural fire regimes, and management incompatible with conservation of mature forests.

The Science Assessment uses a systematic and transparent approach to integrating and analyzing the extensive amount of data available for the central Sierra (portions of El Dorado, Placer, Nevada, Sierra, and Yuba counties) and identifying candidate areas for developing conservation and management strategies. A modeling tool, developed from the Ecosystem Management Decision Support (EMDS) System, allowed us to visualize, in an unbiased manner, the distribution of the various characteristics of the study area that contribute to resource values and threats.

The relative extent to which sections of land are candidates for conservation action (i.e., support resource values that are threatened) is presented as maps with sections assigned to one of seven color categories along a continuous scale, from most suitable as a candidate for conservation action to least suitable. Large portions of the study area rank as highly suitable candidates for conservation action, with about 60% (860,000 acres) of the study area falling within the three highest suitability categories. The majority (460,000 acres) of these lands are in public ownership. About 7% of the study area (109,000 acres) is within the highest suitability category; with the majority in private ownership (70,000 acres). High suitability areas are widespread throughout the western half of the study area, particularly between Interstate 80 and Highway 20 and north of Highway 49, and in the northeastern portion of the study area. The portions of the study area least suitable for conservation action are in non-forested, higher-elevation areas that are designated public wilderness areas or have poor access and low development potential.

Subsequent phases of the *Sierra Checkerboard Initiative* will develop and implement conservation strategies for areas that support both high resource values and that are highly threatened, as identified in this Science Assessment. Phase II will build from the Phase I results to develop and prioritize conservation solutions to enhance resource values and ameliorate threats. Strategies will consider information from the modeling tool as well as ownership patterns, land protection and management status (existing conservation investments), public agency objectives and priorities, land and timber market considerations, local land protection and stewardship initiatives, political and social considerations, and availability of funding. The positive contribution that forest and fire management by the wood products industry can make to conservation will be integral to developing conservation solutions in Phase II. Therefore, timber resources and the factors that contribute to the ability of landowners to manage their forest lands are discussed in the Science Assessment.

Conservation strategies will consist of a combination of implementing mechanisms, including land acquisition or land exchange, conservation easements, management agreements, and other plans or agreements to minimize threats and enhance resource values. Strategies must take a long-term view, adapt to changing conditions, and consider the potential for management to improve future resource conditions, as the success of some land management activities will be measured over decades.

1. INTRODUCTION

Background

The Sierra Nevada, California's iconic mountain landscape, is intimately linked to the history and heritage of the state as well as the nation. The multiple and often competing resource values of the Sierra Nevada, ranging from biodiversity to recreation to timber harvest, are as dramatic as its image—scenic and spiritual, yet industrial and extractive; recreational and residential, yet wild and imperiled. Now more than ever before, these values are increasingly threatened as a result of ownership patterns, coupled with conflicting management objectives, expanding residential development, and threat of catastrophic fires.

Threats to resource values are particularly evident in the central Sierra Nevada, where the ownership pattern is a *checkerboard* of public and private lands (Figure 1). This ownership pattern is a part of the rich history of the region when the United States government granted alternate square miles to the Central Pacific Railroad during the building of the transcontinental railroad in the 1860s. Many private individuals and companies now own these land grants, which are interspersed in a checkerboard pattern with public land administered by the U.S. Forest Service.

The checkerboard ownership pattern of the Sierra Nevada challenges the effectiveness of regional land management efforts. To be effective, land management efforts should be implemented at a landscape scale, consistent with the scale at which ecosystem processes operate. Currently, land management objectives and practices often differ on public and private lands with respect to land use, public access, road construction and maintenance, fuel and fire management, and vegetation restoration. This results in fragmented habitats, irregular access for public recreation, and conflicts over timber harvest. The growing human population and continued expansion of residential development in the central Sierra over the next 20 years will further diminish resource values and complicate sustainable resource management by altering land use patterns, fragmenting habitats, introducing nonnative species, degrading water quality, changing hydrological processes, and altering fire regimes.

Sierra Checkerboard Initiative

In recognition of these threats to the rich legacy of the Sierra Nevada, The Trust for Public Land (TPL) commissioned this Science Assessment to illustrate the resource values of the region and to initiate development of a vision—the *Sierra Checkerboard Initiative*—for a more sustainable landscape in the central Sierra. TPL and its partners—the Sierra Nevada Forest Protection Campaign and California Wilderness Coalition—share a set of common goals, which reflect the varying interests of numerous public and private stakeholders, and wish to address issues of watershed protection, recreation and open space, wildlife and wilderness values, timber harvest, and development at a scale not previously undertaken in the region. The goals of the *Sierra Checkerboard Initiative* are:

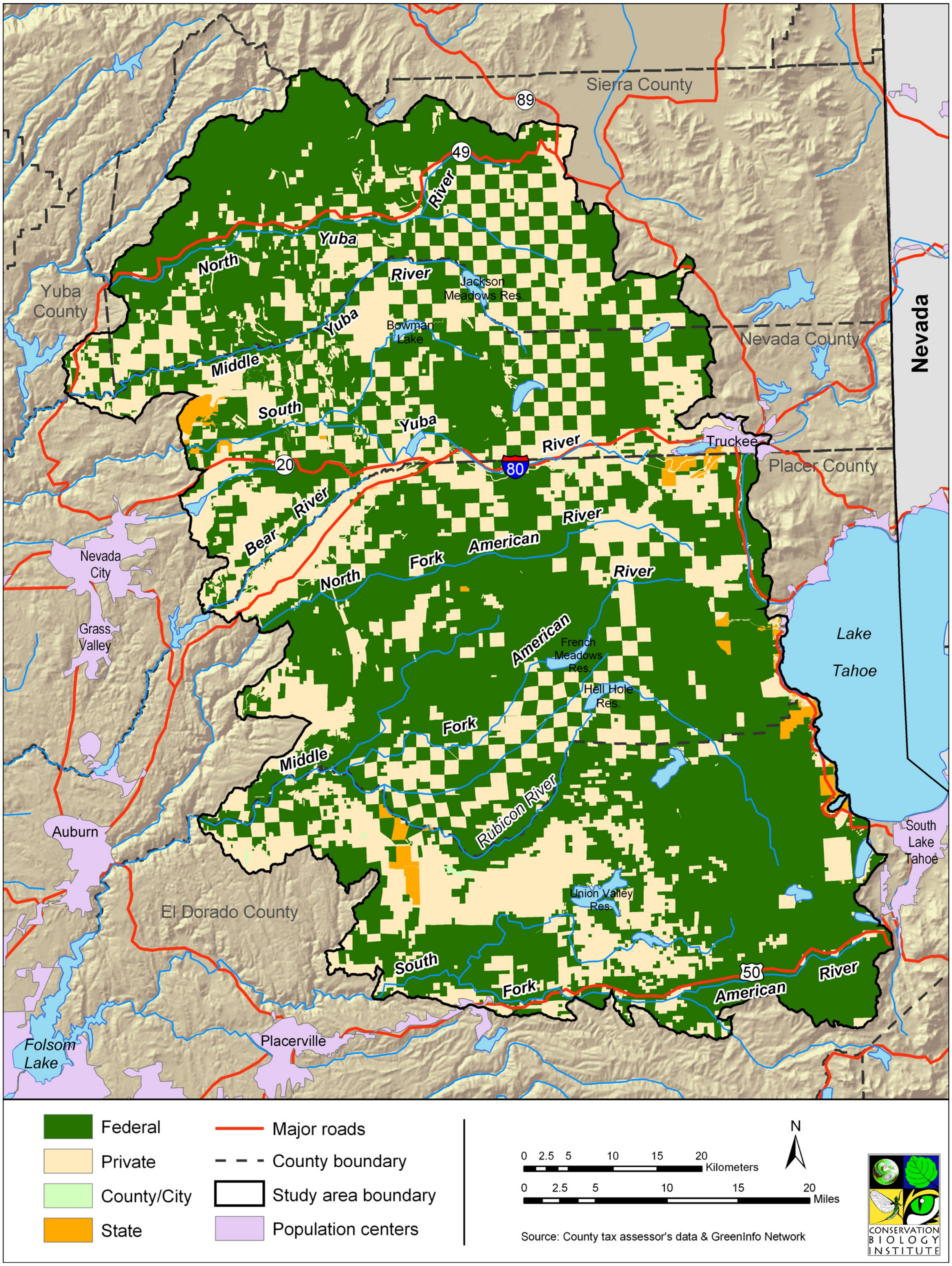

Figure 1—Public and private ownership patterns in the *Sierra Checkerboard Initiative* study area.

- Maintain and enhance natural resource condition and integrity;
- Improve passive recreational opportunities; and
- Support forest product management and fire management, in balance with species and ecosystem needs.

Phase I of this initiative, the Science Assessment, is based on the belief that strategies for land conservation and management must rely on a sound scientific foundation. The Science Assessment focuses on identifying areas of high resource values—biodiversity, mature forest connectivity, and passive recreation—as well as areas under threat by development, unnatural fire regimes, and management incompatible with conservation of mature forests. Areas that support high resource values and are highly threatened will be considered as candidate areas for conservation in Phase II of the *Sierra Checkerboard Initiative*. Section 6 (Next Steps) of this Science Assessment describes some considerations for designing conservation strategies in Phase II. Section 6 also describes the timberlands in the study area and some of the management issues facing landowners in the forest product industry, as these issues will be integral to the success of the *Sierra Checkerboard Initiative*.

In Phase II, TPL and its partners will develop land realignment and management strategies to maintain and enhance resource values in light of the threats they face. Through coalitions with other nonprofit organizations, government agencies, landowners, and other stakeholders, TPL and its partners will develop funding and political strategies to implement the identified strategies. In Phase III, TPL will work with its partners and supporters to implement the site-specific conservation strategies developed during Phase II. This will likely require public funding measures and, quite possibly, federal legislation. TPL and its partners will work closely with federal, state, county, and local elected officials and other stakeholders on these issues.

Objectives of the Science Assessment

The Science Assessment provides a mechanism for developing and implementing comprehensive and collaborative strategies for resource protection in the Sierra Nevada. The importance of these resources is evident in the large amount of attention and research the region has received since the early 1990s. The five-part series—*Majesty and Tragedy: The Sierra in Peril* by Tom Knudson of the Sacramento Bee—perhaps first raised the public's consciousness about the complexities of environmental issues in the Sierra Nevada. Various studies and planning initiatives have been conducted since then (Erman 1999), including the California Resources Agency's summit, *Sierra Now: A Vision for the Future* (Environment Now 1992), *Sierra Economic Summit* led by business and industry representatives, *Sierra Nevada Ecosystem Projec*t (SNEP 1996), Sierra Nevada Forest Protection Campaign's *Conservation Strategy* (SNFPC 1999), *Sierra Nevada Forest Plan Amendment* (USFS 2004), California Wilderness Coalition's *Guide to Wildlands Conservation in the Greater Sierra Nevada Bioregion* (CWC 2002), Pacific Rivers Council's *Conservation of Aquatic Diversity in the Sierra Nevada* (PRC 1998), and *Sierra Nevada Ecoregional Plan* developed by The Nature Conservancy (TNC 1999). The Science Assessment presented in this report represents a unique and independent approach that synthesizes information from these analyses and other available data for the region. A panel of Science Advisors, selected from various academic institutions, the National Park Service, and U.S. Forest Service, reviewed and advised on the data and approach used for the Science Assessment.

The specific objectives of the Science Assessment are:

- Identify areas that support attributes of high biodiversity, connectivity between mature forests, and potential for passive recreation.
- Describe and measure major threats to these attributes.
- Integrate and analyze the extensive amount of data available for the region using a systematic, transparent approach that allows logical conclusions to be made about the distribution of resource values and threats in the region.
- Identify candidate areas for developing conservation and management strategies relating to enhancing biodiversity, mature forest connectivity, and passive recreation value.
- Introduce concepts for developing integrated conservation strategies in future phases of the *Sierra Checkerboard Initiative*.

The 1.53 million-acre study area for the Science Assessment is located in portions of El Dorado, Placer, Nevada, Sierra, and Yuba counties (Figure 1). It is defined by the North Fork Yuba River watershed on the north, the South Fork American River on the south, the lower extent of mid-montane conifer (mixed conifer) communities on the west, and the crest of the Sierra Nevada plus eastside watershed subbasins sufficient to capture the checkerboard lands to the east.

A product of the Science Assessment is a modeling tool that is discussed further in Section 4 (Integrating and Assessing Information). The tool allows us to explicitly define our conceptual model for assessing resource values and threats, integrate numerous disparate datasets describing the varied characteristics of the study area, and display the results of the assessment in a map format that is understandable. The model provides TPL with a powerful and flexible tool for conducting the Science Assessment as well as for designing conservation solutions in Phase II of the *Initiative*.

2. RESOURCE VALUES IN THE SIERRA CHECKERBOARD REGION

The study area for the *Sierra Checkerboard Initiative* represents a geographic sample of the myriad resource values in the Sierra Nevada. This assessment focuses on a subset of these values—biodiversity, mature forest connectivity, and passive recreation. Attributes of these values are summarized in this section to establish the context for the Science Assessment.

Biodiversity

The Sierra Nevada range was formed over the last 5 million years during a period of mountain building that occurred throughout California (Wakabayashi and Sawyer 2001). The Sierra is a massive block of ancient granitic rock uplifted as a result of the enormous tectonic forces that shaped the landscape of the western U.S. The range includes a diversity of localized geologic formations. Formation of the Sierra was a profound event that dramatically altered topography, changed regional climate patterns, and produced local latitudinal and elevational gradients of temperature and precipitation (Stine 1996). Lineages of ancestral species responded by evolving to fill niches created by these alterations. Global climate change and extensive glaciation in the mountain peaks further drove the movement and evolution of Sierra flora and fauna. Over the last 10,000 years, Native Americans actively managed Sierran habitats, using tools such as fire to meet their societal needs (Anderson and Moratto 1996). The diversity of biological resources in the Sierra—its *biodiversity*—is a product of this long, dynamic history. The attributes of Sierran biodiversity and the ecological and evolutionary processes that sustain them are a major focus of TPL's *Sierra Checkerboard Initiative*.

Biogeographic patterns

Biogeography is the study of how plants and animals are distributed on earth and the factors that influence those distribution patterns. The biogeography of the Sierra Nevada is a product of millennia of climatic, geologic, and evolutionary dynamics. The result of this dynamic history is a biologically unique region, distinct from other regions of California and the world. Biogeographic patterns are often organized into hierarchical categories that become increasingly distinct at each finer level. For example, the flora of the study area has been organized into a four-tiered hierarchy consisting of provinces (California Floristic Province), regions (Sierra Nevada), subregions (High Sierra Nevada), and districts (Northern High Sierra Nevada) (Hickman 1996).

The California Floristic Province is one of the world's 34 global biodiversity hotspots (Conservation International 2005). Biodiversity hotspots are areas supporting high concentrations of species, particularly endemic species that are found nowhere else on Earth. Although these hotspots comprise less than 2.3% of the Earth's vegetated land surface, an estimated 50% of the world's plant species and 42% of its animal species are endemic to these 34 hotspots (Conservation International 2005). Approximately 44% of plant and vertebrate species of the California Floristic Province are endemic (Myers et al. 2000). Within the California Floristic Province, the Sierra Nevada region is recognized as a center of plant endemism, supporting high numbers of both relict and newly evolved species (Raven and Axelrod 1995). The Sierra supports over 50% of California's flora and, for its size, is predicted to be the most floristically diverse area in North America (Shevock 1996). Thus, the Sierra is a globally unique region, making its protection critically important.

The High Sierra Nevada subregion supports mixed evergreen and coniferous forests, which grade into oak woodland communities at lower elevations of the west slope (Sierran Foothills subregion) and into sagebrush steppe on the east slope (Great Basin Province) (Rundel et al. 1995, Young et al. 1995, Hickman 1996, Barbour and Minnich 2000). The diverse vegetation communities in the study area can be grouped into oak woodlands, grasslands and meadows, riparian communities and wetlands (including marshes and fens), various shrub and chaparral communities, and a number of conifer communities (Figure 2). Major forest and woodland communities, as defined by Barbour and Minnich (2000), tend to be distributed with respect to elevation, with forest types intermixing depending on topography, moisture, and substrate. Within the study area, mixed evergreen forests support canyon live oak (*Quercus chrysolepis*), black oak (*Quercus kelloggii*), and Douglas-fir (*Pseudotsuga menziesii*). Mid-montane forests are dominated by ponderosa pine (*Pinus ponderosa*), white fir (*Abies concolor*), sugar pine (*Pinus lambertina*), and incense cedar (*Calocedrus decurrens*). Upper montane forests are dominated by red fir (*Abies magnifica*) and lodgepole pine (*Pinus contorta* ssp. *murrayana*). Subalpine woodlands are comprised of white pine (*Pinus monticola*) and whitebark pine (*Pinus albicaulis*), while Sierran east-side forests are dominated by Jeffrey pine (*Pinus jeffreyi*). The diversity of plant associations in the Sierra increases when considering locally unique groupings of species that vary geographically within the Sierra Nevada region (Walker 1992, Sawyer and Keeler-Wolf 1995).

The vegetation associations in the Sierra provide habitat for a rich assortment of wildlife, including a variety of endemic species (Erman 1996, Graber 1996, Jennings 1996, Kimsey 1996, Moyle et al. 1996). The Sierra Nevada supports approximately 401 terrestrial vertebrate species or 62% of the vertebrate species in California (Graber 1996). However, the genetic diversity of Sierran flora and fauna can be overlooked by simply counting numbers of species (Rogers et al. 1996). An increasing body of research demonstrates significant regional genetic variation within Sierran taxa, variation that is the stuff of evolution (e.g., Tan and Wake 1995, Wake 1997, Rodriguez-Robles et al. 1999, Shaffer et al. 2000, Rodriguez-Robles et al. 2001, Jockusch and Wake 2002). The genetic structure of Sierran biological resources is a product of the dynamics of the California landscape; in fact, the formation of the Sierra Nevada range is considered a driving force in the evolution of many taxa in California (Calsbeek et al. 2003).

Watersheds and aquatic resources

The water resources of the Sierra Nevada account for about 28% of California's total runoff, provide an important part of the State's developed water supply, and support a rich array of

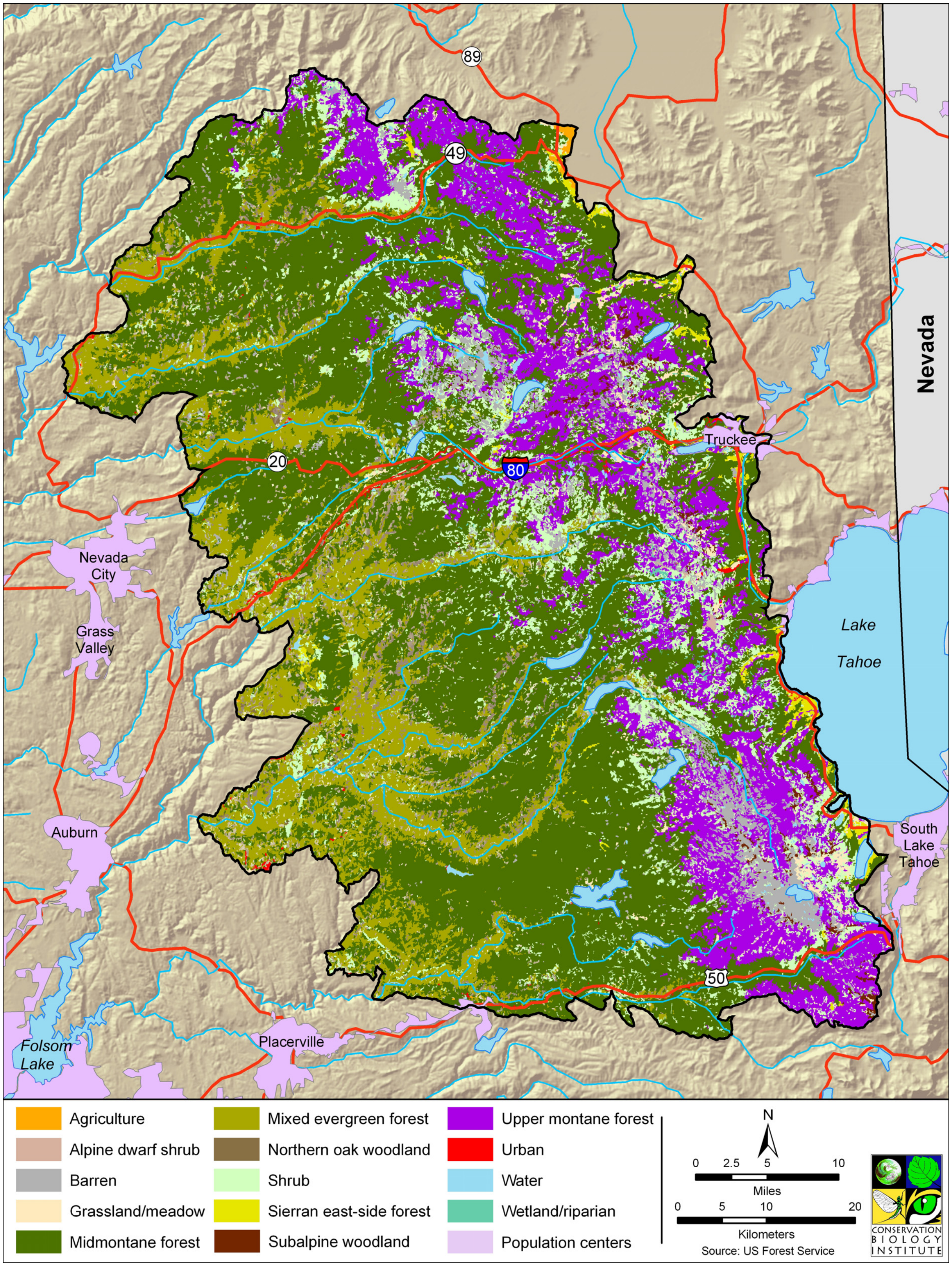

Figure 2—Major groupings of vegetation communities in the *Sierra Checkerboard Initiative* study area.

aquatic habitat types and species (Kattelmann 1996, Moyle 1996). The study area includes portions of the Yuba and American river watersheds and smaller portions of five other watershed basins (Figure 3). Riparian corridors sustain a disproportionately high level of biodiversity relative to the area of the landscape they occupy (NRC 2002), supporting both productive habitat for diverse species and critical environmental processes (Naiman et al. 1993). When other aquatic and wetland systems such as springs, peatlands, and fishless lakes and ponds are also considered, the cumulative biodiversity of aquatic and wetland systems in the study area is truly exceptional (Erman 1996, Moyle 1996).

The water resources of the Sierra support most of the water used by California's cities, agriculture, industry, and hydroelectric facilities (Kattelmann 1996). As a result of the continued growth of these users, the resource values of Sierran aquatic and wetland habitats are increasingly threatened (Moyle 1996). Land use changes, impoundments, and diversions alter riverine flow regimes (Poff et al. 1997) and water quality (Paul and Meyer 2001). These, in turn, affect the structure of aquatic and riparian communities. Non-riverine systems such as lakes, springs, and fens are also extremely sensitive to human impacts (Erman 1996, Jennings 1996, Moyle 1996). Protecting the integrity of watersheds where natural environmental processes still function and restoring basins to enhance natural functions are critical to the conservation of aquatic resources and fundamental to the conservation objectives of the *Sierra Checkerboard Initiative*.

Late-successional forests

Succession refers to the normal process of change in the species and structural composition of plant communities as they age. Early-successional forest communities first establish after creation of an opening in the forest; they are open in structure and dominated by herbs, shrubs, and young trees. As a community ages into later successional stages, it becomes dominated by larger trees and a closed canopy. Late-successional forests, which develop over hundreds of years, are characterized by large-diameter, old growth trees, snags, and down logs. We use the term *mature forests* in this assessment to distinguish forest stands that are younger than true late-successional forests, but possess characteristics (e.g., larger tree diameters and more closed canopies) that are important for species that rely on late-successional forests.

Late-successional forests provide many important ecosystem functions that also benefit human society (Franklin and Fites-Kaufmann 1996). The concern over the status of these forests was the impetus for the Congressional appropriation for the Sierra Nevada Ecosystem Project (SNEP), designed to assess the distribution and condition of late-successional/old-growth forests (LSOG) in the Sierra Nevada (SNEP 1996). Elements of late-successional forest structure are important for wildlife habitat quality in the Sierra (Graber 1996) and are considered crucial for conservation in forests throughout the world (Lindenmayer and Franklin 2002). Commercially important forest types in the Sierra Nevada, such as west-side mixed conifer (mid-montane forests) and Sierran east-side forests, appear to be particularly deficient in late-successional forest characteristics relative to their pre-settlement conditions (Franklin and Fites-Kaufmann 1996).

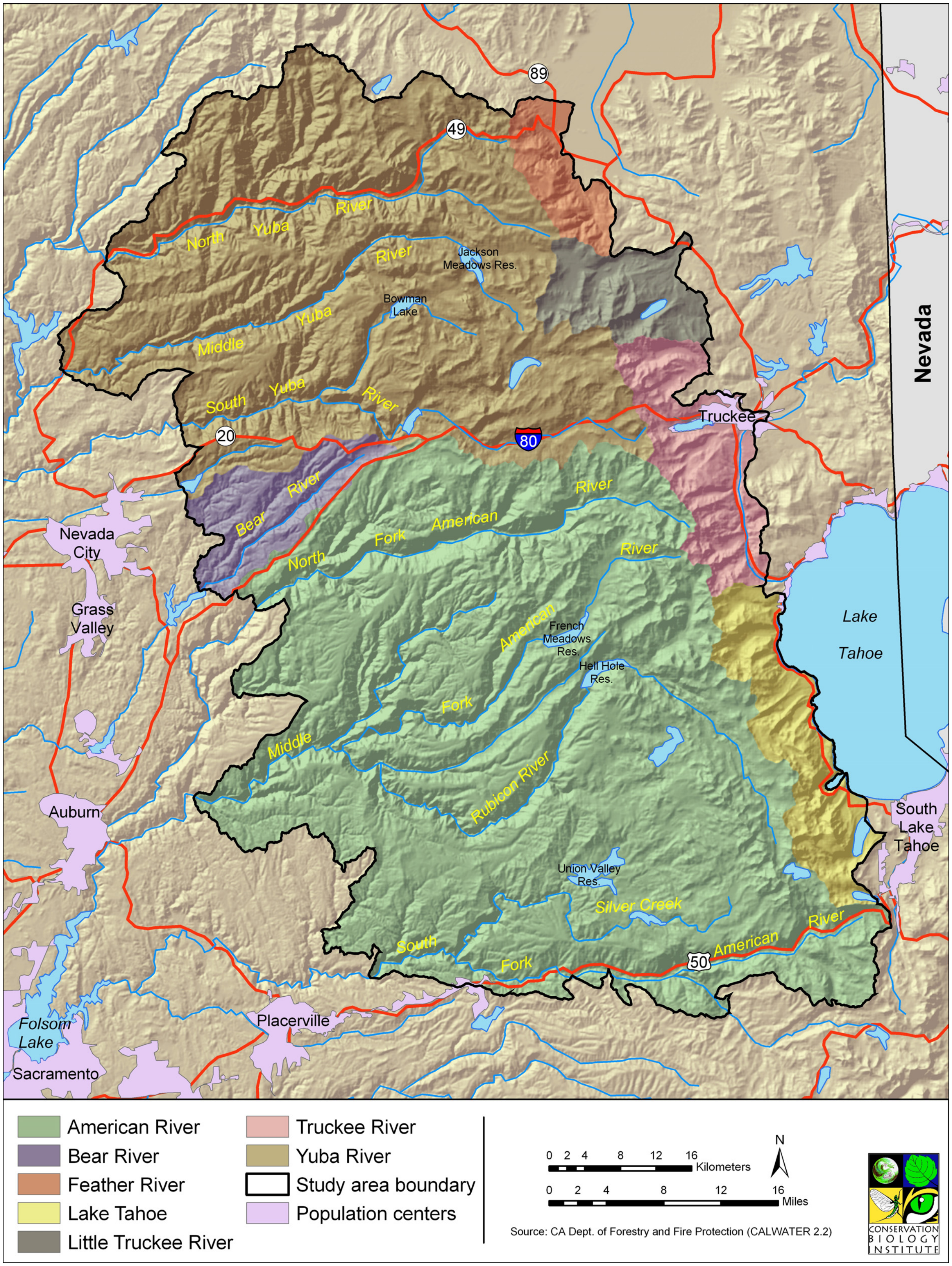

Figure 3—Major watershed units within the *Sierra Checkerboard Initiative* study area.

Evidence suggests that the current distribution of late-successional forests in the Sierra Nevada is much less extensive than prior to western settlement (McKelvey and Johnston 1992, Franklin and Fites-Kaufmann 1996). However, forest structure in the Sierra is a complex, fine-grained mosaic (Franklin and Fites-Kaufmann 1996), with a mix of tree sizes and structural characteristics within a single stand. The overall distribution of late-successional forests in the study area is difficult to determine (Franklin and Fites-Kaufmann 1996, Langley 1996), as different approaches to quantifying their distribution yield varying results (Davis 1996). The SNEP approach (Franklin and Fites-Kaufmann 1996), which mapped and ranked forests on public lands based on their relative contribution to LSOG functions, may be the most appropriate way to display late-successional forest function in the study area. However, the relatively gross scale of the SNEP approach, and the lack of ranking on private lands, does not lend itself to the level of analysis for this Science Assessment (see Section 4).

Based on the SNEP approach, the study area supports little forest area with *very high* contribution to LSOG function—2% of the study area, which is largely restricted to the Lavezzola Creek basin of the North Yuba River watershed (Figure 4). The majority of the study area (68%) is comprised of forests with no contribution (*none*), *very low* contribution, or *low* contribution to LSOG function. However, relatively significant forest areas with moderate (19%) and high (11%) contribution to LSOG function are scattered throughout the study area; these may serve as focal areas to manage for enhancing future late-successional functions.

Special status resources

The Sierra Nevada supports a variety of special status species, with over 250 vascular and non-vascular plant species considered rare (Shevock 1996) and 69 vertebrate species listed or otherwise considered sensitive by state or federal government agencies (Graber 1996). The California Natural Diversity Database (CNDDB 2005) and SBI (2004) record 98 taxa in the study area that are listed as threatened or endangered, are candidates for listing, or have global or state heritage rankings (Attachment 1). This is likely an underestimate of the richness of rare species in the study area, because much of the study area has not been surveyed for special status species or the results of these surveys are not always recorded in publicly available databases.

Due to its central location within the Sierra Nevada, the study area is geographically important for maintaining the long-term viability of many sensitive species. For example, Beck and Gould (1992) present California spotted owl (*Strix occidentalis occidentalis*) survey data showing that the Tahoe and Eldorado National Forests supported 28% of the known pairs of this species in the Sierra Nevada between 1970 and 1991. Thus, the study area, which lies at the heart of these two National Forests, supports a significant fraction of the Sierran population of this species. Beck and Gould also identified two areas of concern for the California spotted owl within the study area, partially because of the checkerboard land ownership patterns which they consider to present habitat fragmentation risks for spotted owls.

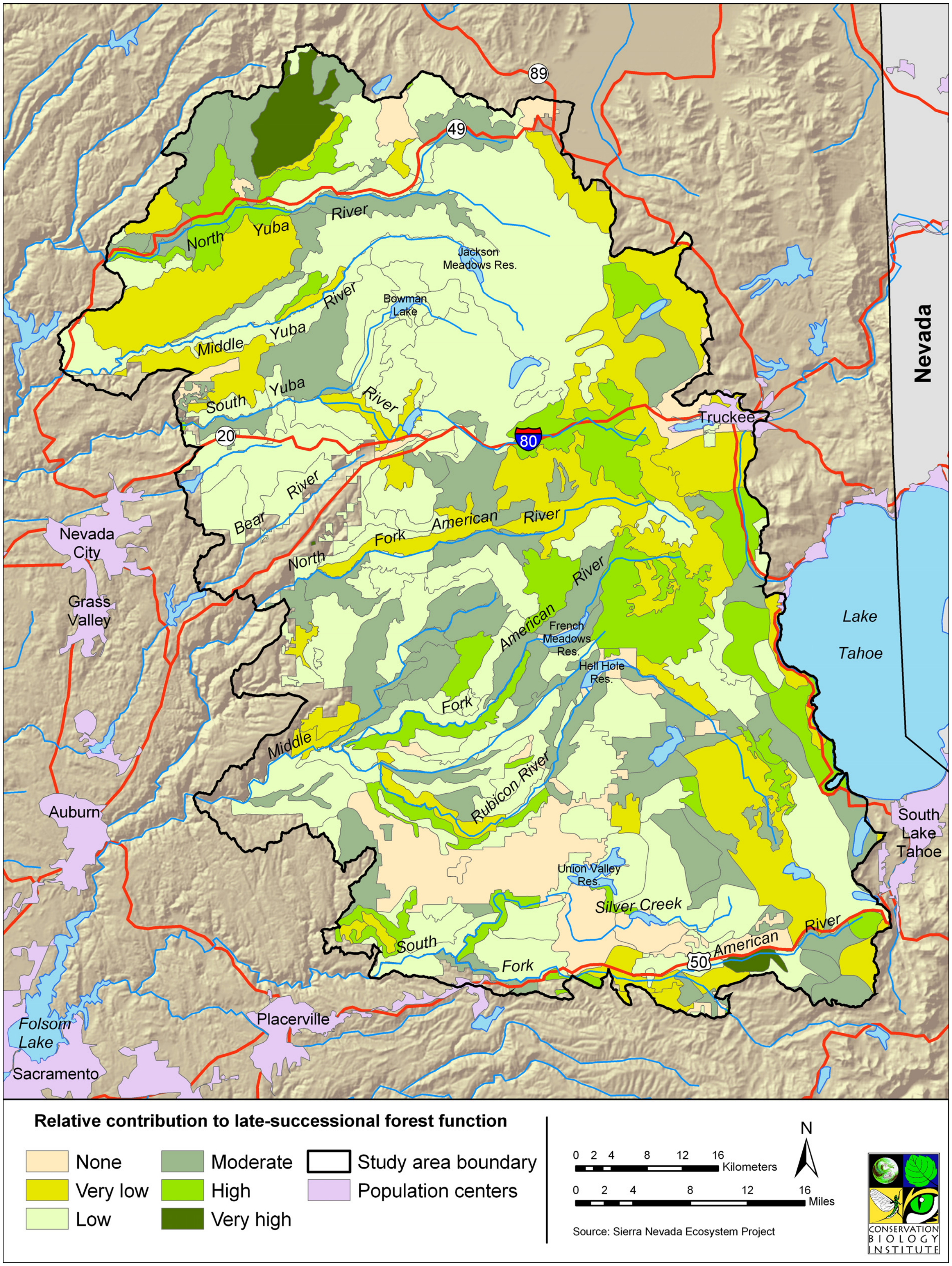

Figure 4—Ranking of forests on public lands by their relative contribution to late-successional forest functions (Franklin and Fites-Kaufmann 1996).

Mature Forest Connectivity

Conservationists are increasingly interested in conserving not only existing biological diversity but the process of evolution itself (Moritz 2002, Spector 2002). Maintaining the connectivity of the Sierran landscape is thus an important regional conservation objective because species need large, interconnected landscapes to respond to environmental changes through evolutionary innovation. Maintaining habitat connectivity is particularly important given the anticipated changes in environmental conditions and habitat distributions resulting from global climate changes. Paleoecological data documenting prehistoric conditions indicate that biogeographic zonation in the Sierra Nevada has shifted along elevational gradients in response to warming and cooling trends (Woolfenden 1996). For example, during prehistoric warming periods, the Sierran treeline migrated to higher elevations (Stine 1996, Woolfenden 1996). Climate models are projecting warmer climates in the future, which may result in drying vegetation communities, increased frequency of severe fires, and elevational shifts in forest composition and structure (USGS 2005).

Ensuring that organisms can disperse across the landscape is necessary for maintaining population dynamics and gene flow. For example, the fisher (*Martes pennanti*) is present in the northern and southern Sierra Nevada but is absent from the mid-montane forests in the study area, presumably as a result of habitat modifications and heavy historic trapping (Zielinski et al. 1995, Zielinski et al. 2000). Thus, unless there is multi-generational dispersal of fishers through the study area, the northern and southern populations will remain genetically isolated from each other, exposing the southern population to a greater risk of extinction (Zielinski et al. in press). Because of the distances involved, establishing a healthy population of fishers in the study area is requisite to connecting the northern and southern populations. Maintaining existing habitat connectivity within forest types and managing fragmented areas to improve connectivity are crucial for habitat specialists such as the fisher.

Many wildlife species migrate seasonally between habitats or elevations in response to changing weather, so habitat connectivity across elevations is critical for facilitating these movements. Much of the late-successional mixed coniferous forests, lower elevation woodlands and shrub communities, stream and riparian habitats, and, potentially, more open, early-successional forests in the study area are vulnerable to alterations from exurban development, impoundments and water diversions, timber harvest, and fire suppression and catastrophic fire. Therefore, dispersal of species that depend on these habitats may be compromised (Graber 1996). These issues emphasize the need to manage habitats to support healthy populations and allow adequate dispersal of individual wildlife species at a landscape scale.

Passive Recreation

The Sierra Nevada's scenic beauty is world-renowned, and recreation is a significant activity for residents and non-residents alike. Recreation on public land alone accounts for 50-60 million recreational visitor days (RVDs) per year (Duane 1996a). Recreation on private land has not been quantified, but is estimated at an additional 3-4 million RVDs per year (Duane 1996a). The majority of recreation on public land occurs on land administered by the U.S. Forest Service, which in the study area includes portions of the Tahoe National Forest, Eldorado National Forest, and Lake Tahoe Basin Management Unit (Figure 5). As the populations of California and Nevada continue to grow, particularly in counties within and adjacent to the Sierra, the demand for recreation and the potential for conflict between recreation and other land uses are likely to increase (Duane 1996a).

Passive recreational activities, such as camping, hiking, horseback riding, bicycling, and nature study, account for a large proportion of recreation in the Sierra (Duane 1996a). Recreationists are generally seeking the outstanding natural features of the Sierra such as its lakes and streams, dramatic granitic landforms, old-growth forests, meadows, and roadless areas, which are embodied in designated areas of Wilderness, Wild and Scenic Rivers, and state parks, and which are accessible by trails such as the Pacific Crest Trail. The demand for recreation in the study area is high because of the diversity of recreational opportunities, ski resorts, Lake Tahoe, and easy access from nearby population centers. The combined annual RVDs of the Tahoe National Forest, Eldorado National Forest, and Lake Tahoe Basin Management Unit accounted for 34% of the total RVDs of the national forests in the Sierra between 1987 and 1993 (Duane 1996a). The study area will continue to be important for meeting future recreational demand in the Sierra, which is anticipated to increase with population growth.

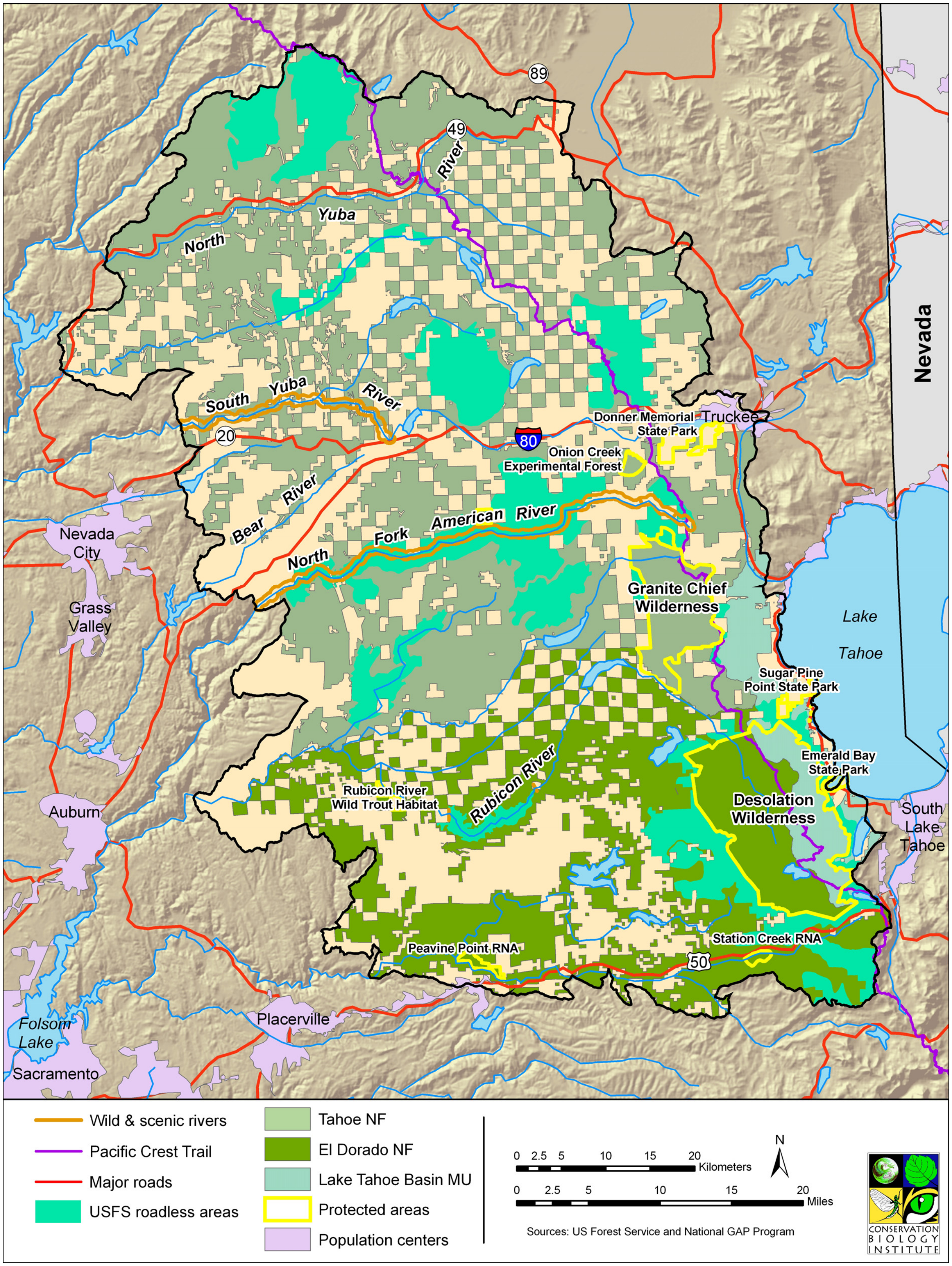

Figure 5—Examples of passive recreational opportunities in the *Sierra Checkerboard Initiative* study area: public lands, protected areas, and the Pacific Crest Trail.

3. THREATS TO RESOURCE VALUES

The resource values of the Sierra Nevada have been increasingly threatened by human activities over the last 150 years. The *Sierra Checkerboard Initiative* focuses on three major areas—exurban development, management incompatible with conservation of mature forests, and unnaturally severe fire regimes. Obviously, there are other threats to the region, including global warming, invasive plant species, and others, but we have elected to focus on these three threats in the Science Assessment because of their immediacy, our ability to understand their patterns, and the ability of TPL and its partners to craft conservation strategies that might ameliorate these threats.

Exurban Development

The Sierra Nevada conjures up images of scenic vistas, rugged terrain, and vast expanses of natural open space. However, increasing human settlement in the Sierra is having a profound impact on these values (Duane 1996b). While the study area represents less than 15% of the acreage of the Sierra Nevada, the population in and around the study area represented over 40% of the Sierra Nevada total in 1990 (Duane 1999). Furthermore, the California Department of Finance projected a population growth rate of 179% between 1990 and 2040 in the western portion of this area (in Duane 1996b). Much of this growth is associated with low-density exurban residential development, although there is higher density suburban development associated with denser population centers along the western and eastern margins of the study area (Figure 6). Population growth appears to be along major transportation corridors such as Highway 20, Highway 49, Highway 50, and Interstate 80.

Threats to the ecological integrity and resource values of the study area, associated with urbanization and road building, are cited throughout the SNEP resource assessments, e.g., for rare and endemic plants (Shevock 1996), butterflies (Shapiro 1996), aquatic invertebrates (Erman 1996), fish (Moyle 1996), amphibians (Jennings 1996), terrestrial vertebrates (Graber 1996), genetic diversity (Rogers et al. 1996), water resources (Kattelmann 1996), watershed integrity (Moyle and Randall 1996), and riparian habitat (Kondolf et al. 1996). The largest threat to biodiversity in California is considered to be loss and fragmentation of habitat (Stein et al. 2000). Urban sprawl, defined as low-density, automobile-dependent development in natural areas outside of cities and towns, imperils 65% of species listed as Threatened or Endangered in California (Czech et al. 2001).

The indirect effects of development on natural resources are more insidious, causing an array of adverse edge effects such as altered microclimates (Saunders et al. 1991, Pickett et al. 2001) and fire regimes (Keeley and Fotheringham 2001), increased invasions by exotic plant and animal species (Suarez et al. 1998, Brothers and Spingarn 1992), changes in vegetation structure (McBride et al. 1996, Pickett et al. 2001), loss of top predators and changes in inter-specific interactions (Bolger et al. 1991, Crooks 2002), and altered species population dynamics (Soulé et al. 1988). Road networks associated with human development can have broad geographic

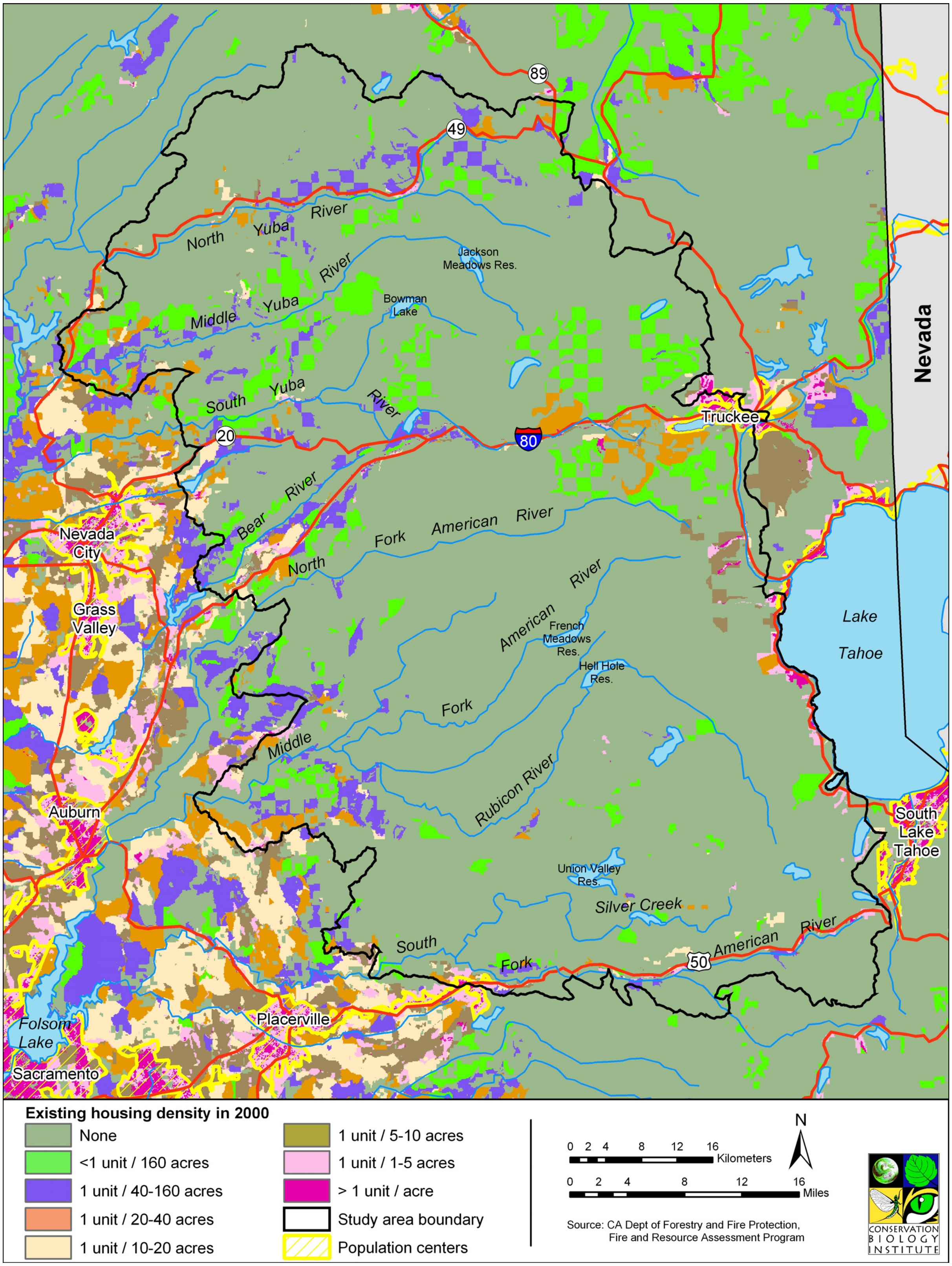

Figure 6—Existing housing density in the *Sierra Checkerboard Initiative* study area.

impacts, including increased sediment and pollution loads and water quality degradation (Duane 1996b, Kattelmann 1996), disrupted wildlife migration patterns, and increased mortality via roadkill (Beier 1995, Trombulak and Frissell 2000).

The watersheds of the Sierra Nevada deliver 65% of the water supply for California residents (Timmer 2003). The quality of this supply has a direct relationship to land use in the central Sierra. The loss of vegetative cover and increase in area of impervious surfaces as a result of road and housing development contribute to an increase in runoff and pollutant loading into waterways. The effects of increasing urban pollutant and sediment loads, along with increasing instream temperatures associated with the loss of riparian habitat, can negatively affect aquatic ecosystems and the sustainability of native fish populations and other aquatic species. For example, cold-water fishes such as trout face competition from nonnative warm-water species that are more tolerant of human-altered conditions. At the same time, reduction of vegetative cover and increase in the area of impervious surfaces could diminish groundwater recharge from precipitation, negatively affecting the quantity and quality of local groundwater and surface water supplies.

Natural features valued by recreationists, such as lakes and streams, scenic vistas, old-growth forests, meadows, and roadless areas, are also affected by exurban development. Proximity of development to designated areas of Wilderness, Wild and Scenic Rivers, state parks, roadless areas, and trails through the national forests can conflict with aesthetic values and potentially restrict access. In addition, low-density residential development triggers fuel management and fire risk reduction strategies to protect human life and property at the wildland-urban interface (e.g., USFS 2004). These management practices can conflict with measures aimed at conserving late-successional forest functions, as discussed further below.

Management Incompatible with Conservation of Late-Successional Forests

Conservation of late-successional forests of the Sierra Nevada is generally accepted as an important regional conservation objective by public land management agencies. Maintenance of *(1) sufficient, well-distributed, high-quality LSOG forests for the organisms and functions associated with such systems; and (2) conditions that facilitate connectivity for organisms moving between LSOG forests areas* were specific objectives of the SNEP Science Team in developing management strategies for the Sierra Nevada (Franklin and Fites-Kaufmann 1996). The *Sierra Nevada Forest Plan Amendment* (SNFPA) intended to provide regionally consistent direction for old forest conservation (USFS 2004). California Forest Practices Rules strive to protect late-successional forest acreages and connectivity. Improving contributions to LSOG functions and the connectivity of mature forest habitats are also objectives of the *Sierra Checkerboard Initiative*. However, some consider current forest management approaches in the study area to be incompatible with these objectives.

The majority of federally administered lands in the Sierra are managed for multiple objectives or uses, including ecosystem values, timber production, and reduced risk of catastrophic fire (USFS 2004). Some of these objectives or uses may conflict with objectives focused on conservation of late-successional forests. For example, the Proposed Action in the *Supplemental Environmental Impact Statement for the SNFPA* (USFS 2004) pursues more aggressive fuel treatments than the 2001 *SNFPA Record of Decision* (USFS 2001), including removal of medium-size trees by the wood products industry to pay for these treatments. While the 2004 *SNFPA Record of Decision* recognizes the need to maintain a viable commercial timber industry as part of the fuel treatment strategy (USFS 2004), the State of California and several conservation organizations have filed a legal challenge to the revised 2004 SNFPA because they consider the 2004 *Record of Decision* to conflict with measures aimed at conserving late-successional forests.

Private lands within Timber Production Zones are under the jurisdiction of the California Department of Forestry and Fire Protection and regulated by the California Forest Practice Rules. According to Menning et al. (1996), the California Forest Practice Rules have fairly narrow definitions of late-successional forest stands and relatively arbitrary standards for maintaining forest patch size and habitat connectivity. Furthermore, Menning et al. (1996) believe some of these rules may actually encourage fragmentation of large, contiguous stands of late-successional forest.

Unnatural Fire Regimes

Fire is a crucial landscape-scale process for maintaining biodiversity in the Sierra Nevada. The Sierran fire regime is somewhat variable and dependent on factors such as elevation, vegetation community type, drought cycles, and topography. There is general agreement that 20th century fire management practices have virtually eliminated low and moderate intensity fires but are unable to eliminate high intensity fires (Skinner and Chang 1996). Thus, woodlands and forests in the Sierra have become dominated by high severity, stand-replacing fires, a fire regime that is outside the natural range of variability for this system (Skinner and Chang 1996). This unnatural fire regime has altered forest structure (Chang 1996), which threatens components of the Sierran ecosystem.

The Fire and Resource Assessment Program (FRAP) of the California Department of Forestry and Fire Protection has predicted and mapped the threat from wildfires (Figure 7a). Fire threat integrates the likelihood of a given area burning and the potential fire behavior or hazard in that area (FRAP 2003). FRAP also compared these wildfire threats (i.e., predicted wildfire characteristics) to historic fire regimes and predicted ecosystem responses. This measure, known as *condition class* (FRAP 2003), ranks the relative risk of losing key ecosystem components from altered fire regimes, with higher ranks representing higher risk (Figure 7b). Fire threat in the study area is, by and large, mapped as moderate, with very high threat along the lower west slope, particularly in the northern two-thirds of the study area. The study area is generally mapped as having a moderate to high condition class or risk of losing key ecosystem components from wildfires. The highest risk areas are on the west slope in the northern two-thirds of the study area.

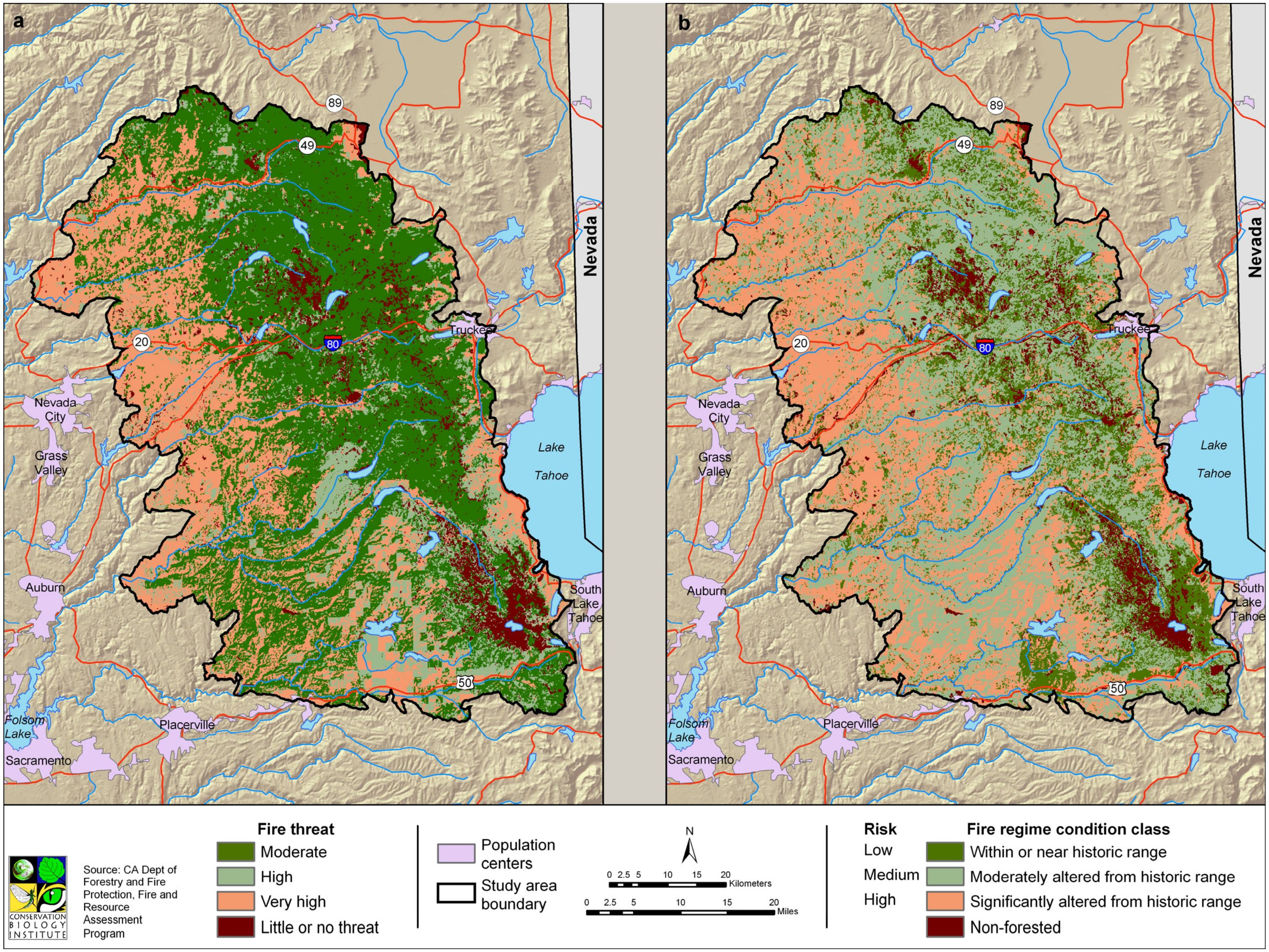

Figure 7—a) Fire threat and b) Condition class and relative risk of losing key ecosystem components due to unnatural fire regimes.

4. INTEGRATING AND ASSESSING INFORMATION

The primary values of interest to the *Sierra Checkerboard Initiative* (Section 2) and the principal threats to these values (Section 3) exhibit complex interrelationships that vary substantially across the large study area. A *systematic* approach is therefore needed to describe and integrate the distribution of resource values and threats across the study area to identify candidate areas for implementing future conservation actions. In addition, a *transparent* approach is key to evaluating and presenting appropriate conservation and management strategies that can be embraced by diverse stakeholders.

This section describes a modeling tool developed for the *Sierra Checkerboard Initiative* to evaluate areas that support high resource values (i.e., biodiversity, mature forest connectivity, and passive recreation opportunities) and exhibit potential threats to these values (i.e., risk of exurban development, risk of management incompatible with conservation of mature forests, and risk from an unnatural fire regime). This tool allowed us to (1) clearly define our conceptual model of the relationships of resource values and threats to the various characteristics of the study area, (2) integrate the extensive database available for the area to assess the contributions of these diverse characteristics to the spatial distribution of resource values and threats, and (3) clearly display the results. The tool provides the systematic and transparent approach required by the *Sierra Checkerboard Initiative*, but also the flexibility to easily update results with new data, visualize in an unbiased manner the distribution of various characteristics that contribute to resource values and threats, and evaluate how alternative conservation strategies may affect the characteristics that contribute to these values and threats.

In Phase I of the *Sierra Checkerboard Initiative*, sites that exhibit both high resource value and high potential threats are identified as *candidates for conservation action*. These results are presented in Section 5. Phase II of the *Sierra Checkerboard Initiative* will use the tool to focus on designing conservation solutions—site-specific strategies and implementation mechanisms to maintain and enhance resource values and reduce threats (Section 6).

Knowledge-based Assessment

Due to the complexity of ecosystems, the relative lack of quantitative information on their dynamics and interdependencies, and the necessarily subjective determinations as to what are *desirable* ecosystem characteristics, it is extremely difficult to develop quantitative models to predict these characteristics. *Fuzzy logic*, a branch of mathematical set theory, allows imprecise information typical of natural resource science to be used in modeling (Reynolds et al. 2000). This knowledge-based reasoning approach allows us to characterize an ecological system in terms of characteristics or conditions (e.g., acres of late-successional forest, numbers of special status species, levels of habitat fragmentation, etc.) and their logical relationships to one another. In consultation with the Science Advisors, we concluded that a fuzzy logic knowledge-based approach would be an appropriate tool for the Science Assessment.

We employed the Ecosystem Management Decision Support (EMDS) System (Reynolds et al. 2002) to evaluate whether an area is a good candidate for conservation action. EMDS is a knowledge-based decision-support software system that incorporates hierarchical fuzzy logic networks, constructed in the NetWeaver knowledge-base engine, into a Geographic Information System (GIS). Our conceptual model for assessing the suitability of a site as a candidate for conservation action was constructed as a fuzzy logic network. The model uses networks connected by logic operators, i.e., *and, or,* and *union* operators, to evaluate the relationships between and among values and threats within the study area, and the relationships and dependencies of characteristics and conditions that we identified as contributing to these values and threats (Figures 8a-8e). A section of land (generally 640 acres) was used as the unit for assessment. We considered this unit to be an appropriate size for this assessment because sections are large enough to integrate meaningful landscape characteristics (such as mosaics of habitat patches, road density, and land cover changes), but also provide an adequate number of units within the study area (2,550 units total) to identify regional patterns in the results. In addition, much of the checkerboard ownership pattern in the study area follows section boundaries.

For example, Figure 8a can be interpreted as follows:

> A *site is a good candidate for conservation action* to the degree that it has both a *threat to resource value* ***and*** a *high resource value*. A site has a *high resource value* to the degree that it has either *high biodiversity value* ***or*** *high mature forest connectivity* ***or*** *high passive recreation value*. A site has a *high threat to resource value* to the degree that it has either *high risk of exurban development* ***or*** *high risk of unnatural fire* ***or*** *high risk of incompatible mature forest management*.

At the terminus of the logic network (Figures 8b, 8c, 8d, 8e) are links to data (identified as rectangles in the logic network diagram) that evaluate the degree to which specific characteristics or conditions postulated in the model are met. [For example, the condition *low development density* (Figure 8b) is evaluated in EMDS using a data set created by FRAP that describes housing density within the study area (Figure 6).] EMDS uses these data to evaluate the strength of evidence for the postulated condition for each analytical unit, with results ranging from +1 to -1, as follows:

- The strength of the evidence is highest (+1).
- The strength of the evidence is lowest (-1).

Using the specific logic operators assigned in the model, the results for each *condition* (ovals in the network diagram) are assessed and combined with the results for all other conditions within the logic network model to assess whether a site is a good candidate for conservation action. An example of how the model derives quantitative results using the different logic operators is provided in the Technical Appendix.

Results are displayed in map form, showing the support for the postulated characteristics or conditions (e.g., the site is a good candidate for implementing a conservation action) of each

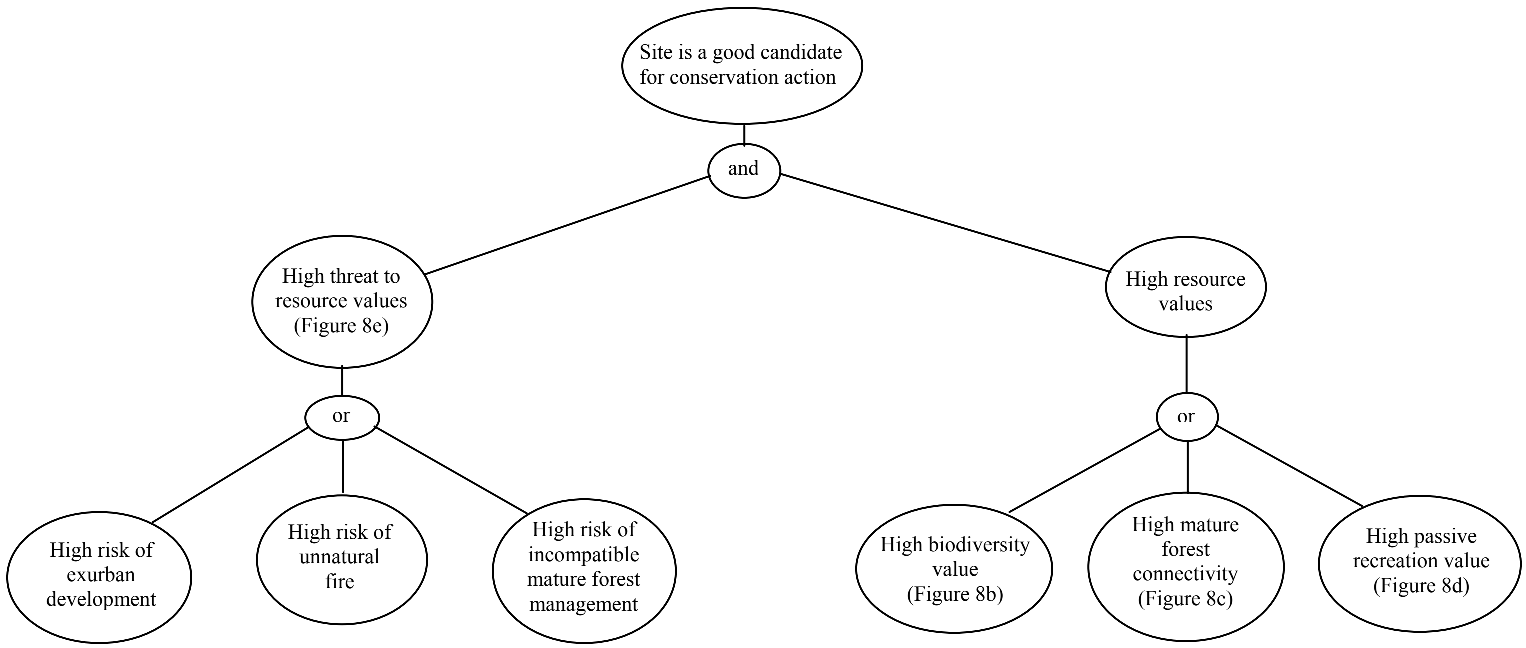

Figure 8a—Fuzzy logic network used to evaluate the relationships between and among various values and threats within the *Sierra Checkerboard Initiative* study area, as a way to prioritize areas as candidates for conserving biodiversity, mature forest connectivity, or passive recreation (i.e., priorities for *conservation actions*).

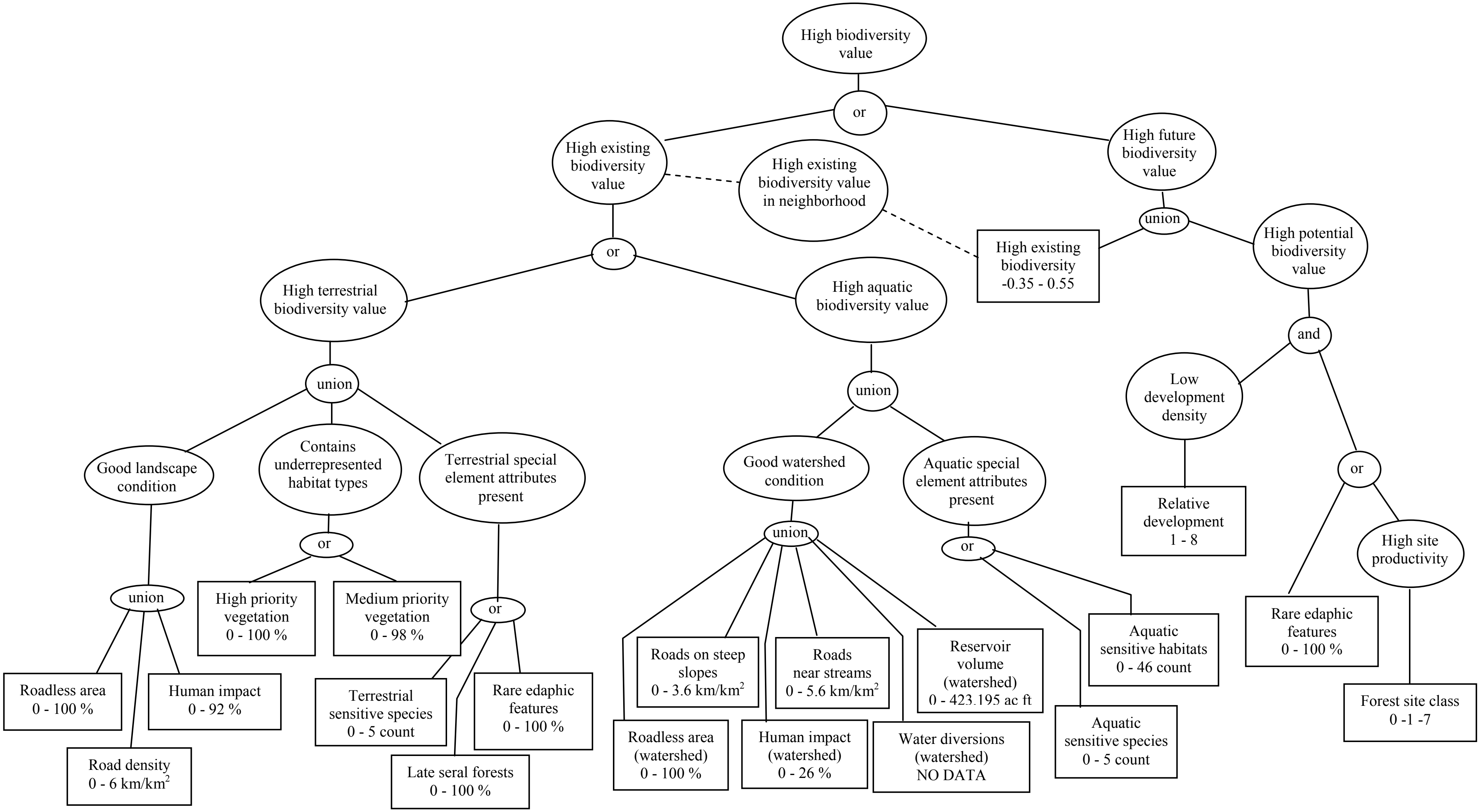

Figure 8b—Fuzzy logic network used to evaluate the relationships between conditions related to biodiversity.

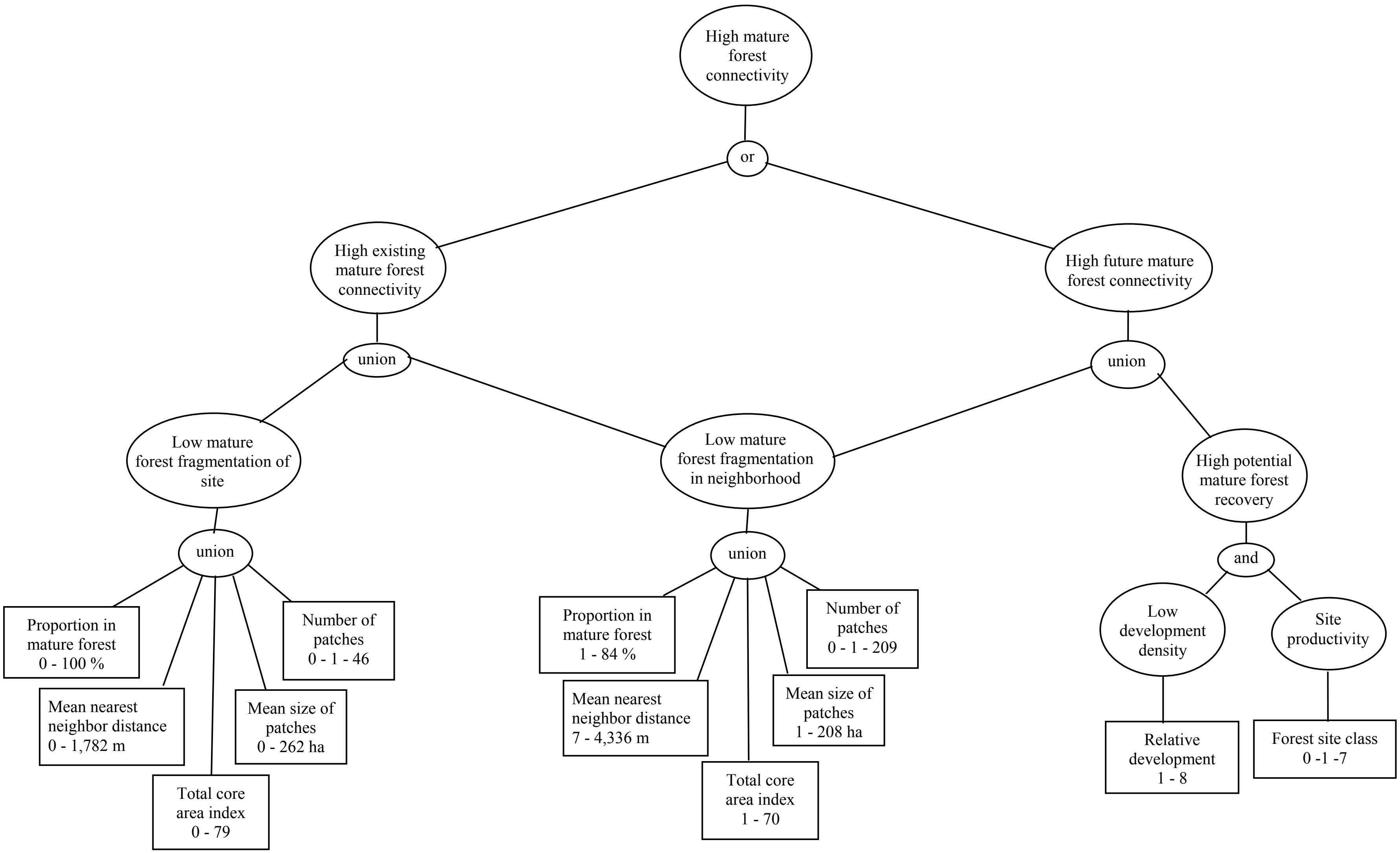

Figure 8c—Fuzzy logic network used to evaluate the relationships between conditions related to mature forest connectivity.

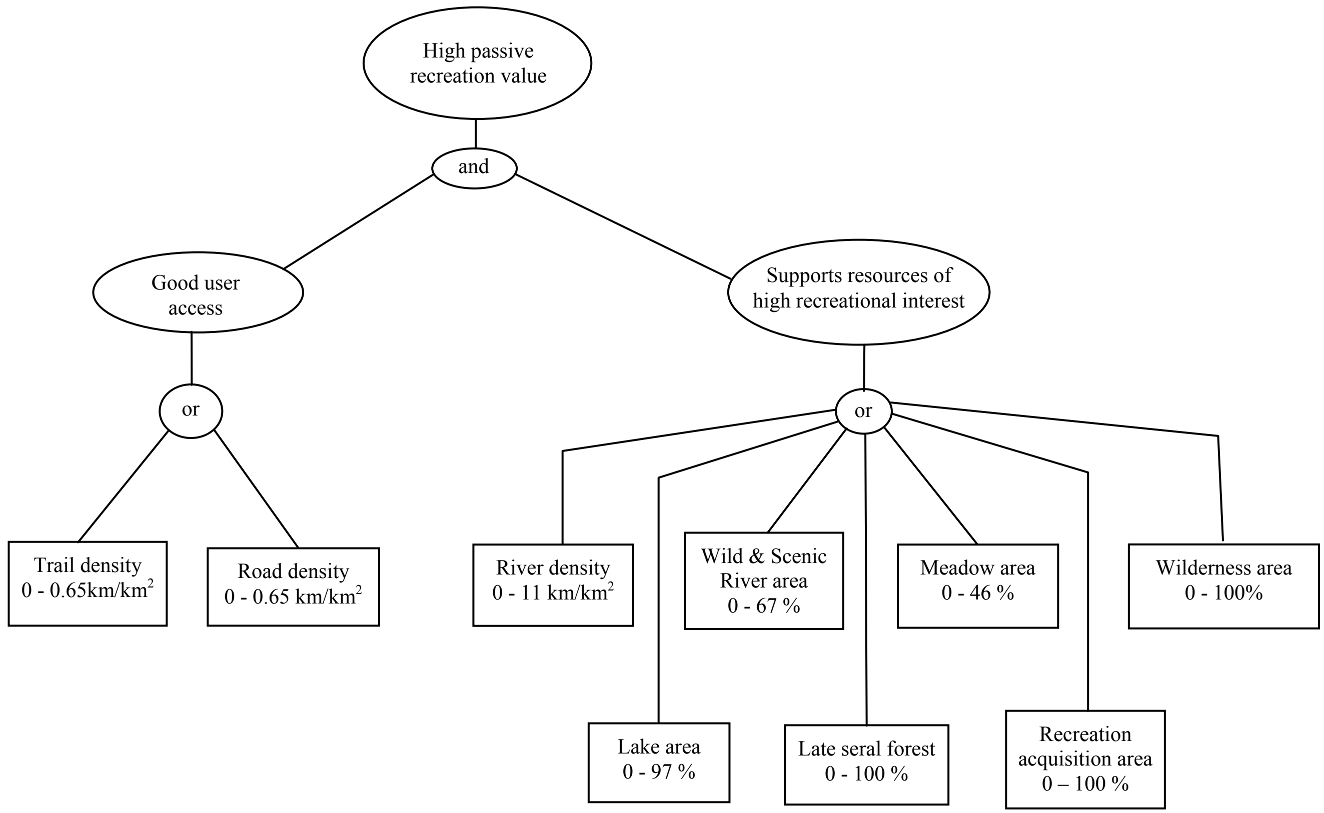

Figure 8d—Fuzzy logic network used to evaluate the relationships between conditions related to passive recreation value.

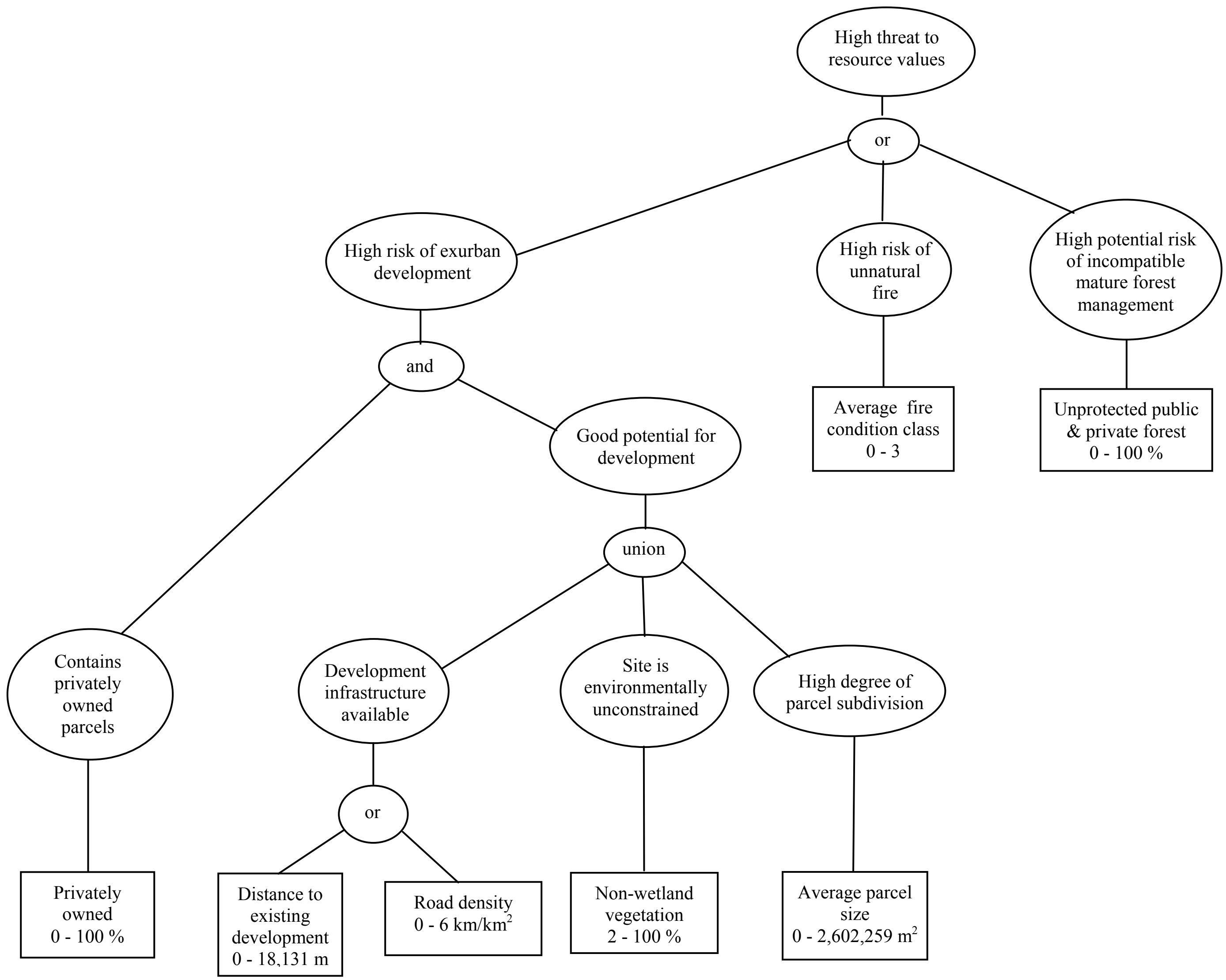

Figure 8e—Fuzzy logic network used to evaluate the relationships between conditions related to threats to resources values.

analytical unit (i.e., sections of land) in a series of colors ranging from dark green (relatively supported or high) to dark orange (relatively unsupported or low). These colors actually represent a continuous, relative scale that has been broken into the seven categories shown in the figures, using natural breaks in the distribution of EMDS results. The same color class on different maps typically represents different ranges of EMDS results (e.g., dark green represents the highest EMDS result regardless of its absolute value).

While the logic model is a powerful tool, it is important to emphasize that these results are specific to the model that was formulated for the Science Assessment. The results indicate the *relative* support for the postulated characteristic or condition and *not* an absolute value or judgment of good or bad, high or low, etc. In the Phase I Science Assessment, the EMDS logic model is used to evaluate the characteristics and suitability for future conservation actions. The logic model also provides a tool that will be used for developing, comparing, and prioritizing site-specific conservation actions in Phase II of the *Sierra Checkerboard Initiative* (Section 6).

Data Sources and Limitations

Details of the technical approach of the Science Assessment, including fuzzy logic model formulation, EMDS analysis, and results, are provided in the Technical Appendix (on CD in the back pocket of this report). The data sets used in the EMDS analysis, their source, and whether/how they were manipulated are described in the Annotated Data List for the *Sierra Checkerboard Initiative* Science Assessment, also in the Technical Appendix. The logic network in the Technical Appendix allows the user to access all maps of the EMDS results and obtain information about the datasets used in each portion of the assessment. The Technical Appendix can also be accessed at:

http://www.consbio.org/cbi/metadata/sierra_checkerboard/technical_appendix.htm

In some instances, the analysis was affected by available data and resolution. For example, the vegetation data used in the Science Assessment were derived from two sources: (1) the U.S. Forest Service Region 5 Remote Sensing Laboratory's existing vegetation database (CALVEG), and (2) vegetation data developed by the Tahoe National Forest (TNF). Both data sets provide information on vegetation type, size structure, and density of forests, but were derived using different techniques at different points in time. The CALVEG database includes refined tree size data only for the Eldorado National Forest (ENF), reflecting additional ground-truthing conducted at ENF's request. This resulted in an obvious discontinuity in forest size structure at the ENF administrative boundary. In addition, TNF staff consider their data to be more accurate than the CALVEG data within the TNF. Therefore, we elected to use the TNF data where it existed and the CALVEG data for areas outside the TNF. This resulted in a composite data set, with inconsistent mapping of some attributes, particularly tree size, across administrative boundaries of the National Forests.

We used the California Wildlife Habitat Relationships (WHR) size and cover attributes of the composite data set described above (CALVEG and TNF data) to identify areas contributing to late-successional forest functions and values in the study area. As discussed previously, we believe that the SNEP LSOG database, which maps contributions to late-successional forest function, is probably the most suitable data for assessing distribution of late-successional forests, but is at a scale too coarse for the EMDS analysis. For analyses of special terrestrial elements and resources of recreational interest, we wanted to target areas of highest contribution to late-successional forest functions and values. For special terrestrial elements and resources of recreational interest, we used only WHR size classes 5 and 6 (trees >24 in. diameter) and identified these areas as *late seral forests* to distinguish them from the SNEP late-successional forest mapping.

In the analysis of connectivity, we wanted to expand the forest size classes included in the analysis because stands of smaller diameter trees can provide significant connectivity functions even for species associated with older forests. For use in connectivity analyses, we used forests with the following WHR attributes, which were defined as *mature forests*:

- WHR size class 4 (trees 11-24 in. diameter) with WHR cover class >40%, and
- WHR size classes 5 and 6 (trees >24 in. diameter)

However, the 11 in. lower boundary of the mature forest size class is lower than we would have preferred for this analysis. For example, some research on California spotted owls has suggested that this species may preferentially use conifer trees greater than 20 in. diameter (Verner et al. 1992).

5. IDENTIFYING CANDIDATE AREAS FOR CONSERVATION ACTION

The goal of the *Sierra Checkerboard Initiative* is to create a more sustainable and efficient land use and management pattern for the central Sierra by implementing conservation actions such as management agreements, conservation easements, land exchanges, and land acquisition. The objective of the Phase I Science Assessment is to identify areas that are candidates for implementing these future conservation actions, which will be considered in more detail in Phase II of the *Sierra Checkerboard Initiative*. As discussed in Section 4, candidate areas for conservation action have two primary characteristics:

1. They support attributes contributing to biodiversity, mature forest connectivity, or passive recreation value; and
2. These resource values are threatened principally by exurban development, management incompatible with conservation of late-successional forests, or unnatural fire regimes.

The relative extent to which sections of land in the study area support these two conditions is presented in Figure 9 as seven categories along a continuous scale, from most suitable (higher support for both conditions) to least suitable (lower support for both conditions). Therefore, areas ranked as most suitable candidates for conservation action (Figure 9) are those that support relatively higher resource values (Figure 10) and relatively higher threats to resources (Figure 11); these highest rankings are shown in the darkest shade of green. Areas ranked as least suitable have relatively lower resource values and relatively lower threats; these lowest rankings are shown in the darkest shade of orange or brown. The rankings are *relative*—i.e., the lowest rankings do not imply that a site has no resource value, no threat, or no merit for implementing conservation actions, but rather the rankings are merely the lowest along the continuum of results produced by the model.

Figure 12 shows the percentage of the study area falling within each of the seven relative suitability categories. About 60% of the study area falls within the three highest suitability categories, with a majority (54%) of these higher suitability areas located on public land. Figures 13-18 (at the end of this section) show the conditions contributing to the results shown in Figures 10 and 11 and, ultimately, to the rankings for conservation action (Figure 9). These conditions include biodiversity value (Figure 13), mature forest connectivity (Figure 14), passive recreation value (Figure 15), risk of exurban development (Figure 16), risk of unnatural fire regimes (Figure 17), and risk of management incompatible with conservation of late-successional forests (Figure 18). The dependencies of the conservation action rankings on these conditions, and the interdependencies of these conditions themselves, are shown in the logic network (Figure 8a-8e). Details of the logic network, the definition of the various conditions and characteristics that contribute to the conservation action rankings, and the data sets used to assess the conditions and characteristics are described further in the Technical Appendix. Table 1 summarizes the conditions and characteristics used in the logic model.

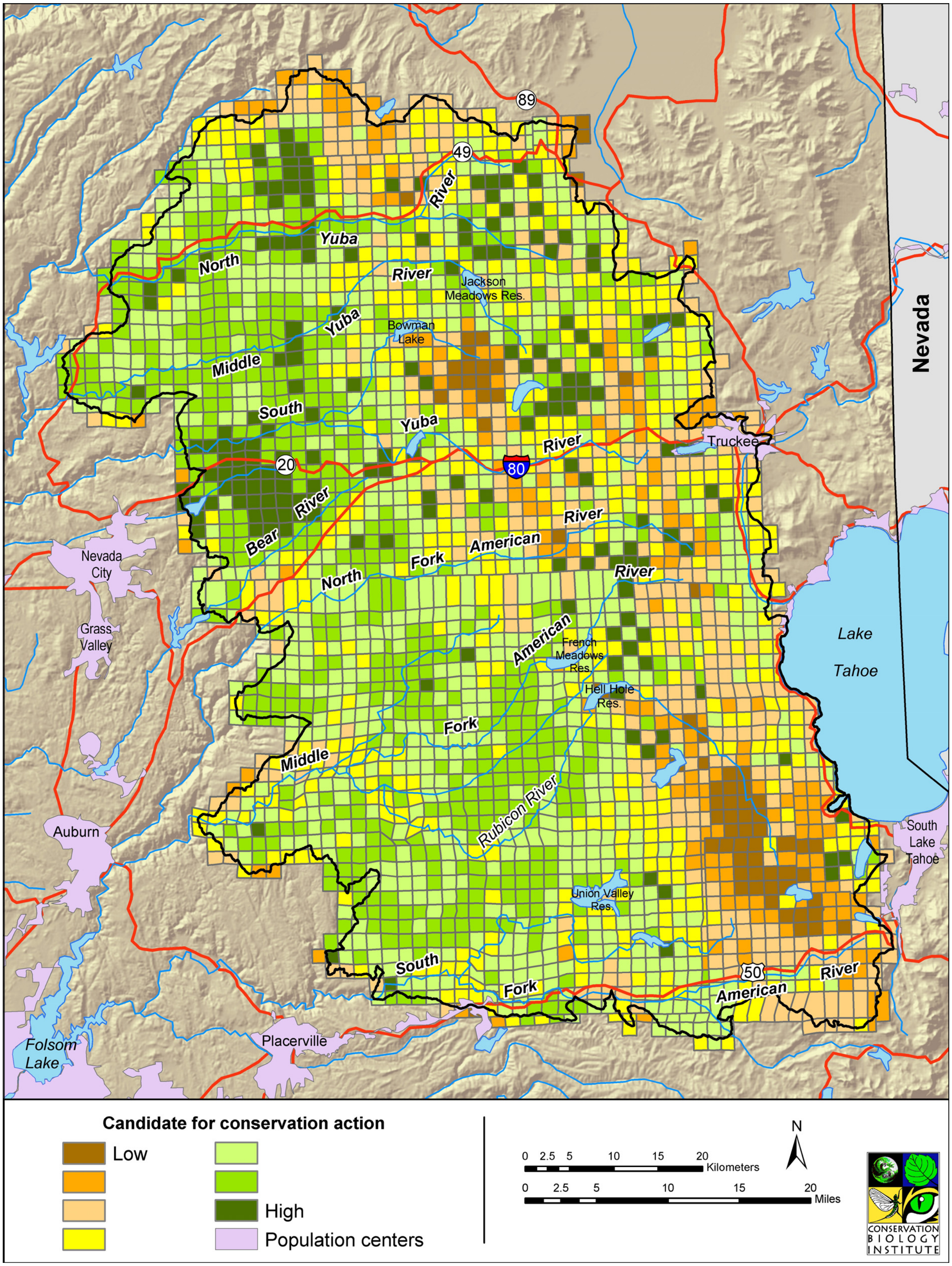

Figure 9—Relative suitability for conservation action, based on conditions used in the logic model (Figure 8).

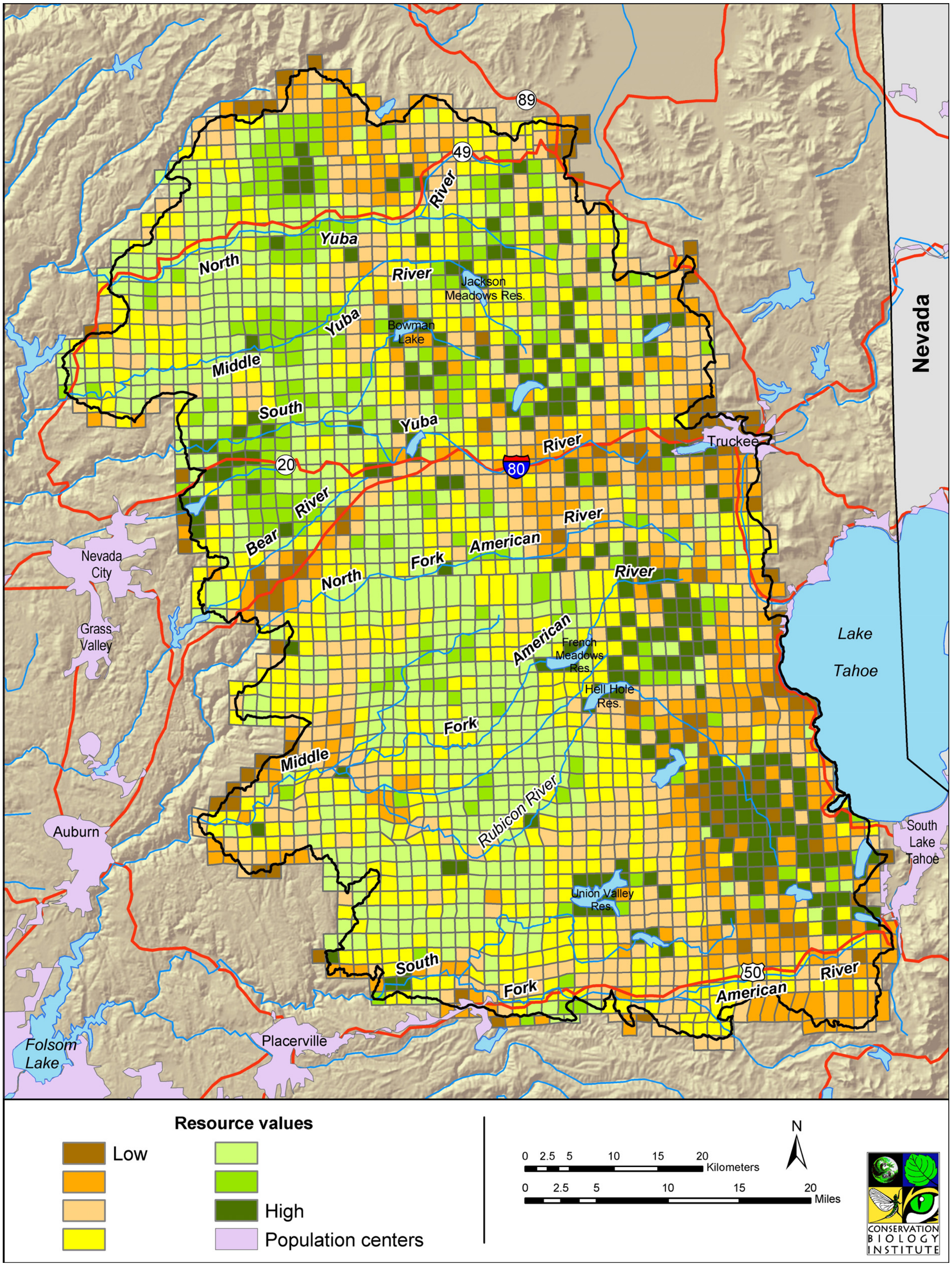

Figure 10—Relative rankings of resource value, based on conditions used in the logic model (Figure 8).

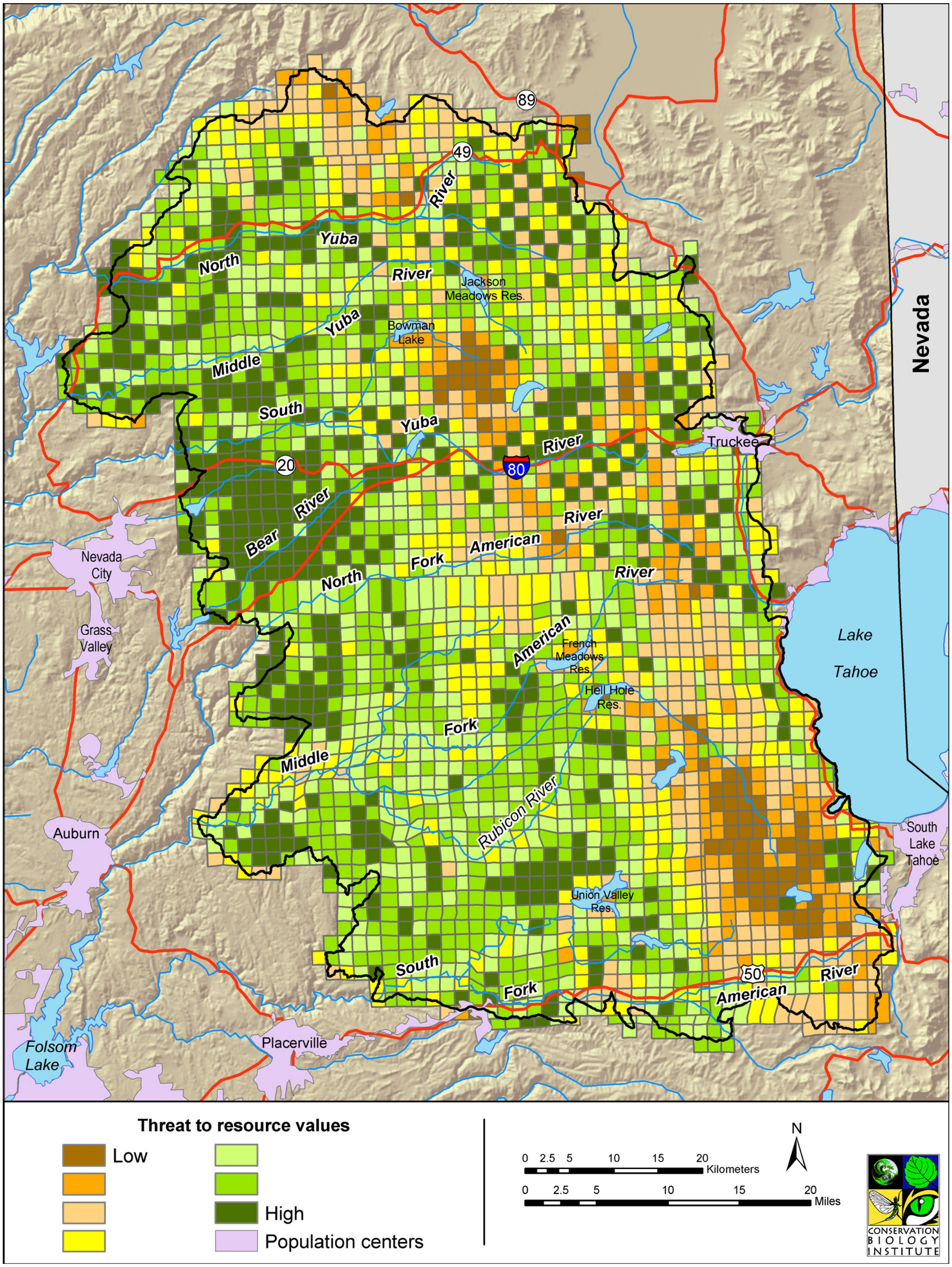

Figure 11—Relative rankings of threat to resource value, based on conditions used in the logic model (Figure 8).

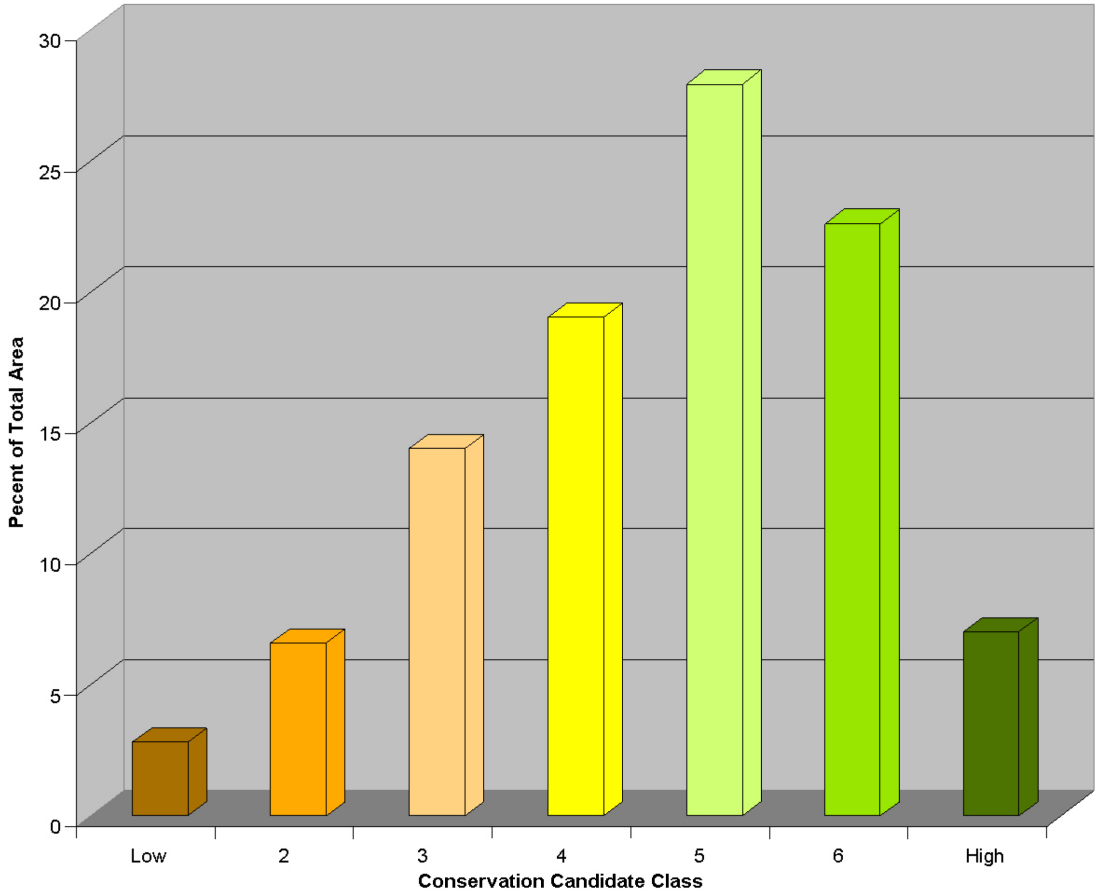

Figure 12—Percentage of the study area falling into seven categories of relative suitability for conservation action.

Large portions of the study area rank as highly suitable candidates for conservation action (Figure 9, Figure 12). These areas are scattered throughout the study area but are widespread throughout the western half of the study area, particularly between Interstate 80 and Highway 20 and north of Highway 49, and in the northeastern portion of the study area. Consistent with the logic model, these areas rank highest in terms of resource values (Figure 10) and threat to resource values (Figure 11). The portions of the study area least suitable for conservation action, based on the model parameters, are in non-forested, higher-elevation areas in the Desolation Wilderness and Grouse Lakes area (Figure 9), which are also areas of relatively low or intermediate resource value (Figure 10) and very low threat (Figure 11).

Clusters of sections ranked as most suitable candidates for conservation actions are distributed throughout the study area. Three examples of areas ranked as highest suitability for conservation action (area A—Deer Creek subbasin, area B—Lavezzola Creek subbasin of the North Yuba River watershed, and area C—Maiden Valley/Bald Ridge) and one ranked as lowest suitability for conservation action (area D—Desolation Wilderness) are shown in Figure 19. These example areas are discussed below to further illustrate how the distributions of the various resource values and threats contribute to the conservation action results.

Examples of Areas Ranked as Highest Suitability for Conservation Action

A—Vicinity of the Deer Creek subbasin (Yuba River Watershed)

This area supports mid-montane and mixed evergreen forests. These community types are ranked as a high priority for conservation because they are not well-represented in existing protected areas within the study area. On the other hand, landscape and watershed conditions are relatively low quality, primarily because of the high density of roads in this area. However, the area has high potential for supporting high biodiversity in the future if threats can be reduced. Connectivity between mature forest trees is relatively good, based on the size and number of mature forest patches and the distance between them. Because of the area's high productivity and low development density, connectivity has a high potential to be improved with appropriate management in the future. This area ranks relatively high for passive recreation suitability, because there is good access as well as features of interest to recreationists, i.e., numerous rivers, late seral forest, and a designated Wild and Scenic River (South Yuba River).

As much of this area is privately owned, the high degree of threat is associated with expanding suburban and exurban development, particularly along the Highway 20 and Interstate 80 corridors. Risk of losing key ecosystem components from fires is high, due to unnatural accumulation of fuels, and activities incompatible with conservation of mature forests may occur on unprotected private and public land in the area.

B—Lavezzola Creek subbasin of the North Yuba River watershed

This area has high resource value because it supports primarily mature mid-montane and mixed evergreen forests, contributes to late-successional forest functions, is roadless, and is well-connected at the landscape level. The watershed condition of the Lavezzola Creek subbasin is ranked relatively high, as a result of its roadless nature and thus low level of human impact. Most of this area has relatively low value for passive recreation because of poor access in designated roadless areas. However, the tributaries to the North Yuba River and late seral forests, which are resources of recreational interest, contribute positively to the area's value for passive recreation.

Exurban development is not a risk in this area, because the majority of the land is publicly owned and has few roads. However, this area exhibits high threats to resource values because of its risk of unnatural fire regimes, presumably as a result of unnatural fuel accumulation. This area also ranks high for management incompatible with conservation of mature forest, because these forests are outside of formally protected areas, and some road building is allowed.

C—Maiden Valley/Bald Ridge area

This area has high resource value because it supports moderate biodiversity values, moderate mature forest connectivity, and high passive recreational values. Characteristics that contribute to biodiversity values in the area include mature mid-montane forests and terrestrial special elements. Existing roads and trails provide good access for recreational users, and the area supports resources of recreational interest.

The resources in this area are highly threatened by exurban development and management incompatible with conservation of mature forests. Exurban development risk is high due to the presence of privately owned property with good road access near other development. Risk of incompatible mature forest is high because of the presence of mature forest stands that are not in reserves or protected areas. Risk of unnatural fire regimes in the area is low.

Example of Area Ranked as Low Suitability for Conservation Action

D—Desolation Wilderness

Although this area supports high resource values, it has low suitability for conservation actions because it is ranked as having low threats. The area supports high passive recreational values, as the wilderness area is a resource of recreational interest, and good landscape and watershed condition. Characteristics that contribute to low biodiversity values are the lack of special elements, presence of vegetation communities well-represented in protected areas (e.g., upper montane and subalpine forests), and low forest productivity. The low mature forest connectivity value results from the lack of mature forests and the naturally fragmented nature of this high elevation area.

The resources in this area have a low risk of exurban development and low threat of incompatible mature forest management. This is largely because the area is designated as public wilderness land and is therefore off-limits to development and timber harvest. Risk of unnatural fire regimes in the area is also low.

Table 1—Hierarchical summary of characteristics and conditions used in the logic model for ranking sections of land as good candidates for conservation action.

A. Resource value

1. Biodiversity value

i. Existing biodiversity value

- Terrestrial biodiversity value
  - Landscape condition
    - o High percentage of roadlessness
    - o Low road density
    - o Low percentage of human impact (land cover change)
  - Under-represented habitat types
    - o High percentage of priority vegetation communities
  - Terrestrial special elements
    - o High number of sensitive species
    - o High percentage of late-seral forests
    - o High percentage of rare edaphic features
- Aquatic biodiversity value
  - Watershed condition
    - o Low road density on steep slopes
    - o Low road density near rivers/streams
    - o High percentage of roadlessness (subbasin scale)
    - o Low cumulative dam influence (subbasin scale)
    - o Low percentage of human impact (land cover change - subbasin scale)
  - Aquatic special elements
    - o High number of sensitive habitats
    - o High number of sensitive species

ii. Future biodiversity value

- Average existing biodiversity value results within a 5km^2 neighborhood
- Potential biodiversity value
  - o Low development density
  - o High percentage of rare edaphic features
  - o High forest productivity

2. Mature forest connectivity

i. Existing mature forest connectivity

- Site mature forest fragmentation
  - o High percentage of mature forest
  - o Low number of mature forest patches
  - o Large mean size of mature forest patches
  - o Low mean nearest neighbor distance between mature forest patches
  - o High total core area index
- Neighborhood (5km^2) mature forest fragmentation
  - o High percentage of mature forest
  - o Low number of mature forest patches
  - o Large mean size of mature forest patches
  - o Low mean nearest neighbor distance between mature forest patches
  - o High total core area index

Table 1 (continued).

- ii. Future mature forest connectivity
  - Neighborhood ($5km^2$) mature forest fragmentation
    - o High percentage of mature forest
    - o Low number of mature forest patches
    - o Large mean size of mature forest patches
    - o Low mean nearest neighbor distance between mature forest patches
    - o High total core area index
  - Potential forest growth
    - o Low development density
    - o High forest productivity

3. Passive recreation value

- i. Access to recreational resources
  - o Adequate trail density
  - o Adequate road density
- ii. Recreational resources
  - o High percentage of lakes
  - o High river density
  - o High percentage of meadows
  - o High percentage of Wild and Scenic Rivers
  - o High percentage of late-seral forests
  - o High percentage of recreation acquisition areas identified by recreation authorities
  - o High percentage of wilderness

B. Threat to resource value

1. Risk of exurban development

- i. Site contains privately owned parcels
  - o High percentage of site privately owned
- ii. Development infrastructure available
  - o Short distance to existing development
  - o High road density
- iii. Site is environmentally unconstrained
  - o Low percentage of wet vegetation types
- iv. Degree of parcel subdivision
  - o Low average parcel size

2. Risk of unnatural fire

- o High average FRAP condition class

3. Risk of management incompatible with conservation of mature forests

- o High percentage of mature forest outside of protected and roadless areas

o = data sets used to assess characteristics and conditions

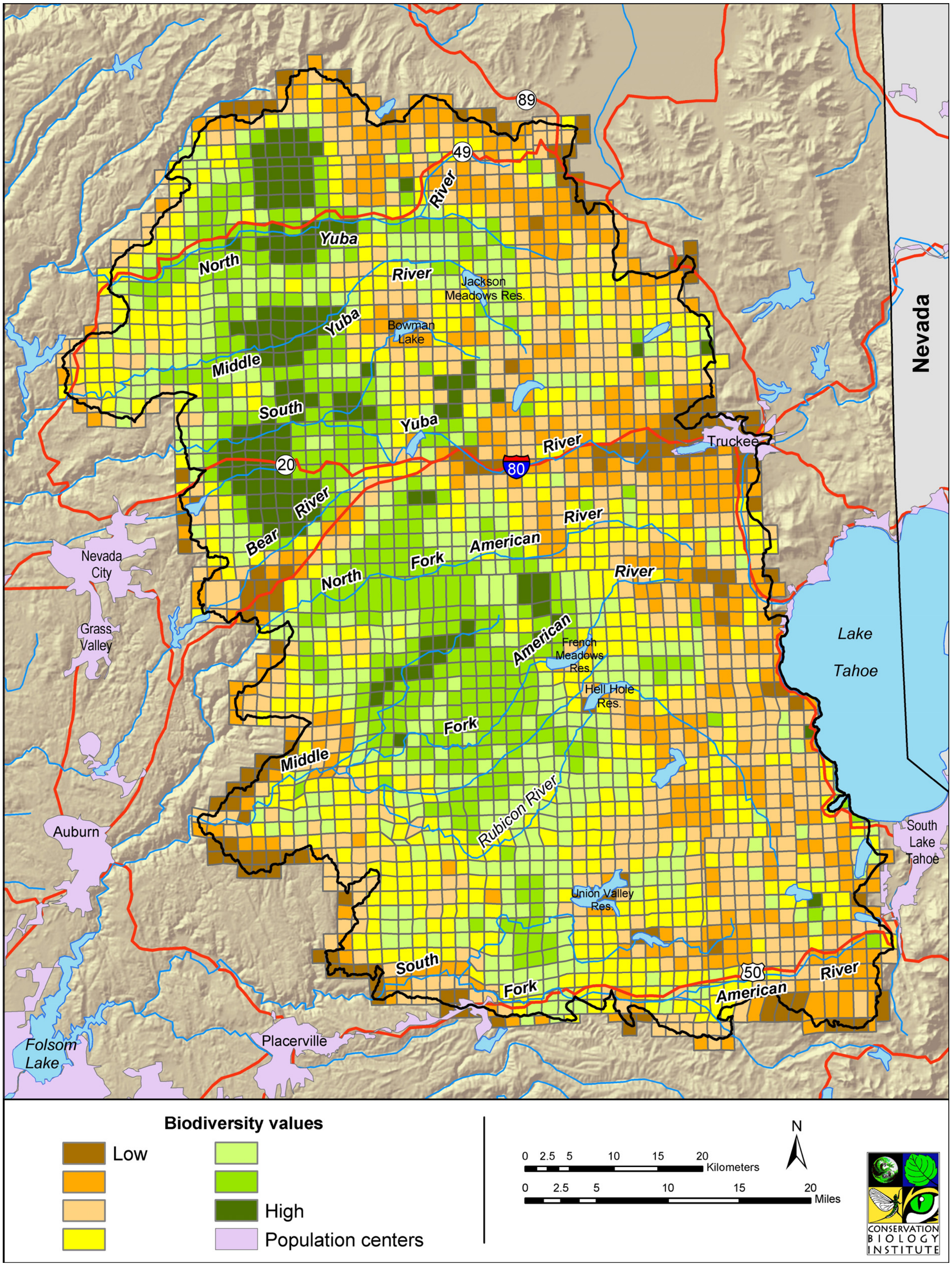

Figure 13—Relative rankings of biodiversity value, based on conditions used in the logic model (Figure 8).

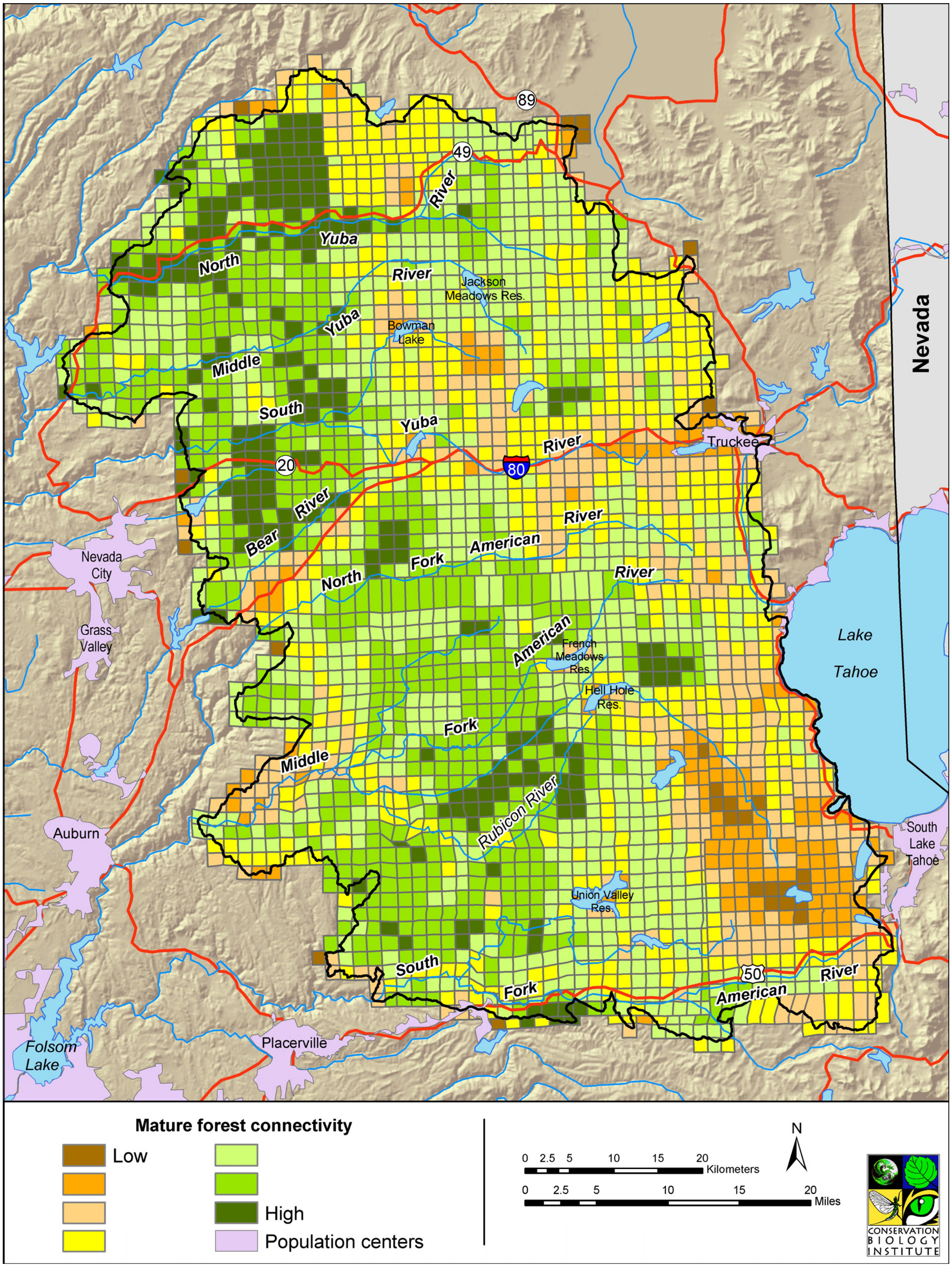

Figure 14—Relative rankings of mature forest connectivity, based on conditions used in the logic model (Figure 8).

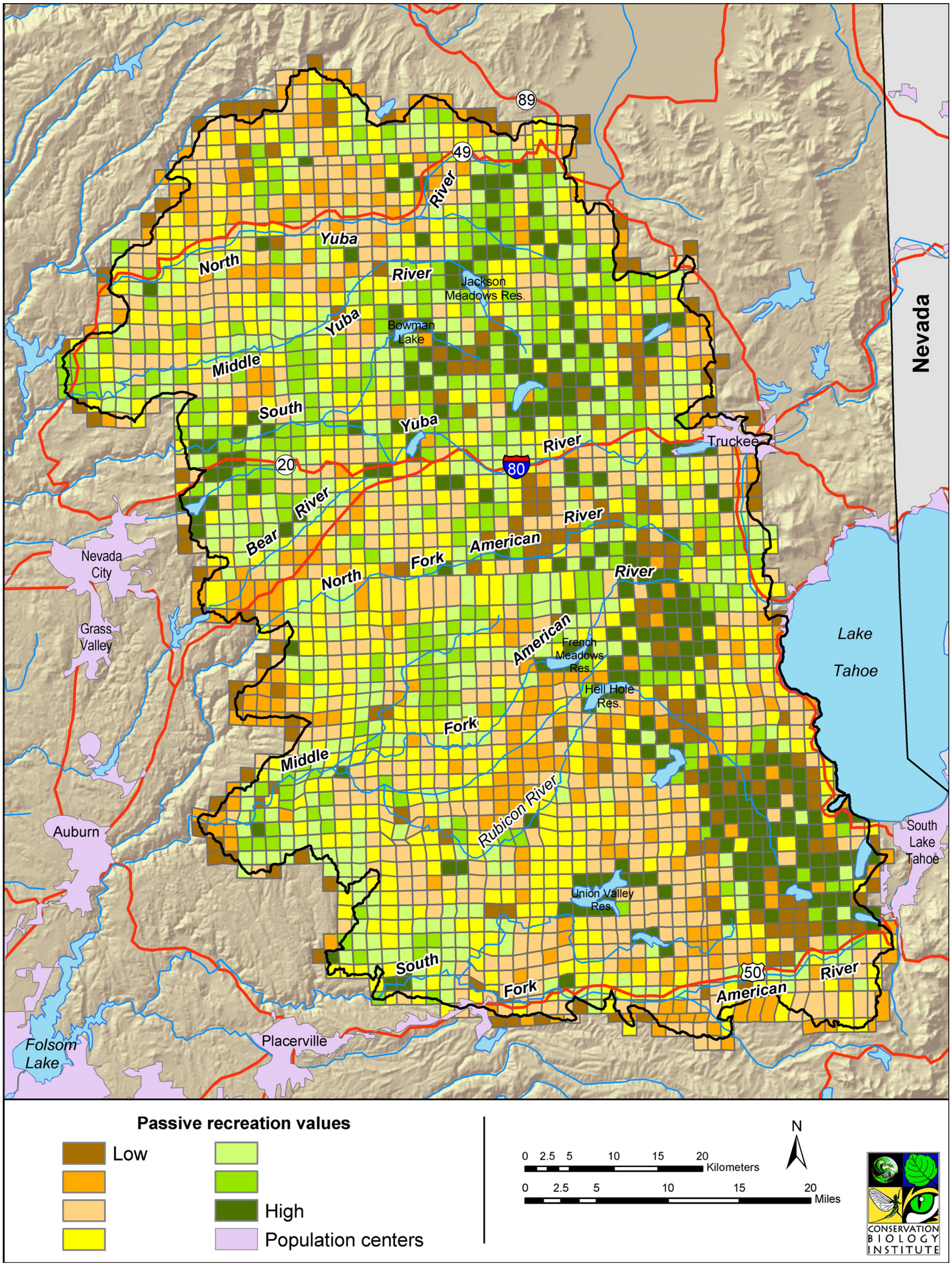

Figure 15—Relative rankings of passive recreation value, based on conditions used in the logic model (Figure 8).

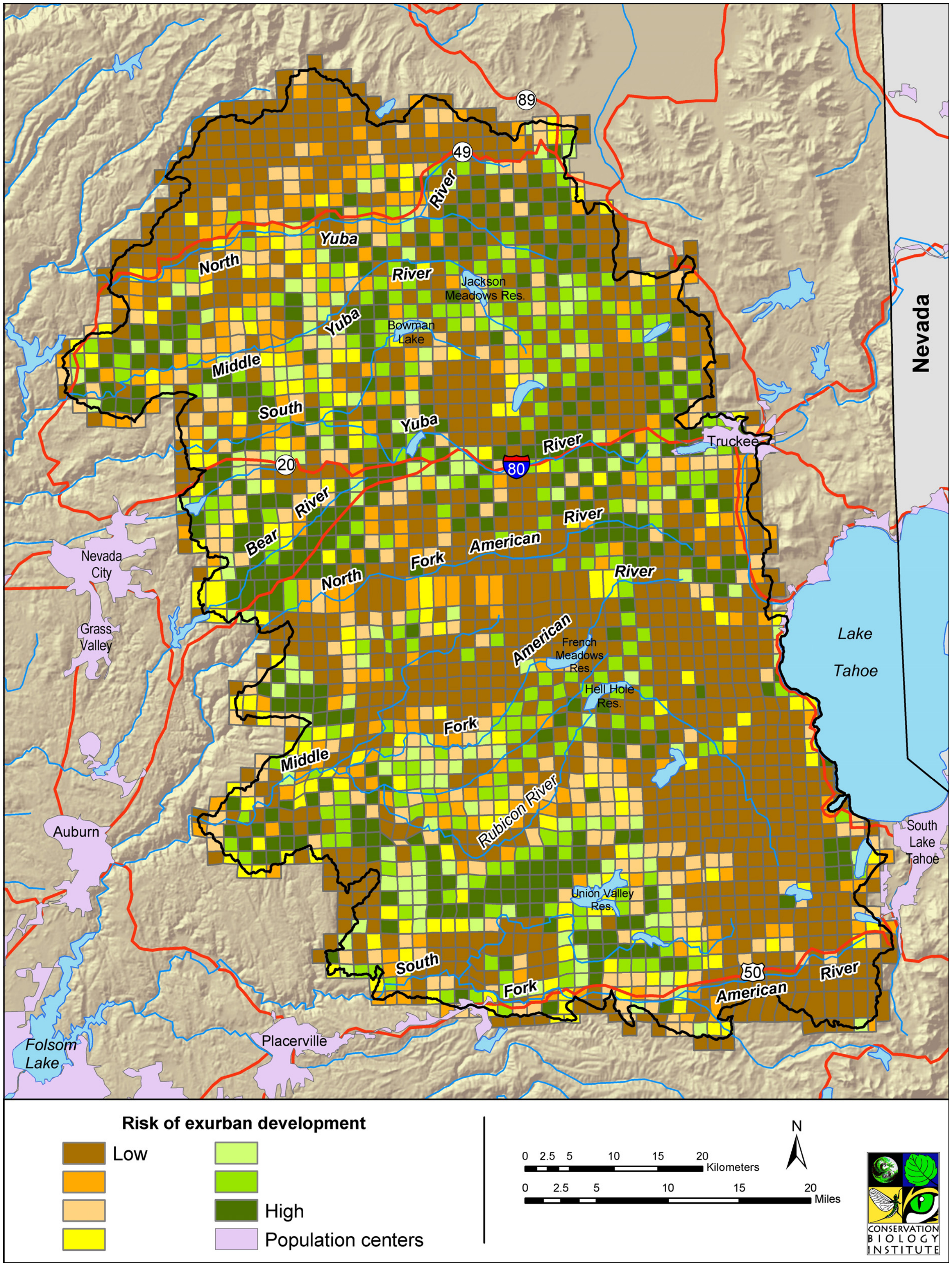

Figure 16—Relative rankings of risk of exurban development, based on conditions used in the logic model (Figure 8).

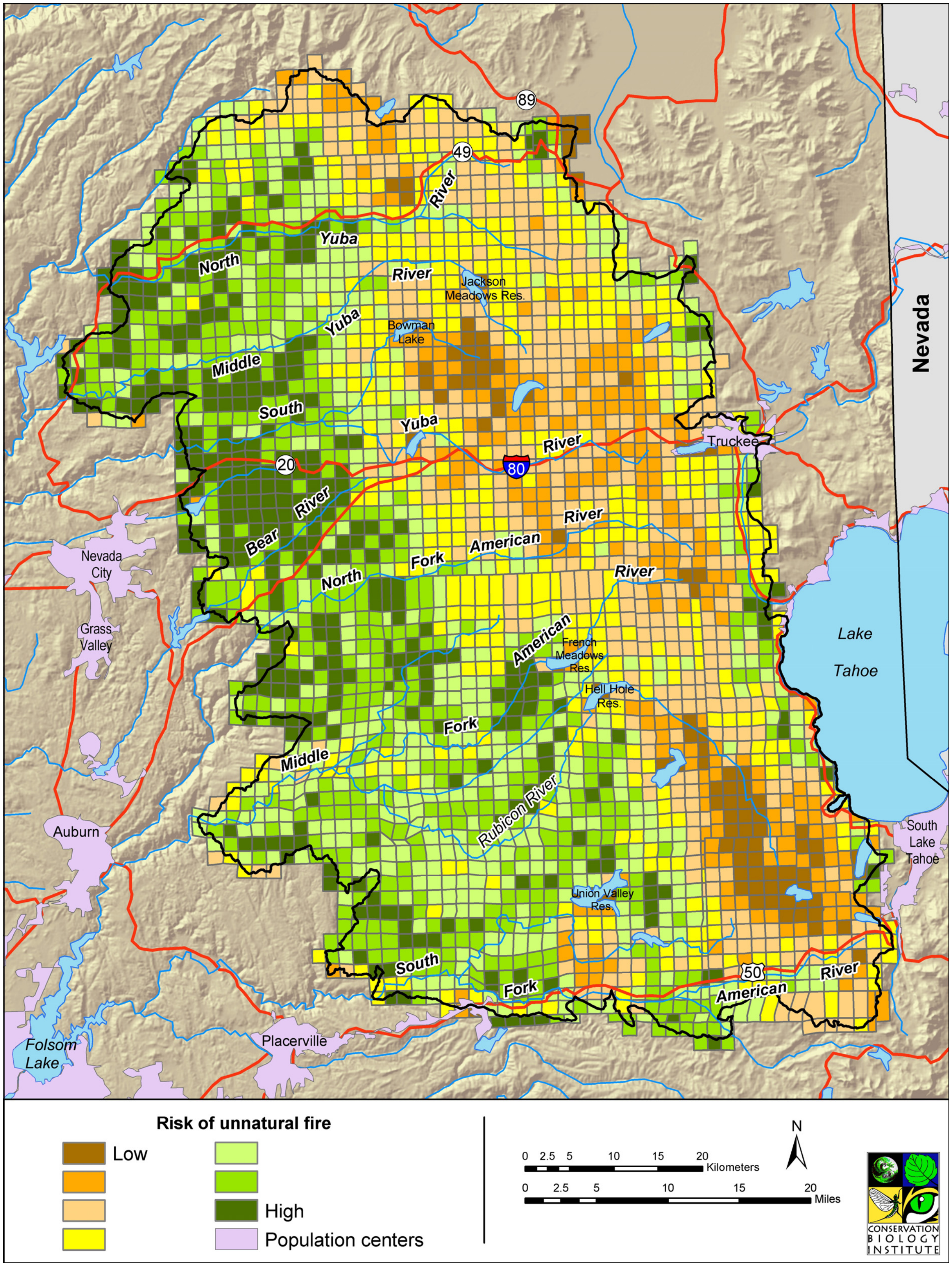

Figure 17—Relative rankings of risk of unnatural fire regimes, based on conditions used in the logic model (Figure 8).

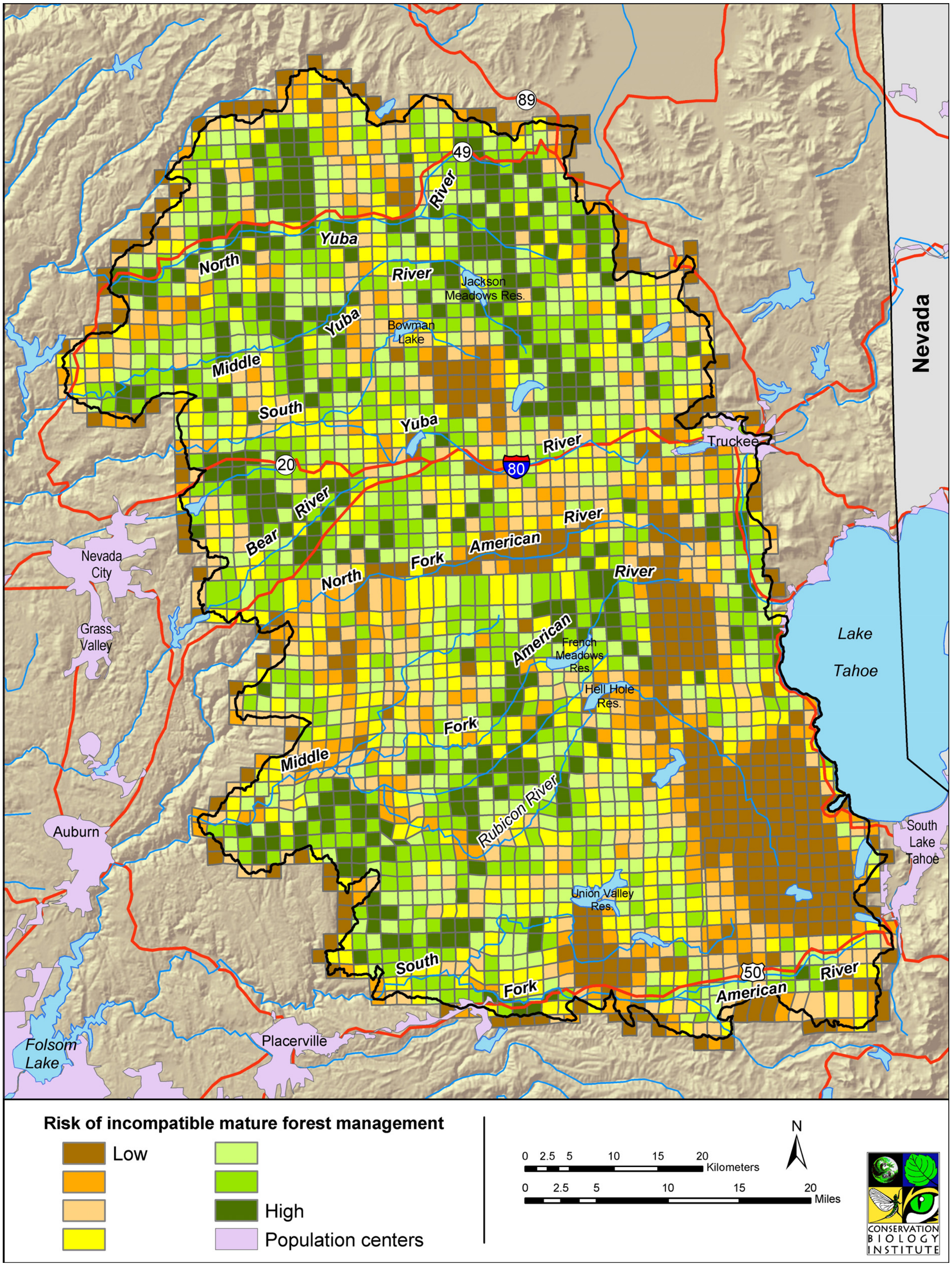

Figure 18—Relative rankings of risk of management incompatible with conservation of mature forests, based on conditions used in the logic model (Figure 8).

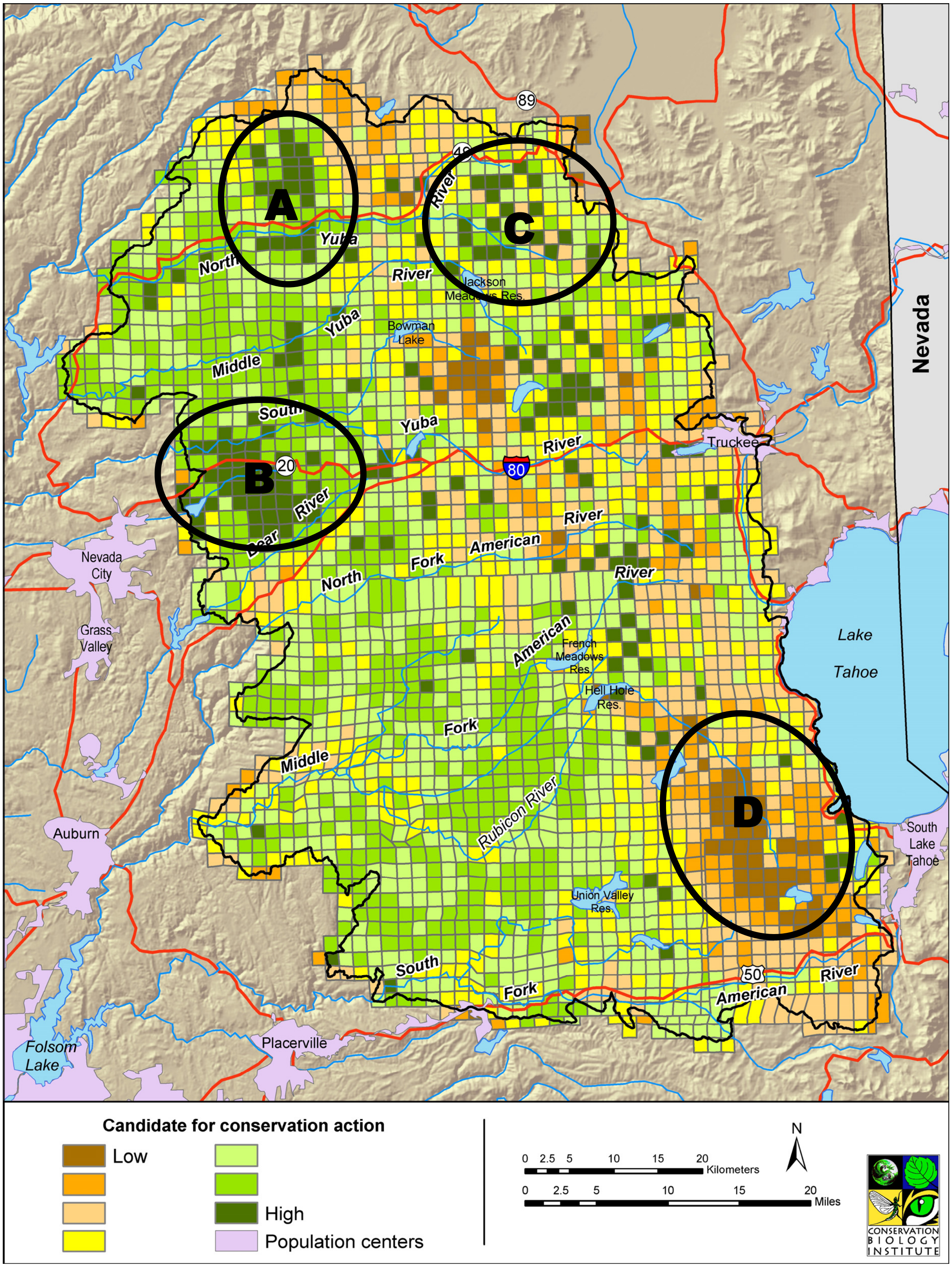

Figure 19—Examples of three areas (A, B, C) ranked as highest and one as lowest (D) suitability for conservation action. A. Deer Creek watershed. B. Lavezzola Creek subbasin. C. Maiden Valley/Bald Ridge area. D. Desolation Wilderness.

6. NEXT STEPS—DEVELOPING INTEGRATED CONSERVATION STRATEGIES

In the Science Assessment, we evaluated the suitability of individual sections of land (generally 640 acres) for consideration for future conservation actions. The Assessment did not evaluate site-specific actions at a parcel level. Phase II of the *Sierra Checkerboard Initiative* will address that level of detail by developing and prioritizing conservation strategies, i.e., potential actions to enhance resource values and ameliorate threats within the study area. Conservation strategies will require a range of tools for implementation, such as fee title acquisition, conservation easements, management agreements, and land exchange. Strategies will consider information from lower levels of the logic model (provided in the Technical Appendix) for specific parcels within the study area, as well as information not considered in the logic model, such as patterns of ownership, land protection and management status (existing conservation investments), public agency objectives and priorities, landowner interests and aspirations, land and timber market considerations, local land protection and stewardship initiatives, political and social considerations, and availability of funding. Because the contributions by and engagement of the wood products industry will be integral to developing and implementing conservation strategies in Phase II of the *Sierra Checkerboard Initiative*, timber resources and the factors that contribute to their management are discussed below.

Regional Setting for Forest Management

Approximately 78% of the study area, or 1.2 million acres, supports commercially important conifer and mixed conifer forests (i.e., mid-montane forest, upper montane forest, Sierran east-side forest). This represents approximately 3% of California forest lands. Land ownership in the study area is a mixture of public and private landowners (Table 2). Within the private sector, land ownership can be further divided into industrial landowners and other small landowners. Management objectives among the various landowners vary widely and are driven by a number of social, cultural, and economic factors.

Table 2—Acreages of high, medium, and low commercial value timber in the study area, by ownership (obtained from the timber value ranking described in Attachment 2 and shown in Figure 20).

Ownership	High	Medium	Low	Total
U.S. Forest Service	290,623	375,378	65,114	731,115
Other public agencies	20,696	15,770	3,140	39,606
Industrial timber companies	90,460	132,092	19,815	242,367
Other private	77,045	92,224	14,234	183,503
Total coniferous forest	478,824	615,464	102,303	1,196,591

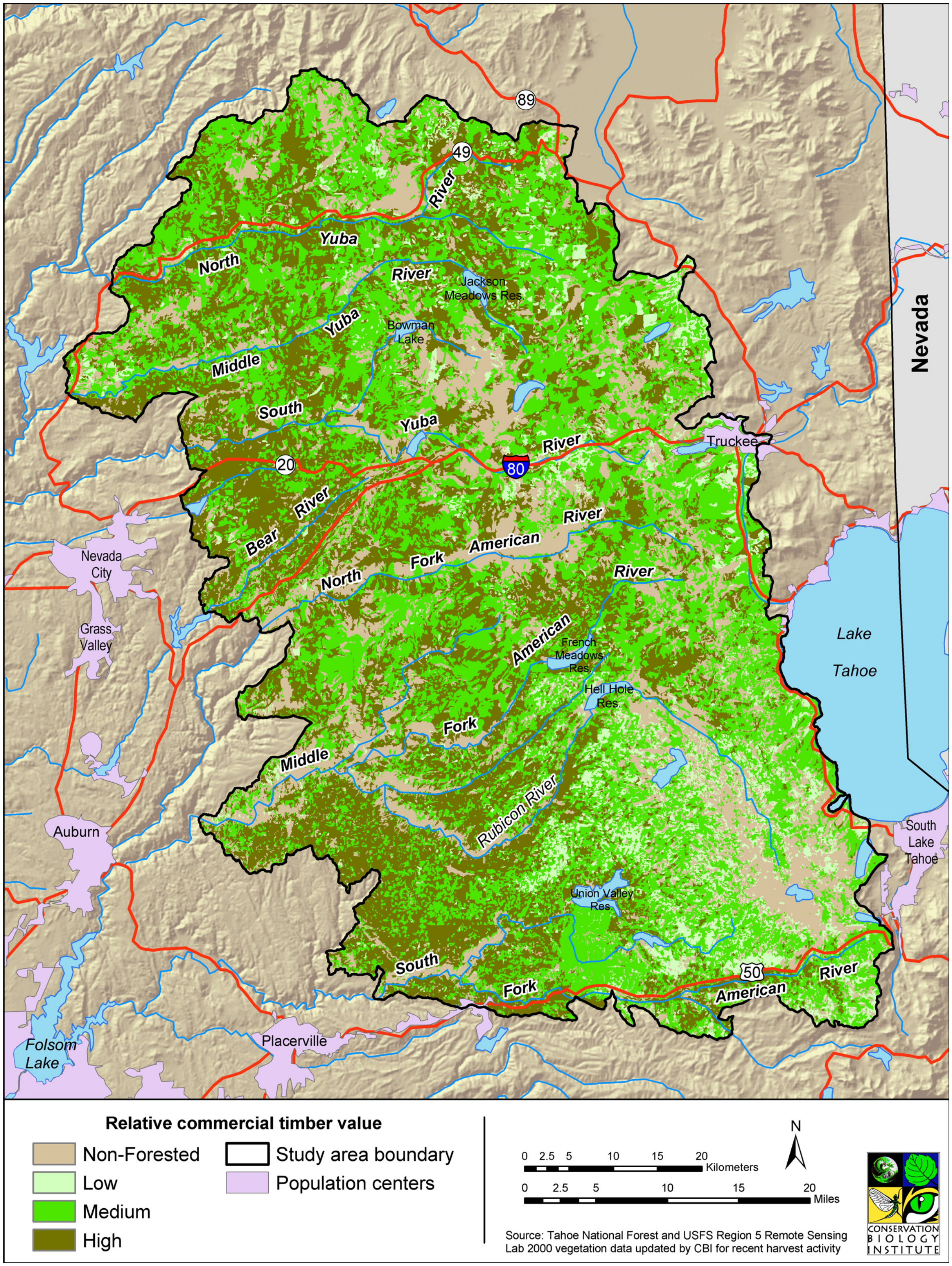

Figure 20—Distribution of relative commercial timber value based on tree species, size, and density.

Supporting forest management that is compatible with other resource values is an important objective of the *Sierra Checkerboard Initiative*. Timber harvests can be compatible with other resource values by implementing forestry practices that prevent watershed degradation, maintain or enhance habitat quality, increase contributions to late-successional forest functions, and improve habitat connectivity in lands between forest reserves. In addition, forest management that is economically viable increases the management opportunities available to forest landowners and potentially reduces the sale of land holdings for residential development, whose impacts are profound and essentially irreversible.

Managing forest stands to be resilient to wildfire is an important consideration. The demands for infrastructure to support fuels management are similar to those for timber production—transportation, processing, and workers. An added constraint to management directed at reducing risk of catastrophic fires is the cost of removing brush and small material that contributes to fire danger. Some landowners choose to offset this cost through commercial timber harvest, while others look to secondary manufacturing markets for the wood products (e.g., furniture, biomass processing), make private investments, or seek public funds to defray costs.

Timber harvest

In the last 5 years, the average timber harvest from El Dorado, Nevada, Placer, Sierra, and Yuba counties represents about 10% of the total harvest in California. Timber harvest in the Sierra Nevada peaked in the 1950s following the post-World War II spike in housing demand and again in the 1980s (Stewart 1996). However, the source of the harvest differed dramatically, with the 1950s peak primarily from private land and the 1980s peak from a greater percentage of public land. Recent timber harvests in the Sierra have declined significantly as a result of increasing restrictions on both public and private lands. Between 1993 and 2003, annual timber harvest in the five-county area fell from 411 million board-ft (MMBF) to 220 MMBF, and harvests in the next couple of years are expected to decrease an additional 10-20% (California State Board of Equalization 2005). Annual timber harvest within the Tahoe and Eldorado National Forests has declined by an even higher percentage, with sawtimber (trees >10 in. diameter) contracts declining from 260 MMBF in 1988-1990 to less than 60 MMBF in 2001-2003 (USFS 2004).

The infrastructure needed to support the harvest of trees to generate a financial return includes a number of key services—roads suitable for hauling logs, mills to process raw material, and equipment operators and loggers to remove trees. The availability of these services can vary as the flow of timber changes. For example, since the 1950s, over 650 sawmills have closed in California, and there are fewer than 40 still in operation today. Many of these closures were the result of changes in milling technology and improvements in efficiency. However, some mills closed because too little timber was harvested to support their operation. There are currently 14 mills that do business in the Sierra Nevada and use timber from the study area.

To assess the distribution of commercially important forests in the study area, we ranked the relative commercial value of forests as a function of tree species, size, and density (Attachment 2). We ranked each factor as high, medium, or low, summed the scores for each of the three factors, and mapped the distribution of commercial timber value based on the rankings of these scores (Figure 20). The ownership pattern of high commercial value forests parallels the ownership pattern of all forests, with 61% found on U.S. Forest Service land, 20% on industrial timber land, 15% on other private land, and 3% on other public land (Table 2).

Barriers to a viable wood products industry

The long-term economic viability of a sustainable wood products industry depends on a viable business environment and the availability of productive forest land for harvest. Several factors currently pose potential barriers to the economic viability of the industry. These factors include exurban development pressure that increases the demand for and value of developable timberland, the complicated regulatory environment and increased costs associated with regulatory compliance, global competition for wood products, and the short-term planning horizon for timber harvest planning.

Exurban development of private lands within the checkerboard ownership pattern fragments forest land and is a threat to the wood products industry. Non-contiguous tracts of forest lands create relatively high operating costs due to the challenges of managing travel between tracts, avoiding trespassing, maintaining roads, planning for fire suppression, scheduling sustainable watershed-level harvest, and controlling insect infestation and nonnative invasive species. In addition, proximity of working forests to residential development creates conflicts between the noise and disruption of harvest activities and the expectations of new rural homeowners. Industrial timberland adjacent to residential development may be attractive to sell to development interests, particularly if the challenges and costs of operating on that land become excessive and the land values for development increase with increasing demand.

The wood products industry needs a fairly long planning horizon to effectively manage a forest that can sustain long-term commercial activity and be economically viable. The regulatory environment makes this difficult because of the short time frame of Timber Harvest Plans and the varying requirements of multiple agencies. Regulatory requirements also increase a landowner's operational costs. The wood products industry must maintain an adequate base of commercial activity, skilled loggers, and contract workers to sustain its regional viability. The industry would benefit from (1) regulatory tools that allow for longer term certainty, so that necessary investments in capital and forest health can be made with confidence, and (2) financial incentives that encourage forest management practices more compatible with conservation objectives in particular portions of the study area.

Considerations for Developing Conservation Strategies

Given the diverse site-specific resource values, threats, and strategic considerations, formulating and evaluating conservation strategies will be extremely complex. Developing a means to comparably evaluate the net benefits of strategies that differ in their focus and implementation approach will be needed to justify large investments of resources.

Conservation strategies must consider regional conditions within the context of the long-term goals of the *Sierra Checkerboard Initiative* (Section 1) and the regional conservation objectives to achieve these goals. These objectives include:

- Prevent the degradation of watershed functions in high integrity watershed basins, improve watershed function in moderate integrity basins, protect and enhance habitat quality for native aquatic species, and protect water quality and quantity.
- Increase the acreage of under-represented vegetation communities managed primarily for conservation values.
- Increase landscape-scale connectivity, both north-south and upslope-downslope (east-west), for priority wildlife species.
- Improve the condition and connectivity of riparian, meadow, and wetland habitats to benefit native species.
- Improve incentives for private landowners to manage lands in a manner that supports conservation and the maintenance of ecological values.
- Increase access to trails and passive recreation areas and the quality of passive recreation opportunities.
- Protect and improve visual quality in key recreation areas (e.g., along the Pacific Crest Trail).
- Encourage and support the implementation of practices that maintain an economically viable forest products industry compatible with species and ecosystem conservation objectives in the central Sierra Nevada.
- Protect human life and property in areas at-risk from catastrophic fire by strategic fuel management, prescribed burning, and land use planning.
- Implement land planning and land management strategies that allow fire to be restored as a natural process over the long term.
- Use best available science and information to identify threats and opportunities for conservation, passive recreation, and sustainable forestry values.

Conservation strategies may consist of a combination of implementing mechanisms, including land acquisition, land exchange, conservation easements, management agreements, and other plans or agreements to minimize threats and enhance resource values of individual parcels. Strategies must adapt to changing conditions, such as changes in land ownership, protection levels, forest structure, species status, and recreational demand. Conservation actions must also consider the potential for management to improve future resource conditions, as the success of some land management activities will be measured over decades.

Land uses and management regimes can be modified or redistributed within the landscape through land acquisitions or exchanges. For example, specific land uses or management prescriptions that are compatible with regional conservation objectives and the land management objectives of the land owner can be consolidated. Alternatively, management agreements and conservation easements can be used to modify management regimes and land uses without changing ownership, with the goal of consistent management across lands with different owners.

Matrix lands between reserve areas are also important for achieving conservation objectives (e.g., Lindenmayer and Franklin 2002). Privately owned forest lands provide varying levels of wildlife habitat quality and can be managed to improve contribution to late-successional forest functions and connectivity between mature forests. Management agreements or conservation easements with industrial timber companies and other private landowners would facilitate consistent management across matrix lands.

Designating new reserves is another potential conservation implementation tool. Allowable land uses in reserve areas are generally restricted to those most compatible with resource protection objectives, while less compatible land uses are allowed outside of reserve areas. These areas are often placed into public ownership or deeded to a land conservancy. However, formally protecting land by placing it into reserves can limit certain public uses and management options. If establishing new reserves is a conservation strategy, then the regional extent and configuration of reserves must be considered to ensure that they accomplish desired regional conservation objectives (e.g., maintaining viable populations of target species, ecosystem processes, and passive recreation opportunities). Establishing new reserves adjacent to or linked to existing protected areas will maximize conservation value while consolidating management costs, but strategically establishing new reserve lands to meet regional conservation objectives may also be warranted.

Areas supporting biological communities that are under-represented in existing reserves are often prioritized for addition to reserves. In the study area, these under-represented communities are generally located on the lower west slope and are threatened by expanding suburban and exurban development on private land. Other management or reserve priorities include areas that exhibit high ecosystem integrity, for example, roadless areas or intact watershed basins whose natural processes have not been greatly altered by human activities. Areas supporting these high value resources may be acquired by purchase from willing sellers or as part of land exchanges. They can also be protected via local zoning ordinances, such as those developed under Natural Community Conservation Planning (NCCP) programs or Habitat Conservation Plans.

Examples of potential strategies that may be appropriate for achieving the conservation objectives in the study area are outlined below, with potential involved parties shown in parentheses. This list is not intended to be exhaustive, but rather to illustrate the diversity of strategies, partners, and strategic alliances at all levels of government and the private sector necessary to achieve the goals of the *Sierra Checkerboard Initiative*.

Potential Strategies for Conservation Actions

1. Consolidate public and private ownerships to improve natural resources management efficiency and effectiveness and recreational access (U.S. Forest Service, private land owners).
    a. Acquisition of inholdings within National Forests or adjacent private lands

   b. Public-private land exchanges
   c. Acquisition or exchange of priority recreational resources such as private lands supporting the Pacific Crest Trail easement

2. Develop land management agreements and easements that maintain or enhance habitat values around existing and potential habitat reserves and other protected lands, provide for a viable regional timber industry, and reduce fire threats (private timber interests).
   a. Management agreements in areas of private land important for maintaining or improving watershed functions, wildlife habitat quality, and late-successional forest functions and mature forest connectivity
   b. Management agreements to facilitate prescribed burns and to reduce hazardous fuel loads on private land at the wildland-urban interface
   c. Conservation easements on private lands to encourage land uses and management practices compatible with site-specific resource goals

3. Work within public policy frameworks to provide incentives for conservation of important resource areas and foster conservation-compatible land use practices for private lands, working landscapes, and rural communities (local, state, and federal levels of government).
   a. NCCP programs
   b. General Plan updates
   c. Zoning ordinances (lower densities provide greater opportunity for achieving many conservation objectives)
   d. Timber Harvest Plans
   e. Working landscapes programs, e.g., strategically located timber harvests to reduce fuel loads, maintaining agricultural uses as buffers to urbanized areas
   f. Environmental protection ordinances and land use restrictions
   g. Mitigation banking programs
   h. Inter-governmental Memoranda of Understanding for land management coordination
   i. Federal designation of resource areas

4. Develop programs to enhance habitat connectivity (local, state, and federal levels of government, private landowners).
   a. Road and right-of-way improvements to improve wildlife movement connectivity, such as construction and maintenance of wildlife undercrossings and overcrossings
   b. Mitigation banking agreements
   c. Conservation easements
   d. Management agreements

5. Develop programs to protect watersheds, surface and ground water quantity, flow regimes, and water quality (water districts, California Department of Water Resources, California Environmental Protection Agency, private landowner and water rights holders).
   a. Acquisition and management of high integrity watershed basins
   b. Water conservation programs

    c. Acquisition of water rights
    d. Grazing easements around sensitive aquatic and wetland habitats

6. Develop and support propositions that authorize bonds for conservation and management of natural open space, water resources, and park lands (State Resources Agency, private land trusts, community groups).
    a. Public education and outreach efforts for propositions
    b. Coordination with state and local land acquisition and stewardship efforts

7. LITERATURE CITED

Anderson, M.K., and M.J. Moratto. 1996. Native American land-use practices and ecological impacts. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Barbour, M.G., and R.A. Minnich. 2000. California upland forests and woodlands. *In* Barbour, M.G., and W.D. Billings (eds.), North American terrestrial vegetation. Cambridge University Press, Cambridge. 2nd ed.

Beck, T.W., and G.I. Gould, Jr. 1992. Background and the current management situation for the California spotted owl. *In* Verner, J., K.S. McKelvey, B.R. Noon, R.J. Gutierrez, G.I. Gould Jr., and T.W. Beck (technical coordinators), The California spotted owl: a technical assessment of its current status. General Technical Report PSW-GTR-133. USDA Forest Service, Albany, CA.

Beier, P. 1995. Dispersal of juvenile cougars in fragmented habitat. Journal of Wildlife Management 59:228-237.

Bolger, D.T., A.C. Alberts, and M.E. Soulé. 1991. Occurrence patterns of bird species in habitat fragments: sampling, extinction, and nested species subsets. American Naturalist 137:155-166.

Brothers, T.S., and A. Spingarn. 1992. Forest fragmentation and alien plant invasion of central Indiana old-growth forests. Conservation Biology 6(1):91-100.

California Natural Diversity Database (CNDDB). 2005. Wildlife and Habitat Data Analysis Branch, California Department of Fish and Game.

California State Board of Equalization. 2005. Timber yield tax harvest value tables in California timber harvest by county. http://www.boe.ca.gov/proptaxes/timbertax.htm

California Wilderness Coalition (CWC). 2002. A guide to wildlands conservation in the greater Sierra Nevada bioregion. February.

Calsbeek, R., J.N. Thompson, and J.E. Richardson. 2003. Patterns of molecular evolution and diversification in a biodiversity hotspot: the California Floristic Province. Molecular Ecology 12:1021-1029.

Chang, C. 1996. Ecosystem response to fire and variations in fire regime. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Conservation International. 2005. Biodiversity hotspots revisited. Center for Applied Biodiversity Science at Conservation International. http://www.biodiversityhotspots.org/xp/Hotspots

Cooper, D.J., and E.C. Wolf. 2004. A survey of Sierra Nevada fens. Unpublished data presented at the U.S. Forest Service Region 5 Botany Meeting, Davis, CA. November 17-21, 2003.

Crooks, K.R. 2002. Relative sensitivities of mammalian carnivores to habitat fragmentation. Conservation Biology 16:488-502.

Czech, B., K. Doyle, J. Kostyack, B. McNitt, G. Sugameli, C. Whitaker, K. Whitcomb-Blylock, J. Byrd, and G. Stall. 2001. Paving paradise: sprawl's impact on wildlife and wild places in California. Unpublished report, National Wildlife Federation.

Davis, F.W. 1996. Comparison of late seral/old growth maps from SNEP versus the Sierra Biodiversity Institute. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume III, Assessments, commissioned reports, and background information. University of California at Davis, Centers for Water and Wildland Resources.

Duane, T. 1996a. Recreation in the Sierra. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Duane, T. 1996b. Human settlement, 1850-2040. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Duane, T. 1999. Shaping the Sierra: nature, culture, and conflict in the changing West. University of California Press, Berkeley, CA.

Environment Now. 1992. Sierra now: a vision for the future. Environment Now, Malibu, CA.

Erman, N.A. 1996. Status of aquatic invertebrates. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Erman, D. 1999. Case study: Sierra Nevada Ecosystem Project. *In* Johnson, K.N, F. J. Swanson, M. Herring, and S. Greene (eds.), Bioregional assessments: science at the crossroads of management and policy. Island Press, Washington, DC.

Franklin, J.F., and J. Fites-Kaufmann. 1996. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Fire and Resource Assessment Program (FRAP). 2003. The changing California: forest and range 2003 assessment. Assessment Summary. California Department of Forestry and Fire Protection. October.

Graber, D.M. 1996. Status of terrestrial vertebrates. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Hickman, J.C. (ed.). 1996. The Jepson Manual: higher plants of California. University of California Press, Berkeley, CA. 3rd ed.

Jennings, M.R. 1996. Status of amphibians. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Jockusch, E.L., and D.B. Wake. 2002. Falling apart and merging: diversification of the slender salamanders (Plethodontidae: *Batrachoseps*) in the American West. Biological Journal of the Linnean Society 76:361-391.

Kattelmann, R. 1996. Hydrology and water resources. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Keeley, J.E., and C.J. Fotheringham. 2001. The historical role of fire in California shrublands. Conservation Biology 15:1536-1548.

Kimsey, L.S. 1996. Status of terrestrial insects. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Kondolf, G.M., R. Kattelmann, M. Embury, and D.C. Erman. 1996. Status of riparian habitat. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Langley, P.G. 1996. Quality assessment of late seral old-growth forest mapping. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Lindenmayer, D.B., and J.F. Franklin. 2002. Conserving forest biodiversity: a comprehensive multiscaled approach. Island Press, Washington, DC.

McBride, J.R., W. Russell, and S. Kloss. 1996. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

McKelvey, K.S., and J.D. Johnston. 1992. Historical perspectives on forests of the Sierra Nevada and Transverse Ranges of Southern California: forest conditions at the turn of the century. *In* Verner, J., K.S. McKelvey, B.R. Noon, R.J. Gutierrez, G.I. Gould Jr., and T.W. Beck (technical coordinators), The California spotted owl: a technical assessment of its current status. General Technical Report PSW-GTR-133, U.S. Forest Service Pacific Southwest Region, San Francisco, CA.

Menning, K., K.N. Johnson, and L. Ruth. 1996. *In* Sierra Nevada Ecosystem Project, final report to Congress, addendum. University of California at Davis, Centers for Water and Wildland Resources.

Moritz, C. 2002. Strategies to protect biological diversity and the evolutionary processes that sustain it. Systematic Biology 51:238-254.

Moyle, P.B. 1996. Status of aquatic habitat types. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Moyle, P.B., and P.J. Randall. 1996. Biotic integrity of watersheds. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Moyle, P.B., R.M. Yoshiyama, and R.A. Knapp. 1996. Status of fish and fisheries. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Muir, J. 2001. The mountains of California. The Modern Library, New York, NY.

Myers, N., R. Mittermeier, G.A.B. da Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature 403:853-858.

Naiman, R.J., H. Decamps, and M. Pollock. 1993. The role of riparian corridors in maintaining regional biodiversity. Ecological Applications 3:209-212.

National Research Council (NRC). 2002. Riparian areas: functions and strategies for management. National Academy Press, Washington, DC.

Pacific Rivers Council (PRC). 1998. Conservation of aquatic diversity in the Sierra Nevada: preliminary identification of aquatic diversity areas and critical refuges with recommendations on their management. May.

Paul, M.J., and J.L. Meyer. 2001. Streams in the urban landscape. Annual Review of Ecology and Systematics 32:333-365.

Pickett, S.T.A., M.L. Casenasso, J.M. Grove, C.H. Nilon, R.V. Pouyat, W.C. Zipperer, and R. Costanza. 2001. Urban ecological systems: linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas. Annual Review of Ecology and Systematics 32:127-157.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The natural flow regime: a paradigm for river conservation and restoration. BioScience 47:769-784.

Raven, P.H., and D.I. Axelrod. 1995. Origin and relationships of the California flora. California Native Plant Society, Sacramento, CA.

Reynolds, K.M., M. Jensen, J. Andreasen, and I. Goodman. 2000. Knowledge-based assessment of watershed condition. Computers and Electronics in Agriculture 27:315-333.

Reynolds, K.M., S. Rodriguez, and K. Bevans. 2002. Ecosystem Management Decision Support 3.0 User Guide. USDA Forest Service.

Rogers, D.L., C.I. Millar, and R.D. Westfall. 1996. Genetic diversity within species. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Rodriguez-Robles, J.A., D.F. Denardo, and R.E. Staub. 1999. Phylogeography of the California mountain kingsnake, *Lampropeltis zonata* (Colubridae). Molecular Ecology 8:1923-1934.

Rodriguez-Robles, J.A., G.R. Stewart, and T.J. Papenfuss. 2001. Mitochondrial DNA-based phylogeography of North American rubber boas, *Charina bottae* (Serpentes: Boidae). Molecular Phylogenetics and Evolution 18(2):227-237.

Rundel, P.W., D.J. Parsons, and D.T. Gordon. 1995. Montane and subalpine vegetation in the Sierra Nevada and Cascade Ranges. *In* Barbour, M.G., and J. Major (eds.), Terrestrial vegetation of California. California Native Plant Society, Sacramento, CA.

Saunders, D.N., R.J. Hobbs, and C.R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology 5:18-32.

Sawyer, J.O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento, CA.

Shaffer, H.B., G.M Fellers, A. Magee, and S.R. Voss. 2000. The genetics of amphibian declines: population substructure and molecular differentiation in the Yosemite toad, *Bufo canorus* (Anura, Bufonidae) based on single-strand conformation polymorphism analysis (SSCP) and mitochondrial DNA sequence data. Molecular Ecology 9:245-257.

Shapiro, A.M. 1996. Status of butterflies. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Shevock, J.R. 1996. Status of rare and endemic plants. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Sierra Biodiversity Institute (SBI). 2004. Threatened and endangered species point locations. Unpublished digital data.

Sierra Nevada Ecosystem Project (SNEP). 1996. Sierra Nevada Ecosystem Project, final report to Congress, Volume I, Assessment summaries and management strategies. University of California at Davis, Centers for Water and Wildland Resources.

Sierra Nevada Forest Protection Campaign (SNFPC). 1999. Ensuring the ecological integrity of national forests in the Sierra Nevada: a conservation strategy. January.

Skinner, C.N., and C. Chang. 1996. Fire regimes, past and present. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Soulé, M.E., D.T. Bolger, A.C. Alberts, J. Wright, M. Sorice, and S. Hill. 1988. Reconstructed dynamics of rapid extinctions of chaparral-requiring birds in urban habitat islands. Conservation Biology 2:75-92.

Spector, S. 2002. Biogeographic crossroads as priority areas for biodiversity conservation. Conservation Biology 16:1480-1487.

Stein, B.A., L.S. Kutner, G.A. Hammerson, L.L. Master, and L.E. Morse. 2000. State of the states: geographic patterns of diversity, rarity, and endemism. Chapter 5 *in* Stein, B.A., L.S. Kutner, and J.S. Adams (eds.), Precious heritage: the status of biodiversity in the United States. Oxford University Press, New York, NY.

Stewart, W.C. 1996. Economic assessment of the ecosystem. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume III, Assessments, commissioned reports, and background information. University of California at Davis, Centers for Water and Wildland Resources.

Stine, S. 1996. Climate, 1650-1850. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Suarez, A.V., D.T. Bolger, and T.J. Case. 1998. Effects of fragmentation and invasion on native ant communities in coastal Southern California. Ecology 79(6):2,041-2,056.

Tan, A., and D.B. Wake. 1995. MtDNA phylogeography of the California newt, *Taricha torosa* (Caudata, Salamandridae). Molecular Phylogenetics and Evolution 4:383-394.

The Nature Conservancy (TNC). 1999. Sierra Nevada ecoregional plan. December.

Timmer, K.L. 2003. Troubled water of the Sierra. Sierra Nevada Alliance, South Lake Tahoe, CA.

Trombulak, S.C., and C.A. Frissell. 2000. Review of the ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18-30.

U.S. Forest Service (USFS). 2001. Sierra Nevada Forest plan amendment, final environmental impact statement. United States Department of Agriculture, Forest Service, Pacific Southwest Region. January.

U.S. Forest Service (USFS). 2004. Sierra Nevada Forest plan amendment, final environmental impact statement. Volume 1. United States Department of Agriculture, Forest Service, Pacific Southwest Region. January.

U.S. Geological Survey (USGS). 2005. The Western Mountain Initiative. Program Report, March 2005. http://www.cfr.washington.edu/research.fme/wmi/2005report.htm

Verner, J., K.S. McKelvey, B.R. Noon, R.J. Gutierrez, G.I. Gould Jr., and T.W. Beck (technical coordinators). 1992. The California spotted owl: a technical assessment of its current status. General Technical Report PSW-GTR-133. USDA Forest Service, Albany, CA.

Wakabayashi, J., and T.L. Sawyer. 2001. Stream incision, tectonics, uplift, and evolution of topography of the Sierra Nevada, California. The Journal of Geology 109:539-562.

Wake, D.B. 1997. Incipient species formation in salamanders of the *Ensatina* complex. Proc. Natl. Acad. Sci. 94:7761-7767.

Walker, R.E. 1992. Community models of species richness: regional variation of plant community species composition on the west slope of the Sierra Nevada, California. Masters thesis, University of California Santa Barbara, CA.

Woolfenden, W.B. 1996. Quaternary vegetation history. *In* Sierra Nevada Ecosystem Project, final report to Congress, Volume II, Assessments and scientific basis for management options. University of California at Davis, Centers for Water and Wildland Resources.

Young, J.A., R.A. Evans, and J. Major. 1995. Sagebrush steppe. *In* Barbour, M.G., and J. Major (eds.), Terrestrial vegetation of California. California Native Plant Society, Sacramento, CA.

Zielinski, W. J., T.E. Kucera, and R.H. Barrett. 1995. Current distribution of the fisher, *Martes pennanti*, in California. California Department of Fish and Game 81:104-112.

Zielinski, W.J., R.L. Truex, F. V. Schlexer, L.A. Campbell, and C.R. Carroll. In press. Historical and contemporary distributions of carnivores in forests of the Sierra Nevada, California, USA. Journal of Biogeography.

Zielinski, W.J., R.L. Truex, L.A. Campbell, C.R. Carroll, and F. V. Schlexer. 2000. Systematic surveys as a basis for the conservation of carnivores in California forests. Progress Report II: 1996-1999. October 4.

Attachment 1

Selected Sensitive Species and Habitats Documented within the Sierra Checkerboard Study Area*

*** not a comprehensive list**

Common Name	Scientific Name	Fed/State List[1]	Global Rank[2]	State Rank[3]
Plants				
Congdon's onion	*Allium sanbornii* var. *congdonii*		G3T3	S3.3
Sanborn's onion	*Allium sanbornii* var. *sanbornnii*		G3T3	S3.2
simple androsace	*Androsace occidentalis* var. *simplex*		G5T5	S1.3
Nissenan manzanita	*Arctostaphylos nissenana*		G2	S2.2
green spleenwort	*Asplenium trichomanes-ramosum*		G4	S1.3
woolly-leaved milk-vetch	*Astragalus whitneyi* v. *lenophyllus*		G5T3	S3.3
upswept moonwort	*Botrychium ascendens*		G2G3	S1.3?
Bolander's bruchia	*Bruchia bolanderi*		G2G3	S2.2
Pleasant Valley mariposa lily	*Calochortus clavatus* var. *avius*		G4T3	S3.2
Sierra Valley evening-primrose	*Camissonia tanacetifolia* spp. *quadiperforata*		G5T3	S3.2
shore sedge	*Carex limosa*		G5	S3?
Sheldon's sedge	*Carex sheldonii*		G4	S2.2
alpine dusty maidens	*Chaenactis douglasii* var. *alpina*		G5T5	S2.3?
Red Hills soaproot	*Chlorogalum grandiflorum*		G2	S2.2
Brandegee's clarkia	*Clarkia biloba* ssp. *brandegeeae*		G4G5T2	S2.2
fell-fields claytonia	*Claytonia megarhiza*		G4?	S2S3
clustered-flower cryptantha	*Cryptantha glomeriflora*		G3Q	S3.3
clustered lady's-slipper	*Cypripedium fasciculatum*		G4	S3.2
California pitcherplant	*Darlingtonia californica*		G3G4	S3.2
Tahoe draba	*Draba asterophora* var. *asterophora*		G4T2	S1.3
Cup Lake draba	*Draba asterophora* var. *macrocarpa*		G4T1	S1.2
English sundew	*Drosera anglica*		G5	S2S3
subalpine fireweed	*Epilobium howellii*		G1	S1.3
Oregon fireweed	*Epilobium oreganum*		G2	S2.2
starved daisy	*Erigeron miser*		G2	S2.3
Nevada daisy	*Erigeron nevadincola*		G5T4	S2.3
Donner Pass buckwheat	*Eriogonum umbellatum* var. *torreyanum*		G5T2	S2.2
Butte County fritillary	*Fritillaria eastwoodiae*		G3Q	S3.2
American manna grass	*Glyceria grandis*		G5	S1.3?
Parry's horkelia	*Horkelia parryi*		G2	S2.2
short-leaved hulsea	*Hulsea brevifolia*		G3	S3.2
Sierra Valley ivesia	*Ivesia aperta* var. *aperta*		G2T2	S2.2
Plumas ivesia	*Ivesia sericoleuca*		G2	S2.2
Webber's ivesia	*Ivesia webberi*		G2	S2.1

Common Name	Scientific Name	Fed/State List[1]	Global Rank[2]	State Rank[3]
red-anthered rush	*Juncus marginatus* var. *marginatus*		G5T5	S2S3
Cantelow's lewisia	*Lewisia cantelovii*		G3	S3.2
long-petaled lewisia	*Lewisia longipetala*		G2	S2.2
saw-toothed lewisia	*Lewisia serrata*		G2	S2.2
Quincy lupine	*Lupinus dalesiae*		G3	S3.2
bog club-moss	*Lycopodiella inundata*		G5	S1?
three-ranked hump-moss	*Meesia triquetra*		G5	S2.2
Jones's muhly	*Muhlenbergia jonesii*		G3	S3.3
yellow bur navarettia	*Navarretia prolifera*		G4T3	S3.3
northern adder's-tongue	*Ophioglossum pusillum*		G5	S1.2
closed-throated beardtongue	*Penstemon personatus*		G2	S2.2
Stebbins's phacelia	*Phacelia stebbinsii*		G3	S3.2
Nuttall's pondweed	*Potamogeton epihydrus* ssp. *nuttallii*		G5T5Q	S2.2?
slender-leaved pondweed	*Potamogeton filiformis*		G5	S1S2
white-stemmed pondweed	*Potamogeton praelongus*		G5	S1S2
sticky pyrrocoma	*Pyrrocoma lucida*		G3	S3.2
white-beaked rush	*Rhynchospora alba*		G5	S3.2
brownish beaked-rush	*Rhynchospora capitellata*		G5	S2S3
Tahoe yellow cress	*Rorippa subumbellata*	FE	G1	S1.1
water bulrush	*Scirpus subterminalis*		G4G5	S2S3
marsh skullcap	*Scutellaria galericulata*		G5	S2.2?
Layne's ragwort	*Senecio layneae*	CR	G2	S2.1
Munroe's desert mallow	*Sphaeralcea munroana*		G4	S1.2
lesser bladderwort	*Utricularia minor*		G5	S3.2
Siskiyou Mountains huckleberry	*Vaccinium coccineum*		G5Q	S2.2?
Cusick's speedwell	*Veronica cusickii*		G5	S3.3
woolly violet	*Viola tomentosa*		G3	S3.2
Invertebrates				
Lake Tahoe benthic stonefly	*Capnia lacustra*		G1	S1
Great Basin rams-horn	*Helisoma newberryi*		G1Q	S1
Shirttail Creek stonefly	*Megaleuctra sierra*		G1?Q	S1?
Button's Sierra sideband (snail)	*Monadenia mormonum buttoni*		G1G2T1	S1
South Forks ground beetle	*Nebria darlingtoni*		G1	S1
spiny rhyacophilan caddisfly	*Rhyacophila spinata*		G1G2	S1S2
Fish				
mountain sucker	*Catostomus platyrhynchus*		G5	S2S3
hardhead	*Mylopharodon conocephalus*		G3	S3
Lahontan cutthroat trout	*Oncorhynchus clarki henshawi*		G4T3	S2

Common Name	Scientific Name	Fed/State List[1]	Global Rank[2]	State Rank[3]
Amphibians				
Yosemite toad	*Bufo canorus*		G2	S2
Mount Lyell salamander	*Hydromantes platycephalus*		G3	S3
California red-legged frog	*Rana aurora draytonii*		G4T2T3	S2S3
foothill yellow-legged frog	*Rana boylii*		G3	S2S3
mountain yellow-legged frog	*Rana muscosa*		G2	S2
Reptiles				
San Bernardino ringneck snake	*Diadophis punctatus modestus*		G5T2T3	S2?
Coast (California) horned lizard	*Phrynosoma coronatum (frontale)*		G4T3T4	S3S4
Birds				
Cooper's hawk	*Accipiter cooperii*		G5	S3
northern goshawk	*Accipiter gentilis*		G5	S3
sharp-shinned hawk	*Accipiter striatus*		G5	S3
golden eagle	*Aquila chrysaetos*		G5	S3
black swift	*Cypseloides niger*		G4	S2
yellow warbler	*Dendroica petechia brewsteri*		G5T3?	S2
willow flycatcher	*Empidonax traillii*	CE	G5	S1S2
greater sandhill crane	*Grus canadensis tabida*	CT	G5T4	S2
bald eagle	*Haliaeetus leucocephalus*	CE	G4	S2
harlequin duck	*Histrionicus histrionicus*		G4	S2
osprey	*Pandion haliaetus*		G5	S3
great gray owl	*Strix nebulosa*	CE	G5	S1
California spotted owl	*Strix occidentalis occidentalis*		G3	S3
Mammals				
Sierra Nevada mountain beaver	*Aplodontia rufa californica*		G5T3T4	S3?
California wolverine	*Gulo gulo*	CT	G4T3Q	S2
Sierra Nevada snowshoe hare	*Lepus americanus tahoensis*		G5T3T4Q	S2?
white-tailed jack rabbit	*Lepus townsendii*		G5	S3?
American (=pine) marten	*Martes americana*		G5	S3S4
Pacific fisher	*Martes pennanti pacifica*		G5T3T4Q	S2S3
Sierra Nevada red fox	*Vulpes vulpes necator*	CT	G5T3	S1
Habitats				
Darlingtonia seep			G4	S3.2

[1] **Federal/State Listed Species**

FE = Federally endangered, FT = Federally threatened, CE = California endangered, CT = California threatened, CR = California rare

[2] **Global Ranks**

G1 = Extremely endangered: <6 viable element occurrences (EO), or <1,000 individuals, or <2,000 acres of occupied habitat
G2 = Endangered: about 6-20 Eos, or 1,000 – 3,000 individuals, or 2,000 – 10,000 acres of occupied habitat
G3 = Restricted range, rare: about 21-100 EOs, or 3,000 – 10,000 individuals, or 10,000 – 50,000 acres of occupied habitat
G4 = Apparently secure; some factors cause concern, such as narrow habitat or continuing threats
G5 = Demonstrably secure; commonly found throughout its historic range

T-Ranks

A subspecies is given a T-Rank. This is attached to the Global Rank for the full species. The State Ranks, in this case, will refer to the status of the subspecies within California. The T-Ranks have the same general definitions as the Global Ranks.

[3] **State Ranks**

Statewide status of a full species or a subspecies: S1 to S5
Same general definition as Global Ranks, but just for taxa within California

Other Notations: applicable to Global Ranks, State Ranks, and T-Ranks
G1G3 = proper rank is most likely within this range of ranks
G2? = proper rank is probably G2
G? = we don't have enough information to rank the species
GH = all sites are historical; this species may be extinct, but further field work is needed
GX = species is extinct (SX = species is extirpated from California)
GXC = species is extinct in the wild but it exists in cultivation
G2Q = species is endangered but there is some question about the taxonomy

Attachment 2
Procedure for Evaluating and Mapping Commercial Timber Value

The objective of this analysis was to map the relative commercial timber value of forests in the study area on a simple high, medium, and low classification scheme. The analysis was conducted in three steps: (1) Commercially important conifer forests were separated from other vegetation community types, such as oak woodlands and non-forested communities. (2) These forests were ranked on the basis of tree density (stocking), tree size, and species mix, using a scoring as follows: high = 3, medium = 2, and low = 1. (3) Scores for the three factors were summed and assigned high, medium, or low values.

The commercial timber value analysis was performed using the <u>SP_VEG_COMP</u> vegetation database (see Technical Appendix). The <u>SP_VEG_COMP</u> vegetation data are compiled from the USFS Remote Sensing Laboratory (RSL) and the Tahoe National Forest (TNF), which designate forest communities (dominant tree species), tree densities, and average tree sizes differently. Thus, the analysis accounts for the different designations in the two databases. The specific designations used to assign high, medium, and low scores are tabulated below. The relevant attributes from the two databases are shown in capitalized letters in the table.

Step 1—Identify commercially important forests.				
For all areas except TNF, use **RSL-COVER-TYPE =** CON (Conifer forest/woodland) or MIX (Mixed conifer forest/woodland. For TNF, use **TNF-VEG-TYPE =** E or L or M or R or W or X or NX.				
Step 2—Rank and score commercially important forests.				
	Data Attribute	**High = 3**	**Medium = 2**	**Low = 1**
Rank Density	**% Crown Closure**	**>70%**	**40% - 69%**	**0% -39%**
All areas except TNF	RSL DENSITY	7 or 8 or 9	4 or 5 or 6	0 or 1 or 2 or 3
For TNF	TNF DENSITY[1]	G	N	S or P or X
Rank Size	**Visible Crown Diameter**	**> 24 ft**	**12 ft – 24 ft**	**< 12 ft**
All areas except TNF	RSL SIZE CLASS	4 or 5 or 6	3	N or 0 or 1 or 2
For TNF	TNF SIZE CLASS[2]	4 or 5 or 6	3	0 or 1 or 2
Rank Species Mix	**Species Mix**	**Douglas fir, ponderosa pine, mixed pine**	**Mixed fir, red fir, white fir**	**Lodgepole pine, eastside pine, mixed conifer/hardwood, etc.**
All areas except TNF	RSL VEGETATION TYPE	DF or DP or PP or MP	MF or RF or WF	EP or IC or JP or KP or LP or MB or PD or SA
For TNF	TNF VEGETATION TYPE	M	R or W	L or E or X
Step 3 – Sum scores for the three factors and assign final ranks.				
Commercial Timber Value	**Total Score**	7, 8, or 9	5 or 6	3 or 4

1 Where the TNF DENSITY value was blank and the TNF COMMENTS indicated bare ground or plantation, the DENSITY SCORE was assigned a 1.

2 Where the TNF SIZE CLASS value was blank and the TNF COMMENTS indicated bare gound or plantation, the SIZE-SCORE was assigned a 1.

Attribute Code Definitions

RSL DENSITY (% crown closure)

0 = 0-9%
1 = 10-19%
2 = 20-29%
3 = 30-39%
4 = 40-49%
5 = 50-59%
6 = 60-69%
7 = 70-79%
8 = 80-89%
9 = 90-100%
X = Not determined

TNF DENSITY (% crown closure)

X = Conifer plantation
S = <20%
P = 20-39%
N = 40-69%
G = >70%

RSL SIZE CLASS

N = Non-sticked (area not reforested)
0 = Seedlings (derived from plantation age)
1 = Saplings (derived from plantation age)
2 = Poles (crown diameter <12 ft)
3 = Small (crown diameter 12-24 ft)
4 = Medium (crown diameter 24-40 ft)
5 = Large (crown diameter >40 ft)
6 = Multi-layered

TNF SIZE CLASS

0 = Plantation, <10 years old
1 = Saplings (crown diameter <5 ft)
2 = Poles (crown diameter 6-12 ft)
3 = Small sawtimber (crown diameter 13-24 ft)
4 = Medium sawtimber (crown diameter 25-40 ft)
5 = Large sawtimber (crown diameter >40 ft)
6 = Two-storied

RSL VEGETATION TYPE

DF = Pacific Douglas fir
DP = Douglas fir-pine
EP = Eastside pine
IC = Nonnative/ornamental conifer
JP = Jeffrey pine
KP = Knobcone pine
LP = Lodgepole pine
MB = Mixed conifer-giant sequoia
MF= Mixed conifer-fir
MP = Mixed conifer-pine
PD = Gray pine
PP = Ponderosa pine
RF = Red fir
SA= Subalpine conifers
WF = White fir

TNF VEGETATION TYPE

E = Eastside pine
L = Lodgepole pine
M = Mixed conifer
R = Red fir
W = White fir
X = Mixed hardwood conifer
NX = Recently harvested

COVER IMAGES: *(Clockwise, from left) Skiing in the Sierra by James Milton; leaves by Phil Schermeister; kayaking on the Upper Sacramento River by Phil Schermeister; rainbow trout by Doug Stamm; South Yuba River by Phil Schermeister.*

BACK PAGE IMAGES: *(Right) Barker Pass overlooking Lake Tahoe. Both images by Phil Schermeister.*

For more information about the Trust for Public Land's Sierra Checkerboard Initiative, please contact:

David Sutton
Sierra Nevada Program Director
(415) 495-5660 ext. 347
dave.sutton@tpl.org

Robin Park
Project Manager
(415) 495-5660 ext. 339
robin.park@tpl.org

The Trust for Public Land
116 New Montgomery Street
San Francisco, CA 94105
(800) 714-5263
(415) 495-5660
(415) 495-0541 (fax)
www.tpl.org/california

THE TRUST *for* PUBLIC LAND
CALIFORNIA

Founded in 1972, the Trust for Public Land (TPL) is a national nonprofit organization that conserves land for people to enjoy as parks, gardens, and other natural places, ensuring livable communities for generations to come.

TPL's experienced staff use real estate and fundraising expertise to help local communities and government agencies protect lands of scenic, recreational, and ecological significance.

To date, TPL has acquired and protected more land in the Sierra Nevada than any other non-profit organization—more than 60,000 acres, with a fair market value of more than $60 million. In the process, TPL has developed strong relationships and credibility with public agencies, major landowners, and local conservation groups. For more information about the Trust for Public Land and our work in the Sierra Nevada, please visit our web site at www.tpl.org/california.

CONSERVATION BIOLOGY INSTITUTE

The Conservation Biology Institute provides scientific expertise to support conservation and recovery of biological diversity in its natural state through applied research, education, planning, and community service. For more information, please visit www.consbio.org.

Printed on recycled paper