Final Report to the Joint Fire Science Program

Multi-Jurisdictional Application of ForestERA Landscape Decision Support Tools in North-Central New Mexico

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Table of Contents

Executive Summary

The North-Central New Mexico Landscape Assessment was a collaborative, landscape-scale effort that engaged stakeholders in a series of meetings and workshops to identify and prioritize areas of forest and associated lands in greatest need of management attention. The focal landscape assessment area included public, tribal, and private lands within a 3.4 million-acre study region. Our 2-year process culminated in a three-day workshop in October 2006, where over 50 regional stakeholders were convened to address these issues using a spatial decision support system designed by the Forest Ecosystem Restoration Analysis (ForestERA) Project at Northern Arizona University (NAU). ForestERA staff, along with staff from the Bureau of Land Management, Forest Guild and the Australian National University, provided a forum where stakeholder values, concerns, and ideas could be translated into spatially-explicit prioritization and management action scenarios based on the best available science. The result was a set of science-based solutions which met national policy priorities while remaining grounded in the needs of local stakeholders.

Stakeholders participating in the workshop were divided into four groups as a means of exploring alternative approaches to common problems. The results of these breakout group exercises indicated high levels of participant agreement about landscape-scale values, and risks to these values. In particular, workshop participants valued the preservation and restoration of healthy watersheds, biodiversity, and water resources. Risks to these values included the potentially negative consequences of increased development, political barriers, inaction, and poor land management practices.

These values were translated in a variety of ways by the four groups, leading to the creation of series of maps and other spatial data products reflecting a detailed and spatially explicit understanding of management priorities and appropriate actions. While some differences in priority areas for treatment are evident in management scenario maps, overall, there was a reasonable level of concurrence among groups' priorities. Agreement tended to be highest in those locations where high fire risk and hazard, important watersheds and water resource areas, areas threatened by urbanization and high diversity habitats coincided. High priority areas crossed many land jurisdictions, included

watersheds for drinking water and the headwaters of major drainages, and areas of the wildland-urban interface (WUI) that intermix with diverse vegetation types and areas of high cultural value.

Management action scenarios developed by the four individual groups ranged from the very general to the very specific and prescriptive. Of all the workshop products, results from of the management scenario exercises probably exhibited the greatest variation. There was consistent interest in implementing management actions of intermediate- and high-intensity in habitats dominated by ponderosa pine and mixed-coniferous vegetation types, as well as piñon-juniper stands at risk, for example, of large-scale fire. Among groups, low- to intermediate-intensity management actions (e.g., thinning followed by prescribed fire) were most commonly considered treatment actions, while areas defined by no management action constituted over 50% of the landscape. Predicted effects of a fifth management action scenario, one that integrated the work of all four groups, were assessed, focusing on fire hazard reduction, and Mexican spotted owl habitat occupancy.

The independent work of the four groups, drawing on the same data sources to address the same prioritization and management challenges, provides a novel assessment of the level of agreement that exist on these potentially contentious social issues, and how they might be resolved. Analysis of the overall process, drawing on incisive analytical approaches from the social sciences, indicates that the participatory, science-based process led to great agreement among stakeholders, as well as a strong relationship between individual stakeholders' values and their forest policy preferences.

The north-central New Mexico Landscape Assessment represents one of the first efforts in the nation to engage stakeholders in a collaborative, landscape-scale assessment of public lands using an interactive and integrative science-based approach. It is also unique in that it addressed several national policy directives simultaneously. The broad concurrence in stakeholder values and perceived risks that were identified during this spatially-explicit process provide and unprecedented opportunity to inform and integrate planning efforts in the region at multiple spatial scales.

Introduction

The north-central New Mexico Landscape Assessment was a stakeholder-based collaborative process to identify and prioritize forested areas in greatest need of management attention at the landscape scale. The assessment was designed to reflect the needs and interests of multiple local and regional stakeholders, while addressing forest policy directives to restore forest and woodland ecological health at the national and state levels. Stakeholders in north-central New Mexico, in partnership with the Forest Guild of Santa Fe, New Mexico, invited the Forest Ecosystem Restoration Analysis (ForestERA) Project at Northern Arizona University (NAU) to organize and support an effort to provide collaborative, science-based recommendations for forest restoration planning at all levels, from individual projects, such as those funded by the Collaborative Forest Restoration Program (CFRP), to Community Wildfire Protections Plans (CWPPs), and other federal lands management plans.

ForestERA Spatial Decision Support System

We implemented a spatial decision support system based on a spatial-analytical approach and process pioneered by the ForestERA project (see Hampton et al. 2005, 2006, Sisk et al. 2006) to meet specific planning needs in the assessment area. In collaboration with multiple stakeholders in north-central New Mexico, we used ForestERA research and spatial data products to help land-use planners identify suitable management activities, such as restoration and fuel treatments, across broad spatial extents. For example, with the help of these data and tools, managers, scientists, and stakeholders were able to view patterns of vegetation, wildlife habitat, fire hazard and risk, and other issues of interest across the entire north-central New Mexico landscape. We used a series of group processes, tailored to the needs of local communities and interest groups, to identify stakeholder values, ideas, and recommendations, and translated these values onto maps that showed highest priority areas for treatment, recommended treatment actions, and the predicted cumulative effects of these actions. These data layers, maps, and predictions are based on the most current, peer-reviewed scientific information available, and facilitate a dynamic interface between collaboratively-defined community values and the best available science. The ForestERA process also introduced a social research component to quantitatively evaluate the impact and influence of the public participation process on stakeholder values and policy preferences. This social science component of the project allowed us to better understand the attitudes of participants toward landscape-scale forest management issues and restoration alternatives.

Policy Mandates and Directives

Recent federal policies, such as the Healthy Forests Restoration Act and the Healthy Forests Initiative, state policies, such as the New Mexico Forest and Watershed Health Plan (2004), and the collaboratively developed New Mexico Forest Restoration Principles (2006), underscore the consensus that there exists a need for landscape-level analyses that integrate the best available science with collaborative efforts to guide restoration projects. Landscape assessments, such as this one, can simultaneously meet a multitude of policy directives and scientific recommendations (Table 1). Indeed, this workshop is the first effort in New Mexico to address all of these identified needs in an integrated manner.

Project Background

The North-Central New Mexico Landscape Assessment Study Area

The focal landscape assessment study area encompassed 3.4 million acres in north-central New Mexico, and included public, tribal, and private lands (Figure 1). Elevations in the study area, which included the southern Sangre de Cristo Mountains, ranged from 5,000 - 13,000 feet. The regions diverse habitats included grassland and sagebrush, ponderosa pine, mixed conifer, spruce-fir, and tundra vegetation types. These lands were managed by more than a dozen public and tribal entities, as well as private land ownerships. Many of the organizations in charge of managing these lands lacked comprehensive data on forest and woodland fuel conditions, watershed risks, endangered species, wildland urban interface areas, and community and economic infrastructure, and comprehensive landscape-level spatial data were largely lacking or unavailable prior to this project (see Needs Assessment, Appendix A).

ForestERA Tools and the Collaborative Process

To address gaps in information and data, the ForestERA Project provided stakeholders with a science-based process and two-year forum to develop strategies for reducing fire threat and to focus fuel reduction funds on the highest priority areas across the landscape. The agencies and municipalities charged with managing the forests and communities in this landscape are extremely concerned about the increasing frequency and severity of high-intensity crown fire, like that manifested dramatically in the 2000 Cerro Grande Fire. Most partnering agencies and organizations have their own fire and forest management objectives and differing level of resources available with which to develop scientific information to guide their management. As a result, these entities have not been able to build a scientific framework for identifying fuels reduction needs across jurisdictions. Recently, multiple stakeholders involved in forest and fire planning across this diverse region formed a collaborative group to develop landscape-scale data and to conduct a multi-jurisdictional analysis of wildfire risks and treatment alternatives and priorities. This group approached the ForestERA Project at NAU about developing a scientific foundation and spatial modeling tools to allow managers to strategically plan and prioritize fuel reduction and restoration treatments.

The core group of agency partners in the collaboration included the BLM/Taos Field Office and the following New Mexico counties: Santa Fe, Taos, Rio Arriba and San Miguel. These partners were responsible for convening the collaborative, developing the initial assessment proposal, and leading the proposed project. A second group of project sponsors, who participated in the project development and actively contributed to implementation, included the Santa Fe and Carson National Forests, Bureau of Indian Affairs, and the individual tribal and land grant entities. Two non-governmental organizations are also engaged in the collaborative. The Forest Trust coordinated and facilitated the multi-jurisdictional collaborative and The Nature Conservancy contributed data about reference ecological conditions. A list of project cooperators and collaborators is included in the assessment Data Atlas (Appendix B).

ForestERA tools and processes are well-suited to collaborative landscape assessments, as they present the best available science in a spatially explicit format which is both amenable to collaboration (groups can use the tool to inform decision-making) and dynamic (it has the ability to model the effects of various treatments). ForestERA tools are implemented using a geographic information system (GIS) platform that allows stakeholders to choose, for example, management-relevant data layers, rank specific areas based on spatially-explicit attributes (e.g., steepness of slope, proximity to infrastructure, or susceptibility to crown fire), specify buffer zones around elements of interest, and view the predicted landscape-scale effects of management actions.

The North-Central New Mexico Landscape Assessment was guided by the principle that science-based landscape assessments – including those responding to national- and state-level directives – should be grounded in the needs and interests of local communities and stakeholders. In this case, stakeholders included individuals with a wide variety of interests, experiences, and expertise, and this diversity was reflected in a survey and series of interviews that the Forest Guild conducted as part of a stakeholder "needs assessment" (Appendix A). This input provided ForestERA and others involved in project planning with guidance on topics such as: what kinds of spatial data to collect; what ecological models to build; what interests and individuals to include in the stakeholder workshop; what issues to address during the workshop; and how to structure workshop processes and agenda.

After we identified stakeholder needs, we invited federal, state, local and tribal managers to participate in data and tool development. The result of this multifaceted collaborative approach was a set of data, spatial analysis tools, and workshop processes that responded to the needs and interests of local communities and stakeholders. Many stakeholder groups provided spatial data that ForestERA staff used to form "wall-to-wall" data layers across the study area. ForestERA evaluated these data for consistency and described them using formal metadata documentation. A detailed description of the foundational, derived, and supplemental spatial data developed for the New Mexico assessment can be found in the north-central New Mexico Data Atlas (Appendix B). At various stages in the developmental stages of the project, meetings were held in northern New Mexico to present preliminary products and discuss the trajectory of the project's development. Meetings were held in Santa Fe, Taos, and Española, and smaller gatherings and one-on-one discussions took place in several smaller communities.

Many of the data layers described in the Data Atlas were collaboratively developed with local stakeholders. For example, we worked with the Taos Soil and Water District and the Northern New Mexico Acequia Association to develop a new data layer identifying acequias in each subwatershed in the study area. Another example is the Wood User and Processor map, which is based on data provided by Region 3 of the USDA Forest Service and information gathered by the Forest Guild on all known "wood-related" businesses on public and private forested land within 60 miles of the assessment study area boundary (see Workshop Handbook, Pp. 21-22, Appendix C).

In another collaborative effort involving stakeholders, ForestERA convened a Watershed Topic group of about a dozen north-central New Mexico watershed professionals. The group reviewed currently available data on streams, wells, springs, reservoirs, impaired waters, erosion predictions and other watershed-related data for the assessment area. On August 3, 2006, we held an all-day meeting of this group at the Santa Clara Pueblo, New Mexico, to develop watershed-focused recommendations for use in the formal landscape assessment. After reviewing the ForestERA data layers for accuracy and completeness, the group developed a list of priorities to be considered when planning restoration and fuel reduction treatments at the October 2006 workshop (see below).

Finally, the Santa Clara Pueblo collected most of the vegetation plot data that ForestERA used to develop maps of forest structure. By working with a broad range of collaborators, the ForestERA team was able to identify important data "gaps," then contract with the Santa Clara field crews to collect additional field data that successfully leveraged existing information. This process is illustrative of the power of collaborative landscape-level science and planning efforts.

The North-Central New Mexico Landscape Assessment Workshop

The north-central New Mexico Landscape Assessment workshop was held October 17-19, 2006 at the Taos Convention Center in Taos, NM, which was selected for its location near the center of the assessment area. Approximately 60 stakeholders participated in the workshop, along with 15 workshop planners and facilitators from ForestERA, the Forest Guild, and BLM/Taos Field Office. Not all participants were present for all portions of the workshop, but a core group of approximately 30 stakeholders were present from beginning to end. Participants represented interests that included the New Mexico State Forestry Division, Mexicano Land Trust, Taos Soil and Water Conservation District, Taos, Picuris, Santa Clara, and San Juan Pueblos and representatives of the Eight Northern Pueblo Council, U.S. Forest Service (Carson and Santa Fe National Forests), New Mexico Department of Environmental Quality, New Mexico Forest and Watershed Restoration Institute, New Mexico Environmental Department Surface Water Quality Bureau, New Mexico Acequia Association, local counties, towns, conservation organizations such as The Nature Conservancy and Forest Guardians, cattle ranchers, economic development organizations, local colleges, and many others. The workshop benefited from a recent history of collaboration between many of these entities, largely within the framework of various CFRP projects and large watershed-based resource management efforts.

The workshop consisted of four major elements or "steps": 1) presentations on forest planning perspectives by leading representatives of diverse stakeholder organizations, 2) an introduction to landscape assessment concepts and ForestERA data and tools; 3) the prioritization of areas for forest restoration treatments; and 4) the creation of management action scenarios for improving ecological health across the landscape. Steps three and four were conducted using a replicated small group approach. Prior to the workshop, known participants were divided into four groups (identified by the colors: red, green, yellow, and blue). Composition of the groups was determined by Forest Guild and ForestERA staff in order to maximize the diversity of interests in each group. The replicated small group approach was used to allow more individual input into decisions than would occur using a large group approach, as well as to foster a diversity of solutions.

Step 1 consisted of a series of opening remarks by local community leaders, followed by Step 2, an in-depth discussion of the need for landscape-scale assessment and presentation of ForestERA tools. These presentations allowed workshop participants to gain a greater understanding of the conceptual framework for the assessment, while familiarizing them with workshop processes and with the capabilities of ForestERA data and tools.

Step 3 was the prioritization exercise, which began with a discussion of individual group members' values, related to the lands and waters in the study area. A small-group process known as the "nominal group technique" was used to elicit ideas and rank these values. Briefly, the nominal group technique begins with silent deliberation on a question, in this case, "What values are important to consider when attempting to prioritize areas for restoration of ecological health?" A round-robin session follows, in which each participant names one of their identified values (each value is recorded on a large flip-chart). Once each person has named one value, the round-robin continues until an acceptable number of ideas have been identified. Group members discuss and clarify what each identified value represents, and combine values which are fundamentally similar. Finally, each member is given a select number of votes, and they are asked to vote for those values they feel are most important. The resulting list gives a ranked set of values for use in later discussions. A similar process was used to identify risks to highly valued landscape features or processes.

The prioritization exercise continued with a discussion of spatial data layers that could be used to represent identified values and risks. In some cases, groups decided to modify existing layers to better suit their data needs. Once a list of data layers was agreed upon by the group, each layer was assigned a weighting factor representing its importance relative to other layers. For example, if a group felt that the Vertebrate Species Richness layer was twice as important as the Mexican Spotted Owl Predicted Distribution layer, the Vertebrate Species Richness layer would get a rank of "2" and the owl layer a rank of "1". These weighted layers were then combined using a GIS overlay technique to create a composite priority map. High-priority regions represent places where important values and risks coincide, and lower-priority regions represent places where values and risks are fewer or less important.

Step 4 included a revisiting of the prioritization process before moving on to recommending management actions to address areas of combined value and risk. Each individual group was given an opportunity to reassess data layers (including the integration of new layers created by other individual breakout groups) and reassign weights. Next, they began a new process of assigning management action recommendations based on spatial features, such as vegetation, slope, political designation (e.g., wilderness areas), predicted fire behavior, or other factors of importance to the group. Several management actions (e.g., light burn, heavy burn, and light-, intermediate-, and high-intensity thinning) were already pre-programmed into ForestERA tools, but groups were encouraged to define other actions to suit their specific goals and objectives. The groups assigned priority rankings to all management actions, which differed from the "weights" given to value and risk layers, in that they determined what management action would prevail when two or more management actions could apply to the same place. Finally, the prioritization and management action results for each group were combined by identifying the management actions recommended for the 300,000 acres of highest-priority land (approximately 10% of the total assessment area). The outcomes for each of the group exercises are reported in the Individual Group Scenario Results section, below.

The exercises and products resulting from the stakeholder workshop, and the larger 2-year assessment, provided stakeholders with data, tools, and collaboratively-developed products that can be used to: a) create a scientific foundation for fuels reduction and forest restoration work; b) communicate about landscape-scale priorities and coordinate management actions across jurisdictions; c) leverage fuels treatment funds and resources to better achieve restoration goals; and d) establish baseline conditions to monitor changes in wildfire and forest conditions at the landscape scale. At the workshop, we distributed all spatial data layers of forest structure (canopy closure, basal area, tree density, and dominant vegetation), fire risk and hazard, watershed risks, and wildlife species of concern spanning the entire study area. Final results from the prioritization and management action work are conveyed in this report, and will be distributed in a shorter, brochure format to all workshop participants in the near future (note, this is an additional "deliverable" made possible by leveraging funds with collaborating scientists, managers, and other partners.

Individual Group Scenario Results

Blue Group

The Blue Group chose what they referred to as an "Integrated Forest Management" approach to prioritize areas in need of restoration and management attention in the north-central New Mexico study area. First the group identified landscape-scale values and risks important to the group, then, individually, members of the group ranked the relative importance of these values and risks (Tables 2 and 3). Next, members used the ranked values and risks to characterize specific management objectives and identify spatial data layers that fit their criteria (see exercise worksheet in Appendix D1). Specifically, the Blue Group focused on management objectives that valued the following: 1) good water quality; 2) biodiversity maintenance and restoration; and 3) forest products. Highly ranked risks to these values included factors that influenced historical soil loss and the potential for future erosion, and active crown fire behavior.

Priority Areas for Management Attention

The Blue Group identified three relevant spatial data layers representing water features important for supporting high-quality water in the north-central New Mexico study area: 1) perennial rivers and streams; 2) water bodies; and 3) springs and seeps (Appendix A1). Prior to analysis, all rivers, streams, springs, and seeps were buffered at 100 ft and these areas were converted to 30 x 30-m pixels. The valuation of good water quality was characterized at the scale of the 6^{th}-order watershed by summing all pixels occurring within each watershed. Watersheds were then ranked according to the total number of pixels contained in each watershed (i.e., more pixels equals "better"). The value of biodiversity maintenance and restoration was summarized using data layers that quantified vertebrate species richness, forage potential, and vegetation diversity; and identified ecoregional conservation areas defined by The Nature Conservancy (TNC). Using ForestERA's dominant vegetation data layer, the group elected to create the vegetation diversity data layer by counting the total number of dominant vegetation types (excluding agricultural and developed areas) occurring within any given 1-km^2 area on the landscape, and assigning this total value to each pixel on the study area. Areas relevant to the production of forest products were defined by data layers that included continuous values for quadratic mean diameter (higher equals "better") and distance from economic infrastructure (less equals "better").

In representing the risk to areas of historical soil loss and the potential for future soil erosion, the Blue Group used the ForestERA post-fire erosion data layer to identify areas of greatest erosion potential, as well as eroded areas most likely to be in need of restoration (Appendix A1). The group used ForestERA's crown fire behavior layer to quantify the risk of active crown fire behavior in forested areas dominated by ponderosa pine or "drier" mixed-coniferous stands.

To develop their prioritization scenario map, the Blue Group assigned weights to each of the above value and risk layers by multiplying the weight of each layer by its binary (0 or 1) or continuous (0 to 1) value range. Finally, the Group additively combined all of these weighted layers (10 layers in all) and rescaled (between 0 and 100) the raw result to produce a final prioritization map (Figure 2A). The top 300,000 acres of highest priority areas in the study area were identified using this final prioritization scenario map and extracted for use in mapping the priority management areas described below.

Management Action Recommendations

In developing their management action scenario, the Blue Group selected possible management actions for areas identified in the prioritization scenario map. For areas where good water quality was to be maintained, for example, the group chose to reduce conifer encroachment in higher elevation riparian habitats by recommending the removal of 30% of the overstory canopy dominated by mixed-conifer species. To mitigate the invasion of exotic plants (e.g., tamarisk and Russian olive), "bosque" treatments were assigned to lower elevation riparian habitats. The group recommended that these riparian treatments be implemented within 30m of all streams, rivers, springs, and seeps. For the purpose of maintaining biodiversity, represented by forage potential and vegetation diversity, the Blue Group selected to implement high-intensity thinning treatments (followed by prescribed fire) in mixed-conifer habitats; and intermediate-intensity treatments (followed by prescribed fire) in piñon-juniper habitats with mollisol soils. These prescriptions, however, were assigned with the caveat that treatments should only be implemented after considering local-scale context and conditions.

For ponderosa pine-dominated habitats, the Blue Group suggested a high-intensity thinning treatment to improve forage potential, and an intermediate-intensity treatment to enhance vegetation diversity, control cheatgrass seeding and invasion, and reduce crown fire behavior (see below and Appendix D1). In areas where the two types of treatments overlapped, the management treatment with the highest assigned priority rating took precedence.

The Blue Group used the crown fire behavior layer to identify areas of "active" and "passive" crown fire potential. To minimize the potential for "unnatural" stand-replacing fires, the group recommended high-intensity thinning treatments in ponderosa pine and mixed-conifer habitats with active crown fire potential. Areas with "passive" crown fire potential were assigned intermediate-intensity treatments and areas predicted to be characterized by "surface" fire behaviors were assigned a low-intensity treatment. By assigning a spectrum of treatment intensities in areas prone to stand-replacing fire, cheatgrass seeding and invasion, for example, could be more easily managed. The Blue Group did not assign management actions to layers associated with forest products (values) or post-fire soil loss and erosion potential (risks).

Once management actions were assigned to areas on the landscape, the resulting map was "filtered" to include only those patches ≥100 acres, so as to minimize the prevalence of smaller "fragmented" treatments. The final management action map included five unique treatment types: light-, moderate-, and high-intensity thinning (each followed by light burning), riparian conifer encroachment treatment, and a bosque treatment (Figure 3). Specific information about the parameters defining the light-, moderate-, and high-intensity thinning treatments are detailed in the North-central New Mexico Landscape Assessment Workshop Handbook (Appendix C). For the entire study area, high-intensity thinning treatments were the management action most often (30%) recommended by the Blue Group, followed by an intermediate-intensity thinning treatment (12%), and low-intensity thinning treatment (3%). Treatments in riparian areas constituted less than 1% of the total area recommended for treatment. Management actions were undefined in the remaining areas (~54%).

Prioritized Management Action Recommendations

For the top 300,000 acres identified using the final prioritization scenario map, management actions recommended by the Blue Group were also mapped in these areas (Figure 4). In these high priority areas, high-intensity thinning treatment were the management action most often (57%) recommended by the Blue Group, followed by an intermediate-intensity thinning treatment (15%), and low-intensity thinning treatment (2%). Treatments in riparian areas again constituted less than 1% of areas recommended for treatment. Management actions were undefined in the remaining high priority areas (~25%).

Additional Blue Group recommendations

Several of the landscape-scale values (e.g., sustaining natural heritage, maintaining landscape aesthetics, etc.) and risks (e.g., politically-driven management decisions, biases against collaboration, unmanaged recreation, etc.) identified as important by the Blue Group either lacked quantitative data or were qualitative in nature. Due to these limitations, the Blue Group chose to not directly address these factors in the development of prioritization scenarios. However, the group agreed that these values and risks, particularly those that were high ranking, should bear weight on all management decisions. Moreover, the Blue Group also recommended that management actions consider more specific evaluations prior to treatment using ForestERA data, including layers describing potential habitat for the Tasseled-eared Squirrel and the Rio Grande Cutthroat Trout, and the TNC fish layer, where applicable.

Green Group

The Green Group objectives for prioritization focused on protecting watersheds, riparian areas and surface waters values, while working with local communities in their traditional uses to enhance, restore and conserve the landscape, water and cultural values. Their management recommendations focused on fire hazard reduction, restoring riparian bosque habitats and eradication of invasive species. These values, risks and management actions are detailed in the Green Group Scenario Worksheet (Appendix A2).

Priority Areas for Management Attention

First, through discussion, the Green Group identified a list of important values and risks on the landscape. Each member then voted for their top five choices for risks and top four choices for values (These are summarized in Tables 4 and 5). The top priority values and risks provided direction for the subsequent discussion and mapping of values at risk.

The prioritization scenario map was developed using nine of the eleven risks and values identified by the Green Group. Of these, five were values: surface waters, riparian habitat, specific watersheds, WUI and biodiversity, and four were risks: fire risk, fire hazard, piñon-juniper fire threat, and post-fire erosion potential. One value and one risk were not used in this mapping effort as there was no way to map the value of maintaining cultural and traditional use of land grants and pueblos. Instead the group agreed that this value should provide a framework within which the prioritization and management recommendations would take place. The non-riparian invasive species risk was not used due to a lack of reliable data for invasive species across the landscape.

To map the nine values and risks, the Green Group selected one or more spatial layers, summarized below. For analysis purposes, the Green Group assigned each of these layers a categorical or continuous value range (see Appendix A2, column 4) and assigned a priority weight (see Appendix A2, column 5) representing the relative importance of each. Fire hazard and specified watersheds received the highest weight of 3 followed by riparian habitat and surface waters at 2.8, biodiversity and invasive species at 2.5 and fire risk, piñon-juniper fire threat and WUI at 2.

Values Layers

Surface waters: The group identified surface waters as high-value landscape features. We combined springs, perennial streams, and lakes, and weighted these features into a new data layer named “Surface Waters”. The value range of the springs, perennial streams and springs were 0.5, 1, and 0.25 respectively with the final combined layer receiving a priority weight of 2.8.

Riparian habitats: Riparian habitats are important, rare, and declining across the study area. Because they are subject to increasing threats due to invasive woody plants and unnatural fire, they constitute an important landscape value.

We combined the four, somewhat limited Southwest ReGAP (or "GAP") riparian land cover classes (S091, S092, S093, S095) into an aggregate GAP data layer. To this aggregated riparian layer, we added the Rocky Mountain Alpine-Montane Wet Meadow (S102) class. We then created a layer of buffered perennial streams (30-m buffer) and rivers (60-m buffer on the Rio Grande) to capture additional riparian vegetation. The union of the GAP and buffered streams layers created our final Riparian Habitats data layer. All of these features were given a value of 1 and a priority weight of 2.8.

<u>Watersheds feeding acequias and assumed recharge zones:</u> The group felt that acequias constituted important landscape values, both for their cultural value and their role as recharge zones for local aquifers and wetlands. The upper watersheds, whose runoff feeds acequia systems, were identified as an important value, since the retention of high watershed values in these areas provides basic ecological and cultural services, including surface water. We identified watersheds with acequia systems, then selected the sub-watersheds that serve as the catchment basins that deliver runoff to the acequias. The municipal watersheds were also identified as important landscape features because of their importance to communities. The critical municipal watersheds in the assessment area were identified by local hydrology and soil scientists in a Watershed Topic Group meeting held in August 2006 by ForestERA.

The group also felt that all watersheds feeding permanent streams were important because of their potential role as groundwater recharge zones. We identified all watersheds with perennial streams, which resulted in a data layer covering the vast majority of the study area, with the exception of extensive sage flats and shrublands in the Rio Grande valley.

Each of these three different watershed categories received an equal value range of one in the final prioritization map. There was one participant who felt strongly that municipal watersheds should outweigh the riparian and acequia watershed 3 to 1. This is not reflected in the prioritization because 1) we did not feel there was a consensus among the group and 2) the municipal watersheds are also riparian and acequia watersheds so they are triple counted in this scenario using all three types of watersheds. The final layer received a priority rating of 3.

Green Group Wildland-Urban Interface (ggWUI): We started with the urban and rural structures layer to represent the "urban" areas and buffered these areas by 0.5 mile. Next we used the ForestERA WUI layer, and extracted the features identified as infrastructure: "highways", "communication towers" and "power lines". Each of these features was buffered by 1/4 mile on all sides (360˚).

We combined these layers per the direction of the group, with the value range of infrastructure as 0.25 and the "urban" areas as a higher weight of 1. The final layer received a priority weight of 2.

Green Group biodiversity layer: The group felt that vertebrate species richness alone was an insufficient indicator of landscape-level biological diversity. To expand this layer to reflect floras, we combined the vertebrate species richness layer, derived from Southwest ReGAP, with a vegetation diversity layer. We created a layer reflecting vegetation type diversity by using a 1 km^2 moving-average filter to calculate vegetation type diversity across the study area. We rescaled the two layers and combined them, with equal weighting, to create the final biodiversity layer. The final layer was rescaled from 0 to 1 and given a priority weight of 2.5.

Risk Layers

Fire risk: Fire risk reflects the likelihood of a large fire occurring (see Dickson et al. 2006). We rescaled this layer from 0 to 1 and gave it a priority weight of 2.

Fire hazard: Fire hazard represents the expected intensity of fire, should a fire ignite at any point on the landscape. We rescaled this layer from zero to one and gave it a priority weight of three.

Piñon-juniper fire threat: Based on input from the group, we rescaled the piñon-juniper fire threat layer, giving both low and intermediate fire severity classes values of zero, meaning that only the high severity class entered into the prioritization effort. This reflects group members' experience that woodlands in this region seldom burn at intermediate severity, and that only the high-severity crown fires should influence prioritization of management attention. This layer was given a priority weight of 2.

Post-fire watershed erosion potential: The group agreed that the potential for high post-fire erosion was important for two reasons. Watersheds that are prone to high erosion rates following fire should be prioritized for management attention because treatment will encourage the development of an herbaceous understory, thereby reducing erosion rates, both before and after possible fire effects. Treatment also reduces the probability of large crown fires, and the elevated erosion rates that would follow any large crown fire in a sensitive watershed. The group decided on a value range of zero for slight and moderate post-fire erosion potential, meaning that only the severe and very severe classes entered into the prioritization effort. The group gave the final layer a priority weight of 1.5.

*Layers that could not be developed***:**

Invasive species/noxious weeds (*Risk*)

Despite considerable interest and high ecological and cultural importance, spatial data on invasive species is very limited across the study areas. Considerable effort was exerted during 2005-06 to locate robust data on this issue, without success. Data evaluated by the ForestERA team was consistently biased toward road sides, effort was uneven across the study area, precluding insightful mapping and spatial data. Members of the green group identified other possible data sources, which will be explored.

These efforts resulted in two intermediate layers, one for *values*, the other for *risks*. These intermediate layers were then combined using a spatial overlay process to produce a final prioritization layer. The influence of the criteria of highest importance to the Green Group is evident in the spatial patterns of the scaled prioritization map (Figure 2B). Shown in red through yellow colors, the highest priority areas for management attention are riparian corridors throughout the study area, and the intersection of the riparian and urban corridors north, south and east of Espanola. These are a result of assigning high priorities to the combination of surface waters, riparian habitat, watersheds and the Green Group ggWUI areas. Throughout the prioritization map the influence of the ggWUI and other high priority areas are evident south of Taos, north-east of Santa Fe and in areas surrounding Truchas and Pecos to name a few. These areas come from the interaction of the four layers already listed in addition to the biodiversity layer.

Management Action Recommendations

The Green Group defined management recommendations for three of the value criteria layers and none for the risk layers listed in Appendix A2. Knowing we were time limited at the workshop, ForestERA staff requested, and was granted permission by Green Group participants to interpret the Green Group's discussions into the final steps needed to complete the mapping process. For this, we added two management recommendations for fire risk and piñon-juniper fire threat, and ranked the management actions. The ranking of layers is a way to define which management action will override another when they are recommended for the same area. The management actions are based on the Vegetation Treatment Recommendation section of the north-central New Mexico Landscape Assessment Handbook (Pp. 14-16). These recommendations are considered typical treatments for forests in the Southwest and were developed by the ForestERA team working with experts in forest management and fire ecology.

Management action recommendations from the Green Group varied from Wildland Fire Use[1] for areas of mixed conifer, to reducing canopy cover in piñon-juniper woodlands, and removing invasive species in bosque/riparian areas. A detailed description of each management action recommendation used in the management action scenario, and its rank, is included in Appendix A2. The ranking applied to each layer and ranged from 1 to 5, with one representing the highest rank. ForestERA assigned these ranks after the workshop, based on discussions by Green Group participants at the workshop. There was strong support in the group for managing the natural resources at the watershed level, so the watershed criteria layer received the highest ranking of 1.

From the beginning, participants expressed concern for the protection of villages and infrastructure, especially in areas that were isolated and had limited access. We

[1] Wildland Fire Use is "the application of the appropriate management response to naturally ignited wildland fires to accomplish specific resource management objectives in predefined designated areas outlined in fire management plans" (USDI/USDA 2005).

understood management actions in these areas to be high priority for the group, so we applied a rank of 2 to the WUI criteria layer. Using the priority weighting as an indication of the layer's importance to the Green Group, we chose to apply a rank of 3 to the riparian habitat criteria layer. Lastly, we applied a rank of 4 to both the fire hazard and piñon-juniper fire threat layers. They address fire in piñon-juniper, ponderosa pine, and mixed conifer, and we felt they were of equal importance based on the group's discussion and the equal priority weighting of these two layers.

The final management action map (Figure 5) consists of nine management recommendations, that include: heavy burn (covering 7% of the study region), low-intensity thin / burn (4%), high-intensity thin / burn (25%), Wildland Fire Use (23%), high-intensity thin with 2" chip slash or burn (1%), with the remaining four types (low/intermediate-intensity thin and select group cut, intermediate-intensity thin only, riparian bosque treatment, piñon-juniper fire threat mitigation) totaling less than 5%. Thirty-seven percent of the total study area received "no action", meaning the group did not define any management actions for those areas.

The Green Group's management action recommendations are reflected in the dominant patterns in the management action map (Figure 5). The group stressed the importance of managing watersheds for proper function and condition. To achieve this, the group recommended Wildland Fire Use, and, secondarily, small group select cuts (marked in tan in Figure5) to create openings for aspen, and forage regeneration in mixed conifer areas. and a mix of low and high-intensity thin/burn (in light and dark green respectively) and prescribed fire (heavy burn in red) in piñon-juniper systems, depending on the existing canopy cover density across the municipal, riparian and acequia feeding watersheds. In piñon-juniper savannas heavy burns would consist of prescribed fire burning of most overstory trees. Low and high intensity thins are a reduction in woody biomass based on the existing vegetation structure followed by a prescribe burn. With a rank of 1 these treatments take precedence over other management actions.

In general, treatments were focused in the WUI area to protect human communities, cultural sites and infrastructure from wildfire. Several of the treatments recommended for Green Group's WUI area were specific to vegetation type. In piñon-juniper vegetation, the group recommended high-intensity thin, followed by either leaving two inches of chip mulch on the ground or by prescribed burn. Ponderosa pine would receive a high-intensity thin followed by prescribed slash pile burning, and mixed conifer would receive light to medium thinning and small group select cuts. As the Green Group considered the WUI areas important to address with treatments, we applied a ranking factor of 2.

To address the restoration of riparian habitats in the bosque, wet meadows and riparian areas, the Green Group recommended removal of invasive vegetation from within the native vegetation by thinning, burning, or chemical applications, and removing excessive down woody material. These treatments received a rank of 3 and are represented in yellow as the “riparian bosque treatment” throughout the study area.

Management actions to reduce fire hazard, fire intensity and subsequent watershed impacts included intermediate-intensity thin-only treatments and high-intensity thinning followed by prescribed burning in areas of medium to high fire hazard in mixed conifer and ponderosa pine vegetation types respectively. Prior management actions from the Green Group indicated that thinning alone in mixed conifer was preferable to thinning and prescribed fire. More general fire threat mitigation treatments were recommended in piñon-juniper woodlands and forests with a high fire threat. These two layers were considered of equal importance to the group so a rank of 4 was applied to both.

Prioritized Management Action Recommendations

The prioritization exercise enabled the Green Group to identify the 300,000 acres, with no patch size smaller than 100 acres that were of the highest priority for management action. Seven out of the nine management treatment types recommended by the Green Group are represented in the priority treatment areas seen in Figure 6. The high-intensity thin and burn treatment was the dominant treatment type, covering 46% of the high priority areas, followed by Wildland Fire Use (23%) and riparian bosque treatment (22%). The remaining 9% of the highest priority area was represented by the following management treatments: heavy burn, low-intensity thin/burn, high-intensity thin with two inch chip slash or prescribed burn, or no action defined.

Additional Green Group Recommendations

Several themes that recurred in group discussions were either not possible to capture in the mapping exercise or bear repeating. One of these focused on management actions that would reduce or eliminate invasive species, while restoring or encouraging native species growth. Another management focus was encouraging aspen growth and regeneration over pine and mixed conifer species, and reducing the overall basal area, tree density and canopy cover in ponderosa pine. Finally, there was great emphasis on management actions occurring within the framework of land grant and pueblo traditional and cultural uses of the area landscape.

Red Group

The goal of the Red Group's scenario was to improve forest and watershed health while providing for the needs of local communities, including protecting acequias and WUI areas from negative impacts of wildfire. In addition, the Red Group included recommendations for minimizing urban sprawl.

Priority Areas for Management Attention

The Red Group's objectives in prioritizing areas for management attention focused on improving and protecting water resources, forests, rangelands, wildlife, and human communities from the negative impacts of catastrophic wildfire and subsequent sedimentation, forest treatments, and urban sprawl. The group identified the following top values in order of importance: watershed function and integrity, forest and rangeland health and productivity, community access to resources, and biodiversity (Table 6). The following top factors that put these values at risk for destruction or degradation: urban and rural sprawl, recreation impacts, fire mismanagement, historical non-sustainable wood utilization businesses and lack of current-day businesses, invasive species, and wildfire (Table 7).

To develop a map of priority areas for management attention across the study region, the Red Group selected spatial layers based on the values and risks they identified as most important (see Criteria Layers column in Red Group Scenario Worksheet Appendix D3). However, they concluded that recreation and invasive plant spatial data that is comprehensive and accurate enough for this exercise does not exist for the study area. The group also acknowledged that some of the values and risks they identified could not be represented well in map-based form, such as bad fire management practices. Criteria layers representing these values and risks were not included in the scenario.

The Group based priority weights for each layer on their votes on landscape values and risks (Tables 6 and 7), however they adjusted the weighting factors following discussions of data availability and other considerations. The weighted layers were combined spatially to determine priority areas for management attention (Figure 2C). The highest priority areas are in areas with impaired watersheds, watersheds feeding acequias, watersheds with Cutthroat Trout (indicator of healthy riparian systems), high fire hazard, high post-fire sedimentation and high density of unimproved roads. The remaining criteria listed in the Group's scenario worksheet played a lesser role due to lower priority weights, smaller area covered, or lower average values in the layer.

Management Action Recommendations

The Red Group's management recommendations focused on wildfire reduction to reduce sedimentation potential and impacts near communities, protection of wildlife from both wildfire and treatment effects, and restoring historic grasslands. However, for the most part, the group chose to leave implementation-level management actions to those carrying out the work and specified only general recommendations.

The group favored high intensity thinning and prescribed burning treatments in ponderosa pine and mixed conifer where fires were predicted to actively crown in the ForestERA crown behavior layer. No management actions were specified for sagebrush or spruce-fir communities. Where passive-crowning was predicted, light thinning and burning was preferred, however in locations in which post-fire sedimentation potential was also high, treatments were bumped up to intermediate intensity. In piñon-pine and juniper (P-J) ecosystems within 0.5 mile of human communities, as represented by the ForestERA rural and urban structure layer, P-J fire threat mitigation (i.e., any number of mechanical or chemical treatments) were proposed. Again, the Red Group left more specific treatment details to be determined by fire managers and others working on a more localized level.

In Northern Goshawk Post-fledging Family Areas (PFAs), the Red Group indicated that canopy cover should remain high following any treatments in these areas. Average canopy cover in PFAs in ponderosa pine was not thinned below 50% or below 60% in mixed-species and spruce-fir as recommended by Reynolds et al (1992). In Mexican Spotted Owl Protected Activity Centers (PACs), the Red Group indicated that management actions in the scenario should follow the Recovery Plan Guidelines for the Mexican Spotted Owl (USDI Fish and Wildlife Service 1995). The Guidelines (Pp. 86, 88) recommend thinning trees <9 inches DBH on 10% of high fire risk PACs and applying light burning treatments on the remainder to improve owl prey habitat and reduce fire hazard. Of the 16 PACs in the study area, the two with the highest average fire hazard (based on the ForestERA Fire Hazard layer) were classified with low-intensity thinning and burning treatments in the Red Group scenario. Note that the fine-scaled recommendations in the Guidelines for areas centered directly surrounding nest sites within the PACs are not considered in this scenario. The Guidelines also recommend that site-specific factors should be considered in refining treatments.

To increase forage potential and reduce woody vegetation encroachment on grasslands, prescribed fire was recommended for grasslands and canopy cover was reduced to 20% or below for all tree species growing in mollisol soils. These soils are an indicator of historical grassland and savannah conditions. In designated Wilderness areas, the group indicated that Wildland Fire Use may be most appropriate.

Prioritized Management Action Recommendations

Areas in the Red Group's management action map (Figure 7) coinciding with the top priority ~300,000 acres as defined by the priority map (Figure 2C) appear in the prioritized management action map (Figure 8). A large portion of the priority area is near the town of Questa in the northern portion of the study area, however priority areas are found throughout the Sangre de Cristo mountain range as well as near the towns of Taos, Truchos, Pecos and Ojo Caliente. All eight of the management actions specified by the group occur in the top priority areas. The dominant management action recommendations are in order of area covered: no action, intermediate thinning followed by burning, PJ fire threat mitigation, light burning, and high-intensity thinning and burning.

Yellow Group

The Yellow Group scenario used a watershed approach to address biodiversity (rare and common species), watersheds health, and community well being (protection from fire, social and economic sustainability, and access to fuel wood). Yellow Group participants all agreed on the central role forests play in north-central New Mexico.

The Yellow Group's participants agreed to disagree on some details but there was strong consensus on the importance of biodiversity, community well being. One of the greatest risks to the values of Yellow Group participants is exurban development, which include new homes and commercial space built outside existing urban or even suburban areas, and inhabited by people new to the area. The risk to forest values from exurban development is better addressed by land use planning than forest management, so the Yellow Group discussed exurban development and attempted to map areas of concern, but did not include those areas in their forest management prioritization map. The Yellow Group's management recommendations focused on WUI areas, bosques, and restoring the ecological role of fire across the landscape. The Yellow Group emphasized that in all areas site specific analysis would take precedence over generalized landscape recommendations. For example, impacts to cultural sites not included in the maps because of their sensitivity would be assessed at the project scale. The specifics of how the yellow group prioritized the landscape are detailed in the Yellow Group Scenario Worksheet (Appendix D4).

Priority Areas for Management Attention

The Yellow Group compiled an exhaustive list of forest values and risks threatening those values. Some values were combined because they were so closely linked, such as the value of rare species and the value of biodiversity. The Yellow Group then prioritized their list of values and risks using a modified voting (nominal group) technique and created the ranks shown in Tables 8 and 9, respectively.

Next the Yellow Group examined ways that their values and risks could be depicted geographically. In the move from conceptual values to maps, some values and risks were split or recombined. For example the values of acequias and healthy watersheds were combined under the healthy watersheds value. These values and risks are listed in the scenario worksheet (Appendix D4). The Yellow Group came to a consensus on priority weights to assign for each of the criteria layers in Appendix D4.

Many of the maps were taken directly from the Data Atlas, but some were combinations of other maps. The value of healthy watersheds was represented in a map of 6th level watersheds that contained acequias or impaired streams. The risk of fire was mapped through a combination of fire hazard, fire risk, and the piñon-juniper fire threat map in areas where piñon-juniper was the dominant vegetation.[2] The group created a prioritization map by weighting the criteria layer inputs. The resulting map (Figure 1D) gave greatest priority to riparian areas and areas of high fire threat where they occurred in watersheds with impaired streams, acequias, or high risk of sedimentation. The group then identified the 300,000 acres with the highest priority, did not set a minimum patch size, but small acreage near communities could be treated as easily as larger, more remote patches.

Management Action Recommendations

In many areas across the study area, the Yellow Group felt that applying best management practices tailored to site specifics was more appropriate that a generalized prescription. The group voted on management actions to derive a ranking for each action (a rank of 1 trump's a rank of 2, etc).

The Yellow Group's recommendations are reflected in the final management action map (Figure 9). The Yellow Group recommended a heavy thin treatment in the WUI interface (approx. 40-60 BA) areas, and moderate thinning treatments in intermix, upwind buffer, and related infrastructure areas. The group recommended light thinning

[2] At the workshop, the Yellow Group ranked the 3 piñon-juniper (P-J) types represented in the P-J fire threat model by giving the low-severity/high frequency P-J forest a 1 value range, the mixed severity/frequency a 5 value range, and the high severity/low frequency P-J forest a 10 value range. During the review process, comments from yellow group participants indicated that the priority map should not give priority to the high severity/low frequency P-J forest type (persistent woodland) outside of the WUI. This is due in a large part to the emerging consensus among P-J scientists that the persistent woodland P-J type is not beyond its range of natural variability and therefore does not require management or restoration attention compared to the other P-J types. Subsequently, the priority and management maps were recalculated and classified. Value range for the PJ Fire Threat model were altered so that the low-severity/high frequency P-J forest has a 10 value range, the mixed severity/frequency a 5 value range, and the high severity/low frequency P-J forest a 1 value range. This new priority map gives attention to P-J savanna types over P-J persistent woodlands. The management maps were also altered so that the management action of light thin/burn in P-J was not applied to the high severity/low frequency P-J fire type.

and burning for other high priority areas, while allowing for the removal of valuable materials, fuel wood utilization, or mastication based on local needs and markets. Areas of piñon-juniper classified as having a high severity/low frequency fire regime were excluded from management. The group suggested that trees ≥16 inches DBH (diameter at breast height) should be left untouched, and emphasized that wood products from trees less than 16 inches be removed where possible. More generally, the group suggested integrating communities' need for firewood with fuel reduction treatments. In riparian areas, or bosques, the Yellow Group recommended appropriate fuel mitigation, restricted grazing in streams, and removal of invasive species. In order to reduce fire threat, the Yellow Group suggested light intensity thinning and burning in piñon-juniper (excluding high severity/low frequency types), mixed conifer, and ponderosa pine on slopes ranging from 0-30%, with appropriate wood product removal prior to burning and no treatment in spruce-fir and alpine meadows. Non-commercial and non-timber forest resources were not considered in the prioritization scheme, but the Yellow Group discussed potential management to improve forage and herbaceous production through prescribed fire in grasslands, juniper stands, and areas with mollisol soils (indicative of former grasslands).

Prioritized Management Action Recommendations

Management actions for the top priority areas (Figure 10) are dominated by no management action areas. Participants of the Yellow Group advocated for what they felt were ecologically appropriate management actions. As a result, the group decided to focus management actions on specific vegetation types, and to recommend a no action strategy on steep slopes where active management might have negative site impacts. The no actions areas make up 35% of the top priority areas, followed by WUI treatments (25%), thinning and burning in ponderosa pine (19%) and piñon-juniper (10%) . Areas around Taos/Angel Fire, Penasco, and Questa are the largest blocks of top priority WUI treatments. Outside of WUI areas, the top priority management activities were more dispersed because of the focus on less steep areas. On the western side of the study area around Los Alamos there are extensive but discontinuous areas of piñon-juniper and juniper thinning and burning management recommendations. In the southern section of the study area in the Pecos drainage, there are extensive areas of mixed conifer and ponderosa pine management recommendations. Similarly, up slope from Pilar, Taos and Questa areas there are management recommendations for thinning and burning in ponderosa pine.

Prioritization and Management Action Scenario Syntheses

Prioritization Scenario Synthesis

We synthesized the prioritization scenarios produced by each of the four individual groups by computing and mapping the average priority value among all four prioritizations (Figure 11). The distribution of average prioritization values ranged between 12 and 100, and was approximately normal, with a mean of 46.8 (1SD = 12.5). Figure 11 reflects the landscape-scale values and risks that were collaboratively identified and prioritized (i.e., ranked) by each of the four individual groups (see Tables 10 and 11), and then mapped using representative layers from the JFSP Data Atlas. As a final step, the features of these representative layers were assigned weights by group members. This work occurred in an open and deliberative breakout group. Table 10 lists the landscape values and the importance each group assigned to the values. Common values of high importance by topic area were healthy watersheds, water resources, biodiversity, and (red group). Table 11 lists the landscape risks and the importance assigned to each risk by the groups. Common risks of high importance were land development, political barriers, uncharacteristic wildfire, and the risk of inaction.

We evaluated the variation among individual group prioritizations by mapping standard deviation values around the average prioritization value (Figure 12). To more broadly categorize and visualize priority areas on the landscape, we reclassified the average prioritization values using a quantile classification method, which placed the distribution of cells on the landscape into five equal area classes (Figure 13). We also used the map of average prioritization values to identify and map the top, or "highest priority" 300,000 acres on the landscape (Figure 14). Values from this map ranged between 48.2 and 100, and were approximately normally distributed, with a mean of 65.7 (1SD = 4.7).

The synthesized, average prioritization map (Figure 12) shows several areas of high priority across the study area. The map of highest priority areas (Figure 14), a selection of the top 300,000 acres on the landscape, highlights the areas deemed by workshop participants to be in need of attention. These areas, broadly speaking from north to south are: the Questa, Red River, and Angel Fire Corridor; Taos Canyon (east of Taos along Hwy. 64); the Rio Vallecitos watershed; the Peñasco to Truchas to Santa Cruz corridor; Santa Clara Creek watershed; the Rio Nambe watershed; the Santa Fe watershed; and the Pecos watershed. These areas of prioritized importance, which cross many land jurisdictions, include drinking water watersheds, headwaters of major drainages, areas of the WUI where human infrastructure intermingles with piñon-juniper, ponderosa, and mixed-conifer vegetation types, and areas of high cultural value.

Management Action Scenario Synthesis

We synthesized the management action scenario maps produced by each of the four individual groups by first classifying each management action into one of four "treatment intensities": low, intermediate, high, and "no action" (Table 12). Each of these intensities could be considered as a coarse measure of the relative impact a given treatment would have on forest structure attributes, including canopy cover or tree density reductions, or vegetation composition, for example. Because there was a high degree of variation in the original management action alternatives identified and proposed among the four groups, we asked facilitators and spatial analysts from each group to reclassify all management actions into one of these four treatment intensities. With this reclassification, we assigned an integer value of "1" to the low-intensity treatment class, "2" to the intermediate-intensity class, "3" to the high-intensity class, and a value of "0" to the no action class (see Figures 15A-D). Prior to reclassifying each management action map, we created a larger, more contiguous "footprint" for each management action by smoothing the entire landscape with a 10×10-cell moving window and eliminating all patches less than 100 acres. These steps were necessary to permit overlay analyses that were less affected by landscape "fragments," and to create a final treatment intensity synthesis map. Patches <100 acres were reclassified and incorporated into the largest surrounding patch. We combined the four reclassified treatment intensity maps to produce a map of average treatment intensity values (Figure 16, Table 13).

To evaluate concordance among management actions recommended by each group, we overlaid each of the four treatment intensity maps and classified levels of agreement as complete, high, moderate, low, or none (Figure 17, Table 14). Specifically, areas of complete agreement were classified as those areas where each of the four groups recommended management actions with the same treatment intensity, including no action. Areas of high agreement were typically those areas where three groups recommended the same treatment intensity. Areas of moderate agreement were typically classified as areas where each of two groups identified two similar treatment intensities. Areas of low agreement were usually classified as those areas where only two groups identified the same treatment intensity. An agreement level of “none” was assigned to those areas where each group recommended treatments of different intensities.

The treatment intensity maps shown in Figure 15 can be used to interpret and generalize the management approach of each individual group. All four groups generally avoided recommending treatments in grasslands and shrublands. The blue group focused high and intermediate intensity management in upland forests. The red group focused intermediate intensity management in upland forests, bosques, and in the WUI. The green group focused high intensity management actions in most areas with little management attention given to the sagebrush plateau. The yellow group focused mixed intensity management in most areas with little management attention given to the sagebrush plateau. Figure 17 compares the level of agreement between each group’s treatment intensity maps. Of particular note, general areas of no management agreement between groups, from north to south were: Vermejo Park Ranch, the northeast portion of the Rio Vallecitos watershed including Tres Piedras its environs, select patches proximate to Ojo Sarco and Trampas, areas near Glorieta and Pecos National Historic Park, and in the Colonias and San Yisidro drainages west of Las Vegas.

Predicted Effects of Management Actions

Predicted effects analysis is a capability of the ForestERA spatial decision support system which models changes in forest structure based on stakeholder defined and assigned management actions, and relates these structural changes to effects on wildlife, fire behavior, and other issues of concern. To evaluate the influence of treatments defined by the individual group management action scenarios, we predicted the effects of the three treatment intensity types identified in Table 12 on two key landscape factors: fire hazard and Mexican Spotted Owl habitat. For simplicity, we used the results of the management action synthesis (see *Management action scenario synthesis* section), specifically results for the average treatment intensity level computed from the four individual groups (Figure 16). For all cells occurring in each treatment intensity type, we calculated percent reductions in tree density, basal area, and canopy cover values that would be expected based on a review of the literature and the opinion of forest management experts (see Table 15). These reduced values were then used as the input conditions for the "post-treatment" fire hazard and Mexican Spotted Owl models, which were implemented only in those areas identified in the management action synthesis.

Predicted Effects of Treatments on Fire Hazard

Applying the methods described in the Data Atlas (Pp. 21, Appendix B), we used the fire modeling program FlamMap (see Stratton 2004) and forest structure data, including canopy cover and crown bulk density, to predict the effects of average treatment intensity levels on fire hazard. For a "pre-treatment" comparison, we summarized fire hazard values only within those areas identified in the management action synthesis (see Figure 16). Results of the post-treatment analysis of fire hazard were dramatic, and indicated that the group-defined management actions, and their associated average treatment intensities, were sufficient to reduce heat output and mitigate fire hazard (Figures 18 and 19). Results of this predicted effects analysis also indicated an approximately 10% and 15% reduction in fire hazard when treatments were characterized by intermediate- and high-intensity levels, respectively (Figures 19). Across the treated areas, these reductions, particularly in ponderosa pine-dominated forests, resulted in an almost complete transition of fire behaviors from active to passive.

Predicted Effects of Treatments on Mexican Spotted Owl Habitat

To predict the effects of management actions and average treatment intensity levels on the probability of Mexican Spotted Owl habitat occupancy, we used recent known point-of-location occurrence data from the study region (n = 127) and multiple habitat variables, including elevation, topographic roughness, vegetation type, tree density, and basal area. We used statistical models (i.e., multiple linear regression) to predict the pre- and post-treatment probability of habitat occupancy only within those areas identified in the management action synthesis (Figures 20 and 21). Results of this predicted effects analysis suggested a small (~3%) increase in the probability of Mexican Spotted Owl habitat occupancy in low-intensity treatment areas (Figure 21). Results also indicated an approximately 5% and 17% reduction in the probability of habitat occupancy when treatments were characterized by intermediate- and high-intensity levels, respectively (Figure 19C).

Evaluation of the Collaborative Process

To evaluate the effect of the ForestERA participatory process and its capacity for strengthening public participation and resolving contentious forest and fire management issues, we conducted simple post-process surveys, but complemented these with more in-depth analysis drawing on advanced methods from the social sciences. Given that evaluation of on-the-ground impacts is a difficult task due to the lag between landscape-level planning, the design of specific management projects, and implementation, social scientists from Northern Arizona University and Australian National University collaborated with the ForestERA team to evaluate the short-term effects of the participatory democratic process on participant attitudes and preferences towards forest restoration issues. This project element was based on extensive theoretical and empirical experience with deliberative democratic processes, and allowed us to better understand how individual preferences and group consensus are affected by participation in the collaborative elements of the ForestERA landscape assessment. As part of this collaboration with Australian National University, this JFSP study became part of a larger international comparative effort to investigate the politics of deliberation in real-world situations, led by collaborating social scientists Simon Niemeyer and John Dryzek.

The evaluation consisted of using the Q method, an alternative to conventional attitudinal survey techniques, to more precisely characterize the various debates over forest restoration and management. Conventional assessment of environmental values, beliefs, attitudes, and perceptions toward ecological restoration, using mail and telephone surveys, are becoming increasingly common in the literature. There remains, however, a weak link made between values and the structure of policy preferences, especially with respect to restoration policymaking. The Q method is considered to be particularly suited for the study of issues that are socially contested and publicly debated, such as the conflicted public discourse regarding wildfire and forest management policy. The objectives of this evaluation were to examine how participation in the landscape assessment changed participants' perspectives regarding land restoration issues, their specific policy preferences, and their opinion of the values and preferences of others in the process. Additionally, given that the ForestERA process progresses in multiple stages with differing levels of involvement – from the initial stage of networking with stakeholders, to the development of data layers, to more intense interactions during the workshops – this offered the opportunity to conduct the evaluation in sequence with these different stages and analyze how perspectives changed as the level of information that stakeholders received increased and their involvement in the process intensified. Consequently, we were also interested in assessing whether the scientific information provided to stakeholders, or their level of involvement in the workshop itself, had a differential impact on stakeholder perspectives. In other words, if changes were observed, were they attributed to increasing scientific information, or to the participatory nature of the collaborative process, or both?

Q methodology allows a more precise characterization of the various debates embedded in forest restoration and management by "mapping" individual respondent's subjective orientation and the structure of held values and beliefs, with little involvement by the researcher in defining *a priori* the structure of the ideas and concepts that participants are responding to. In this way, the workshop participants define the issues and categories themselves, rather than responding to researchers' questions.

This process began by gathering statements from local New Mexico newspapers, community newsletters, technical reports, government documents, statements from NGO's and community groups' websites, literature on forest restoration, and other sources. The ForestERA team initially gathered over 100 statements and organized them according to the following categories: values (anthropocentric and nonanthropocentric), forest restoration treatments, economic impacts of restoration, public involvement in forest policy, and science in forest management. Forty-five different statements were selected to represent the range of stakeholder views, including both negative and positive attitudinal orientations, which are part of the local discourse on forest management and restoration. During each Qsort, participants recorded their level of agreement or disagreement with each of these statements and then “sorted” them in a manner that created a normal distribution, allowing a more incisive statistical analysis of how the values reflected in this exercise corresponded to each participant’s forest policy preferences.

All of the respondents completed the same Qsort exercise at three different stages during our landscape assessment project: at the initiation of their involvement in the project; before the participatory workshop but following approximately one year of data sharing and informal interactions; and after the participatory workshop, following 3 days of intensive collaborative work, as detailed in this report. This longitudinal sampling at key points along the project’s time line provides a means of evaluating the influence of the scientific information, per se, as distinct from the influence of the intensive participatory process that occurred during the Taos workshop. Data analysis is still in progress, but preliminary results indicate that the participation of stakeholders in the workshop strengthened the relationship between their values and beliefs and their policy perspectives (often termed “intersubjective rationality”). Figure 22 shows that this relationship, illustrated by plotting the pairwise correlation of respondents’ values against the correlation of their policy preferences, increased during the workshop, and that there was a tighter clustering of positions, indicating stronger consensus. It is also interesting that the pre-workshop plot (Figure 22A) reflects a relatively high initial concordance among stakeholders. This may reflect the influence of the pre-workshop data collection and information sharing efforts that preceded the landscape assessment workshop, or it may result from other influences, such as public debate that preceded our work on this project. Analysis of the first set of Qsorts, now underway, should shed light on these issues and allow a more robust evaluation of the ForestERA collaborative process.

Discussion and Conclusions

Products and outcomes of the North-central New Mexico Landscape Assessment and workshops present creative, collaborative, and scientifically grounded approaches to the challenges of forest restoration and management at the landscape scale. The recommendations, values, and maps resulting from the ForestERA process and spatial decision support system are the products of diverse, informed stakeholders working together with the best available information to address issues important to them. Indeed, workshop products encompass a range of values, interests, concerns, priorities, and approaches to restoration and land management in north-central New Mexico. Specifically, these products identify areas in greatest need of management attention, indicate courses of action for addressing restoration needs, and provide a framework for understanding the values and concerns of diverse stakeholders. Despite the diversity in both participants and workshop products, areas of convergence and constructive discourse emerged around several key points:

• *Values*: Stakeholder values related to the lands of the assessment area span the range from the aesthetic to the intrinsic to the economic. Yet there is an overall belief in the interdependency between healthy forests and healthy communities, and workshop participants were eager to get to work restoring degraded forest conditions. Three key values (i.e., topic areas) were seen as integral to this effort: 1) the preservation and restoration of healthy forested watersheds, including function and integrity (e.g., water quantity & quality); 2) biodiversity, including forest, woodland, and wildlife diversity, and the maintenance of native species and their habitats; and 3) water resources, including wet meadows, riparian areas, bosques, rivers, streams, and snow and water catchments.

• *Risks*: There was an overall recognition of the risk that wildfire poses to the region's forests. However, there was also great concern about the potentially negative consequences of: 1) increased development, including exurban development, urban and suburban sprawl and impacts, and land conversion; 2) political barriers that facilitate politically-driven management decisions and result in a lack of public input into management actions; 3) doing nothing, or taking “no action;” and 4) poor land management practices, such as inadequate timber harvest and management planning, “one size fits all” prescriptions, and inappropriate grazing management. Perhaps not coincidentally, many other landscape-scale risks identified align well with the “four threats” to National Forests outlined by the U.S. Forest Service, namely fire and fuels, invasive species, loss of open space, and unmanaged recreation.

• *Priorities*: Based on these values and risks, priority areas for management attention tended to be those where high fire risk and hazard, important watersheds and water resource areas, areas threatened by urbanization, and high diversity habitats coincide. In general, these areas included the Questa, Red River, and Angel Fire Corridor; Taos Canyon (east of Taos along Hwy. 64); the Rio Vallecitos watershed; the Peñasco to Truchas to Santa Cruz corridor; Santa Clara Creek watershed; the Rio Nambe watershed; the Santa Fe watershed; and the Pecos watershed. Highest priority areas crossed many land jurisdictions, included watersheds for drinking water and the headwaters of major drainages, and areas of the WUI that intermix with diverse vegetation types and areas of high cultural value. Importantly, priority areas derived from the workshop should be seen as complementing, rather than challenging, for example, Community Wildfire Protection Plan (CWPP) priorities.

• *Management Actions*: Management action scenarios developed by the four individual groups ranged from the very general to the very specific and prescriptive. Of all the workshop products, results from of the management scenario exercises probably exhibited the greatest variation. For example, the Blue Group focused high and intermediate intensity management in upland forests. However, the Red Group focused intermediate intensity management in upland forests, bosques, and in the WUI. The Green Group focused high intensity management actions in most areas with little management attention given to the sagebrush plateau. Lastly, the Yellow Group focused mixed intensity management in most areas with little management attention given to the sagebrush plateau. In general, each group avoided recommending management actions in grassland and shrubland vegetation types. Thus, low to moderate levels of agreement among the individual group treatment intensity maps tended to be more typical outside of these vegetation types. On average, areas defined by no management action were most commonly identified on the assessment area and constituted over 50% of the landscape.

Among groups there was consistent interest in implementing management actions of intermediate- and high-intensity in habitats dominated by ponderosa pine and mixed-coniferous vegetation types, as well as piñon-juniper stands at risk of large-scale fire. Areas dominated by riparian and bosque vegetation types were also considered suitable for treatments of intermediate intensity. Management actions characterized by moderate- to high-intensity treatments in order to mitigate wildand fire hazard in WUI areas were also commonly recommended. In addition, management actions that included treatment intensities resulting from Wildland Fire Use policies and approaches were also considered. Notably, general areas of little or no agreement among groups, from north to south were: Vermejo Park Ranch, the northeast portion of the Rio Vallecitos watershed including Tres Piedras its environs, select patches proximate to Ojo Sarco and Trampas, areas near Glorieta and Pecos National Historic Park, and in the Colonias and San Yisidro drainages west of Las Vegas.

• *Predicted Effects*: Because of the complex nature of many of the individual group management action scenarios, we used a simple synthesis of the four groups' recommendations (i.e., average treatment intensity) and decided to focus our analysis of the predicted effects of management actions on two response variables, fire hazard and Mexican Spotted Owl. Importantly, these response variables tend to guide many aspects of forest and land management on the assessment area landscape and the region surrounding it. Results of the predicted effects analysis indicated a substantial reduction in fire hazard when treatments were characterized by intermediate- and high-intensity levels. Since wildfire threat was a significant risk to landscape-scale values identified by each individual group, this level of reduction in fire hazard was expected, given the results of the prioritization and management action exercises. Indeed this reduction, particularly in ponderosa pine-dominated forests, resulted in an almost complete transition of fire behaviors from active to passive crown fire. Perhaps surprisingly, results of the predicted effects analysis indicated a small increase in the probability of Mexican

Spotted Owl habitat occupancy in low-intensity treatment areas. However, when treatments were characterized by intermediate- and high-intensity levels, a substantial (5-17%) reduction in the probability of habitat occupancy was predicted. Importantly, results from these predicted effects analyses indicate that there are management action scenarios that, for example, may be used to identify "trade offs" between fire threat mitigation and the maintenance of essential wildlife habitats.

In addition to the outcomes described above, a number of other important products emerged from the workshop and group exercises. For example, new data layers, representing specific factors of importance to stakeholders, were created "on the fly" during group deliberations and in discussions among all participants. These custom layers included overall biodiversity (i.e., wildlife and habitat diversity), layers to support recreation planning and management, and layers to describe vital watershed characteristics. These new layers, along with the extensive set of spatial data provided to stakeholders at the beginning of the workshop, make up a collection of high-quality spatial information with potential applications to more formal forest planning efforts, project-scale analyses, post-management monitoring, reporting, research, and outreach. These data have been made available to all interested parties, allowing further exploration of existing data and creation of new layers and products.

The north-central New Mexico Landscape Assessment represents one of the first efforts in the nation to engage stakeholders in a collaborative, landscape-scale assessment of public lands using an interactive and integrative science-based approach. It is also unique in that it addressed several national policy directives simultaneously. The broad concurrence in stakeholder values and perceived risks that were identified during this spatially-explicit process provide an unprecedented opportunity to inform planning efforts in the region at multiple spatial scales, and the collaboratively derived management scenario maps represent a "big picture" context to guide specific forest management projects, as well as for assessing the appropriateness of future plans and proposals.

Future Work

While much was accomplished during the three-day stakeholder workshop, there are a number of future steps which will help to refine workshop products and integrate outcomes into future planning and analysis efforts. The following is a brief description of potential next steps.

• *Report back to stakeholders*: Copies of this report will be distributed to workshop participants for their consideration and feedback. While all attendees and contributors participated in a review of their individual group reports, this final report will provide a chance to participate in a more comprehensive synthesis and framing of workshop processes and outcomes. In addition, we are producing an attractive and more broadly accessible brochure to summarize the important outcomes and themes contained in this final report. This brochure will be made available to workshop participants, regional land management agencies and stakeholders, and current and future project collaborators.

• *Distribute data DVD to interested parties*: A comprehensive DVD containing spatial data layers and associated metadata will be distributed to all interested parties, including Forest Service staff, staff from the New Mexico Game and Fish Department, Pueblo and Tribal resource managers, conservation organizations, economic developers, local governments (such as towns and counties), and university researchers, among others.

• *Align workshop data and outcomes with other tools*: A number of other spatially explicit, landscape-scale efforts are underway in the region. These include a mid-scale vegetation map for the Southwest region of the U.S. Forest Service, and fire regime-condition class modeling, as well as other statewide or National Forest planning efforts. Future work may be needed to coordinate these endeavors so that their respective data sets and functions complement each other. Ongoing work will also focus on integrating the data, tools, and results of this assessment into planning efforts at forest (e.g., individual Forest Plan revisions) and state levels.

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Table 1. Policy directives and scientific recommendations for collaborative landscape assessments.

Policy		Collaboration	Best available science	Landscape -level planning	Prioritization of treatments	Coordination with state & local governments
New Mexico Forest and Watershed Health Plan		×	×	×	×	×
National Forest Management Act	2005 Planning Rule	×	×	×		×
Healthy Forests Restoration Act		×		×	×	×
HFI/HFRA Interim Field Guide		×	×	×	×	×
Executive Order 13352 of August 26, 2004: Facilitation of Cooperative Conservation		×				×
National Fire Plan Documents	Managing the Impact of Wildfires on Communities and the Environment	×		×		×
	10-year Comprehensive Strategy	×	×	×	×	×
	10-year Strategy Implementation Plan	×		×	×	×
Forest Service Strategic Plan, 2000 Revision		×	×		×	×
New Mexico Forest Restoration Principles		×	×	×	×	×
GAO Report GAO 08601-6-AT Implementation of the Healthy Forest Restoration Initiative					×	×
GAO Report GAO-03-805: Wildland fire management: Additional actions required to better identify and prioritize lands needing fuels reduction					×	
USDA/DOI Wildland Fire Use Implementation Procedures Reference Guide		×	×	×		×
RMRS Report GTR-291: Research Needs for Forest and Rangeland Management in Arizona and New Mexico		×	×	×		

Table 2. Landscape-scale values identified by the Blue Group, including number of votes received and relative ranking for each value.

Value	Number of Votes	Rank
Good water quality (e.g., lakes, rivers, and streams)	4	1
Maintain and restore native biodiversity (species and habitat)	4	1
Forest products (e.g., firewood, manufactured wood products)	2	2
Reduce crown fire potential in ponderosa pine	2	2
Soil retention and restoration	2	2
Recreational opportunities	1	3
Sustaining our natural heritage	1	3
Create an maintain “fire safe” communities	1	3
Maintenance and restoration of landscape aesthetics	1	3
Maintaining and increasing water quantity	0	4
Livestock forage	0	4

Table 3. Landscape-scale risks identified by the Blue Group, including number of votes received and relative ranking for each risk.

Risk	Number of Votes	Rank
Politically-driven management decisions	4	1
"Uncharacteristic" fire regime (i.e., outside of historic range of natural variability)	3	2
Doing "nothing" (no management)	3	2
Bias against collaboration	3	2
Climate change	1	3
Unmanaged recreation (e.g., OHV, high-use trails)	1	3
Poor timber harvest and management planning	1	3
Lack of a landscape-level approach to management	1	3
Inadequate personnel training and qualifications	1	3
Invasive species (plants and animals)	0	5
Land conversion for development	0	5

Table 4. Landscape-scale values identified by the Green Group, including number of votes received and relative ranking for each value.

Values	Number of Votes	Rank
Healthy watersheds above acequias and riparian areas	6	1
Water (surface waters), wet meadows, riparian areas, bosque	5	2
Protection of villages and infrastructure	4	3
Continuity of traditional culture	4	4
Cultural ecological resiliency	3	5
Soil integrity	3	5
Sustainable ecosystems	2	5
Proper ecosystem function	2	5
Forest and woodland diversity	2	6
Endangered Species (T&E) Conservation	2	6
Irrigation water quality and quantity	2	6
Economic opportunities, traditional and new	2	6
Air quality	1	6
Old growth forest	1	6
Public access and recreation	1	7
Watershed corridors	1	7
Native plant communities and ethnobotanical resources	1	7
Viewsheds	1	7
Open ponderosa pine forests	0	7
Evacuation corridors	0	7
Wildlife corridors	0	7
Plant migration corridors	0	8

Table 5. Landscape-scale risks identified by the Green Group, including number of votes received and relative ranking for each risk.

Risks	Number of Votes	Rank
Ground water pumping	4	1
Checkerboard land ownership/stewardship patterns	3	2
Inappropriate grazing	1	3
Insect outbreaks and forest diseases	1	3
Extreme storms and resulting erosion and sedimentation	1	4
Excessive wood burning in stoves	0	5
Unenforced regulations (e.g. OHV, poaching)	0	5
Habitat fragmentation (utility corridors)	1	5
Urban and suburban sprawl and their impacts	8	8
Invasive species	4	8
Wildfire	7	8

Table 6. Landscape-scale values identified by the Red Group, including number of votes received and relative ranking for each value.

Values	Number of Votes	Rank
Watershed function and integrity (e.g., water quality and quantity)	8	1
Forest and rangeland health and productivity	7	2
Community access to resources (e.g., fuel wood, medicinal plants)	4	3
Wildlife, general biodiversity	4	3
Recreation	1	5
Spiritual connection to the land	1	5
Open space	1	5
Human built environment	1	5
Wood products and jobs	1	5
Viewsheds-scenic value	0	10

Table 7. Landscape-scale risks identified by the Red Group, including number of votes received and relative ranking for each risk.

Risks	Number of Votes	Rank
Urban and rural sprawl; migration into area	6	1
Recreational abuse (e.g., ATVs, camping next to rivers, trash)	5	2
Fire mismanagement-either too much suppression or not enough fire, inappropriate management	5	2
Resource use beyond a sustainable capacity / greedy business / lack of businesses	4	4
Invasive and noxious weeds	4	4
Wildfire	3	6
Climate change	3	6
Destruction of traditional lifestyles	3	6
Insects and disease	2	9
Restoration of economic capacity	2	9
Livestock and wildlife losses or removal; under-grazing	1	11
Over-grazing; encroachment of woody vegetation due to reduction in fire adapted grasses	1	11
Community communication	1	11
Over allocation of water (e.g., water transfers like Buckman diversion)	1	11
Drought	1	11

Table 8. Landscape-scale values identified by the Yellow Group, including number of votes received and relative ranking for each value.

Values	Number of Votes	Rank
Biodiversity, rare and common species	6	1
Community welfare (Economic development, fuel wood, fire protection)	5	2
Large blocks of open space - undeveloped	4	3
Watershed preservation and restoration	4	3
Natural processes operating in forests	4	3
Old and large trees	3	4
Snow and water catchments (water yield, water quality)	3	4
Traditional land use	3	4
Knowing that it is there	2	5
Acequias	2	5
Visual quality	2	5
Non-timber forest resources (plants, animals)	2	5
Protection of cultural sites and religious use areas	1	6
Areas of low to no human intervention (roadless areas) / Habitat for non-human species	1	6
Recreation areas	1	6
Tracking changes in the landscape	1	6
Wetlands	1	6

Table 9. Landscape-scale risks identified by the Yellow Group, including number of votes received and relative ranking for each risk.

Risks	Number of Votes	Rank
Exurban Development	4	1
Wildfire	3	2
One size fits all prescriptions	2	3
Lack of public input in management decisions	2	3
Illegal dumping	2	3
Lack of the return of surface fires	2	3
No Action	2	3
Overuse (abuse) of the resource (landscape)	2	3
Public disenfranchisement / alienation (vandalism)	2	3
Invasive Species	2	3
Unrestricted off-road vehicle use	1	4

Table 10. Relative ranking of landscape-scale **values** in general topic areas discussed by each of the four groups. “NS” indicates topic area or rank value “Not Specified” by a group.

	Ranking				
Topic area	Blue	Red	Green	Yellow	Description
Healthy watersheds	NS	1	1	3	Preservation and restoration of healthy watersheds, function and integrity (e.g., water quantity & quality).
Biodiversity	2	3	6	1	Forest, woodland and wildlife diversity, maintenance of native species and habitat.
Water resources	1	NS	2	4	Wet meadows, riparian areas, bosques, rivers, streams, snow and water catchments.
Forest products	2	5	NS	2	Fuel wood (yellow) and manufactured products, job preservation.
Community protection	3	5	3	2	Protection of human communities and infrastructure from fire.
Soils	2	NS	5	NS	Soil retention, restoration, and integrity.
Traditional culture	3	5	3	4	Sustaining natural heritage, continuity of traditional culture, traditional land use, spiritual connection to land.
Recreation	3	5	7	6	Maintenance of recreational areas and opportunities.
Aesthetics	3	10	7	5	Viewsheds, visual qualities, and maintenance and restoration of landscape aesthetics.
Old-growth forests	NS	NS	6	4	Areas with old and large trees and stands.

Table 11. Relative ranking of landscape-scale **risks** in general topic areas discussed by each of the four groups. "NS" indicates topic area or rank value "Not Specified" by a group.

	Ranking				
Topic area	Blue	Red	Green	Yellow	Description
Development	5	1	1	1	Exurban development, urban and suburban sprawl and impacts, land conversion for development.
Political barriers	1	NS	NS	3	Politically-driven management decisions, lack of public input into management (yellow).
No action	2	NS	NS	3	"Doing nothing," no management.
Wildfire	2	6	2	2	Uncharacteristic fire regime or outside of historic range of variability.
Poor land management practices	3	2	3	3	Poor timber harvest and management planning, one size fits all prescriptions (yellow), inappropriate grazing (green)
Unmanaged recreation	3	2	5	4	Unrestricted or "unenforced" ORV use, high trail use.
Invasive species	5	4	3	3	Invasive (and noxious) plants and animals.
Unsustainable resource use	NS	3	3	3	Overuse (abuse) of the resource (landscape), greedy businesses, inappropriate grazing practices.
Climate change	3	6	NS	NS	Impacts and threats due to climate change.
Insect outbreaks and disease	NS	9	3	NS	Forest insect outbreaks and diseased trees.

Table 12. Treatment intensity classification assigned to each of the individual group management actions.

	Treatment intensity		
Management action	Low	Intermediate	High
Yellow Group			
WUI treatment			X
Ponderosa pine thin/burn		X	
Mixed conifer thin/burn		X	
Piñon-Juniper thin/burn	X		
Juniper thin/burn			X
Blue Group			
High intensity thin/burn			X
Intermediate intensity thin/burn		X	
Light intensity thin/burn	X		
Riparian conifer encroachment treatment		X	
Bosque treatment		X	
Red Group			
Light burn	X		
Wildland Fire Use		X	
High intensity thin/burn			X
Intermediate intensity thin/burn		X	
Light intensity thin/burn	X		
Canopy cover reduced to <20%			X
Canopy cover NOT reduced to <60%	X		
Piñon-Juniper fire threat mitigation		X	

Table 12. Continued.

Green Group			
Heavy burn			✕
High intensity thin/burn			✕
Low intensity thin/burn	✕		
Wildland Fire Use			✕
High intensity thin			✕
Intermediate intensity thin		✕	
Low intensity thin	✕		
Riparian bosque treatment		✕	
Piñon-Juniper fire threat mitigation		✕	

Table 13. Acreage totals and summary statistics for the four treatment intensity classes assigned to management actions defined by each of the four groups. Each proposed management action was reclassified as one of four treatment intensities.

Treatment intensity	Total acreage				Average	SD[1]
	Blue	Red	Green	Yellow		
Low	82,949	473,145	22,357	287,901	216,588	205,339
Intermediate	415,390	1,006,955	55,325	654,532	533,051	400,587
High	1,042,531	128,470	2,134,216	335,379	910,149	905,032
No action	1,867,291	1,799,308	1,196,233	2,124,021	1,746,713	392,723

[1] One standard deviation of the mean.

Table 14. Classified levels of agreement and acreage totals used to map and evaluate concordance among treatment intensities (low, intermediate, high, and no action) assigned by each of the four groups.

Classified level of agreement	Acreage	Percent of total acreage
Complete[1]	746,484	22%
High	476,913	14%
Moderate	531,572	16%
Low	1,508,036	44%
None	138,592	4%
Total:	3,401,597	

[1] Includes areas where no action was recommended.

Table 15. Pre- and post-treatment summary statistics (means and SD) for three treatment intensity levels (low, intermediate, high) assigned to management actions defined by each of the four groups.

	Pre-treatment						Post-treatment					
Forest structure attribute	Low	SD	Intermediate	SD	High	SD	Low	SD	Intermediate	SD	High	SD
Tree density (trees per hectare)	258.6	227.7	479.2	271.6	580.3	251.0	129.3	113.8	167.7	95.1	116.1	50.2
Basal area (m^2/ha)	13.3	9.2	24.1	11.7	25.3	9.7	6.6	4.6	8.4	4.1	5.1	1.9
Canopy cover (%)	31.5	26.2	47.4	25.0	49.6	22.2	15.8	13.1	16.6	8.8	9.9	4.4

Table 16. Effects of three forest treatment intensities, represented as reductions in tree density, basal area, and canopy cover. Minimum and maximum estimates, derived from the literature or expert opinion, are indicated in parentheses.

Treatment intensity	Tree density	Basal area	Canopy cover	Description
High	80 (70-90)	60 (50-70)	40 (25-55)	Representative of a "full" restoration, heavy fuels reduction, multi-age group selection, or WUI-based treatment.
Intermediate	65 (55-75)	40 (30-50)	30 (15-45)	Representative of a "moderate" or "full" restoration, moderate fuels reduction, or WUI-based treatment.
Low	50 (40-60)	20 (10-30)	20 (15-25)	Representative of a "light" restoration or fuels "maintenance" treatment.

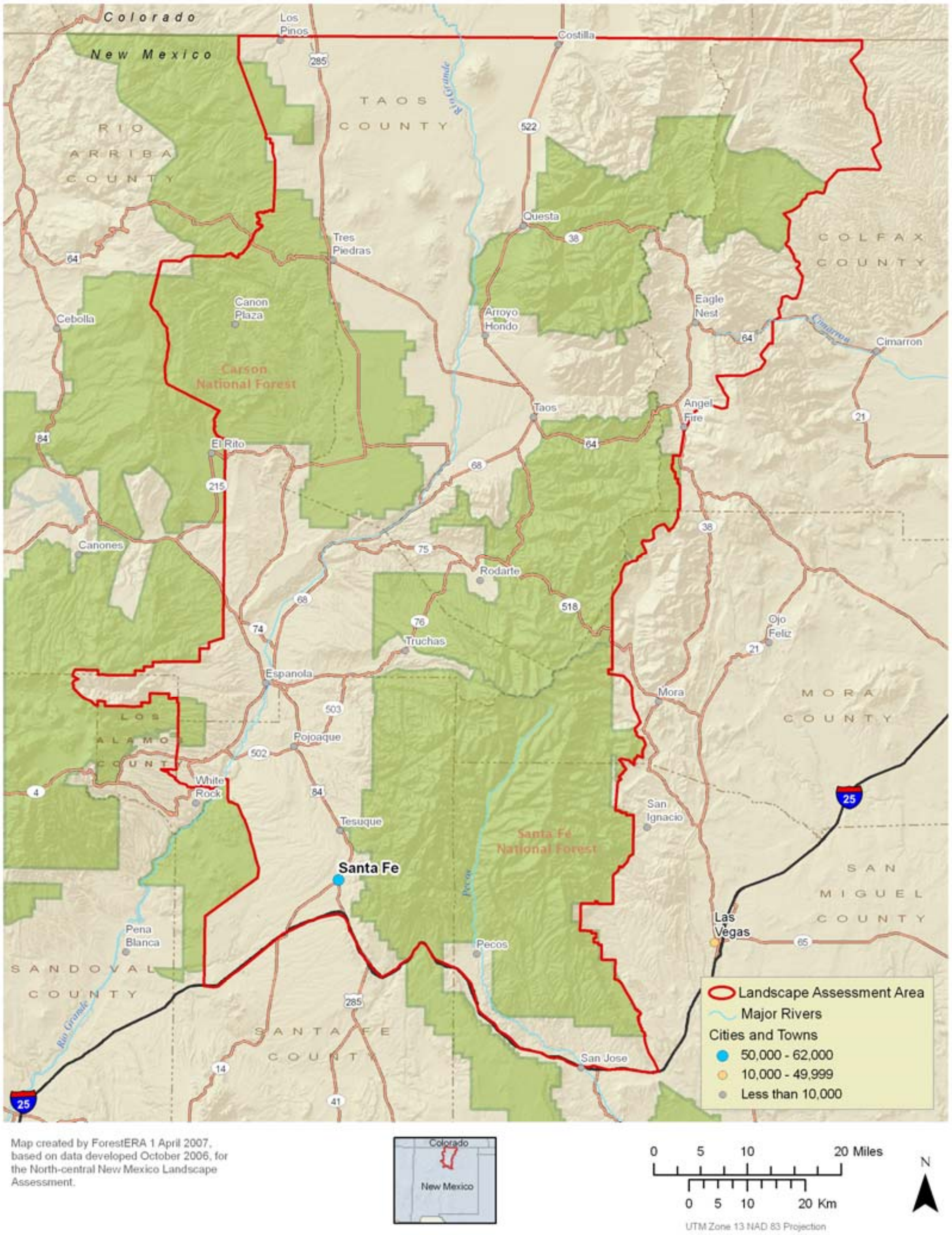

Figure 1. Map detailing the 5,315-mi^2 (13,767-km^2) ForestERA North-central New Mexico Landscape Assessment study area. The study area includes a diverse range of vegetation types, including grassland and sagebrush, ponderosa pine, mixed conifer, spruce-fir, and tundra. The area also includes the southern Sangre de Cristo Mountains with elevations ranging from 5,000 - 13,000 feet. Land managers include eight northern Pueblos, the Carson and Santa Fe National Forests, private land owners, state lands departments, and the Bureau of Land Management. The area includes portions of six counties and extends from the Colorado-New Mexico border, south to Interstate 25.

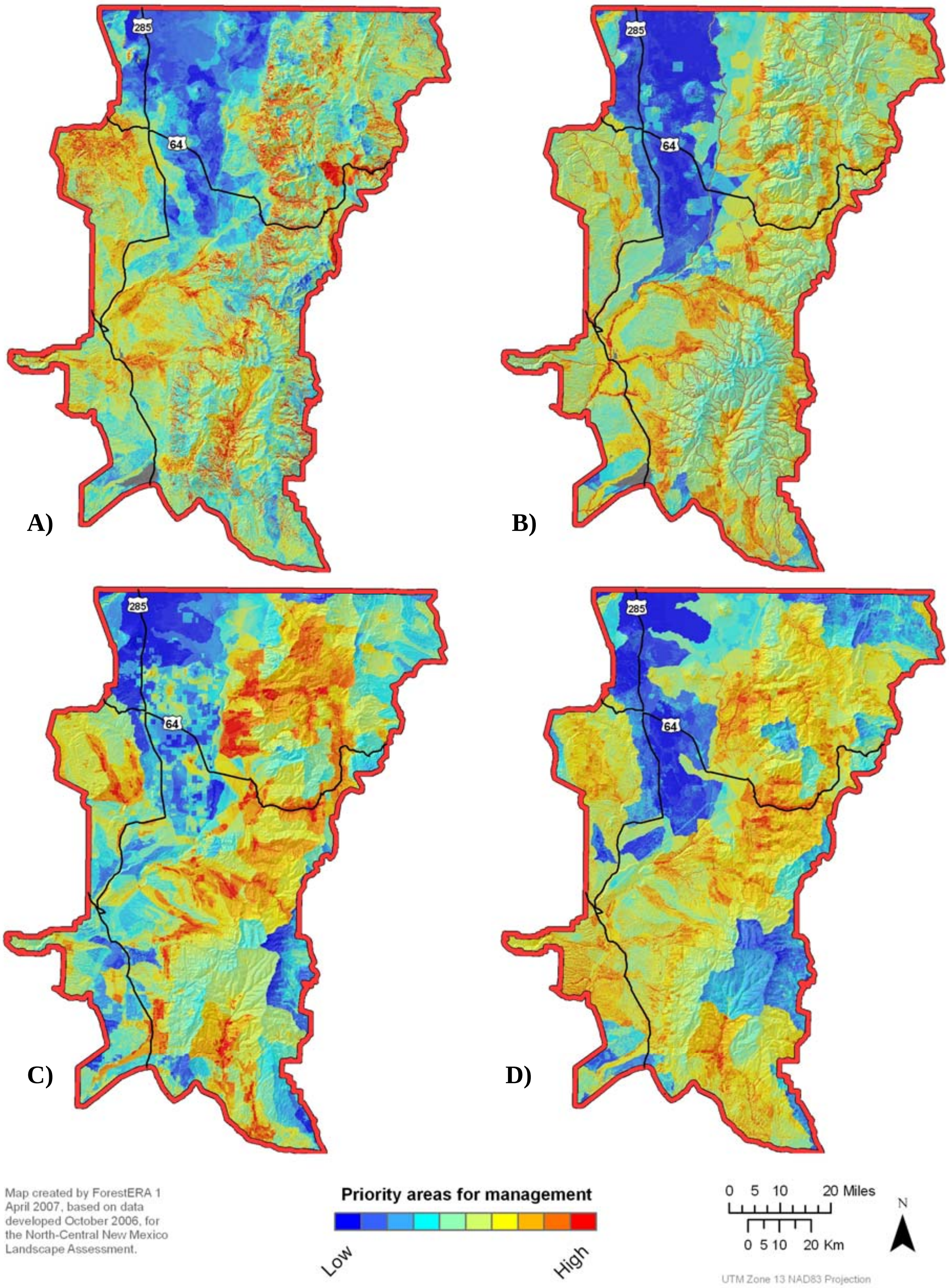

Figure 2. Prioritization map generated by combining weighted values and risks identified by the A) Blue, B) Green, C) Red, and D) Yellow Groups.

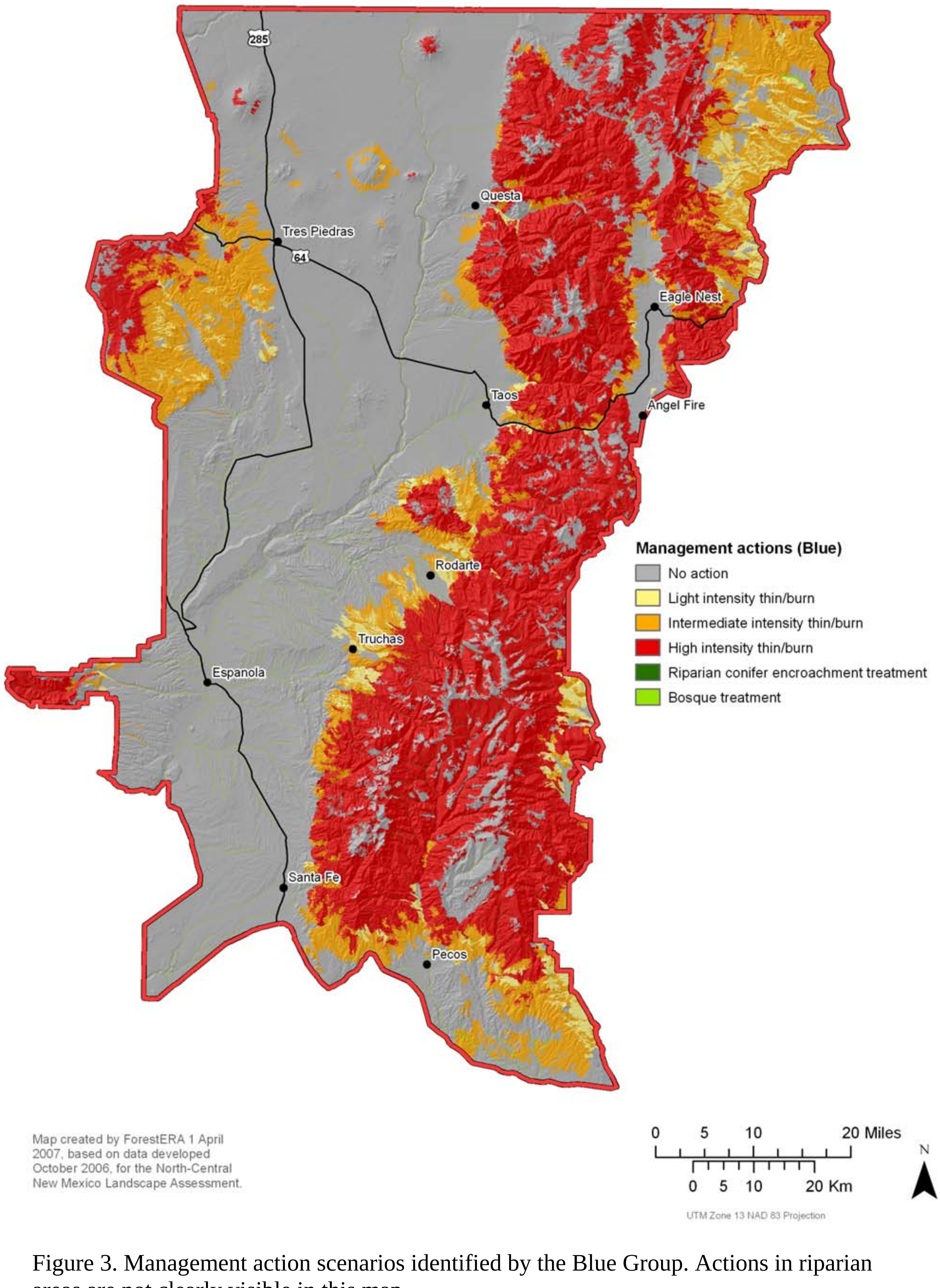

Figure 3. Management action scenarios identified by the Blue Group. Actions in riparian areas are not clearly visible in this map.

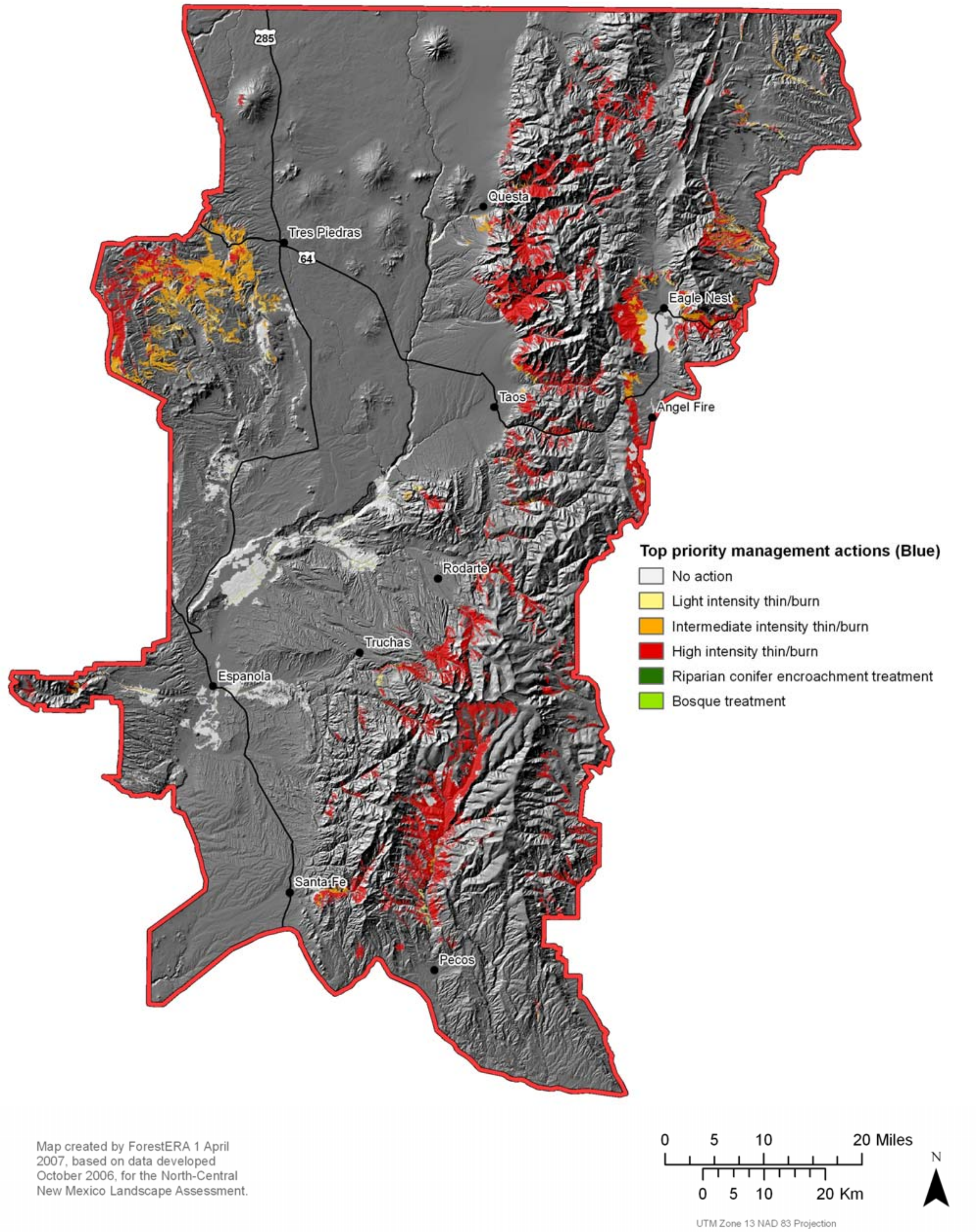

Figure 4. Management action scenarios identified by the Blue Group within the top 300,000 priority acres on the study area. Actions in riparian areas are not clearly visible in this map.

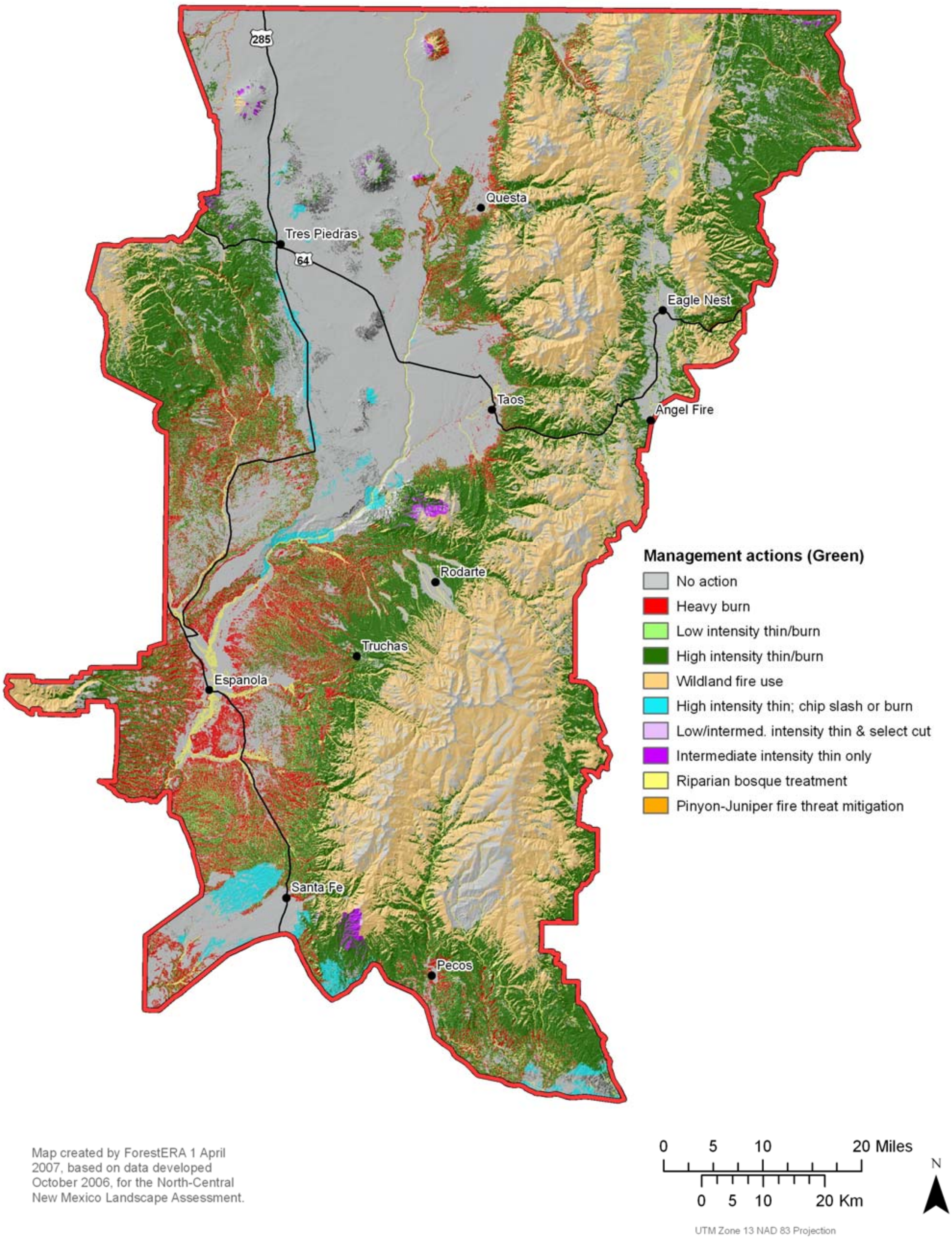

Figure 5. Management action scenarios identified by the Green Group.

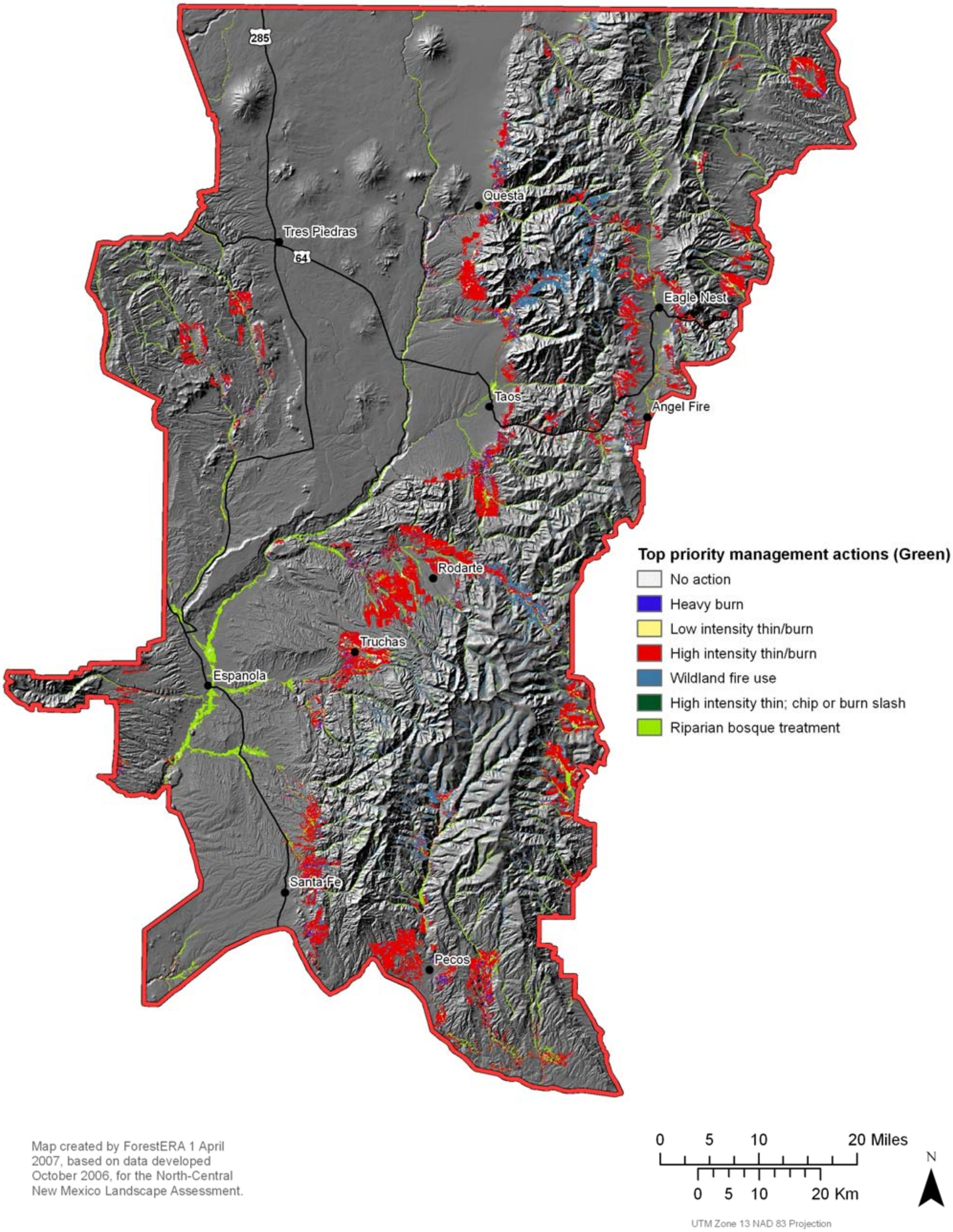

Figure 6. Management action scenarios identified by the Green Group within the top 300,000 priority acres on the study area. Actions in riparian areas are not clearly visible in this map.

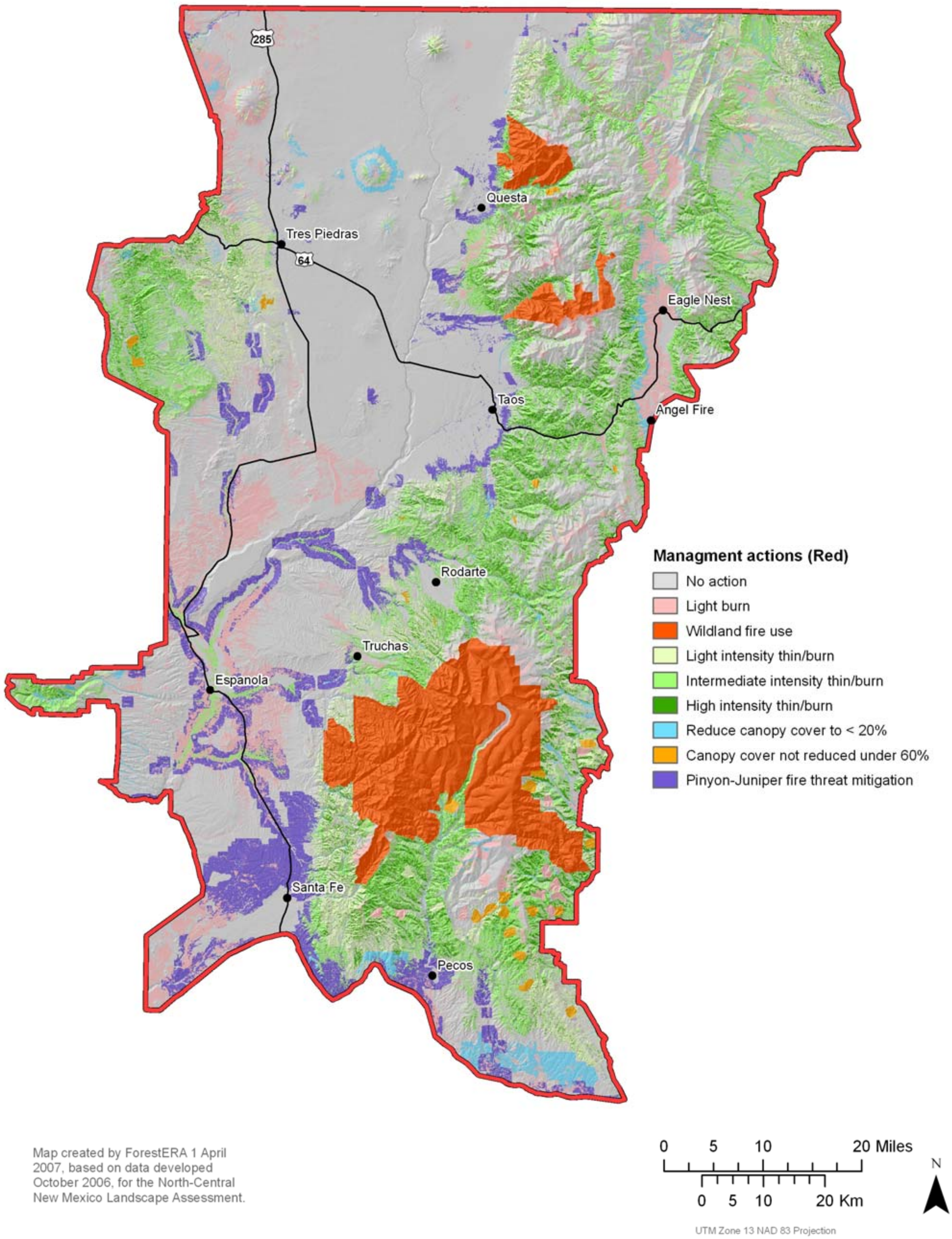

Figure 7. Management action scenarios identified by the Red Group.

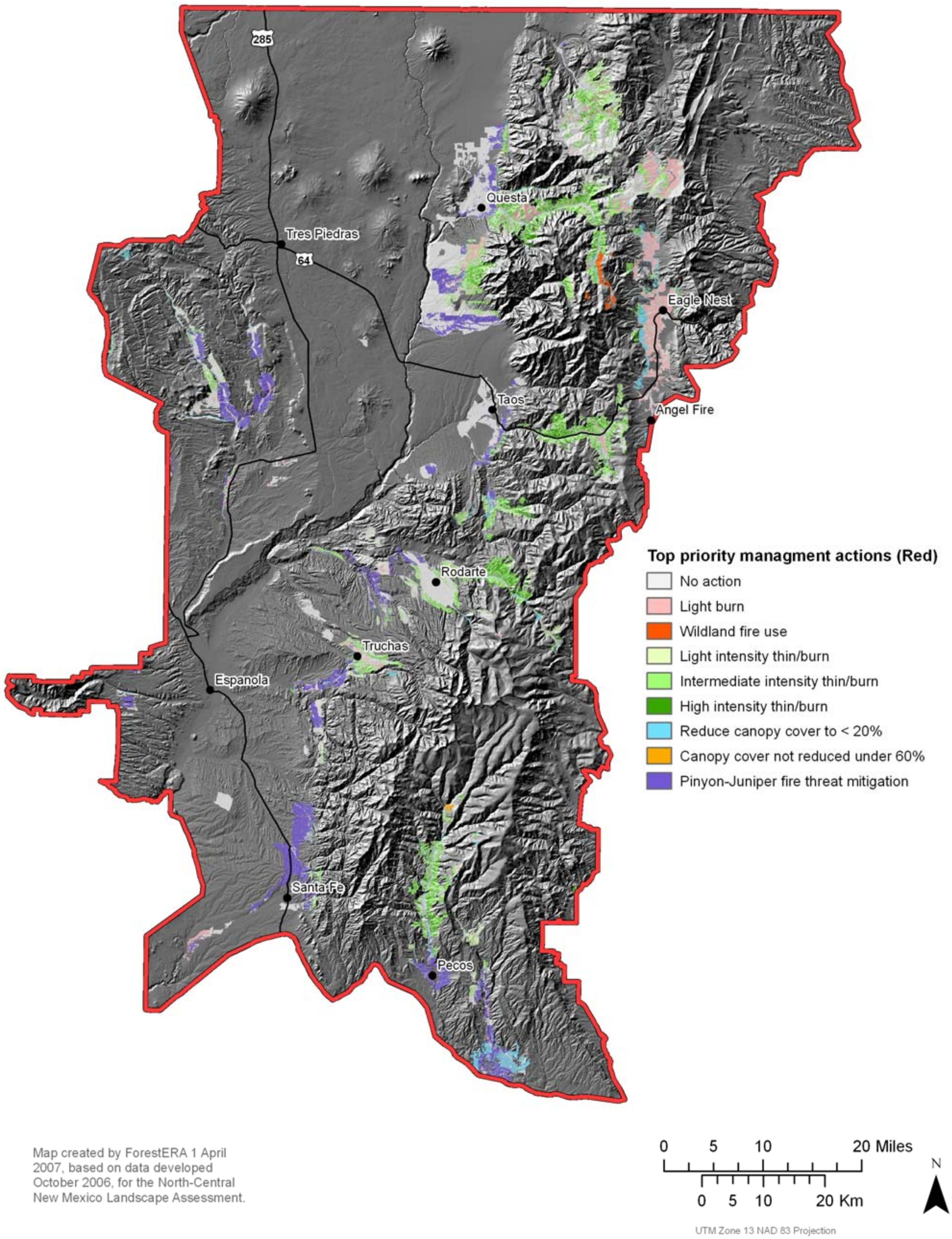

Figure 8. Management action scenarios identified by the Red Group within the top 300,000 priority acres on the study area.

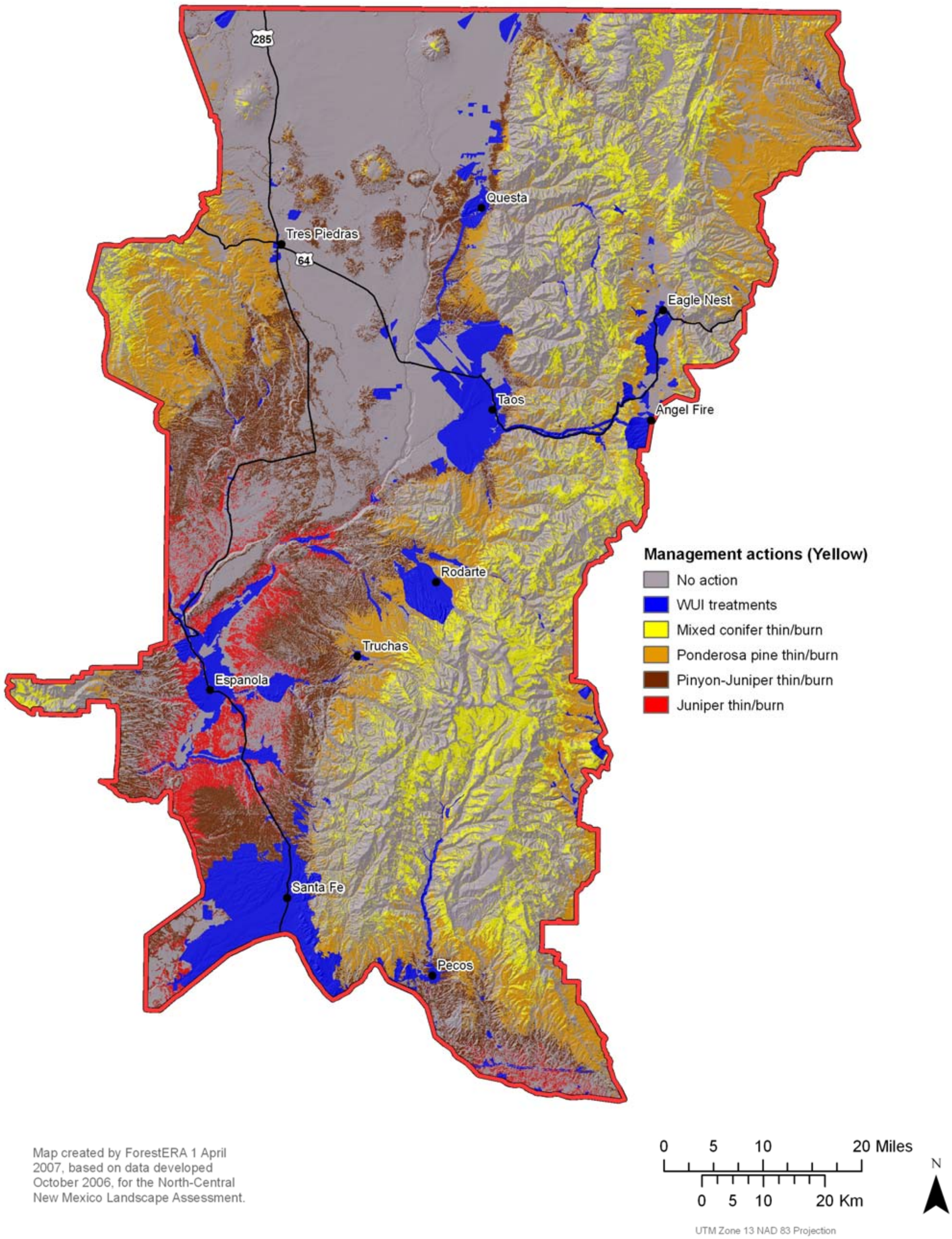

Figure 9. Management action scenarios identified by the Yellow Group.

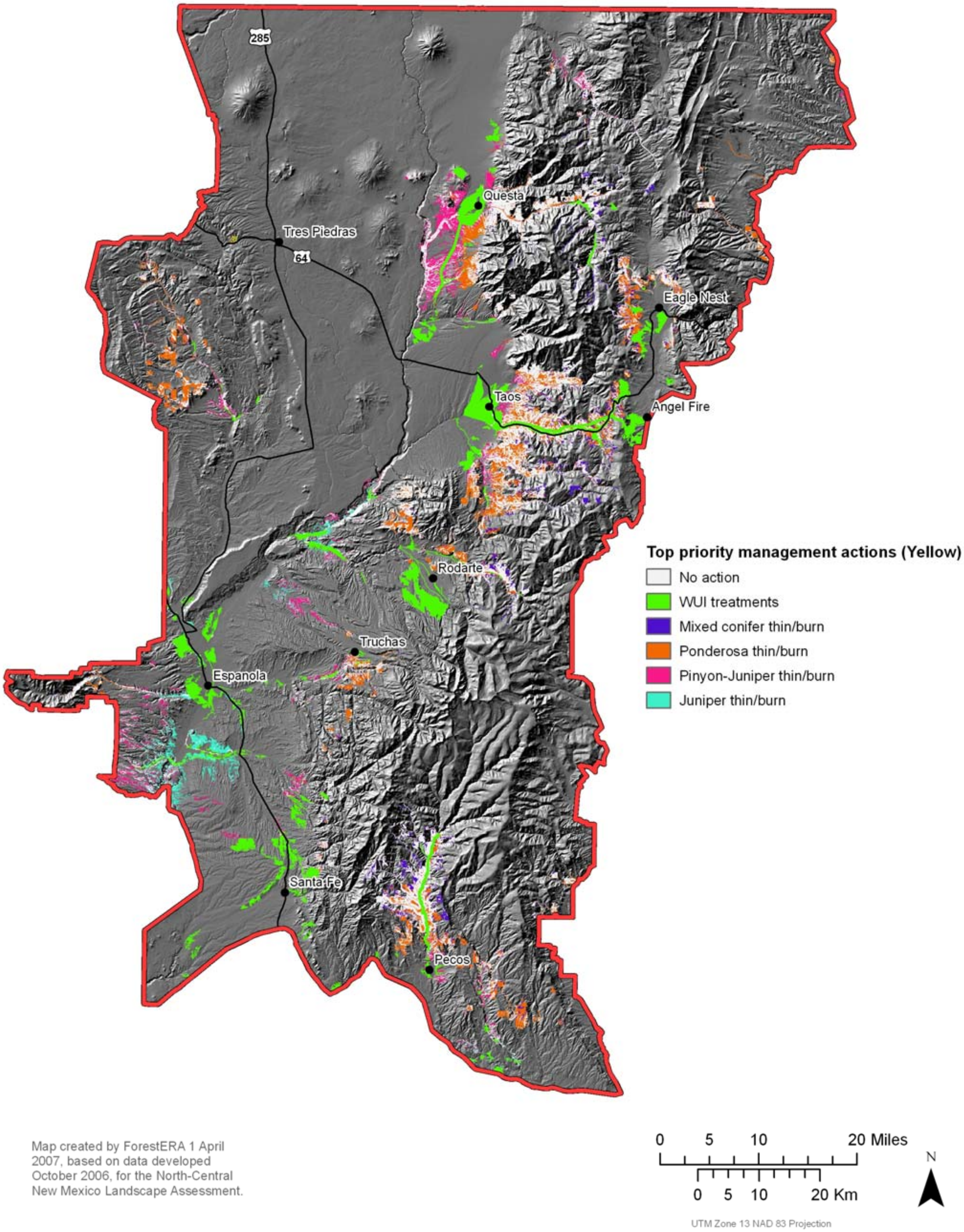

Figure 10. Management action scenarios identified by the Yellow Group within the top 300,000 priority acres on the study area.

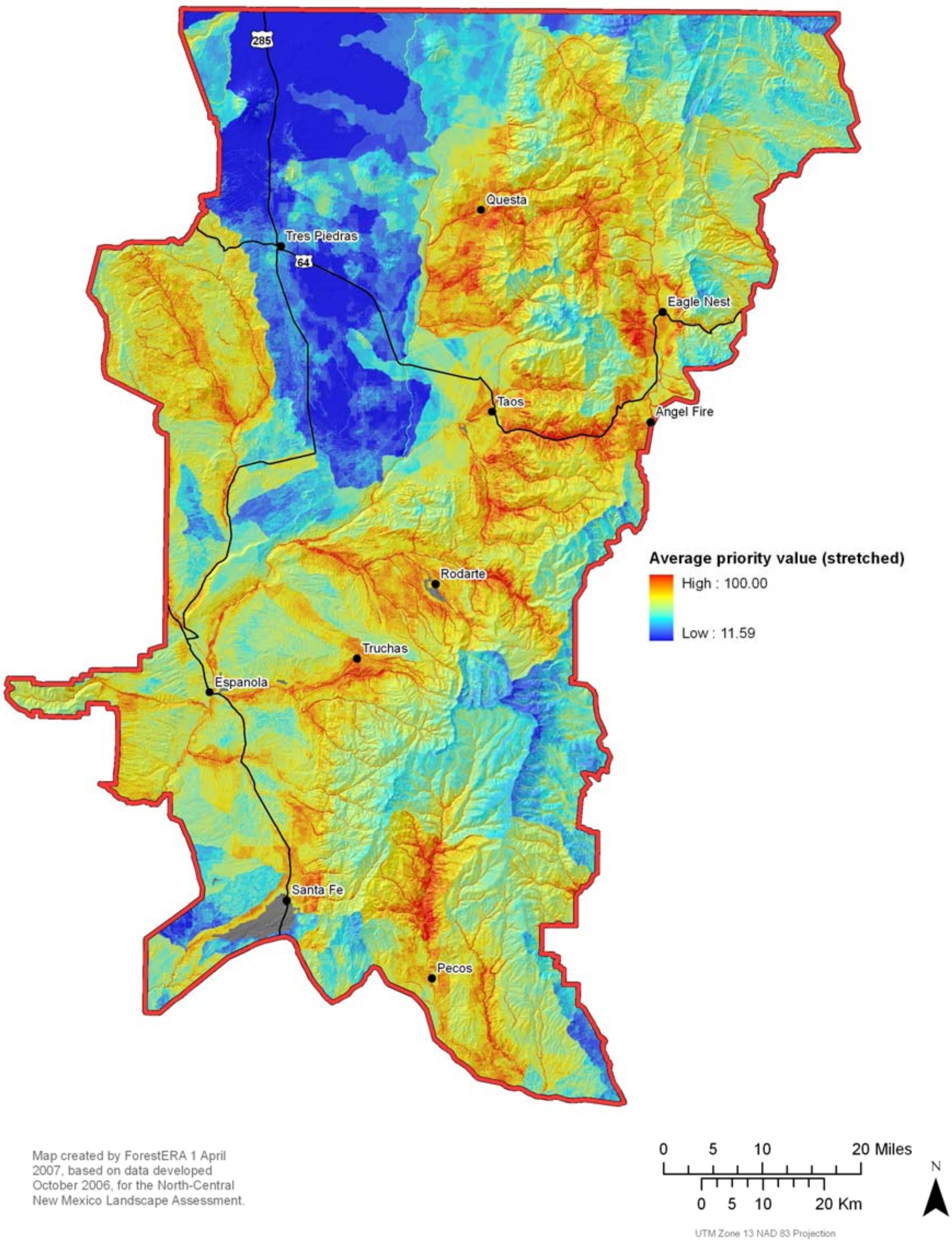

Figure 11. Synthesized map of average priority values computed using the individual prioritization scenarios produced by each group.

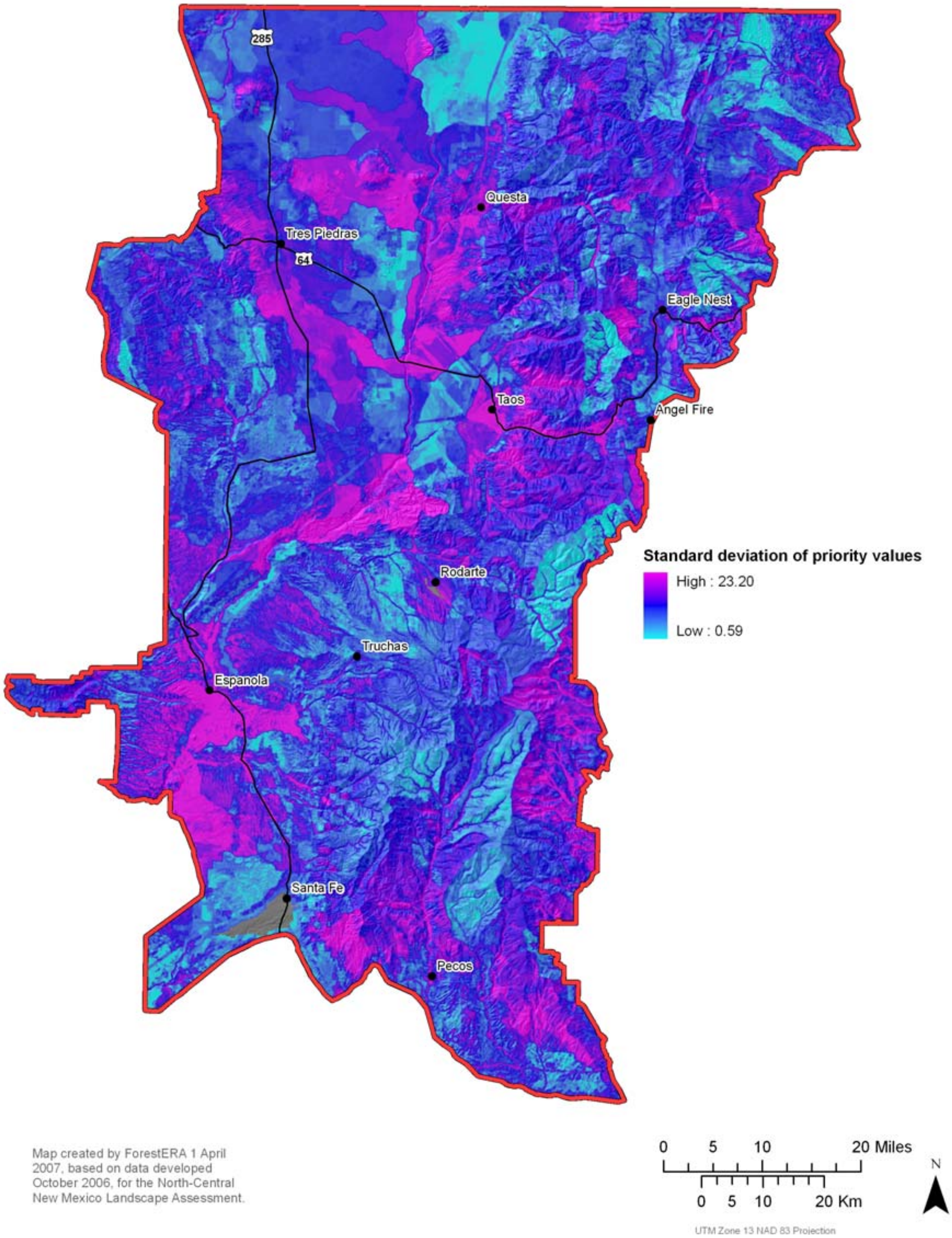

Figure 12. Map of standard deviation of priority values computed using the individual prioritization scenarios produced by each group. Higher values indicate areas of higher variability among prioritization values defined by each of the four groups. Approximately 95% of the total variation fell between 0.59 and 23.2.

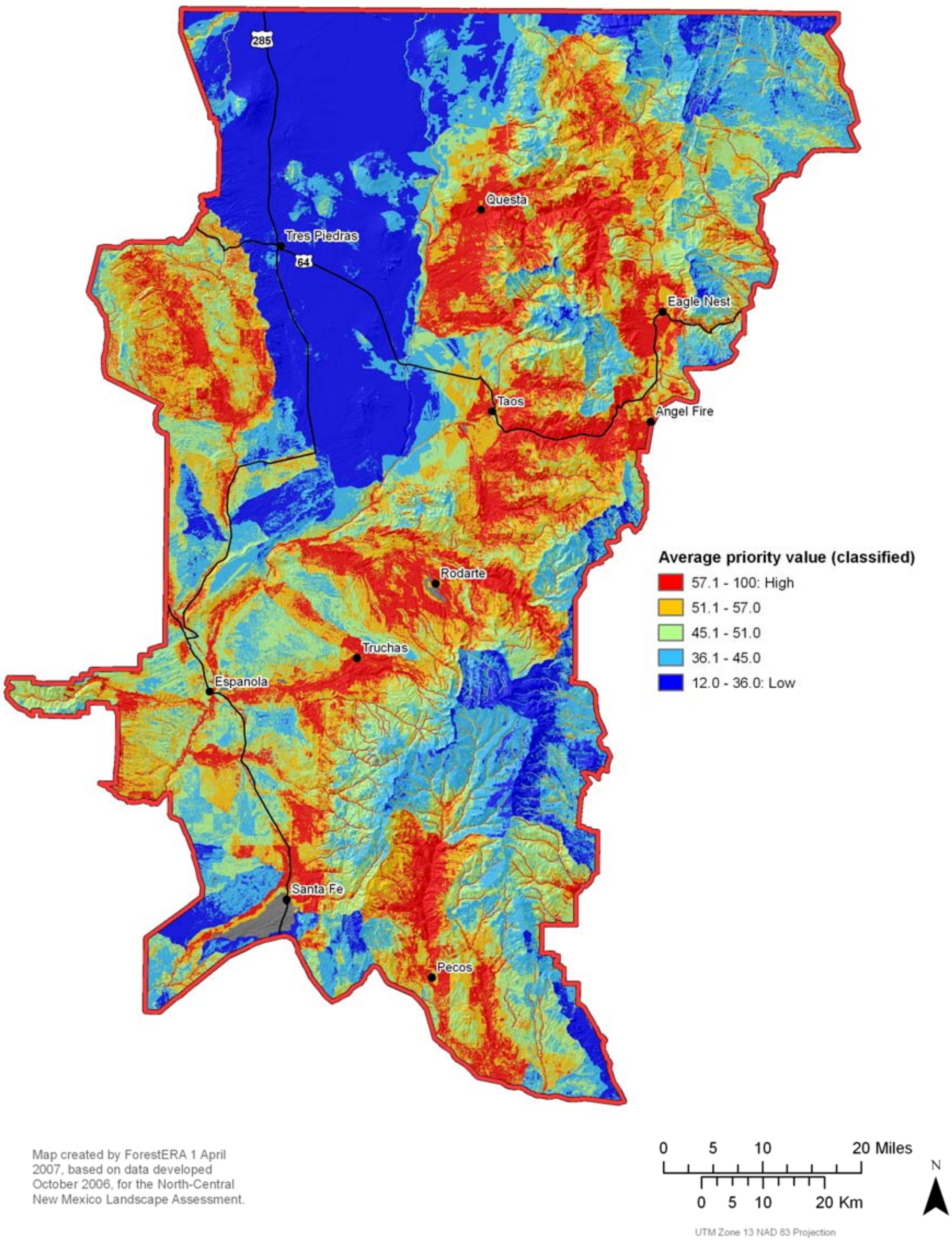

Figure 13. Map of reclassified average priority values synthesized using the individual prioritization scenarios produced by each group.

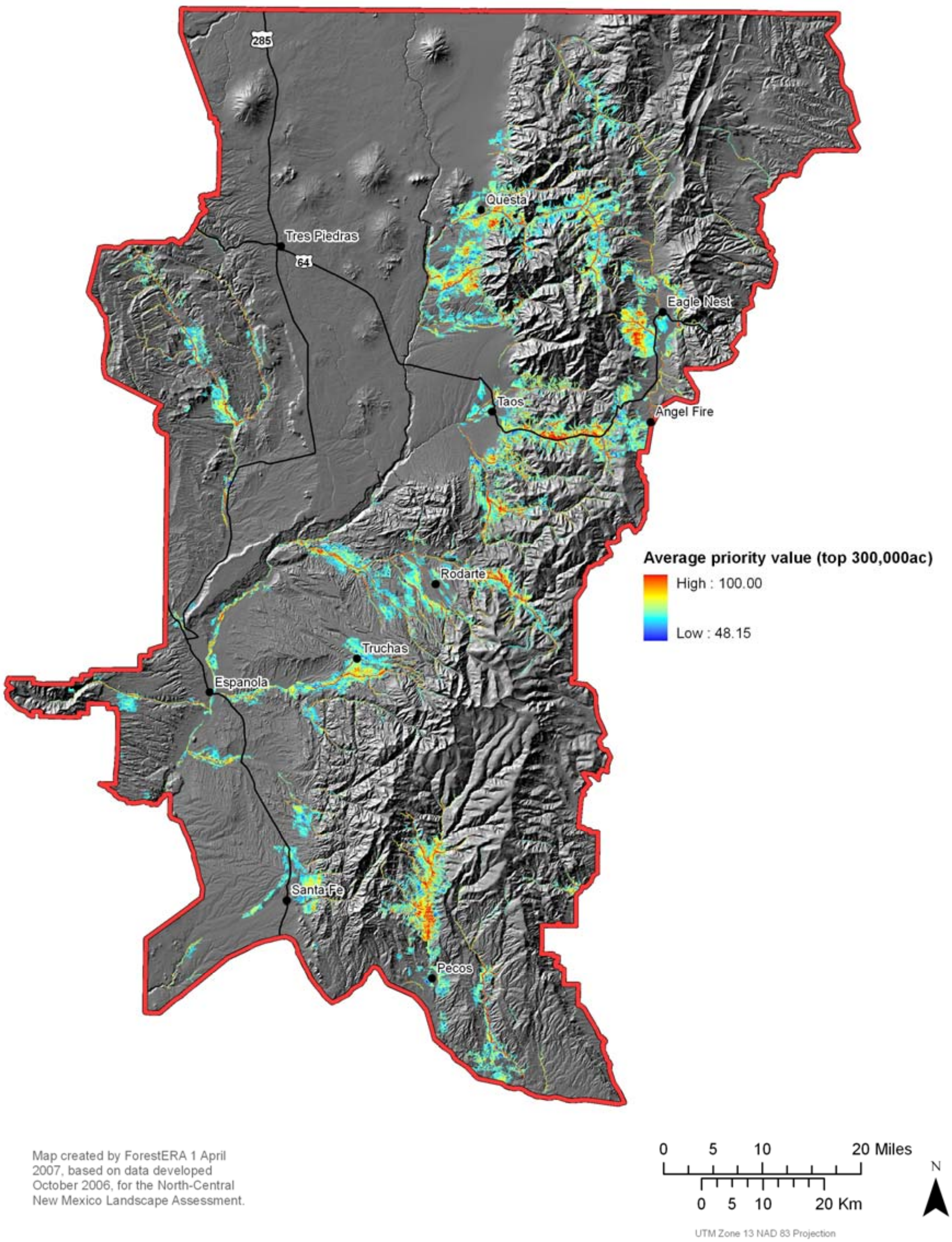

Figure 14. Map of the highest (top 300,000 acres) average priority values synthesized using the individual prioritization scenarios produced by each group.

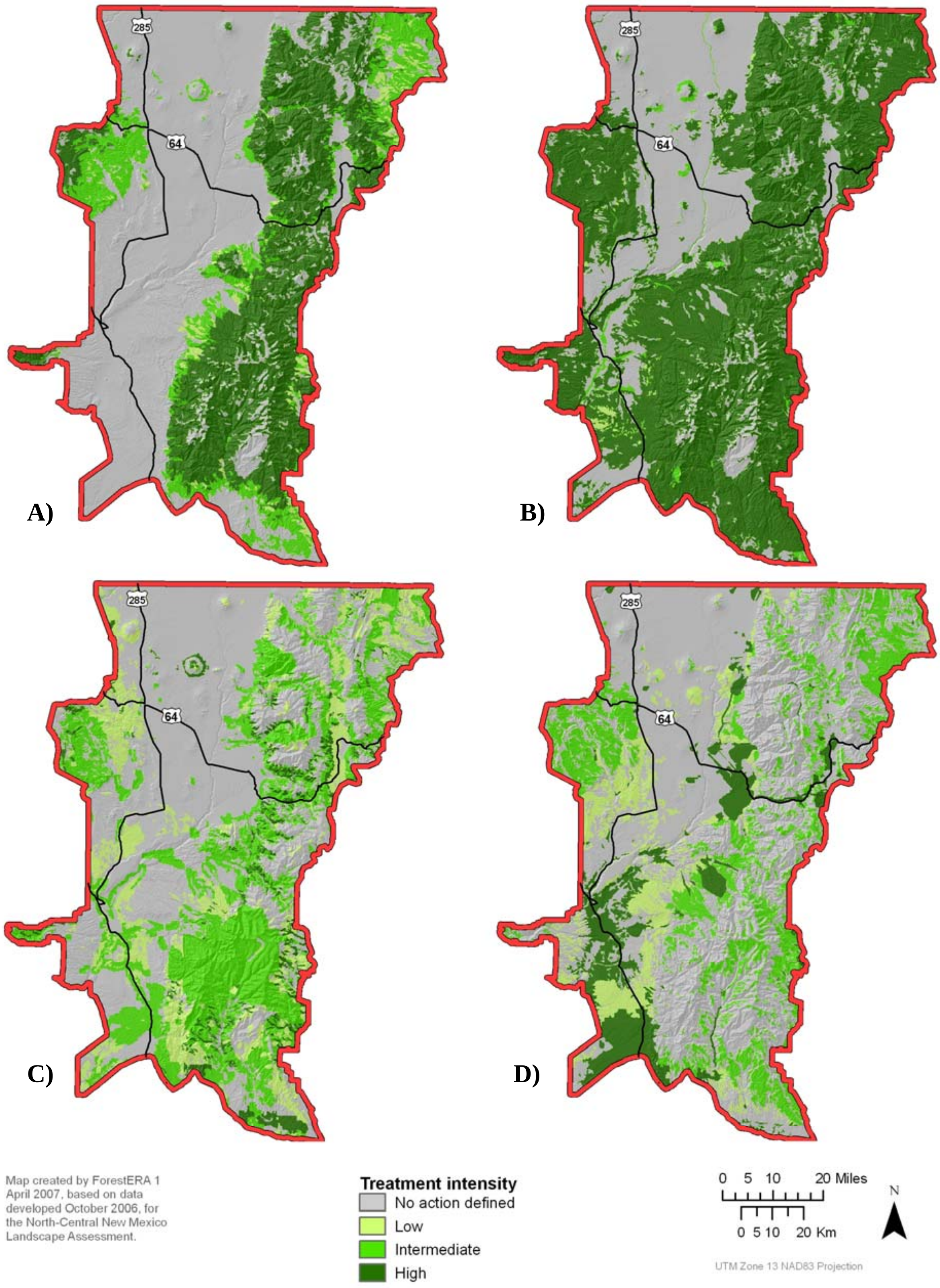

Figure 15. Treatment intensity maps for the A) Blue, B) Green, C) Red, and D) Yellow Groups.

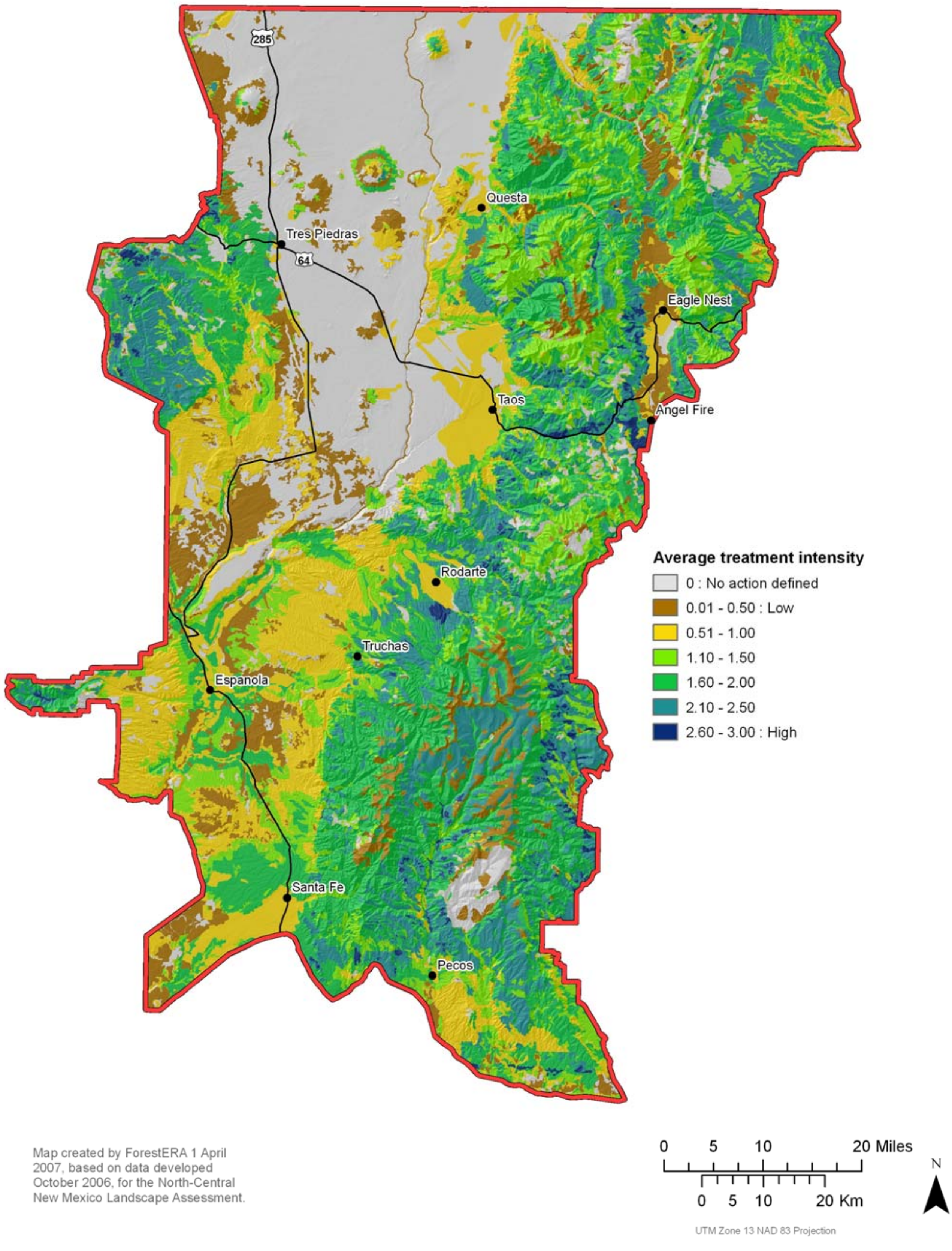

Figure 16. Map of average treatment intensity values created using the individual treatment intensity maps produced by each group.

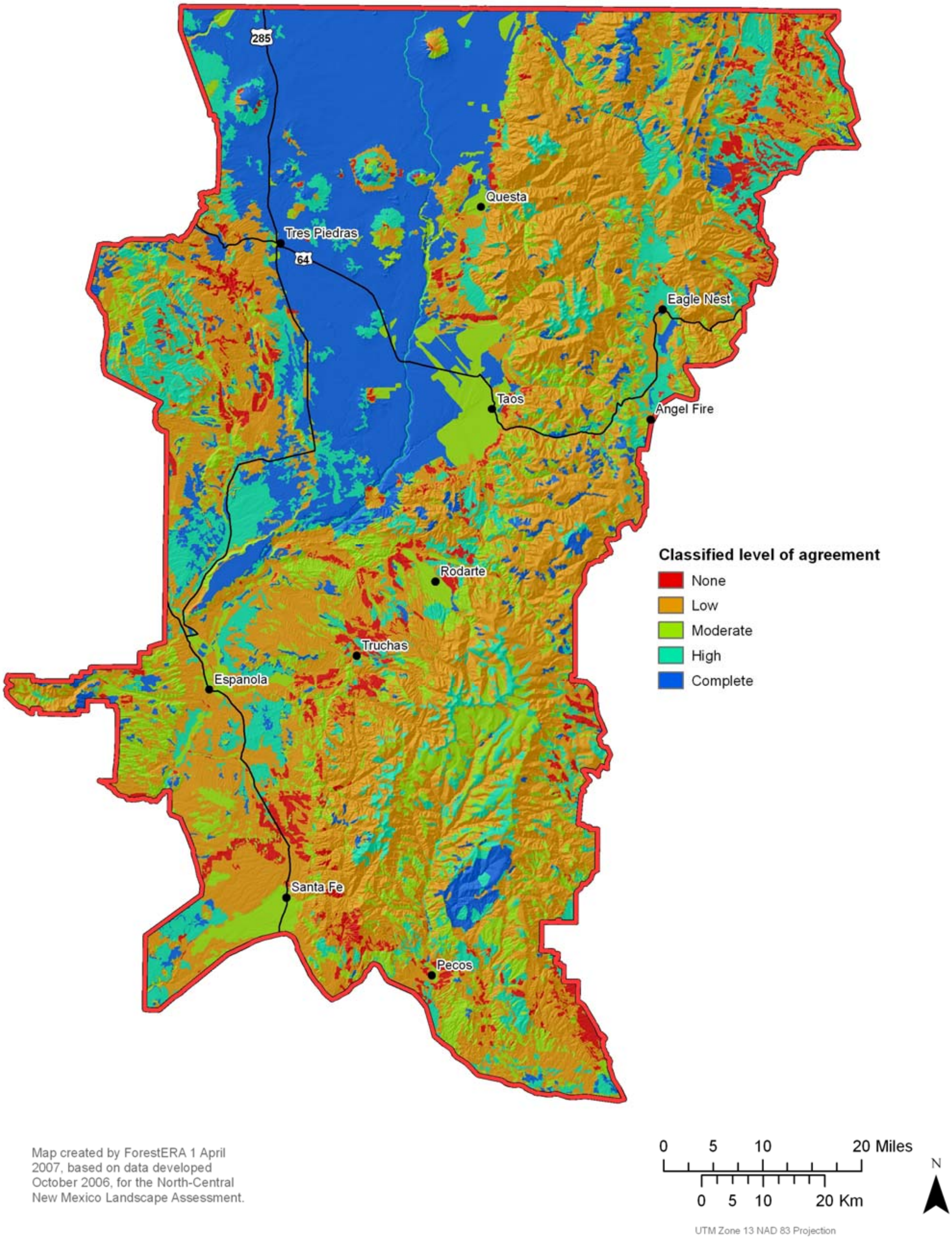

Figure 17. Classified level of agreement among the treatment intensity maps created by each of the four groups.

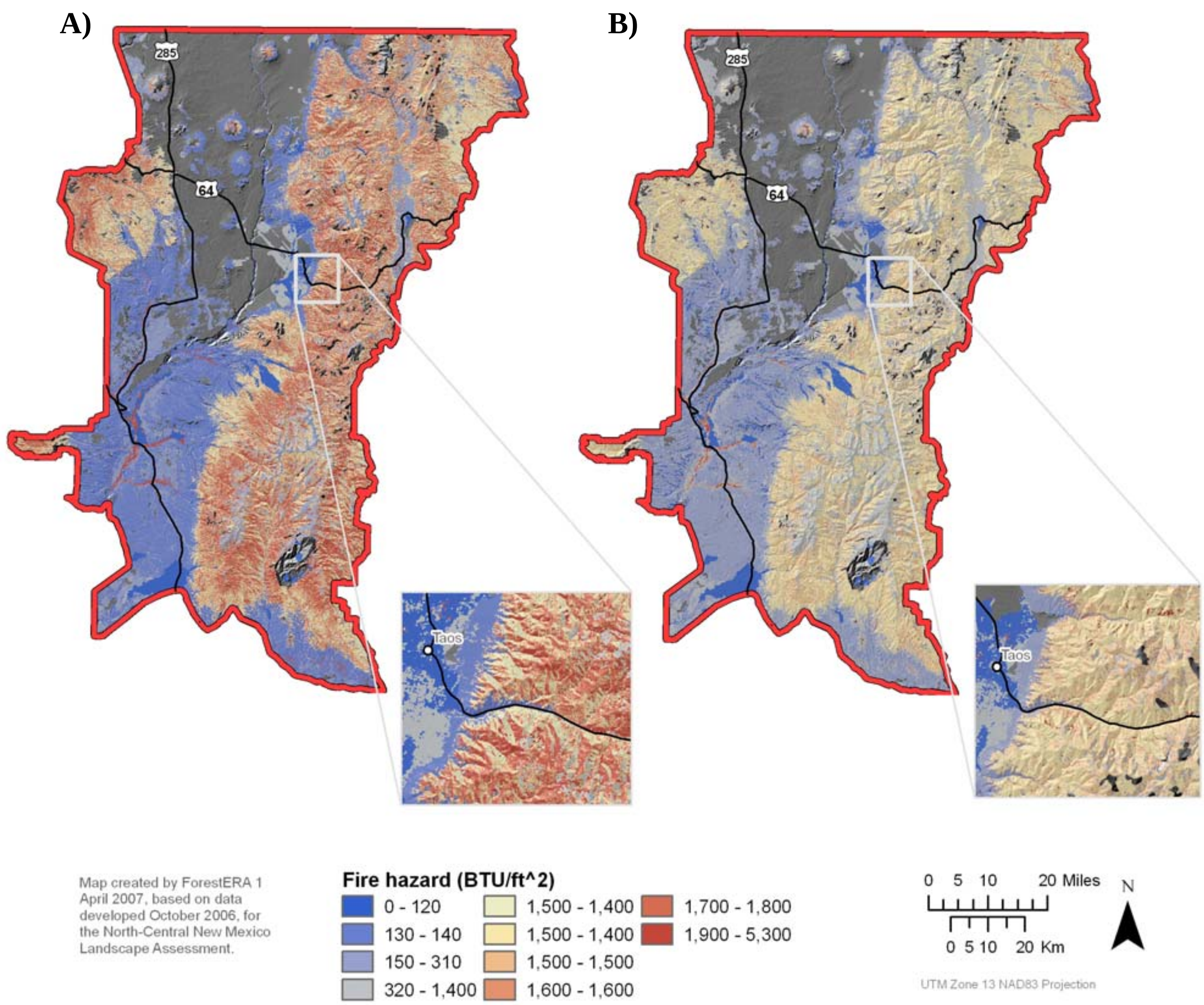

Figure 18. Fire hazard on the A) pre-treatment landscape and the B) predicted effects of the average treatment intensity values on post-treatment fire hazard. Inset provided for detail.

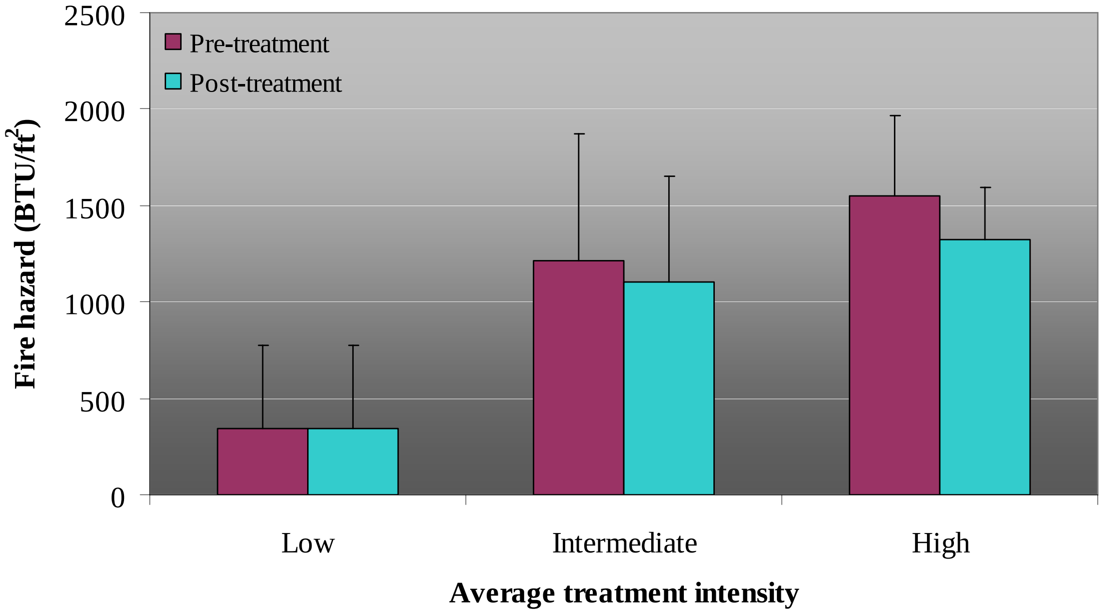

Figure 19. Mean (±SD) pre- and post-treatment estimates of fire hazard for each treatment intensity level. Predicted effects of post-treatment fire hazard are based on the average treatment intensity values computed among groups.

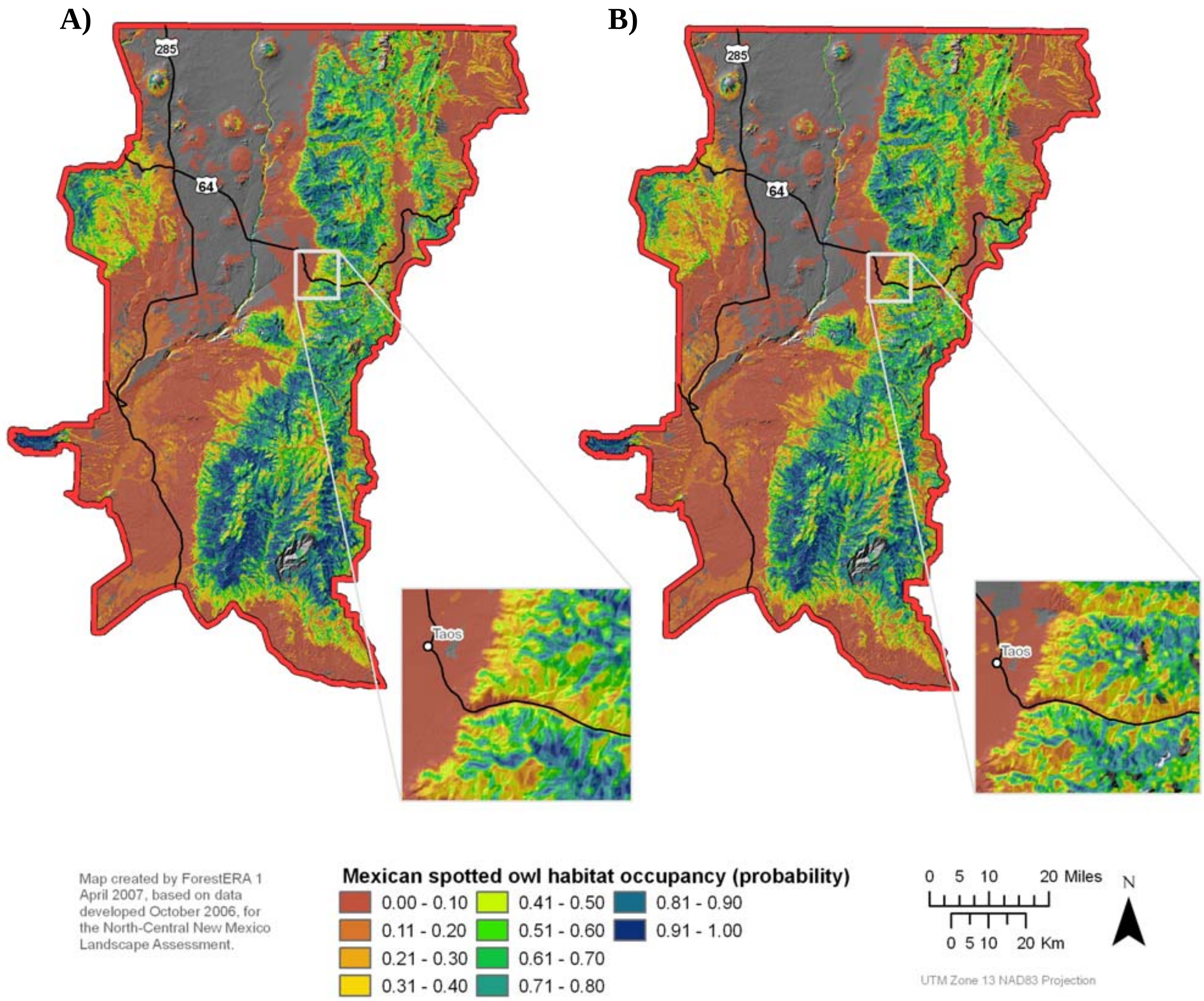

Figure 20. Probability of Mexican Spotted Owl habitat occupancy on the A) pre-treatment landscape and the B) predicted effects of the average treatment intensity values on post-treatment owl occupancy. Inset provided for detail.

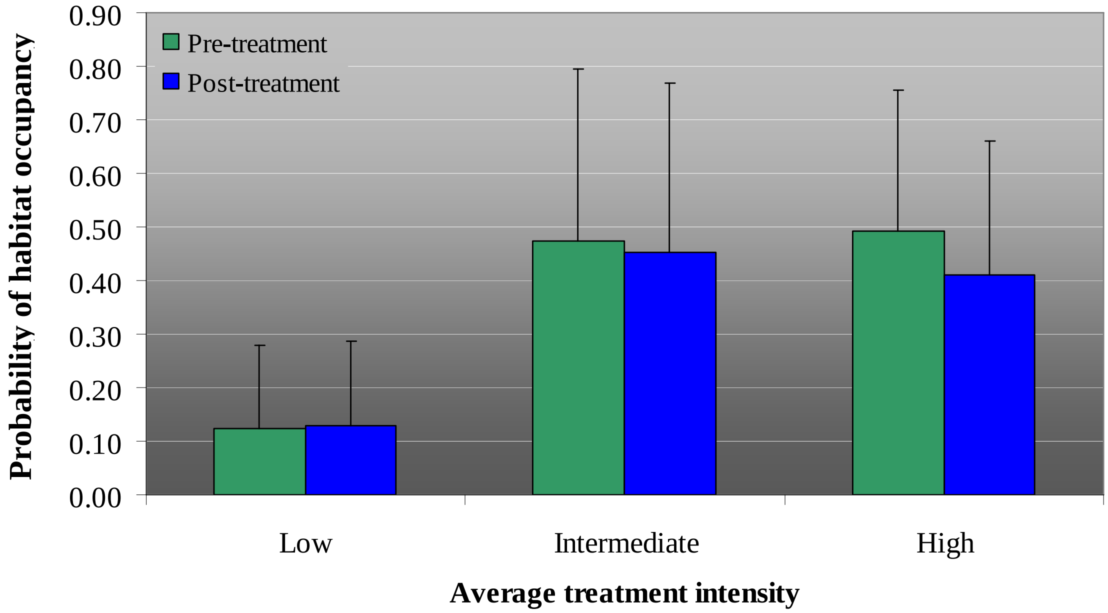

Figure 21. Mean (±SD) pre- and post-treatment estimates of probability of Mexican Spotted Owl habitat occupancy for each treatment intensity level. Predicted effects of post-treatment habitat occupancy are based on the average treatment intensity values computed among groups.

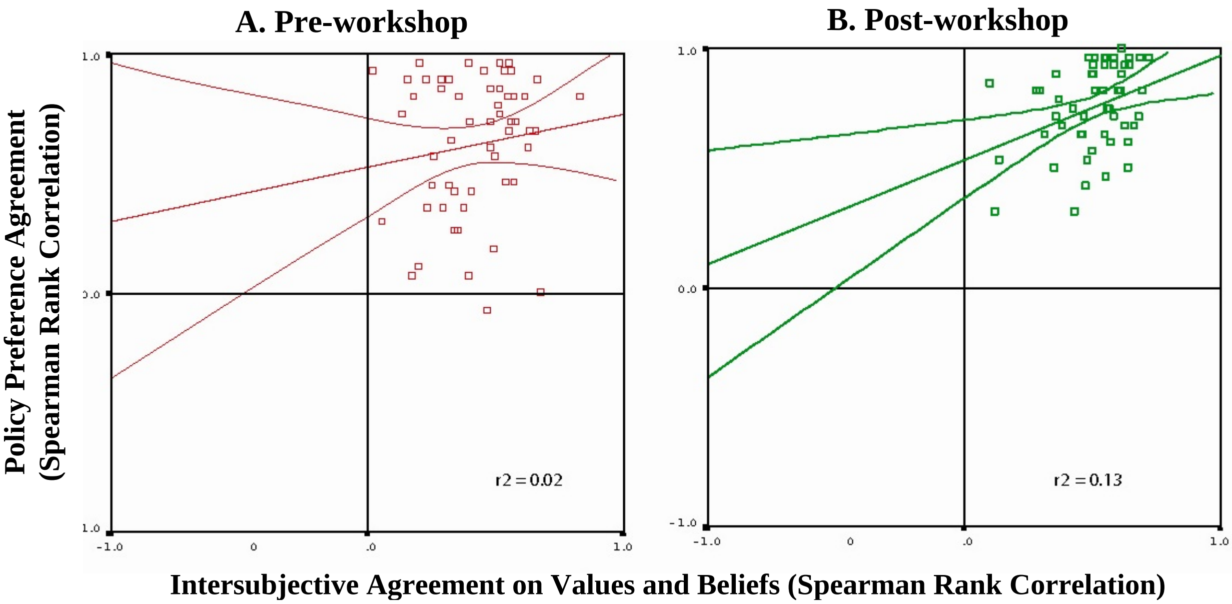

Figure 22. Pre- and post-workshop intersubjective rationality for the North-central New Mexico Landscape Assessment. The graphs show the level of agreement among stakeholders, with each point representing a particular pairing of workshop participants. The x-axis shows the correlation of values and beliefs for each pairing, and the y-axis shows their correlation with respect to forest management policy preferences. Relatively tight clustering in the pre-workshop graph indicates a fairly high level of initial agreement among participants, which is not surprising given that participants entered the workshop with considerable knowledge and experience on forest and fire management issues. Changes in the pre- and post-workshop graphs indicate an improvement in the alignment of values with policy preferences (intersubjective rationality) during the process, and a stronger consensus among stakeholders.