Pretreatment Data to Evaluate the Effects of Fuel Management Treatments in the Spring Mountains National Recreation Area

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On page 8 of the report, the authors appear to have incorrectly cited Boyd (2004) for the assertion that *Ericameria nauseosa* is a larval host plant for *Chlosyne acastus robusta* and inadvertently omitted *Chrysothamnus viscidiflorus* from the study design. In his 2004 report, Boyd does not make this assertion. Boyd (2004) reported *Chrysothamnus viscidiflorus* as a verified larval host plant for *Chlosyne acastus robusta*. This error also occurs on pages 72 (appendix F), 73 (table 1), 74 (table 2), and 76 (table 3) where *E. nauseosa* is included and noted to be a larval host plant (LHP) for *Chlosyne acastus robusta*. Additionally, as of January 25, 2012 such a relationship between any other subspecies of *Chlosyne acastus* and *E. nauseosa* had not been found in a review of information of larval host plants for all subspecies of *C. acastus* (personal communication, Corey Kallstrom, U.S. Fish and Wildlife Service, Southern Nevada Field Office.)

On page 13 of the report, the authors listed *Adenostoma fasciculatum* among the dominant plants seen in the project area. This species was not previously known from the area, no voucher specimens or photographs were made of the plant, and this species identification should be considered inconclusive (personal communication, 25 January 2012, Corey Kallstrom, U.S. Fish and Wildlife Service, Southern Nevada Field Office based upon 10 November 2011 email from Jennifer Brickey, U.S. Forest Service, Humboldt-Toiyabe National Forest, Spring Mountains National Recreation Area.)

References

Boyd, B. 2004. Report on Butterfly Investigation in the Spring Mountains, Nevada, 2002-2003. Unpublished report prepared for the U.S. Forest Service, Spring Mountains National Recreation Area in cooperation with the U.S. Fish and Wildlife Service. Prepared on 30 September 2004.

-Susan Wainscott, Adaptive Management Coordinator, Desert Conservation Program

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Executive Summary

Fire risk is a very real management concern in the wilderness urban interface (WUI) of the west. It has been estimated that over 10 million hectares of forests in the United States are currently in an elevated fire hazard condition, and much of this land area is widely thought to need some form of active management such as prescribed fire, mechanical treatments, or both (McIver et al. 2009). Within the Spring Mountains National Recreation Area (SMNRA) of the Humboldt-Toiyabe National Forest, fuels reduction treatments are being implemented to reduce the risk of catastrophic fire within WUI areas. These treatments cumulatively cover 800 hectares (2,000 acres) and occur where MSHCP covered plant species or host plant of covered butterfly species, and covered ecosystems, are present. Scientists from the U.S. Geological Survey, Western Ecological Research Center (USGS) established and collected pre-treatment data from over 200 sampling plots for three listed ecosystems, 5 covered plant species, and resource host plants associated with 3 covered butterfly species throughout the SMNRA. Here, we provide pre-treatment baseline vegetation information (conditions) for the listed ecosystems and covered plant populations according to the specific guiding hypotheses of this project, which are:

- Plant abundance, density and cover at the population level,
- Power analyses based on count data for each of the 18 populations considered
- Tree, shrub, nonnative annual and native perennial plant density and cover for the listed ecosystems among treatment and control plots
- Diversity ordering for native annual and perennial species in context of the listed ecosystems among treatment and control plots

We also discuss the role of this project in context of vegetation dynamics throughout the arid west as well as in other on going fire and fuel treatment projects. In addition we provide suggestions for guiding follow-up sampling efforts and suggest ways that the post treatment data could be evaluated. Finally we provide recommendations for this project especially in terms of potential post treatment effects and consequences.

INTRODUCTION

Background, Need, and Project Description

The Nevada Community Wildfire Risk/Hazard Assessment, a collaborative community-based wildland fire assessment, identified communities that are at risk to wildfire in and around the Spring Mountains National Recreation Area (SMNRA) (USFS 2007). Fuel accumulations in this region are the result of a Century of fire suppression which is recognized throughout the western United States as a cause of altered the fire regimes and increased risk of catastrophic wildfires that threaten human life, property, and the integrity and functioning of ecosystems (Keeley 2006). It was determined that existing escape routes for residents of these communities and forest users are compromised due to nearby vegetative conditions that may result in fire behavior that does not allow for safe fire suppression or evacuation (USFS 2007). In response to this assessment, it was determined there was a need to thin continuous stands of fuels on National Forest lands in the wildland-urban interface (WUI) to create defensible space from fires around communities, protect existing infrastructure, and establish effective escape routes (USFS 2007). The Spring Mountains Hazardous Fuel Reduction Project (fuel reduction project) was developed to reduce the wildfire risk to life and property in the SMNRA WUI. Treatments were not designed to stop a wildfire, but rather to reduce flammability of vegetation to allow suppression forces a higher probability of successfully attacking a wildfire.

The SMNRA fuel reduction project falls within the boundaries of the Multiple Species Habitat Conservation Plan (MSHCP) of Clark County, Nevada (www.accessclarkcounty.com). This plan is designed to protect 78 covered species (14 reptiles, 1 amphibian, 8 birds, 4 mammals, 8 insects, 2 mollusks and 41 species of plants), and the goal for each covered species is that there be no net unmitigated loss or fragmentation of habitat. The MSHCP also includes protection for covered ecosystems/habitats. Eight covered species (5 plants and 3 butterflies) and 3 covered ecosystems occur within the fuels reduction project area. These covered plant and butterfly species are either endemic to the Spring Mountains or have very limited distributions outside of the mountain range. Many are found in mixed-conifer and pinyon-pine plant community types which is where the majority of the thinning treatments are planned in the Spring Mountains.

The effects of the fuel thinning treatments on the covered species of this region are largely unknown, raising significant concern that they could have adverse affects on both the covered species, and the covered ecosystems of the Spring Mountains. For example, it is possible that the disturbance created by mechanical fuel treatments may promote the dominance of invasive plants, at least in the short-term, which could have negative effects on desirable native plants through competition for limiting resources (e.g. Brooks et al. 2004). Alternatively, at least one covered plant species, Clokey eggvetch (*Astragalus oophorus*), may benefit from the construction of fuel breaks, which will open up the forest understory much like fire would. It has been suggested that this species may increase following vegetation removal by fire (TNC 1996), and similar results may occur following vegetation removal by fuelbreak construction. In addition, many of the butterfly species may benefit by fuel treatments that reduce cover of trees and large shrubs if the treatments promote the growth of understory larval host plants, or otherwise increase plant species diversity. Several of these covered species occur in project area, such as the Spring Mountains acastus checkerspot (*Chlosyne acastus*), dark blue butterfly (*Euphilotes ancilla pupura)*, and Mount Charleston blue butterfly (*Icaricia shasta charlestonensis*).

In order to create shaded fuel breaks, treatment areas have been and are in the process of being thinned to reduce tree canopy cover and ladder fuels, reducing the threat of high intensity crown fire and enabling firefighters to better protect private homes and property and USFS facilities and campgrounds. There is additional hope that these treatments will either have no negative or have positive effects on plant species diversity and populations of plant and butterfly species covered under the MSHCP. However, there is no information available to determine if all of these goals are attainable, or which types of fuel treatments may be most benign, or even beneficial, to covered species.

In response to these concerns and unknowns, SMNRA staff enlisted the services of scientists from the U.S. Geological Survey, Western Ecological Research Center (USGS) to help procure funding to design and implement a program to evaluate the effects of the thinning treatments on these covered species and ecosystems. There was some hope that USGS would have the opportunity to collect post-treatment data to evaluate short-term treatment effects. However, resampling was not possible due to the delay in implementing the treatments. Accordingly, this report only describes the sampling plan and summarizes the pretreatment data collected prior to implementation of the thinning treatments. Because it is very important that resampling be done after all treatments have been implemented, a section is also included providing recommendations on how to accomplish that task.

Elements of the MSHCP Addressed by this Project

Specific objectives of the MSHCP (Clark County MSHCP/EIS, Section 1.2.2):

1. Avoidance of the necessity to list additional species in Clark County and the conservation and recovery of currently listed species;
2. Identification and evaluation of the effectiveness of alternative and adaptive habitat management techniques over time and utilizing the Adaptive Management Process (AMP) set forth herein; and
3. Early involvement of interested agencies, landowners, managers, and other stakeholders in advance of proposals for specific conservation strategies in and effort to minimize conflicts and delays and facilitate appropriate public and private development.

Goals and objectives of Phase 1 of the MSHCP (Clark County MSHCP/EIS, Section 1.2.3):

1. Methodology - To develop and to adopt a biologically sound methodology to be used to analyze the status of habitats and species within Clark County;
2. Adaptive Management Plan - To develop, reach agreement upon, and propose measures to implement a long-term adaptive management and monitoring program which may be useful and informative to policy makers, landowners, and land managers in reaching land use, development, and conservation decisions in the future;
3. Implementation Plan - To agree upon and adopt plans to implement conservation measures which reduce the likelihood of future listings in the County which meet the legal requirements for incidental take permits and which will not appreciably reduce the likelihood of the survival and recovery of the species in the wild;
4. Species Not Currently Listed - To identify those species which are likely to be listed in the near future and which, if listed, are likely to have a significant economic or social impact upon the residents of Clark County, to identify conservation measures which are likely to substantially reduce the likelihood of such listing and to result in the conservation and recovery thereof, to commit the implementation of such conservation measures, and to secure incidental take permits should such species be listed in the future that would become effective upon the listing of such species,
5. Measurable Biological Objectives: To identify measurable biological objectives consistent with the overall goal of no net unmitigated loss or fragmentation of habitat and to maintain stable or increasing populations of Covered Species in Intensively Managed Areas and Less Intensively Managed Areas.

Recommendations of the Biennial Adaptive Management Report (2004) for upland initiative project in this project include the following:

1. Effectiveness monitoring for all implementation projects that do not have a record of demonstrated conservation benefits.

Species

Covered plant species that occur in the fuel reduction project area include:

- *Angelica scabrida* (rough angelica)
- *Astragalus aequalis* (Clokey milkvetch)
- *Astragalus oophorus* var. *clokeyanus* (Clokey eggvetch)
- *Townsendia jonesii* var. *tumulosa* (Charleston grounddaisy)
- *Arenaria kingii* ssp. *rosea* (King's sandwort)

Covered butterfly species and their larval and/or nectar host plants that also occur in the fuel reduction project area include:

- *Chlosyne acastus* (Spring Mountains acastus checkerspot)
  - Larval host plants: rabbit brush (*Ericameria nauseosa*) (Boyd 2004)
  - Nectar host plants: dogbane (*Apocynum sp*.), Palmer's penstemon (*Penstemon palmeri*), narrowleaf yerba santa (*Eriodictyon angustifolium*), sweetclover (*Melilotus sp*.), ceanothus (*Ceanothus sp*.), lobe-leaf groundsel (*Packera multlobata*) (Boyd et al. 2000), and golden-eye (*Viguiera multiflora*) (RECON 2000).
- *Euphilotes enoptes* (dark blue butterfly),
  - Larval and nectar host plants: sulfur flower buckwheat (*Eriogonum umbellatum* var. *subaridum*) (RECON 2000) and juniper buckwheat (*Eriogonum umbellatum* var. *juniporinum*) (Boyd and Austin 2002).
- *Icaricia shasta* (Mt Charleston blue butterfly)
  - Larval host plant: Torrey's milkvetch (*Astragalus calycosus*).
  - Main nectar host plants: Torrey's milkvetch and Clokey fleabane (*Erigeron clokeyi*). Other nectar plants: heath aster (*Chaetopappa ericoides*), Lemmon's hymenoxys (*Hymenoxys lemmonii*), and pinyon aster (*Machaeranthera canescens*).

Species Threats

101a Monitor key populations or habitat area conditions
101b Provide for adaptive management responses to adverse changes
102a Monitor key populations or habitat area conditions
102b Provide for adaptive management responses to adverse changes
301a Identify key sensitive populations and habitats
301b Develop a fire management program that provides protection for sensitive resources
301c Provide for adaptive management responses to adverse changes
302a Identify key habitat areas potentially susceptible to fire and manage to minimize conversion
302b Remove or manage species from key susceptible habitat areas
302c Provide for adaptive management responses to adverse changes

Ecosystem/Habitats

Pinyon−Juniper Ecosystem
Mixed Conifer Forest Ecosystem
Sagebrush Ecosystem

Ecosystem Threats

301a Identify key sensitive populations and habitats
301b Develop a fire management program that provides protection for sensitive resources
301c Provide for adaptive management responses to adverse changes
302a Identify key habitat areas potentially susceptible to fire and manage to minimize conversion
302b Remove or manage species from key susceptible habitat areas
302c Provide for adaptive management responses to adverse changes
1001a Prohibit or limit by permit requirements the collection of wood in key habitat areas
1001b Provide alternative areas for wood collecting

Conservation/Management Actions

USFS(16): Secure funding for research based on priorities identified below.
USFS(17): Encourage and support research in the Spring Mountains NRA, particularly in the Carpenter Canyon Research Natural Area, to assist with management concerns as well as to focus on basic research interests.
USFS(19): Conduct research on the species of concern and ecological communities of the Spring Mountains NRA by prioritizing research needs and identifying funding sources.
USFS(24): Use the results of monitoring activities to, where feasible and necessary, refine management strategies for protection of the species of concern. Where monitoring has indicated status decline or habitat degradation for the species of concern, develop and implement strategies to avert further decline or degradation, and improve species status and habitat quality.
USFS(104): Ensure that restoration projects focus on protection and enhancement of the species of concern and do not inadvertently cause irretrievable damage to the habitats of the species of concern (e.g., open water for bats, mud puddles for butterflies).

Goals of the Project

As listed in Interlocal Agreement 2005-USGS-551-P:

1. Establish no less than 50 vegetation monitoring plots in both treated and untreated (control) areas. These plots will be used to measure population data for covered plant species, population data for the larval and nectar host plants of covered butterfly species, species diversity data for the plant community, and perennial plants in particular, and data on non-native plant presence and abundance.
2. Collect and analyze/synthesize pre-treatment vegetation data.
3. Produce a report describing baseline vegetation conditions.

Hypotheses to be Addressed with Future Sampling

Mechanical fuel treatments will significantly:

(for MSHCP covered species)

1. increase density and cover of Charleston grounddaisy, King's sandwort, Clokey eggvetch, Clokey milkvetch, and rough Angelica.
2. change the abundance and diversity of butterfly larval host and nectar plants.

(for MSHCP covered ecosystems)

3. decrease stem density and cover of trees and shrubs
4. increase density, cover, and diversity of non-native invasive plants.
5. increase density, cover, and diversity of native annual plants.
6. increase stem density, cover, and diversity of native perennial grasses.

We would have liked to have collected follow-up data during at least the first post-treatment year, however delayed implementation of thinning treatments prevented this. Accordingly, this report only focuses on the monitoring design, sampling locations, and summary information related solely to pre-treatment vegetation data. These plots can be re-sampled in the future with additional funding to determine post-thinning effects and evaluate the hypotheses listed above.

METHODS

Study Site

The Spring Mountains, located in southern Nevada within the Humboldt-Toiyabe National Forest, are a long, linear, north-south aligned range of mountains that rise from desert valleys at elevations below 2,000 ft to nearly 12,000 ft at the top of Mt. Charleston. This elevation gradient translates into a variety of climate and vegetation zones. Because they stand so tall and are completely surrounded by desert, the Spring Mountains form an island of mountainous habitat in a sea of desert. Except for private in holdings, the Spring Mountains are administered primarily by the U.S. Forest Service within the SMNRA. Much of the SMNRS lies within a 30 minute drive from the edge of the Las Vegas metropolitan area, and in some places development has reached the immediate boundaries of the SMNRA.

The vegetation in the SMNRA is diverse, but it tends to form zones based on differences in precipitation and rates of evaporation which are directly tied to elevation. At lower elevations, the dominant plant community is Mojave Desert Scrub and dominated by widely scattered creosote bush, white bursage, Mojave yucca, and other shrubs. Above the desert scrub the vegetation becomes more abundant and diverse as Joshua tree (*Yucca brevifolia*), blackbrush (*Coleogyne ramossissima*), sagebrush (*Artemesia* spp.), pinyon pine (*Pinus monophylla*) and juniper (*Juniperus* spp.) occur. With increasing elevation montane mixed coniferous forests emerge and include Ponderosa pine (*Pinus ponderosa*), white fir (*Abies concolor*), bristlecone pine (*Pinus longaeva*) and limber pine (*Pinus flexilis*) at the upper elevations of this community type. Above timberline (11,000 ft), subalpine tundra-like vegetation can be found and is composed of many species of grasses, sedges, forbs, mosses, lichens, and a few mixed shrubs. Throughout these community types and along the riparian zones that dissect them is a diverse flora of annual and perennial plants, many of which are either endemic to the Spring Mountains or a considered to be covered under the Spring Mountains multiple species habitat and conservation plan (MSHCP). A subset of the covered plant species as well those used as host plants by three covered butterfly species and select plant community types are the focus of the current monitoring plan (Table 1).

Fuel Reduction Thinning Treatments

The thinning treatments are being used to create new and maintain existing fuel breaks on approximately 2,300 acres of throughout the SMNRA to reduce risk of catastrophic fire and allow for safe escape routes. In particular, thinning treatments are being implemented to create fuel breaks along selected access routes, property boundaries, camp grounds, picnic areas, administrate sites, communication sites and other areas based on the following three factors that are known to affect wildfire behavior: 1) vegetation type, 2) landscape topography, and 3) weather patterns.

In general, two treatment types are included in the implementation plan: shaded fuel breaks and brush thinning. Shaded fuel breaks target areas dominated by mixed-conifer forests, ponderosa pine forests, pinyon-juniper woodlands, and mountain mahogany woodlands. In these shaded fuel breaks areas, trees are thinned to reduce the potential of crown fires. Tree thinning distances may vary from 10 to 30 ft or more between tree crowns, depending upon species, size, slope and wind patterns. Lower limbs of trees are also pruned to reduce ladder fuels and keep surface wildfires from transitioning into the crowns. Shrub cover is also reduced in the understory and the resulting density varies depending on shrub height and topographic slope. Brush thinning is intended for all other non-forested areas (i.e., shrub lands). In these areas, shrub coverage density is reduced by various amounts depending on mean shrub height and topographic slope.

A variety of methods to accomplish the proposed vegetative treatments as well as biomass removal methods are used in this project. The specific methods depend upon vegetation types, potential effects on resources, topography, road access, and proximity to features such as residences and powerlines. Thinned material is either cut by hand or machine; ground or crushed on site by machine; cut, chipped and left on site; hand-piled and burned on site; removed from the site by hand, removed by ground-based equipment or aerial systems such as cable systems or helicopters; chipped off site; or cut into firewood and removed by the public. However, crews were instructed not to use mechanical or other heavy equipment within 5 meters of the edges of research sampling plots, not stage chipping stations within plots, not to burn piles within plots, or drag thinned materials through sampling plots.

The project area was divided into 192 units based upon vegetation type, thinning prescription, and treatment methodology. This resulted in a multitude of combinations which makes evaluating specific thinning methods impossible. Accordingly, the monitoring plan described in this report is designed to only compare thinned (pooling all of the approaches used) with unthinned areas. A complete list of these units, prescriptions, and treatment methodologies is provided in Appendix C of this report.

The fuel reduction project has targeted 2,332 acres for mechanical thinning treatments. Implementation of treatments began during 2008 and as of spring 2010 approximately half of the treatments have been implemented. It is currently unknown when thinnings in remaining treatment areas will be completed.

MSHCP Covered Species (Covered Plants and Host Plants for Covered Butterflies)

All monitoring plots for MSHCP covered species are located in Kyle Canyon, Lee Canyon, or Deer Creek. In order to locate areas to monitor we obtained information from previous field surveys, published and unpublished reports, spatial vegetation data layers obtained form the USFS and USFWS, and information obtained from literature searches, flora records and herbarium records. This information, along with additional field surveys conducted by USGS field staff, allowed us to locate populations of covered species.

Because the treatments where restricted to the linear portions of the NRA, primarily along roadsides and the buffer around structures, we first focused our efforts toward locating and establishing plots in these areas (i.e. within the treatment polygon). Once a population of a given species was determined to occur within a treatment area polygon, we randomly located a/an replicate plot(s) within that polygon. Then, using the species account information if available, we systematically surveyed adjacent areas for the occurrence of that respective species to locate and establish a control plot. Effort were made to match biotic (i.e., canopy cover, shrub density, plant community) and abiotic (i.e., exposure and soil) characteristics between treatment and control plots. We restricted the establishment of control plots to within 100 m of the treatment boarder and avoided placing control plots <20 m from the treatment polygon boundary to avoid potential confounding effects in the control area associated with disturbances anticipated to occur in the treatment area.

The plot size was 16 x 8 m for all species except for *Astragalus calycosus*, *Chaetopappa ericoides* and *Erigeron clokeyi* where the plot size was 8 x 4 m. The plot sizes were made smaller for these three species because it was determined that the area typically occupied by local populations of these species was considerably less than other species considered. All plots were subdivided into four equal width belts (A, B, C, and D) and wooden corner stakes of each plot are labeled A to D in a clockwise manner with stake A starting in the north west corner (Photo 1). We used two field tapes to establish the plot perimeter while three tapes divide the plot into the four belts. Tapes were run the length of the plot starting on the shortest side that has stake A. To relocate plots, stake A was marked with a 5 m accuracy GPS unit and the azimuth from stake A to stake B was recorded (see Figure 1 for visual examples of plot layout and orientation). All plots were relocated and re staked as needed in 2009. Wooden stakes were used in the intial plot establishment to minimize hazards that metal stakes would have otherwise posed to thinning crews. However, after all thinnings are completed, each plots should be more permanently marked with steel rebar type stakes.

The biophysical setting was described at each sampling plot. To estimate cover we used a modified densitometer technique (see Strickler 1959) where we took five composite densitometer readings of above ground plant cover at each corner as well as in the center of the plot. Estimates for canopy cover are obtained using the calculations outlined in Strickler (1959). Plant community composition was characterized by recording all plant species present within and around a 10 m buffer outside the plot. Total understory cover was determined by making ocular estimates at the plot scale and a complete species list was created for each plot. Slope was determined using a Silva Ranger compass and aspect was determined using ArcGIS.

For species specific sampling, a single belt (e.g., A, B, C, or D) was randomly selected to be sampled for the focal species. Each time an individual of the focal species was detected the observer recorded its location by noting where along tape it occurs (e.g., belt B, 3.3 m). The observer also collected all metrics for that individual as outlined in Table 3 (and see below). Using belt B, 3.3 m as an example this indicates that a focal individual was found within belt B at 3.3 m from the start location of that tape or zero (Photo 2). This data is used to characterize pretreatment vegetation conditions and to summarize and evaluate plant abundance, cover and density among treatment and control sampling areas.

For all species we recorded various metrics for plant vigor and reproductive maturity (Table 2). These included plant size (i.e., major diameter, perpendicular diameter, and height). The major diameter is measured in centimeters across the longest axis of that individual plant, therefore the perpendicular axis or diameter is recorded for the same focal plant perpendicular relative to the first measurement. These data quantitatively describe above ground plant cover. The height of the tallest portion of that plant (in centimeters) was also noted. The number of stems tallied is simply a count of the number of stems of that individual that originate from the base (above ground) of the individual (this is count data). For plants that were reproductively mature, we collected information on various reproductive features (i.e., number of flowers, flower heads, or inflorescences). Again, all reproductive metrics are counts/individual. Only plants that had at least 50% above ground biomass inside of the belt were considered for sampling.

If the number of plants sampled was less than 100 in the first randomly selected belt in a given plot (i.e. A, B, C or D), then another belt was randomly selected and sampled. This procedure was repeated until at least 100 plants were considered or all four belts were sampled. This information was gathered and is intended for comparison or longer term monitoring in context of the thinning treatments and may potentially be used in part for population viability/demographic type analyses.

MSHCP Covered Ecosystems

Sampling plots for the treatment and control areas were randomly located using ArcGIS within the three targeted ecosystem types using the vegetation community spatial data layer provided by USFS, Pinyon−Juniper Ecosystem, Mixed Conifer Forest Ecosystem, and Sagebrush Ecosystem. There where however several cases were the sampling plot location determined using ArcGIS in conjunction with the vegetation data layer did not correspond to accurately represent the plant community determine upon field visits. For example in many occasions we randomly placed plots to occur in either the sagebrush and/or pinyon-juniper community types that were found to more accurately represent either chaparral (i.e., *Adenostoma fasciculatum*) or *Cercocarpus* spp. dominated community types upon field visits to those locations. In these cases field crews relocated plots into the closest or nearby representation of the specific community type being represented. Control plots were initially constrained to be located within 100 m of a nearby treatment plot but many plots had to be relocated because they fell outside of the target plant community type. As with the cover population plots, an effort was made to match biotic (i.e., canopy cover, shrub density, plant community) and abiotic (i.e., exposure and soil) characteristics between treatment and control plots.

The sampling unit consisted of a 5 x 30 m FMH brush belt transect (USDI National Park Service 2001), overlaid with a 20 x 50 m modified Whittaker plot (mod-whit plot) (Stohlgren et al. 1995). Within these plots we collected information on tree and shrub density and cover, herbaceous (native and non native) density and cover, cover of dead and non living substrate types and species richness (i.e., diversity) as described individually below.

The density of woody perennial plants were recorded in the 5 x 30 m belt transect centered within each mod-whit plot. Each individual having >50% of its rooted base within the belt transect was counted. Data was recorded by species and age class. The age classes for all individuals was identified as either dead, immature-seedling, resprout, or mature-adult. Density of herbaceous plants was collected within five 1 m^2 subplots along one of the two 30 m sides of the brush belt transect as subsamples 5 total subplots. Herbaceous plants were counted by species for each frame, separating live and dead individuals.

Cover of woody perennial and herbaceous plants, non-vascular plants, litter, and soil was measured using the point-intercept method, using one of the 30 m sides of the brush belt transect. Starting at the end of each transect and repeated every 30 cm, a 0.25 inch diameter sampling rod (a rigid plumb bob), graduated in decimeters, was lowered so that the sampling rod is plumb to the ground. Since the transect length is 30 m, there were 100 points from 30 to 3,000 cm. The height at which each species touches the sampling rod was recorded, tallest to shortest. If the rod failed to intercept any vegetation, the substrate was recorded (bare soil, rock, forest litter, etc.).

Plant diversity was calculated at multiples scales within the 20 x 50 m mod-whit plot. The effects of disturbance on plant diversity can vary among spatial scales. We used spatially nested modified-Whittaker plots in this study. Plant species richness was measured for all species recorded at 1, 10, 100, and 1,000 m^2 scales. As part of this project we collected and report baseline vegetation characteristics for the three following ecosystems (plant communities), these are the Sagebrush, Pinyon-Juniper, and the Mixed Coniferous Forest. The total number of plots sampled for each ecosystem is shown in Table 1.

The sampling plots have been marked with wood grate stake monuments, and georeferenced using GPS equipment. As suggested above for the covered species plots, the sampling plots should be relocated and staked with more permanent rebar or similar metal marking stakes at the conclusion of the thinning operation.

Data Syntheses and Analyses

Because this data set only consists of pre-treatment data, we did not conduct statistical analyses to assess effects the thinning treatments may have had on either any of the covered plant populations, host plants for the covered butterflies, or the listed ecosystems (plant communities). We do however, as outlined in goal 3 (see above), describe baseline vegetation conditions as they relate specifically to the hypotheses of this project (see above). Therefore we rely on hypotheses 1 and 2 (i.e., 1. increase density and cover of Charleston grounddaisy, King's sandwort, Clokey eggvetch, Clokey milkvetch, and rough Angelica; and 2. change the abundance and diversity of butterfly larval host and nectar plants) to describe baseline conditions for covered plant species (populations) and/or host plants associated for the covered butterfly species and hypotheses 3-6 (i.e., 3. decrease stem density and cover of trees and shrubs; 4. increase density, cover, and diversity of non-native invasive plants; 5. increase density, cover, and diversity of native annual plants and 6. increase stem density, cover, and diversity of native perennial grasses) to report baseline vegetation conditions for the listed ecosystems (plant communities) and hypotheses.

MSHCP Covered Species

For each of the 5 MSHCP covered plant species, and for the 13 host plant species for each of the 3 MSHCP covered butterfly species we preformed and include graphical illustrations for prospective power analyses using SAS (SAS Institute, Inc., 2008). Because the data suggest a lot of between-plot heterogeneity, yet we are assuming there is not a lot of within-plot variability over time (because these species are mainly perennials), the most effective data analysis is a paired two-sample test. Each "pair" consists of a before and an after count. We already have the data for the "before" sample. Therefore to estimate the after data for a particular hypothetical treatment effect, we simulated 1000 random datasets of "after" samples. Then, for each before-after pair, which then we were able to calculate a percent difference, and then applied a standard t-test to evaluate whether treated plots have a different percent difference compared to control plots. We repeated this for a range of treatment effect sizes from -50% to 50%.

For these simulations, we assumed 5% and 10% standard deviation (SD) on the repeated measurement within plots. For example, a control plot with 200 plants might later be counted as 200 plants +/- a SD of 10 or 20 next time it's sampled. Recall that the rule of thumb that approximately 68% of random observations are within 1 SD of the mean, and 95% of random observations are within 2 SD. So, a SD of 5 or 10 implies that approx. 2/3 of the simulated "after" counts were within 5% or 10% of the original value, and approximately. 95% were within 10% or 20% of the original value. As another example, a treatment plot with 200 plants might be subjected to a hypothetical -50% treatment effect and later have 100 plants +/- a SD of 5 or 10. We used a normal distribution for all simulations, and no negative counts were generated.

In addition we report baseline vegetation conditions per hypotheses 3 and 4 (see above) and have summarized plant abundance, density and cover for each of the 18 species considered herein across the control and treatment plots. Plant abundance (count) is the mean number of plants recorded per plot across all sampled plots for any respective species. Whereas plant density is simply plant abundance scaled to the unit area sampled and reported per square meter. Plant cover was determined by using the length (cm) of the major diameter of each plant and the perpendicular diameter (cm) for the plant and calculating individual plant coverage in square centimeters using the area formula for an ellipse A=Pi*a*b/4. Where *a* is the major diameter and *b* is the perpendicular diameter. We then calculated the mean plant cover/plot (m^2) and averaged that across all sampled plots for each of the 18 sampled populations. All summarizations for this data set were conducted in JMP 8 (JMP 8.0, SAS Institute, Inc., 2008).

While hypothesis 2 also considers diversity in the context of plant populations, we advise the Clark County DCP that diversity is not a metric associated with populations but rather communities (multiple populations co existing in a common area). Consequently we did not address species diversity in context of this hypothesis for the MSHCP covered butterfly host plants. In the recommendation section below we do outline more appropriate analyses for understanding how these vegetation thinning activities might affect the host plants in subsequent post treatment years of the MSHCP covered butterflies (e.g., survival analyses, demographic analyses).

MSHCP Covered Ecosystems

The listed ecosystems of specific interest are the Pinyon–Juniper, Mixed Conifer Forest, and Sagebrush communities that occur in or near the fuels thinning treatment area throughout the

SMNRA. As noted above, pretreatment information was obtained from multiple plots in each ecosystem type using modified Whittaker plots. For this data set we summarized the data consistent with each of the hypotheses among the treatment and control plots of this project to report baseline conditions of the vegetation. Because our data set is comprised of count data, the data in most cases did demonstrate normal distributions and therefore would not meet assumptions associated with traditional statistical tests. As such we transformed the response data using a square root (i.e., SQRT in excel) transformation – which resulted in a normal data set with equal variances.

Tree and shrub density using transformed count data and cover as percent of total cover type detected are summarized individually by species for each of the listed ecosystems. Plant densities are summarized for plants/150 m^2 whereas plant cover is based on percent of total cover per species or guild as consider for each listed ecosystem type. Density of non native invasive species, native annual species and native perennial species was determined by calculating the mean number of individuals per m^2 that were recorded in the herbaceous sampling plots (see above). Native perennial cover and density only includes forbs and grasses. For plant density we provide a comparison using one-way ANOVA for either tree or shrub density per vegetation type and by species within vegetation type per treatment and control. Error bars were created using 95% confidence intervals.

We also report species richness and diversity specific to the hypotheses. To understand patterns of species diversity we constructed Rényi curves (Rényi 1961) to help interpret patterns of species diversity among the guilds and habitat types identified as priority as part of this project (Seaby & Henderson, 2006). This method of diversity ordering allows for the interpretation of diversity patterns across a range of indices by plotting the index values against the scale parameter to consider, in this case, current or baseline information related to species diversity prior to the fuels thinning conditions. The figures presented can be interpreted by considering that larger Rényi index values (y-axis) suggest greater levels of species diversity at a given point along the scale parameter (x-axis). The scale parameter represents a range of diversity metrics that differ in their sensitively to abundant species; lower scale parameter (0, 1) values give less weight to abundant species than do larger scale parameter values (3, 4). The diversity calculations were done in Species Diversity & Richness 4.1.2 (Pisces Conservation Ltd., Seaby & Henderson, 2006). For interpretation consider whether the curve is consistently greater (higher on the y-axis) across all points along the x-axis in which cases diversity can be considered to be greater for that group/condition. However if ever the lines cross along the x-axis then no meaningful interpretation can be made as related to greater or lower species diversity for the group/condition in question. Species diversity was considered for native annual and native perennial species for each of the three listed ecosystems per treatment and control plots where applicable. We did not summarize species diversity beyond counts by species for non native invasive species because only 4 unique species were detected in a subset of plot as part of our sampling.

RESULTS

Objectives Completed

The following provides information specific to the goals of this project indicating that the objectives were completed to the best possible degree.

While we present information for each of the populations/ecosystems simultaneously per each hypotheses considered, we caution the reader that this is not intended as a final comparison among or across populations/ecosystem types but rather a concise mode of presenting baseline conditions of the taxa or community types considered in this project. As such these are not statistical comparisons but merely summarizations to capture current or pre-treatment conditions solely. Additional summarizations and analyses should be done relative to each population/ecosystem or guild within each respective group once post treatment information is available.

Even through we were able to install and sample over 100 more plots than our Interlocal Agreement (2005-USGS-551-P) with Clark County indicated, these data, especially for the covered plant population and butterfly resource plants, may not be adequate to fully address and discern the effects associated with the thinning operations. This project was faced with several hurdles which limited our ability to more comprehensively sample in context of thinning operations on witin the SMNRA. We outline the limitations to these results here. For example, because of constraints associated with the participating federal agencies and the timeline for the thinning activities established by USFS crews we were limited to only a single field season to conduct all pre surveying activities and field work. This meant we had 5-6 months to acquire all the necessary information (maps, records, reports) to prepare for and to conduct all of our field efforts. We worked very closely (daily/weekly communication) with thinning operation crews to coordinate our activities so that we would not impede their progress. This meant that they largely directed our activities to locations (treatment units) that were soonest to be treated, regardless of the species or community phenology or ecology. In short we were advised by thinning crew leads as to where they wanted us to work and in what order to work in. While this is likely not a problem for the perennial species it is possible that we under or misrepresented the annual species due to sampling in mid summer rather than earlier in the season.

We were also limited in the spatial availability of areas to survey/sample. We were advised by USFS and USFWS staff to focus our efforts to Lee and Kyle canyons and Deer and Cold creeks areas. In addition, because we were charged with monitoring plant response in the context of a fuels thinning operations in a WUI, we were restricted to sample within the linear reaches of the thinning operation (c. 100 m) and immediately adjacent to those areas (c. 50-100 m) – and were not charged with sampling the entire NRA. As such we could only locate and sample the populations of the covered species if they occurred within these areas. In this light it is important to keep in mind that we were considering covered, listed and/or species of concern whose natural distributions are limited, and are naturally uncommon within the areas we were considering. In addition, the available records for the covered plant populations and/or covered ecosystems where either not available, extremely limited or in some cases wholly inaccurate.

We feel it important to make clear these limitations so that future efforts to extend the utility of this work take into account this project's history. The data set that now exists is to our knowledge the most expansive for the species and communities in question and with additional resources could be extended to areas within the NRA beyond that considered by this project.

MSHCP Covered Species

Baseline Vegetation Conditions

We established 169 sampling plots for the five MSHCP listed plant species and select host plants for the three covered butterfly species considered (see Table 1). This effort resulted in plant abundance (counts), density and cover as well as various metric of vegetative and reproductive condition or vigor for over 20,000 individual plants. Table 2 summarizes the metrics recorded as part of the pre-treatment sampling effort. Table 3 reports individual plant abundance, density and cover for all plant species considered.

Power Analyses

The power curves were generated using the log of mean plant density data. This was done based on the assumption that a log or similar transformation will be used to analyze the count data once post treatment data has been collected (Figure 2). Because these data indicate a good deal of among-plot heterogeneity, but we are assuming there will not be a lot of within-plot variability in time, we used a paired two-sample test. Each "pair" consists of a before and an after count. The "before" sample data has been collected and is presented herein, so, for a particular hypothetical treatment effect, we was simulated 1000 random datasets of "after" samples. For each before-after pair, we calculated a percent difference, and then applied a simple t-test to test whether treated plots have a different percent difference compared to control plots. Then we repeated for a range of treatment effect sizes from -40% to 40%. As stated we assumed a 5% and 10% standard deviation (SD) on the repeated measurement within plots. For example, a control plot with 200 plants might later be counted as 200 plants +/- a SD of 10 or 20 the next time it's sampled (hypothetically post treatment). Note that the rule of thumb us that approximately 68% of random observations are within 1 SD of the mean, and 95% of random observations are within 2 SD. So, a SD of 5 or 10 implies that approx. 2/3 of the simulated "after" counts were within 5% or 10% of the original value, and approx. 95% were within 10% or 20% of the original value. As another example, a treatment plot with 200 plants might be subjected to a hypothetical -50% treatment effect and later have 100 plants +/- a SD of 5 or 10. For these, we used a normal distribution for all simulations.

MSHCP Covered Ecosystems

We installed 54 plots among the three MSHCP listed ecosystems (plant community) which included 20 plots in the pinyon-juniper, 18 plots in the mixed conifer and 16 plots in the sagebrush ecosystems. We were able to positively identify 171 unique species of which 164 were native and 7 were exotic (4% of the total). Additional analyses once post treatment data is available are suggested in the recommendations section below. The following description of baseline vegetation conditions is organized according the hypotheses of this project.

Shrub and Tree Density and Cover

As noted, we collected information related to shrub and tree density in the 5 x 30 m brush belt section of the modified Whittaker sampling plot. Shrub densities for each listed ecosystem are presented in Table 4. Shrub and tree cover is presented as total present of all cover types per point intercept sampling as part of the community sampling scheme. Five species of trees and 22 species of shrubs were recorded in the Pinyon-Juniper plots; density of shrubs and trees by species are summarized in Figure 3 (trees) and Figure 4 (shrubs). Six species of trees and 8 species of shrubs were recorded in the mixed conifer plots; density of shrubs and trees by species are summarized in Figure 5 (trees) and Figure 6 (shrubs) for the mixed conifer sampling plots. For the in the sagebrush community, 7 species of trees and 25 species of shrubs were recorded density plots. Density of shrubs and trees in the sagebrush plot are presented by species are summarized in Figure 7 (trees) and Figure 8 (shrubs). One-way ANOVA comparisons among the treatment and control plots within each respective community type indicate that prior to treatment activities the only difference detected was among tree density in the sagebrush ecosystems type the treatment plots had more trees than the control plots ($F=5.02, _{1,42}$; $P=0.030$). All other non significant results for comparisons are given in figures 3 and 4 for the pinyon-juniper plots, figures 5 and 6 for the mixed conifer ecosystem plots and 7 and 8 for the sagebrush ecosystem type.

Invasive Species Cover, Density, and Diversity

Only four non native invasive species were detected in the community plots as part of either the cover or herbaceous density sampling. These include *Bromus tectorum*, *B. madritensis*, and *Erodium cicutarium* which were found in the sagebrush and *Bromus tectorum* and *B. madritensis* were found in the Pinyon-Juniper plots and a single occurrence of *B. inermis* was recorded in a mixed conifer plot. *B. tectorum* was found in 4 sagebrush plots and 2 pinyon-juniper plots; *B. madritensis* was in 4 sagebrush plots; *E. cicutarium* was found in 2 sagebrush plots and *B. inermis* was found in a single mixed conifer plot. The densities of these species are summarized in Table 5. We note however that three additional species were recorded as being present in vicinity of some community plots, these include *Salsola tragus* (Prickly Russian thistle), *Sisymbrium altissimum* (Tall tumblemustard) and *Tragopogon dubius* (Yellow Salsify). The species were recorded as part of the completed final data but were not considered in summarizations of plant density or cover since they were not detected in either the point intercept cover or herbaceous species density sampling. Table 5 summarizes the non native species density and cover for each listed ecosystem.

Native Annual Species Cover, Density, and Diversity

Total native annual species richness (total number of species), density and cover were relatively low for each of the three listed ecosystems (Table 6). Density for annual forbs and grasses is presented as mean plant density by guild based on occurrences in the plots individuals of each respective guild was detected. Note that annual forbs and grasses were not detected in either the herbaceous sampling plots or by the point intercept (cover) sampling in the mixed conifer plots.

As illustrated in Figure 9, native annual species diversity is relatively similar among both the sagebrush and pinyon-juniper ecosystem types. Greater Rényi index values suggest greater diversity for a given population at any given scale parameter. The scale parameters are differing diversity indices with 0 representing species number, 1 representing Shannon's H, 2 representing Simpson's D, and so on. With increasing scale parameter values, more abundant species/functional groups are progressively weighted more heavily. Diversity can only be understood to be greater if a line for a specific treatment/plant community remains above (higher) than another, for example the sagebrush control plots (black line) are above the sagebrush treatment plots (red dashed line), which indicates species diversity is greater in the sagebrush control plots. The same can be said about the pinyon juniper control plots, which had notably greater native annual species diversity than the treatment plots in this listed ecosystem. We note that native annuals were not detected in the herbaceous density plots in the mixed coniferous ecosystem type and therefore were not included in this analysis.

Native Perennial Species Cover, Density, and Diversity

Native perennial shrub and tree species cover and density recorded in the 5 x 30 m (150 m^2) brush belt within the larger modified Whitaker plots are presented in above in subsection '*i*'. Here we limit our treatment of native perennial species cover and density data that was collected based on point intercept and herbaceous density sampling plots for perennial forbs and grasses. Species density and cover is summarized for each of the three listed ecosystems (Table 7). Perennial forb density was 12.1 plants/m^2 in the treatment plots and nearly half that at 6.2/m^2 in the control plots. Plant density was very similar among forbs in the mixed conifer plots, however forb density was greater in the control plots at 6.4 plants/m^2 in the sagebrush ecosystem and only 3.1 plants/m^2 in the treatment plots for that ecosystem type. Interestingly, perennial grasses seemed were found to be uncommon in the any of the community types however they were greatest in the mixed conifer control plots where they were found to be 8.0 plants/m^2 (see Table 7).

Species richness for all perennial native species recorded from sampling plots (Table 8). For a complete species list see Appendix A. The patterns for species diversity (Figure 10) suggest that the mixed conifer treatment plots are only very slightly greater than the control plots, but these differences are likely not biological meaningful. The treatment plots in the sagebrush plots are consistently lower than the control plots. And the treatment plots in the pinyon juniper plots are only slightly lower than the control plots (Figure 10).

Evidence Objectives/Needs were Met/Fulfilled

As specifically outlined in Exhibit A (Scope of Work), on page 6 of the Interlocal Agreement 2005-USGS-551-P between Clark County, NV., Department of Air Quality and Environmental management and the US Geological Survey; the agency (USGS) shall collect biophysical data within a minimum of 50 monitoring plots including providing detailed sampling and analyses methods and detailed data collection and management. As evidence that the objectives were met and fulfilled we (USGS) herein report on baseline vegetation conditions for 54 plant community plots for each of the three listed ecosystems combined and 169 plots for the MSHCP listed covered plant species and select host plant of the MSHCP three covered butterfly species considered. The data both tabular and spatial as summarized here has been provided to Clark County.

Moreover, the design/development and implementation of our sampling scheme as reported herin, provides methodologically sound baseline conditions of the vegetation within (treatment plots) or near (control plots) the fuels thinning polygons. Further these plots, all of which were permanently marked both on the ground and geo-referenced, supply the U.S. Forest Service with the template for an ecologically sound, interpretable, and easily repeatable monitoring design that can be maintained and sampled in years and decades to come so as to better understand the effects these fuels reduction treatments may have on covered and listed populations and ecosystems.

Maps

Locations of all sampling areas and plots are summarized below in Table 9, however to preserve space we have placed all referenced maps in Appendix B.

Evaluation/Discussion of Results

MSHCP Covered Species

A baseline data set now exists for the 18 population considered as part of this project, which was the maximum possible, given the existing information available and the new surveys that we were able to complete prior to thinning treatments commencing. Not only does this provide a good starting point of basic data for potentially understanding the effects of the fuels treatments on specific plant taxa of which is completely unknown, this also provides the template for a straightforward, interpretable, and repeatable monitoring systems for these species. For this monitoring and surveying system to more useful and statistically robust efforts should be made by interested stakeholders (USFS) to locate additional population locations of the covered species beyond which was considered as part of this project.

It remains to be seen how these species might respond in the short or long-term to these fuels reduction treatments. Because generally we lack an understanding of the specific habitat requirements for the species in question, we omit any such speculation. Recommendations for this element of the project are provided below.

MSHCP Covered Ecosystems

A paucity of information exists as to the effects both direct and indirect fuels thinning actions might have on plant populations and communities both in terms of species responses, composition or community physiognomy. In general, thinning is designed to reduce fire risk by directly removing fuel materials out of the landscape by mimicking post wildlife patterns. However little is understood how thinning operations might compare to vegetation conditions where natural processes and feedbacks are intact. Moreover, available reports make specific interpretations difficult as to how thinning compares to prescribed fires in terms of reducing future fire risk, largely because translation of information derived from one community type to another is difficult and prescribe fires in general produce highly variable outcomes (Agee and Lolley 2006) unlike what generally results from systematic thinning actions. Because we are limited to pretreatment data that was further constrained geographically (along roadsides) we limit our outline to baseline conditions found in the SMNRA and discuss how these patterns may have developed in context of available literature and speculate resultant post thinning patterns as they are relevant to the guiding hypotheses of this project.

We found shrub density to be greatest in the mixed conifer plots and lowest in the sagebrush plots, although the opposite pattern was demonstrated with shrub cover where the sagebrush plots had over 20% cover by native shrub species (although sagebrush was often a co-dominant). The species with the greatest shrub cover in the pinyon-juniper plots was *Coleogyne ramosissima* followed by *Gutierrezia microcephala*, the latter of which had the greatest shrub density in the sagebrush plots as well. The sagebrush plots demonstrated a fair degree of variation in *Artemisia* spp. density and cover, although the sagebrush plots also had the highest shrub species richness with 25, which was more than twice the shrub species richness of the mixed conifer plots. Tree density was lowest in the sagebrush plots but greatest in the pinyon-juniper plots, however tree cover was highest in the mixed conifer plots. Although species identity varied among the three ecosystems, tree species richness was similar. How these vegetation patterns might compare to those found in an unaltered state is uncertain, however, considering current conditions in a larger or regional context is none the less interesting. Note that tree density was significantly greater in the desert sagebrush community yet no differences were detected among the species specific comparisons. This is result is a function of the inclusion of 5 species (ABICON, CERLED, JUNOST, JUNSCO and QUEGAM) for comparisons highlighted in figure 7A (all individuals/species combined) where as only two species (AMEUTA and PINMON) were recorded at a minimum number of plots among the treatment types to be included in the analyses at the species level of inference.

Throughout the arid west researchers have noted a general reduction of arid shrublands (e.g., *Artemisia*) and the expansions of arid woodlands (e.g., *Juniperus*). The underlying mechanisms driving these patterns are likely very complex and variable in time and space. However, one important dynamic in this context is fire; both the shift of fire regimes and/or suppression (Weisberg et al 2007). Invasion of western juniper into big perennial bunchgrass/sagebrush dominated vegetation in southwest Idaho appears to be directly related to cessation of periodic fires (Burkhardt and Tisdale 1976). It has been suggested, based on evidence from adjacent climax juniper stands, that fires were frequent for at least several hundred years preceding European settlement (Burkhardt and Tisdale 1976, Schaffer et al. 2003). During the past century fires have been much less frequent due to active control, roads development and other fire barriers, as well as reduced fuel because of grazing pressure and a shift towards decreased precipitation (Knapp 1998). The resultant patterns are expansion of pinyon-juniper woodlands to lower elevation slopes into sagebrush or other shrubland types. Shrublands are not only threatened by increased woody species dominance; due to long-term grazing pressure the loss of perennial native grasses and forbs has lead to general reduction of species diversity and an increase in shrub cover.

One of the big concerns with any vegetation management action like fuels thinning is the likelihood that post treatment conditions may be more easily colonized by nonnative invasive species (Brooks et al. 2004). Understanding the dynamic between fuels thinning treatments and nonnative species is becoming more pressing with the increase in large fuels reduction programs throughout the United States. This pattern of native to nonnative dominance is often associated with other types of disturbances such as intensive grazing, fire and/or shifts in natural fire regimes coupled with poor management that in extreme cases has resulted in total plant community conversion (Brooks and Pyke 2001, Valone et al. 2002). One of the primary hypotheses of this project was that nonnative invasive species will increase in density, cover and diversity post thinning. We, however, only detected 7 species throughout all the listed ecosystems and at much lower densities than have been reported in other regional wildland settings (Brooks 2009) where species cover of *Bromus* spp. and *Erodium* spp. were between 60-90%. One study found that nonnative plant abundance was over 200% higher on fuel breaks than in adjacent wildland areas and nonnative cover was greatest with fuel breaks associated with bull dozers as compared to other methods (Merriam et al. 2006). While conditions associated with disturbances have been known to promote increased dominance by nonnative invasive species, it is uncertain what implications these studies have for the treated areas in the SMNRA.

Native perennial species abundance and diversity was considered as part of this project. We recorded the greatest species richness as well as diversity in the sagebrush ecosystem. It will be interesting to learn how richness and more formal diversity metrics might respond to the fuels thinning treatments, especially where fuel rich forms, like trees and dense shrubs, are likely to be removed disproportionally to other less woody and other herbaceous species. Species rich communities have also been cited has having increased resistance to nonnative species invasions (Kennedy et al. 2002). Certainly the dynamic between sustained native diversity and the increased potential for invasive species post treatment, as has been shown in other thinning projects (Merriam et al. 2006), should be systematically evaluated in the NRA.

Conclusions

Efforts to minimize the potential for large catastrophic fires include the use of prescribed fire and/or, more recently the implementation of mechanical fuels thinning techniques. The latter of these techniques, so called fire surrogate actions, has been given recent widespread attention (Schwilk et al. 2009, McIver and Weatherspoon 2010) largely due to the U.S National Fire and Fire Surrogate (FFS) study. The FSS is a multi-site, multidisciplinary research project that evaluates the ecological consequences of prescribed fire and associated mechanical surrogates intended to reduce fire risk and restore resilience in seasonally dry forests (McIver et al. 2009). The FSS was developed with the primary goal to measure and compare the effectiveness and ecological consequences of commonly used fuel reduction treatments.

In general, reports indicate these fire surrogates or mechanical thinning operations can be effective short-term methods for removing plant biomass (Harrod et al. 2009), however, the effects vary among prescribed fire and mechanical thinning. In a study comparing fire and fire surrogate operations, it was found that mechanical treatments were more effective at reducing over story tree density and basal area and at increasing the quadratic mean tree diameter whereas prescribed fire were more effective at creating snags, killing seedlings, increasing height to live crown and reducing surface woody fuels (Schwilk et al. 2009). Schwilk et al. (2009) suggest that if the management objectives are to produce stands with fewer, larger diameter trees, reduce surface fuel mass, and increase herbaceous richness combining prescribed fire with mechanical thinning may be a viable management option, although such may increase nonnative species abundances. At the same time, we poorly understand the longer term effects on plant population or community dynamics let along on other features of the ecosystem such as native wildlife species or the soil erosion potential.

Recommendations

To specifically address the hypotheses outlined in the study and to meet the overall goals of this project (see above) the following set of considerations and data analyses are suggested.

Field Data Collection

We strongly encourage the USFS to relocate and more permanently mark the boundaries of all field sampling plots. Maps and UTM location included here can direct that effort. If resources become available we suggest the USFS also install additional control plots within the design established here. Increasing the number of control plots would help account for the background heterogeneity and help focus efforts toward understanding the effects of these treatments on focal taxa/communities.

Post-treatment data should be collected between 2 and 3 times in the future to understand what effect these thinning treatments have on various population and/or community level metrics of interest. However, because a paucity of information exists relative to how thinning or mechanical fuels reduction activities affect plant population and community dynamics, it would be prudent to collect post treatment data at multiple times in the future, for example at 1, 3 and 5+ years post treatment. Because the treatments will have taken place over several years and may be extremely different among the treatment polygons, care needs to be taken to address confounding effects potentially associated with inter-annual variation in the plant response metrics.

Analyses for the Covered Plant Populations

To help focus this discussion and future analyses and interpretations, we provide a useful analyses and considerations with the addition of post treatment data specific to metrics and features of the hypotheses outlined above.

The covered plant populations and covered butterfly resource plants can be evaluated in a number of complimentary ways. First, in context of the fuels thinning treatments, we suggest that once post thinning data are available comparing using one-way Analyses of Variance (ANOVA) or Repeated Measures analyses where the response variables are either plant cover or density and the predictor variable is treatment type. The one-way ANOVA would be useful to simply understand what effect the thinning treatment had on plant density and cover at a single point in the future, whereas the Repeated Measures test would allow for an interpretation for changes in cover and density where repeated temporal survey data are available. It might also be useful to consider using a Generalized Linear Model (GLM) type models. GLM's have increased power with data sets where modeling count data is needed, as in this case, where normal distributions are not expected. However because the data provided and those anticipated to be collected are count data, we suggest using a common data transformation to meet the assumptions (normality, equal variances), including the square root and/or log transformation.

At the same time, there may be great utility in establishing a population viability or demographic study with the covered plant population plot data. We suggest considering to develop a cohort life table for each or select species. By monitoring individual in time one can calculate the age specific mortality rate (q_x) and the survivorship (l_x) if recruited indviduals are marked and tracked in time between sampling intervals and years. With that information one can plot the log of the number of survivors at each age interval against time to develop survivorship curves for each species and treatment combination. Survivorship curves allow the investigator to determine whether species follow Type I (low juvenile mortality rates), II or III (high juvenile mortality rates) survivorship curves which indicate periods within the species establishment where specific management measures may be taken to potentially increase success. Additional analyses may include Repeated Measures Analysis of Variance (ANOVA) and/or Standard Least Squares (LS means) where response variables such as plant survival, size, q_x, $l_{x,}$ and may be considered according to treatment effects. This information may be useful in understanding whether treatment types may be a viable restoration technique and offer more specific insight to the population biology of these species.

Analyses for the Listed Ecosystems

The guiding hypotheses for the listed ecosystems included presupposed changes associated with density and cover associated with various plant guild (i.e., shrubs, trees, non natives, etc.) and plant species diversity among and across life stages and the treatment types.

Changes in density cover or abundance of specific focal groups (e.g., MSHCP covered species) or guilds (e.g., perennial species, shrubs or trees) can be assessed by comparing appropriate metrics by using paired t-tests, LS Means, Repeated Measures ANOVA or maybe most appropriate given this data set GLM techniques. Here the response variable would be density or cover count data and treatment type would be the predatory variable. If data is collected systematically over more than a single year, Repeated Measure techniques are appropriate. We suggest that these analyses be performed with 0.05 for significance (Seaby & Henderson 2006).

Because species diversity is a feature of interest for four of the six hypotheses, we suggest determining several variations of species diversity and evenness and applying randomization tests to compare species diversity and evenness between treatment and/or vegetation types (Solow, 1993). Rényi curves (Rényi 1961) or similar diversity ordering techniques (e.g., Hill's series) can help interpret patterns of species diversity among the guilds and habitat types identified as priority as part of this project (Seaby & Henderson, 2006). This method of diversity ordering allows for the interpretation of diversity patterns across a range of indices by plotting the index values against the scale parameter. The output can be interpreted by considering that larger Rényi index values (y-axis) suggest greater levels of species diversity at a given point along the scale parameter (x-axis). The scale parameter represents a range of diversity metrics that differ in their sensitively to abundant species; lower scale parameter (0, 1) values give less weight to abundant species than do larger scale parameter values (3, 4). To further aid interpretation consider that if the curve is consistently greater (higher on the y-axis) across all points along the x-axis in which cases diversity can be considered to be greater for that group/condition. However if ever the lines cross along the x-axis then no meaningful interpretation can be made as related to greater or lower species diversity for the group/condition in question. At the same time, with information on the number of species and number of individuals/species (as would be needed for the above set of analyses) pair-wise comparisons of select diversity and evenness models can be used and randomization comparisons (similar to t-tests) can be done to compare diversity among the groupings of interest (treatment vs. control). We suggest using several common diversity indices including Shannon Wiener, Simpsons or Brillouins (Seaby & Henderson, 2006). There are several useful statistical community software packages that can be used for these types of tests and include those developed by Pisces Conservation Ltd. and Primer E packages.

Additional Considerations

Any subsequent post treatment sampling and evaluation should, where appropriate, consider results in context of other fire surrogate projects. Considering post thinning conditions beyond simply weighing resultant changes to potential shifts in fire risk but noting how patterns relate to important ecological processes in the long-term (10+ years). These processes may influence elements such as plant community succession (patterns especially nonnative species), plant-soil feedbacks or wildlife effects should be considered in the context of this project.

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Appendices

Appendix A. Species list for all species encountered in the plant community/ecosystem sampling.

Local Code	NRCS* Code	Scientific Name	Common Name	Habit	Annual/ Perennial
ABICON	ABCO	*Abies concolor*	White fir	Tree	Perennial
ACHHYM	ACHY	*Achnatherum hymenoides*	Indian ricegrass	Grass	Perennial
ACHOCC	ACOC3	*Achnatherum occidentale*	Western needlegrass	Grass	Perennial
ACHSPE	ACSP12	*Achnatherum speciosum*	Desert needlegrass	Grass	Perennial
AGRDES	AGDE2	*Agropyron desertorum*	Desert wheatgrass	Grass	Perennial
AMEUTA	AMUTU	*Amelanchier utahensis*	Utah serviceberry	Tree	Perennial
ANTROS	ANRO2	*Antennaria rosea*	Rosy pussytoes	Forb	Perennial
ARAFEN	ARFE	*Arabis fendleri*	Fendler's rockcress	Forb	Perennial
ARAPEN	ARPE	*Arabis pendulina*	Rabbit ear rockcress	Forb	Perennial
ARAPER	ARPE2	*Arabis perennans*	Perennial rockcress	Forb	Perennial
ARCDIV	ARDI3	*Arceuthobium divaricatum*	Pinyon dwarf mistletoe	Forb	Perennial
ARCPUN	ARMA	*Arctostaphylos pungens*	Whiteleaf manzanita	Shrub	Perennial
AREKIN	ARKI	*Arenaria kingii*	King's Sandwort	Forb	Perennial
AREMAC	ARMA3	*Arenaria macredenia*	Mojave sandwort	Forb	Perennial
ARIPUR	ARPU9	*Aristida purpurea*	Purple threeawn	Grass	Annual
ARTCAN	ARCA13	*Artemisia cana*	Silver sagebrush	Shrub	Perennial
ARTLUD	ARLU	*Artemisia ludoviciana*	White sagebrush	Forb	Perennial
ARTTRI	ARTR2	*Artemesia tridentada*	Giant Sagebrush	Shrub	Perennial
ASTCAL	ASCA9	*Astragalus calycosus*	Torrey's milkvetch	Forb	Perennial
ASTLEN	ASLE8	*Astragalus lentiginosus*	Freckled milkvetch	Forb	Perennial
ASTLENFRE	ASLEF2	*Astragalus lentiginosus* var. *fremontii*	Fremont's milkvetch	Forb	Annual
ASTMIN	ASMIV	*Astragalus minthorniae*	Minthorn's milkvetch	Forb	Perennial
ASTNEW	ASNE6	*Astragalus newberryi*	Newberry's milkvetch	Forb	Perennial
ASTNUT	ASNU4	*Astragalus nutallianus*	Smallflowered milkvetch	Forb	Annual
AST SPP	Astspp.	*Astragalus species*	milkvetch	Forb	Perennial
ATRCAN	ATCA2	*Atriplex canescens*	Four winged salt bush	Shrub	Perennial
BERFRE	MAFR3	*Mahonia fremontii*	Fremont's mahonia	Shrub	Perennial
BERREP	MARE11	*Mahonia repens*	Creeping barberry	Shrub	Perennial
BOUGRA	BOGR2	*Bouteloua gracilis*	Blue grama	Grass	Perennial
BROANA	BRAN	*Bromus anomalus*	Nodding brome	Grass	Perennial
BROINE	BRIN2	*Bromus inermis*	Smooth brome	Grass	Perennial
BROMAD	BRMA3	*Bromus madritensis*	Compact brome	Grass	Annual
BROTEC	BRTE	*Bromus tectorum*	Cheatgrass	Forb	Annual
BURFRE	MAFR3	*Mahonia fremontii*	Fremont's mahonia	Shrub	Perennial
CALBRU	CABR4	*Calochortus bruneaunis*	Bruneau mariposa lily	Forb	Perennial
CALFLE	CAFL	*Calochortus flexuosus*	Winding mariposa lily	Forb	Perennial
CALSPP	CALOC	*Calochortus species*	Mariposa lily	Forb	Perennial
CASANG	CAAN7	*Castilleja angustifolia*	Northwestern Indian paintbrush	Forb	Perennial
CASLIN	CALI4	*Castilleja linariifolia*	Wyoming indian paintbrush	Forb	Perennial
CEAGRE	CEGR	*Ceanothus greggii*	Desert ceanothus	Shrub	Perennial
CENGRE	CEGR	*Ceanothus greggii*	Desert ceanothus	Shrub	Perennial

CERLED	CELE3	*Cercocarpus ledifolius*	Curl-leaf mountain mahogany	Tree	Perennial
CHAALB	CHAL11	*Chamaesyce albomarginata*	Whitemargin sandmat	Forb	Perennial
CHAERI	CHER2	*Chaetopappa ericoides*	Rose heath	Forb	Perennial
CHAFEN	CHFE3	*Chamaesyce fendleri*	Fendler's sandmat	Forb	Perennial
CHASET	CHSE8	*Chamaesyce setiloba*	Yuma sandmat	Forb	Annual
CHASTE	CHST	*Chaenactis stevioides*	Esteve's pincushion	Forb	Annual
CHEALB	CHAL7	*Chenopodium album*	Lambsquarters	Forb	Annual
CHRNAU	ERNAJ	*Ericameria nauseosa*	Rubber rabbitbrush	Shrub	Perennial
CHRVIS	CHVI8	*Chrysothamnus viscidiflorus*	Yellow rabbitbrush	Shrub	Perennial
CIRCLO	CICL2	*Cirsium clokeyi*	Clokey's thistle	Forb	Perennial
COLRAM	CORA	*Coleogyne ramosissima*	Blackbrush	Shrub	Perennial
COMUMB	COUM	*Comandra umbellata*	Bastard toad flax	Forb	Perennial
CORPAR	COPA9	*Cordylanthus parviflorus*	Purple bird's beak	Forb	Annual
CREINT	CRIN4	*Crepis intermedia*	Limestone hawk's beard	Forb	Perennial
CRY SPP	CRYPT	*Cryptantha species*	Cryptantha	Forb	Annual
CRYCON	CRCO12	*Cryptantha confertiflora*	Basin yellow cryptantha	Forb	Perennial
CRYFEN	CRFE3	*Cryptantha fendleri*	Sanddune cryptantha	Forb	Annual
CRYFLA	CRFL6	*Cryptantha flavoculata*	Roughseed cryptantha	Forb	Perennial
CRYFLA	CRFL6	*Cryptantha flavoculata*	Roughseed cryptantha	Forb	Perennial
CRYGRA	CRGR3	*Cryptantha gracilis*	Narrowstem cryptantha	Forb	Annual
DESPIN	DEPI	*Descurainia pinnata*	Western tansymustard	Forb	Annual
DRACUN	DRCU	*Draba cuneifolia*	Wedgeleaf draba	Forb	Annual
ECHENG	ECEN	*Echinocereus engelmannii*	Engelmann's hedgehog cactus	Shrub	Perennial
ELYELY	ELEL5	*Elymus elymoides*	Squirreltail	Grass	Perennial
ENCVIR	ENVI	*Encelia virginensis*	Virgin River brittlebush	Shrub	Perennial
EPHNEV	EPNE	*Ephedra nevadensis*	Nevada jointfir	Shrub	Perennial
EPHVIR	EPVI	*Ephedra viridis*	Mormon tea	Shrub	Perennial
ERIANG	ERAN2	*Eriodictyon angustifolium*	Narrowleaf yerba santa	Shrub	Perennial
ERIARG	ERAR3	*Erigeron argentatus*	Silver fleabane	Forb	Perennial
ERICON	ERCO27	*Erigeron concinnus*	Navajo fleabane	Forb	Perennial
ERIDIV	ERDI4	*Erigeron divergens*	Spreading fleabane	Forb	Annual
ERIFAS	ERFA2	*Eriogonum fasiculatum*	Mojave buckwheat	Shrub	Perennial
ERIINF	ERIN4	*Eriogonum inflatum*	Desert trumpet	Forb	Annual
ERIPAL	ERPA11	*Eriogonum palmerianum*	Palmer's buckwheat	Forb	Annual
ERIPUL	DAPU7	*Dasychloa pulchella*	Wooly grass	Grass	Perennial
ERIUMB	ERUM	*Eriogonum umbellatum*	Sulphur flower buckwheat	Shrub	Perennial
EROCIC	ERCI6	*Erodium cicutarium*	Redstem stork's bill	Forb	Annual
ERYCAP	ERCA14	*Erysimum capitatum*	Western wallflower	Forb	Perennial
ESCVIV	ESVI2	*Escobaria vivipara*	Spinystar	Shrub	Perennial
FALPAR	FAPA	*Fallugia paradoxa*	Apache plume	Shrub	Perennial
FRAALB	FRAL5	*Frasera albomarginata*	Desert frasera	Forb	Perennial
FRIATR	FRAT	*Fritillaria atropurpurea*	Chocolate lily	Forb	Perennial
GARFLA	GAFL2	*Garrya flavescens*	Ashy silktassel	Shrub	Perennial
GIL SPP	GILIA	*Gilia species*	Gilia	Forb	Annual
GILTRA	GITR	*Gilia transmontana*	Transmontane gilia	Forb	Annual

GUTMIC	GUMI	*Gutierrezia microcephala*	Threadleaf snakeweed	Shrub	Perennial
GUTSAR	GUSA2	*Gutierrezia sarothrae*	Snakeweed	Shrub	Perennial
HELMUL	HEMU3	*Heliomeris multiflora*	Showy goldeneye	Forb	Perennial
HESCOM	HECO26	*Hesperostipa commata*	Needle and Thread	Grass	Perennial
HORMUR	HOMU	*Hordeum murinum*	Mouse barley	Grass	Annual
HYMCOO	HYCO2	*Hymenoxys cooperi*	Cooper's rubberweed	Forb	Perennial
HYMFIL	HYFI	*Hymenopappus filifolius*	Hymenopappus	Forb	Perennial
HYMLEM	HYLE	*Hymenoxys lemmonii*	Rubberweed	Forb	Perennial
IPOARI	IPAR2	*Ipomopsis arizonica*	Scarlet gilia	Forb	Perennial
JUNOST	JUOS	*Juniperus osteosperma*	Utah juniper	Tree	Perennial
JUNSCO	JUSC2	*Juniperus scopulorum*	Rocky Mountain juniper	Tree	Perennial
LAPRED	LAOC	*Lappula occidentalis*	Flatspine stickseed	Forb	Annual
LEPLAS	LELA	*Lepidium lasiocarpum*	shaggyfruit pepperweed	Forb	Annual
LINDIC	LIDI2	*Linanthus dichotomus*	Eveningsnow	Forb	Annual
LINLEW	LILE3	*Linum lewisii*	Lewis flax	Forb	Perennial
LINNUT	LINU	*Linanthus nuttalii*	linanthus	Forb	Perennial
MACCAN	MACAC	*Machaeranthera canescens*	Hoary tansyaster	Forb	Annual
MIRBIG	MIBIR	*Mirabilis bigelovii*	Bigelow's desert four-o-clock	Forb	Perennial
MIRMUL	MIMU	*Mirabilis multiflora*	Colorado four o'clock	Forb	Perennial
MONODO	MOOD	*Monardella odoratissima*	Mountain monardella	Forb	Perennial
OENCAE	OECA10	*Oenothera caespitosa*	Tufted evening primrose	Forb	Annual
OENHOW	OEHO2	*Oenothera howardii*	Howard's evening primrose	Forb	Perennial
OPUACA	CYAC8	*Cylindropuntia acanthocarpa*	Buckhorn cholla	Shrub	Perennial
OPUBAS	OPBA2	*Opuntia basilaris*	Beavertail pricklypear	Shrub	Perennial
OPUCHL	OPCH	*Opuntia chlorotica*	Dollarjoint pricklypear	Shrub	Perennial
OPUECH	CYEC3	*Cylindropuntia echinocarpa*	Wiggins' cholla	Shrub	Perennial
OPUERI	OPPOE	*Opuntia erinacea*	Grizzlybear pricklypear	Shrub	Perennial
OPUPHA	OPPH	*Opuntia phaeacantha*	Tulip pricklypear	Shrub	Perennial
OROFAS	ORFA	*Orobanche fasciculata*	Clustered broomrape	Forb	Annual
OXYPER	OXPE2	*Oxytheca perfoliata*	Roundleaf oxytheca	Forb	Annual
PACMUL	PAMU11	*Packera multilobata*	lobed groundsel	Forb	Annual
PEDSEM	PESE2	*Pedicularis semibarbata*	Pinewood lousewort	Forb	Perennial
PENPAL	PEPA8	*Penstemon palmeri*	Palmer's penstemon	Forb	Perennial
PENROS	PERO10	*Penstemon rostriflorus*	Bridge penstemon	Forb	Perennial
PENTHO	PETH2	*Penstemon thompsoniae*	Thompson's penstemon	Forb	Perennial
PENUTA	PEUT	*Penstemon utahensis*	Utah penstemon	Forb	Perennial
PHADIS	PHDI	*Phacelia distans*	Distant phacelia	Forb	Annual
PHAFRE	PHFR2	*Phacelia fremontii*	Fremont's phacelia	Forb	Annual
PHLCON	PHCO11	*Phlox condensata*	Dwarf phlox	Forb	Perennial
PHLGRA	MIGRG4	*Microsteris gracilis*	Slender phlox	Forb	Annual
PHLSTA	PHST11	*Phlox stansburyi*	Cold desert phlox	Shrub	Perennial
PHYCHA	PHCH2	*Physaria chambersii*	Chamber's twinpod	Forb	Perennial
PHYHED	PHHE4	*Physalis hederifolia*	Ivyleaf groundcherry	Forb	Perennial
PINFLE	PIFL2	*Pinus flexilis*	Limberpine	Tree	Perennial
PINLON	PILO	*Pinus longaeva*	Bristlecone	Tree	Perennial
PINMON	PIMO	*Pinus monophylla*	Singleleaf pinyon	Tree	Perennial
PINPON	PIPO	*Pinus pondersoa*	Ponderosa	Tree	Perennial

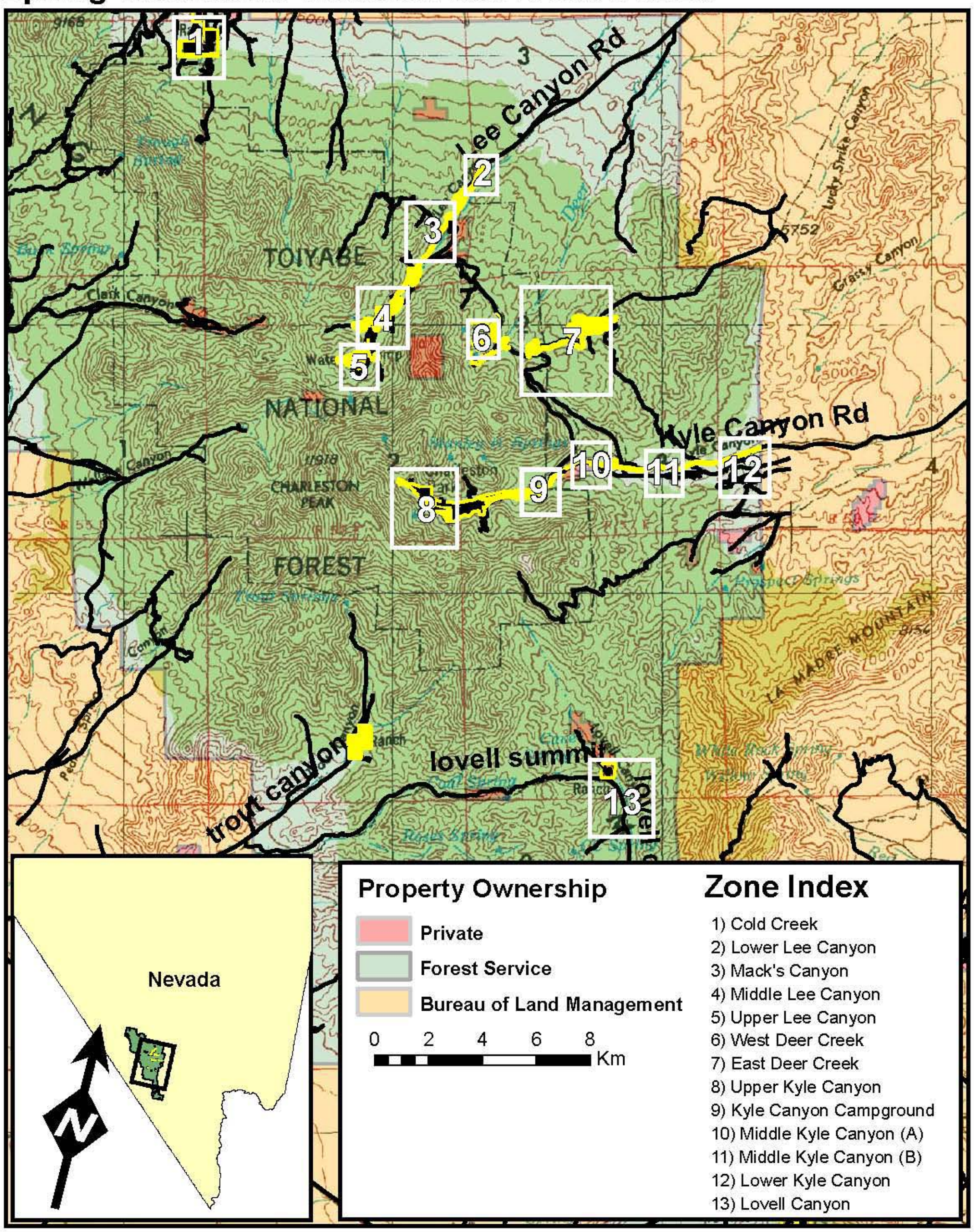
PLAPAT	PLPA2	*Plantago patagonica*	Woolly plantain	Forb	Annual
POASEC	POSE	*Poa secunda*	Bluegrass	Grass	Perennial
POPTRE	POTR5	*Populus tremuloides*	Quaking aspen	Tree	Perennial
POTCRI	POCR4	*Potentilla crinita*	Bearded cinquefoil	Forb	Perennial
PRUFAS	PRFA	*Prunus fasciculata*	Desert almond	Shrub	Perennial
PURMEX	PUME	*Purshia mexicana*	Mexican cliffrose	Shrub	Perennial
PYRCHL	PYCH	*Pyrola chlorantha*	Greenflowered wintergreen	Forb	Perennial
QUEGAM	QUGA	*Quercus gambelii*	Gambel oak	Tree	Perennial
RIBAUR	RIAU	*Ribes aureum*	Golden currant	Shrub	Perennial
RIBCER	RICE	*Ribes cereum*	Wax currant	Shrub	Perennial
SALDOR	SADO4	*Salvia dorrii*	Purple sage	Shrub	Perennial
SALTRA	SATR12	*Salsola tragus*	Prickly Russian thistle	Forb	Annual
SAMMEX	SAME	*Sambucus mexicana*	Mexican elderberry	Shrub	Perennial
SCLPOL	SCPO4	*Sclerocactus polyancistrus*	Redspined fishhook cactus	Shrub	Perennial
SISALT	SIAL2	*Sisymbrium altissimum*	Tall tumblemustard	Forb	Annual
SOLSPA	SOSP	*Solidago sparsiflora*	Goldenrod	Forb	Perennial
SOLVEL	SOVE6	*Solidago velutina*	Threenerve golenrod	Forb	Perennial
SPHAMB	SPAM2	*Sphaeralcea ambigua*	Desert globemallow	Shrub	Perennial
SPHGRO	SPGR2	*Sphaeralcea grossulariifolia*	Gooseberry globemallow	Shrub	Perennial
STAPIN	STPI	*Stanleya pinnata*	Desert princesplume	Shrub	Perennial
STEEXI	STEX	*Stephanomeria exigua*	Small wirelettuce	Forb	Annual
STRCOR	STCO6	*Streptanthus cordatus*	Heartleaf twistflower	Forb	Perennial
STRLON	STLO4	*Streptanthella longirostris*	Longbeak jewelflower	Forb	Annual
SYMLON	SYLO	*Symphoricarpus longifloris*	Desert snowberry	Shrub	Perennial
SYMORE	SYOR2	*Symphoricarpus oreophilus*	Mountain snowberry	Shrub	Perennial
TETCAN	TECA2	*Tetradymia canescens*	Spineless horsebush	Shrub	Perennial
THAFEN	THFE	*Thalictricum fendleri*	Fendler's meadowrue	Forb	Perennial
TOWJON	TOJO	*Towsendia jonesii*	Jone's towsend daisy	Forb	Perennial
TRDU	TRDU	*Tragopogon dubius*	Yellow Salsify	Forb	Annual
UROLIN	MILI5	*Microseris lindleyi*	Silverpuffs	Forb	Annual
VIOCHA	VICH2	*Viola charlestonensis*	Mt. Charleston Violet	Forb	Perennial
VULOCT	VUOC	*Vulpia octoflora*	Sixweeks fescue	Grass	Annual
XYLTOR	XYTO2	*Xylorhiza tortifolia*	Mojave woodyaster	Forb	Perennial
YUCBAC	YUBA	*Yucca baccata*	Banana yucca	Shrub	Perennial
YUCBRE	YUBR	*Yucca brevifolia*	Joshua tree	Shrub	Perennial
YUCSCH	YUSC2	*Yucca schidigera*	Mojave yucca	Shrub	Perennial
ZIGPAN	ZIPA2	*Zigadenus paniculatus*	Foothill deathcamas	Forb	Perennial

* The USDA-NRCS species codes can be found at the PLANTS on-line database: http://plants.usda.gov/.

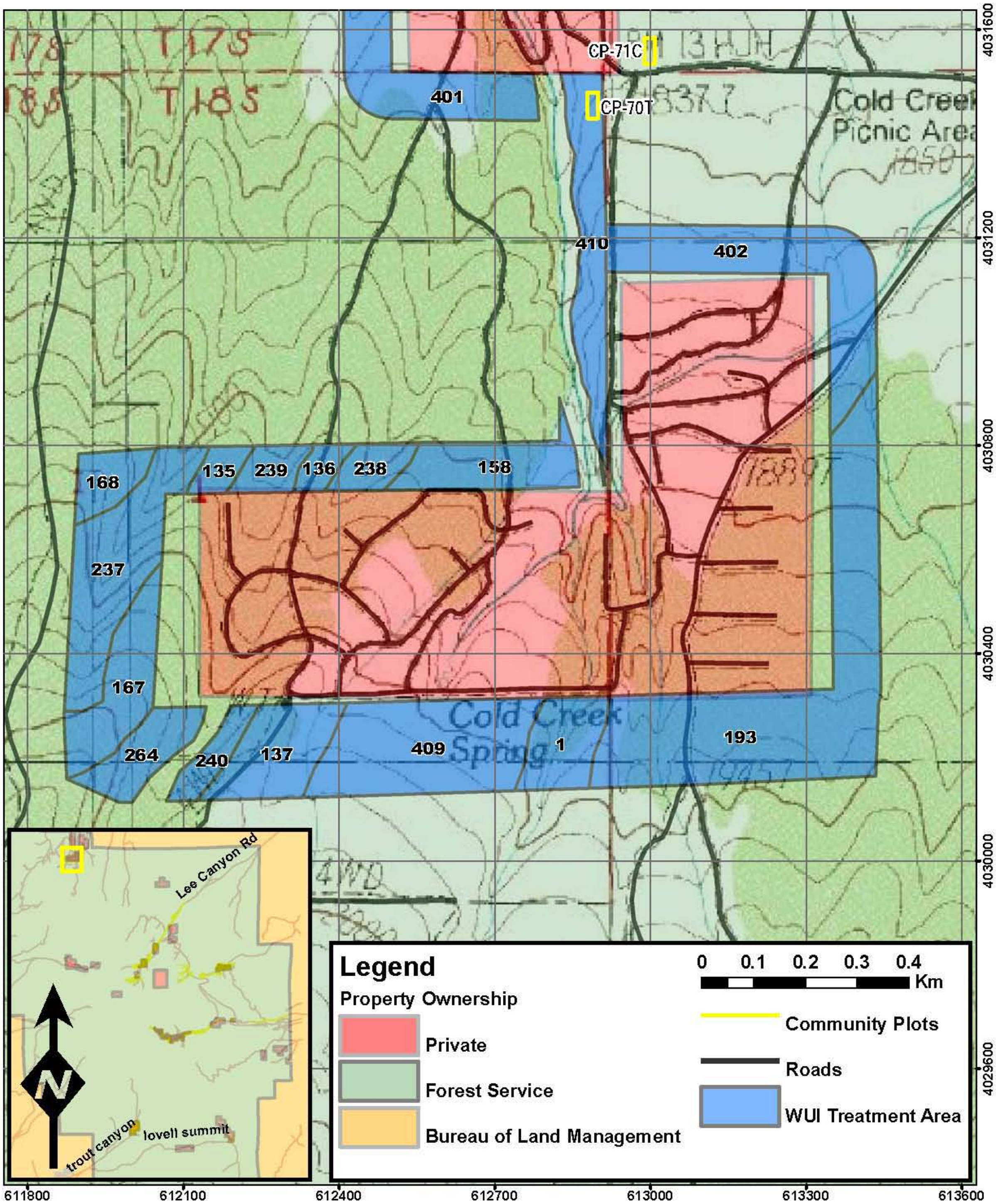
Appendix B. Project maps illustrating the sampling locations (zones) and plots. The organization for maps is shown in Table 9 above.

Vicinity Map and Zone Index

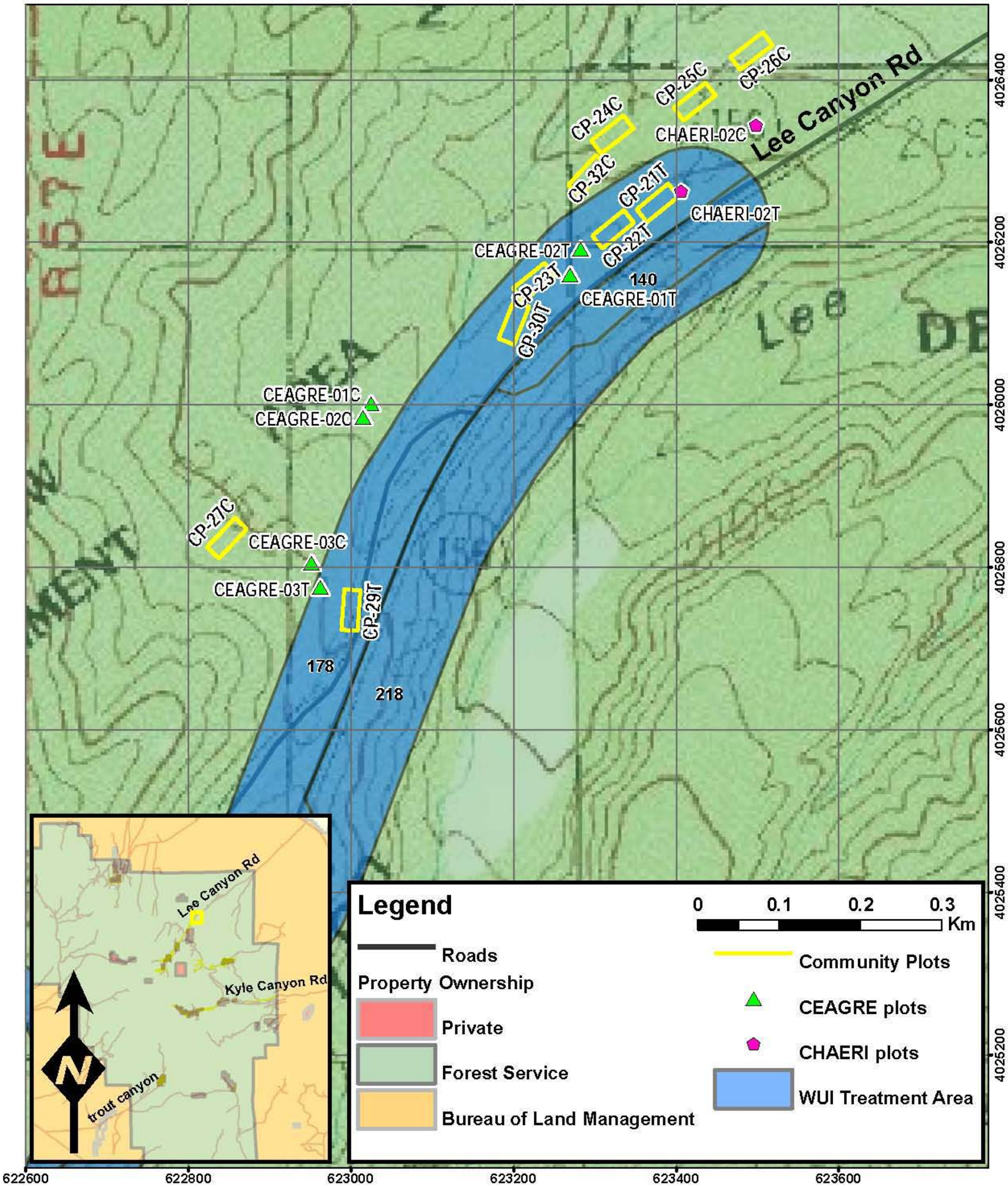
Spring Mountains National Recreation Area



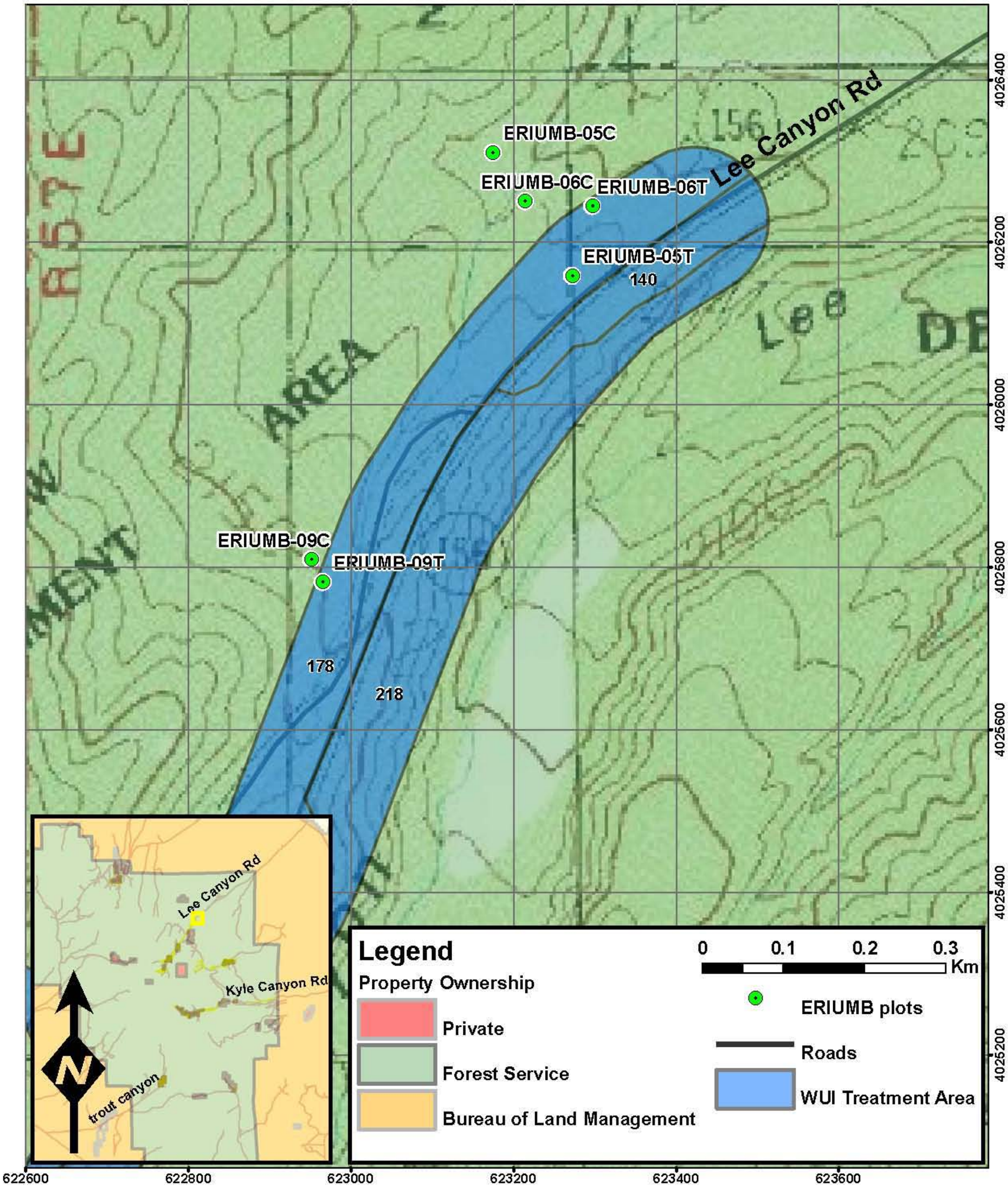
Zone 1 - Map 1: Cold Creek
Community Plots [70T, 71C]



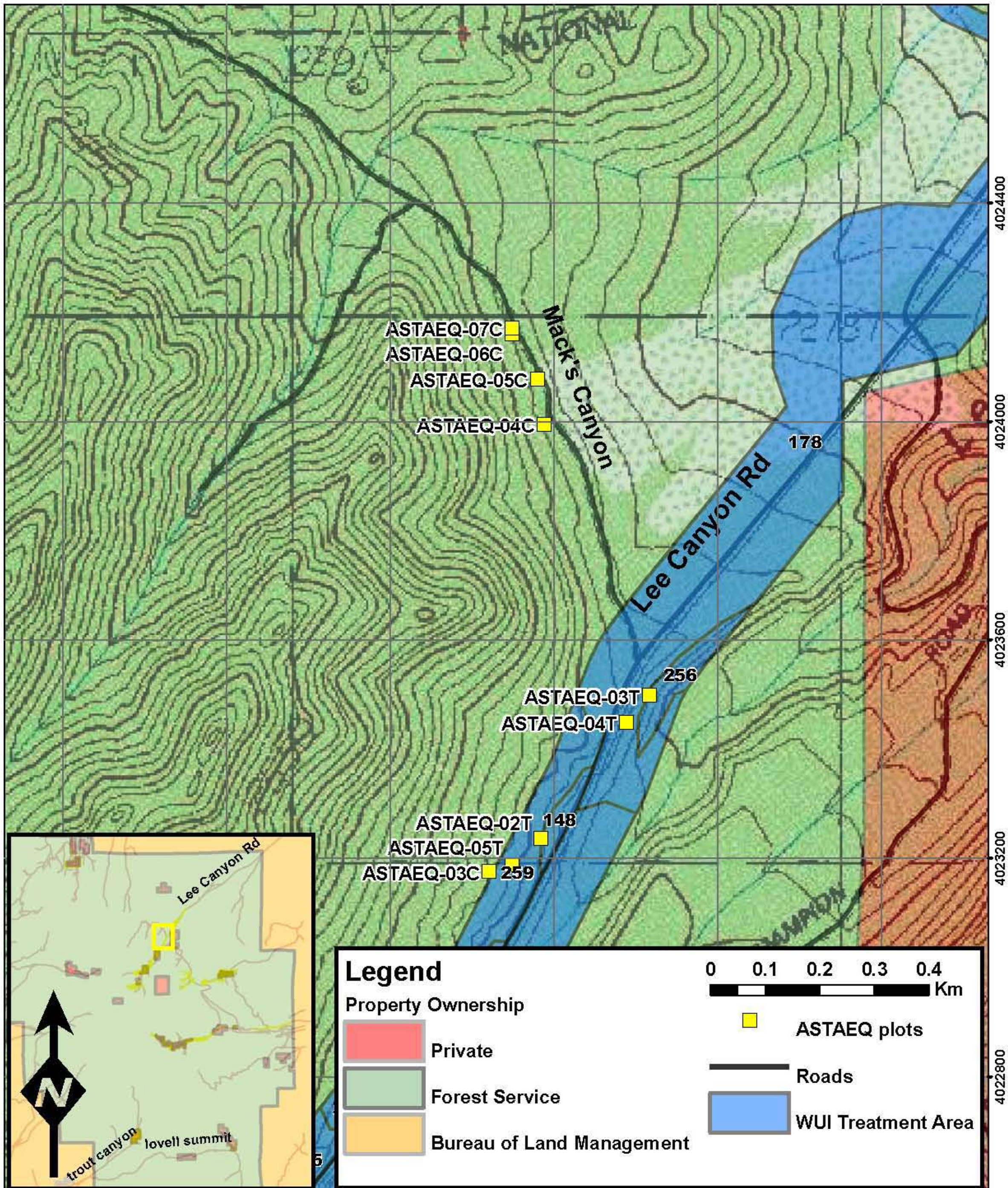
Zone 2 - Map 1: Lower Lee Canyon
Community Plots [21T, 22T, 23T, 24C, 25C, 26C, 27C, 29T, 30T, 32C]
Ceanothus greggii [01C, 01T, 02C, 02T, 03C, 03T]
Chaetopappa ericoides [02C, 02T]



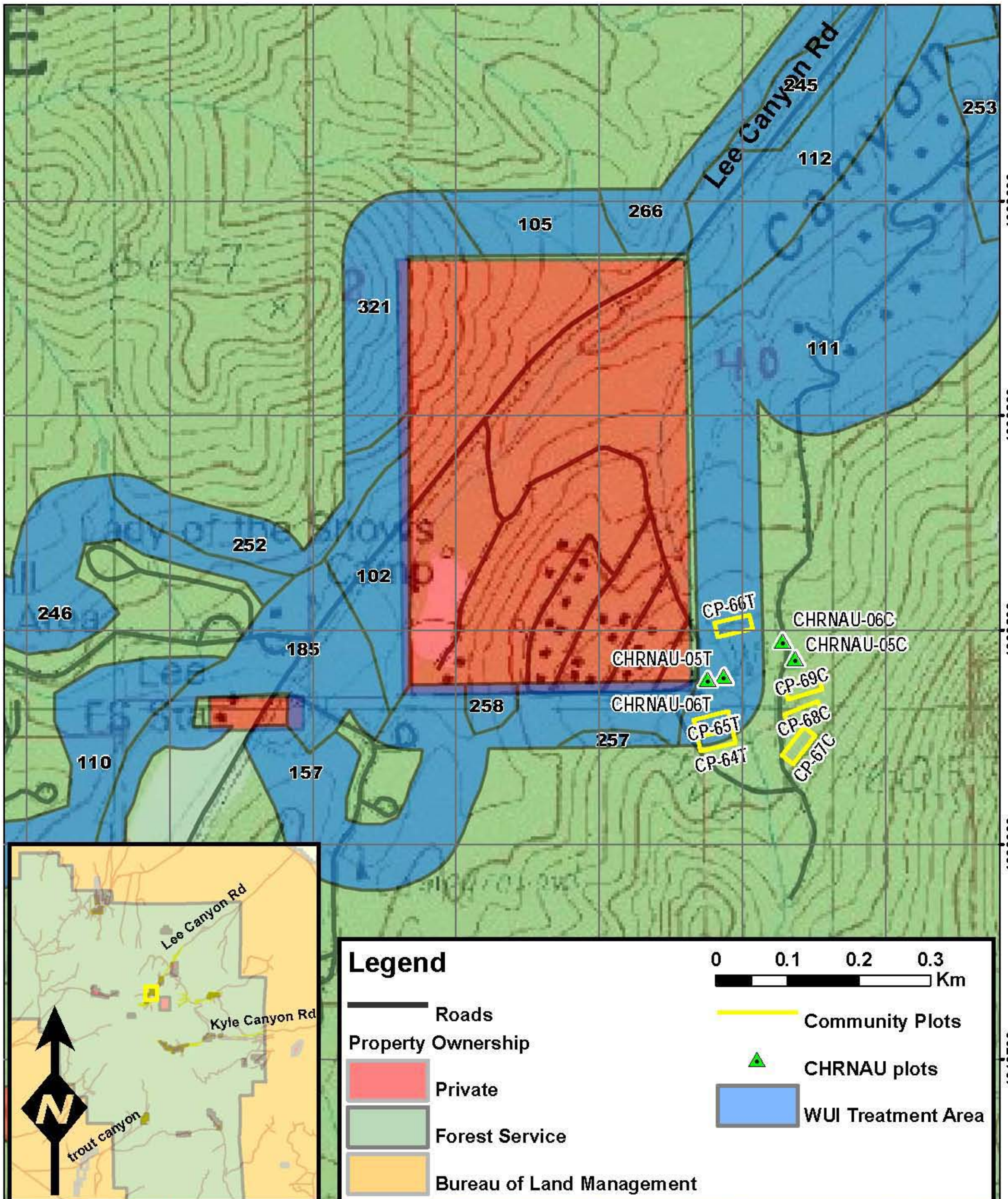
Zone 2 - Map 2: Lower Lee Canyon
Eriogonum umbellatum **[05C, 05T, O6C, 06T, 09C, 09T]**



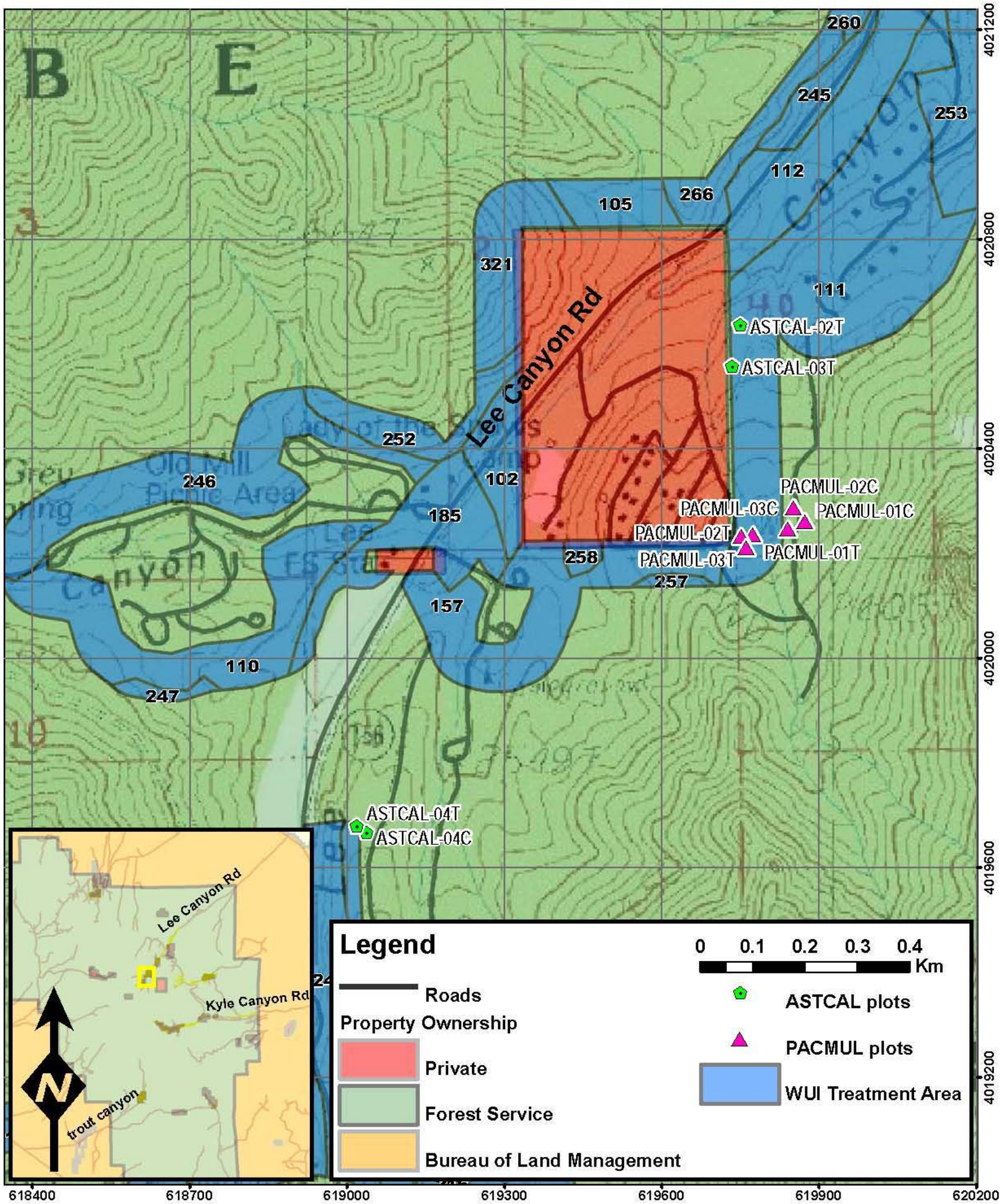
Zone 3 - Map 1: Mack's Canyon
Astragalus aequalis [02T, 03C, 03T, 04C, 04T, 05T, 05C, 06C, 07C]



Zone 4 - Map 1: Middle Lee Canyon
Community Plots [64T, 65T, 66T, 67C, 68C, 69C]
Chrysothamnus (Ericameria) nauseosus [05C, 05T, 06C, 06T]



Zone 4 - Map 2: Middle Lee Canyon
***Astragalus calycosus* var. *calycosus* [02T, 03T, 04C, 04T]**
***Packera multilobata* [01C, 01T, 02C, 02T, 03C, 03T]**

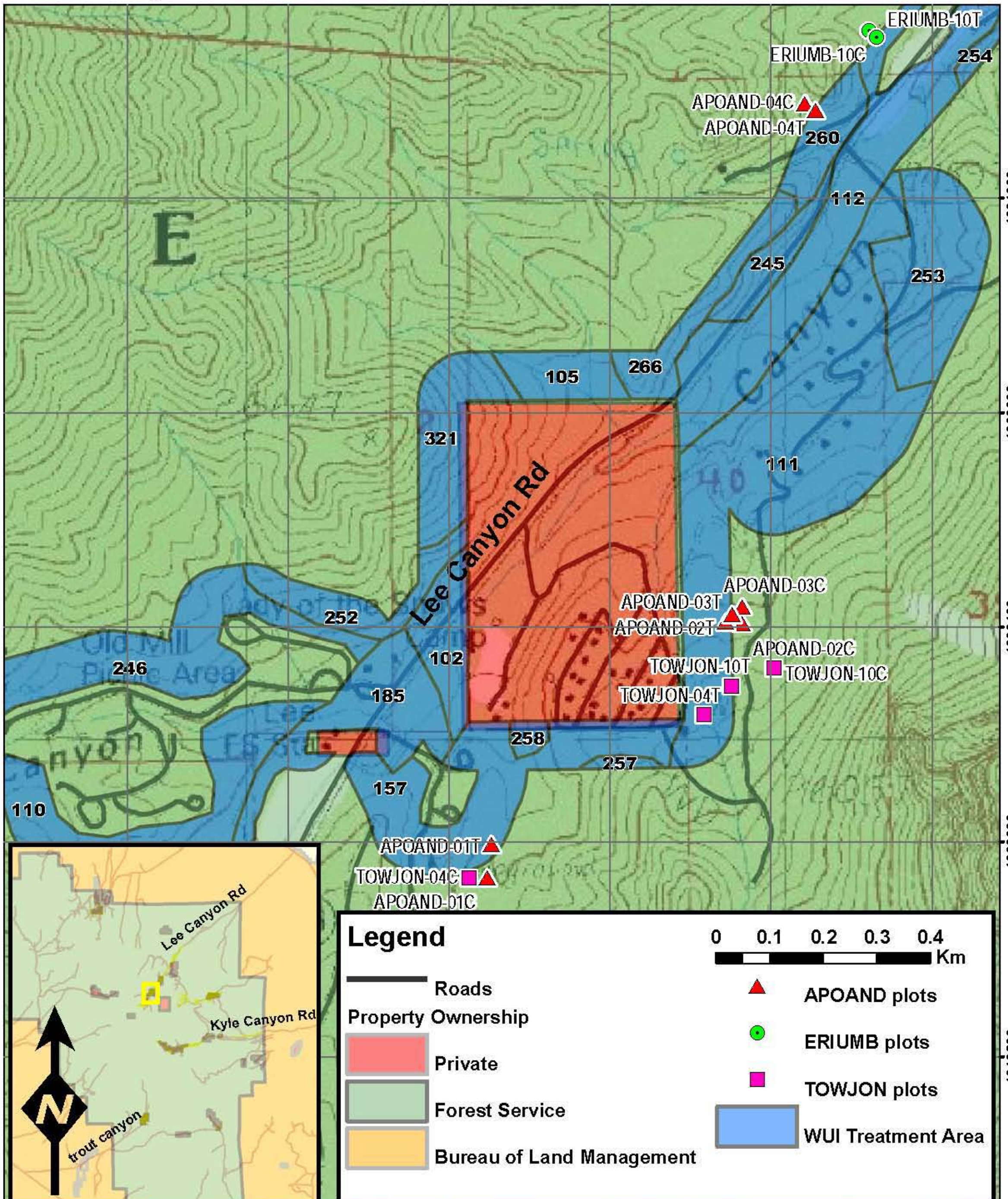


Zone 4 - Map 3: Middle Lee Canyon

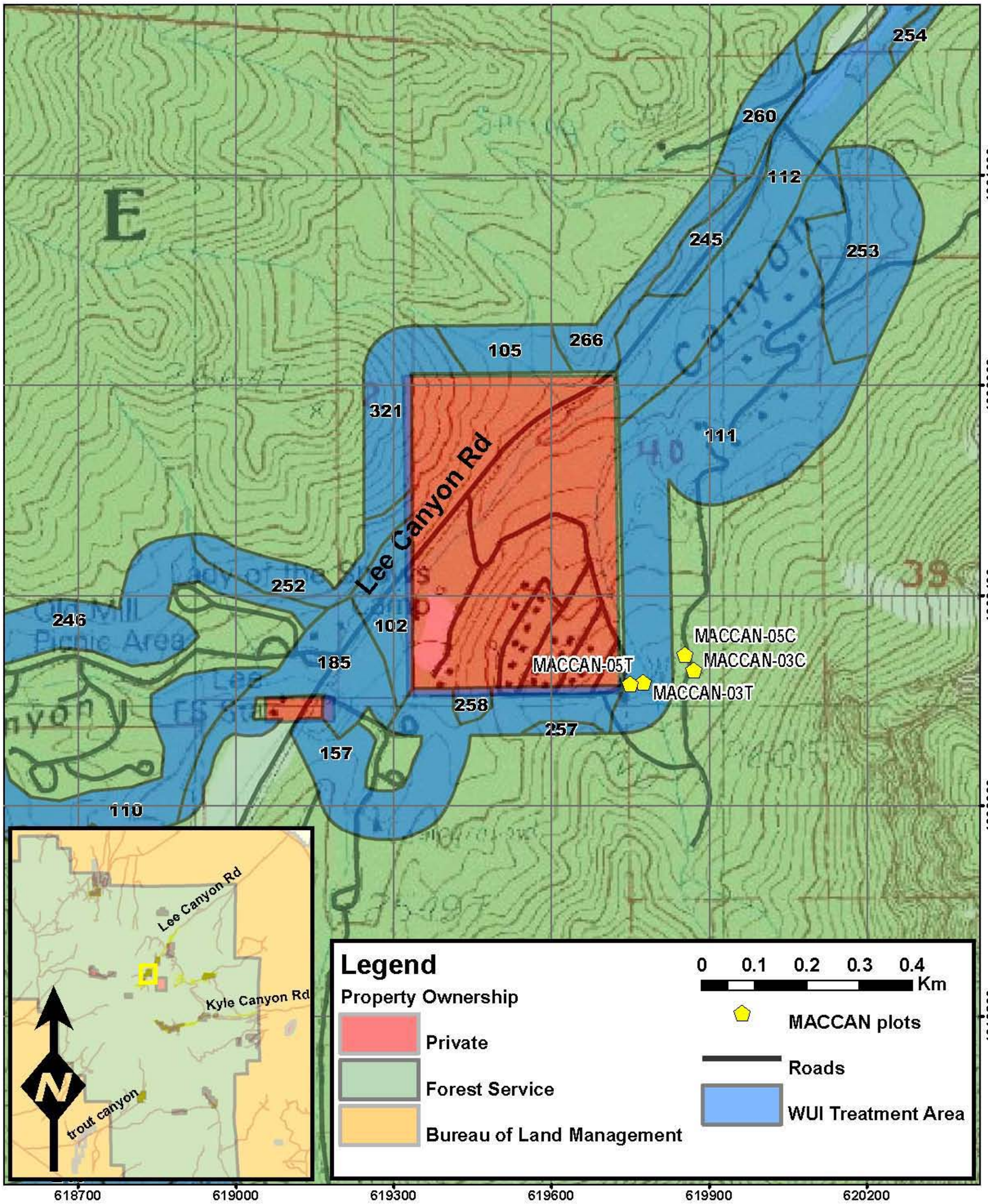
Apocynum androsaemifolium **[01C, 01T, 02C, 02T, 03C, 03T, 04C, 04T]**

Eriogonum umbellatum **[10C, 10T]**

Townsendia jonesii* var. *tumulosa **[04C, 04T, 10C, 10T]**



Zone 4 - Map 4: Middle Lee Canyon
***Machaeranthera canescens* [03C, 03T, 05C, 05T]**

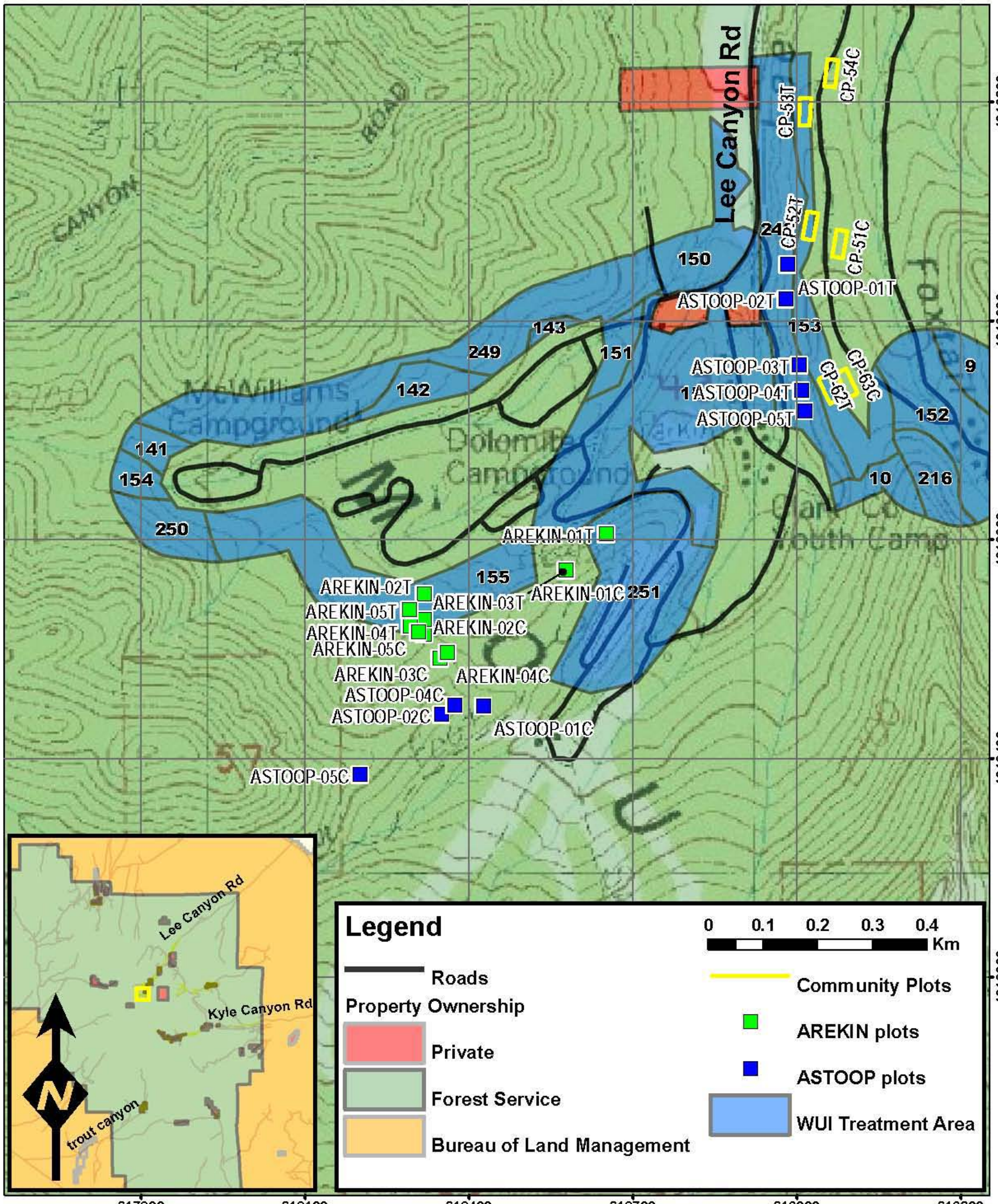


Zone 5 - Map 1: Upper Lee Canyon

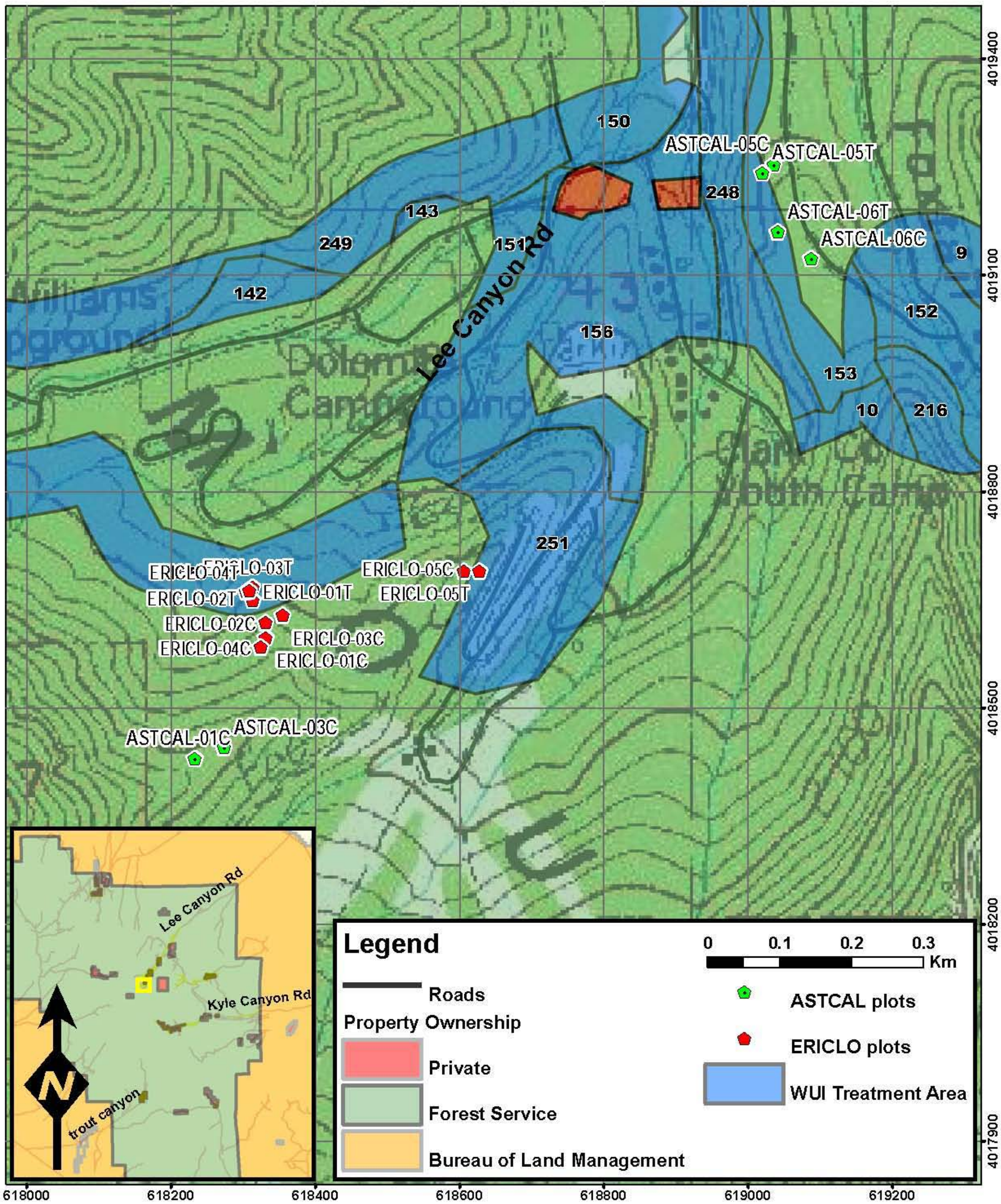
Community Plots [51C, 52T, 53T, 54C, 62T, 63C]

Arenaria kingii* ssp. *rosea [01C, 01T, 02C, 02T, 03C, 03T, 04C, 04T, 05C, 05T]

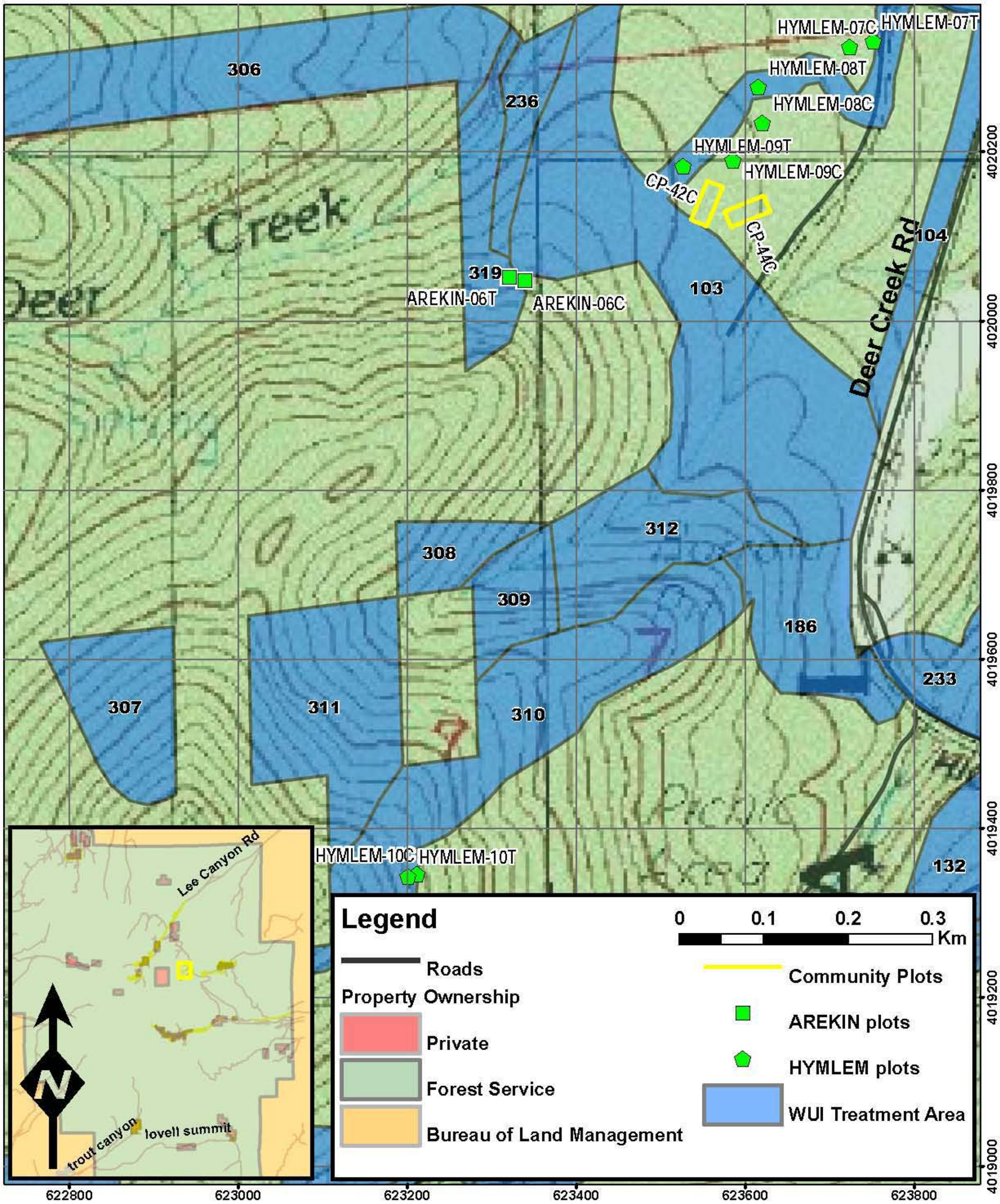
Astragalus oophorus* var. *clokeyanus [01C, 01T, 02C, 02T, 03T, 04C, 04T, 05C, 05T]



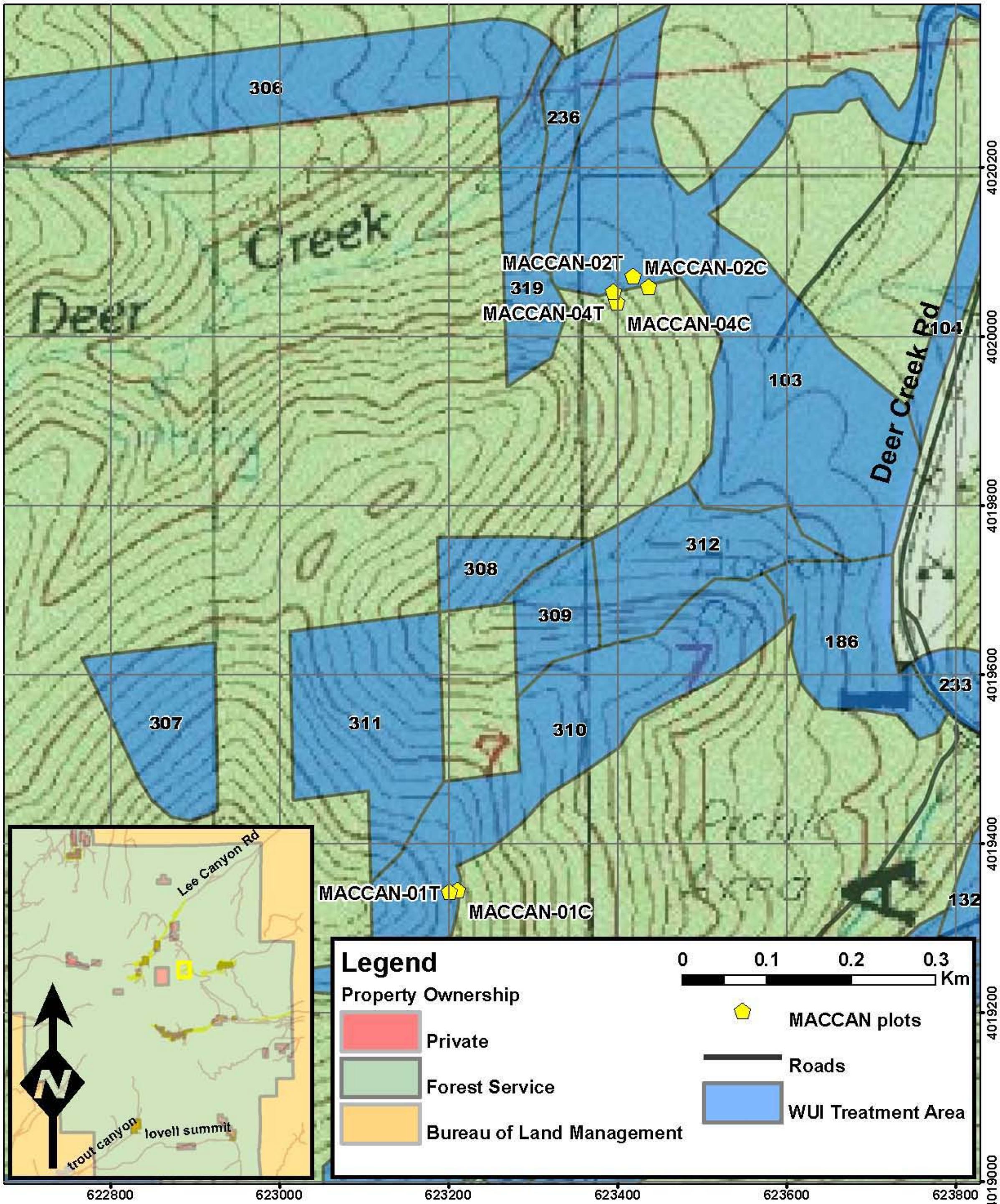
Zone 5 - Map 2: Upper Lee Canyon
Astragalus calycosus* var. *calycosus [01C, 03C, 05C, 05T, 06C, 06T]
Erigeron clokeyi [01C, 01T, 02C, 02T, 03C, 03T, 04C, 04T, 05C, 05T]



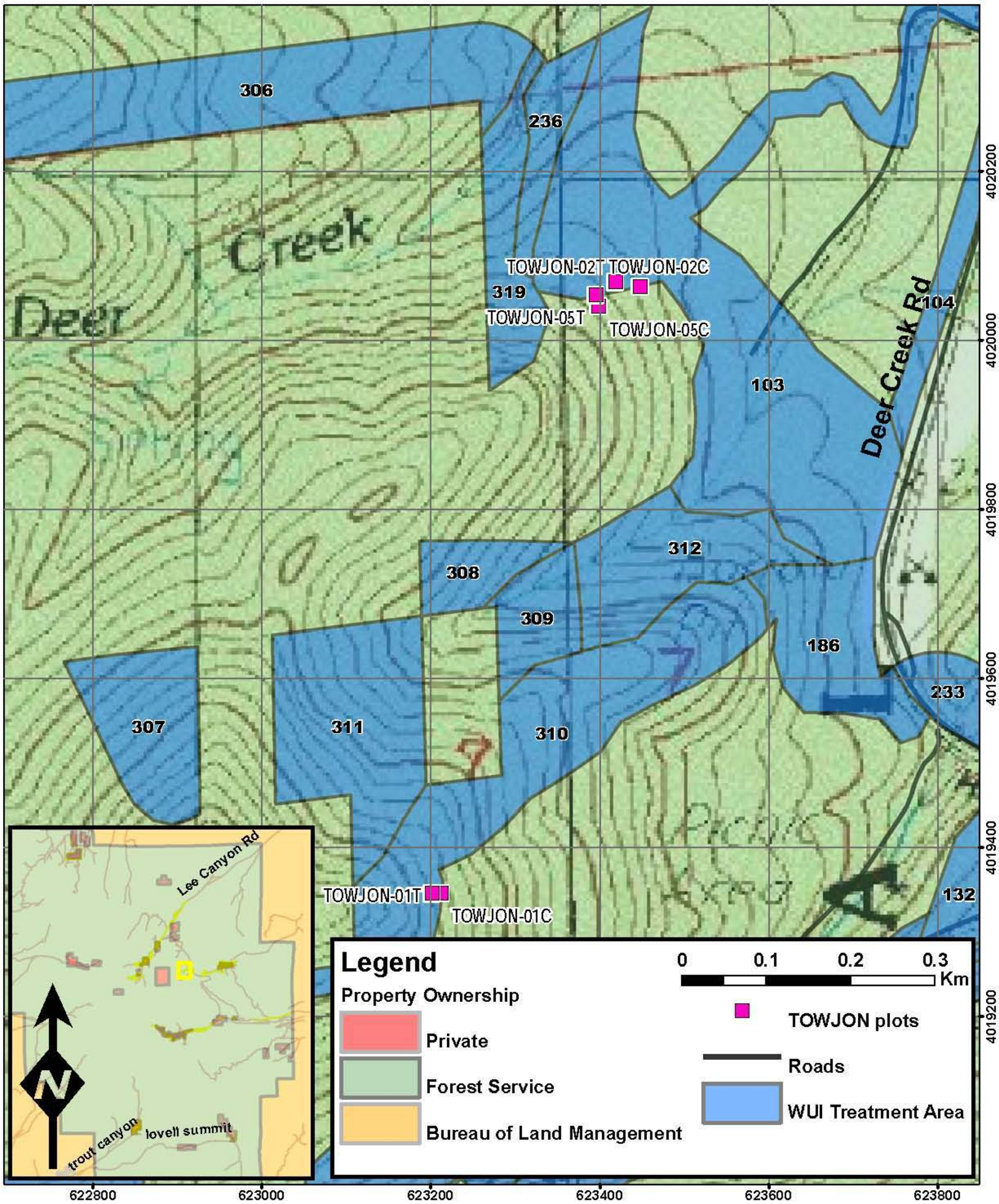
Zone 6 - Map 1: West Deer Creek
Community Plots [42C, 44C]
Arenaria kingii* ssp. *rosea [06C, 06T]
Hymenoxys lemmonii [07C, 07T, 08C, 08T, 09C, 09T, 10C, 10T]



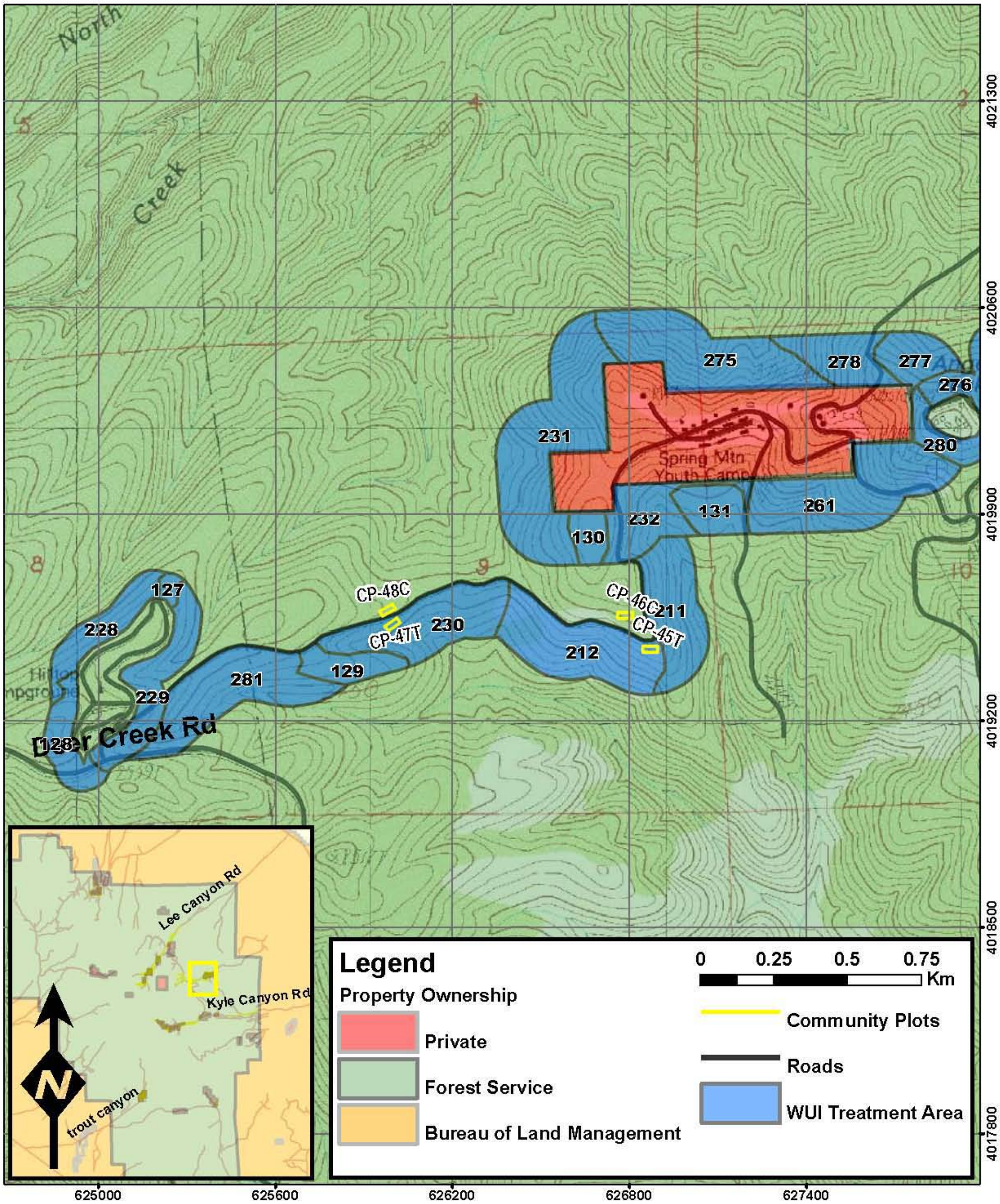
Zone 6 - Map 2: West Deer Creek
***Machaeranthera canescens* [01C, 01T, 02C, 02T, 04C, 04T]**



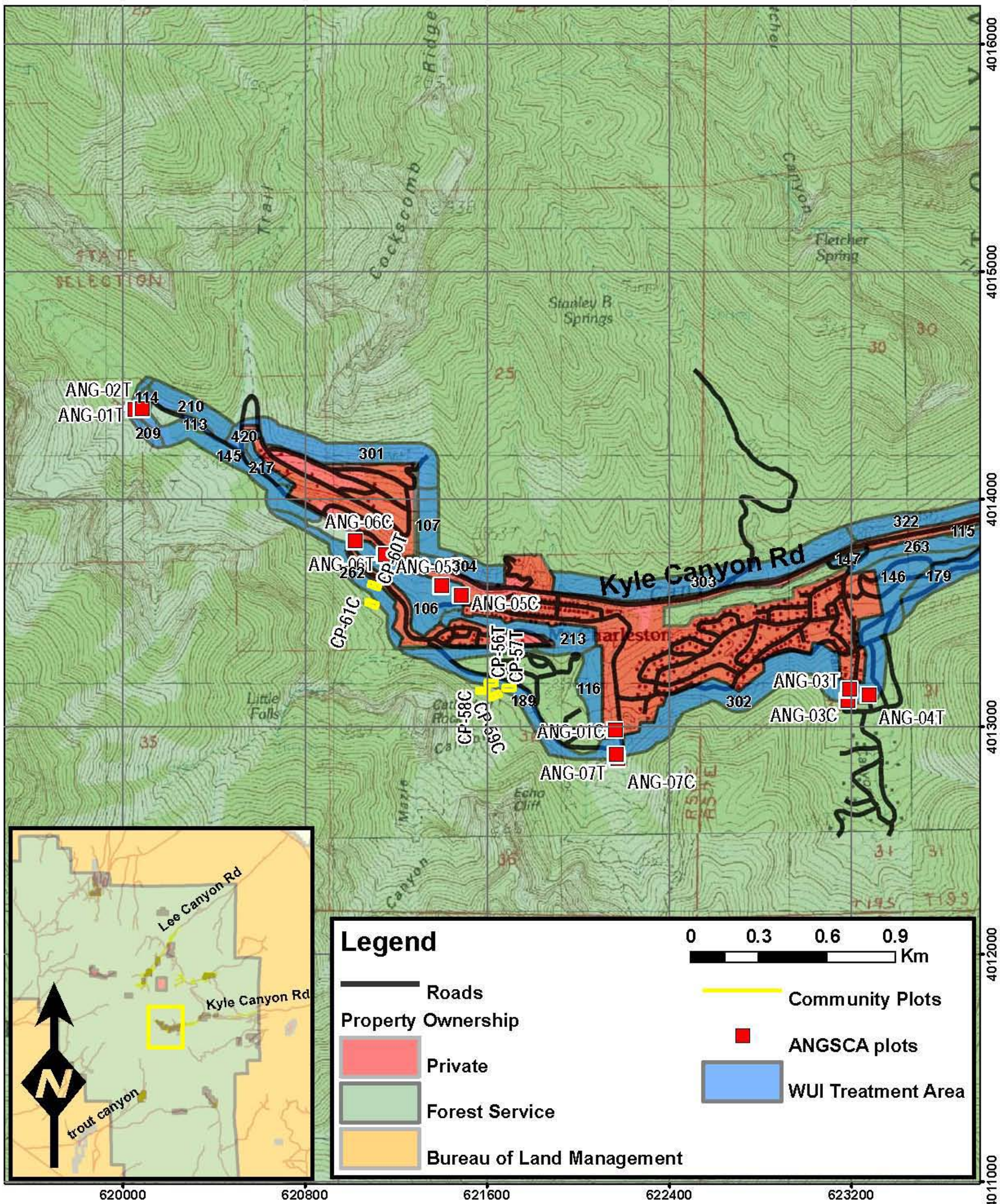
Zone 6 - Map 3: West Deer Creek
***Townsendia jonesii* var. *tumulosa* [01C, 01T, 02C, 02T, 05C, 05T]**



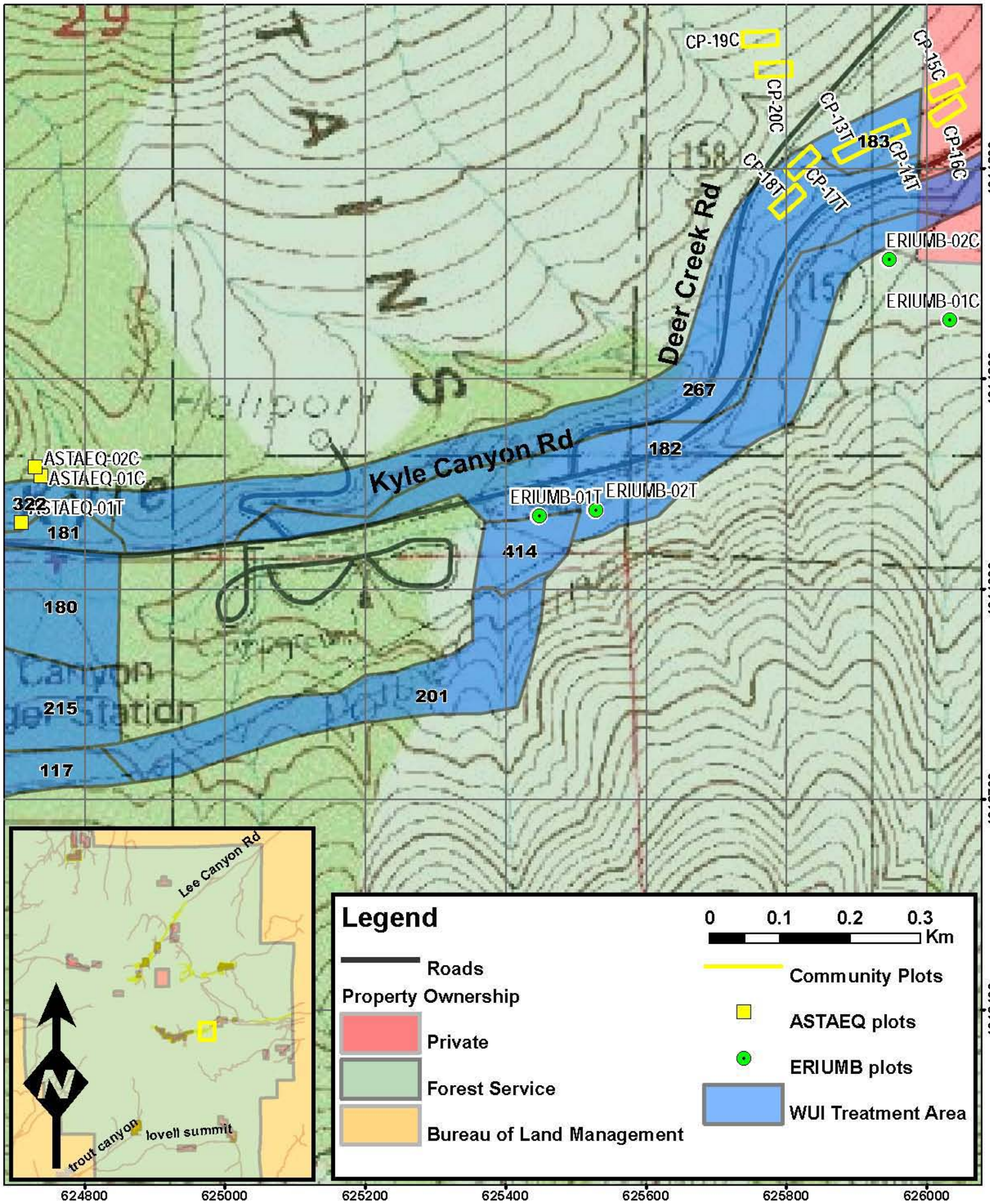
Zone 7 - Map 1: East Deer Creek
Community Plots [45T, 46C, 47T, 48C]



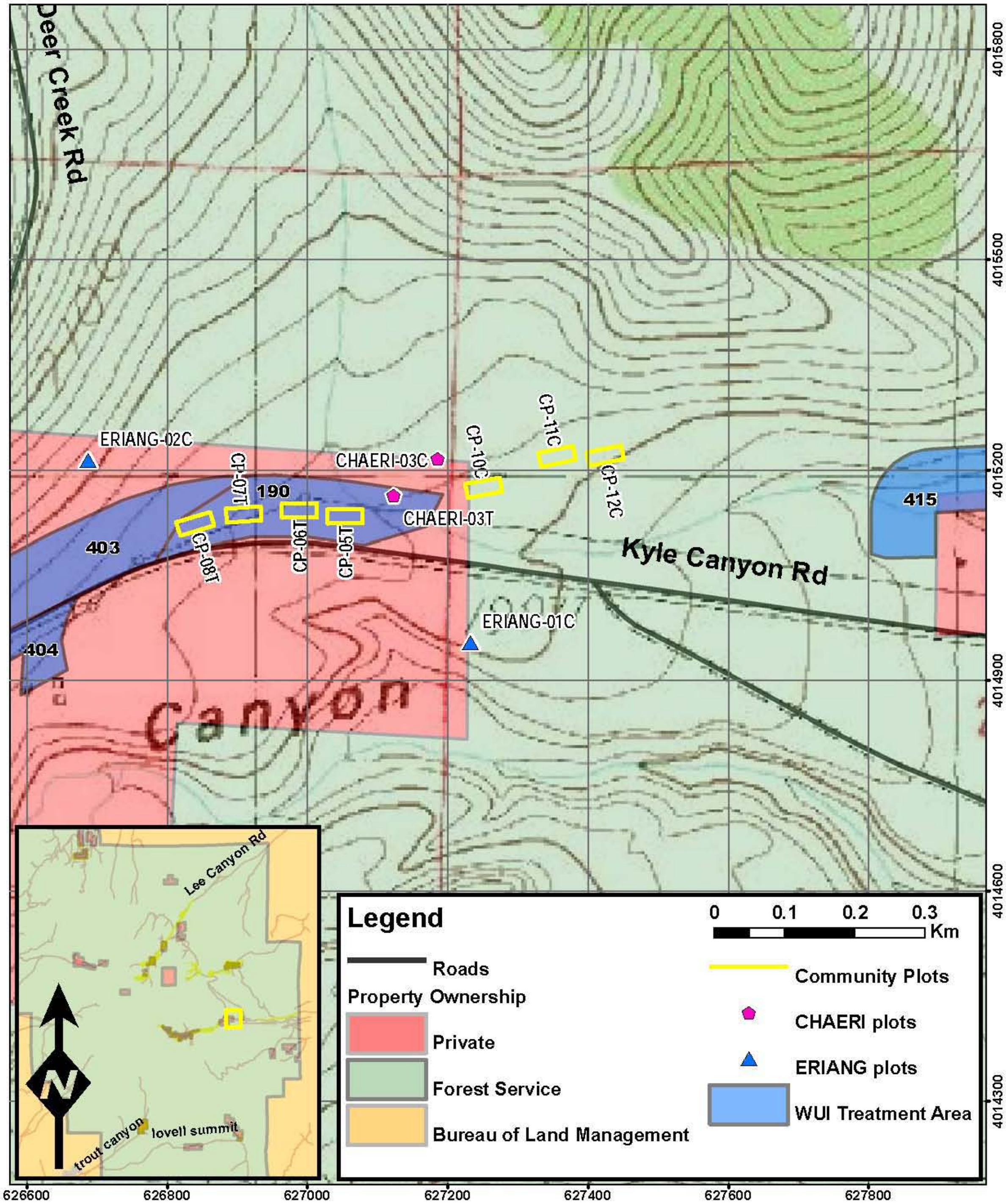
Zone 8 - Map 1: Upper Kyle Canyon
Community Plots [56T, 57T, 58C, 59C, 60T, 61C]
Angelica scabrida [01C, 01T, 02T, 03C, 03T, 05C, 05T, 06C, 06T, 07C, 07T]



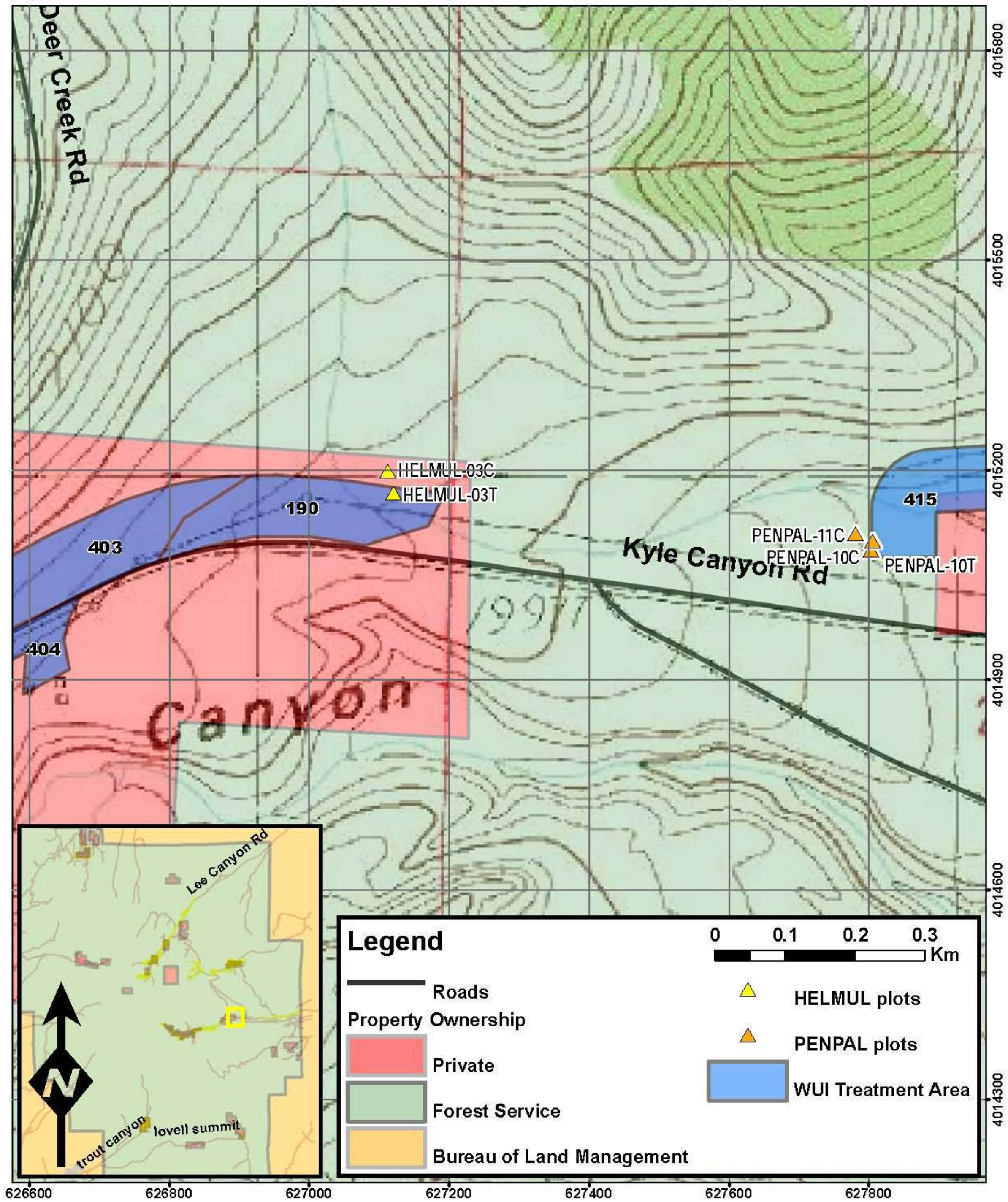
Zone 9 - Map 1: Kyle Canyon Campground
Community Plots [13T, 14T, 15C, 16C, 17T, 18T, 19C, 20C]
Astragalus aequalis [01C. 01T, 02C]
Eriogonum umbellatum [01C, 01T, 02T, 02C]



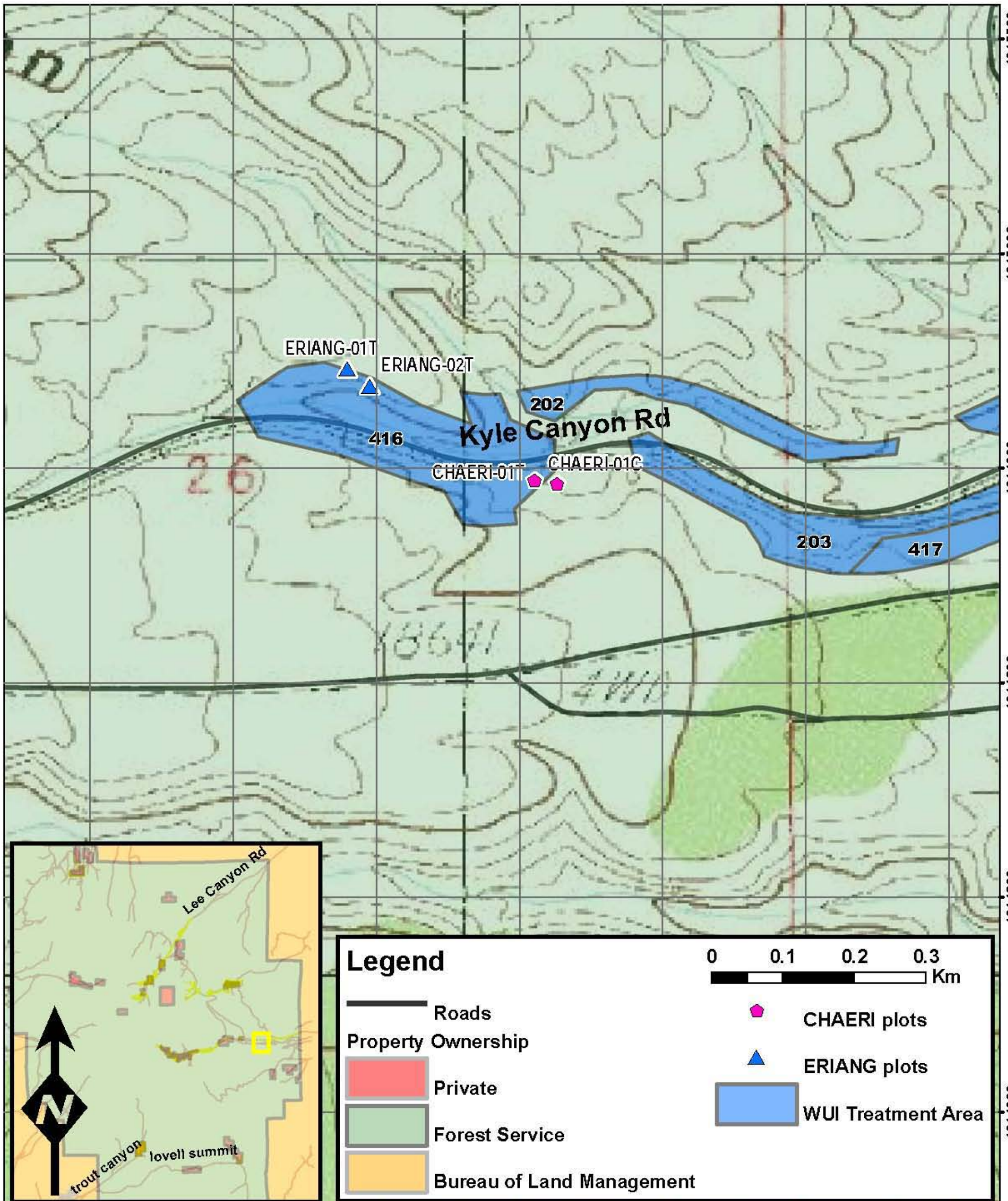
Zone 10 - Map 1: Middle Kyle Canyon (A)
Community Plots [05T, 06T, 07T, 08T, 10C, 11C, 12C]
***Chaetopappa ericoides* [03C, 03T]**
***Eriodictyon angustifolium* [01C. 02C]**



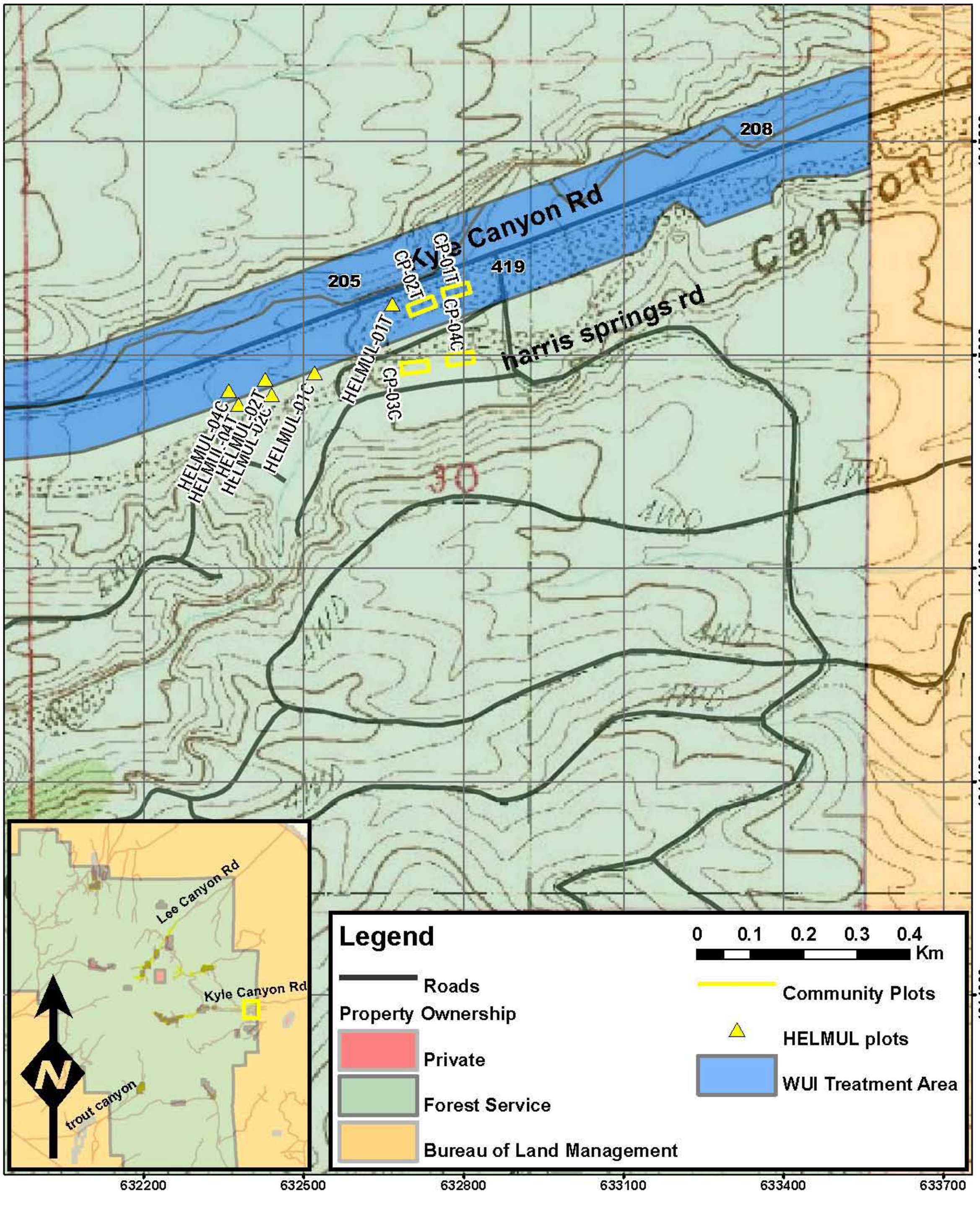
Zone 10 - Map 2: Middle Kyle Canyon (A)
Heliomeris multiflora* var. *nevadensis [03C, 03T]
Penstemon palmeri [10C, 10T, 11C]



Zone 11 - Map 1: Middle Kyle Canyon (B)
Chaetopappa ericoides **[01C, 01T]**
Eriodictyon angustifolium **[01T, 02T]**



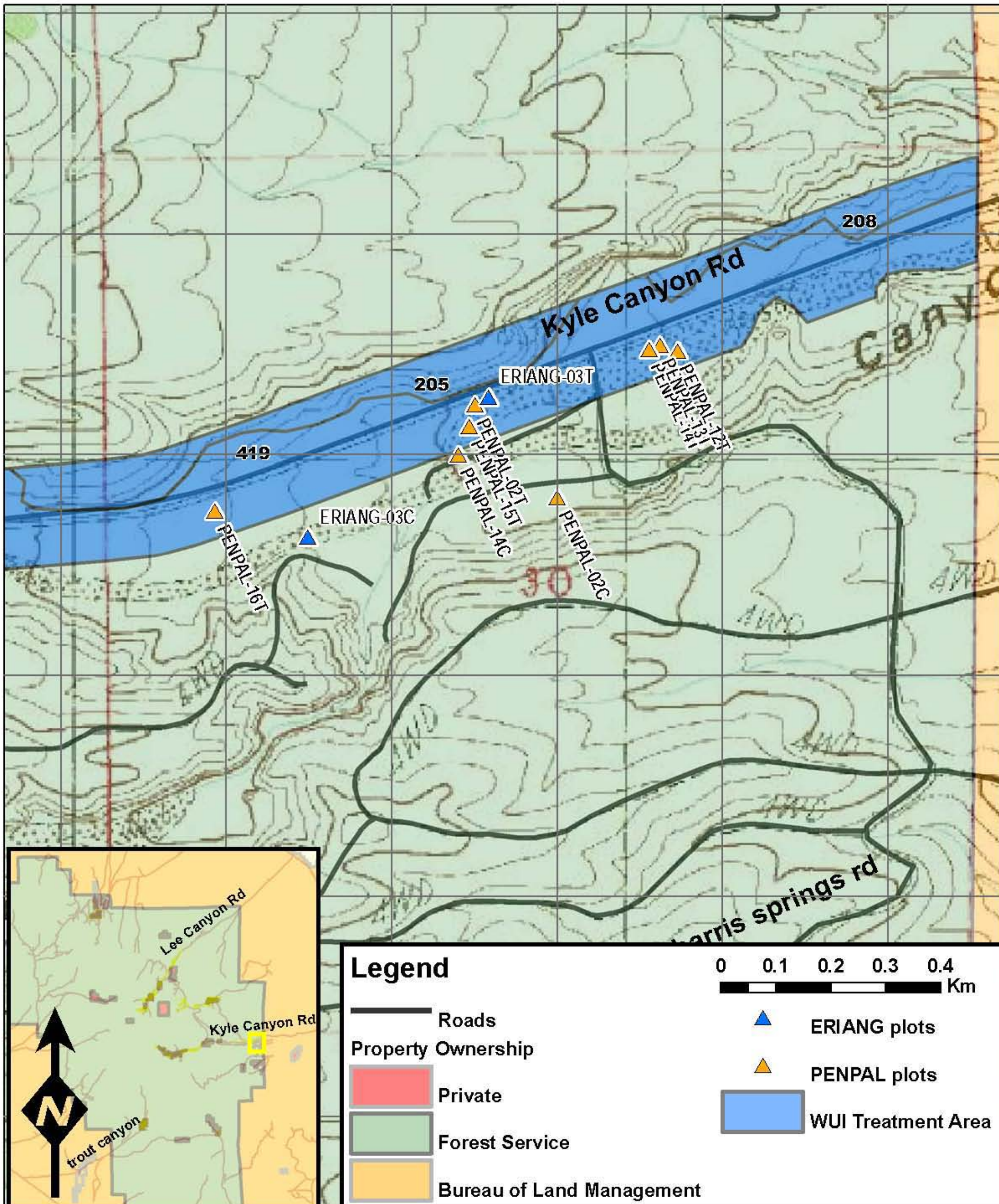
Zone 12 - Map 1: Lower Kyle Canyon
Community Plots [01T, 02T, 03C, 04C]
Heliomeris multiflora* var. *nevadensis [01C, 01T, 02C, 02T, 04C, 04T]



Zone 12 - Map 2: Lower Kyle Canyon

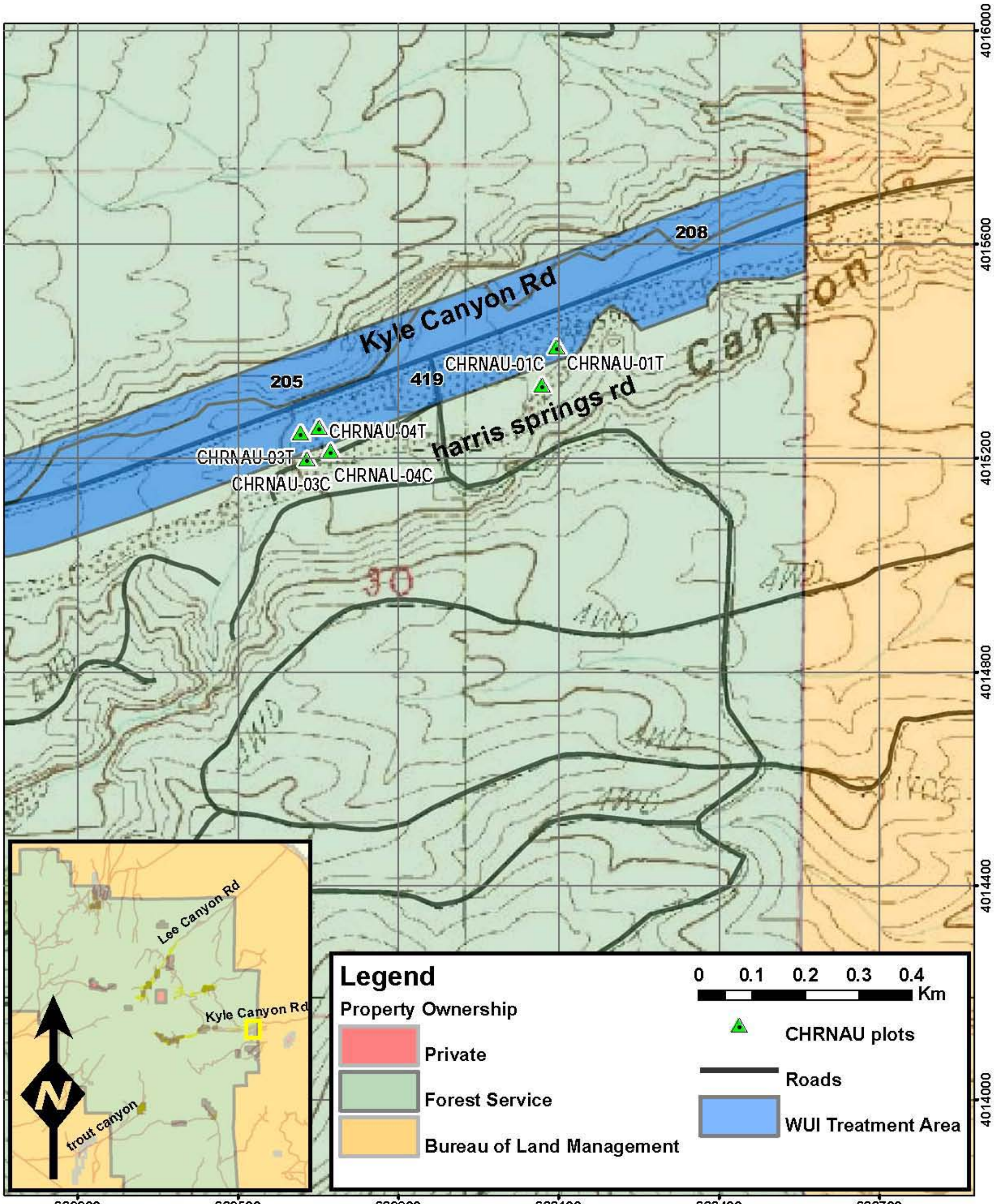
Eriodictyon angustifolium **[03C, 03T]**

Penstemon palmeri **[02C, 02T, 12T, 13T, 14C, 14T, 15T, 16T]**



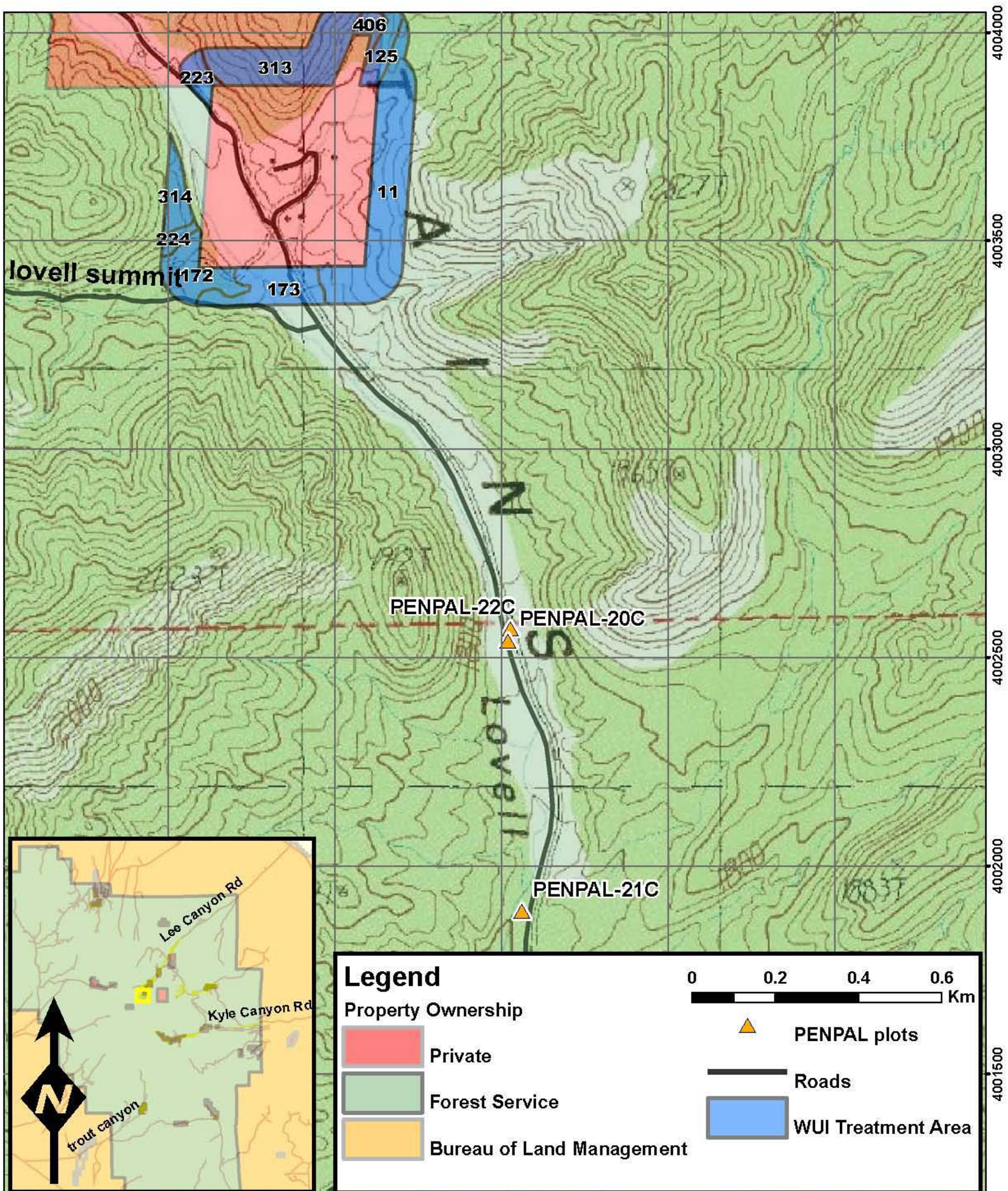
Zone 12 - Map 3: Lower Kyle Canyon

Chrysothamnus (Ericameria) nauseosus [01C, 01T, 03C, 03T, 04C, 04T]



Zone 13 - Map 1: Lovell Canyon

Penstemon palmeri **[20C, 21C, 22C]**



Appendix C. Treatment units and prescriptions as shown by unit number, treatment removal method and the estimated number of acres to be treated per method and number. Removal methods are suggestions and may change based on site-specific implementation per USFS professional option. In all cases, removal methods that are considered to have less resource impacts may be used upon implementation in place of other methodologies.

Unit Number	Treatment/Removal Method	Acres
1	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	6
5	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	1
6	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	7
7	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	1
8	Prune; Hand cut trees and shrubs; Handpile and burn	3
9	Prune; Handpile and burn limbs	4
10	Prune; Handpile and burn limbs	2
11	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	15
12	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	7
101	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	3
102	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	6
103	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	30
104	Prune; Hand cut trees and shrubs; Remove by cable or by hand	4
105	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	5
106	Prune; Hand cut trees and shrubs; Remove by cable or by hand	17
107	Prune; Hand cut trees and shrubs; Remove by cable or by hand	7
108	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	17
109	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	3
110	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	19
111	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	45
112	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	36
113	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	1
114	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	1
115	Prune; Hand cut trees and shrubs; Remove by cable or by hand	3
116	Prune; Hand cut trees and shrubs; Remove trees by helicopter or by hand; Handpile and burn limbs and shrubs	8
117	Prune; Hand cut trees and shrubs; Remove by ground-based machine or by hand; Handpile and burn limbs and shrubs	8
119	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	2

125	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	2
127	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	2
128	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	10
129	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	8
130	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	5
131	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	9
132	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	3
132	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	25
133	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	15
135	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	2
136	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	2
137	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	8
138	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	4
139	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	2
140	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	5
141	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	2
142	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	3
143	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	1
144	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	18
145	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	16
146	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	25
147	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	2
148	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	1
149	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	5
150	Prune; Hand cut trees; Remove trees by cable or by hand; Handpile and burn limbs	6
151	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	2
152	Prune; Hand cut trees; Remove trees by cable or by hand; Handpile and burn limbs	11
153	Prune; Hand cut trees; Remove trees by cable or by hand; Handpile and burn limbs	8
154	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	2
155	Prune; Handpile and burn limbs	15

156	Prune; Hand cut trees; Remove trees by cable or by hand; Handpile and burn limbs	26
157	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	18
158	Prune; Hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	8
160	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	18
161	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	5
162	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	7
163	Prune; Hand cut trees and shrubs; Handpile and burn	34
164	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	3
165	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	19
166	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	16
167	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	8
168	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	4
172	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	4
173	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	5
174	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	20
175	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	1
176	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	17
177	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	2
178	Prune; Hand cut trees and shrubs; Remove trees by ground-based machine; Handpile and burn limbs and shrubs	125
179	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	15
180	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	16
181	Prune; Hand cut trees; Remove trees by cable or by hand; Handpile and burn limbs	2
182	Prune; Hand cut trees and shrubs; Remove by hand	19

183	Prune; Machine or hand cut trees; Remove trees by ground-based machine; Masticate limbs and shrubs	3
185	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	12
186	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	6
187	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	12
189	Prune; Hand cut trees and shrubs; Remove by cable or by hand	19
190	Prune; Masticate limbs and shrubs	7
192	Prune; Masticate limbs and shrubs	119
193	Prune; Masticate limbs and shrubs	35
201	Prune; Hand cut shrubs; Chip on site or remove by cable or by hand or Handpile and burn	12
202	Prune; Hand cut shrubs; Chip on site or remove by cable or by hand	4
203	Prune; Hand cut shrubs; Chip on site or remove by cable or by hand	27
204	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	3
205	Prune; Hand cut shrubs; Chip on site or remove by cable or by hand	16
208	Prune; Hand cut shrubs; Chip on site or remove by cable or by hand	7
209	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	2
210	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	8
211	Prune; Hand cut trees and shrubs; Remove trees by skyline; Handpile and burn limbs and shrubs	21
212	Prune; Hand cut trees and shrubs; Remove trees by skyline; Handpile and burn limbs and shrubs	27
213	Prune; Hand cut trees and shrubs; Remove by cable or by hand	12
214	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	7
215	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	16
216	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	3
217	Prune; Hand cut trees and shrubs; Chip on site or remove by cable or by hand	3
218	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	37
219	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	2
223	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	2
224	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	1

228	Prune; Hand cut trees and shrubs; Remove trees by helicopter; Handpile and burn limbs and shrubs	12
229	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	17
230	Prune; Hand cut trees and shrubs; Remove trees by skyline; Handpile and burn limbs and shrubs	24
231	Prune; Hand cut trees and shrubs; Remove trees by skyline; Handpile and burn limbs and shrubs	45
232	Prune; Hand cut trees and shrubs; Remove trees by skyline; Handpile and burn limbs and shrubs	16
233	Prune; Hand cut trees and shrubs; Remove trees by helicopter; Handpile and burn limbs and shrubs	7
234	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	4
235	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	12
236	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	3
237	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	14
238	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	3
239	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	3
240	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	3
241	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	7
242	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	1
243	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	2
244	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	2
245	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	4
246	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	20
247	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	1
248	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	13
249	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	18
250	Prune; Handpile and burn limbs	4
251	Prune; Handpile and burn limbs	16
252	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	6
253	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	15
254	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	1
255	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	2
256	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	3

257	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	1
258	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	1
259	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	9
260	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	5
261	Prune; Hand cut trees and shrubs; Remove trees by skyline; Handpile and burn limbs and shrubs	33
262	Prune; Hand cut trees and shrubs; Remove by helicopter or by hand	10
263	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	13
264	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	5
265	Prune; Hand cut trees and shrubs; Handpile and burn	4
266	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	6
267	Prune; Hand cut trees and shrubs; Remove trees by cable or by hand; Handpile and burn limbs and shrubs	29
268	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	2
269	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	3
271	Prune; Hand cut trees and shrubs; Handpile and burn	13
272	Prune; Hand cut trees and shrubs; Handpile and burn	7
273	Prune; Hand cut trees and shrubs; Handpile and burn	8
275	Prune; Hand cut trees and shrubs; Remove trees by skyline; Handpile and burn limbs and shrubs	33
276	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	17
277	Prune; Hand cut trees and shrubs; Remove trees by skyline; Handpile and burn limbs and shrubs	9
278	Prune; Hand cut trees and shrubs; Remove trees by skyline; Handpile and burn limbs and shrubs	12
279	Prune; Hand cut trees and shrubs; Remove trees by skyline; Handpile and burn limbs and shrubs	4
280	Prune; Hand cut trees and shrubs; Remove trees by skyline; Handpile and burn limbs and shrubs	8
281	Prune; Hand cut trees and shrubs; Remove trees by skyline; Handpile and burn limbs and shrubs	28
301	Prune; Hand cut shrubs; Remove by helicopter or by hand	20
302	Prune; Hand cut trees and shrubs; Remove trees by helicopter or by hand; Handpile and burn limbs and shrubs	30
303	Prune; Hand cut trees and shrubs; Remove trees by helicopter or by hand; Handpile and burn limbs and shrubs	30
304	Prune; Hand cut trees and shrubs; Remove by helicopter or by hand	7
305	Prune; Hand cut trees and shrubs; Remove trees by helicopter or by hand; Handpile and burn limbs and shrubs	8
306	Prune; Hand cut trees and shrubs; Remove trees by helicopter; Handpile and burn limbs and shrubs	15
307	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	6

308	Prune; Hand cut trees and shrubs; Remove trees by helicopter; Handpile and burn limbs and shrubs	2
309	Prune; Hand cut trees and shrubs; Remove trees by helicopter; Handpile and burn limbs and shrubs	3
310	Prune; Hand cut trees and shrubs; Remove trees by helicopter; Handpile and burn limbs and shrubs	15
311	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	10
312	Prune; Hand cut trees and shrubs; Remove trees by helicopter; Handpile and burn limbs and shrubs	7
313	Prune; Hand cut trees and shrubs; Handpile and burn	10
314	Prune; Hand cut trees and shrubs; Remove trees by helicopter; Handpile and burn limbs and shrubs	2
316	Prune; Hand cut trees and shrubs; Remove trees by helicopter; Handpile and burn limbs and shrubs	2
317	Prune; Hand cut trees and shrubs; Remove trees by helicopter; Handpile and burn limbs and shrubs	21
318	Prune; Hand cut trees and shrubs; Remove trees by helicopter; Handpile and burn limbs and shrubs	9
319	Prune; Hand cut trees and shrubs; Remove trees by helicopter; Handpile and burn limbs and shrubs	4
320	Prune; Hand cut trees and shrubs; Remove trees by helicopter; Handpile and burn limbs and shrubs	3
321	Prune; Hand cut trees and shrubs; Remove trees by helicopter; Handpile and burn limbs and shrubs	9
322	Prune; Hand cut trees and shrubs; Remove trees by helicopter or by hand; Handpile and burn limbs and shrubs	31
401	Prune; Masticate limbs and shrubs	24
402	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	17
403	Prune; Masticate limbs and shrubs	14
404	Prune; Hand cut shrubs; Remove by hand	4
406	Prune; Masticate limbs and shrubs	1
408	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	6
409	Prune; Masticate limbs and shrubs	17
410	Prune; Hand cut shrubs; Chip on site or remove by hand	10
413	Prune; Masticate limbs and shrubs	1
414	Prune; Hand cut shrubs; Handpile and burn shrubs and limbs	3
415	Prune; Masticate limbs and shrubs	8
416	Prune; Masticate limbs and shrubs	13
417	Prune; Masticate limbs and shrubs	3
418	Prune; Masticate limbs and shrubs	20
419	Prune; Masticate limbs and shrubs	86
420	Prune; Hand cut shrubs; Chip on site or remove by hand	4
421	Prune; Hand cut trees and shrubs; Remove trees by cable; Handpile and burn limbs and shrubs	3

Appendix D. Example data sheets for the listed ecosystem sample techniques including the point intercept cover sampling, herbaceous species sampling, shrub density and species richness.

Park/Unit 4-Character Alpha Code: ________

FMH-16 **30 m TRANSECT DATA SHEET**

Plot ID: ____________________ B/C (Circle One) Date: ___/___/___

Burn Unit: ____________________ Recorders: ____________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ____-yr02 ____-yr05 ____-yr10 ____-yr20Other: ____-yr____; ____-mo____

Phenological Stage: ____________________ (Circle One) Q4–30 m w 0P–30P

Pnt	Tape	Hgt (m)	Spp; Species or Substrate Codes (tallest to lowest)					
1	0.3							
2	0.6							
3	0.9							
4	1.2							
5	1.5							
6	1.8							
7	2.1							
8	2.4							
9	2.7							
10	3.0							
11	3.3							
12	3.6							
13	3.9							
14	4.2							
15	4.5							
16	4.8							
17	5.1							
18	5.4							
19	5.7							
20	6.0							
21	6.3							
22	6.6							
23	6.9							
24	7.2							
25	7.5							
26	7.8							
27	8.1							
28	8.4							
29	8.7							
30	9.0							
31	9.3							
32	9.6							
33	9.9							
34	10.2							
35	10.5							
36	10.8							
37	11.1							
38	11.4							
39	11.7							
40	12.0							
41	12.3							
42	12.6							
43	12.9							
44	13.2							
45	13.5							
46	13.8							
47	14.1							

Date Entered: ___/___/___ FMH-16

Pnt	Tape	Hgt (m)	Spp; Species or Substrate Codes (tallest to lowest)					
48	14.4							
49	14.7							
50	15.0							
51	15.3							
52	15.6							
53	15.9							
54	16.2							
55	16.5							
56	16.8							
57	17.1							
58	17.4							
59	17.7							
60	18.0							
61	18.3							
62	18.6							
63	18.9							
64	19.2							
65	19.5							
66	19.8							
67	20.1							
68	20.4							
69	20.7							
70	21.0							
71	21.3							
72	21.6							
73	21.9							
74	22.2							
75	22.5							
76	22.8							
77	23.1							
78	23.4							
79	23.7							
80	24.0							
81	24.3							
82	24.6							
83	24.9							
84	25.2							
85	25.5							
86	25.8							
87	26.1							
88	26.4							
89	26.7							
90	27.0							
91	27.3							
92	27.6							
93	27.9							
94	28.2							
95	28.5							
96	28.8							
97	29.1							
98	29.4							
99	29.7							
100	30.0							

Species observed within ___ m of either side of the transect but not intercepted: ____________________

____

____

____

____

FMH-16

Park/Unit 4-Character Alpha Code: ________

FMH-18 **HERBACEOUS DENSITY DATA SHEET** Page __ of __

Plot ID: ______________________ B / C (Circle One) Date: ___/___/___

Burn Unit: ______________________ Recorders: ______________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

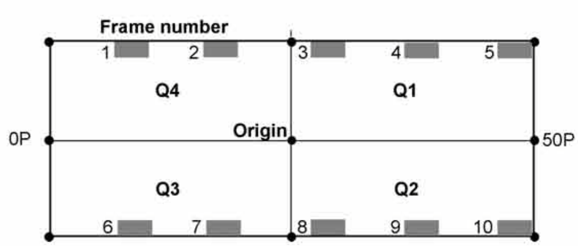
00-PRE ___ Post ___-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr___; ___-mo___

Transect: Q4–Q1 w Q3–Q2 w 0P–50P w Q4–30 m w 0P–30P (Circle One)

For living and dead plants within the transect, count each individual having >50% of its rooted base in the sampling area.

Frame Size:______m²   Side of transect monitored facing 30P (Brush Plots Only):________

Frame #	Spp	Live	Num	Frame #	Spp	Live	Num
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	



Date Entered: ___/___/___ FMH-18

Frame #	Spp	Live	Num	Frame #	Spp	Live	Num
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	
		Y N				Y N	

FMH-18

Park/Unit 4-Character Alpha Code: ________

FMH-17 **SHRUB DENSITY DATA SHEET** Page ___ of ___

Plot ID: ______________________ B / C (Circle One) Date: ___/___/___

Burn Unit: ______________________ Recorders: ______________________

Burn Status:Circle one and indicate number of times treated, e.g., 01-yr01, 02-yr01

00-PRE ____ Post ____-yr01 ___-yr02 ___-yr05 ___-yr10 ___-yr20Other: ___-yr___; ____-mo___

Transect: Q4–Q1 w Q3–Q2 w 0P–50P w Q4–30 m w 0P–30P (Circle One)

For living and dead plants within the transect, count each individual having >50% of its rooted base in the belt. The optional interval field (Int) can be used to divide the belt into subunits to facilitate species counts. Record Age Class (Age) code (see below).

Belt Width:____m Length:____m Side of transect monitored facing 30P (Brush Plots Only):________

Int	Spp	Age	Live	Num / Tally	Int	Spp	Age	Live	Num / Tally
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	
			Y N					Y N	

AgeClassCodes: **I** Immature–Seedling **R** Resprout **M** Mature–Adult

Date Entered: ___/___/___ FMH-17

Park/Unit 4-Character Code:_________

FMH-USGS-1 **SPECIES RICHNESS DATA SHEET** Page ___of___

Plot ID:____________________ Burn Unit:______________ Recorders:______________________________ Date:___/___/___

Check living species present within each subplot

Spp	1	2	3	4	5	6	7	8	9	10	A	B	C	K

Appendix E. Example data sheets for the covered population sampling efforts including the SNNRA plant metrics data sheet and the plot description data sheet**.**

SMNRA Plant Metrics Data Sheet **Species:** **Plot** **Treatment/Control**						**Date** **Observers**			
Belt	**Location**	**Mjr Diam**	**Per Diam**	**Height**	**Inflores. height**	**Stem #**	**Infores #**	**flower heads #**	**Flowers #**
Comments/Notes:									

SMNRA Plant Populations Plot Description Data Sheet

Species:	Date:
Plot #:	Observers:
Treatment / Control	Belts Sampled:

Topography	
Slope:	
Aspect:	
Azimuth:	

Densiometer Measurements				
	N	E	S	W
A				
B				
C				
D				

Occular Estimates			
% sand			
% gravel			
% cobble			
% boulder			
Organic Matter Thickness			
Understory Cover			

Species List

Comments

Appendix F. Distance rules based on interplant distance for each species as to when to consider a plant a unique individual.

Distance Rules for MSHCP covered plants, NHP's, and LHP's	
Scientific name	**Distance rule**
Angelica scabrida	>10 cm between stem origin
Astragalus aequalis	>10 cm between stem origin
Astragalus oophorus var. clokeyanus	>10 cm between stem origin
Townsendia jonesii var. tulmulosa	>2 cm between stem origin
Arenaria kingii spp. rosea	>4 cm between stem origin
Ericameria nauseosa	If plant height is >50cm: 20cm between stem origin; If plant height is <50cm: 10cm between stem origin.
Apocynum androsaemifolium	>5 cm betweem stem origin
Penstemon palmeri	>10 cm between stem origin
Ceanothus greggii	>10 cm between stem origin
Eriodictyon angustifolium	If plant height is >50cm: 10 cm between stem origin; If plant height is <50cm: 4 cm between stem origin.
Packera multilobata	3 cm
Heliomeris multiflora var. nevadensis	3 cm
Eriogonum umbellatum var. subaridum	10 cm
Astragalus calycosus var. calycosus	>1 cm between plant edge
Erigeron clokeyi	>2 cm between stem origin
Chaetopappa ericoides	>2 cm between stem origin
Hymenoxys lemmonii	>3 cm between stem origin
[Machaeranthera canescens	>4 cm between stem origin

Tables

Table 1. Species, populations and ecosystems considered as part of this project. The total number of permanent established plots both within the WUI thinning treatment area 'T' and control 'C'.

Species and Communities Considered	Total Plots Sampled		Individuals Sampled	
	T/C	Total	T/C	Total
MSHCP Plant Species				
Angelica scabrida (rough angelica)	7/5	12	502/360	862
Astragalus aequalis (Clokey milkvetch)	5/7	12	227/239	466
Astragalus oophorus (Clokey eggvetch)	5/4	9	507/416	923
Townsendia jonesii var. *tumulosa* (Charleston grounddaisy)	5/5	10	546/429	975
Arenaria kingii ssp. *rosea* (King's sandwort)	6/6	12	1395/933	2328
Spring Mtns. Acastus Checkerspot Host Plants				
Ericameria nauseosa (rabbitbrush)	5/5	10	479/384	863
Apocynum androsaemifolium (spreading dogbane)	4/4	8	1199/951	2150
Penstemon palmeri (Palmer's penstemon)	7/7	14	94/321	415
Eriodictyon angustifolium (narrowleaf yerba santa)	3/3	6	998/768	1766
Ceanothus greggii (desert ceanothus)	3/3	6	137/193	330
Packera multlobata (lobe-leaf groundsel)	3/3	6	477/474	951
Heliomeris multiflora (Nevada goldeneye)	4/3	7	320/906	1226
Mount Charleston Blue Butterfly Host Plants				
Astragalus calycosus (Torrey's milkvetch)	5/5	10	1217/1267	2484
Erigeron clokeyi (Clokey fleabane)	5/5	10	880/824	1704
Chaetopappa ericoides (heath aster/rose heath)	3/3	6	524/1041	1565
Hymenoxis lemmonii (Lemmon's rubberweed)	6/4	10	1120/740	1860
Machaeranthera canescens (Pinyon aster)	5/5	10	173/294	467
Dark Blue Butterfly Host Plants				
*Eriogonum umbellatum** (Sulfur flower/juniper buckwheat)	5/6	11	491/440	931
Listed Ecosystems (Plant Communities)				
Pinyon−Juniper	10/10	20	na	na
Mixed-conifer	9/9	18	na	na
Sagebrush	8/8	16	na	na

Table 2. Summarization of the plant metrics that were collected for the MSHCP covered plant and cover butterfly host plant plots.

Species	Density	Cover	Basal height	Stem #	Inflores-cence #	Flower-heads [1]	Flower #
MSHCP Plant Species							
Angelica scabrida	x	x	x	x	x*		
Astragalus aequalis	x	x	x	x			x
Astragalus oophorus	x	x	x				x
Townsendia jonesii	x	x	x				x
Arenaria kingii	x	x	x		x		
Spring Mtns. Acastus Checkerspot Host Plants							
Ericameria nauseosa	x	x	x				
Apocynum adrosaemifolium	x	x	x	x			x
Penstemon palmeri	x	x	x		x*		x
Eriodictyon angustifolium	x	x	x				
Ceanothus greggii	x	x	x				
Packera multilobata	x	x	x		x*		
Heliomeris multiflora	x	x	x	x		x	
Mount Charleston Blue Butterfly Host Plants							
Astragalus calycosus	x	x	x				x
Erigeron clokeyi	x	x	x			x*	
Chaetopappa ericoides	x	x	x			x	
Hymenoxys lemmonii	x	x	x		x	x	
Machaeranthera canescens	x	x	x		x	x*	
Dark Blue Butterfly Host Plants							
Eriogonum umbellatum	x	x	x		x*		

Notes: *also measured height of inflorescences. Cover metric is based on major diameter and perpendicular diameter. [1] Indicates that measurements were taken only for species in the Asteraceae Family.

Table 3. Baseline vegetation conditions including abundance (total number), density and cover for the 5 MSHCP covered plant species and the 13 associated host plants for the NSHCP covered butterfly species. Values shown are means and SD.

MSHCP Plant Species	Abundance[1] Mean (SD)		Density (m^2) Mean (SD)		Cover (%)[3] Mean	
	Treatment	Control	Treatment	Control	Treatment	Control
Angelica scabrida (rough angelica)	71.7 (75.4)	72.0 (40.7)	1.4 (2.7)	1.1 (1.5)	7.5	7.9
Astragalus aequalis (Clokey milkvetch)	45.4 (21.4)	34.1 (21.5)	0.4 (0.2)	0.3 (0.2)	1.3	1.3
Astragalus oophorus (Clokey eggvetch)	101.4(38.9)	104.0 (64.2)	1.0 (0.7)	0.8 (0.5)	1.6	0.8
Townsendia jonesii var. *tumulosa* (Charleston grounddaisy)	109.2(130.5)	85.8 (54.8)	1.3 (2.1)	0.9 (0.9)	0.09	0.1
Arenaria kingii ssp. *rosea* (King's sandwort)	232.5(132.1)	133.3 (52.0)	4.9 (1.9)	3.6 (2.3)	1.2	0.8
Spring Mtns. Acastus Checkerspot Host Plants						
Ericameria nauseosa (rabbitbrush)	95.8 (55.4)	76.8 (47.1)	1.56 (1.5)	1.32 (1.4)	21.9	15.1
Apocynum androsaemifolium (spreading dogbane)	299.8(129.4)	237.8(188.1)	4.45 (4.6)	2.53 (1.5)	6.9	3.7
Penstemon palmeri (Palmer's penstemon)	13.4 (14.1)	45.9 (37.5)	0.10 (0.1)	0.36 (0.3)	0.2	0.5
Eriodictyon angustifolium (narrowleaf yerba santa)	332.7(162.5)	256.0(141.2)	2.60 (1.8)	2.0 (1.1)	16.5	37.2
Ceanothus greggii (desert ceanothus)	45.7 (18.2)	64.3 (34.9)	0.36 (0.1)	0.5 (0.2)	14.9	27.2
Packera multilobata (lobe-leaf groundsel)	159.0 (28.6)	158.0 (34.6)	3.44 (0.6)	3.9 (0.9)	0.3	0.3
Heliomeris multiflora (Nevada goldeneye)	80.0 (81.8)	232.0(263.1)	1.76 (2.8)	5.3 (9.1)	1.5	3.9
Mount Charleston Blue Butterfly Host Plants						
Astragalus calycosus (Torrey's milkvetch)	243.4 (150.6	253.4 (127.2)	20.0 (10.8)	26.2 (18.3)	2.6	2.9
Erigeron clokeyi (Clokey fleabane)	176.0 (64.7)	164.8 (89.5)	16.2 (9.1)	10.7 (7.4)	1.7	1.2
Chaetopappa ericoides (heath aster/rose heath)	174.7 (154.5	347.0 (223.3)	5.5 (4.8)	10.8 (6.9)	0.8	1.6
Hymenoxis lemmonii (Lemmon's rubberweed)	133.8 (20.7)	185.0 (107.7)	2.4 (1.3)	5.3 (3.8)	1.5	3.1
Machaeranthera canescens (Pinyon aster)	34.6 (27.9)	58.8 (37.7)	0.3 (0.2)	0.4 (0.3)	0.1	0.2
Dark Blue Butterfly Host Plant						
*Eriogonum umbellatum** (Sulfur flower/juniper buckwheat)	82.7 (59.5)	73.3 (59.7)	0.7 (0.5)	0.57 (0.47)	0.8	0.4

[1] These values are mean plants/plot.
[2] Densities were calculated across all plots and are shown per square meters.
[3] Cover was determined by directly measuring all individual plants sampled across the longest axis or diameter and the perpendicular axis. We then used the area of an ellipse or Area=π*(0.5a)*(0.5b) where a is the longest diameter and b is the perpendicular axis to assess the cover values. Values are mean plant percent cover/m^2.

Table 4. Mean shrub and tree species density and absolute cover for each three listed ecosystem. Density is based on 150 m^2 with 95% confidence intervals shown in parenthesis. Cover values are calculated as percent of total cover from the point intercept sampling transects within the modified Whittaker sampling plots.

ECOSYSTEM TYPE	DENSITY (MEAN)		COVER (% OF TOTAL)	
	Treatment	Control	Treatment	Control
SHRUBS				
Pinyon−Juniper	14.8 (24.0)	16.8 (32.7)	13.3	16.8
Mixed-conifer	23.5 (37.1)	16.1 (30)	3.3	2.2
Sagebrush	8.6 (10.8)	12.4 (26.8)	20.2	18.7
TREES				
Pinyon−Juniper	12.6 (14.8)	13.0 (11.0)	23.0	19.8
Mixed-conifer	9.3 (11.6)	7.1 (8.0)	28.7	28.3
Sagebrush	20.1 (33.7)	6.9 (6.8)	11.3	17.1

Table 5. Mean density of non native invasive species in the plots where they were detected. Recall that five 1 sq m^2 subplots were sampled for herbaceous species in each plot. Values reported are means (m^2) across those subplots and averaged among plots. Non native cover is reported absolute cover for all plots by species for each of the three listed ecosystems. Empty cells indicate that the species was not detected in that ecosystem type and/or treatment.

	LISTED ECOSYSTEM					
Non Native Density	**Sagebrush**		**Pinyon-Juniper**		**Mixed Conifer**	
Species	Treatment	Control	Treatment	Control	Treatment	Control
Bromus tectorum	2.7 (2.8)	15.8 (16.4)	14.4 (14.1)	45.8 (15.2)	--	--
Bromus madritensis	2.9 (3.9)	14.4 (18.0)	--	--	--	--
Erodium cicutarium	1.8 (1.6)	0.6 (0.9)	--	--	--	--
Bromus inermis	--	--	--	--	0.2 (0.4)	--
Non Native Cover	**Sagebrush**		**Pinyon-Juniper**		**Mixed Conifer**	
Species	Treatment	Control	Treatment	Control	Treatment	Control
Bromus tectorum	0.18	0.51	0.35	0.11	--	--
Bromus madritensis	trace	0.13	trace	0.06	--	--
Erodium cicutarium	trace	0.13	--	--	--	--
Bromus inermis	--	--	--	--	--	--

Table 6. Native species richness (total number), individual mean density (and standard deviation) for plots species recorded present and cover (absolute) for each of the three listed ecosystems.

	LISTED ECOSYSTEM					
	Sagebrush		**Pinyon-Juniper**		**Mixed Conifer**	
Native Annual Richness	Treatment	Control	Treatment	Control	Treatment	Control
Forbs	9	13	7	8	--	--
Grasses	--	1	--	--	--	--
Native Annual Density	**Sagebrush**		**Pinyon-Juniper**		**Mixed Conifer**	
Forbs	3.2 (2.6)	13.0 (25.4)	11.3 (9.1)	16.4 (18.3)	--	--
Grasses	--	8.4 (5.6)	--	--	--	--
Grasses	--	--	--	--	--	--

Table 7. Mean native perennial plant (forbs and grasses) species density (m^2) with standard deviation in parentheses for the plots where encountered and cover (absolute) for native perennial forb and grasses for each of the three listed ecosystems. Shrub and tree cover and density are reported in table 3 above.

ECOSYSTEM TYPE	**DENSITY (MEAN/M²)**			
	Forb		**Grass**	
	Treatment	Control	Treatment	Control
Pinyon−Juniper	12.1 (25.3)	6.2 (10.3)	1.9 (2.64)	0.6 (1.3)
Mixed-conifer	7.7 (15.7)	7.3 (12.6)	0.4 (0.9)	8.0 (10.1)
Sagebrush	3.1 (3.9)	6.4 (7.6)	--	--

	COVER (% OF TOTAL)			
	Forb		**Grass**	
	Treatment	Control	Treatment	Control
Pinyon−Juniper	0.69	1.08	1.45	1.70
Mixed-conifer	4.31	2.96	3.21	1.79
Sagebrush	0.44	0.90	0.09	0.32

Table 8. Total species richness for perennial native species detected among the three listed ecosystems in the species richness plots. Note that more species were detected in the species richness plots than may have been recorder in either the density or cover sampling.

ECOSYSTEM TYPE	SPECIES RICHNESS*							
	Forbs		Grasses		Shrubs		Trees	
	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Pinyon−Juniper	52	53	8	6	20	25	5	5
Mixed Conifer	32	28	8	5	10	10	7	8
Sagebrush	46	49	9	8	27	30	5	6

*data included 6 unidentified species thought to be native perennials.

Table 9. Organization for all mapped plot by species or listed ecosystem.

Population Plots			
Inference	**Region**	**Zone/Map**	**Plot Numbers**
Species			
Angelica scabrida	Upper Kyle Canyon	8/1	01C, 01T, 02T, 03C, 03T, 05C, 05T, 06C, 06T, 07C, 07T
Apocynum androsaemifolium	Middle Lee Canyon	4/3	01C, 01T, 02C, 02T, 03C, 03T, 04C, 04T
Arenaria kingii ssp. *rosea*	Upper Lee Canyon	5/1	01C, 01, 02C, 02T, 03C, 03T, 04C, 04T, 05C, 05T
Arenaria kingii ssp. rosea	West Deer Creek	6/1	06C, 06T
Astragalus aequalis	Mack's Canyon	3/1	02T, 03C, 03T, 04C, 04T, 05C, 05T, 06C, 07C
Astragalus aequalis	Kyle Canyon Campground	9/1	01C, 01T, 02C
Astragalus calycosus var. *calycosus*	Middle Lee Canyon	4/2	02T, 03T, 04C, 04T
Astragalus calycosus var. *calycosus*	Upper Lee Canyon	5/2	01C, 03C, 05C, 05T, 06C, 06T
Astragalus oophorus var. *clokeyanus*	Upper Lee Canyon	5/1	01C, 01T, 02C, 02T, 03T, 04C, 04T, 05C, 05T
Ceanothus greggii	Lower Lee Canyon	2/1	01C, 01T, 02C, 02T, 03C, 03T
Chaetopappa ericoides	Lower Lee Canyon	2/1	02C, 02T
Chaetopappa ericoides	Middle Kyle Canyon (A)	10/1	03C, 03T
Chaetopappa ericoides	Middle Kyle Canyon (B)	11/1	01C, 01T
Chrysothamnus (Ericameria) nauseosus	Middle Lee Canyon	4/1	05C, 05T, 06C, 06T
Chrysothamnus (Ericameria) nauseosus	Lower Kyle Canyon	12/3	01C, 01T, 03C, 03T, 04C, 04T
Erigeron clokeyi	Upper Lee Canyon	5/2	01C, 01T, 02C, 02T, 03C, 03T, 04C, 04T, 05C, 05T
Eriodictyon angustifolium	Middle Kyle Canyon (A)	10/1	01C, 02C
Eriodictyon angustifolium	Middle Kyle Canyon (B)	11/1	01T, 02T
Eriodictyon angustifolium	Lower Kyle Canyon	12/2	03C, 03T
Eriogonum umbellatum	Lower Lee Canyon	2/2	05C, 05T, 06C, 06T, 09C, 09T
Eriogonum umbellatum	Middle Lee Canyon	4/3	10C, 10T
Eriogonum umbellatum	Kyle Canyon Campground	9/1	01C, 01T, 02C, 02T
Heliomeris multiflora var. *nevadensis*	Middle Kyle Canyon (A)	10/2	03C, 03T
Heliomeris multifora var. *nevadensis*	Lower Kyle Canyon	12/1	01C, 01T, 02C, 02T, 04C, 04T
Hymenoxys lemmonii	West Deer Creek	6/1	07C, 07T, 08C, 08T, 09C, 09T, 10C, 10T

Cont. next page *Machaeranthera canescens*	Middle Lee Canyon	4/4	03C, 03T, 05C, 05T
Machaeranthera canescens	West Deer Creek	6/2	01C, 01T, 02C, 02T, 04C, 04T
Packera multilobata	Middle Lee Canyon	4/2	01C, 01T, 02C, 02T, 03C, 03T
Penstemon palmeri	Middle Kyle Canyon (A)	10/2	10C, 10T, 11C
Penstemon palmeri	Lower Kyle Canyon	12/2	02C, 02T, 12T, 13T, 14C, 14T, 15T, 16T
Penstemon palmeri	Lovell Canyon	13/1	20C, 21C, 22C
Townsendia jonesii var. *tumulosa*	Middle Lee Canyon	4/3	04C, 04T, 10C, 10T
Townsendia jonesii var. *tumulosa*	West Deer Creek	6/3	01C, 01T, 02C, 02T, 05C, 05T
Community Plots			
Vegetation Type			
Pinyon-Juniper	Cold Creek	1/1	70C, 71T
Pinyon-Juniper	Lower Lee Canyon	2/1	21T, 22T, 23T, 24C, 25C, 26C, 27C, 29T, 30T, 32C
Mixed Conifer	Middle Lee Canyon	4/1	64T, 65T, 66T, 67C, 68C, 69C
Mixed Conifer	Upper Lee Canyon	5/1	51C, 52T, 53C, 54T, 62T, 63C
Sagebrush	West Deer Creek	6/1	42C, 44C
Sagebrush	East Deer Creek	7/1	45T, 46C, 47T, 48C
Mixed Conifer	Upper Kyle Canyon	8/1	56T, 57T, 58C, 59C, 60T, 61C
Pinyon-Juniper	Kyle Canyon Campground	9/1	13T, 14T, 15C, 16C, 17T, 18T, 19C, 20C
Sagebrush	Middle Kyle Canyon (A)	10/1	05T, 06T, 07T, 08T, 10C, 11C, 12C
Sagebrush	Lower Kyle Canyon	12/1	01T, 02T, 03C, 04C

Figures

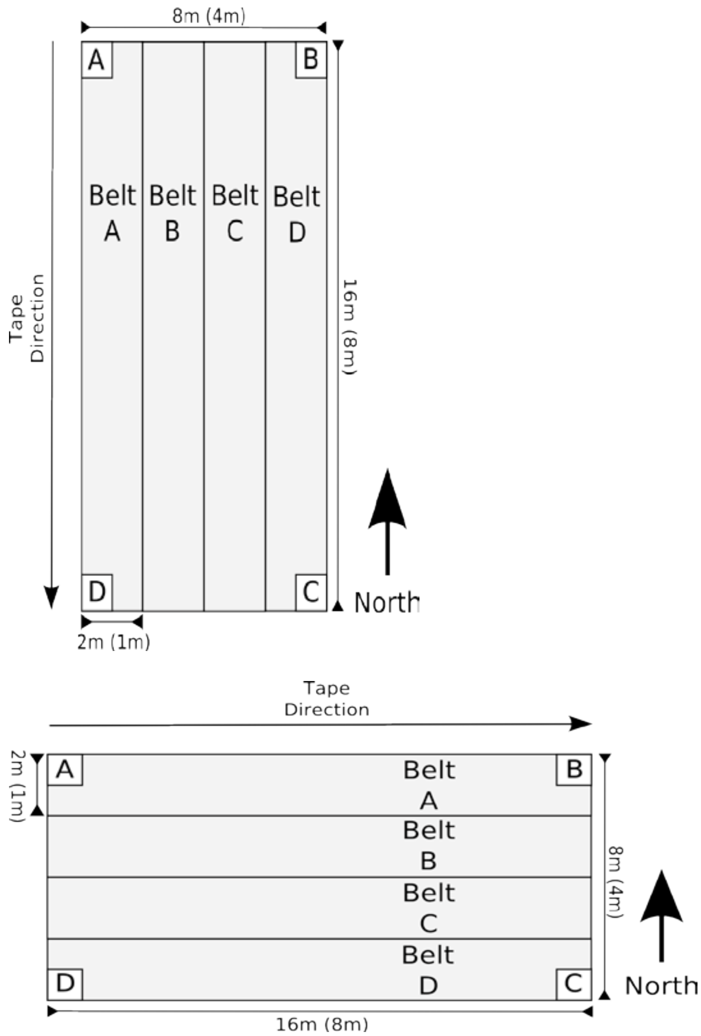


Figure 1. (top) An example of a plot in which the length of the plot runs in a north to south orientation. Numbers in parentheses represent plot dimensions of an 8m x 4m plot. (bottom) An example of a plot in which the length of the plot runs west to east. Numbers in parentheses represent plot dimensions of an 8m x 4m plot.

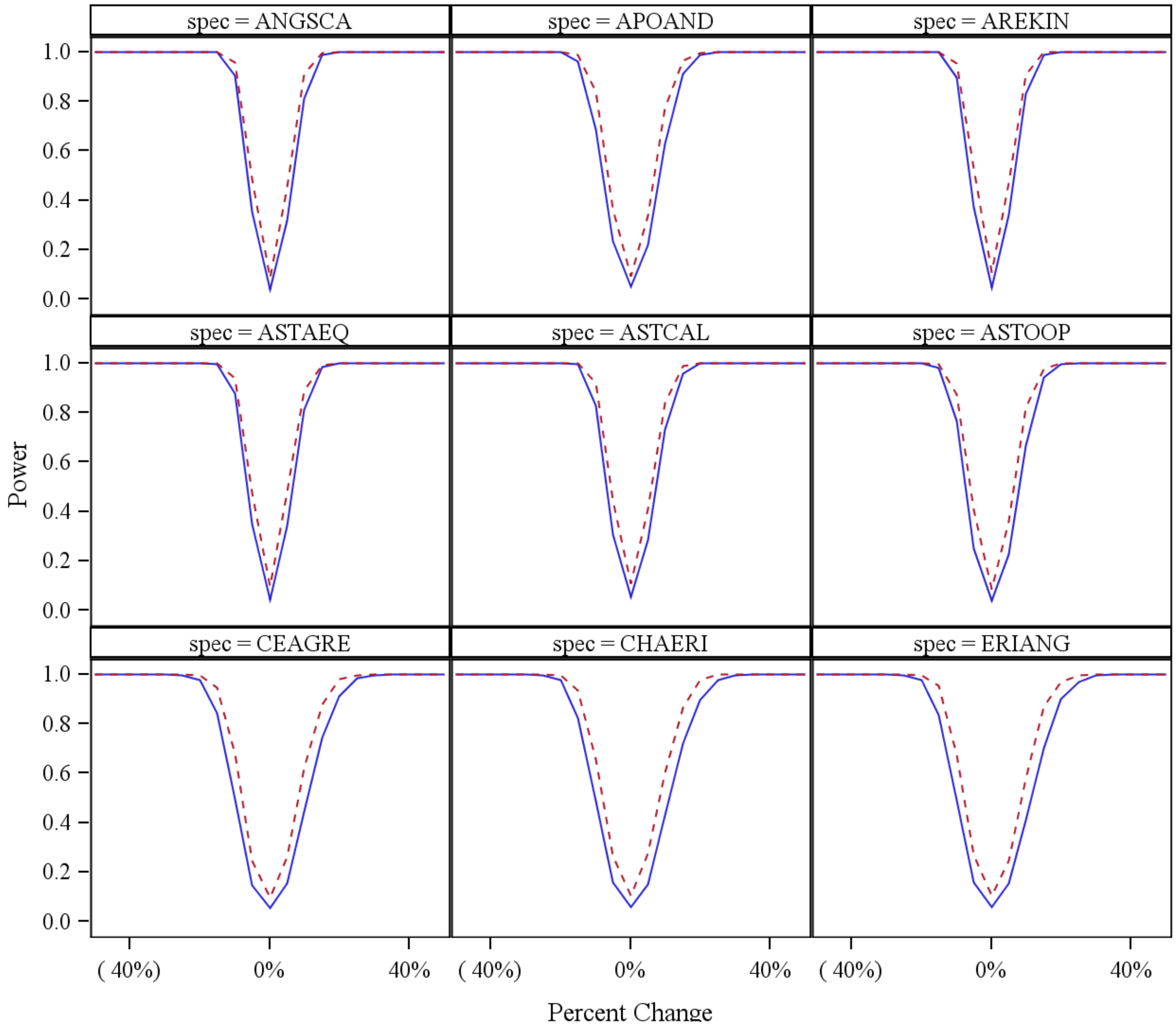


Figure 2-A (see caption below)

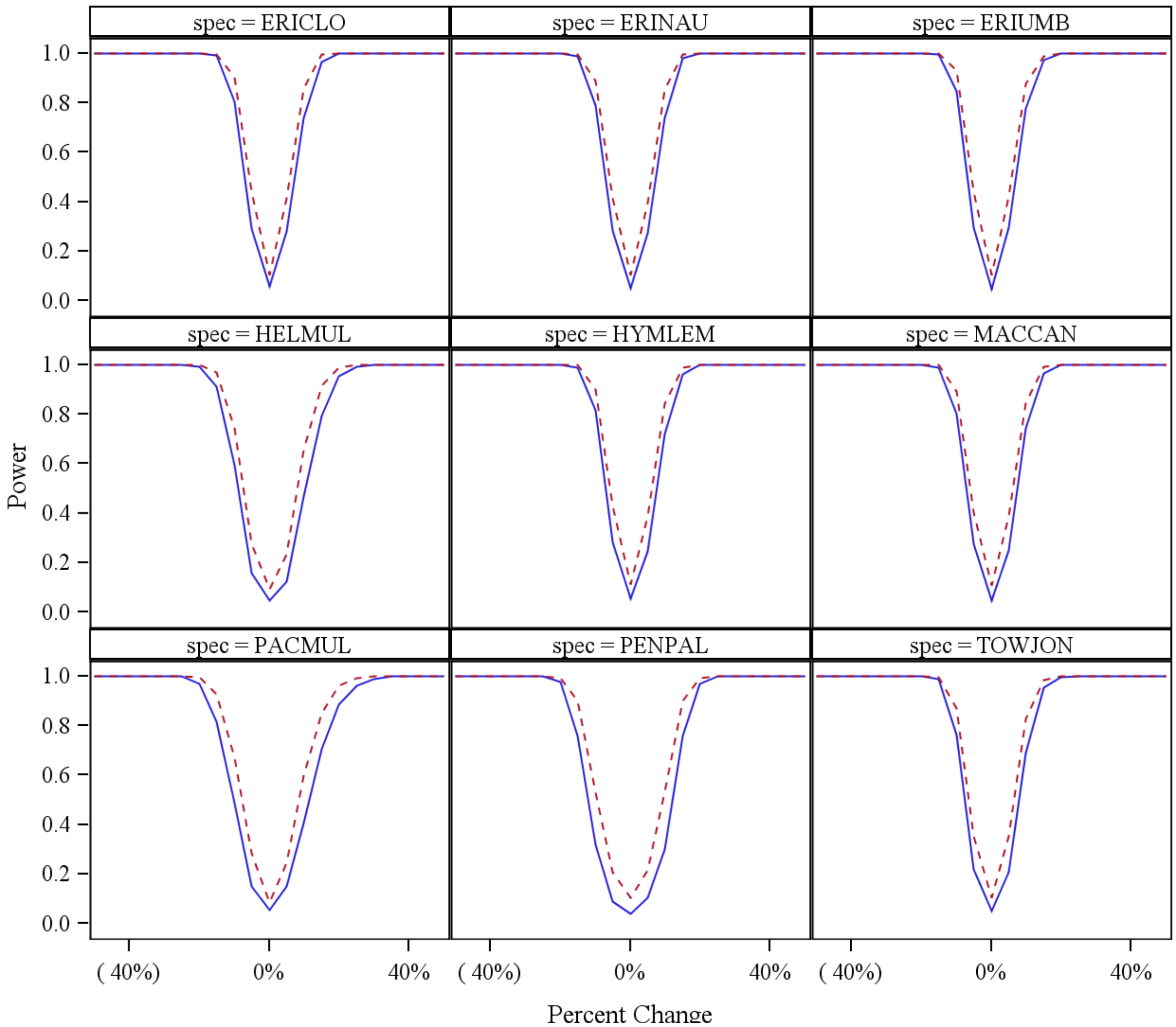


Figure 2-B (see caption below)

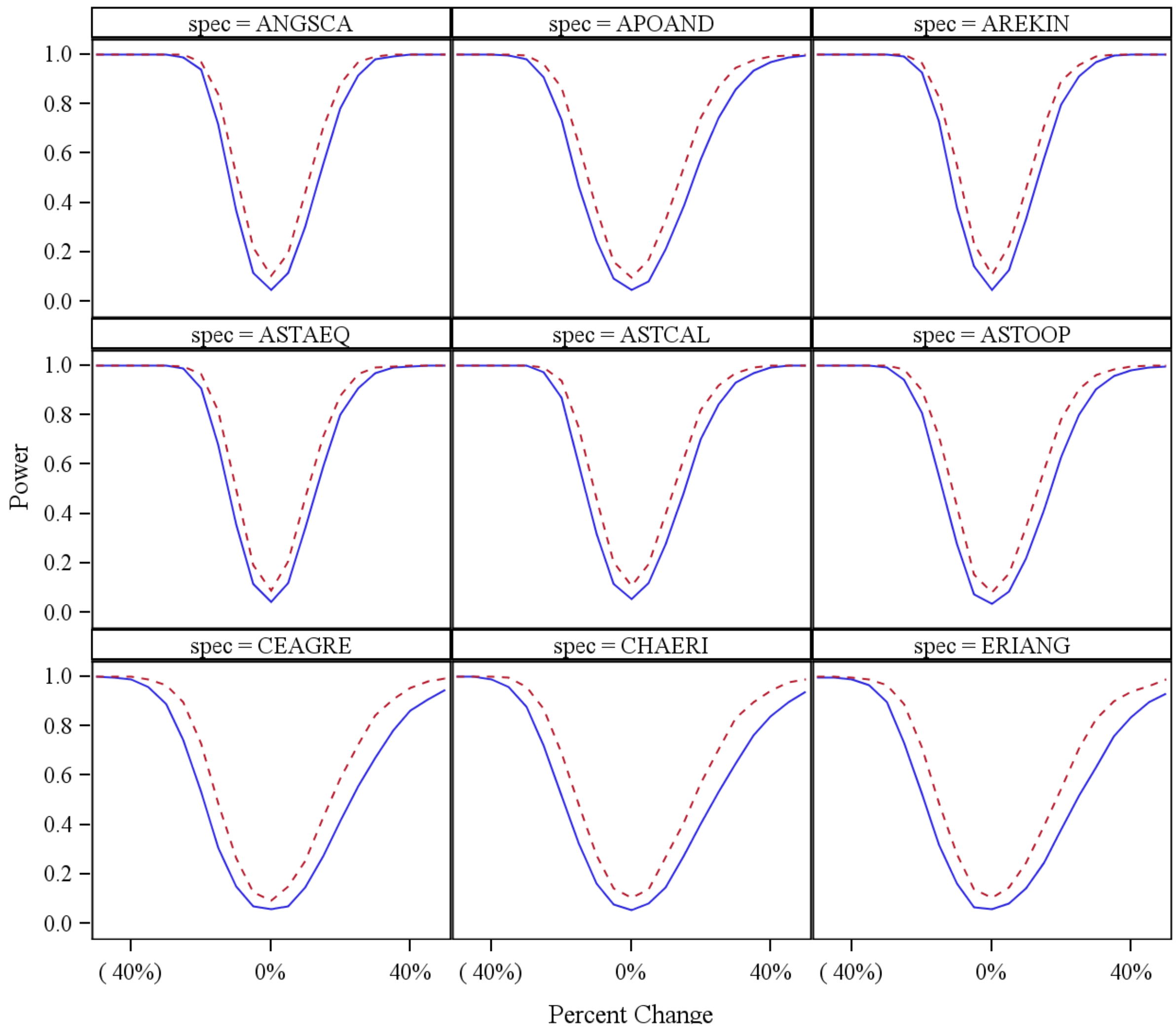
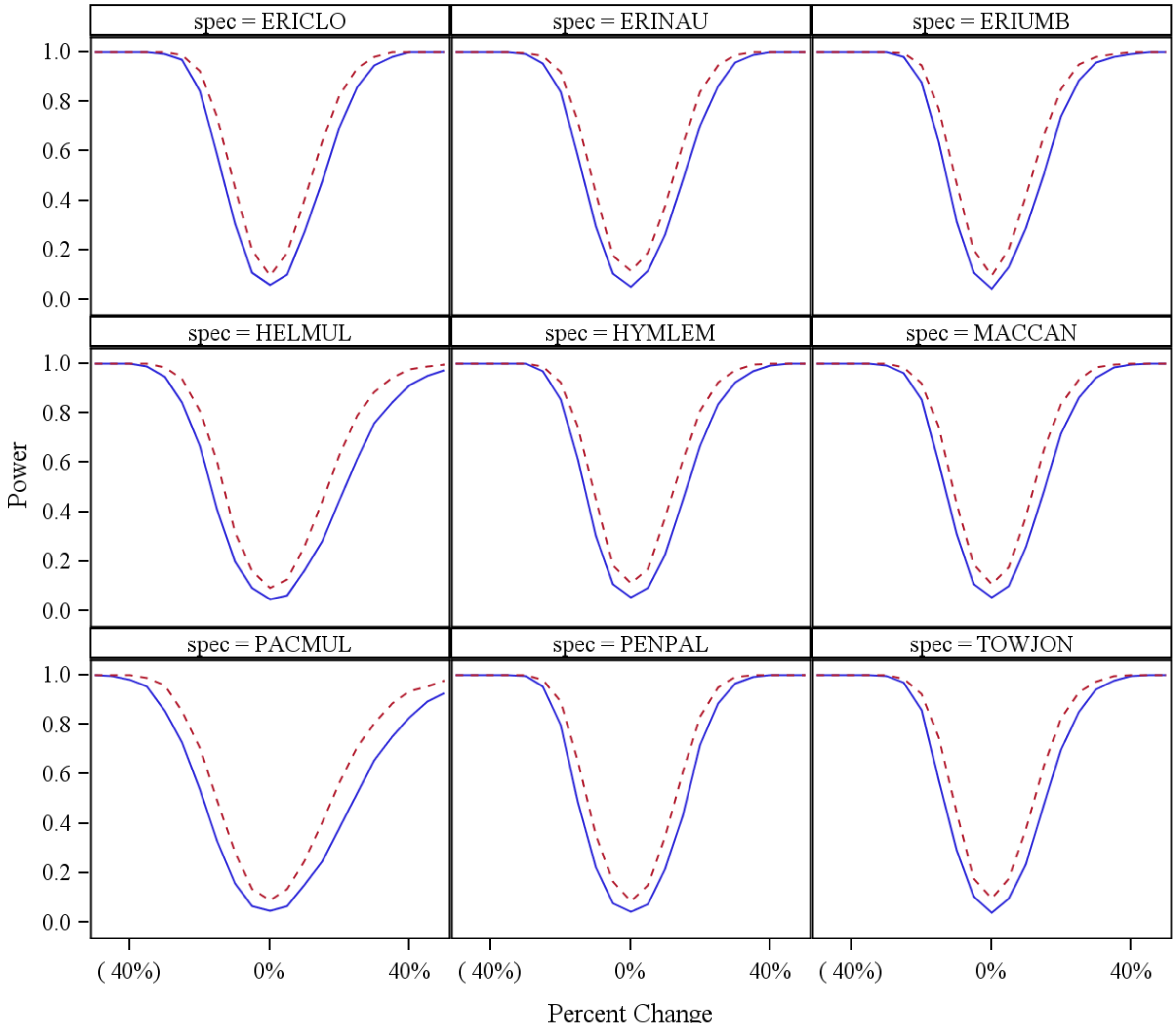
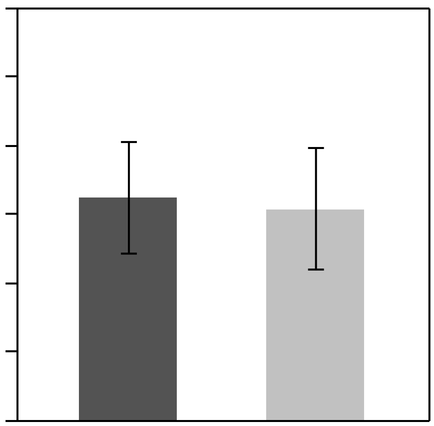
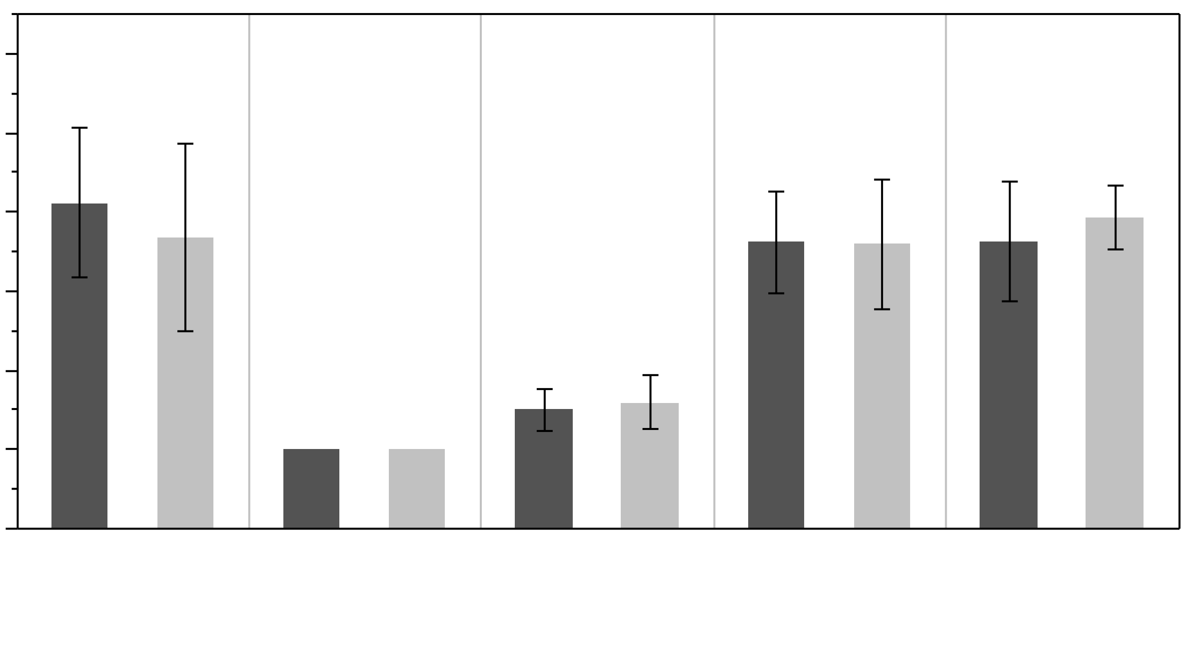


Figure 2-C (see caption below)

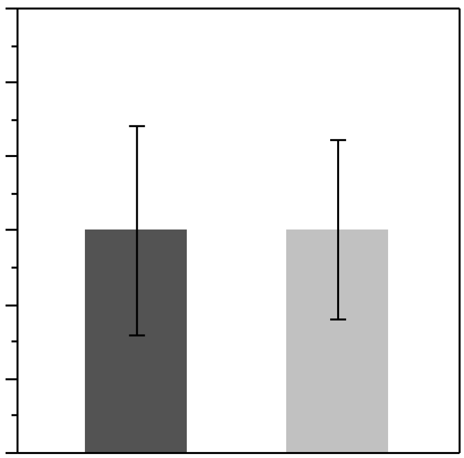


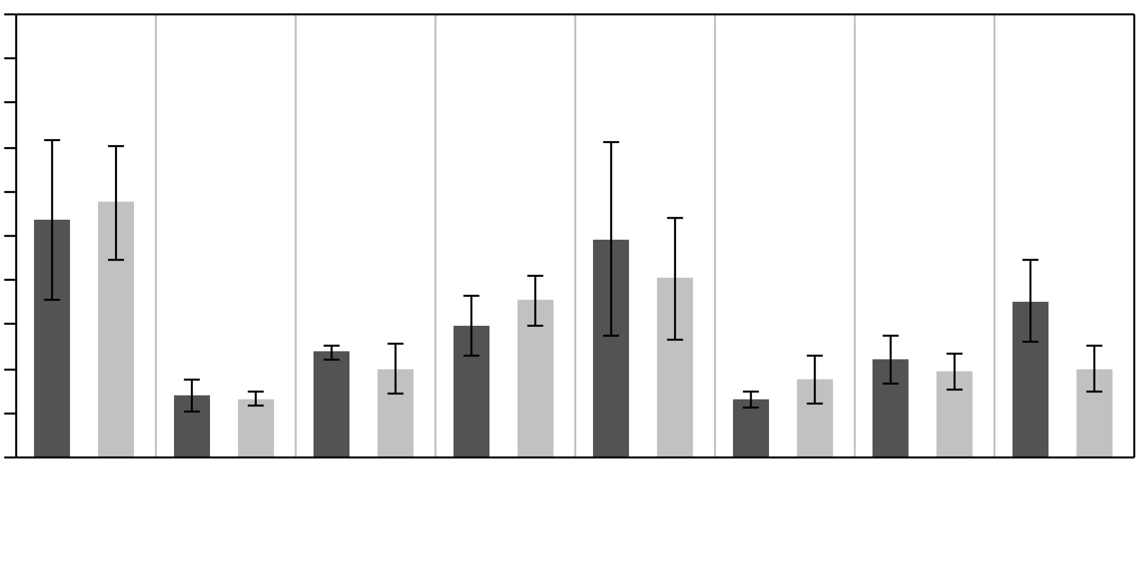
Figures 2 A, B, C and D. Power of detecting treatment effects as a function of the size of the treatment effect (percent change) based on tests at the alpha 0.05 (solid line) and 0.10 (dashed red) significance levels. Figures A and B are based on 0.5 relative standard deviation or a percent standard deviation of 5% and Figure C and D are based on 0.1 relative standard deviation or a percent deviation of 1%. Note that the power to detect changes is shown on the y-axis and percent change at each alpha level is shown on the x-axis. Species codes are shown in Appendix A.



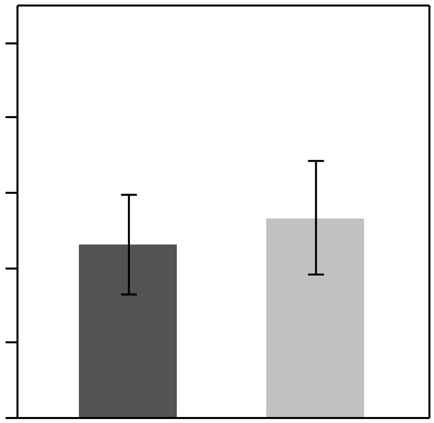


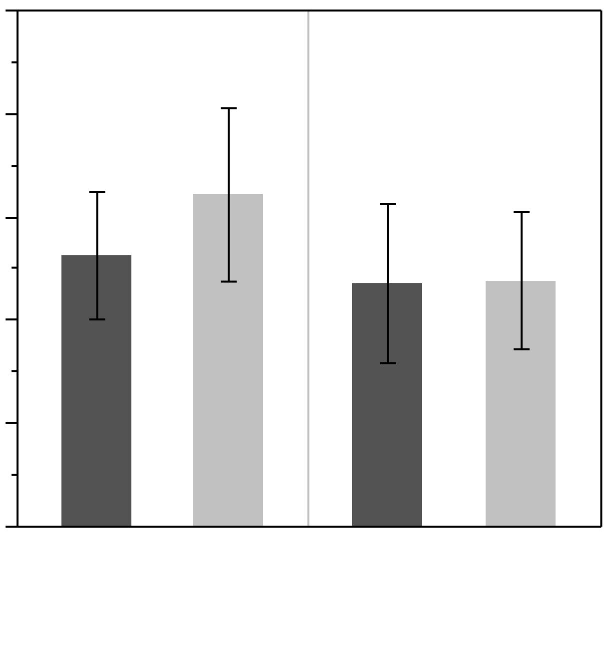
Figures 3 A and B. Tree density for all individuals of all species combined for the Pinyon-Juniper listed ecosystem (A-top) among the treatment and control plots and individually by species (B) based on mean tree density per 150 m^2 plots. Species comparisons among treatment and control plots are provided for 'A' and for 'B' where *ns* indicates non significant result and ** indicates that insufficient individuals where present to drawn comparative results. Data are square root transformed means and bars indicated a 95% confidence interval. Species codes are shown in Appendix A.





Figures 4 A and B. Shrub density for all individuals of all species combined for the Pinyon-Juniper listed ecosystem (A-top) among the treatment and control plots and individually by species (B) based on mean tree density per 150 m^2 plots. Species comparisons among treatment and control plots are provided for ‘A’ and for ‘B’ where *ns* indicates non significant result and ** indicates that insufficient individuals where present to drawn comparative results. Data are square root transformed means and bars indicated a 95% confidence interval. Species codes are shown in Appendix A. The following species were not included because a lack of data in one of the treatment types to evaluate comparisons; ARCPUN, CEAGRE, CHRNAU, COLRAM, EPHNEV, ERIFAS, ESCVIV, FALPAR, OPUPHA, STEPAU, and SYMLON. Species codes are shown in Appendix A.





Figures 5 A and B. Tree density for all individuals of all species combined for the mixed conifer listed ecosystem (A-top) among the treatment and control plots and individually by species (B) based on mean tree density per 150 m^2 plots. Species comparisons among treatment and control plots are provided for ‘A’ and for ‘B’ where *ns* indicates non significant result and ** indicates that insufficient individuals where present to drawn comparative results. Data are square root transformed means and bars indicated a 95% confidence interval. Species codes are shown in Appendix A. The following species were not included because a lack of data in one of the treatment types to evaluate comparisons; CERLED, JUNOST and PINFLE. Species codes are shown in Appendix A.

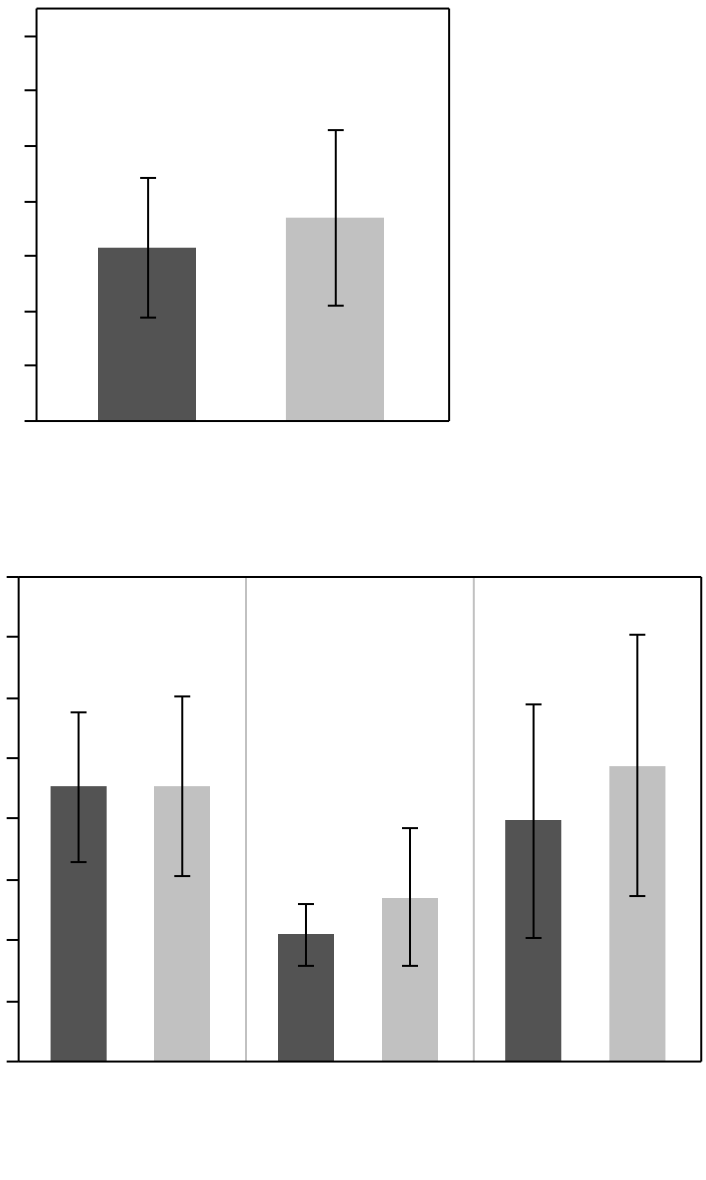
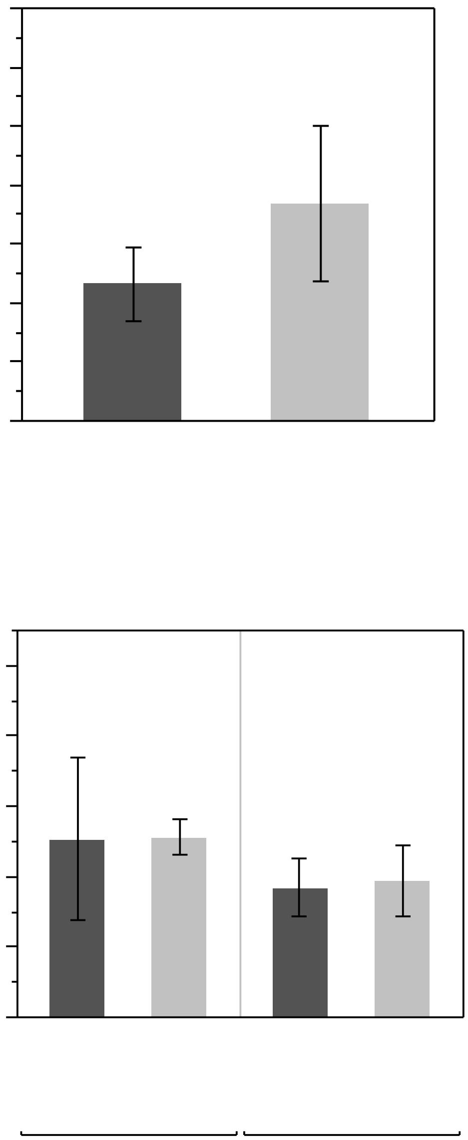
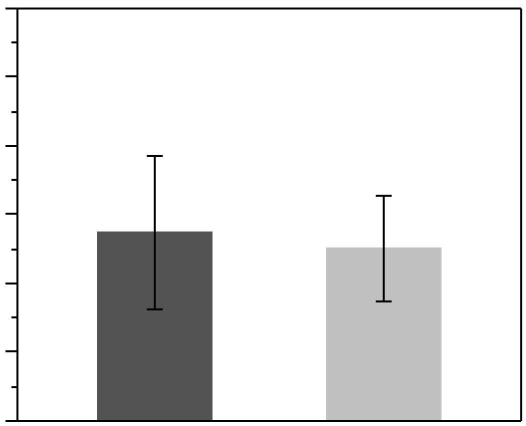
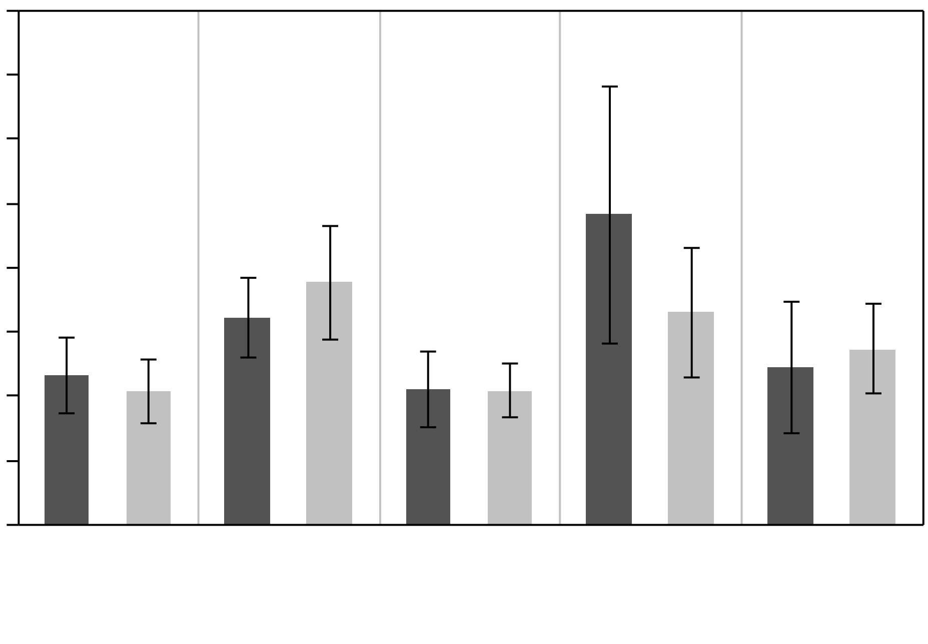


Figure 6 A and B. Shrub density for all individuals of all species combined for the mixed conifer listed ecosystem (A-top) among the treatment and control plots and individually by species (B) based on mean tree density per 150 m^2 plots. Species comparisons among treatment and control plots are provided for 'A' and for 'B' where *ns* indicates non significant result and ** indicates that insufficient individuals where present to drawn comparative results. Data are square root transformed means and bars indicated a 95% confidence interval. Species codes are shown in Appendix A. . The following species were not included because a lack of data in one of the treatment types to evaluate comparisons; CHRVIS, ERIUMB, RIBAUR, RIBCER and SAMMEX. Species codes are shown in Appendix A.

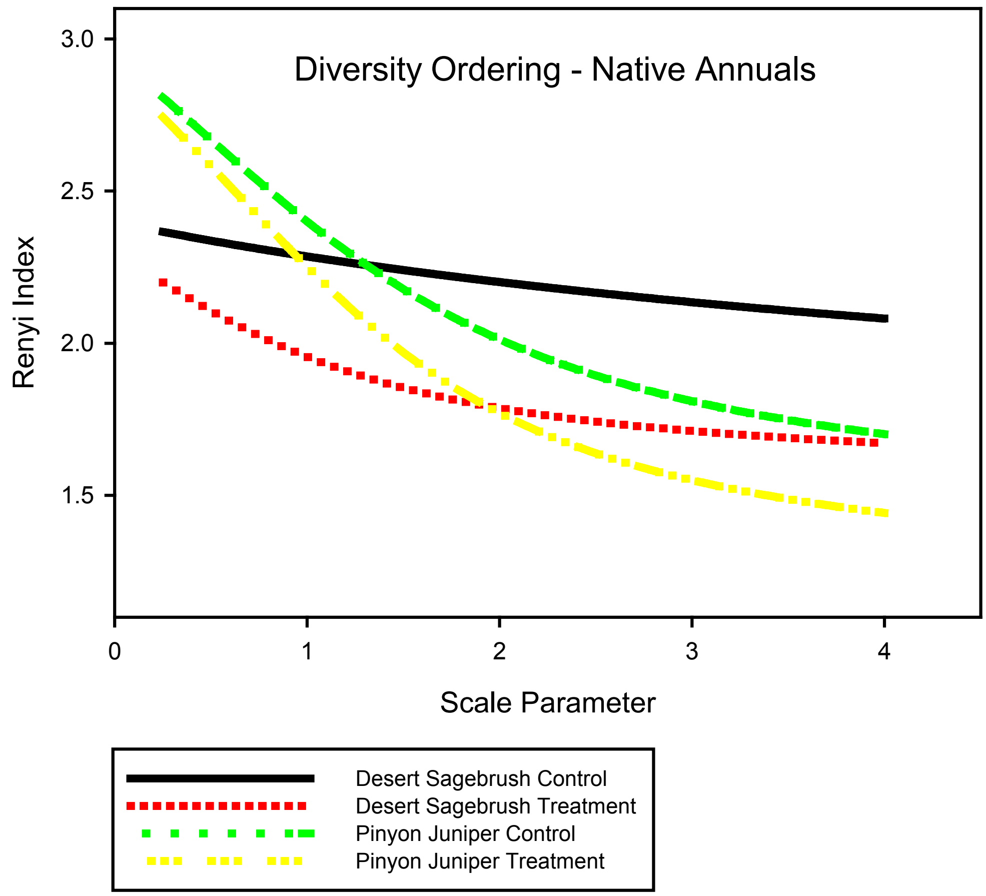


Figures 7 A and B. Tree density for all individuals of all species combined for the Desert Sagebrush listed ecosystem (A-top) among the treatment and control plots and individually by species (B) based on mean tree density per 150 m^2 plots. Species comparisons among treatment and control plots are provided for 'A' and for 'B' where *ns* indicates non significant result and ** indicates that insufficient individuals where present to drawn comparative results. Data are square root transformed means and bars indicated a 95% confidence interval. Species codes are shown in Appendix A. The following species were not included because a lack of data in one of the treatment types to evaluate comparisons; ABICON, CERLED, JUNOST, JUNSCO and QUEGAM. Species codes are shown in Appendix A.





Figures 8 A and B. Shrub density for all individuals of all species combined for the Desert Sagebrush listed ecosystem (A-top) among the treatment and control plots and individually by species (B) based on mean tree density per 150 m^2 plots. Species comparisons among treatment and control plots are provided for ‘A’ and for ‘B’ where *ns* indicates non significant result and ** indicates that insufficient individuals where present to drawn comparative results. Data are square root transformed means and bars indicated a 95% confidence interval. Species codes are shown in Appendix A. The following species were not included because a lack of data in one of the treatment types to evaluate comparisons: ATRCAN, BERFRE, CEAGRE CHRVIS COLRAM, CHRNAU, EPHNEV FALPAR, GARFLA, OPUECH, OPUERI, OPUPHA, SYM SPP. and YUC SPP. Species codes are shown in Appendix A.



Figures 9. Diversity ordering of Rényi curves based on plotting the Rényi index against the scale parameter for the species level of native annuals species for the sagebrush and Pinyon Juniper listed ecosystems. Greater Rényi index values suggest greater diversity for a given population at any given scale parameter. The scale parameters are differing diversity indices with 0 representing species number, 1 representing Shannon's H, 2 representing Simpson's D, and so on. With increasing scale parameter values, more abundant species/functional groups are progressively weighted more heavily.

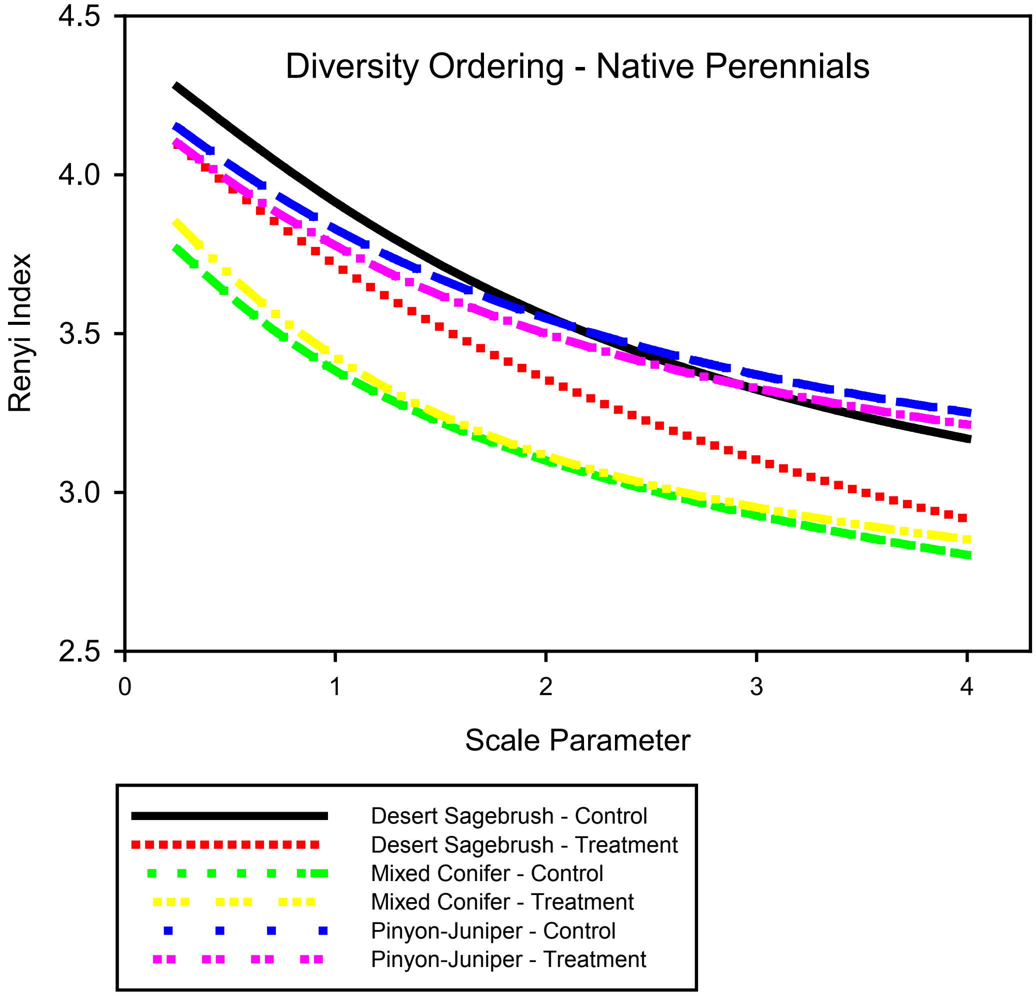


Figure 10. Native perennial species (forbs, grasses, shrubs and trees) diversity ordering of Rényi curves based on plotting the Rényi index against the scale parameter for the species level of native perennial species for three listed ecosystems by treatment type. Greater Rényi index values suggest greater diversity for a given population at any given scale parameter. The scale parameters are differing diversity indices with 0 representing species number, 1 representing Shannon's H, 2 representing Simpson's D, and so on. With increasing scale parameter values, more abundant species/functional groups are progressively weighted more heavily.

Photos

Photo 1. The “B” corner stake of a population treatment plot**.**

Photo 2. Population plot showing each of the four sampling belts.

Photo 3. Close up of *Erigeron clokeyi* a host plant for the Mt, Charleston Blue butterfly.

Photo 4. Community sampling plot in the pinyon-juniper listed ecosystem.