University of Nevada, Reno

The Effects of Elevation, Tree Cover, and Fire on Ant Populations in a Pinyon-Juniper Dominated Watershed

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by

Eugénie M. MontBlanc

Peter F. Brussard and Jeanne C. Chambers, Thesis Advisors

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Abstract

Climate change and fire suppression have facilitated expansion of pinyon-juniper woodlands into sagebrush-steppe ecosystems of the Great Basin, resulting in a loss of biological diversity. In order to assess the effects of restoration efforts using prescribed fire, ant species richness, abundance, and composition were examined pre- and post-burn along the elevation and tree cover gradients encompassed by a pinyon-juniper woodland in a central Nevada watershed. Ants were sampled using pitfall traps in six sites, representing paired burn and control sites in a randomized block design. Species richness remained unchanged for all treatments. Burn treatment and tree cover had no significant effect on ant populations. According to ANOVA and multivariate analyses, elevation had the greatest effect on changes in ant communities, likely due to increased moisture availability. These results suggest that maintaining habitat mosaics along a range of elevations can result in maximum ant species diversity.

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Introduction

Climate change, overgrazing by livestock, and fire suppression have facilitated expansion of single-leaf pinyon (*Pinus monopylla*) and Utah juniper (*Juniperus osteosperma*) woodlands into sagebrush ecosystems of the Great Basin (Tausch et al. 2004, Miller and Tausch 2001, Chambers et al. 2000, Miller and Rose 1999, Tausch et al. 1981). The tree expansion has occurred over an elevation gradient that includes several sagebrush community types: Wyoming sagebrush (*Artemisia tridentata wyomingensis*) at the lowest elevations, Vasey sagebrush (*Artemisia tridentata vaseyana*) at intermediate elevations, and mountain brush communities with Vasey sagebrush at the highest elevations (Chambers et al. 2000). Increases in tree stand densities over time result in the reduction of both sagebrush and perennial herbaceous vegetation (Miller et al. 2000, Tausch and Tueller 1990). The reduction in fine herbaceous vegetation and increase in dense woody vegetation have resulted in a decrease in more frequent, low-impact fires and an increase in less frequent but more severe crown fires (Kauffman 2004, Miller and Rose 1999, Swetnam 1993). The decrease in perennial herbaceous vegetation coupled with the altered fire regimes has facilitated the invasion of the fire-adapted annual grass, cheatgrass (*Bromus tectorum*), into these ecosystems (Chambers et al. 2000, Miller et al. 2000). These changes have placed sagebrush ecosystems and their associated animal taxa at risk of decline or extirpation (Wisdom et al. 2002).

Management of these ecosystems is increasingly focused on prescribed fire or fire surrogate treatments like mechanical removal. These types of fire treatments are used to manipulate wildlife habitat by reducing the incidence of severe wildfires and stimulating regeneration of certain plant species (Andrew et al. 2000, York 2000). To use fire

treatments to manage the expansion of pinyon-juniper woodlands effectively managers must first gain an understanding of how patterns of diversity and abundance in animal communities change over environmental gradients and with increases in tree cover. Only then can the influences of prescribed fire on these patterns be examined.

Ecologists are paying increasing attention to ants as bioindicators in restoration and land use management (Andersen and Sparling 1997, Andersen and Muller 2000, Andrew et al. 2000, Golden and Crist 2000, Andersen et al. 2003, Andersen et al. 2004). Ants are abundant, diverse, and ecologically dominant in almost every terrestrial environment around the world (Hölldobler and Wilson 1990, Wilson 2000). Ants are important to ecosystems in a variety of roles such as herbivores, predators, scavengers, seed dispersers, plant and arthropod mutualists, and soil engineers (Andersen et al. 2002, Sanders et al. 2003, Maeto and Sato 2004). Ants have been found to be good indicators of ecological condition and respond in ecologically interpretable ways to environmental variation (Agosti et al. 2000, Andrew et al. 2000, Read and Andersen 2000, Bestelmeyer and Wiens 2001, Andersen et al. 2002, Andersen et al. 2003, Maeto and Sato 2004). They have been shown to respond to forest and rehabilitated site succession (Puntilla et al. 1994, York 1994, Andersen et al. 2003) and various fire regimes (Andersen and Yen 1985, Andersen 1991, York 1994, York 2000, Bliss et al. 1999, Farji-Brener et al. 2002). Patterns of ant species richness and composition in areas undergoing restoration often reflect recolonization by other invertebrate groups as well as changes in soil microbial biomass. Aboveground ant activity has been correlated with belowground decomposition processes at disturbed sites, providing support for the use of ants as indicators of restoration success following disturbance (Andersen and Sparling 1997). These

characteristics make ants an appropriate taxon to consider in assessments of restoration and management programs.

Landscape variation and environmental gradients can affect species assemblages and must be considered when evaluating bioindicators. Sagebrush-steppe ecosystems vary in terms of soil characteristics and vegetation composition over elevation gradients. They also vary in relation to the degree of encroachment as reflected by tree stand densities (Tausch and Tueller 1990, Miller and Tausch 2001). Ant abundances and community composition are mediated by differences in microclimate, food resources, and soil properties (Bestelmeyer and Wiens 2001). Previous studies of the use of ants as bioindicators show that ants respond to soil texture and moisture gradients (Bestelmeyer and Wiens 1996, Whitford et al. 1999, Bestelmeyer and Wiens 2001, Sanders et al. 2003) and indicate that ants should vary with elevation and tree stand density as well.

Studies of ant communities in arid ecosystems suggest various responses to environmental differences and to disturbance. There are few previous studies on changes in ant diversity along elevation gradients or in response to fire in the Great Basin. Species richness was shown to be highest at mid elevations (Sanders 2002) or at high elevations (Sanders et al. 2003) depending on study area size and geometric constraints or on temperature and water availability, respectively. Following fire, ant communities in Idaho and New Mexico showed no significant changes (Zimmer and Parmenter 1998, Bliss et al. 1999) except for an increase in abundance (Zimmer and Parmenter 1998). Studies from other parts of the world, however, suggest mixed responses to fire. One study in New South Wales, Australia, found that ant community richness decreases with time since fire because fire suppression reduces the range of understory vegetation age

classes (York 1994). Much of the work shows that it is ant community composition rather than species richness that changes following fire (Andersen and Yen 1985, Andersen 1991, York 2000, Farji-Brener et al. 2002). Nearly all studies show that abundance increases after fire.

Much of the work on ants in the Great Basin has focused on individual species or groups of species with specific functions such as seed harvesting or thatch-mound building (Davidson et al. 1984, Davidson et al. 1985, Crist and MacMahon 1991a, Crist and MacMahon 1992, Mull and MacMahon 1997, McIver and Yandell 1998). I am unaware of any previous studies examining ant community response to varying tree densities; however, there are studies that examine ant response to habitat heterogeneity as influenced by trees, grazing regime, and forest fragments (Punttila et al. 1994, Bestelmeyer and Schooley 1999, Bestelmeyer and Wiens 2001). In the Sonoran Desert, ant species composition but not richness was influenced by tree-shaded microhabitats compared to open ground (Bestelmeyer and Schooley 1999). Other studies in the arid western United States have shown that ant communities respond primarily to soil texture rather than to grazing, vegetation, or disturbance regime (Whitford et al. 1999, Bestelmeyer and Wiens 2001). One study in southern Finland determined that age-distribution of the forest and forest fragmentation affected ant species composition and richness, with the greatest richness in the early stages of forest succession (Punttila et al. 1994).

Investigating ant community assemblages under various environmental conditions can help us better understand species diversity and ecosystem function. Knowledge of this important group of terrestrial invertebrates in sagebrush and pinyon-juniper habitats

will facilitate more informed predictions about the response of this system to fire management treatments. The objectives of this project were to provide baseline data on ant species diversity and community composition along two environmental gradients and to measure ant community response to a prescribed fire in a pinyon-juniper woodland. I measured ant species richness, population abundance, and composition along an elevation gradient, within three tree densities, and before and after a prescribed fire treatment. My specific questions were: (1) how do ant species richness, population abundance, and community composition change in relation to the elevation gradient that typifies pinyon-juniper woodlands in the Great Basin? (2) how do ant species richness, population abundance, and composition change with increases in tree cover? (3) how do ant species richness, population abundance, and composition change in response to prescribed fire? and (4) how are changes in ant species richness, population abundance, and composition related to the vegetation community cover or environmental characteristics that occur over the elevation and tree cover gradients?

Methods

Study Area

The study sites were located along an elevation gradient within Underdown Canyon (39°10′ N, 117°25′ W) in the Shoshone Mountain Range of Lander County, Nevada (Fig. 1). This area is part of the Humboldt-Toiyabe National Forest (Austin Ranger District) and the Battle Mountain District of the BLM in central Nevada. The sites were located on north facing alluvial fans and ranged from 2073 m to 2347 m in elevation (Fig. 2). Underdown Canyon shares the cool desert climate that typifies the

Great Basin: cold and wet in the winter and hot and dry in the summer. Annual precipitation arrives mostly during the winter and spring months, and the yearly average ranges from 23 cm at lower elevations to 50 cm at higher elevations (Chambers et al. 2000). The temperature regime ranges from an average of -7.2°C in January to 29.4°C in July (Weixelman et al. 1996). The geology of this canyon is characterized by volcanic rock (Chambers et al. 2000). The soil is classified as Loamy-skeletal Frigid Xeroll derived from welded tuff, and all layers of the soil profile have a sandy loam texture to 100 cm (Benjamin Rau, UNR, unpublished data). There are two springs in the upper reaches of this canyon, and the stream system is ephemeral, only flowing during runoff from spring snowmelt. Livestock grazing was the primary historical land use in this area; however, grazing had not occurred for seven years prior to this study (Terry Nevius, USDA Forest Service, Austin Ranger District, personal communication).

The pinyon-juniper woodlands are dominated by single-leaf pinyon with lower densities of Utah juniper, western juniper (*Juniperus occidentalis*), and Utah-western juniper hybrids. Associated sagebrush communities are dominated by Wyoming sagebrush at lower elevations and include perennial grasses such as Sandberg's bluegrass (*Poa secunda secunda*), bottle-brush squirrel tail (*Elymus elymoides*), and needle-and-thread grass (*Stipa comata*). Higher elevation sagebrush communities are dominated by mountain big sagebrush and perennial grasses such as Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Pseudoruegneria spicata*). Forbs in the study area include *Eriogonum* species, *Crepis acuminata, Phlox longifolia, Agoseris glauca, Lupinus argenteus*, and *Penstemon* species (Chambers et al. 2000).

Study Design

A randomized block design was used. Ants were sampled in six sites, representing paired burn and control sites at each of three elevations. To determine how ant species richness and population abundance change over the elevation gradient, paired burn and control sites were located at low (2103 and 2073 m), intermediate (2225 and 2195 m), and high (2347 m) elevations. Three replicate plots were located within each of the paired burn and control sites. To control for variation in tree cover among these plots, the plots were to be located in areas characterized by intermediate tree cover (approximately 38% cover, 6722 kg/ha); however, it was not possible to select identical tree covers on all sites along the elevation gradient. Therefore, tree cover was an artifact of, and had a negative relationship with, elevation. To determine how ant species richness and population abundance change with differences in tree cover, three replicate plots were located in areas characterized by low (12% cover, 2152 kg/ha), intermediate (38% cover, 6722 kg/ha), and high (74% cover, 14213 kg/ha) tree covers (Reiner 2004) within the paired burn and control sites at the intermediate elevations (2103 and 2073 m) (Fig. 3). Plots varied in terms of shape, but all were 0.1 ha in size. The prescribed burns were conducted on 10-13 May 2002 by Humboldt-Toiyabe National Forest personnel using standard techniques.

Ant Sampling

Pitfall traps were used to sample ant species because most ants in arid and semi-arid systems are ground-dwelling and ground-foraging species (Jeff Knight, NV Dept. of Agriculture, Entomology Laboratory, personal communication). Twelve traps were

placed in each replicate plot. Six traps were placed randomly along each of two, parallel, 30 m transect lines spaced 10 m apart. Pinflags were used to mark the trap locations. The traps were made of 120 ml, 6.5 cm diameter, plastic, disposable sampling cups. At each random point on a transect line a hole was dug, and two empty sample cups, one inside the other, were placed into the hole (Bestelmeyer et al. 2000). The soil was smoothed around the lip of the bottom cup to make the cup flush with ground level. The top cup (filled with dirt and debris) was removed leaving a clean sample cup in the ground. Thirty mls of propylene glycol was poured into each of the cups as a preservative. Propylene glycol has been shown neither to attract nor repel ants; therefore, it has been incorporated into standard ant sampling methods (Bestelmeyer et al. 2000). Unscented, powdered laundry detergent was sprinkled on top of the antifreeze to break the surface tension. Traps were left open in the field for seven days.

To assure that I was not missing species that might be able to avoid pitfall traps or might only forage when attracted to food sources, I set trial bait traps using film canisters with mashed greasy potato chips in the bottom of each canister in all plots at the mid-tree cover sites. No ants were found in the canisters after two hours, and again after four hours. It was, therefore, decided that bait traps were unnecessary to employ in this study and that no ants at the potato chip baits meant that no *Solenopsis invicta*, the red imported fire ants, inhabit these sites (Jeff Knight, NV Dept. of Agriculture, Entomology Laboratory, personal communication).

Ant species richness and abundance were sampled prior to the burn in 2001 and after the burn in 2002. Because ant activity is regulated by soil moisture, sampling was conducted both early in the growing season when soils were relatively wet and late in the

growing season when soils were relatively dry. The first two sampling periods were conducted before the scheduled burn treatments from 18-20 June to 25-27 June 2001 and from 6-8 August to 13-14 August 2001. The second two sampling periods were conducted after the burn from 11-12 June to 18-19 June 2002 and from 5-6 August to 12-13 August 2002.

Ant traps were collected, labeled, and stored at 4° C until processed. Samples were processed by pouring each sample through a 355 µm sieve and retrieving the ants, which were then rinsed and preserved in ethanol. Samples were sorted, and ants were identified to species. Wheeler and Wheeler's, *The Ants of Nevada* (1986), was used to key the ants. Jeff Knight, Nevada State Entomologist, and Dr. Philip Ward, U.C. Davis Entomologist, helped with identifications. Dr. Philip Ward verified all reference specimens. Voucher specimens will be deposited at the U.C. Davis Bohart Museum of Entomology and the Nevada Department of Agriculture, Entomology Laboratory.

Vegetation and Environmental Variables

Vegetation and cover variables were collected by Alicia Reiner (Reiner 2004). Understory vegetation data were sampled in 50, 1x2 m microplots within each of the 30 replicate plots along the elevation and tree cover gradients described above. Belt transects were located in a stratified random manner and were positioned perpendicular to the long axis of each replicate plot and spanned the width of the plot. Shrub and perennial bunchgrass and forb species were identified in each microplot. Tree, shrub, and forb species were measured for two crown diameters and total plant height. Perennial bunchgrasses were measured for two basal diameters and total plant height. The crown

or basal diameter measurement pairs were converted into areas using standard algorithms. For each species measured, the crown or basal area was summed by plot and converted into a percent cover value (Reiner 2004).

The cover variables sampled and used in this study were aerial cover and ground cover values. Aerial cover values were obtained by summing plant species percent cover values for each vegetation type (tree, shrub, grass, and forb). Although tree cover continued to influence sites by providing some shade, these cover effects were greatly reduced post-fire and were not measured. Ground cover values were obtained by converting point count data (bare ground, gravel, and litter) into percent cover values (Reiner 2004). Ground cover variables were not measured on burn plots in 2002.

Precipitation was collected in standing rain gauges near the low elevation sites (2081 m) and near the high elevation sites (2381 m). Overwinter (OW) (mid-October to May) and growing season (GS) (May to mid-October) precipitation measurements were taken. Overwinter precipitation data for Underdown Canyon at the low elevation gauge (2081 m) is missing for the pre-burn year. Riley, an adjacent canyon with very similar precipitation values for both 2001 and 2002, received 10.0 cm of overwinter precipitation at 2102 m in 2001. Using Riley Canyon's overwinter precipitation value for 2001, the precipitation regime for Underdown Canyon follows. Pre-burn year: Low OW=10.0 cm, GS=4.5 cm; High OW=22.0 cm, GS=6.0 cm. Post-burn year: Low OW=21.0 cm, GS=3.6 cm; High OW=27.6 cm, GS=5.6 cm.

Data Analysis

To examine the effects of elevation and tree cover on treatment response, data were analyzed using separate Analyses of Variance (ANOVA) (Proc Mixed; SAS 2002-2004). Mixed effects model ANOVAs were used. I used mixed effects models because they treat fixed effects as fixed and random effects as random, compared to the standard generalized linear models that treat random effects as fixed effects (Turner 2003). I used a three-block, split-plot design where the three blocks were the three elevation classes (low, mid, high) for the elevation analysis or the three tree cover classes (low, mid, high) for the tree cover analysis. These blocks were split into two factors, burn treatment (burn or control) and year (pre-burn or post-burn). Significance levels for all analyses were set at P-values of 0.05 or below.

The elevation sites used in this study were located in only one canyon without replication in other canyons. This means that the elevation sites were random location variables rather than fixed variables. Therefore, to test for differences in ant abundance with increasing elevation I used a mixed effects model ANOVA with Best Linear Unbiased Predictor (BLUP) estimates for the random elevation variables. To test for differences in ant abundance with increasing tree cover, a mixed effects model ANOVA was used. In this case, density classes (low, mid, high) were fixed variables and were used as covariates for ant abundance. Backward stepwise regression was used after testing each variable with the full model. Ant species richness values did not vary widely, and when total ant species richness was plotted against ln-transformed abundance, elevation, and tree cover no distinct patterns were observed (Fig. 4). Therefore, no further analyses were used to examine species richness.

Ant abundance in pitfall traps varies widely depending on a number of factors such as proximity of traps to nests, effects of substrate on forager movement, and individual species response to traps (Bestelmeyer and Wiens 2001). Analyses performed using actual counts of total abundance produced non-homogeneous variability. Therefore, total ant abundances were ln-transformed at the trap level to reduce the variability in capture rates.

I also examined the effects of elevation, tree cover, and burn treatment on the environmental variables using the same statistical models that were used for the ant data. The variables examined in these analyses were percent cover values for trees, shrubs, grasses, forbs, bare ground, gravel, and litter. Arc-sin transformations were run on these percent cover values before running the analyses.

Multivariate analyses were used to examine ant communities in relation to plant communities and other environmental variables. Cluster analyses (TWINSPAN; PC-ORD 1999) were used first to examine patterns in ant species composition and plant species composition among sites. TWINSPAN is based on division of sequential reciprocal averaging ordinations and organized ant or plant species into groups using similarities in species abundance categories among sample locations. TWINSPAN analyses were run using both plant frequency values and percent cover values. Both methods yielded similar results. The variables used in the final TWINSPAN analyses were raw measures of ant abundance and percent cover values for plant species. Seven dominance levels were assigned to these values. For ant species the abundance levels were: 1=≤1, 2=2-10, 3=11-20, 4=21-50, 5=51-100, 6=101-1000, and 7=≥1001. For plant species the percent cover levels were: 1=≤0.02, 2=0.03-0.10, 3=0.11-0.50, 4=0.51-1,

5=2-5, 6=6-10, and 7=≥11. Canonical Correspondence Analysis (CCA; PC-ORD 1999) was used to examine how ant communities are structured relative to vegetation and environmental variables. CCA is an ordination method in which the ordination of the samples and species is constrained by their relationships to environmental variables (McCune and Mefford 1999). The variables used in the CCA analyses were raw measures of ant abundance and percent cover values for trees, shrubs, grasses, forbs, bare ground, gravel, and litter. All default options were chosen for these analyses.

When TWINSPAN and CCA analyses revealed distinct ant community groups, ant species were assigned to functional groups to gain a better understanding of the ecological roles of the groups. Functional group designations were modified from Andersen (1997) and Bestelmeyer and Schooley (1999) with the help of Brandon Bestelmeyer (personal communication). Ant species in our study were classified into eight functional groups: (1) members of the genus *Camponotus,* which are usually nocturnal (Bestlemeyer and Schooley 1999); (2) cold climate specialist distributions, which are centered on the cool-temperate zone (Andersen 1997); (3) cryptic species, which forage predominantly within the soil and litter and have little interaction with surface foraging ants (Andersen 1997); (4) dominant cold climate specialists, which are cold climate specialists that are abundant, highly active, and aggressive species (Wheeler and Wheeler 1996, Punttila et al. 1996); (5) generalized myrmicines, which are widespread genera occurring in most habitats and that rapidly recruit to, and successfully defend, clumped food resources (Andersen 1997); (6) hot climate specialists, which are arid-adapted species (Andersen 1997); (7) opportunists, which are unspecialized, submissive species often common in disturbed habitats (Andersen 1997, Bestelmeyer and

Schooley 1999); and (8) social parasites, which are species that prey upon other species or the resources of other species (Wheeler and Wheeler 1996, Punttila et al. 1996).

Results

Effects of Elevation, Treatment, and Year

VEGETATION

TWINSPAN ordination results revealed distinct plant communities at the low-mid and mid-high ranges of the elevation gradient with almost perfect site separation of the sample locations in the pre-burn year (App. 1). Species restricted to the low-mid elevations and found in abundance of 0.1% cover or more include the shrubs *Artemisia tridentata wyomingensis* and *Ephedra viridis* and the grass *Agropyron spicatum* (Table 1). Species restricted to the mid-high elevations and found in abundance of 0.1% cover or more include the shrubs *Artemisia tridentata vaseyana, Artemisia arbuscula,* and *Symphoricarpos oreophilus* and the grasses *Festuca idahoensis* and *Koeleria macrantha*. Ubiquitous species found in all plots include the shrub *Chrysothamnus viscidiflorus,* the forbs *Eriogonum microthecum* and *Lupinus argenteus,* and the grasses *Elymus elymoides* and *Poa secunda*. In the post-burn year the plant communities were divided primarily by burn or control treatment and secondarily by elevation (App. 2). The burn treatment did not shift species community groups along the elevation gradient, but it did result in the loss of many species on the burn plots (Table 1) including the forbs *Eriogonum microthecum* and *E. umbellatum*, the grasses *Agropyron spicatum* and *Koeleria macrantha*, and all of the shrubs.

AERIAL AND GROUND COVER

The cover variables also differed significantly along the elevation gradient and in response to differences in treatment and year (Table 2). Responses were varied. As elevation increased in the pre-burn year, shrub, bare ground, and litter cover values increased while tree and gravel cover decreased (Table 3). Grass cover was lowest on the mid-elevation plots and highest on the high elevation control plot, while forb cover values remained relatively unchanged. In the post-burn year, shrubs were burned completely on treatment plots, but maintained similar 2001 cover values on control plots (Table 3). Grasses experienced an 18-59% reduction in cover from 2001 to 2002 on control plots and a 74-95% reduction on burn plots. Forb cover had a mixed response from 2001 to 2002. On the mid and low elevation control plots, forb cover was reduced 12-40%, and on the low burn plot it was reduced by 93%. On the mid burn plot forb cover remained the same; however, it increased by 40% on both the control and burn high elevation plots. Litter cover decreased slightly on the mid to high elevation plots and increased on the low elevation plots. Bare ground increased on all control plots, and gravel values remained relatively unchanged.

ANTS

I analyzed 29 species of ants from 17 genera and three subfamilies (Tables 4-5) (Fig. 5). The number of ant species found in Underdown Canyon is comparable to that of other studies in arid ecosystems (Bestelmeyer and Wiens 2001, Sanders et al. 2003). A total of 32 species was found, but only 29 of these species were included in the analyses due to identification problems with certain *Formica, Myrmica,* and *Lasius* species.

Formica obscuripes was included with *Formica integroides*, *Myrmica* sp. near *fracticornis* was included with *Myrmica tahoensis*, and *Lasius niger* was included with *Lasius sitiens*. Also, the characteristic used to distinguish between *Formica manni* and *Formica neogagates* was color. Solid black individuals were identified as *F. neogagates* and bi-colored individuals were identified as *F. manni*. Color is highly varied in these desert species (Dr. Philip Ward, UC Davis, personal communication), but because they separated nicely with elevation, they were treated as distinct species.

TWNSPAN ordination results for ant species in both years showed that elevation sites could be organized by ant community composition (App. 3-4), with distinct communities at the low-mid and mid-high elevations (Fig. 5). The ant species that make up these communities come from different functional groups. The low-mid elevations are characterized by generalized myrmicines such as *Crematogaster mormonum*, opportunists such as *Aphaenogaster occidentalis*, and hot climate specialists such as *Myrmecocystus testaceus* and *Pogonomyrmex occidentalis*. The mid-high elevation sites are characterized by dominant cold climate specialist species that are thatch mound builders such as *Formica integroides* and *F. ravida* and opportunists like *Myrmica tahoensis* and *Formica subpolita*. Ubiquitous species comprise many functional groups and include *Camponotus vicinus*, *Formica argentea*, and *Temnothorax nevadensis*. Species found in very small abundances were assigned to the rare category. These include species from the genera *Brachymyrmex, Pheidole, Stenamma,* and *Formicoxenus*. The species that make up these communities did not change post-burn.

Results of the mixed effects ANOVA on ln-transformed ant abundance with BLUP estimate analyses for random effects showed significant differences in abundance

along the elevation gradient (Table 6). Ant abundance increased with increasing elevation in both years (Fig. 6). There were significant interactions of elevation with treatment and year as well as a treatment by year interaction, which was a significant fixed effect (Table 6). Although abundance decreased in the post-burn year on control sites, abundance increased after the burn on burn sites (Fig. 6). Ant abundance was higher on average in control sites compared to burn sites.

Although ant and plant communities both showed site separation along the elevation gradient, CCA analyses of environmental variables for all plots in 2001 showed that ant community groupings are more strongly associated with elevation and percent tree cover along the elevation gradient than with understory vegetation (Fig. 7). CCA analyses of control plots on the elevation sites in 2002 yielded the same results. The R^2 values generated from the analyses for the environmental variables revealed that elevation was the only significant variable in determining ant species organization on all plots in 2001 (Table 7). Comparing the burn plots in the pre and post-burn years using CCA analyses revealed little change post-burn (Fig. 8). The ordination on burn plots shows that ant species are primarily influenced by soil texture and elevation in both years, yet neither of these variables had significant R^2 values (Table 7).

Effects of Tree cover, Treatment, and Year

VEGETATION

TWINSPAN ordination results revealed a distinct separation between the burn and control tree cover plots according to plant species in 2001 (App. 5), however, plant community groups are not so distinct. The only species that occupies the control plots

exclusively in abundance of 0.1% cover or greater is the forb *Lygodesmia spinosa* (Table 8). The two species that occupy the burn plots almost exclusively and are found in abundance of 0.1% or more are the shrub *Chrysothamnus nauseosus* and the grass *Koeleria macrantha*. Ubiquitous species found in all plots include the shrubs *Artemisia tridentata vaseyana* and *Chrysothamnus viscidiflorus,* the forbs *Eriogonum microthecum* and *Lupinus argenteus,* and the grasses *Achnatherum therberianum, Elymus elymoides, Festuca idahoensis,* and *Poa secunda*. The TWINSPAN results also show a separation of the high tree cover plots from the rest of the plots (App. 5). Some species are not found in, or have decreased abundances in, the high tree cover plots. These species include the forbs *Eriogonum microthecum* and *E. umbellatum*, and the grass *Agropyron spicatum* (Table 8).

In the post-burn year, TWINSPAN ordinations distinctly sort the plots again by control or burn site (App. 6), but many of the plant species are completely absent from the burn plots. These include the forbs *Eriogonum microthecum*, *Eriogonum umbellatum,* and *Gilia inconspicua,* the grass *Koeleria macrantha*, and all shrubs (Table 8). Again, there is an additional separation of high tree cover plots from all other plots within each site (App. 6). Some species, like the forbs *Crepis accuminata* and *Eriogonum elatum*, are absent from, or have decreased abundances in, the high tree cover plots (Table 8).

AERIAL AND GROUND COVER

The cover variables differed significantly along the tree cover gradient and in response to differences in treatment and year (Table 9). As tree cover increased along the

gradient from low tree cover plots to high tree cover plots on both control and burn sites in 2001, litter increased while shrub, grass, forb, bare, and gravel cover decreased (Table 10). These patterns remained the same in the second year. Percent grass cover decreased by 37-60% in 2002 on control plots and by 81-93% on burn plots. Forb cover remained relatively unchanged on control and burn plots in 2002. Bare ground cover values increased on control plots in 2002 while shrub, gravel, and litter cover values remained similar to the previous year.

ANTS

Of the 29 ant species that were found on the elevation plots, 26 of those were found on the tree cover plots. These species, functional groups, and abundance values are listed by site in tables 11 and 12. TWNSPAN ordination results for the tree cover gradient plots showed that no clear patterns of ant community organization resulted in response to tree cover in the pre-burn year (App. 7). TWINSPAN ordinations for these plots in the post-burn year separated the control and burn plots, and, secondarily, separated the high tree cover plots from the low and mid tree cover plots (App. 8). On high tree cover plots, abundance tended to decrease for some ant species like *Formica lasioides* and *F. manni*, and increase for others like *Myrmecocystus testaceus*. Some species are found predominantly in control plots like *Aphaenogaster occidentalis* and *Camponotus sansabeanus*, while others are found predominantly in the burn plots such as *Formica integroides* and *F. subpolita*. Since these ant species are located in the same sites as they were for the elevation study, this may be due to an effect of elevation rather than of site treatment difference.

Results from the mixed effects ANOVA on ln-transformed ant abundance along the tree cover gradient revealed no significant responses related to tree cover (Table 13). It did, however, yield a significant result for the treatment by year interaction using the full model, and for the treatment effect using the reduced model. These results reinforced the treatment by year interaction observed on the elevation sites; ant abundance decreased in the second year on control plots and increased in the second year on burn plots (Figs. 6 and 9). The treatment effect on the tree cover sites is opposite the treatment effect on the elevation sites, showing that ant abundance was higher on average in burn plots compared with control plots (Fig. 9). Ant abundance was lowest on high tree cover plots for burn and control sites in both years (Tables 11-12), although this result was not significant using mixed effects analysis.

The CCA analysis for all tree cover plots in 2001 shows that ants are not clearly associated with any of the environmental variables (Fig. 10). CCA analyses of the control plots for the post-burn year yielded similar results. The only variable with a significant R^2 value for all tree cover plots in 2001 was bare ground cover (Table 14). Comparing burn plots in the pre- and post-burn years using CCA analyses reveals little change in ant communities post-burn (Fig. 11). In both years, few environmental variables are associated with ant abundance, and patterns of ant community organization are not distinct.

Discussion

Effects of Elevation

Distinct low and high elevation ant communities exist in Underdown Canyon, according to TWINSPAN and CCA analyses. The low elevation community is comprised of hot climate specialists, generalized myrmicines, opportunists, and one *Camponotus* and includes eight ant species: *Monomorium ergatogyna, Crematogaster mormonum, Aphaenogaster unita, A. occidentalis, Camponotus sansabeanus, Myrmecocystus testaceus, Formica manni,* and *Pogonomyrmex occidentalis.* The environmental characteristics that define this community are lower elevation, increased tree cover, and gravel ground cover. The high elevation community is comprised of dominant cold climate specialists and opportunists and includes seven species: *Formica lasioides, F. ravida, F. neogagates, F. integroides, F. subpolita, Tapinoma sessile,* and *Myrmica tahoensis.* The defining environmental characteristics for this community are higher elevation, increased shrub cover, and increased bare and litter ground cover. Although plant species exhibited similar patterns in TWINSPAN analyses, vegetation did not seem to be a driving factor for ant community organization.

Opportunists, cold climate specialists, social parasites, cryptic species, one camponotus, and one dominant cold climate specialist species were found across all elevations. No hot climate specialists were found at the two high elevation sites, and no generalized myrmicines, with the exception of one individual, were found at the mid-high elevation sites. Hot climate specialists are adapted to arid environments, and generalized myrmicines are predominant at desert sites (Andersen 1997). This suggests that the lower elevations had real ecological differences that resulted in ant community changes.

A drier moisture regime in the low elevation sites would affect soil texture, plant communities, and ant activity. Since many of the functional group classifications were modified from ant functional groups in other parts of the world, especially Australia, it is possible that the functional group classification scheme used here is too broad and does not accurately reflect the ecological roles of ant species in Underdown canyon. One example to support this potential problem is that the species *Formica manni* is labeled as an opportunist in Andersen's modified functional group classification for North American ants (1997), but this species is known by local myrmecologists to be a xerophilic, or thermophilic, species (Dr. Philip Ward, UC Davis, personal communication).

Ant population abundance was also affected by the elevation gradient. More mesic conditions resulting in greater soil moisture at higher elevations could cause abundances to increase due to increased levels of primary production and decreased levels of physiological stress, such as desiccation. Sanders et al. (2003) suggested this was the case for increases in ant species richness at high elevations in their arid Nevada locations. Increased precipitation also allows for a greater capacity to support vegetation, including shrubs. The dominant cold climate specialists, our most abundant group of ant species, are thatch builders that collect honeydew from aphid tending on shrubs (McIver and Yandell 1998). More shrubs at higher elevations means that more of the dominant and highly abundant ant species will be present. This would explain why ant communities were most strongly associated with the elevation and tree cover lines in our CCA analyses. As elevation increased, tree cover decreased, resulting in increased cover of other types of vegetation, such as shrubs.

Effects of Tree cover

Tree cover had no significant effect on ant populations, although ant populations tended to have the lowest abundances in the high tree cover plots. This decreased abundance could be due to the possibility that ants might not be as easily trapped where larger litter mats allow for more dimensions in which to forage and avoid traps.

Ant species assemblages tended to be organized more by location on the alluvial fans rather than by tree cover. Plant groupings often showed this same pattern. Trees are expanding into the existing sagebrush ecosystem, and our tree cover classes are an artificial construct of that process. Ant and plant species organization most likely reflects the remnant sagebrush community and local heterogeneity on the fan. Local tree cover will not reflect true habitat differences when too much spatial variability exists within a site.

Effects of Fire

The burn treatment increased ant abundances in pitfall traps, but it did not cause changes in community composition or richness. Increases in abundance following fire have been previously documented (Andersen and Yen 1985, Majer 1997, Andersen and Müller 2000, York 2000, Farji-Brener et al. 2002). Fire often has little direct effect on ant populations because of their ability to take refuge in underground nests. Fire modifies habitat structure and food resources, which can affect ant population response (Andersen 1991). Decreases in litter biomass and increases in ground surface insolation can increase the likelihood of ant capture (Andersen and Müller 2000) or "trapability" (York 2000). The burns were conducted in the spring when soil moisture was higher.

Increased soil moisture contributes to greater patchiness in burn severity. Higher severity burns in mid-summer or fall might have had increased effects on both vegetation and ants.

The interaction between treatment and year on the elevation and tree cover sites can most likely be explained by soil moisture differences. The pre-burn growing season received more precipitation than the post-burn growing season. Thus, ant abundances likely would be greater in the first year on the control plots. This is just what was observed. Abundances were greater in the second year on the burn plots, which shows that the effect of the fire overshadowed the effect of decreased precipitation.

Implications for Management and Conservation

Elevation was the greatest factor in determining differences in ant community composition and abundance. Also, ants were resilient to the fire one season after the prescribed burn. Further sampling in subsequent years would reveal whether or not this will be a lasting effect. It is noteworthy that most ant nests in the study plots survived the fire and remained active throughout the season. Some thatch nests, built by *Formica* species, had completely burned. Yet, colony relocation and the construction of new thatch mounds were witnessed at many locations within burned sites. If plant growth, regeneration, and seedling establishment occur following the fire, I would assume that ant species will remain largely unaffected by this fire. However, many thatching ants tend aphids on sagebrush for most of their dietary needs (McIver and Yandell 1998). If the surrounding sage plants do not re-establish quickly, the thatching ant colonies could see a decline in abundance over time or even colony demise.

Modern conservation biology maintains that mosaics of varying land use and natural habitat features support higher species diversity (MacDougall et al. 2004, Oliver et al. 2004, Bestelmeyer and Wiens 2001). These habitat features can be manipulated by well-designed prescription burns (Andrew et al. 2000). Our study results imply that burns that are conducted as a mosaic can provide a variety of habitat conditions and facilitate the persistence of a diversity of ant species. Also, because ant species are closely aligned with elevation gradients, conservation management in these ecosystems should include a range of elevations to ensure maximum conservation of species and diversity.

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Appendix 1. TWINSPAN two-way ordered table demonstrating the relationship between plant species cover and sample locations on the elevation sites in 2001. Under the sample location heading, the first two lines describe the study sites along the elevation gradient (03=low, control; 04=low, burn; 07=mid, control; 08=mid, burn; 13=high, burn; and 14=high, control) and the third line denotes the plot replicate number (1-3) within each of those sites. Percent cover of plant species is represented by seven dominance categories (1=≤0.02, 2=0.03-0.10, 3=0.11-0.50, 4=0.51-1, 5=2-5, 6=6-10, 7=≥11). Plant species with greater than 0.1% cover were used in this figure.

Plant species	Sample Locations 111111000000000000 343344888777444333 112323123123123123		
Cordylanthus ramosus	__3213_____	11111	
Artemisia arbuscula	__4555_____	11111	
Carex vallicola	33__31_____	11110	
Penstemon deustus & watsonii	32233___2_____1___	11110	
Koeleria macrantha	334344244_____	1110	
Artemisia tridentata vaseyana	777677777__7_____	1110	T
Festuca idahoensis	55666733554_____	1101	W
Agropyron smithii	152_3_12___3_____	1101	I
Antennaria rosea	2_3333___12_2_____	1101	N
Symphoricarpos oreophilus	76556415442_____	1101	S
Lygodesmia spinosa	2_41_21___22___111	1001	P
Phlox hoodii	334444333423_1_423	1001	A
Eriogonum umbellatum	332_2_2_3331_12__2	10001	N
Leptodactylon pungens	5_5_23_431_52_312_	10001	
Eriogonum microthecum	33334445434254322_	10001	D
Chrysothamnus viscidiflorus	555555555455545_33	10001	i
Chrysothamnus nauseosus	_3_23__12___3_3___	10000	v
Poa fendleriana	3_3___432452_____	0111	i
Cryptantha flavoculata	_____322223_____	0111	s
Achnatherum thurberianum	35121_4343441_1212	0110	i
Crepis acuminata	1_11_2_2223_11____	0110	o
Elymus elymoides	353353454535323333	0101	n
Lupinus argenteus	455555555555555555	0101	s
Arenaria aculeata	2_2213222331332322	01000	
Stipa comata	_3_____5_____	0011	
Eriogonum elatum	_____1243534433__1	00101	
Poa secunda	333323554555666666	001001	
Agropyron spicatum	_____3_12_333___	001001	
Bromus tectorum	_1_____1_4122_2__1	0001	
Ephedra viridis	_____24_33_____	0001	
Artemisia tridentata wyomingensis	___2_____57_656766	00000	
	000000000111111111 000000111000111111 001111 000111		

Appendix 2. TWINSPAN two-way ordered table demonstrating the relationship between plant species cover and sample locations on the elevation sites in 2002. Under the sample location heading, the first two lines describe the study sites along the elevation gradient (03=low, control; 04=low, burn; 07=mid, control; 08=mid, burn; 13=high, burn; and 14=high, control) and the third line denotes the plot replicate number (1-3) within each of those sites. Percent cover of plant species is represented by seven dominance categories (1=≤0.02, 2=0.03-0.10, 3=0.11-0.50, 4=0.51-1, 5=2-5, 6=6-10, 7=≥11). Plant species with greater than 0.1% cover were used in this figure.

	Sample Locations		
	001110000000000111		
	774443337444888333		
Plant Species	311231232123123123		
Koeleria macrantha	23343_____	111	
Symphoricarpos oreophilus	_5554_____	111	
Stipa comata	5_____	110	
Leptodactylon pungens	4___3_1_____	110	
Artemisia tridentata vaseyana	77777___5_____	110	
Bromus tectorum	2411__111_____1___	1011	T
Agropyron smithii	3_54____3_____2_	1011	W
Eriogonum umbellatum	_3432__15_____	10101	I
Eriogonum microthecum	_545522_4_____	10101	N
Chrysothamnus viscidiflorus	45555_335_____	10101	S
Carex vallicola	_1232_____3__	10100	P
Festuca idahoensis	24557___3_____353	100	A
Antennaria rosea	1_23311_3_____11	100	N
Gilia inconspicua	12_111113_____	0110	
Achnatherum thurberianum	435531122___123353	010	D
Cordylanthus ramosus	____3_____3_	010	i
Penstemon deustus & watsonii	___4_____3_3	010	v
Elymus elymoides	4553312342_2333322	0011	i
Phlox hoodii	234453333___233353	0011	s
Eriogonum elatum	34___1__43___33___	0011	i
Cryptantha flavoculata	33_____3___222___	0011	o
Poa secunda	3435455554323332 33	00101	n
Crepis acuminata	_2__2___3____33111	00101	s
Lupinus argenteus	445555535233555565	00101	
Lygodesmia spinosa	1___22112_____32_	00100	
Arenaria aculeata	_5_243234211121122	00100	
Poa fendleriana	_____3_____	0000	
Agropyron spicatum	_____3_____	0000	
Artemisia tridentata wyomingensis	_2___7667_____	0000	
	000001111111111111		
	011110000111111111		
	000000111		
	000111		

Appendix 3. TWINSPAN two-way ordered table demonstrating the relationship between ant species and sample locations on the elevation sites in 2001. Under the sample location heading, the first two lines describe the study sites along the elevation gradient (03=low, control; 04=low, burn; 07=mid, control; 08=mid, burn; 13=high, burn; 14=high, control) and the third line denotes the plot replicate number (1-3) within each of those sites. Ant species abundance is represented by seven dominance categories (1=≤1, 2=2-10, 3=11-20, 4=21-50, 5=51-100, 6=101-1000, 7=≥1001).

	Sample Locations		
	111101100000000000		
	333484487778444333		
Ant Species	123321231231123123		
Formica integroides	35616661_____1___	000	
Formica subpolita	4532455311_1__1___	000	
Formica neogagates	2511_11____1_____	000	
Solenopsis molesta	____1111_____	000	T
Tapinoma sessile	35554432_212_____	0010	W
Formica ravida	126651514__1_____	0010	I
Formica lasiodes	55341451_131_____	0010	N
Myrmica tahoensis	354443431254___1__	0011	S
Stenamma smithi	_____1_____	0011	P
Camponotus vicinus	333132345555432111	010	A
Lasius sitiens	____1_211232____2_	010	N
Polyergus breviceps	_34_131__5___11__5	011	
Temnothorax nevadensis	112222311211_1_113	011	D
Temnothorax rugatulus	11111111_1_____11_	011	i
Formica argentea	3544335333331222_1	011	v
Pogonomyrmex occidentalis	____2_____5___5___	10	i
Formica(microgyna gp.)sp.1	55_____3_1_31451_	10	s
Formica manni	1___2__1223_433111	10	i
Aphaenogaster occidentalis	_____1_331_334333	1100	o
Myrmecocystus testaceus	_____1_2____152	11010	n
Monomorium ergatogyna	___1_____245	11010	s
Temnothorax nitens	_____111	11010	
Brachymyrmex depilis	_____1	11010	
Crematogaster mormonum	_____32443	11011	
Aphaenogaster uinta	_____1111	11011	
Camponotus sansabeanus	_____1____444333	111	
	000000000000111111		
	000000001111000111		
	00111111		
	000001		
	00111		

Appendix 4. TWINSPAN two-way ordered table demonstrating the relationship between ant species and sample locations on the elevation sites in 2002. Under the sample location heading, the first two lines describe the study sites along the elevation gradient (03=low, control; 04=low, burn; 07=mid, control; 08=mid, burn; 13=high, burn; 14=high, control) and the third line denotes the plot replicate number (1-3) within each of those sites. Ant species abundance is represented by seven dominance categories (1=≤1, 2=2-10, 3=11-20, 4=21-50, 5=51-100, 6=101-1000, 7=≥1001).

	Sample Locations		
	111111000000000000		
	333444878874447333		
Ant Species	123123221331231123		
Formicoxenus diversipilosus	___1_1_____	00000	
Stenamma smithi	___1_____	00000	
Stenamma snellingi	__1_____	00000	
Polyergus breviceps	11_12_2_____	00001	
Formica integroides	35566_61_4_____	00001	
Formica lasioides	554343_111_____	00001	
Tapinoma sessile	4554345234_____	0001	
Formica subpolita	5545525_25_____	0001	
Formica neogagates	151121__11_____	0001	
Temnothorax rugatulus	3111_1_1_____11_	001	
Formica ravida	216166__11____5___	001	
Myrmica tahoensis	55533152455___1___	01	
Temnothorax nevadensis	1122133233111111_1	01	
Formica argentea	4553424255323311_1	01	
Camponotus vicinus	332111354443215___	10	
Lasius sitiens	____1_21443_1_2_3_	10	
Pogonomyrmex occidentalis	_____4___5_25____	110	
Temnothorax nitens	1_____1__1___	110	
Formica(microgyna gp.)sp.1	55_____1__31135__	110	
Formica manni	1____111_2243331_1	110	
Solenopsis molesta	___1__1__111__111_	1110	
Myrmecocystus testaceus	_____3__11151	111100	
Monomorium ergatogyna	_____144	111100	
Brachymyrmex depilis	_____1__	111100	
Pheidole pilifera	_____1_____1	111100	
Camponotus sansabeanus	_____13341434	111101	
Crematogaster mormonum	_____123_443	111101	
Aphaenogaster uinta	_____1_2_2_1	111101	
Aphaenogaster occidentalis	1_____4_1_4544313	11111	
	000000000011111111		
	000000011100000111		
	0011111 01111		
	00001		

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Appendix 5. TWINSPAN two-way ordered table demonstrating the relationship between plant species cover and sample locations on tree cover plots in 2001. Under the sample location heading the first line describes the site treatment (7=control, 8=burn) along the tree density gradient, the second line describes the tree density (1=low, 2=mid, 3=high), and the third line denotes the plot replicate number (1-3) within each of the treatment-density combinations. Percent cover of plant species is represented by seven dominance categories (1=≤0.02, 2=0.03-0.10, 3=0.11-0.50, 4=0.51-1, 5=2-5, 6=6-10, 7=≥11). Plant species with greater than 0.1% cover were used in this figure.

	Sample Locations		
	888888888777777777		
	233311221211122333		
Plant Species	112323231312321123		
Chrysothamnus nauseosus	____4312__2_____	0000	
Leptodactylon pungens	___14343253___1___	0000	
Penstemon deustus & watsonii	_____2_____	0000	
Agropyron smithii	1___1_2__3_____	0001	
Koeleria macrantha	23_33344_____	0001	T
Stipa comata	_3_____25_____	0001	W
Symphoricarpos oreophilus	15_55_543__2_241__	00111	I
Achnatherum thurberianum	443345345442343132	011000	N
Cryptantha flavoculata	322222222322222322	011001	S
Phlox hoodii	312134333312224332	011001	P
Elymus elymoides	444444544541335545	011001	A
Poa secunda	555455545533555555	011001	N
Artemisia tridentata vaseyana	75357777777777533_	011001	
Bromus tectorum	_1_11_1_32__114__1	011010	D
Chrysothamnus viscidiflorus	5213_5555555554322	011011	i
Eriogonum microthecum	4__1445442443433__	011011	v
Arenaria aculeata	2__1432231_2333222	011011	i
Eriogonum elatum	21_2444354545351__	011011	s
Lupinus argenteus	522255555555555442	011011	i
Agropyron spicatum	____223___2__21___	0111	o
Eriogonum umbellatum	21_233_331335331__	100	n
Festuca idahoensis	332354353_6754533_	100	s
Poa fendleriana	42332_324255354333	100	
Ephedra viridis	_5_3___2_35_4_4412	101	
Antennaria rosea	____12__2_21_211_2	101	
Crepis acuminata	___212221_33332111	110	
Lygodesmia spinosa	1_1_____122222____	110	
	000000000011111111		
	000011111100000111		
	00000100001		
	00001		

Appendix 6. TWINSPAN two-way ordered table demonstrating the relationship between plant species cover and sample locations on tree cover plots in 2002. Under the sample location heading the first line describes the site treatment (7=control, 8=burn) along the tree density gradient, the second line describes the tree density (1=low, 2=mid, 3=high), and the third line denotes the plot replicate number (1-3) within each of the treatment-density combinations. Percent cover of plant species is represented by seven dominance categories (1=≤0.02, 2=0.03-0.10, 3=0.11-0.50, 4=0.51-1, 5=2-5, 6=6-10, 7=≥11). Plant species with greater than 0.1% cover were used in this figure.

	Sample Locations		
	777777777888888888		
	121123233111222333		
Plant Species	122311323123123132		
Agropyron spicatum	33_1_____	000000	
Poa fendleriana	33_3____1_____	000001	
Eriogonum microthecum	545553_____	000010	
Eriogonum umbellatum	55553_____	000010	
Astragalus filipes & obscurus	3_22_1_1_____1	00010	T
Lygodesmia spinosa	3233__1_____2	00010	W
Festuca idahoensis	63654321__2_____	00010	I
Artemisia tridentata vaseyana	75777573_____	000110	N
Chrysothamnus viscidiflorus	655553421_____	000110	S
Ephedra viridis	5__4_4__3_____	000110	P
Koeleria macrantha	4_333_2_____	000110	A
Artemisia tridentata wyomingensis	77__2__2_____	000111	N
Leptodactylon pungens	3__1_14_____	001100	
Gilia inconspicua	332121123_____	001100	D
Antennaria rosea	231___1_2_____	001101	i
Agropyron smithii	_3____3_____	001101	v
Stipa comata	_____53_____	001111	i
Arenaria aculeata	243553_33233121___	10	s
Bromus tectorum	11_14_2_221___1___	10	i
Eriogonum elatum	5454423__443_33_1_	1100	o
Crepis acuminata	33432___1212_33_1_	1100	n
Lupinus argenteus	555544431555555_12	11010	s
Phlox hoodii	233133233334233___	11011	
Achnatherum thurberianum	32113_42232312332_	11011	
Poa secunda	35354433533433322_	11011	
Cryptantha flavoculata	332133322_2322221_	111	
Elymus elymoides	444455444333333331	111	
	000000000111111111		
	000000111000000001		
	001111 00000011		
	011111		
	01111		

Appendix 7. TWINSPAN two-way ordered table demonstrating the relationship between ant species and sample locations on tree cover plots in 2001. Under the sample location heading the first line describes the site treatment (7=control, 8=burn) along the tree cover gradient, the second line describes the tree cover (1=low, 2=mid, 3=high), and the third line denotes the plot replicate number (1-3) within each of the treatment-cover combinations. Ant species abundance is represented by seven dominance categories (1=≤1, 2=2-10, 3=11-20, 4=21-50, 5=51-100, 6=101-1000, 7=≥1001).

	Sample Locations		
	888877878878778777		
	122311121223333123		
Ant Species	323112231113232321		
Pogonomyrmex occidentalis	12____15_____	000	
Formica integroides	561_____1_____	000	
Formica neogagates	1_____1_31_____	000	
Stenamma smithi	_____11_____	000	T
Tapinoma sessile	2421433122_1___22_	001	W
Formica subpolita	2431515__11___1_1_	001	I
Formica lasioides	_11_511331_____11_	001	N
Formica manni	321_25433_21___32_	0100	S
Myrmica tahoensis	44345135341132312_	0101	P
Lasius sitiens	21113313221131112_	0101	A
Temnothorax nevadensis	221112112111111121	0101	N
Temnothorax nitens	___11_____1_____	0101	
Formica ravida	6515__1_1144_11___	011	D
Solenopsis molesta	_11_____1___	011	i
Camponotus sansabeanus	__11_____1_1	100	v
Myrmecocystus testaceus	___5___21_1111___1	100	i
Camponotus vicinus	334555455555434555	101	s
Temnothorax rugatulus	_1111_____1_11_1_	101	i
Formica argentea	233511233334444333	101	o
Crematogaster mormonum	_____11___	11	n
Aphaenogaster occidentalis	1___13111_3123_333	11	s
Polyergus breviceps	_1_____1_____3451	11	
Formica(microgyna gp.)sp.1	_____11_315422_2	11	
	000000000011111111		
	000011111100000111		
	00011100111		

Appendix 8. TWINSPAN two-way ordered table demonstrating the relationship between ant species and sample locations on tree cover plots in 2002. Under the sample location heading the first line describes the site treatment (7=control, 8=burn) along the tree cover gradient, the second line describes the tree cover (1=low, 2=mid, 3=high), and the third line denotes the plot replicate number (1-3) within each of the treatment-cover combinations. Ant species abundance is represented by seven dominance categories (1=≤1, 2=2-10, 3=11-20, 4=21-50, 5=51-100, 6=101-1000, 7=≥1001).

	Sample Locations		
	788888788877787777		
	112212233311212333		
Ant Species	131322312323211123		
Pogonomyrmex occidentalis	_2__345312_____	00	
Formica integroides	_5_4_6_1____1_____	00	
Formica subpolita	322555_131___1____	00	
Brachymyrmex depilis	1_____	00	
Tapinoma sessile	333455_3_13223____	010	
Temnothorax nevadensis	13332312331122111_	010	
Formica lasioides	51111_____1_11_1__	010	
Formica neogagates	11112_____2____	010	
Myrmica tahoensis	544555555531231_32	0110	
Lasius sitiens	144432324431152141	0110	
Formica argentea	135534355511231222	0110	
Formica ravida	_6111__5_5____5__1	0110	
Myrmecocystus testaceus	_____3433___11112	0111	
Formica manni	_2_2312_1142133___	100	
Camponotus vicinus	434443453544555442	101	
Aphaenogaster uinta	_____1__1_____	101	
Pheidole pilifera	_____1_____1_	101	
Stenamma smithi	_____1_____1____	101	
Aphaenogaster occidentalis	11_11__13344444413	110	
Polyergus breviceps	_____2__1_____4__	110	
Temnothorax rugatulus	1_____1____1	110	
Solenopsis molesta	___1_1111_11__1111	110	
Camponotus sansabeanus	_____1_____1111	111	
Crematogaster mormonum	_____1	111	
Temnothorax nitens	_____1___	111	
Formica(microgyna gp.)sp.1	__1_____2__1_13233	111	
	000000000011111111		
	000000111100001111		
	011111		
	00011		

TWINSPAN Divisions

Table 1. Plant species with mean percent cover values greater than 0.1% on the low, mid, and high elevation sites for the pre (2001) and post (2002) burn years. Values are mean percent cover with standard errors in parentheses. Elevation values are meters followed by control (C) or burn (B) site designation

	Low				Mid				High			
Plant Type	2073 C		2103 B		2195 C		2225 B		2347 C		2347 B	
Species	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Grasses and Carices												
Achnatherum thurberianum	0	0	0	0	0.6 (0.2)	0.4 (0)	0.5 (0.1)	0.1 (0)	0.3 (0.3)	1.9 (1.1)	0.1 (0)	0.7 (0.4)
Agropyron smithii	0	0	0	0	0.1 (0.1)	0.2 (0.1)	0	0	0.8 (0.6)	0.6 (0.3)	0	0
Agropyron spicatum	0	0	0.2 (0.1)	0	0	0.1 (0.1)	0.1 (0.1)	0	0	0	0	0
Bromus tectorum	0	0	0	0	0.3 (0.2)	0.2 (0.2)	0	0	0	0	0	0
Carex vallicola	0	0	0	0	0	0	0	0	0.2 (0.1)	0.1 (0.1)	0	0.1 (0.1)
Elymus elymoides	0.2 (0.1)	0.1 (0.1)	0.2 (0.1)	0	1.0 (0.4)	0.8 (0.2)	0.9 (0.2)	0.3 (0.1)	1.6 (0.9)	1.2 (0.8)	0.3 (0.1)	0.2 (0.1)
Festuca idahoensis	0	0	0	0	0.8 (0.5)	0.4 (0.2)	0.7 (0.4)	0	8.4 (2.5)	5.4 (3.1)	5.9 (0.8)	0.8 (0.5)
Koeleria macrantha	0	0	0	0	0	0.1 (0.1)	0.5 (0.2)	0	0.6 (0.2)	0.3 (0.2)	0.4 (0.1)	0
Leymus cinereus	0	0	0.3 (0.3)	0	0.1 (0.1)	0	0	0	0	0	0.1 (0.1)	0
Poa fendleriana	0	0	0	0	0.7 (0.5)	0.1 (0.1)	0.4 (0.2)	0	0	0	0.2 (0.1)	0
Poa secunda	7.2 (1.1)	3.0 (0.6)	6.6 (0.5)	0.4 (0.2)	1.8 (0.3)	0.9 (0.3)	1.4 (0.4)	0.2 (0)	0.1 (0)	0.6 (0.3)	0.2 (0.1)	0.2 (0.1)
Stipa comata	0	0	0	0	0.8 (0.8)	0.4 (0.4)	0	0	0	0	0	0
Forbs												
Antennaria rosea	0	0	0	0	0	0	0	0	0.2 (0.1)	0.3 (0.1)	0.1 (0.1)	0
Arenaria aculeata	0.1 (0.1)	0.1 (0)	0.3 (0.1)	0	0.2 (0.1)	0.6 (0.3)	0.1 (0)	0	0.1 (0.1)	0.2 (0.2)	0	0
Cordylanthus ramosus	0	0	0	0	0	0	0	0	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)	0.1 (0.1)
Crepis acuminata	0	0	0	0	0.2 (0.2)	0.1 (0.1)	0.1 (0)	0.1 (0.1)	0	0	0	0
Cryptantha flavoculata	0	0	0	0	0.1 (0)	0.2 (0)	0.1 (0)	0.1 (0)	0	0	0	0
Eriogonum elatum	0	0	0.3 (0.2)	0.1 (0.1)	1.3 (0.7)	0.6 (0.2)	0.3 (0.2)	0.3 (0.2)	0	0	0	0
Eriogonum microthecum	0	0	0.8 (0.2)	0	0.3 (0.2)	0.7 (0.4)	1.0 (0.2)	0	0.6 (0.2)	1.5 (0.4)	0.2 (0.1)	0
Eriogonum umbellatum	0	0	0	0	0.2 (0.1)	0.4 (0.3)	0.1 (0.1)	0	0.1 (0)	0.3 (0.2)	0.1 (0.1)	0
Leptodactylon pungens	0	0	0.1 (0.1)	0	0.4 (0.4)	0.3 (0.3)	0.4 (0.3)	0	0.1 (0.1)	0.1 (0.1)	1.2 (0.7)	0
Lupinus argenteus	2.5 (0.9)	1.3 (0.6)	2.8 (0.2)	0.2 (0.1)	2.3 (0.7)	1.9 (1.1)	1.5 (0.3)	2.1 (0.4)	2.4 (0.3)	2.6 (0.5)	2.0 (0.6)	3.9 (1.0)
Lygodesmia spinosa	0	0	0	0	0	0	0	0	0	0	0.2 (0.2)	0.1 (0.1)
Penstemon deustus & watsonii	0	0	0	0	0	0	0	0	0	0.2 (0.2)	0.2 (0.1)	0.2 (0.1)
Phlox hoodii	0.3 (0.1)	0.3 (0.1)	0	0	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	0.5 (0.1)	0.9 (0.2)	0.5 (0.1)	0.6 (0.3)
Shrubs												
Artemisia arbuscula	0	0	0	0	0	0	0	0	1.8 (1.2)	0	0.7 (0.4)	0
Artemisia tridentata vaseyana	0	0	0	0	16.0 (12.0)	16.7 (9.1)	16.5 (1.7)	0	26.9 (6.9)	28.6 (3.9)	14.9 (5.1)	0
Artemisia tridentata wyomingensis	9.2 (1.0)	7.7 (1.5)	7.3 (1.7)	0	0	0	0	0	0	0	0	0
Chrysothamnus nauseosus	0	0	0.1 (0.1)	0	0	0	0	0	0.1 (0.1)	0	0	0
Chrysothamnus viscidiflorus	0.1 (0.1)	0.1 (0.1)	1.1 (0.3)	0	1.1 (0.1)	1.6 (0.5)	2.1 (0.6)	0	3.4 (0.3)	3.8 (0.4)	2.2 (0.4)	0
Ephedra viridis	0	0	0.1 (0.1)	0	0.4 (0.2)	0	0	0	0	0	0	0
Symphoricarpos oreophilus	0	0	0	0	0.2 (0.2)	0.7 (0.7)	0.8 (0.5)	0	5.0 (2.1)	1.3 (0.4)	7.1 (4.9)	0

Table 2. Results from mixed effects analysis of variance using arc-sin transformation for environmental variables on elevation sites.

Aerial Cover	Tree			Shrub			Grass			Forb		
Source	df	F	P	df	F	P	df	F	P	df	F	P
Fixed Effects												
Trt	1, 2	0.5	0.5379	1, 2	11.8	0.0754	1, 2	16.4	0.0558	1, 4	2.2	0.2149
Year	–	–	–	1, 4	44.3	0.0027	1, 2	30.5	0.0312	1, 2	0.4	0.6088
Trt*Year	–	–	–	1, 4	40.0	0.0032	1, 26	33.0	<0.0001	1, 4	0.7	0.4450
BLUPs												
Elev	3, 3.16	42.0	0.0049	3, 3.08	28.4	0.0097	3, 4.62	67.8	0.0003	3, 1	28.6	0.1365
Elev*Year	–	–	–	4, 6.22	29.1	0.0004	6, 5.52	79.9	<0.0001	6, 5.05	73.8	<0.0001
Elev*Trt	6, 29.3	419.6	<0.0001	6, 4.70	82.2	0.0001	6, 5.35	78.7	<0.0001	4, 1	22.0	0.1585
Elev*Trt*Year	–	–	–	12, 3.98	43.6	0.0012	10, 32	269.2	<0.0001	12, 1	-3.1	–

Ground Cover	Bare			Gravel			Litter		
Source	df	F	P	df	F	P	df	F	P
Fixed Effects									
Trt	1, 28	30.1	<0.0001	1, 2	19.8	0.0471	1, 2	538.8	0.0019
Year	1, 2	0.1	0.8277	1, 4	53.3	0.0019	1, 2	157.4	0.0063
Trt*Year	1, 28	34.1	<0.0001	1, 4	45.4	0.0025	1, 2	582.1	0.0017
BLUPs									
Elev	3, 3.11	17.8	0.0186	3, 2.69	60.2	0.0056	3, 1	456.4	0.0344
Elev*Year	6, 9.18	19.1	0.0001	4, 5.33	53.0	0.0002	6, 3.66	598.0	<0.0001
Elev*Trt	4, 7.62	19.5	0.0004	6, 4.19	75.2	0.0003	6, 1	336.6	0.0417
Elev*Trt*Year	8, 26.9	21.8	<0.0001	12, 1	69.2	0.0937	12, 1	713.8	0.0292

Table 3. Mean percent cover values (with standard errors in parentheses) of habitat variables on the low, mid, and high elevation sites for the pre (2001) and post (2002) burn years. Elevation values are meters followed by control (C) or burn (B) site designation. Dashes represent uncollected data.

		Low		Mid		High	
Cover Type	Year	2073 C	2103 B	2195 C	2225 B	2347 C	2347 B
Aerial Cover							
Tree	2001	52.8 (2.7)	44.0 (7.0)	35.7 (4.5)	40.8 (5.9)	12.0 (2.2)	33.8 (3.1)
	2002	–	–	–	–	–	–
Shrub	2001	9.2 (0.7)	9.5 (2.1)	18.7 (2.8)	20.8 (1.9)	37.9 (7.8)	26.6 (9.8)
	2002	7.8 (1.4)	0	20.1 (1.9)	0	35.3 (4.2)	0
Grass	2001	7.6 (1.0)	7.3 (0.3)	6.1 (0.7)	4.6 (0)	12.2 (0.7)	7.2 (0.6)
	2002	3.1 (0.6)	0.4 (0.2)	3.6 (0.2)	0.5 (0.2)	10.0 (1.4)	1.9 (0.8)
Forb	2001	3.0 (1.0)	4.1 (0.4)	5.1 (1.2)	2.7 (0.3)	3.5 (0.6)	3.4 (0.7)
	2002	1.8 (0.8)	0.3 (0.1)	4.5 (1.8)	2.7 (0.6)	4.9 (0.8)	4.9 (1.2)
Ground Cover							
Bare	2001	1.5 (0.9)	1.2 (0.9)	1.8 (0.9)	4.4 (3.0)	11.8 (6.7)	10.8 (3.5)
	2002	7.5 (1.8)	–	22.8 (11.3)	–	20.5 (2.2)	–
Gravel	2001	42.7 (2.6)	41.3 (4.5)	34.6 (2.9)	32.6 (4.2)	15.7 (6.8)	17.3 (4.0)
	2002	43.4 (0.8)	–	31.5 (11.4)	–	12.6 (3.7)	–
Litter	2001	43.2 (1.4)	39.8 (2.8)	46.1 (3.0)	45.8 (2.3)	50.2 (1.8)	51.8 (3.7)
	2002	48.6 (2.2)	–	40.6 (2.1)	–	49.2 (3.5)	–

Table 4. Ant species and functional group designation recorded in each control site along the elevation gradient for the pre (2001) and post (2002) burn years. A=Raw abundance, C=% Composition, I=% Incidence in traps.

Elevation (m)		2073						2195						2347					
Year		2001			2002			2001			2002			2001			2002		
Subfamily																			
Species	**Group**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**
Myrmicinae																			
Aphaenogaster occidentalis	O	102	5.7	54.9	81	8.5	50.0	78	5.5	45.8	105	8.9	49.3	1	0.0	1.4	0	0.0	0.0
Aphaenogaster uinta	O	12	0.7	14.1	12	1.3	11.1	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Crematogaster mormonum	GM	156	8.7	78.9	184	19.4	73.6	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Formicoxenus diversipilosus	SP	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	8	0.0	2.8
Monomorium ergatogyna	GM	191	10.7	45.1	128	13.5	43.1	0	0.0	0.0	0	0.0	0.0	1	0.0	1.4	0	0.0	0.0
Myrmica tahoensis	O	1	0.1	1.4	0	0.0	0.0	165	11.6	34.7	126	10.7	38.0	171	0.6	75.0	79	0.3	45.8
Pheidole pilifera	GM	0	0.0	0.0	2	0.2	1.4	0	0.0	0.0	1	0.1	1.4	0	0.0	0.0	0	0.0	0.0
Pogonomyrmex occidentalis	HCS	0	0.0	0.0	0	0.0	0.0	103	7.3	25.0	130	11.0	28.2	0	0.0	0.0	0	0.0	0.0
Solenopsis molesta	CrS	0	0.0	0.0	7	0.7	9.7	0	0.0	0.0	10	0.8	5.6	4	0.0	4.2	3	0.0	2.8
Stenamma smithi	CCS	0	0.0	0.0	0	0.0	0.0	4	0.3	2.8	0	0.0	0.0	0	0.0	0.0	1	0.0	1.4
Temnothorax nevadensis	CCS	36	2.0	21.1	2	0.2	2.8	21	1.5	20.8	16	1.4	9.9	77	0.3	26.4	41	0.2	27.8
Temnothorax rugatulus	CCS	4	0.2	4.2	2	0.2	2.8	1	0.1	1.4	1	0.1	1.4	11	0.0	9.7	6	0.0	8.3
Temnothorax nitens	CCS	3	0.2	4.2	0	0.0	0.0	0	0.0	0.0	2	0.2	2.8	0	0.0	0.0	0	0.0	0.0
Dolichoderinae																			
Tapinoma sessile	?	0	0.0	0.0	0	0.0	0.0	19	1.3	9.7	10	0.8	11.3	213	0.7	75.0	178	0.7	68.1
Formicinae																			
Brachymyrmex depilis	CrS	1	0.1	1.4	2	0.2	2.8	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Camponotus sansabeanus	C	121	6.8	77.5	148	15.6	81.9	0	0.0	0.0	2	0.2	2.8	0	0.0	0.0	0	0.0	0.0
Camponotus vicinus	C	7	0.4	8.5	0	0.0	0.0	425	29.9	98.6	291	24.6	94.4	53	0.2	30.6	10	0.0	11.1
Formica argentea	O	17	1.0	16.9	7	0.7	9.7	114	8.0	54.2	67	5.7	43.7	213	0.7	69.4	108	0.4	59.7
Formica integroides	DCCS	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	0.1	1.4	17163	57.8	65.3	12759	49.3	58.3
Formica lasioides	O	0	0.0	0.0	0	0.0	0.0	34	2.4	12.5	2	0.2	2.8	357	1.2	73.6	146	0.6	55.6
Formica manni	O	20	1.1	18.3	10	1.1	8.3	49	3.5	25.0	54	4.6	26.8	0	0.0	0.0	7	0.0	1.4
Formica (*microgyna* gp.) sp. 1	DCCS	264	14.8	2.8	163	17.2	2.8	47	3.3	16.7	34	2.9	14.1	0	0.0	0.0	0	0.0	0.0
Formica neogagates	O	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	11	0.0	12.5	15	0.1	11.1
Formica ravida	DCCS	0	0.0	0.0	0	0.0	0.0	68	4.8	6.9	233	19.7	16.9	11067	37.3	50.0	12195	47.1	48.6
Formica subpolita	O	0	0.0	0.0	0	0.0	0.0	9	0.6	5.6	0	0.0	0.0	304	1.0	62.5	323	1.2	62.5
Lasius sitiens	CCS	12	0.7	8.5	31	3.3	11.1	57	4.0	27.8	57	4.8	23.9	11	0.0	1.4	1	0.0	1.4
Myrmecocystus testaceus	HCS	711	39.8	12.7	170	17.9	15.3	19	1.3	8.3	40	3.4	16.9	0	0.0	0.0	0	0.0	0.0
Polyergus breviceps	SP	127	7.1	1.4	0	0.0	0.0	207	14.6	1.4	0	0.0	0.0	49	0.2	2.8	20	0.1	2.8
Total Abundance		**1785**			**949**			**1420**			**1182**			**29706**			**25900**		
Total Number of Species		**17**			**15**			**17**			**19**			**16**			**17**		

Functional groups are: C, Camponotus; CCS, Cold Climate Specialists; CrS, Cryptic Species; DCCS, Dominant Cold Climate Specialists; GM, Generalized Myrmicinae; HCS, Hot Climate Specialists; O, Opportunists; SP, Social Parasites.

Table 5. Ant species and functional group designation recorded in each burn site along the elevation gradient for the pre (2001) and post (2002) burn years. A=Raw abundance, C=% Composition, I=% Incidence in traps.

Elevation (m)		2103						2225						2347					
Year		2001			2002			2001			2002			2001			2002		
Subfamily																			
Species	**Group**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**
Myrmicinae																			
Aphaenogaster occidentalis	O	145	15.2	65.3	278	29.7	91.7	0	0.0	0.0	9	0.2	1.4	0	0.0	0.0	1	0.0	1.4
Aphaenogaster uinta	O	2	0.2	2.8	12	1.3	8.3	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Crematogaster mormonum	GM	42	4.4	16.7	32	3.4	20.8	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Myrmica tahoensis	O	0	0.0	0.0	0	0.0	0.0	139	2.7	67.6	355	6.4	91.5	292	4.7	69.4	425	5.8	86.1
Pogonomyrmex occidentalis	HCS	122	12.8	25.0	148	15.8	41.7	10	0.2	5.6	72	1.3	28.2	0	0.0	0.0	0	0.0	0.0
Solenopsis molesta	CrS	0	0.0	0.0	1	0.1	1.4	6	0.1	4.2	4	0.1	4.2	0	0.0	0.0	0	0.0	0.0
Stenamma snellingi	CCS	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	0.0	1.4
Temnothorax nevadensis	CCS	3	0.3	2.8	15	1.6	18.1	20	0.4	15.5	101	1.8	49.3	36	0.6	18.1	25	0.3	23.6
Temnothorax rugatulus	CCS	0	0.0	0.0	0	0.0	0.0	2	0.0	2.8	0	0.0	0.0	25	0.4	20.8	36	0.5	20.8
Temnothorax nitens	CCS	0	0.0	0.0	3	0.3	4.2	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	0.0	1.4
Dolichoderinae																			
Tapinoma sessile	?	0	0.0	0.0	0	0.0	0.0	102	2.0	32.4	217	3.9	54.9	270	4.4	56.9	403	5.5	88.9
Formicinae																			
Camponotus sansabeanus	C	224	23.6	91.7	143	15.3	69.4	1	0.0	1.4	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Camponotus vicinus	C	115	12.1	55.6	40	4.3	29.2	204	3.9	73.2	189	3.4	78.9	122	2.0	70.8	80	1.1	48.6
Formica argentea	O	37	3.9	29.2	79	8.4	45.8	127	2.4	56.3	332	6.0	85.9	233	3.8	81.9	533	7.3	88.9
Formica integroides	DCCS	2	0.2	1.4	0	0.0	0.0	4343	83.1	35.2	3745	67.5	32.4	2300	37.2	45.8	770	10.5	38.9
Formica lasioides	O	0	0.0	0.0	0	0.0	0.0	4	0.1	4.2	5	0.1	7.0	426	6.9	68.1	1236	16.9	86.1
Formica manni	O	152	16.0	41.7	142	15.2	61.1	20	0.4	5.6	16	0.3	8.5	1	0.0	1.4	1	0.0	1.4
Formica (*microgyna* gp.) sp. 1	DCCS	95	10.0	11.1	39	4.2	15.3	0	0.0	0.0	9	0.2	4.2	414	6.7	33.3	906	12.4	41.7
Formica neogagates	O	0	0.0	0.0	0	0.0	0.0	4	0.1	2.8	11	0.2	5.6	148	2.4	30.6	162	2.2	41.7
Formica ravida	DCCS	0	0.0	0.0	0	0.0	0.0	113	2.2	12.7	4	0.1	4.2	1534	24.8	37.5	2382	32.5	37.5
Formica subpolita	O	1	0.1	1.4	0	0.0	0.0	107	2.0	38.0	273	4.9	56.3	266	4.3	61.1	368	5.0	77.8
Lasius sitiens	CCS	0	0.0	0.0	1	0.1	1.4	18	0.3	15.5	191	3.4	49.3	0	0.0	0.0	0	0.0	0.0
Myrmecocystus testaceus	HCS	0	0.0	0.0	3	0.3	4.2	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Polyergus breviceps	SP	11	1.2	2.8	0	0.0	0.0	4	0.1	4.2	14	0.3	8.5	117	1.9	4.2	5	0.1	4.2
Total Abundance		**951**			**936**			**5224**			**5547**			**6184**			**7335**		
Total Number of Species		**13**			**14**			**17**			**17**			**14**			**17**		

Functional groups are: C, Camponotus; CCS, Cold Climate Specialists; CrS, Cryptic Species; DCCS, Dominant Cold Climate Specialists; GM, Generalized Myrmicinae; HCS, Hot Climate Specialists; O, Opportunists; SP, Social Parasites.

Table 6. Results from the mixed effects analysis of variance for ln-transformed ant abundance on elevation sites. Sources include fixed effects and Best Linear Unbiased Predictors (BLUPs) for random effects.

Source	df	F	P
Fixed Effects			
Trt	1, 2	0.2	0.6965
Year	1, 4	4.1	0.1116
Trt*Year	1, 4	7.9	0.0480
BLUPs			
Elev	3, 2.64	34.2	0.0125
Elev*Year	4, 5.23	24.5	0.0014
Elev*Trt	6, 14.5	100.7	<0.0001
Elev*Trt*Year	12, 16.4	53.0	<0.0001

Table 7. R-squared values for canonical correspondence analysis (CCA) axes 1 and 2 of environmental variables associated with the elevation plots. Significance at p≤0.01 is indicated by **.

	All Plots		Burn Plots 2001		Burn Plots 2002	
Variable	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2
Elevation	0.697**	0.013	0.311	0.176	0.388	0.287
Tree	0.442	0.021	0.216	0.005	0.120	<0.001
Shrub	0.110	0.276	0.001	0.442	–	–
Forb	0.045	0.412	0.102	0.000	0.410	0.010
Grass	0.192	0.157	0.005	0.000	0.015	0.240
Bare	0.069	0.359	0.526	0.004	0.301	0.020
Gravel	0.121	0.423	0.211	0.353	0.194	0.540
Litter	0.053	0.184	0.027	0.372	0.035	0.748

Table 8. Plant species with mean percent cover values greater than 0.1% on the low, mid, and high tree cover plots for the pre (2001) and post (2002) burn years. Values are mean percent cover with standard errors in parentheses.

	Control Plots						Burn Plots					
Plant Type	Low		Mid		High		Low		Mid		High	
Species	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Grasses and Carices												
Achnatherum thurberianum	0.4 (0.2)	0.2 (0.2)	0.6 (0.2)	0.4 (0)	0.1 (0.1)	0	1.1 (0.3)	0.1 (0)	0.5 (0.1)	0.1 (0)	0.5 (0.1)	0.1 (0)
Agropyron smithii	0	0	0.1 (0.1)	0.2 (0.1)	0	0	0	0	0	0	0	0
Agropyron spicatum	0	0.1 (0.1)	0	0.1 (0.1)	0	0	0	0	0.1 (0.1)	0	0	0
Bromus tectorum	0	0	0.3 (0.2)	0.2 (0.2)	0	0	0.1 (0.1)	0	0	0	0	0
Elymus elymoides	0.2 (0.2)	0.6 (0.1)	1.0 (0.4)	0.8 (0.2)	1.7 (0.7)	0.9 (0.3)	0.8 (0.1)	0.3 (0)	0.9 (0.2)	0.3 (0.1)	0.8 (0.1)	0.1 (0)
Festuca idahoensis	8.0 (2.2)	4.3 (1.1)	0.8 (0.5)	0.4 (0.2)	0.1 (0.1)	0.1 (0.1)	0.7 (0.2)	0	0.7 (0.4)	0	0.2 (0.1)	0
Koeleria macrantha	0	0.3 (0.2)	0	0.1 (0.1)	0	0	0.2 (0.1)	0	0.5 (0.2)	0	0.1 (0.1)	0
Poa fendleriana	0.8 (0.2)	0.1 (0.1)	0.7 (0.5)	0.1 (0.1)	0.2 (0.1)	0	0.2 (0.2)	0	0.4 (0.2)	0	0.1 (0)	0
Poa secunda	0.6 (0.3)	0.9 (0.6)	1.8 (0.3)	0.9 (0.3)	2.5 (0.4)	0.8 (0.3)	1.2 (0.1)	0.4 (0.2)	1.4 (0.4)	0.2 (0)	1.1 (0.2)	0
Stipa comata	0	0	0.8 (0.8)	0.4 (0.4)	0	0	0	0	0	0	0	0
Forbs												
Antennaria rosea	0	0	0	0	0	0	0	0	0	0	0	0
Arenaria aculeata	0.1 (0.1)	0.4 (0.3)	0.2 (0.1)	0.6 (0.3)	0.1 (0)	0.2 (0)	0.5 (0.3)	0.2 (0.1)	0.1 (0)	0	0	0
Astragalus filipes & obscurus	0	0.1 (0.1)	0	0	0	0	0	0	0	0	0	0
Crepis acuminata	0.3 (0.1)	0.4 (0.1)	0.2 (0.2)	0.1 (0.1)	0	0	0	0	0.1 (0)	0.1 (0.1)	0	0
Cryptantha flavoculata	0.1 (0)	0.1 (0.1)	0.1 (0)	0.2 (0)	0.1 (0)	0.1 (0)	0.1 (0)	0.2 (0.2)	0.1 (0)	0.1 (0)	0.1 (0)	0
Eriogonum elatum	1.3 (0.2)	1.2 (0.2)	1.3 (0.7)	0.6 (0.2)	0	0	0.8 (0.2)	0.5 (0.1)	0.3 (0.2)	0.3 (0.2)	0	0
Eriogonum microthecum	0.7 (0.1)	2.1 (0.5)	0.3 (0.2)	0.7 (0.4)	0.1 (0.1)	0.1 (0.1)	0.6 (0.1)	0	1.0 (0.2)	0	0	0
Eriogonum umbellatum	0.7 (0.3)	1.3 (0)	0.2 (0.1)	0.4 (0.3)	0	0	0.2 (0.1)	0	0.1 (0.1)	0	0	0
Gilia inconspicua	0	0.1 (0.1)	0	0.1 (0.1)	0	0.2 (0.2)	0	0	0	0	0	0
Leptodactylon pungens	0	0.1 (0.1)	0.4 (0.4)	0.3 (0.3)	0	0	0.4 (0.2)	0	0.4 (0.3)	0	0	0
Lupinus argenteus	3.6 (0.4)	3.0 (0.8)	2.3 (0.7)	1.9 (1.1)	0.5 (0.3)	0.3 (0.2)	2.0 (0.4)	1.8 (0.5)	1.5 (0.3)	2.1 (0.4)	0	0
Lygodesmia spinosa	0.1 (0)	0.2 (0)	0	0	0	0	0	0	0	0	0	0
Phlox hoodii	0	0.1 (0)	0.2 (0.1)	0.2 (0.1)	0.1 (0)	0.4 (0.1)	0.4 (0.1)	0.4 (0.1)	0.2 (0.1)	0.2 (0.1)	0	0
Shrubs												
Artemisia tridentata vaseyana	29.5 (6.7)	29.3 (9.0)	19.8 (14.0)	16.7 (9.1)	0.9 (0.8)	1.1 (1.0)	37.1 (5.5)	0	16.5 (1.7)	0	1.8 (0.8)	0
Chrysothamnus nauseosus	0	0	0	0	0	0	0.3 (0.3)	0	0	0	0	0
Chrysothamnus viscidiflorus	2.6 (1.1)	3.2 (1.1)	1.1 (0.1)	1.6 (0.5)	0.1 (0)	0.1 (0.1)	1.4 (0.7)	0	2.1 (0.6)	0	0.1 (0)	0
Ephedra viridis	0.9 (0.7)	1.2 (0.9)	0.4 (0.2)	0	0.3 (0.3)	0.3 (0.2)	0	0	0	0	0.5 (0.5)	0
Symphoricarpos oreophilus	0	0	0.2 (0.2)	0.7 (0.7)	0	0	1.7 (1.6)	0	0.8 (0.5)	0	1.8 (0.9)	0

Table 9. Results from mixed effects analysis of variance using arc-sin transformation for environmental variables on tree cover sites.

Aerial Cover	Tree			Shrub			Grass			Forb		
Source	df	F	P	df	F	P	df	F	P	df	F	P
Full model												
Trt	1, 24.8	3.6	0.0692	1, 28	23.4	<0.0001	1, 1	24.7	0.1265	1, 13.6	15.9	0.0014
Density	2, 24.8	30.0	<0.0001	2, 28	45.3	<0.0001	2, 1	5.4	0.2924	2, 13.6	13.1	0.0007
Density*Trt	2, 24.8	1.8	0.1833	2, 28	5.9	0.0073	2, 1	1.2	0.5411	2, 13.6	0.0	0.9662
Year	1, 22	0.0	1.0000	1, 28	40.2	<0.0001	1, 22	155.8	<0.0001	1, 22	0.6	0.4365
Trt*Year	1, 22	0.0	1.0000	1, 28	47.6	<0.0001	1, 22	16.9	0.0005	1, 22	1.6	0.2167
Reduced model												
Trt	1, 30.2	1.2	0.2888	1, 27.3	4.2	0.0515	1, 21.2	24.1	<0.0001	1, 31.1	11.9	0.0017
Year	1, 26.8	0.0	1.0000	1, 27	28.0	<0.0001	1, 26.8	97.1	<0.0001	1, 26.2	0.4	0.5614
Trt*Year	1, 26.8	0.0	1.0000	1, 27	33.2	<0.0001	1, 26.8	10.5	0.0032	1, 26.2	0.9	0.3538

Ground Cover	Bare			Gravel			Litter		
Source	df	F	P	df	F	P	df	F	P
Full model									
Trt	1, 28	32.4	<0.0001	1, 18.5	22.4	0.0002	1, 28	218.0	<0.0001
Density	2, 28	4.9	0.0145	2, 18.5	1.2	0.3262	2, 28	17.7	<0.0001
Density*Trt	2, 28	0.2	0.8111	2, 18.5	0.6	0.5619	2, 28	0.3	0.7792
Year	1, 28	0.4	0.5119	1, 22	106.1	<0.0001	1, 28	293.7	<0.0001
Trt*Year	1, 28	24.9	<0.0001	1, 22	134.9	<0.0001	1, 28	254.4	<0.0001
Reduced model									
Trt	1, 10.2	11.5	0.0067	1, 6.91	61.4	0.0001	1, 19.2	43.3	<0.0001
Year	1, 27.6	0.5	0.5000	1, 27.4	88.5	<0.0001	1, 27.4	278.7	<0.0001
Trt*Year	1, 27.6	26.4	<0.0001	1, 27.4	112.6	<0.0001	1, 27.4	241.4	<0.0001

Table 10. Mean percent cover values (with standard errors in parentheses) of habitat variables on the low, mid, and high tree cover plots for the pre (2001) and post (2002) burn years. Dashes represent uncollected data.

		Control Plots			Burn Plots		
Cover Type	Year	Low	Mid	High	Low	Mid	High
Aerial Cover							
Tree	2001	17.9 (6.7)	35.7 (4.5)	75.1 (6.3)	21.3 (3.8)	40.8 (5.9)	80.6 (2.6)
	2002	–	–	–	–	–	–
Shrub	2001	33.8 (4.3)	18.7 (2.8)	1.3 (1.2)	42.1 (3.5)	20.8 (1.9)	4.1 (1.8)
	2002	35.9 (3.8)	20.1 (1.9)	1.6 (1.3)	0	0	0
Grass	2001	10.1 (2.1)	6.1 (0.7)	4.7 (0.4)	4.3 (0.1)	4.6 (0)	2.8 (0.1)
	2002	6.4 (0.7)	3.6 (0.2)	1.9 (0.5)	0.8 (0.1)	0.5 (0.2)	0.2 (0.1)
Forb	2001	6.3 (0.3)	5.1 (1.2)	0.9 (0.3)	4.2 (0.5)	2.7 (0.3)	0.4 (0.2)
	2002	7.2 (1.0)	4.5 (1.8)	1.2 (0.2)	3.1 (0.5)	2.7 (0.6)	0.1 (0)
Ground Cover							
Bare	2001	5.1 (0.8)	1.8 (0.9)	2.0 (0.8)	4.8 (1.6)	4.4 (3.0)	0.1 (0.1)
	2002	12.3 (0.8)	22.8 (11.3)	4.2 (0.7)	–	–	–
Gravel	2001	31.2 (3.4)	34.6 (2.9)	28.0 (3.9)	37.5 (1.0)	32.6 (4.2)	25.3 (1.0)
	2002	42.5 (5.0)	31.5 (11.4)	32.1 (9.0)	–	–	–
Litter	2001	44.2 (3.9)	46.1 (3.0)	58.1 (2.8)	41.1 (2.7)	45.8 (2.3)	69.8 (2.4)
	2002	38.6 (2.5)	40.6 (2.1)	60.5 (7.0)	–	–	–

Table 11. Ant species and functional group designation recorded in each control plot along the tree cover gradient for the pre (2001) and post (2002) burn years. A=Raw abundance, C=% Composition, I=% Incidence in traps.

Tree Cover		Low						Mid						High					
Year		2001			2002			2001			2002			2001			2002		
Subfamily																			
Species	**Group**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**
Myrmicinae																			
Aphaenogaster occidentalis	O	93	5.0	51.4	129	12.4	56.9	78	5.5	45.8	105	8.9	49.3	89	9.6	55.7	91	15.2	56.9
Aphaenogaster uinta	O	0	0.0	0.0	1	0.1	1.4	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Crematogaster mormonum	GM	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	2	0.2	2.9	2	0.3	2.8
Myrmica tahoensis	O	192	10.2	41.7	154	14.8	40.3	165	11.6	34.7	126	10.7	38.0	32	3.4	25.7	32	5.3	25.0
Pheidole pilifera	GM	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	0.1	1.4	0	0.0	0.0	1	0.2	1.4
Pogonomyrmex occidentalis	HCS	0	0.0	0.0	0	0.0	0.0	103	7.3	25.0	130	11.0	28.2	0	0.0	0.0	0	0.0	0.0
Solenopsis molesta	CrS	0	0.0	0.0	5	0.5	4.2	0	0.0	0.0	10	0.8	5.6	0	0.0	0.0	9	1.5	8.3
Stenamma smithi	CCS	0	0.0	0.0	0	0.0	0.0	4	0.3	2.8	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Temnothorax nevadensis	CCS	25	1.3	18.1	16	1.5	16.7	21	1.5	20.8	16	1.4	9.9	20	2.2	15.7	8	1.3	8.3
Temnothorax rugatulus	CCS	1	0.1	1.4	1	0.1	1.4	1	0.1	1.4	1	0.1	1.4	2	0.2	2.9	1	0.2	1.4
Temnothorax nitens	CCS	1	0.1	1.4	0	0.0	0.0	0	0.0	0.0	2	0.2	2.8	1	0.1	1.4	0	0.0	0.0
Dolichoderinae																			
Tapinoma sessile	?	157	8.4	45.8	95	9.2	48.6	19	1.3	9.7	10	0.8	11.3	0	0.0	0.0	0	0.0	0.0
Formicinae																			
Brachymyrmex depilis	CrS	0	0.0	0.0	1	0.1	1.4	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Camponotus sansabeanus	C	4	0.2	5.6	0	0.0	0.0	0	0.0	0.0	2	0.2	2.8	4	0.4	2.9	6	1.0	6.9
Camponotus vicinus	C	455	24.3	91.7	240	23.1	84.7	425	29.9	98.6	291	24.6	94.4	268	28.9	82.9	184	30.7	72.2
Formica argentea	O	53	2.8	30.6	11	1.1	13.9	114	8.0	54.2	67	5.7	43.7	183	19.7	58.6	42	7.0	41.7
Formica integroides	DCCS	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	0.1	1.4	0	0.0	0.0	0	0.0	0.0
Formica lasioides	O	476	25.4	36.1	197	19.0	33.3	34	2.4	12.5	2	0.2	2.8	0	0.0	0.0	1	0.2	1.4
Formica manni	O	174	9.3	48.6	97	9.3	34.7	49	3.5	25.0	54	4.6	26.8	0	0.0	0.0	0	0.0	0.0
Formica (*microgyna* gp.) sp. 1	DCCS	11	0.6	5.6	3	0.3	4.2	47	3.3	16.7	34	2.9	14.1	277	29.8	30.0	73	12.2	27.8
Formica neogagates	O	0	0.0	0.0	2	0.2	2.8	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Formica ravida	DCCS	0	0.0	0.0	0	0.0	0.0	68	4.8	6.9	233	19.7	16.9	4	0.4	4.3	7	1.2	6.9
Formica subpolita	O	115	6.1	8.3	34	3.3	11.1	9	0.6	5.6	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0
Lasius sitiens	CCS	54	2.9	36.1	52	5.0	31.9	57	4.0	27.8	57	4.8	23.9	36	3.9	18.6	74	12.3	27.8
Myrmecocystus testaceus	HCS	0	0.0	0.0	0	0.0	0.0	19	1.3	8.3	40	3.4	16.9	9	1.0	7.1	17	2.8	13.9
Polyergus breviceps	SP	63	3.4	1.4	0	0.0	0.0	207	14.6	1.4	0	0.0	0.0	1	0.1	1.4	52	8.7	1.4
Total Abundance		**1874**			**1038**			**1420**			**1182**			**928**			**600**		
Total Number of Species		**15**			**16**			**17**			**19**			**14**			**16**		

Functional groups are: C, Camponotus; CCS, Cold Climate Specialists; CrS, Cryptic Species; DCCS, Dominant Cold Climate Specialists; GM, Generalized Myrmicinae; HCS, Hot Climate Specialists; O, Opportunists; SP, Social Parasites.

Table 12. Ant species and functional group designation recorded in each burn plot along the tree cover gradient for the pre (2001) and post (2002) burn years. A=Raw abundance, C=% Composition, I=% Incidence in traps.

Tree Cover		Low						Mid						High					
Year		2001			2002			2001			2002			2001			2002		
Subfamily																			
Species	**Group**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**	**A**	**C**	**I**
Myrmicinae																			
Aphaenogaster occidentalis	O	7	0.2	8.3	60	1.1	13.9	0	0.0	0.0	9	0.2	1.4	4	0.2	5.6	51	1.9	15.3
Aphaenogaster uinta	O	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	0.0	1.4
Crematogaster mormonum	GM	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	0.1	1.4	0	0.0	0.0
Myrmica tahoensis	O	122	4.2	58.3	233	4.1	77.8	139	2.7	67.6	355	6.4	91.5	109	6.7	52.8	474	17.4	95.8
Pogonomyrmex occidentalis	HCS	13	0.4	8.3	39	0.7	25.0	10	0.2	5.6	72	1.3	28.2	0	0.0	0.0	37	1.4	30.6
Solenopsis molesta	CrS	0	0.0	0.0	0	0.0	0.0	6	0.1	4.2	4	0.1	4.2	1	0.1	1.4	3	0.1	4.2
Stenamma smithi	CCS	1	0.0	1.4	1	0.0	1.4	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	0.0	1.4
Temnothorax nevadensis	CCS	32	1.1	20.8	66	1.2	36.1	20	0.4	15.5	101	1.8	49.3	16	1.0	15.3	59	2.2	41.7
Temnothorax rugatulus	CCS	0	0.0	0.0	0	0.0	0.0	2	0.0	2.8	0	0.0	0.0	3	0.2	4.2	0	0.0	0.0
Temnothorax nitens	CCS	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	1	0.1	1.4	0	0.0	0.0
Dolichoderinae																			
Tapinoma sessile	?	80	2.7	43.1	198	3.5	66.7	102	2.0	32.4	217	3.9	54.9	5	0.3	4.2	24	0.9	15.3
Formicinae																			
Camponotus sansabeanus	C	0	0.0	0.0	0	0.0	0.0	1	0.0	1.4	0	0.0	0.0	2	0.1	2.8	0	0.0	0.0
Camponotus vicinus	C	234	8.0	79.2	253	4.5	76.4	204	3.9	73.2	189	3.4	78.9	352	21.6	90.3	296	10.8	86.1
Formica argentea	O	70	2.4	38.9	102	1.8	55.6	127	2.4	56.3	332	6.0	85.9	237	14.5	68.1	450	16.5	94.4
Formica integroides	DCCS	335	11.4	9.7	271	4.8	15.3	4343	83.1	35.2	3745	67.5	32.4	1	0.1	1.4	1	0.0	1.4
Formica lasioides	O	25	0.9	8.3	6	0.1	8.3	4	0.1	4.2	5	0.1	7.0	0	0.0	0.0	0	0.0	0.0
Formica manni	O	99	3.4	31.9	89	1.6	36.1	20	0.4	5.6	16	0.3	8.5	1	0.1	1.4	7	0.3	6.9
Formica (*microgyna* gp.) sp. 1	DCCS	6	0.2	4.2	7	0.1	1.4	0	0.0	0.0	9	0.2	4.2	18	1.1	4.2	18	0.7	4.2
Formica neogagates	O	25	0.9	9.7	25	0.4	18.1	4	0.1	2.8	11	0.2	5.6	0	0.0	0.0	0	0.0	0.0
Formica ravida	DCCS	1697	58.0	30.6	3911	69.5	18.1	113	2.2	12.7	4	0.1	4.2	725	44.4	31.9	963	35.3	41.7
Formica subpolita	O	141	4.8	23.6	161	2.9	37.5	107	2.0	38.0	273	4.9	56.3	4	0.2	5.6	38	1.4	18.1
Lasius sitiens	CCS	31	1.1	20.8	201	3.6	45.8	18	0.3	15.5	191	3.4	49.3	15	0.9	11.1	140	5.1	45.8
Myrmecocystus testaceus	HCS	1	0.0	1.4	6	0.1	2.8	0	0.0	0.0	0	0.0	0.0	117	7.2	8.3	158	5.8	38.9
Polyergus breviceps	SP	8	0.3	4.2	0	0.0	0.0	4	0.1	4.2	14	0.3	8.5	21	1.3	4.2	8	0.3	1.4
Total Abundance		**2927**			**5629**			**5224**			**5547**			**1633**			**2729**		
Total Number of Species		**18**			**17**			**17**			**17**			**19**			**18**		

Functional groups are: C, Camponotus; CCS, Cold Climate Specialists; CrS, Cryptic Species; DCCS, Dominant Cold Climate Specialists; GM, Generalized Myrmicinae; HCS, Hot Climate Specialists; O, Opportunists; SP, Social Parasites.

Table 13. Results from the mixed effects analysis of variance for ln-transformed ant abundance on tree cover sites using the full and reduced models.

Source	df	F	P
Full model			
Trt	1, 13.3	0.2	0.6671
Density	2, 12.9	0.1	0.9254
Density*Trt	2, 12.9	1.0	0.3895
Year	1, 21.8	0.2	0.6302
Trt*Year	1, 21.8	4.3	0.0491
Reduced model			
Trt	1, 6.03	5.7	0.0541
Year	1, 27.5	0.2	0.6521
Trt*Year	1, 27.5	3.8	0.0620

Table 14. R-squared values for canonical correspondence analysis (CCA) axes 1 and 2 of environmental variables associated with the tree cover plots. Significance at p≤0.05 is indicated by *, and at p≤0.01 by **.

	All Plots		Burn Plots 2001		Burn Plots 2002	
Variable	Axis 1	Axis 2	Axis 1	Axis 2	Axis 1	Axis 2
Tree	0.046	0.286	0.199	0.016	0.040	0.224
Shrub	<0.001	0.130	<0.001	0.008	–	–
Forb	0.011	0.255	0.166	0.002	0.154	0.272
Grass	0.140	0.438	0.469	0.005	0.002	0.613
Bare	0.808**	0.041	0.731*	0.085	0.291	0.461
Gravel	0.002	0.243	0.087	0.060	0.167	0.162
Litter	0.233	0.010	0.230	0.048	0.044	0.296

Fig. 1. The boundary of the Great Basin in the western United States and the location of the study canyon in central Nevada. The study was located in Underdown Canyon in the Shoshone Mountain Range of Lander Co., Nevada (39°10′N, 117°25′W). Figure adapted from Chambers and Miller (2004).

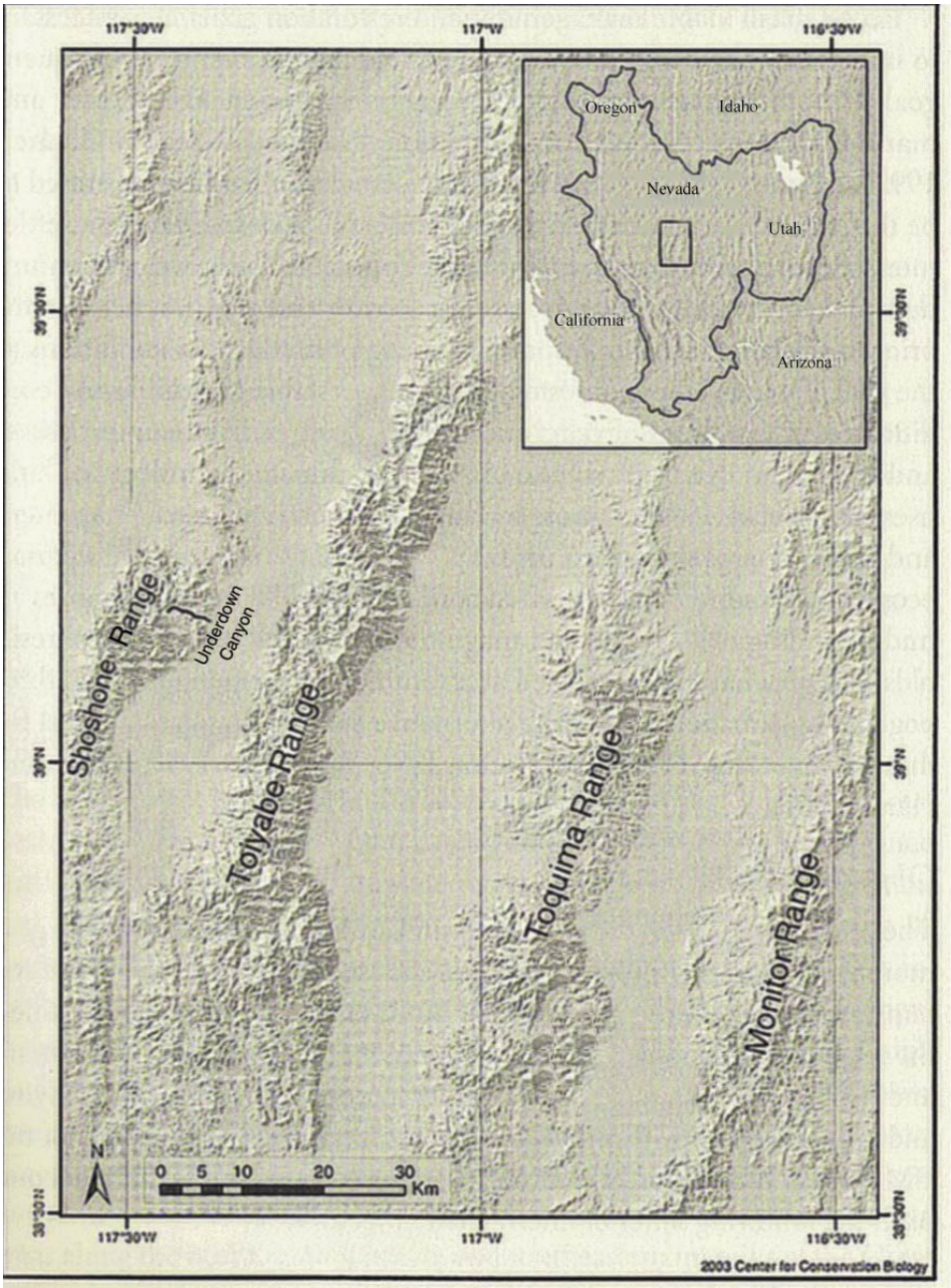


Fig. 2. Study sites were located on north facing alluvial fans along an elevation gradient within Underdown Canyon. Sites labeled #3 and #4 on this figure are the low elevation sites, #7 and #8 are the mid elevation sites, and #13 and #14 are the high elevation sites.

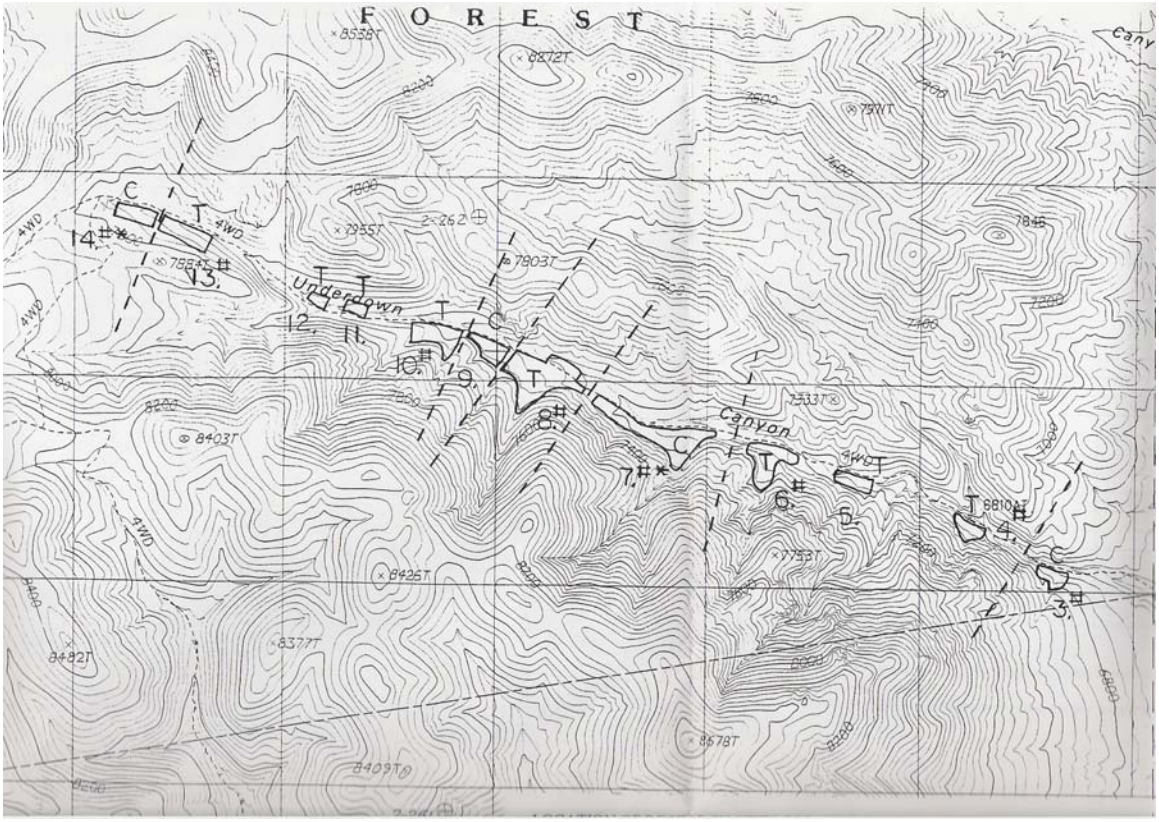
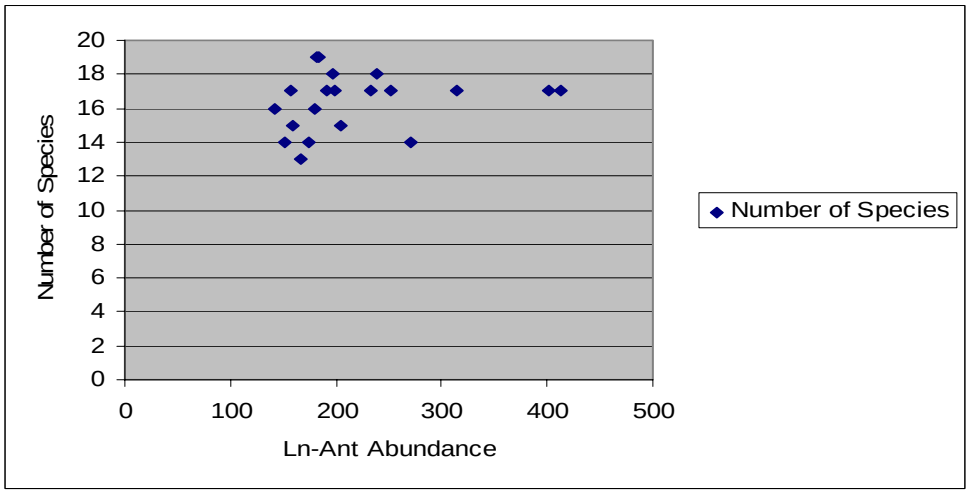
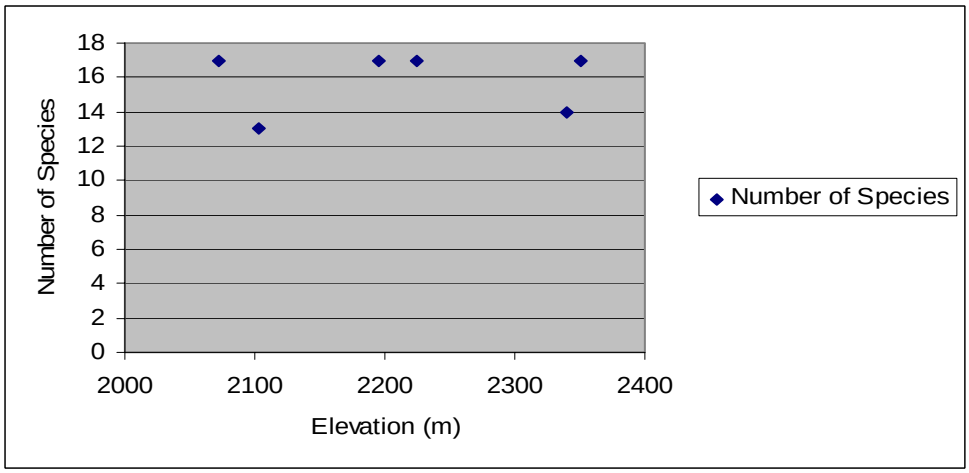
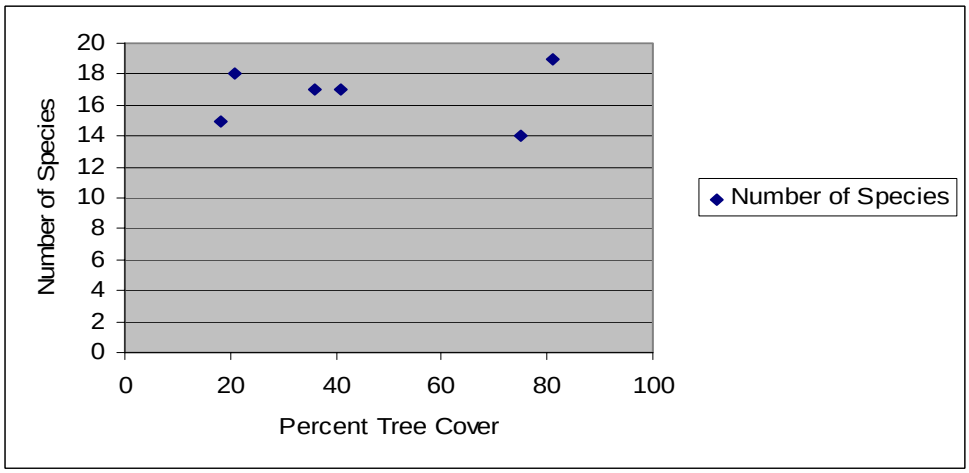


Fig. 3. The number of ant species plotted against ln-transformed ant abundance, elevation, and tree cover. The patterns observed indicate that ant species richness does not vary across the elevation or tree cover gradients.







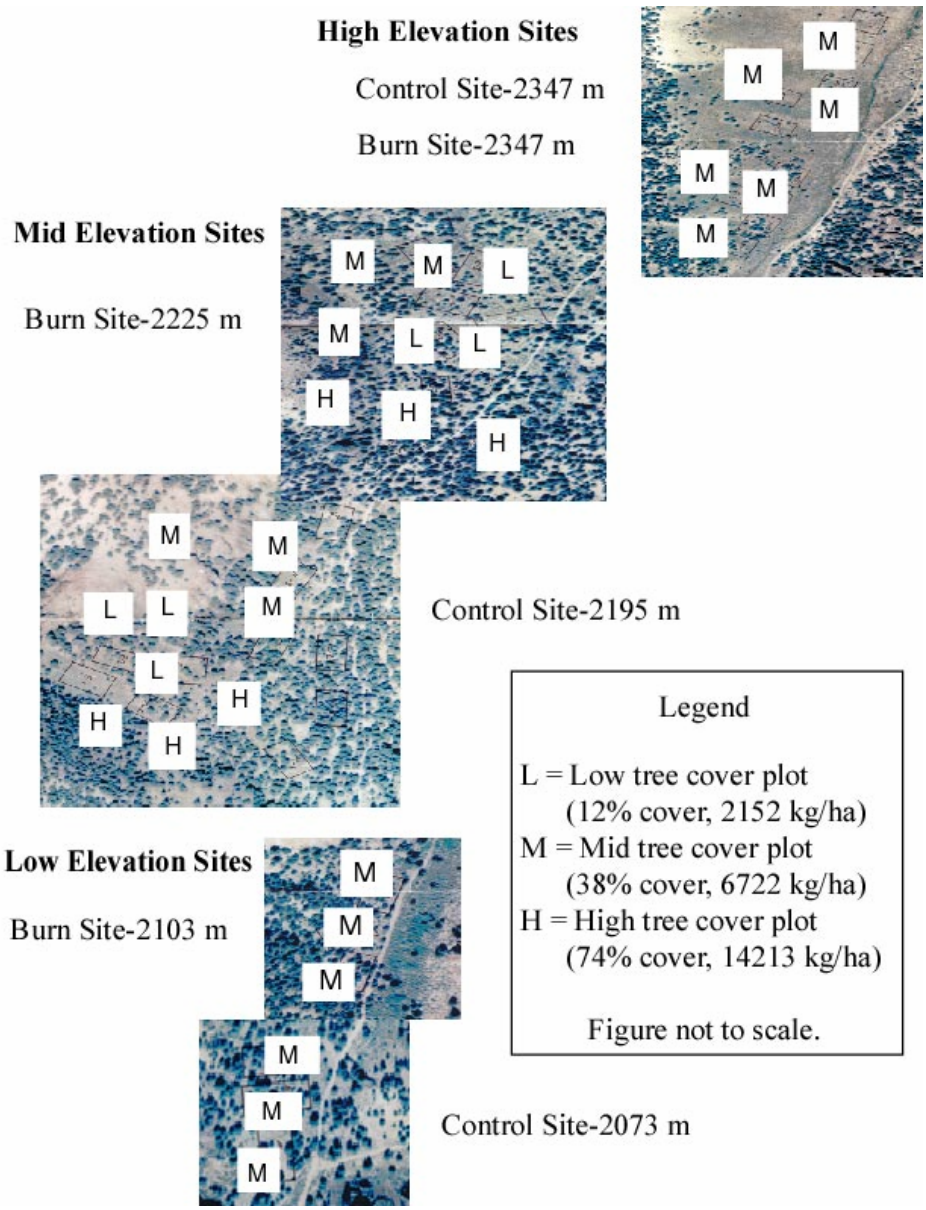


Figure 4. An illustration of the study design.

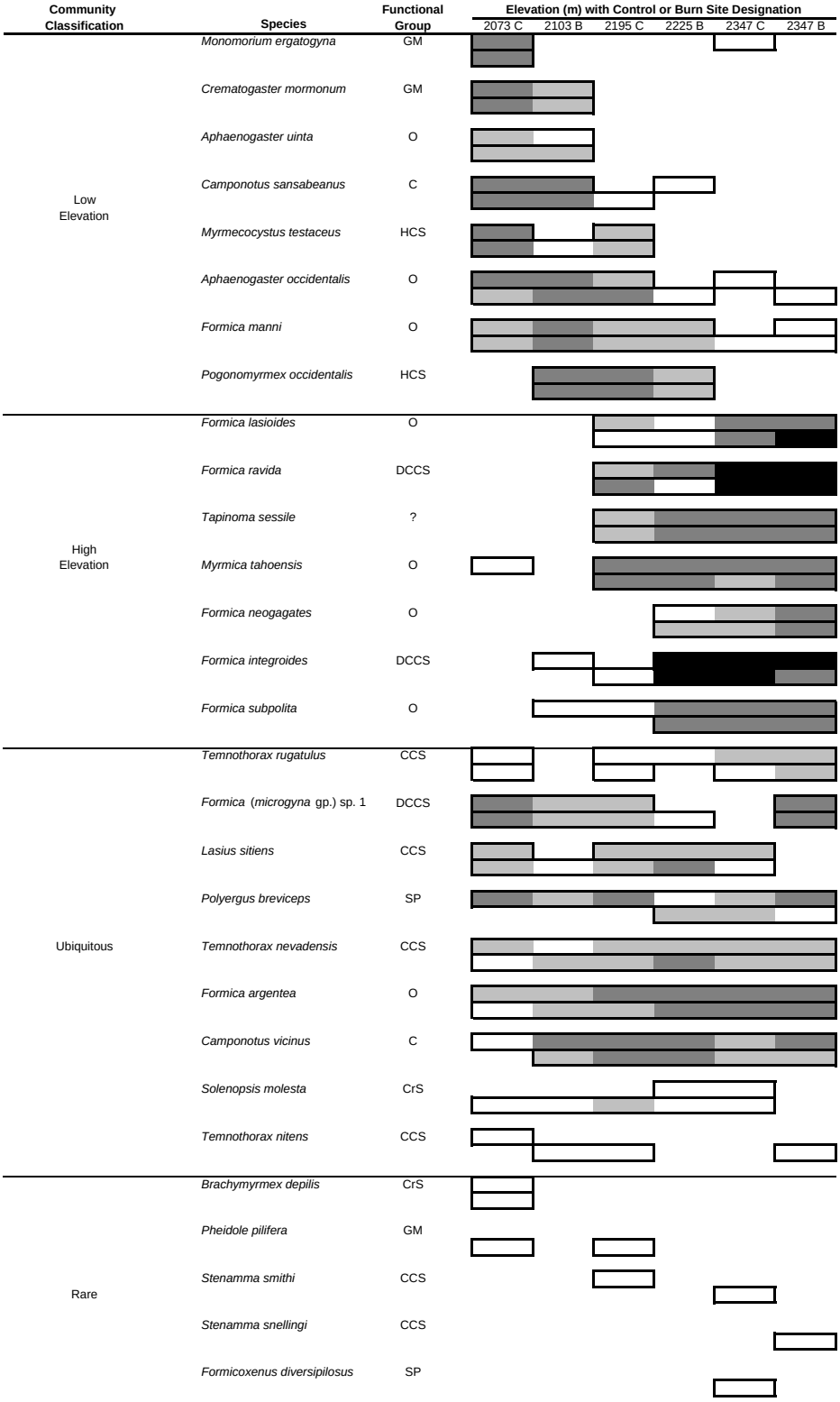


Figure 5. Ant community composition along the elevation gradient. Ant species found in abundance of ten or more on the mid-elevation sites and below are considered low elevation species. Ant species found in abundance of ten or more on the mid-elevation sites and above are considered high elevation species. Abundance color codes are: white=1-9, light grey=10-99, dark grey=100-999, black=1000+. Top bars indicate species abundance in 2001 and bottom bars indicate species abundance in 2002. Functional groups are: C, Camponotus; CCS, Cold Climate Specialists; CrS, Cryptic Species; DCCS, Dominant Cold Climate Specialists; GM, Generalized Myrmicinae; HCS, Hot Climate Specialists; O, Opportunists; SP, Social Parasites.

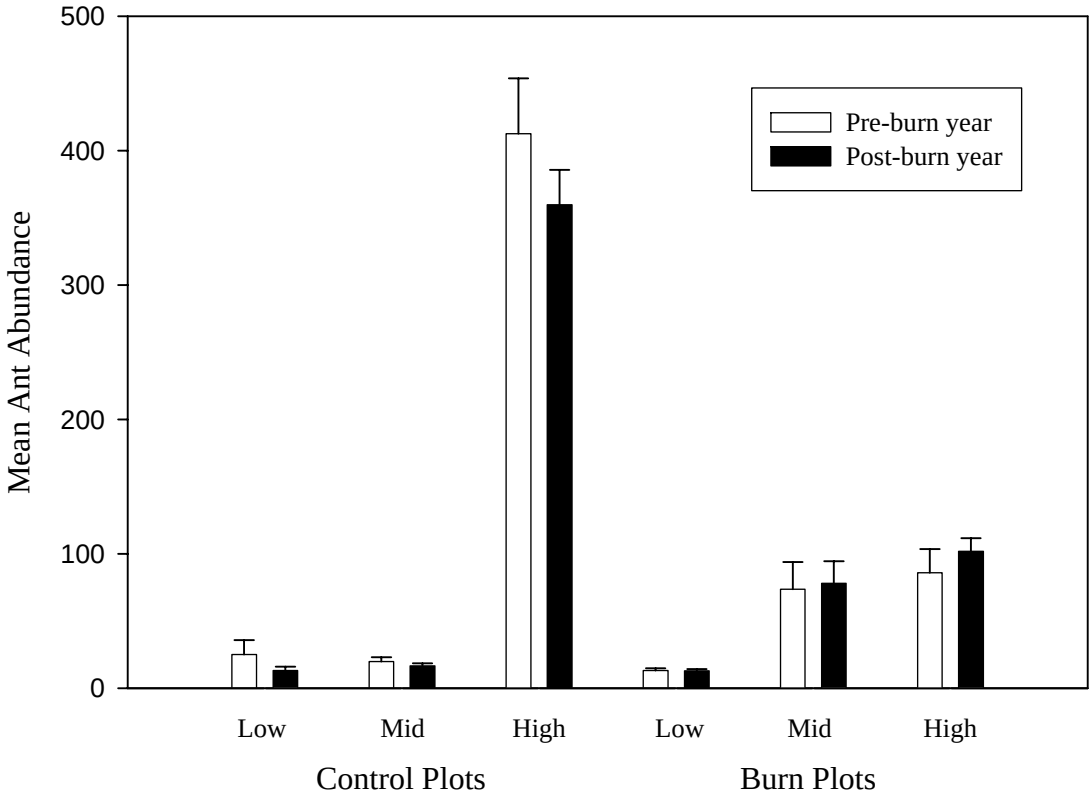


Fig. 6. Mean ant abundance for the control and burn plots at low, mid, and high elevations. Values are mean + S.E.

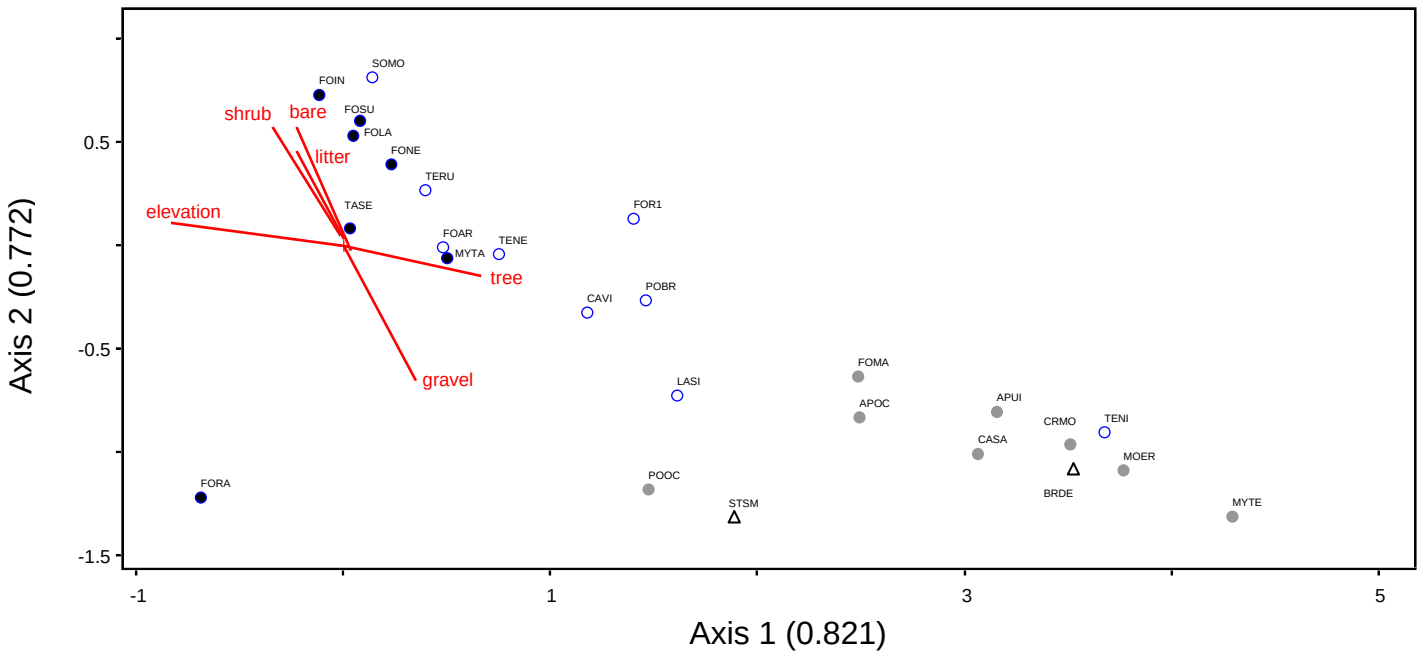
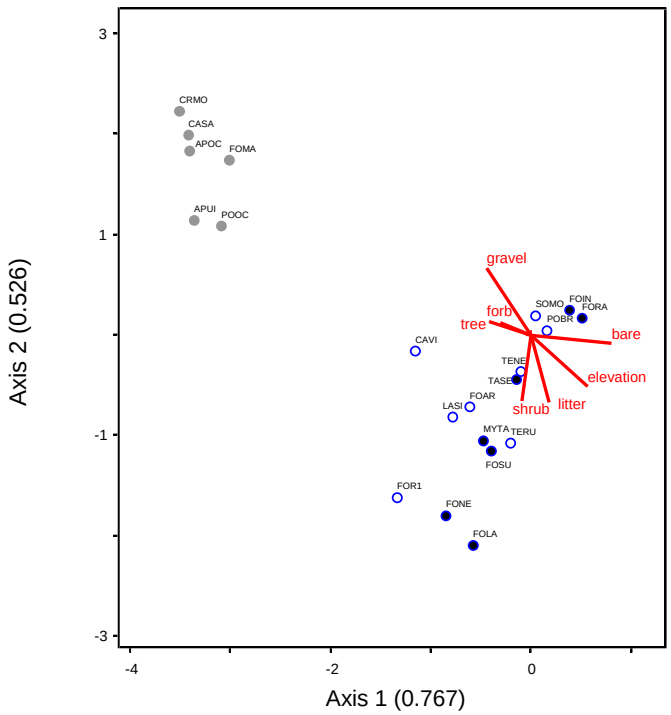


Fig. 7. Canonical correspondence analysis (CCA) ordination of ant species constrained by environmental variables for all elevation plots in 2001. Axis eigenvalues are in parentheses. The ordination shows that ant species are plotted along the elevation and tree cover lines. ● = low elevation species, ● = high elevation species, ○ = ubiquitous species, and Δ = rare species, as designated in Figure 5. Ant species are labeled using the first two letters of the genus name followed by the first two letters of the species name. Full ant species names are listed in Figure 5.

Pre-burn (2001)



Post-burn (2002)

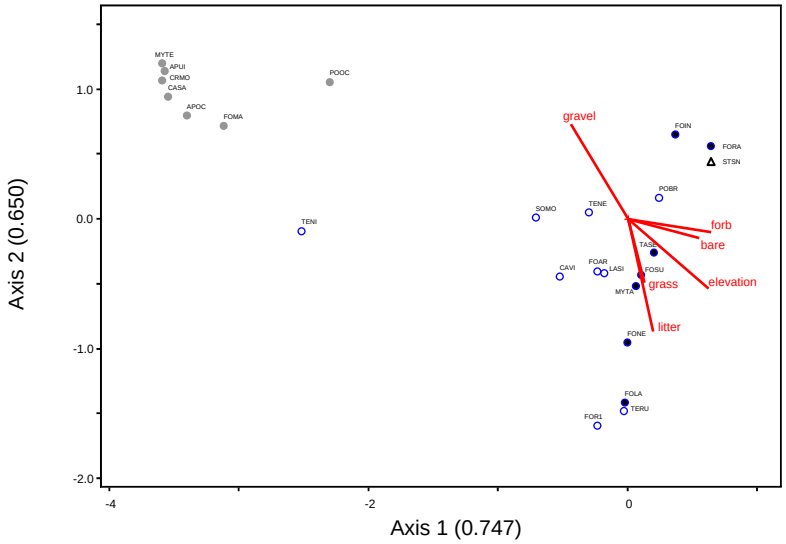


Fig. 8. Canonical correspondence analysis (CCA) ordination of ant species constrained by environmental variables for burn plots on the elevation sites for the pre (2001) and post (2002) burn years. Axis eigenvalues are in parentheses. The ordination shows that ant species are influenced primarily by soil texture and elevation, and secondarily by litter, forbs, and bare ground. ⊙ = low elevation species, ● = high elevation species, ○ = ubiquitous species, and Δ = rare species, as designated in Figure 5. Ant species are labeled using the first two letters of the genus name followed by the first two letters of the species name. Full ant species names are listed in Figure 5.

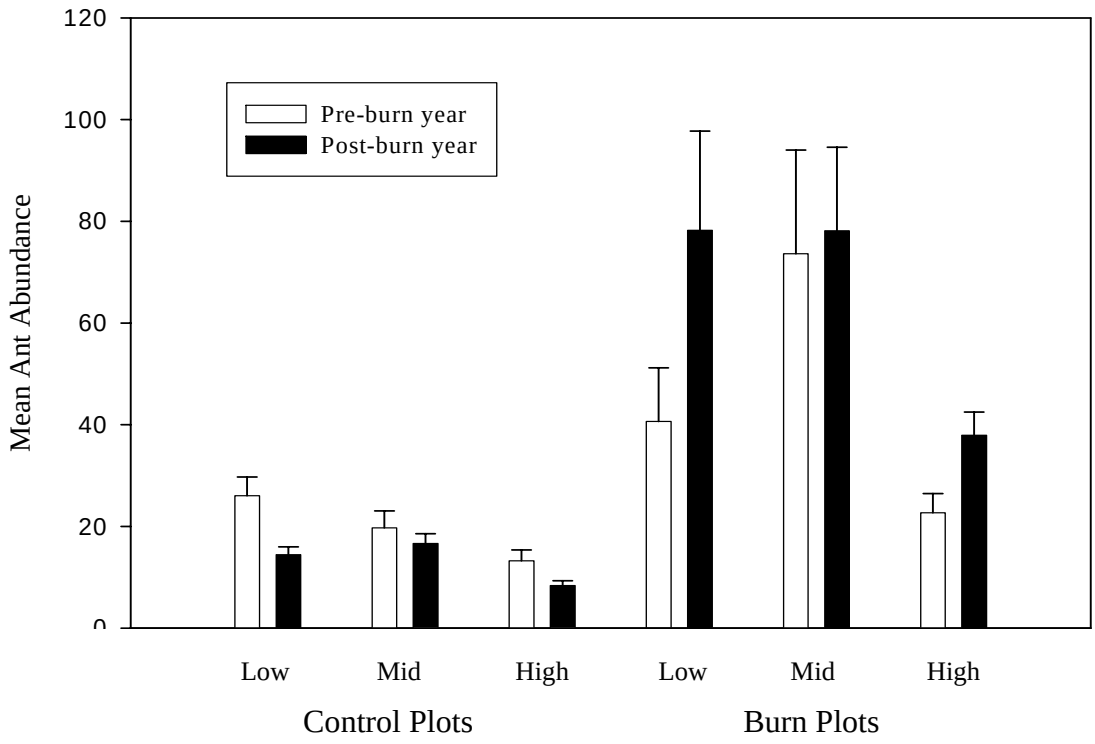


Fig. 9. Mean ant abundance for the control and burn plots at low, mid, and high tree covers. Values are mean + S.E.

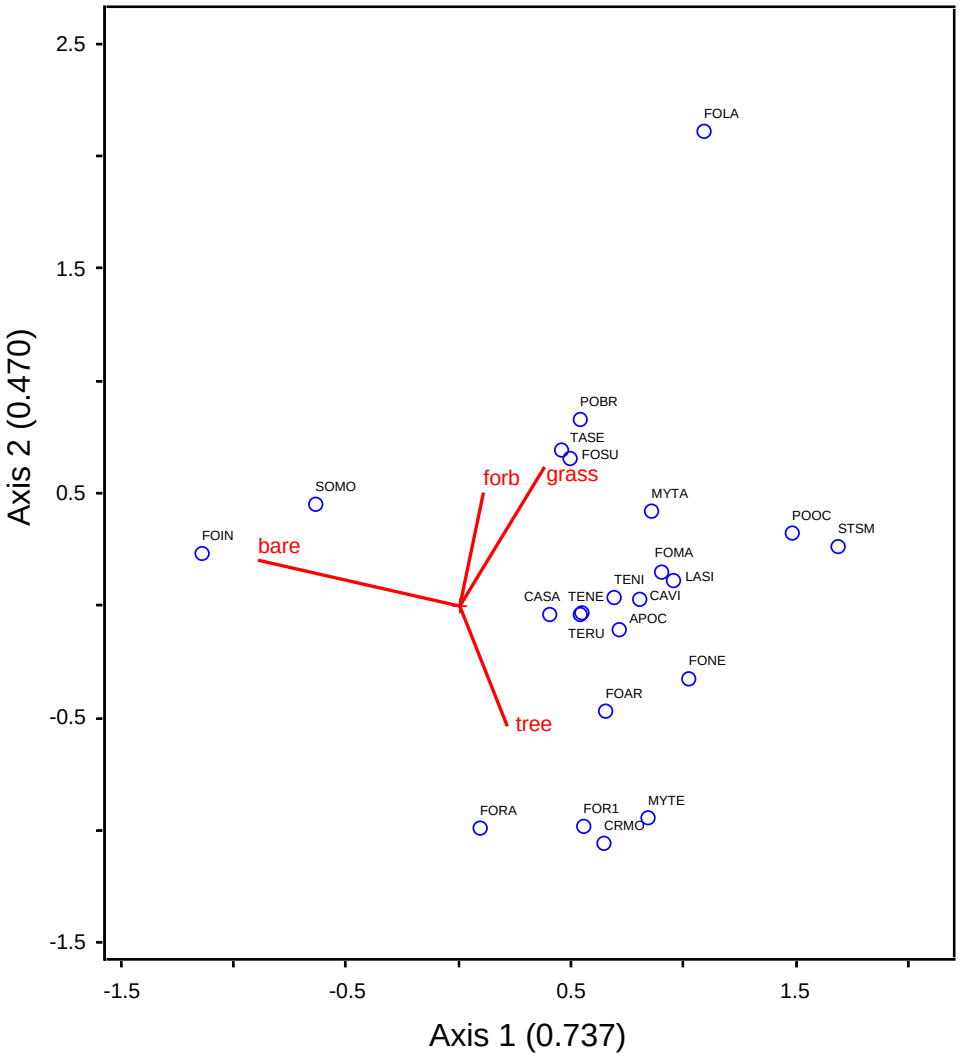


Fig. 10. Canonical correspondence analysis (CCA) ordination of ant species constrained by environmental variables for all tree cover plots in 2001. Axis eigenvalues are in parentheses. The ordination shows no obvious associations with the lines. Ant species are labeled using the first two letters of the genus name followed by the first two letters of the species name. Full species names are listed in Tables 11 and 12.

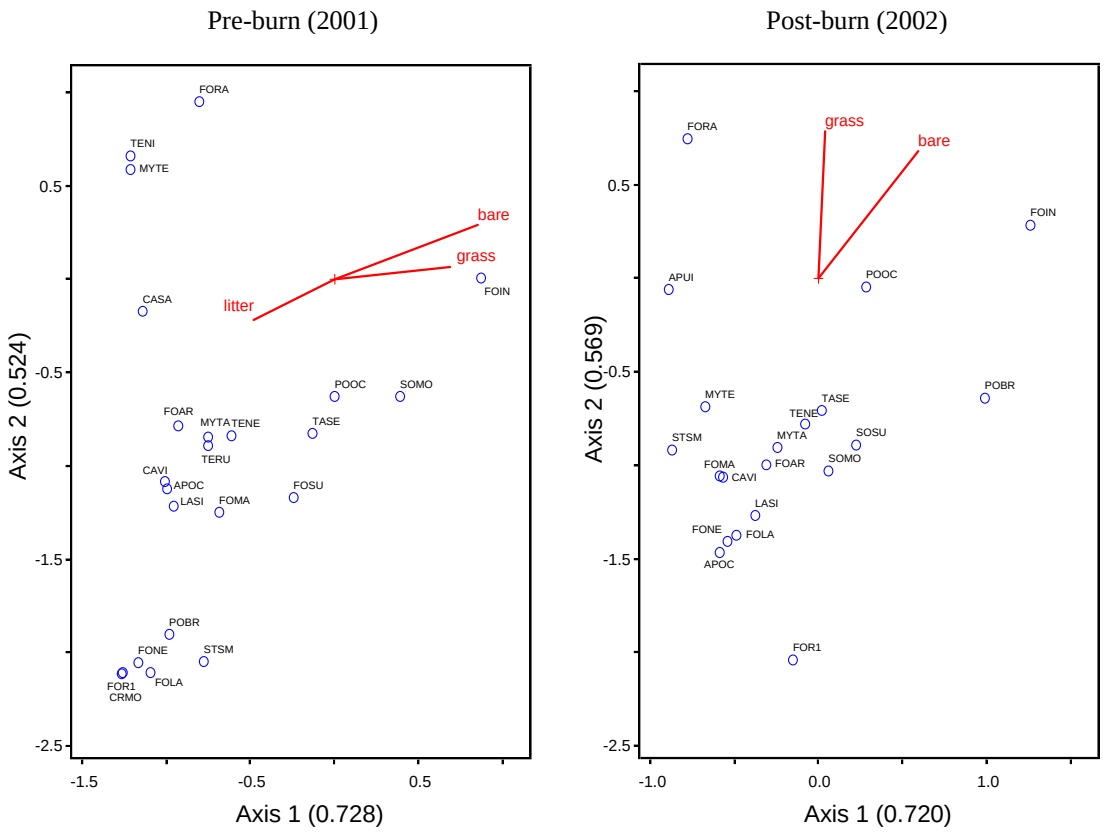


Fig. 11. Canonical correspondence analysis (CCA) ordination of ant species constrained by environmental variables for burn plots on the tree cover sites for the pre (2001) and post (2002) burn years. Axis eigenvalues are in parentheses. Few environmental variables are associated with ant abundance. Patterns of ant species organization are not distinct. Ant species are labeled using the first two letters of the genus name followed by the first two letters of the species name. Full ant species names are listed in Tables 11 and 12.