

Initial Response of Butterflies to an Overstory Reduction and Slash Mulching Treatment of a Degraded Piñon-Juniper Woodland

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Abstract

Overstory reduction and slash mulching (ORMS) has been shown to be an effective means for increasing herbaceous cover and diversity in degraded piñon (*Pinus edulis*) and juniper (*Juniperus monosperma*) woodlands of north-central New Mexico. Local fire history, tree age-class structure, and grazing records suggest that many areas now occupied by dense piñon-juniper woodlands were formerly more open, with grassy understories that supported well-developed soils and a fire regime. At Bandelier National Monument, studies are evaluating the use of ORSM treatments as a restoration management tool. In 1999 and 2001, we evaluated the effects of an ORSM treatment implemented in 1997 upon butterfly abundance and species richness between a pair of treated and control watersheds. Butterfly abundance and species richness were

significantly greater on the treated watershed in both years, and these measures were correlated with significant increases in forb and grass cover in the treated watershed. Five of the 10 most common nectar and larval host plants had significantly greater cover in the treated watershed, including the legume *Lotus wrightii*. Our results suggest that the increased herbaceous cover resulting from an ORSM treatment of a single watershed induced a positive, initial response by butterflies. Using butterflies as indicators of site productivity and species richness, our results suggest ORSM is a promising technique for restoring biodiversity in degraded piñon-juniper woodlands.

Key words: butterflies, *Juniperus monosperma*, lepidoptera, overstory reduction, piñon-juniper woodlands, *Pinus edulis*, restoration, woodland thinning.

Introduction

Piñon-juniper woodlands occupy over 19 million ha in the western United States and represent the most common vegetation type in New Mexico and Arizona (Gottfried et al. 1995). In the Jemez Mountains of north-central New Mexico, many of the piñon pine (*Pinus edulis*) and one-seed juniper (*Juniperus monosperma*) woodlands are degraded with unsustainable erosion rates (Allen 1989; Gottfried et al. 1995; Davenport et al. 1996; Jacobs et al. 1999). Evidence from local fire histories, tree age-class structure, and grazing records suggest the occurrence of piñon and juniper was previously restricted to fireproof rocky, shallow soil sites (Allen 1989; Gottfried et al. 1995; Julius 1999). On deeper soils, pre-settlement forest and woodland savannas presumably had more open stand structure, with well-developed herbaceous understories that minimized soil erosion and carried surface fire. During the last 120 years, livestock grazing and periodic drought reduced herbaceous ground cover and fine fuel continuity, effectively interrupting the surface fire regime

(Allen 1989; Allen & Breshears 1998). In the absence of fire, tree density increased at the expense of herbaceous cover, with concurrent accelerated runoff and erosion of intercanopy soils (Wilcox & Breshears 1995; Wilcox et al. 1996). Ongoing tree encroachment and soil erosion has impeded reestablishment of herbaceous vegetation and is reducing site productivity (Davenport et al. 1996).

Loftin (1999) and Jacobs et al. (1999) have shown that mechanical thinning, consisting of an overstory reduction and slash mulching (ORMS) treatment, increases herbaceous cover in degraded piñon-juniper woodlands of north-central New Mexico. The initial herbaceous response to treatment in their studies reflected a release of perennial forbs and grasses and moisture-induced pulses of annual/biennial forbs from the soil seed bank. This was not surprising, because the understories of many extant piñon-juniper woodlands are best considered as relict communities supporting various successional stages of woodland overstory (Tausch et al. 1999).

At Bandelier National Monument, resource managers are evaluating the feasibility of restoring woodland systems that occupy nearly a third of the Monument (approximately 4,000 ha) as a means for conserving cultural (archeological) and biological resources in the Bandelier wilderness (Sydoriak et al. 2000; Jacobs et al. 2002). As part of this evaluation, the monument established an experimental Watershed Restoration Study (WRS) to

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examine the effectiveness of an ORSM treatment for reducing soil erosion and stabilizing archeological sites in degraded piñon-juniper woodlands.

The objective of this study was to measure how adult butterflies respond to an ORSM treatment. We hypothesized that, if herbaceous cover and diversity increased in response to an ORSM treatment of a piñon-juniper woodland, then butterfly populations would respond positively to the increased availability of nectar and larval food plants. We used butterflies as a measure of system response, because they are increasingly used as biological indicators (Erhardt 1985; Kremen 1992; New et al. 1995; New 1997). They are sensitive to environmental change, relatively well known, and easy to monitor (New et al. 1995). Several studies have measured the response of butterflies to land use practices, including logging and grazing (e.g., Baines et al. 1994; Willott et al. 2000; Lewis 2001; WallisDeVries & Raemakers 2001), and restoration treatments such as native planting, tree thinning, or prescribed burning (Svenge 1996; Lloyd 2001; Ries et al. 2001; Waltz & Covington 2001).

Alpert et al. (1995) and Kruse (1999) documented increases in species richness of some small mammals, songbirds, and deer to ORSM treatments in piñon-juniper woodlands. However, this is the first study to examine the response of insect herbivores to mechanical thinning in piñon-juniper woodlands and to document the butterfly assemblage associated with a piñon pine and one-seed juniper woodland.

Methods

Study Area and Pre-Treatment Condition

We conducted our study in the WRS area of Bandelier National Monument, north-central New Mexico (35°46' N, 106°16' W) (Fig. 1). The WRS area was established in 1996 as part of a multifaceted project to restore piñon-juniper woodlands in Bandelier. The site consisted of a pair of adjacent 40-ha (100 ac) watersheds on Frijolito Mesa (Fig. 1). The watersheds were 1,900–2,000 m (6,300–6,600 ft) in elevation with slopes of less than 15°. Soils were derived from volcanic ash, are shallow, and poorly developed (Davenport et al. 1996). Annual precipitation averages 427 mm (16.8 in), with summer rainfall accounting for nearly half of the moisture.

During January–March 1997, one watershed received a restoration treatment (reducing tree cover from 35 to 10%), while the other received no treatment and remained at 40% tree cover. Pre-treatment (1996) comparisons of the mean ($\pm 90\%$ CI) proportion of each cover type (e.g., trees, forbs, and bare ground) between the treated and control watersheds were not significant (Jacobs et al. 2002).

The mechanical treatment reduced tree overstory by approximately 70% through removal of individuals (both piñon and juniper) less than 20 cm (7.9 in) in diameter at the base (Jacobs et al. 1999). Chain saws were used to

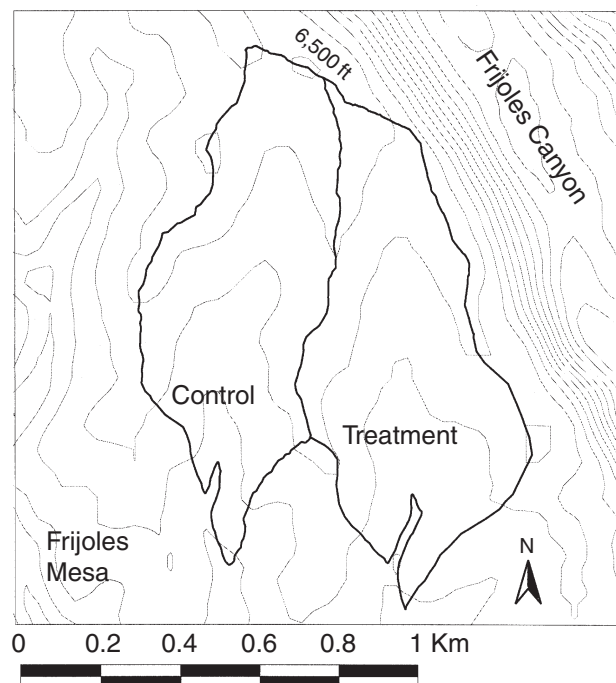


Figure 1. Watershed Restoration Study (WRS) area in Bandelier National Monument, New Mexico, U.S.A.

lop off main limbs and to cut boles flush at the base. The resulting slash was applied as a rough surface mulch and scattered preferentially onto adjacent bare soil interspaces. The two-thirds overstory reduction was consistent with recommendations from earlier work for generating an adequate herbaceous response (Bledsoe & Fowler 1992) and for creating intercanopy spaces sufficiently large (10–20 m [33.8–65.7 ft] between mature trees) to mitigate resource competition between herbaceous cover and adjacent trees (Breshears et al. 1997).

Vegetation Sampling

We used 20, permanently marked, line transects established in each watershed for estimating vegetation cover. Systematically with a randomized start, 10 transects were distributed evenly on both the west and east sides of each watershed at 75–150 m (246–492 ft) intervals. The transects were 100 m (328 ft) in length, beginning at the crest of the ridge and extending down slope perpendicular to the contour. Universal Transverse Mercator coordinates were recorded for each transect with a handheld Trimble Global Positioning System.

We used the line intercept method to estimate vegetation cover in late summer/fall (August–October). Two cover strata, basal intercept and aerial, were sampled with cover recorded to the closest centimeter for each strata per species and cover type. Cover types included bare ground, cactus, forb, grass/sedge, organic litter, fungus, cryptogamic

soil, shrub, subshrub (woody perennial forbs, e.g., snake-weed *Gutierrezia sarothrae*), tree, and unspecified. We used the 1999 data to calculate proportion of cover per growth form/cover type and for individual forb species for each 100-m (328-ft) transect. Data were summed and a mean calculated across all 20 transects within each watershed. We also selected 10 forb species known as nectar sources or larval host plants (personal observation; Scott 1986) to test for a treatment effect upon plants blooming during the butterfly monitoring periods. These species included *Cryptantha jamesii*, *Erigeron divergens*/*E. flagellaris*, *Helianthus petiolaris*, *Hymenopappus filifolius*, *Hymenoxys argentea*, *Senecio multicapitatus*, *Lotus wrightii*, *Lupinus kingii*, *Mentzelia pumila*, and *Eriogonum jamesii* (Table 3).

In 2001, vegetative cover was estimated from a series of 2025-m (82-ft) vegetation line transects (located in pairs on each of five archeological sites per watershed and identical in design to the 100-m [328-ft] transects). These data were used to corroborate vegetation changes on archeological sites with the larger watershed response.

Butterfly Sampling

We counted adult butterflies using a modified Pollard–Yates transect visual observation technique along each of the twenty, 100-m vegetation transects ($n = 20$) in each watershed (Pollard & Yates 1993; Kleintjes et al. 2003). We sampled butterflies twice in 1999 (30 June–3 July and 4–6 July) and twice in 2001 (14 and 15 June and 13–16 July). Equivalent numbers of transects from each watershed were sampled on the same day with all sampling conducted between 0800 and 1500 hr, when average temperatures ranged from 18.3 to 26.0°C and wind speeds were less than 3.0 km/hr (1.9 mi/hr) (Kestrel 2000 monitoring device, Nielsen Kellerman, Minneapolis, MN, U.S.A.).

Each observation per transect consisted of a team of two people walking one behind the other (2 m [6.5 ft] apart) the length of a transect and recording all butterflies observed within 5 m (16 ft) in front of, above, and to the sides of the first observer. Each 100-m (328-ft) transect belt covered an area of 1,100 m² (11,900 ft²) and walked at a steady pace to maintain equivalent time intervals. Each butterfly (Papilionoidea) was identified to species, whereas all Hesperioidea were pooled into a “skipper” group. Taxonomic identification followed that of Opler (1999a). Total number of butterflies and species were counted on each transect with the mean ($\pm 95\%$ CI) number of butterflies and species and total number of species was calculated for each watershed at each sample date. Pollard–Yates indices were also calculated, so that data could be compared among transects of variable length and width in other studies. Species identifications were verified by P. Kleintjes, P. Opler (Colorado State University), and S. Cary (New Mexico State Parks). Voucher specimens were housed at Colorado State University and the University of Wisconsin–Eau Claire.

Data Analysis

Statistical inferences are limited to our (case) study area (Wester 1992). For both 1999 and 2001 data, we compared mean differences in vegetation cover/transect between the watersheds with a two-way ANOVA for cover type, treatment, and their interaction. We compared the mean cover/transect of each selected host plant forb between watersheds with two-tailed t tests. Least squares linear regression was used to examine correlations between butterfly abundance or species richness with forb species richness or the proportion of cover of known nectar species. For the 2001 butterfly data, we compared the mean number of butterfly individuals (abundance) and number of species (richness) between treatment, sample date, and their interaction with a repeated measures two-way ANOVA test. SPSS 10.0 (SPSS, Inc., Chicago, IL, U.S.A.) and MCEXcel98 (Microsoft Corp., Redmond, WA, U.S.A.) were used for analyses.

Results

Butterfly Response

A total of 855 butterflies representing 13 species were observed in the Watershed Restoration Study area in 1999 and 2001. Species and their respective Pollard–Yates indices are given in Table 1. The majority of species were habitat generalists with the exception of *Callophrys gryneus siva*, which was only found in the treated watershed. *C. gryneus siva* use *Juniperus* as a larval host plant.

The ORSM treatment had a significant effect upon butterfly abundance and species richness in the treated watershed for both sample years, with total numbers of butterflies greater in 2001 as compared with 1999. Mean (SE) numbers of butterflies/transect in the treated watershed ranged from 1.55 (± 0.31) in June 1999 to 19.5 (± 2.08) in June 2001 (Fig. 2).

In 1999 mean numbers of butterflies and species did not significantly differ between sampling dates; hence data were pooled and means were compared with t tests. The mean number of butterflies was significantly greater on the treated site ($t = -5.97$, $df = 25$, $p < 0.05$) (Fig. 2), as was mean number of species ($t = -5.86$, $df = 29$, $p < 0.05$) (Fig. 2). We observed a total of four species, excluding skippers, on the control watershed and seven on the treatment.

In 2001 mean numbers of butterflies/transect were also greater on the treated site ($F = 84.7$, $df = 1$, $p < 0.001$) (Fig. 2). In contrast to 1999 there was a significant effect of sample date ($F = 9.6$, $df = 1$, $p < 0.05$) and a significant interaction between date and treatment ($F = 9.4$, $df = 1$, $p < 0.05$). Mean numbers of butterflies were greater in June than July, with five species observed in June and seven in July in the control and nine and twelve species, respectively, in the treated watershed. Mean number of species/transect was significantly greater in the treated

Table 1. Pollard–Yates Indices (PYIs) of abundance of butterfly species observed in the piñon-juniper woodland Watershed Restoration Study Area of Bandelier National Monument, New Mexico, 1999 and 2001.

Common Name	Species	1999		2001	
		Control	Treated	Control	Treated
		PYI	PYI	PYI	PYI
Western swallowtail	<i>Papilio rutulus</i>	0	0	0.09	0.09
Two-tailed swallowtail	<i>Papilio multicaudata</i>	0.09	0.27	0	0.27
Checkered White	<i>Pontia protodice</i>	0	0.09	1.09	4.72
Orange sulfur	<i>Colias eurytheme</i>	0	2.0	1.18	4.54
Clouded sulfur	<i>Colias philodice</i> *	—	—	—	—
Dainty sulfur	<i>Nathalis iole</i>	0.09	0.54	10.18	35.55
Western Green hairstreak	<i>Callophrys affinis</i>	0.09	0.09	0	0.54
Juniper hairstreak	<i>Callophrys (Mitoura) gryneus siva</i>	0	0	0	0.09
Gray hairstreak	<i>Strymon melinus</i>	0	0	0	0.09
Reakirt's Blue	<i>Hemiargus isola</i>	0.09	0.81	0.18	1.54
Lupine Blue	<i>Plebeius (Icaricia) lupini</i>	0	0.09	0.54	4.36
Variegated Fritillary	<i>Euptoieta claudia</i>	0	0	0.09	0.27
Painted Lady	<i>Vanessa cardui</i>	0	0	1.27	3.54

$$PYI = \frac{\text{Number of butterflies}}{\text{Length of sample transect(m)}} \times \text{Sample area (m)}^2$$

**C. philodice* pooled with *C. eurytheme*.

watershed ($F = 66.0$, $df = 1$, $p < 0.001$) but did not differ between dates for either watershed (Fig. 2).

In 1999 and 2001 the most abundant species observed across both watersheds were in the families *Pieridae* (*P. protodice*, *C. eurytheme*, and *N. iole*) and *Lycaenidae* (*H. isola* and *I. lupini*). In 2001 an invasion of *V. cardui* was also noted.

Vegetation Response

In 1999 the vegetation data indicated a strong treatment effect since the ORSM application in early 1997 (Table 2). Mean percent cover of vegetation significantly differed by cover type ($F = 622.7$, $df = 9$, $p < 0.05$), treatment ($F = 4.89$, $df = 1$, $p < 0.05$), and the interaction of cover type*treatment ($F = 53.3$, $df = 9$, $p < 0.05$). Of the nine different cover types, five significantly differed between

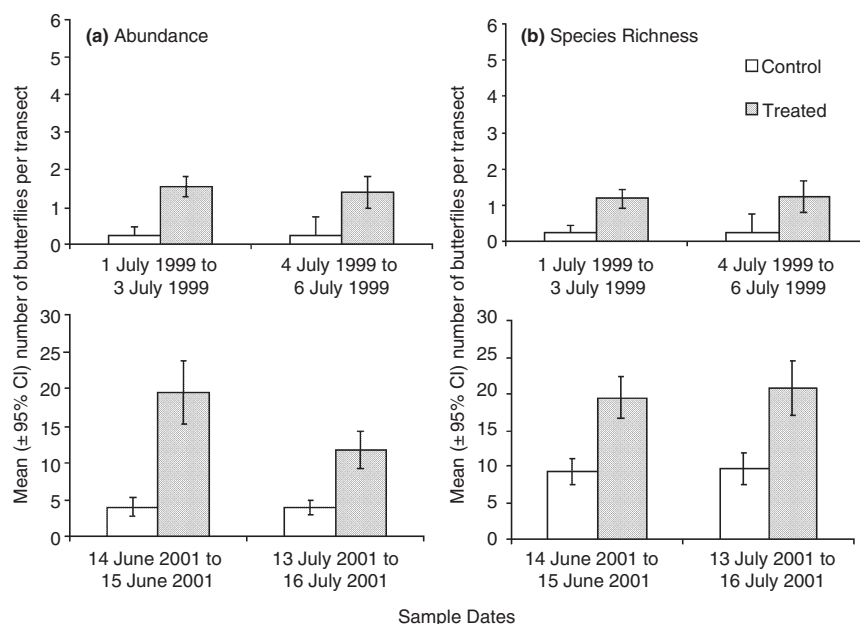


Figure 2. Mean number (95% CI) of butterflies (a) and species (b) per transect in the control versus treated watersheds in the Watershed Restoration Study (WRS) area of Bandelier National Monument, 1999 and 2001.

Table 2. Mean and SE proportion of each cover type between the control and treated watersheds in the Watershed Restoration Study Area of Bandelier National Monument, NM, U.S.A., 1999 and 2001.

Cover Type	1999				2001			
	Control		Treated		Control		Treated	
	x^*	SE	x	SE	x^*	SE	x	SE
Bareground	0.419*	0.022	0.287	0.0173	0.462	0.029	0.391	0.049
Cactus	0.003	<0.001	0.002	0.0006	0.007	0.005	0.000	0.000
Forb	0.024*	0.003	0.177	0.019	0.022*	0.007	0.190	0.029
Grass	0.041*	0.009	0.141	0.019	0.058*	0.013	0.277	0.030
Litter	0.574*	0.023	0.738	0.019	0.518	0.038	0.597	0.049
Fungi	<0.001	<0.001	<0.001	<0.001	0.000	0.000	0.000	0.000
Shrub	0.036	0.006	0.028	0.004	0.015	0.007	0.013	0.013
Subshrub	0.004	0.002	0.024	0.004	0.011*	0.004	0.148	0.060
Tree	0.388*	0.021	0.102	0.014	0.333*	0.034	0.009	0.006
Unspecified	0.002	<0.001	<0.001	<0.001	0.000	0.000	0.000	0.000

*Significant difference in mean proportion of each cover type between the control and treated watershed within each year (one-way ANOVA, $p < 0.05$).

watersheds. Mean proportions of forb, grass, and litter cover significantly increased on the treated watershed, while tree and bare soil cover significantly decreased (Table 2). Forty-eight species of forbs were found in the treated watershed as compared with 35 in the control. The mean ($\pm$ SE) number of forb species/transect in the treated watershed was 15.1 ($\pm$ 1.26) and 8.7 ($\pm$ 1.73) in the control ($t = -6.23$, $df = 35$, $p < 0.001$).

Results from the 2001 vegetation survey were similar to those in 1999 and are considered representative of the treatment effect at the watershed level (Table 2). Vegetation differed significantly by cover type ($F = 115.68$, $df = 9$, $p < 0.001$) and by the interaction of cover type*treatment ($F = 21.75$, $df = 9$, $p < 0.001$), but not by treatment alone. The mean proportion of forb, grass, and subshrub cover was significantly greater in the treated watershed compared with the control.

Relationship Between Butterflies and Vegetation

There was a positive linear relationship between mean number of butterflies and the proportion of forb cover per transect across both watersheds in 1999 ($r^2 = 0.23$, $F = 11.04$, $p < 0.05$), with the control sites supporting less cover and fewer butterflies. There was also a positive but weaker relationship between butterfly numbers and forb species richness ($r^2 = 0.09$, $F = 4.84$, $p < 0.05$). The relationship between butterfly species richness and forb cover ($r^2 = 0.22$, $F = 11.9$, $p < 0.05$) was greater than it was with forb species richness ($r^2 = 0.07$, $F = 4.12$, $p = 0.05$). Noncomparable vegetation transects in 2001 precluded similar analyses.

Of the 10 most abundant nectar or larval host plants occurring in both watersheds, five had significantly greater cover on the treated watershed than in the control in 1999

(Table 3). Of these, *Lotus wrightii* was the most significant ($t = 2.04$, $df = 32$, $p < 0.001$), and butterfly abundance was positively related to the mean proportion of cover of *L. wrightii* ($r^2 = 0.21$, $F = 9.98$, $df = 1$, $p < 0.05$).

Discussion

This study demonstrates the ecological significance of increased herbaceous cover for adult butterflies in a degraded piñon-juniper woodland. We found that herbaceous forb and grass cover increased significantly, as a result of an ORSM treatment, which in turn enhanced abundance and richness of adult butterflies. After 2 years, forb cover increased 4-fold on the treated watershed compared with the control and after 4 years it increased almost 6-fold. Mean numbers of butterflies and species were correlated with these vegetative changes. They were two to four times greater on the treated watershed compared with the control in 1999 and 2001, even though population sizes fluctuated among years.

Our results agree with observations made by Waltz and Covington (2001), who reported increased butterfly abundance and diversity in response to mechanical thinning and increased nectar plant availability after prescribed fire treatments in ponderosa pine forests. Our work provides additional support for the idea that butterflies can serve as sensitive measures of the initial biotic response to vegetation changes that result from natural disturbance, anthropogenic restoration practices (Erhardt & Thomas 1991; Waltz & Covington 2001), or land-use patterns (Blair 1999).

Some of the observed increase in numbers of butterflies in the treated watershed could be attributed to an oasis effect (i.e., attracting butterflies from adjacent untreated areas). However, we interpret the data as illustrative of the potential for enhancing butterfly habitat in response to an

Table 3. Mean and SE proportion of cover of the 10 most abundant known butterfly nectar plants and potential larval host plants in the treated and control watersheds, 1999.

Family	Plant Species	Mean Percent Cover				t Test Results
		Control		Treated		
		x	SE	x	SE	
Boraginaceae	<i>Cryptantha jamesii</i>	0.006	0.003	0.041	0.013	$t = 2.05, df = 27, p = 0.018^*$
Compositae	<i>Erigeron divergens</i> , <i>E. flagellaris</i>	0.001	0.001	0.036	0.027	$t = 2.08, df = 20, p = 0.237$
Compositae	<i>Helianthus petiolaris</i>	0.002	0.002	0.167	0.060	$t = 2.08, df = 20, p = 0.025^*$
Compositae	<i>Hymenopappus filifolius</i>	0.005	0.004	0.284	0.084	$t = 2.07, df = 21, p = 0.003^*$
Compositae	<i>Hymenoxys argentea</i>	0.008	0.008	4.410	4.393	$t = 2.09, df = 19, p = 0.306$
Compositae	<i>Senecio multicapitatus</i>	0.074	0.043	0.222	0.089	$t = 2.03, df = 32, p = 0.115$
Leguminosae	<i>Lotus wrightii</i>	0.874	0.304	7.286	1.092	$t = 2.04, df = 30, p < 0.001^*$
Leguminosae	<i>Lupinus kingii</i>	0.003	0.003	0.015	0.010	$t = 2.05, df = 27, p = 0.289$
Loasaceae	<i>Mentzelia pumila</i>	0.012	0.006	0.555	0.261	$t = 2.08, df = 20, p = 0.014^*$
Polygonaceae	<i>Eriogonum jamesii</i>	0.225	0.056	0.163	0.050	$t = 2.02, df = 38, p = 0.290$

*Two-tailed t test, $p < 0.05$.

ORSM treatment. At a landscape scale, restored woodland communities could presumably attract and support a broader array of butterfly species than currently observed in our small study area. For example, in a related study, we observed an additional 17 species of butterflies from a total of 1,107 observed individuals in five disjunct ORSM-treated areas within the monument (unpublished data). This also suggests that our observations of species richness in the watersheds may have been underestimated due to both the limited sampling area and sampling dates. We only sampled in early summer and therefore may have missed species that fly in April–May (e.g., *Ceonympha tullia*) or in late summer. For instance, we observed *C. gryneus siva* as second brood adults. We also did not include the abundance of individual skippers (*Hesperioidea* species). Although we noted the abundance of skippers, overall numbers were low and identity to species was difficult without capturing species during sampling. Additional work needs to be done to verify the presence and abundance of skipper species in piñon-juniper woodlands and nearby ponderosa grasslands, because many of these species are obligate grass feeders as larvae and therefore have potential as indicators of restored grassland systems.

Many of the early successional forbs responding to restoration treatment are known nectar and oviposition sources for adults and forage for larvae, for example, legumes (Scott 1986). For example, five of the butterfly species we observed on the WRS area belong to the family *Lycaenidae* and two of these (*Hemiargus isola* and *Icaricia lupini*) utilize legumes as larval host plants. We also observed an additional six species of *Lycaenidae* in other ORSM-treated woodlands within the monument (unpublished data). The legume *Lotus wrightii* potentially serves as a larval host plant and adult oviposition site for at least half of the observed butterfly species (*Colias eurytheme*, *Colias philodice*, *Callophrys affinis*, *H. isola*, *I. lupini*, and *Thorybes* spp. [Scott 1986]). The legume *Lupinus kingii* also serves as a potential host plant for *C. eurytheme*,

C. philodice, *Strymon melinus*, *H. isola*, *I. lupini*, and *Vanessa cardui* [Scott 1986]. *Lupinus kingii* is one of several notable ephemeral species that responds to winter moisture and shows significant increases in cover during wet years, even in degraded woodlands (B. F. Jacobs, personal observation). In June 2001 it formed a carpet across much of the piñon-juniper woodlands in the monument. As it senesces rather early, it was not well represented on vegetation transects, as measured by late summer monitoring.

In 2001 we observed high numbers of *V. cardui*. The larvae feed on *Cirsium* spp. (Scott 1986) which are represented by *C. undulatum* in the study area. *Vanessa cardui* also feeds upon species of *Senecio*, *Cryptantha*, and *Helianthus*, all of which were present in the study area. *Cryptantha jamesii* and *Helianthus petiolaris* had significantly greater cover in the treated watershed in 1999 and both were abundant in 2001. In 2001 we observed butterflies (especially *P. protodice* and *V. cardui*) nectaring on *C. jamesii*, with as many as five to ten butterflies observed on a single plant.

Our results and the historical status of piñon-juniper savannas in the Southwest support the idea that piñon-juniper woodland areas formerly supported more diverse butterfly assemblages. It is notable that there is a relative absence of literature documenting butterflies associated with piñon-juniper woodlands (excluding surveys that merely include woodland habitat within their study areas, e.g., Cary & Holland 1992; Holland & Cary 1996; Opler 1999b). Literature referencing the fauna of piñon-juniper woodlands typically refers only to the insect pests of piñon pine and juniper, soil arthropods, and vertebrates (Gottfried et al. 1995; Bogan et al. 1998; Monsen & Stevens 1999). Butterfly lists for the Southwest region often identify the presence of species by association with localities and elevation ranges, whereby habitat must be inferred. The earliest accounts of butterflies most likely associated with piñon-juniper woodlands in the Jemez mountains date back to the Woodgate collection circa

1912–1916 (Holland & Cary 1996). At that time, the system was likely still capable of supporting a residual butterfly assemblage. It would be of interest to compare butterfly assemblages in extant woodland sites that still have well-developed understories with those in comparable thinned and slash-mulched restoration areas.

Allen and Breshears (1998) documented a shift in local piñon-juniper woodlands upslope into former ponderosa pine savanna communities in response to cumulative effects of grazing, loss of fire regime, and drought. Some of these recently colonized woodland areas are still dominated by herbaceous understories more reminiscent of the extant ponderosa systems. In this context, we explored the extent to which butterfly assemblages found in treated piñon-juniper woodlands were comparable with those of upslope ponderosa pine sites in Bandelier. Twenty-three species of butterflies were common among treated piñon-juniper and ponderosa pine grassland survey areas (unpublished data). Only five butterfly species were restricted to ponderosa sites and an additional six to ponderosa-mixed conifer sites. Our treated areas also shared many of the same butterfly species found in the ponderosa restoration sites of Waltz and Covington (2001).

The ORSM treatment of the piñon-juniper Watershed Study Area was effective at increasing herbaceous cover and inducing a positive response by butterflies to the increased availability of nectar and larval host plants. Whether such a treatment would induce a similar response across the larger landscape warrants further study.

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