Butterfly Species Richness and Abundance in Relation to Fire Treatments in Warm, Dry, Mixed Conifer in Southwestern, Colorado, USA

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Introduction

- Due to European settlement during the 20th century, fire regimes were disrupted and the increase in forest regeneration has resulted in a present state of dense, low sweeping canopies of mesic species that create horizontal and vertical fuel complexes that aid in the spread of severe wildfires (Korb et al., 2012).
- Specific restoration treatments can alter the microclimate of an environment. Species such as butterflies (order Lepidoptera), can be used as an indicator species to quantify the effects of forest restoration treatments on microclimate changes. Butterflies are an ideal indicator species because they are sensitive to environmental conditions.

Hypothesis:

- Thin/burn forest restoration treatment areas will have the highest butterfly species richness and abundance because increased understory plant productivity and altered warmer micro-climates. In addition, we also hypothesize that butterfly richness and abundance will be highest during the peak of the growing season (July) in all treatments due to peak plant productivity.

Research Objectives

1. Do various treatments (control, thin/burn, burn alone) affect butterfly species richness, diversity and abundance?
2. Does butterfly abundance change across the growing season and is this change different in alternative restoration treatments?

Study Site

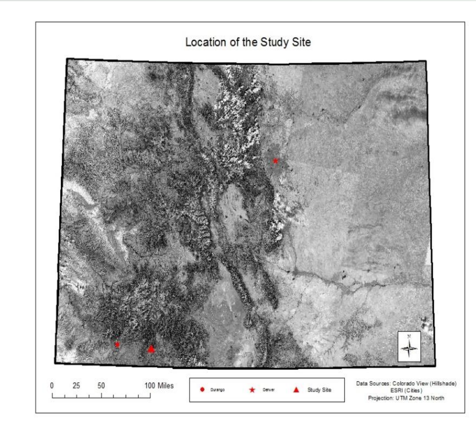


Figure 1. Satellite view of study site in Lower Middle Mountain, San Juan National Forest, Colorado.

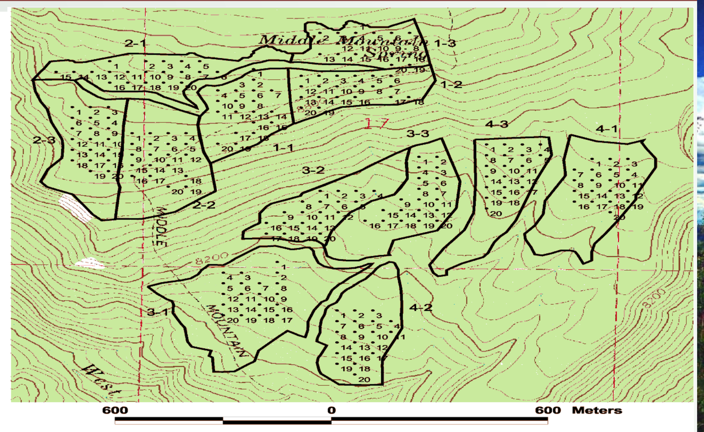


Figure 2. Topographical map of site with treatment blocks and units.

Figure 3. Photograph overlooking site during field research 2015

Experimental Design and Methods

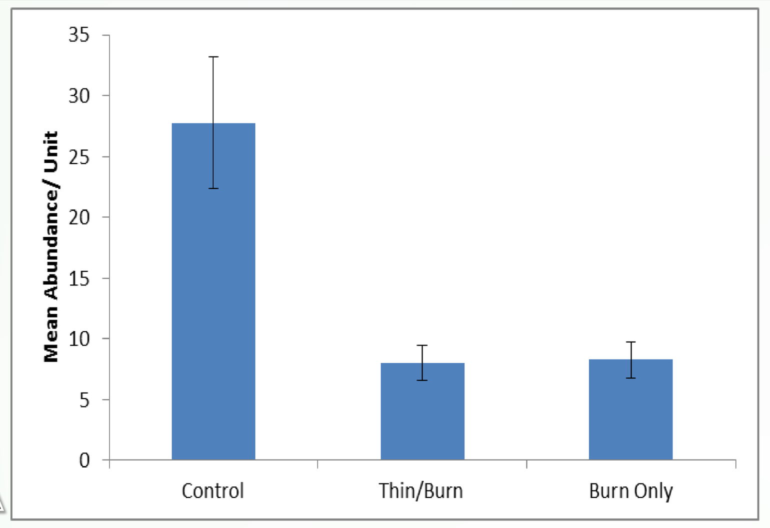
- A hand thinning/burn treatment occurred fall 2004 and prescribed burning took place in 2007-2008. There are four replicate blocks of each treatment (control, thin/burn, burn only), consisting of 20 permanent study plots within each unit. Five plots were randomly selected from each unit (n = 60) (Korb, et al. 2012).
- Data collection took place during the growing season from mid-June until mid-August.
- A 50m x 20m belt transect was set up and walked for 20 minutes at each plot. All butterflies were recorded via photography or on site identification to species.

Figure 3. Representative of each treatment: 1) Control (2-1-3) 2) Thin/Burn (2-2-6) 3) Burn Only (2-3-2).

Results

Table 1: Mean (± SEM) forest stand characteristics by treatment. N=4. Different letters indicate significance at ≤ 0.05 using one-way ANOVA. Data summary from Stoddard et al. in press.

	2009 Tree Canopy (% Cover)	2013 Tree Basal Area (m^2 ha^{-1})	2013 Tree Density (trees ha^{-1})	2013 Seedling ha^{-1} (<40 cm height)	2013 Sapling ha^{-1} (>40.1 cm height and >2.5 cm DBH)	2015 Shrub Density (stem ha^{-1})
Control	49.06 (1.8) a	26.8 (1.3) a	540.6 (49.8) a	276.3 (51.2) a	911.3 (246.5) a	17807.9 (1659.2) a
Thin and Burn	30.78 (1.8) b	11.3 (1.2) b	117.2 (34.5) b	87.5 (36.0) b	2982.5 (817.6) a	42721.6 (13744.2) b
Burn Only	40.31 (0.6) c	20.5 (0.7) c	316.6 (20.9) c	253.8 (53.9) ab	983.8 (520.5) a	26400.0 (5486.0) a



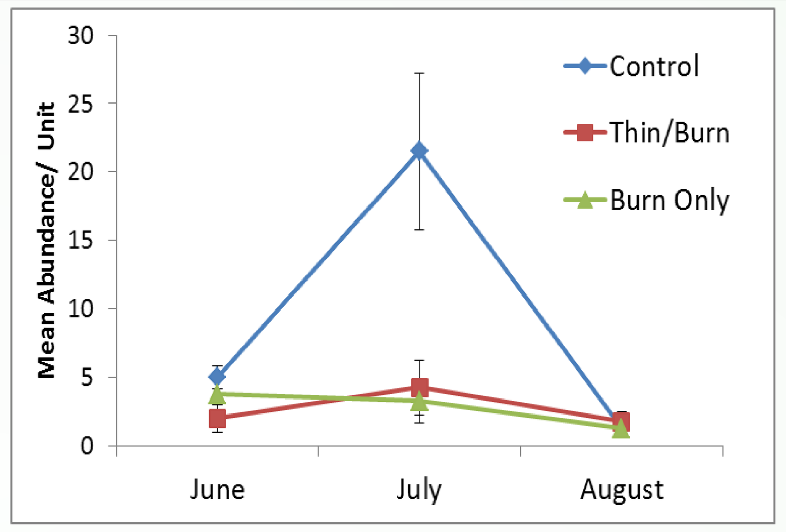


Figure 1. Mean summer abundance of butterflies in each treatment site ± SEM. A) Kruskal Wallis test followed by a Tukey's post-hoc test (T=7.449, p=.024) found a significant difference between total abundance of butterflies in treatments between control and thin/burn treatments (p=0.03) and control and burn only treatments (p=0.4). B) Kruskal Wallis test followed by a Tukey's post-hoc test (T=3.663, p=.04) showed a significant difference in the abundance of butterflies in July between control and thin/burn treatments (p=0.5) and control and burn only treatments (p=0.5).

Table 1. Indicator species across time and treatment. A Monte Carlo test was used to determine each species significance using PC-ORD version 6.0. There was one indicator species for June, four indicator species for July, and no indicator species for August. There is only one indicator species for the control treatment.

Indicator Species	Value (IV)	p*
Sampling Period		
June		
Northern Crescent	50	0.006
July		
Aphrodite Fritillary	49.1	0.0302
Western Tiger Swallowtail	40	0.0148
Cabbage White	36.4	0.0484
Clouded Sulphur	33.3	0.0592
August	No indicator species	No indicator species
Treatment		
Control		
Aphrodite Fritillary	44.1	0.0748
Thin/Burn	No indicator species	No indicator species
Burn Only	No indicator species	No indicator species

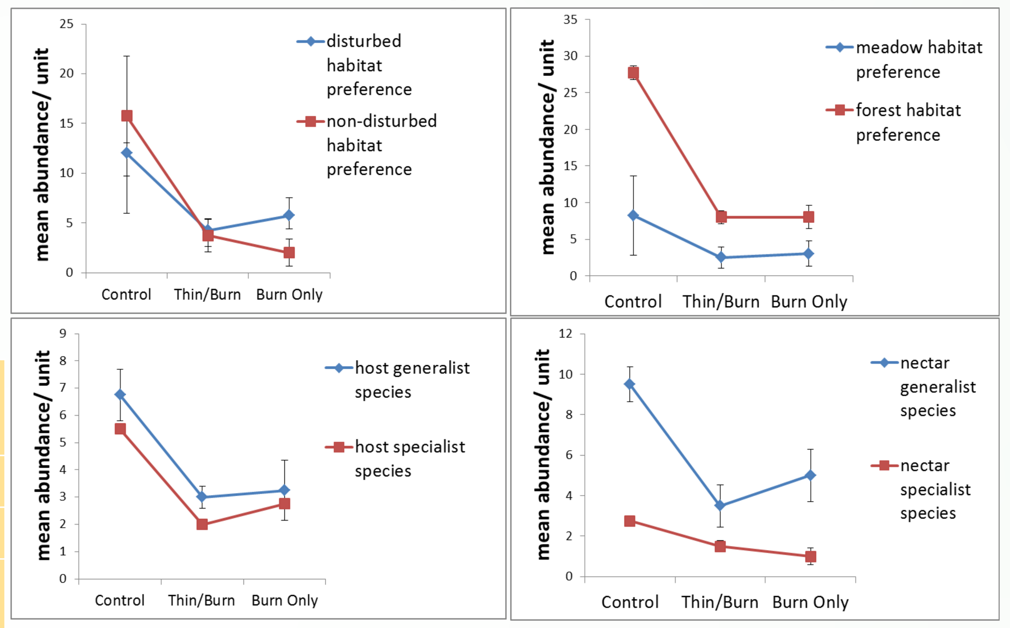


Figure 2. Mean ± SEM butterfly abundance by functional groups: A) meadow habitat preference vs. forest habitat; B) disturbed site preference vs. non-disturbed site preferences; C) nectar generalist vs. nectar specialist; D) plant host generalist vs. nectar specialist. There were no significant differences within a specific treatment (control, thin/burn, burn only) between the two functional group variables (e.g., meadow vs. forest).

Table 2. Species richness and diversity across treatments. There were no significant differences in richness or diversity among treatments determined by a Kruskal Wallis test.

	Species richness	Diversity (H')
Control	3 (0.81)	0.78 (0.28)
Thin/Burn	1.6 (0.57)	0.36 (0.25)
Burn Only	2.08 (0.72)	0.54 (0.28)

Table 3. Permanova based on Bray-Curtis dissimilarities of butterfly abundance for three sampling periods (June, July, August) across three forest restoration treatments.

	d.f.	SS	MS	F	p*
Time	2	1.75	0.87	2.14	0.013
Treatment	6	2.45	0.40	1.12	0.29
Residual	27	9.81	0.36		
TOTAL	35	14.02			

Results Continued

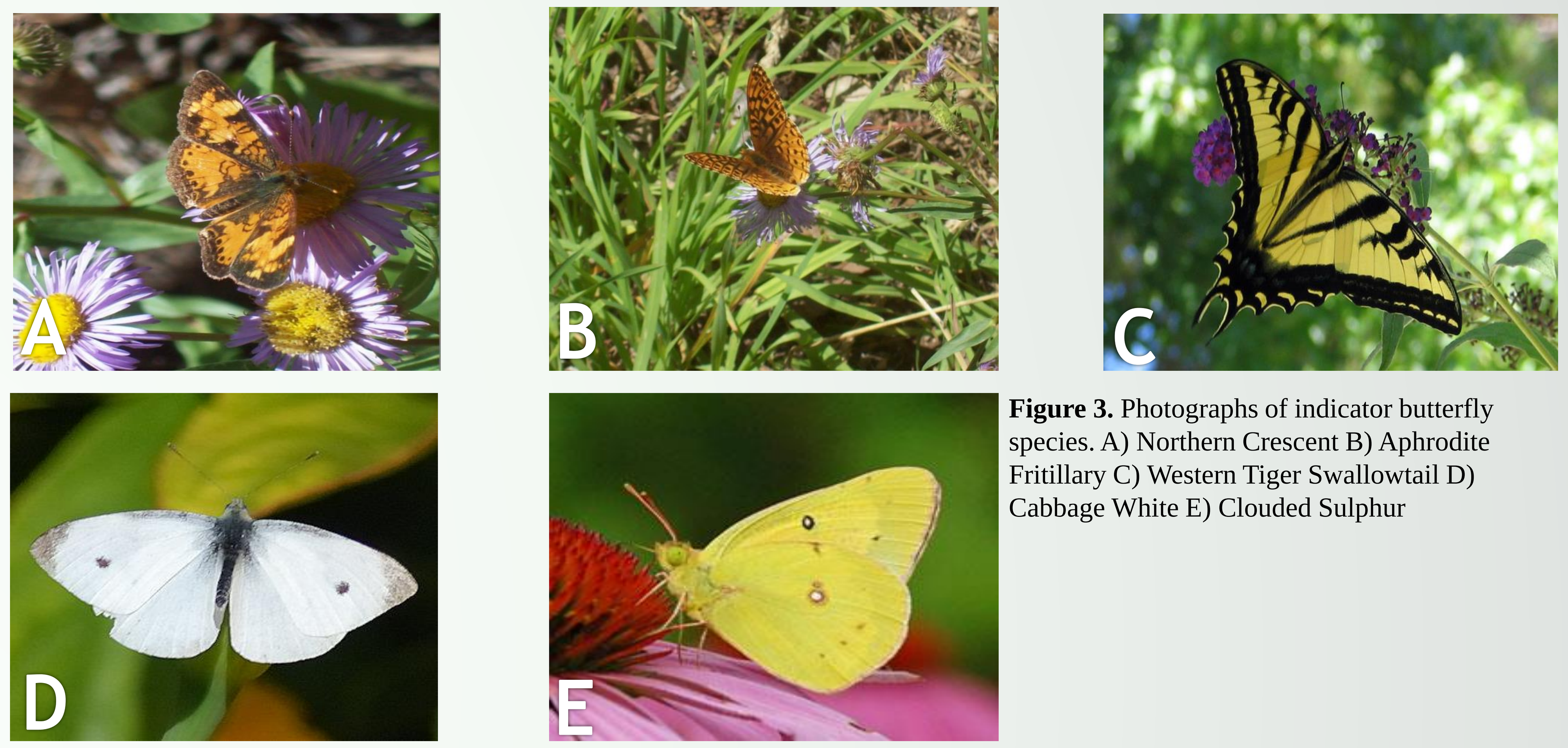


Figure 3. Photographs of indicator butterfly species. A) Northern Crescent B) Aphrodite Fritillary C) Western Tiger Swallowtail D) Cabbage White E) Clouded Sulphur

Major Findings

- **There were no significant differences for butterfly richness or diversity across forest restoration treatments.**
- Multivariate analysis showed butterfly communities (species richness and abundance) **changed significantly across time** (p=0.01) but not among forest restoration treatments.
- Univariate analysis showed significant differences in mean butterfly abundance between control and thin/burn (p=0.03) and control and burn only (p=0.04) treatments. Mean butterfly abundance was also significantly different between July thin/burn and control (p=0.05) and July burn only and control (p=0.05) treatments.
- There was one indicator species for the June sampling period, Northern Crescent, and four indicator species, Aphrodite Fritillary, Western Tiger Swallowtail, Cabbage White and Clouded Sulphur, for the July sampling period and no indicator species for August.
- Forest restoration treatments seven years post treatment in general did not alter butterfly habitat except for one indicator species, Aphrodite Fritillary, which was particularly faithful to control units, although it was present in the other treatment units.
    - Fritillary species show a positive correlation in abundance of one or more species of Viola, but not combined violet abundance, suggesting that the fritillaries segment violet resources by species or habitat
- Butterfly species are more sensitive to changes in season (early, mid, late summer) than forest restoration treatments. Managers should be sensitive to these seasonal changes when implementing forest restoration treatments.

References

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- Korb, J.E., Fule, P.Z., Stoddard, M.T., 2012. Forest restoration in a surface fire-dependant ecosystem: an example from a mixed conifer forest, southwestern Colorado USA. Forest Ecology and Management 269, 10-18.
- Stoddard, M.T., Sánchez Meador, A.J., Fulé, P.Z., Korb, J.E., 2015. Five-year post-resoration conditions and simulated climate-change trajectories in a warm/dry mixed-conifer forest, southwestern Colorado, USA. Forest Ecology and Management, article in press.

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