Pawnee Montane Skipper Vegetation Study for the Upper South Platte Watershed Protection and Restoration Project September 2012

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Cover photograph: An open area of thinned ponderosa pine forest within the 2002 Treatment (*photo by John Sovell*)

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Introduction

Ponderosa pine forests throughout the western United States have become denser, with smaller trees and less understory plant richness or abundance in the last 100 to 150 years, in part because of logging, fire suppression, and the introduction of livestock grazing (Covington et al. 1997, Veblen and Donnegan 2005). In 2000, the U.S. Forest Service (USFS), in cooperation with the Colorado State Forest Service, Denver Water, U. S. Fish and Wildlife Service (USFWS), and other entities, outlined a program to restore lower montane forest in a portion of the Upper South Platte River watershed. A major activity of this program is the use of forest thinning treatments to reduce the risk of large-scale, high-intensity wildfires that could occur where surface fuels have accumulated and dense forest stands have developed. The USFS is restoring the ponderosa pine forest near Trumbull, Colorado using thinning and prescribed burning to reduce tree density as well as reducing ground, ladder, and canopy fuels. The goal is to create a forest structure similar to historic conditions, while reducing fuel loads and diminishing the potential for large-scale, high-intensity wildfires like those that have burned nearby in the last two decades.

Invertebrates are sensitive to ecosystem change and disturbance and they support ecosystem sustainability through processes such as decomposition, energy transfer, and pollination (Recher et al. 1993; Andersen & Sparling 1997). How invertebrates respond to large-scale forest restoration projects is unknown (Holl 1996; Andersen & Sparling 1997; Majer 1997; Davies et al. 1999). However, changes to forest structure caused by forest thinning can affect the abundance of herbivore arthropods including butterflies (Erhardt & Thomas 1991; Siemann et al. 1997). Compared to control forests, treated forests show higher soil moisture and temperature, which enhance arthropod pupation (Covington et al. 1997, Scoble 1992).

The Pawnee montane skipper (*Hesperia leonardus montana*) (PMS) is listed as Threatened under the Endangered Species Act. This butterfly is endemic to the Upper South Platte River Valley, from southeast of Cheesman Reservoir, north around both sides of the reservoir, continuing north along the South Platte River to the North Fork of the South Platte River, and south of Deckers along Horse Creek for approximately six miles. The entire range of this subspecies occupies approximately 25,000 acres. Suitable PMS habitat includes ponderosa pine forest with an understory of dotted gayfeather (*Liatris punctata*) as a primary nectar source and blue grama (*Bouteloua gracilis*) as a larval host plant. Several other plants provide a secondary nectar source, most notably hairy golden-aster (*Heterotheca villosa*).

To assist in evaluating the effects of forest restoration treatments, the USFS, USFWS, and Denver Water sponsored a monitoring program for the PMS. Annual monitoring began in August 2000, was conducted through 2013, and will continue into the future. Three forest restoration treatment areas (2000 treatment, 2002 treatment, and 2004 treatment) and a control area were designated for monitoring. The primary objective of monitoring is to compare skipper use of untreated lower montane forest with use in lower montane forest that has been thinned to reduce fire danger and that is expected to improve PMS habitat.

The monitoring results suggest that restoration prescriptions mimicking the forest cover characteristics of the 2000 Treatment area and Control area and to a lesser extent the 2002 Treatment area should benefit the PMS and contribute to recovery of the species (Sovell 2012). Despite clear evidence that they are benefitting the skipper, the restoration prescriptions have not been evaluated in terms of their actual effects on forest overstory and understory vegetation. This study looked at how differing forest restoration prescriptions affected forest overstory and understory vegetation and subsequently, the abundance of the skipper, with the goal of identifying a model forest restoration prescription for use within the range of the PMS.

Methods

In 2012, vegetation data were collected from 80 plots, 20 in each of the four treatments (Control, 2000 Treatment, 2002 Treatment, and 2004 Treatment). These are the same four treatments monitored for PMS. Data were collected on overstory and understory vegetation as well as ground litter. Overstory data were collected for eight variables using a 0.1-acre circular plot (Table 1 and Figure 1). Basal area for each 0.1 acre plot was also calculated from existing data and included as a ninth variable in the analysis. Data on understory vegetation and ground litter were collected from four, 1 m^2 subplots located within each overstory plot, with one subplot located along each of the four cardinal compass bearings (north, south, east, and west) 3 meters from the center point of the 0.1 acre plot(Figure 1). Information was collected on 12 variables from each of the understory subplots (Table 1). For each variable collected in the 1 m^2 subplots, values were averaged for the four subplots within each overstory plot. We were interested in determining if there are differences among the treatments in the values for each variable and our assumption, or "null hypotheses," is that the values are equal for all four treatments. Differences between treatments by variable were analyzed using a Manova followed by pairwise comparisons using Tukey's HSD for those variables that showed significant differences by treatment at an alpha of 0.05. We want to minimize rejecting this null hypothesis when it is actually true, a type I error, so we have set the error rate to 0.05 for all comparisons. Meaning, we only want to make this error five percent of the time.

Table 1. Variables for which data were collected.

Plot Type	Variable[1]	Measure
0.1 acre overstory plot	Slope	degrees
	Aspect	compass bearing
	Hilltop	yes or no
	Tree count	number of trees
	Diameter at breast height (DBH)	inches at 4.5 feet above ground
	Crown width	feet at the widest point of each tree
	Tree height	feet from ground to tree top
	Height–to-crown	feet from ground to base of live crown

Plot Type	Variable[1]	Measure
	Liatris punctata (LIPU)	percent cover
	Bouteloua gracilis (BOGR)	percent cover
	Heterotheca villosa (HEVI)	percent cover
	Logs	percent cover
	Woody debris	percent cover
1 m^2 subplot	Overstory canopy cover	percent cover
	Soil and rock	percent cover
	Fine litter	percent cover
	Tree stumps	percent cover
	Wood chips	percent cover
	Shrubs	percent cover
	Other herbaceous vegetation	percent cover

[1] Basal area (square feet per acre) for each 0.1 acre plot was also calculated from existing data and included as a ninth variable in the analysis.

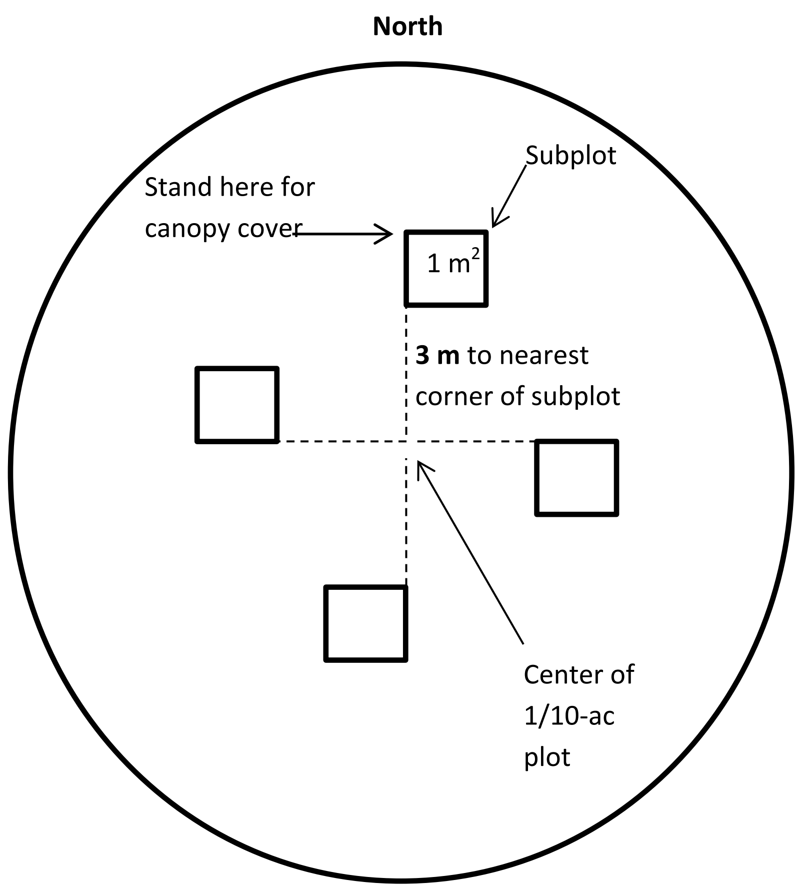

Figure 1. The configuration of the 0.1-acre overstory plot and the four 1-m2 understory subplots.

Results

Some variables exhibited statistically significant differences among the treatments. Vegetation differed significantly between the four treatments for six variables: DBH, tree height, basal area, canopy cover, HEVI, and wood chips (Tables 2 and 3). Two variables, crown width and other herbaceous vegetation, exhibited marginal differences among treatments (Tables 2 and 3). Of these differences, five are related to the structure of the overstory: DBH, crown width, tree height, basal area, and canopy cover. The other three are related to the structure of the understory: HEVI, wood chips, and other herbaceous vegetation.

Table 2. Variables that differed significantly by treatment. Those variables that showed marginally significant differences are shown in italics.

Variable	P – Value	Differences Among Treatments
Skipper Treatment Overall	3.045e-13	Significant difference between the treatments
Overstory Variables		
DBH	0.0204	Control < 2000, 2002 and 2004
Crown width	*0.104*	*Control < 2000, 2002 and 2004*
Tree height	0.02682	Control < 2000, 2002 and 2004
Basal area	0.0006647	Control > 2000, 2002 and 2004
Canopy cover	0.0001281	Control > 2000, 2002 and 2004
Understory Variables		
HEVI	0.0001247	Control > 2000, 2002 and 2004
Wood chips	7.609e -13	2004 > Control, and 2000 and 2002
Other herbaceous vegetation	*0.0666*	*Control < than 2000, 2002 and 2004*

Table 3. Average values by treatment for variables measured.

Variable*	Treatment				Average For All Treatments
	2000	2002	2004	Control	
Significant Differences					
DBH (inches)	10.6	11.7	10.4	**7.2**	10.0
Tree height (feet)	39	43	34	**28**	36
Basal area (feet^2/acre)	55	38	35	**71**	49
Canopy cover (%)	27	28	25	**49**	32
HEVI (% cover)	0.29	0.72	0.21	**1.56**	0.70
Wood chips (% cover)	0.19	0.00	**6.42**	0.01	1.65
Marginally Significant Differences					
Crown width (feet)	15	16	15	**11**	14

Variable*	Treatment				Average For All Treatments
	2000	2002	2004	Control	
Other herbaceous vegetation (% cover)	7.19	9.46	9.78	**<u>4.82</u>**	7.81
Differences Not Significant					
Height to crown (feet)	11	15	14	11	13
LIPU (% cover)	0.06	0.04	0.12	0.06	0.07
BOGR (% cover)	4.13	0.55	0.31	1.51	1.63
Logs (% cover)	0.99	2.91	1.58	0.68	1.54
Woody debris (% cover)	8.54	8.06	5.42	5.61	6.91
Soil and rock (% cover)	24.51	36.74	32.63	33.23	31.78
Fine litter (% cover)	51.94	38.85	43.26	50.63	46.17
Tree stumps (% cover)	1.36	1.64	0.59	0.91	1.12
Shrubs (% cover)	0.19	1.06	1.76	0.01	0.75

*For each variable, those shown in bold and underlined are statistically different than those not shown in bold and underlined. For example, the value for DBH for the control is significantly lower than the DBH for the other treatments.

A second analysis was performed comparing the 2000, 2002, and control treatments to the 2004 Treatment. This comparison was performed to access the difference in vegetative structure between those treatments with a high (2000, 2002, and control treatments) and low (2004 Treatment) abundance of Pawnee montane skippers. Vegetation differed significantly between the high and low abundance treatments for four variables: canopy cover, HEVI, wood chips, and basal area (Table 4). One variable, shrub cover, exhibited a marginal difference (Table 4). Of these differences, two are related to the structure of the overstory: canopy cover and basal area. The other three are related to the structure of the understory: HEVI, wood chips, and shrub cover.

Table 4. Variables that differed significantly among treatments with a high abundance versus the 2004 treatment with a low abundance of Pawnee montane skippers. Those variables with marginally significant differences are shown in italics.

Variable	P – Value	Differences Among Treatments
Skipper Treatment Overall	1,202e-9	Significant difference between the high and low
Overstory Variables		
Canopy cover	0.05374	2004 < 2000, 2002 and control
Basal area	0.01686	2004 < 2000, 2002 and control
Understory Variables		
HEVI	0.02298	2004 < 2000, 2002 and control
Wood chips	8.403e -15	2004 > 2000, 2002 and control
Shrub Cover	*0.09668*	*2004 > 2000, 2002 and control*

When looking at the overstory variables, the differences noted in this study suggest that the forest structure at the control has shorter, smaller trees with shorter limbs arranged in a denser pattern, as evidenced by lower average DBH, reduced crown width, shorter tree height, higher basal area, and higher canopy cover (Table 3). In contrast, average basal area and canopy cover are lower on all of the thinned treatments, suggesting a more mature, open, savanna-like forest structure, with fewer, larger trees. These observations agree with the treatment prescriptions, which were designed to retain larger trees in a more open pattern reminiscent of the historic forest structure.

For the statistically different understory variables, the control had more HEVI and less other herbaceous vegetation (Table 3), which may reflect treatment effects. The 2004 treatment had higher wood chips than the other three treatments (Table 3), most likely as an artifact of the prescription for this treatment. The 2004 treatment was thinned mechanically, but was not subject to prescribed burning, as were the 2000 and 2002 treatments.

Comparison between the high and low abundance treatments indicates a lack of forest or trees in the tile treated areas of the 2004 Treatment and an increased cover of woodchips, again an artifact of the treatment prescription. The tile treated areas consist of clear cuts up to 10 acres in size leaving approximately 20 percent of the area treated. There is also some evidence that the 2004 Treatment has a higher cover of shrubs, which might make this treatment less suitable for the Pawnee montane skipper. Pawnee montane skippers inhabit open ponderosa pine forest with a sparse understory that includes blue grama and dotted gayfeather. An understory that is dominated by an intermediate shrub layer with reduced ground cover, resulting in less blue grama and dotted gayfeather would lower habitat suitability for the Pawnee montane skipper.

Figure 2 shows the "box plots" for those variables that differed either significantly or marginally among the treatment groups. Figure 2 visually summarizes and compares the treatment groups using the median, upper and lower quartiles, and extreme values to convey the level, spread, and symmetry of data values by treatment group. The values for the 2000 and 2002 treatments for canopy cover, wood chips, HEVI, and other herbaceous ground cover are more similar to one another in their median values and sometimes in their spread and quartiles than they are to the 2004 treatment or the control (Figure 2). The 2000 treatment and the control groups are somewhat similar in their values for basal area (Figure 2).

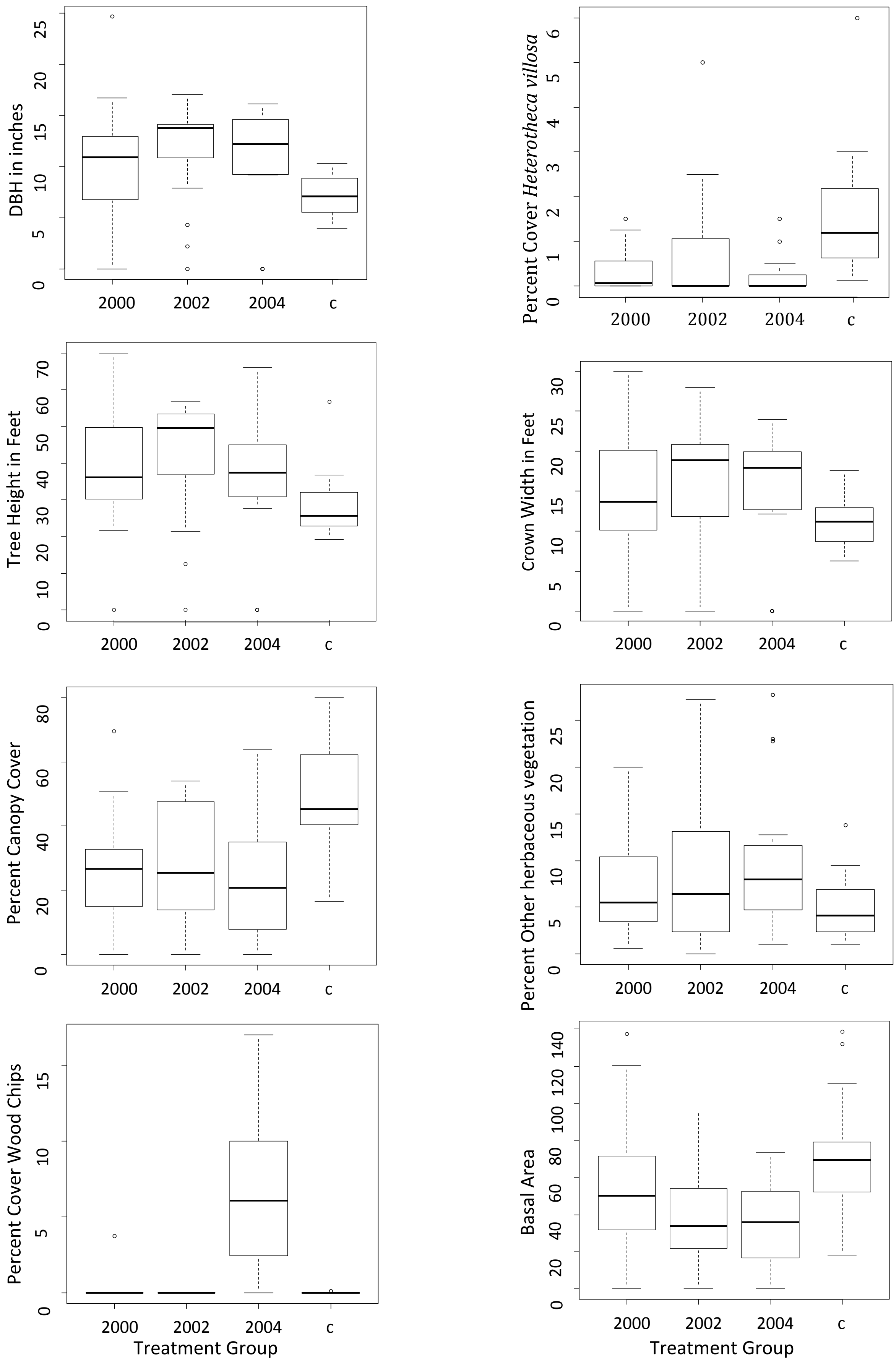

Figure 2. Box plots of the eight variables that differed either significantly or marginally among treatments.

Turning our attention to skipper abundances observed through the monitoring program, it is evident that the 2000 and 2002 Treatments supported higher numbers of skippers in the earlier years of monitoring, followed by higher counts at the Control in later years (Figure 3) (Sovell 2012). Consequently, the total count at these three treatments are nearly equivalent, while counts at the 2004 Treatment have consistently been lower (Figure 3, Table 5) (Sovell 2012).

Table 5. Total count for Pawnee montane skippers, monitoring years 2005 – 2012.

Treatment	Sum of PMS observed
2000	163
2002	164
2004	42
Control	155
Grand Total	**524**

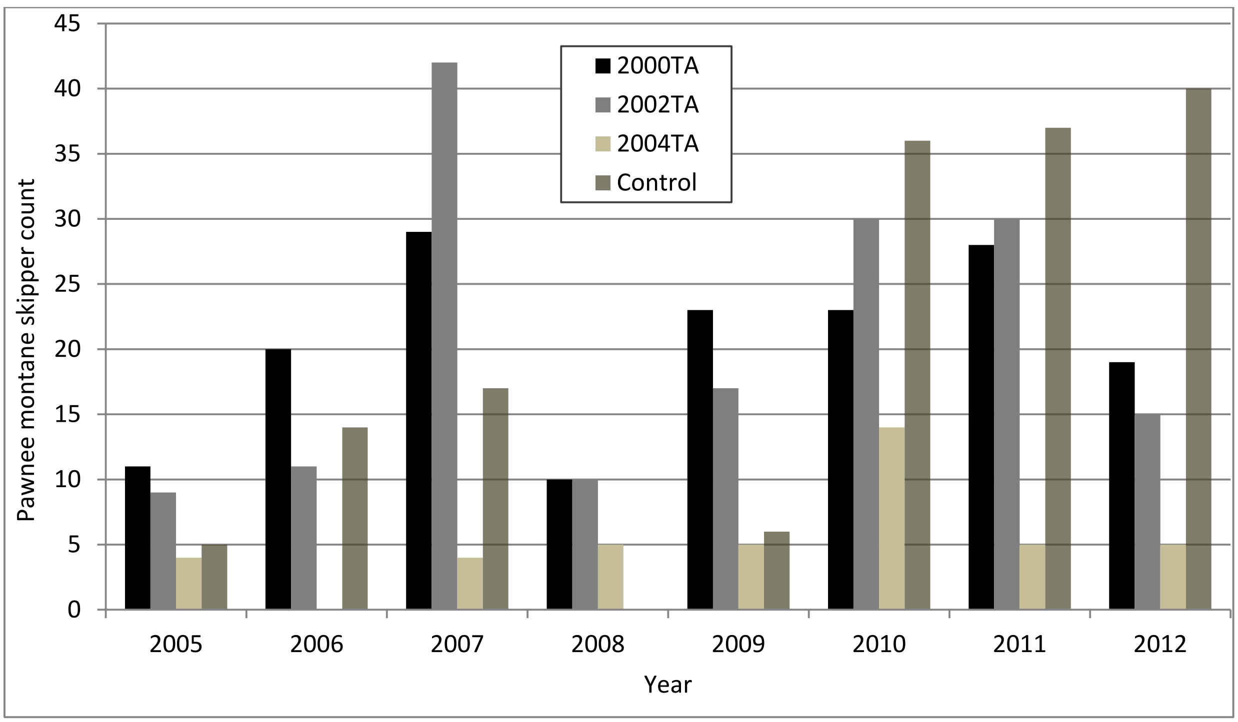

Figure 3. Counts of Pawnee montane skippers, by year and treatment, for the monitoring years 2005 – 2012

Discussion

At this point, it is important to discuss some differences between the Control and the three treatment areas. From the vegetation variables measured, it is clear that the Control has trees with smaller DBH, crown width, and tree height that are closer together, leading to a higher basal area and canopy cover. Yet, this area also supports a high density of PMS. The Control transects measured during skipper monitoring have generally east aspects, in contrast with those in the 2000, 2002, and 2004 treatment units, which are generally west-facing. I think the west aspect at the Control accelerates both the timing of morning warm-up and subsequently the rate of caterpillar development, positively influencing PMS pupation success and adult abundance. Also, Control monitoring transect CS has a very open canopy, particularly on its southeast end, as does transect CM to a lesser extent. It is within these open areas of the control transects where the majority of Pawnee montane skippers have been observed (Sovell 2012). The northwest ends of transects CS and CM and almost all of transect CN have a more closed canopy with younger, smaller, more closely spaced trees (J. Sovell, personal observation). The skipper monitoring transects exhibit great variation in canopy cover values at transect stations. Canopy cover, using a densitometer, was taken from the three thinned areas and the control area at each 50 meter station on the 400 meter monitoring transects where the Pawnee montane skipper was sampled. On the Control transect, measures of canopy cover at transect stations ranged from 0 to 52 percent, with a mean of 32 percent on transect CS to a mean of 73 percent (range 26 to 96 percent) on transect CM (Appendix 1). However, between the station points along transect CM there exist open areas with low canopy cover (Sovell, personal observation). The lowest canopy cover among treatments was recorded for the 2004 Treatment with the lowest cover on transect 242 ($\overline{x}$ = 15 percent with a range of 0 to 60 percent) while transect 243 had the highest canopy cover ($\overline{x}$ = 43 percent with a range of 10 to 77 percent). Values of canopy cover for the 2000 Treatment and 2002 Treatment fell between these extremes, but also varied greatly with a low of 17 percent (range 0 to 67 percent) on 2000 Treatment transect 210 to a high of 54 percent (range 30 to 73 percent) on 2002 Treatment transect 206. Values of canopy cover at transect locations indicate that monitoring transect CS is placed in a more open part of the Control area, compared with the randomly located vegetation plots, which would tend to yield higher PMS counts despite the denser vegetation. Monitoring transect CM contains patches of open areas between transect stations, which could also yield higher PMS counts despite the denser vegetation of the transect. Additionally, the east aspect, in tandem with the open canopy of CS and CM, may create microhabitats that are very suitable habitat for PMS, compensating for the low quality of other parts of the Control area. The abundance of the secondary nectar source in the Control area, HEVI, provides some evidence in favor of this hypothesis.

One unanticipated result of this study was our failure to identify any differences between the 2004 Treatment and the 2000 and 2002 treatments, with the exception of the wood chips variable. However, when the 2000, 2002, and Control treatments were combined and compared to the 2004 Treatment there were statistically significant differences with the 2004 Treatment having less canopy cover, basal area, and hairy golden aster and greater amounts of wood chips and shrub cover. The 2004 Treatment consisted of a series of "tiles," with small clearcuts up to 10 acres in size placed in a matrix of forest. The matrix was also thinned, but not as aggressively as the other treatments. In contrast, the 2000 and 2002 treatments were thinned more uniformly, but more aggressively, with most openings 0.25 acres or less in size (M. Schweich, personal observation). As shown in this study, all three treatments created statistically similar forest overstories (in terms of DBH, crown width, tree height, basal area, and canopy cover), when these variables are averaged across the entire treatment area. Clearly, the variables selected for measurement, or perhaps the sample size used, failed to detect the larger openings in the 2004 Treatment. An examination of the individual plot data showed that several plots fell within openings, which are defined as having a canopy cover of 10 percent or less. One plot was located in an opening in the 2000 Treatment, two plots were in openings in the 2002 Treatment, and four plots were in openings in the 2004 Treatment. No plots in the Control area fell within openings. Even by this measure, the 2004 Treatment is not clearly distinct from the other treatments, although it did have the most plots in openings. Despite the failure to distinguish between the treatments, monitoring data clearly show the 2004 Treatment is not as favorable for PMS as the other treatments. Our current hypothesis is that neither the large openings nor the denser forest matrix in the 2004 Treatment are as suitable for PMS as the open, savanna-like forest structure of the 2000 and 2002 treatments (Sovell 2012). We believe that small openings like those found in the 2000 and 2002 treatments are important for PMS, creating areas where the butterflies primary adult nectar source (*Liatris punctata*) and larval host plant (*Bouteloua gracilis*) can thrive in close proximity to cover provided by surrounding trees. In contrast, large openings like those in the 2004 Treatment create a warmer, drier microclimate and do not have adequate cover, except around their edges.

With regard to the higher percent cover by wood chips in the 2004 treatment, we believe this is an artifact of the treatment methods. Much of the tree removal in this treatment was done using a rotary axe or Bullhog grinder, which essentially grind trees into chips and spread them across the forest floor. Particularly in the tiles, large amounts of chips were created. In addition, broadcast burning was used in the 2000 and 2002 treatments to reduce ground fuels; broadcast burning was not used in the 2004 Treatment. The higher presence of wood chips has the potential to suppress growth of understory vegetation, including LIPU and BOGR, which in turn could lead to decreased PMS abundance; however, we did not find this to be the case in this study.

Management Implications

Forest restoration will continue to be a high priority in the range of the PMS because of the high values at risk in the Upper South Platte watershed. By cross referencing the measures of, and differences in, the vegetation variables with the counts of PMS, it becomes evident that a forest restoration prescription incorporating those aspects of overstory structure (DBH, crown width, canopy cover, tree height, and basal area) that mimic the structure created in the 2000 and 2002 Treatment areas is beneficial to the PMS while also meeting forest restoration objectives. Metrics for restoration prescriptions in the range of the PMS should be based on the ranges measured for the variables of forest structure at the 2000 and 2002 treatments (Table 6). The vegetation values at the Control should not be discounted, but the effect that the east facing aspect has versus the vegetation structure in determining skipper abundance at those transects is difficult to assess.

Table 6. Potential thinning metrics for forest structure variables in suitable PMS habitat

Variable	Metric Range	Relation to PMS Abundance
DBH	10.0 to 12.0 inches	Ambiguous
Crown width	15 to 16 feet	Ambiguous
Canopy cover	< 35 percent	Ambiguous
Tree height	29 to 43 feet	Ambiguous
HEVI	>1 percent cover	Positive
Wood chips	> 5 percent cover	Negative
Basal area	38 to 55 feet^2 per acre	Positive

One aspect of forest structure that was not measured was the average size of forest openings (that is, spacing of trees or distance between groups of trees). Forest restoration treatments seeking to promote a variety of tree size classes in a clumpy spatial arrangement emulating historic forest conditions would most suit the PMS (Figure 5). Thinning should be focused on diameter classes that are overly abundant (Lowe 2005), like the small- to mid-sized classes present on the northwest ends of transects CS and CM and almost all of CN. We want to promote variability of forest structure by creating a mosaic of forested patches and openings of approximately 0.1 acre in average size. Treatment should focus on reducing the continuity of surface and ladder fuels, while simultaneously seeking a broader ecosystem response including creating more forest clearings and inducing positive changes in understory cover, thus benefiting both wildlife and forest hydrologic function (Lowe 2005).

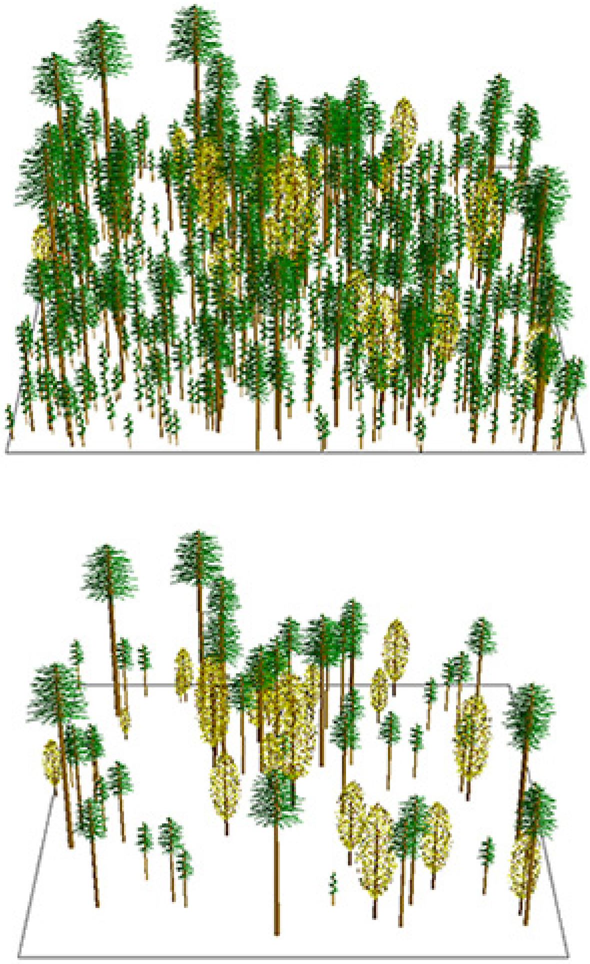

Figure 4. Simulation from another forest restoration study (illustration by Andrew Sanchez-Meador, from Lowe 2005) created using the USDA Forest Service Stand Visualization System showing pre- and post-treatment tree densities at a representative site in northern Arizona. A similar thinning pattern would be appropriate in the range of the PMS.

The percent of HEVI present is of less importance than the other variables shown in Table 5. The presence versus the complete absence of HEVI as a secondary nectar source for the PMS is probably more important than the percent cover that is present. Openings created by forest restoration should promote increased abundance of both HEVI and LIPU, benefitting the PMS.

The 2004 Treatment led to considerable ground cover (wood chips) and soil disturbance throughout the thinned unit. The result appears to be a treatment that produces marginal skipper habitat, most probably because of the complete absence of tree cover like that which occurs at a severely burned site, rather than because of the increased density of the ground cover, but this too could negatively affect the skipper. Consequently, the restoration prescription should not cover more than 25 percent of the unit more than 2 inches deep of wood chips, with few to no chips on the remaining 75 percent of the unit. Any ground litter produced by the thinning process should be kept to a minimum and the resulting slash should be aggregated and either removed or burned.

Sample Prescription

Ultimately, restoration prescriptions that favor PMS should create a heterogeneous tree distribution with small openings in the overstory canopy and an age class distribution including both smaller and larger trees. A sample prescription is provided here. Depending on the actual area to be treated and other treatment objectives (for example, fuel reduction), other parameters may be added to this prescription; however, the basic parameters (basal area, canopy cover, openings, and slash treatment) should not be altered if this prescription is used within the range of the PMS. It is also important to note that the current version of the Upper South Platte Biological Opinion should be consulted for other requirements that may be needed in final prescriptions for each treatment unit.

- The general prescription is thin from below, by removing progressively larger diameter classes until the target basal area has been met. However, a sufficient amount of smaller trees should be retained where available to promote age class diversity.
- Trees selected for retention should have crown ratios greater than 40 percent.
- No required tree spacing should be specified. Thinning goals should be based on a target basal area, averaged across the entire treatment unit.
- Basal area should average less than 60 feet^2 per acre across a treatment unit, but vary between 40 feet^2 per acre and 70 feet^2 per acre, except in openings where few or no trees are present.
- Canopy cover is closely related to basal area (Mitchell and Popovich 1997); therefore, use of these basal area parameters should yield an average canopy cover less than 35 percent across a treatment area, but varying between 25 percent and 40 percent. Openings will have a canopy cover of 10 percent or less.
- The purpose of using a targeted basal area is to avoid creating a uniform, “tree-farm” stand structure, while encouraging thinning that mimics natural, irregular, patchy landscape patterns.
- Openings
  - Openings should average 0.10 acre in size and should not exceed 0.25 acre, except where they are naturally larger (for example, in areas of rock outcrops).
  - No more than 25 percent of a treatment unit should be in openings.
  - When creating openings, target areas that historically were more likely to be open. For example, upper south-facing slopes and ridgelines.
  - A modified thin from below prescription, incorporating some aspects of group selection, may be needed to ensure sufficient openings are created.
- Slash Treatment
  - Slash should be reduced as much as possible. Preferred methods are physical removal or prescribed burning.
  - If slash is piled, avoid placing piles in areas occupied by LIPU or BOGR.
  - In some areas, removal or prescribed burning may not be feasible. If this is the case, care should be taken to minimize the depth and continuity of slash left in the area.
  - Minimize slash deposition in area occupied by LIPU or BOGR
  - If slash is treated by chipping, grinding, or mastication, chips should be spread across no more than 25 percent of the unit to a depth of no more than two inches. The remaining 75 percent of the unit should have few or no chips.

- If slash is treated by lopping and scattering, the maximum slash depth should not exceed 12 inches.

- Existing dead and down woody material (for example, fallen snags) may be limbed, but should not be bucked or removed except as needed for safety. In areas with large numbers of down logs, some may be removed, but some should be left in place. Boles of down logs are not subject to the maximum slash depth requirement.
- Any re-seeding or noxious weed treatments should follow the requirements of the current Upper South Platte Biological Opinion.

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Appendix 1

Percent canopy cover at the 50 meter stations on each 400-meter transect, where Pawnee montane skipper are being monitored ("––" indicates that densiometer data was not collected for that station).

Site	Transect	Station	Canopy Cover Percent
Control	CS	0	0
		50	52
		100	47
		150	28
		200	7
		250	74
		300	27
		350	22
		400	––
	CM	0	88
		50	26
		100	93
		150	96
		200	82
		250	55
		300	89
		350	52
		400	––
	CN	0	32
		50	72
		100	97
		150	60
		200	82
		250	18
		300	90
		350	73
		400	––
2000TA	208&211	0	49
		50	63
		100	55
		150	26
		200	15
		250	52
		300	79
		350	41
		400	49
	209	0	49
		50	46

Site	Transect	Station	Canopy Cover Percent
2000TA	209	100	14
		150	33
		200	42
		250	65
		300	46
		350	28
		400	59
	210	0	26
		50	67
		100	0
		150	0
		200	0
		250	17
		300	3
		350	27
		400	16
2002TA	201	0	28
		50	29
		100	85
		150	81
		200	54
		250	5
		300	91
		350	62
		400	41
	202	0	41
		50	63
		100	33
		150	19
		200	11
		250	71
		300	50
		350	49
		400	75
	203	0	57
		50	10
		100	44
		150	30

Site	Transect	Station	Canopy Cover Percent
2002TA	203	200	12
		250	82
		300	69
		350	92
		400	38
	204	0	69
		50	48
		100	5
		150	32
		200	39
		250	21
		300	22
		350	41
		400	19
	205	0	72
		50	0
		100	65
		150	14
		200	23
		250	4
		300	6
		350	38
		400	0
	206	0	45
		50	73
		100	53
		150	30
		200	53
		250	46
		300	68
		350	68
		400	52
2004TA	241	0	58
		50	57
		100	3
		150	21
		200	20
		250	60
		300	0
		350	1
		400	--

Site	Transect	Station	Canopy Cover Percent
2004TA	242	0	13
		50	2
		100	1.2
		150	60
		200	13
		250	0
		300	0
		350	30
		400	--
	243	0	21
		50	29
		100	54
		150	10
		200	84
		250	77
		300	72
		350	11
		400	33