Effects of Forest Management on Small Mammal Communities at Sugar Creek Conservation Area

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Anthropogenic disturbances are capable of affecting the diversity of mammal communities essential for ecosystem development and sustainability. This study assessed small mammal populations and communities of Sugar Creek Conservation Area alongside the habitat structure created by the current trends of forest management implemented by the Missouri Department of Conservation. Findings from habitat surveys found significant differences among habitat structure between treatment groups, although significant, they were not entirely unexpected based on treatment prescriptions. Simpson's Indices were low throughout all treatment areas (0.18). Although results indicate low diversity throughout treatment areas these findings appear uncertain and cannot be entirely contributed to forest management practice.

Introduction

Habitat disturbance, more specifically, anthropogenic habitat disturbance is a topic of major concern to ecologists and natural resource managers (Pickett and White 1985), generating the need for further investigation into the effects of man-made disturbances in various habitats. Many studies have sought to determine the relationship between habitat disruption and responses of small mammal populations and communities (Klenner and Sullivan 2003; Sullivan and Sullivan 2000; Sullivan et. al. 1999; Moses and Boutin 2000; Hall and Willig 1994; August 1993) as a

factor in determining the health of the ecosystem and the effectiveness of intentional disturbance (e.g. logging, restoration management). Studies have been successful in this attempt, showing small mammals to respond quickly and significantly to habitat disturbances and imparting significant contributions to ecosystem health and sustainability, indicating their importance in maintaining ecosystem integrity.

Disturbance is an essential element to the health of an ecological system but is often hard to define and conceptualize because of the ambiguity involved (Eulinger 2003). Disturbances can be defined based on their frequency and intensity (Pickett and White 1985) or by its effects on species diversity (Hall and Willig 1994). The variations in frequency and intensity have been theorized to result in an increase or decrease in biodiversity and are thought to be best suited at intermediate levels (Connell 1978). Intermediate levels of disturbance represent a non-equilibrium state within the habitat, whereas high levels of disturbance support only tolerant colonizers and habitat generalists, contrary to low levels of disturbance creating a stagnation within the environment, interrupting the establishment of colonizing species (Connell 1978). Such variations represent the need for any intentional disturbances to be documented and measured to ensure effective and healthy implementation.

In terms of assessing the effects of disturbance on small mammal communities and populations, past studies in spruce-fir forests have shown Clethrionomys gapperi (red-backed voles) populations to have little response to partial cuttings, but seem to be negatively effected by clear-cut treatments (Klenner and Sullivan 2003). Conversely, Microtus species have shown a positive response to clear-cut (Sullivan and Sullivan 2001) and, in general, species richness increases in clear-cut areas (Sullivan et al. 1999; Verme 1981) but not always abundance (Fisher, 1995). Peromyscus (white-footed mice and deer mice) species have shown their generalist nature and seem to respond favorably or show no adverse effects in most treatment types (Sullivan et al. 1999; Moses 2000; Klenner 2003; Root et al 1990; Wallen in text). Whereas shrew populations seem less dependent on the type of treatment being applied to canopy vegetation, relying on shrub and leaf-litter cover (Fisher 2005).

Furthermore, because of their use as indicators of ecosystem stress and health in past studies, their direct response to changes in habitat condition and structure (Avenant, 2000; Medellin et al. 2000) and because of their critical niche within the ecosystem as prey items, seed and fungal spore dispersal agents, and consumers of invertebrate and plant product (Klenner and Sullivan 2003), it would seem small mammal community diversity would be an appropriate tool for gauging the effects of disturbance, and more specifically the effects of forest management of vegetative

structure as it is related to small mammal community diversity (Etcheverry et al. 2005; Sullivan et al. 1999).

As such, Sugar Creek Conservation Area (SCCA) provides an optimal area to assess the effects of forest management on small mammal community structure. The area has been under the management jurisdiction of the Northeast branch on the Missouri Department of Conservation since 1974 and within its boundaries has numerous management prescriptions. The focus of this study will provide data regarding the habitat structure of three independently managed stands, as well as an undisturbed stand, and small mammal communities within. Together this data should provide researchers with an opportunity to compare findings between areas and with past studies to assess whether forest management is providing healthy habitat for small mammal community diversity.

Methods and Materials

Study Area

Sugar Creek Conservation Area, located 6.5 km southwest of Kirksville, MO, is under the jurisdiction of the Northeast regional office of the Missouri Department of Conservation (MDC) (Cooper 2005). After decades as farm and grazing land the area was purchased in 1973 (Amerman 2007). Totaling 1026-ha, SCCA is divided into three compartments and is mostly dominated by oak-hickory forest, but also contains prairie restoration projects, meadow and old-field habitats. Located within the 1000-acre northwest sector of the conservation area, Compartment Three (C3) represents the most diversely managed forests. Included in this area are stands prescribed and treated for Timber Stand Improvement (TSI), Timber Harvest Sales (THS), and Clear-cut Timber Harvest. Because of the diverse array of treatment areas located within the compartment, C3 makes a suitable and feasible research area. Within C3, four research areas were surveyed; these included undisturbed forest (Stand 28, 35-acres), Timber Harvest Clear-cut (Stand 42, 13-acres). Timber Harvest (Stand 62, 27-acres), and prescribed Timber Stand Improvement (Stand 69, 21-acres). Four research areas provide a large spectrum of management, offering a fuller picture to assess changes in vegetative and small mammal community structure.

Habitat Survey

A line-intercept survey of vegetative stratum was employed during this study. Habitat surveys began in mid-May 2007 and finished in late June 2007. Within each stand, 10 transects (50m) were surveyed with starting point and bearing determined randomly. Transect data was gathered for three vertical strata, ground cover (0-2m), sub-canopy cover (2-5m), and canopy cover (5m+). Height was gathered for each variable measured, excepted for sub-canopy cover. Canopy height was approximated

using a Suunto® clinometer and diameter at breast height (DBH) was taken for each canopy datum.

Ground-cover variables included herbaceous cover (HGC), woody cover (WGC), down woody debris (DWD), leaf litter (LL), bare ground (Bare), and mixed cover (Mix) (indeterminate herbaceous cover and leaf litter). These variables were chosen because of the relation to habitat preferences of small mammals known to inhabit the region and because of the variation expected between treatment areas. One-way ANOVA analysis was used to determine significant differences between coverage variable across habitats. Tukey's method was employed as the principal post-hoc testing to reveal any further differences between variables and habitat type.

Small Mammal Survey

Small mammals were live trapped over a month long period (June 2007) using Sherman® live-traps with a mark-recapture method, each area was trapped during four successive nights. Traps were baited with agricultural sweet feed and rebaited as needed. During each trapping session, traps were left open during the day, as most areas had sufficient cover and the feasibility of opening and closing traps each days was in question (only three individuals were lost during trapping). Each stand totaled 600 trap nights each with a practice of loose transect placement for each area (area topography and opportune areas for capture were a determining factor in trap placement). Data for mammal captures were recorded (species, weight, sex, right foot length, tail length, right ear length, and history) and animals marked with a red Sharpie® marker on their underside and released. Analysis of small mammal community diversity employed Simpson's Index as it primary tool.

Results

Small Mammal Survey

A total of 42 small mammals representing 3 species were captured in 2,400 trap nights (600 trap nights/stand). Traps success for all sessions was 1.75%. Complete results are shown in Table 1. Across all areas, *Peromyscus leucopus* (white-footed mouse) dominated the survey. This species constituted 90.5% of all captures and was found in all areas. *Blarina* (sp) was the second most common species captured, with 3 captures, composing 7% of total small mammal captures. This species however was found only in Timber Stand Improvement. The only other species recorded during trapping was *Microtus* (sp), trapped in the Timber Harvest area. Simpson's Index was calculated for all areas, these are summarized in Table 1.

Habitat Survey

Assessment using the line-intercept method yielded reliable results. Alongside habitat coverage type, height was also measured for herbaceous and woody ground

covers as well as canopy cover height. Mean height and standard deviation results within research areas are summarized in Table 3. Between all areas herbaceous ground cover height differences were found to be insignificant (F= 0.10, p-value 0.961). Woody ground cover height was found to have significant difference between areas (F= 4.77, p-value 0.007). Canopy cover height results are as follows: Stand 28 (15.85 meters), Stand 42 (29.71 meters), Stand 62 (17.64 meters), and Stand 69 (14.66 meters). These results were not analyzed any further due to confounding variables. Percent coverage details are summarized in Table 2.

Herbaceous Ground Cover (HGC): Herbaceous ground cover was found throughout and had a negative correlation with canopy cover (r= -0.379, p-value 0.016). One-way analysis of variance (ANOVA) using Minitab 15.1 showed significant difference between habitats (F= 5.22, p-value 0.004). Tukey's post-hoc testing revealed no significant difference between the undisturbed area and remaining areas, but a significant difference was found between clear-cut and the Timer Harvest and TSI. Percent coverage estimates revealed clear-cut to have the highest percentage of herbaceous material, covering 24.3% of the area. This finding is not surprising, as clear-cut areas will naturally allow the formation of vegetative ground cover with the lack of any vertical cover.

Woody Ground Cover (WGC): Similarly, WGC was found in all areas and also had a negative correlation with canopy cover (r= -0.729, p-value= 0.000). One-way ANOVA analysis showed significant difference between areas (F= 26.06, p-value= 0.000). Post-hoc analysis revealed significant differences between undisturbed and clear-cut and TSI. Post-hoc testing also revealed significant differences between clear-cut and TSI, as well as between Timber Harvest and TSI. Post-hoc testing shows the negative correlation between canopy cover and woody ground cover to be substantiated.

Down Woody Debris (DWD): Significant difference in DWD was found between areas (F= 8.96, p-value= 0.000). It was not unexpected to find these results as DWD has a negative correlation with canopy cover (r= -0.593, p-value= 0.000). Post-hoc testing shows that clear-cut had the most significant difference when compared with other habitats.

Sub-Canopy Cover (SC): Coverage 2-5 meters above ground differed significantly across areas (F= 16.29, p-value= 0.000), showing a positive correlation with canopy cover (r=0.601, p-value= 0.000). Post-hoc testing indicated undisturbed coverage to be significantly different from those of Timber Harvest and TSI, likewise between clear-cut and TSI, as well as between Timber Harvest and TSI.

Canopy Cover (C): As expected, canopy cover varied significantly across areas (F= 47.33, p-value 0.000), coinciding with percent coverage estimates, post-hoc

testing revealed significant differences between undisturbed and clear-cut and Timber Harvest. The same was found between Clear-cut and Timber Harvest and TSI, in addition to TSI and Timber Harvest. Results, as expected, correspond with the management practice.

Diameter at Breast Height (DBH): Measurements of diameter at breast height was found to differ significantly across areas (F= 3.52, p-value= 0.025). Post-hoc testing reveled though that these findings were less significant as first calculated. Tukey's shows no significant difference between Stand 28 and the other areas, although Stand 42 did differ significantly from Stands 62 and 69 with no significant difference being found between Stands 62 and 69. The results indicate statistical error as the reason for ANOVA significance and Stand 42 is somewhat of an outlier in this analysis, which is not unexpected, as it was clear-cut habitat. The post-hoc testing reveals to us that among areas with considerable canopy cover there is no significant difference between the ages of the trees providing coverage, resulting in areas of even-aged forest.

Leaf Litter/Mix: At the conclusion of data collection it was determined that the variables of leaf litter and mixed ground cover (e.g. indeterminate herbaceous and leaf litter) should be categorized together, due to the fact that HGC played an inconsequential role as cover with leaf litter as crucial coverage. As such, any further discussion regarding leaf litter is in fact the combined totals of leaf litter and mixed cover.

One-way ANOVA showed significant difference across habitats (F= 83.65, p-value= 0.000) and a positive correlation between leaf litter and canopy cover (r= 0.815, p-value= 0.000). These results are not unexpected, as treatment dictates a reduction or maintenance of canopy cover. Further post-hoc analysis showed undisturbed and TSI to be the most similar in terms of leaf litter and canopy cover, showing significant difference between clear-cut and TSI.

Discussion

Habitat Survey

Results from the line-transect survey revealed expected structural elements within each habitat. This is further supported by mean diameter at breast height, with no significant difference between areas, indicating an even-aged canopy. Even-aged management is the current trend of MDC (Clark 2007) and even-aged forest is to be expected given that the entire area was clear-cut around the beginning of the 20th century (Cooper 2005). Additional factors influencing the scope of this study included the inability to gauge successional periods or establish a successional timeline. Establishment of these factors would undoubtedly lead to additional

support regarding the expectation of habitat structure and small mammal species.

Small Mammal Survey

Findings from this study are comparable to past studies from the same area. Cooper (2005) found *P. leucopus* to dominate areas within C3 (90.4%) as well as finding low diversity and richness within the same compartment; Cooper's study recorded a total of four species (*P. leucopus*, *Blarina* (sp), *Tamias striatus*, and *M. ochrogaster*). Further mammal surveys of the area have resulted in higher richness but low diversity, with six species (other than *P. leucopus*) accounting for less than 40% of captures species (*R. megalotis, S. cooperi, Sorex* (sp), *M. ochrogaster, P. maniculatus, Z. hudsonius*) (Burt 2007).

Contrary to these findings, an on going study of Chiropteran species within Sugar Creek has found genuine species diversity (Burt 2007). A total of six species occurring in Missouri have been recorded, including the endangered Indiana bat and maternity roosts (*Myotis sodalis*). Past studies have also indicated a healthy richness of larger mammals, ranging from White-tailed deer (*Odocoileus virginianus*), Bobcat *(Lynx rufus*), and Coyote (*Canis latrans*). Healthy populations of larger mammals, though not as apparent, can be indicators small mammals. Being predators to the smaller, forest floor dwelling animals, local carnivores would seemingly indicate a healthy community of small mammals.

It is a perplexing question to be answered, how is the diversity of mammals other than forest floor small mammals as healthy as it is with the deficits we see in the smaller mammals. This study has again shown *P. leucopus* to dominate forested areas within Sugar Creek, though not surprising being a habitat generalist, its nature would dictate success in varied habitats, but the extent to which it dominates while other species show little or no presence is astounding.

Conclusion

Theory would dictate that with an increase in habitat heterogeneity, such as that seen in the clear-cut, would accompany an increase in species richness (Tews 2004). This process is seen in numerous studies regarding clear-cuts; Sullivan (1999) found mean species richness to increase in clear-cuts when compared with clear-cut burned sites and forested areas. Meta-analysis by Fisher (2005) and Kirkland (1990) also indicates clear-cut areas should report higher species richness, and at times abundance, in comparison to other managed and unmanaged areas. These findings have been corroborated by numerous other studies, although other findings have shown *P. leucopus* populations to dominate clear-cut areas (Root 1990). It may be the clear-cut site at Sugar Creek, though only recently managed in 2004, may possibly be in the establishment stage of its successional process, reducing the

richness of species inhabiting the area (Fisher 2005). This is plausible but habitat assessments were indicative of a heterogeneous habitat, again raising the questions of community diversity within the clear-cut.

Though the Timber Harvest area yielded similar diversity estimates to those of the clear-cut, it did however provide the only microtine capture. The seemingly over-abundance of *P. leucopus* is not unnatural or surprising to find in a forested area such as Timber Harvest site, what is surprising however is the lack of other species. As a genus, Microtus species tend to vary in their habitat preferences, but all species occurring in Missouri have been observed at Sugar Creek or similar conservation areas and the Timber Harvest provides at least one species (*M. pinetorum*) its preferred habitat. Again as with the clear-cut site, habitat structure does not seem to be detrimental to small mammal populations as adequate cover of varied types are provided.

As for the prescribed TSI and the undisturbed site, in which habitat differences were nominal, there seems to be rather sparse support for the difference in small mammal captures. Despite the fact that the undisturbed habitat provided substantial canopy cover and two marshy ponds, there seems no explanation, based on its habitat structure, to account for it rather weak species abundance and richness. However, weather was a significant factor, as it rained periodically during the trap session and bait was consumed by the resulting influx of arthropods. Disturbance by nuisance species was observed to be highest in this area as well. Together these factors show additional trap sessions are needed to re-evaluate this location and provide adequate data for comparison.

The scope of this study does not seem to have the capability of establishing the precedence of forest management effecting small mammal communities in a positive or negative manner and the question still remains as to whether management practices are dictating the low diversity estimates or whether there are other influencing factors determining diversity. Whether these additional factors are limiting food availability needed by microtine, insectivores, and other rodents, it is not within the realm of this study to answer. What can be answered, however, is that habitat structure throughout all areas is comparable to that which would be expected of areas treated in such manners, concluding that the Missouri Department of Conservations practices are successful in terms of creating the prescribed habitats. Nonetheless, this study seems to have brought up more questions that it has answered, resulting in inconclusive findings, though not insignificant ones. Repeated measures of habitat structure, and more importantly, small mammal communities is needed to more thoroughly answer questions pertaining to any positive or negative effects of forest management on the area.

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Species	**Undisturbed (28)**	**Clear-cut (42)**	**Timber Harvest (62)**	**TSI (69)**	Total
P. leucopus	5	14	9	10	38
Blarina (sp)	0	0	0	3	3
Microtus (sp)	0	0	1	0	1
Total 5	14	10	13	42	
Simpson's Index	0	0	0.2	0.38	0.18

Table 1: Capture totals for all small-mammal trapping.

Cover Type	**Undisturbed (28)**	**Clear-cut (42)**	**Timber Harvest (62)**	**TSI (69)**
Canopy	82.26	4.2	38.34	92.44
Sub-Canopy	57.42	22.98	28.5	77.86
HGC	10.06	24.3	8.08	2.46
WGC	9.84	55.5	46.56	10.62
LL 28.22	6.56	34.6	65.98	
DWD	0.9	11.8	10.66	0
Mix 50.68	0	0	19.1	
Bare 0.3	1.84	0.1	1.84	

Table 2: Percent Coverage totals for habitat survey

Habitat	HGC Height Mean	HGC Std. Deviation	WGC Height Mean	WGC Std. Deviation
28	81.18	24.08	74.6	32.9
42	99.2	17.51	40.3	52.7
62	80.54	12.02	81.74	5.9
69	64.13	26.26	80.88	22.54

Table 3: Summary of Herbaceous and Woody Cover Height

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