EFFECTS OF A SMALL-SCALE CLEARCUT ON TERRESTRIAL VERTEBRATE POPULATIONS IN THE MARYVILLE COLLEGE WOODS, MARYVILLE, TN

A Report of a Senior Study

by

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Fall, 2011

Date Approved ______________________, by ______________________

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Editor

Abstract

Ecosystems naturally change over time along with the abundance and diversity of species living within them. Disturbances of ecosystems can be natural large-scale, natural small-scale, anthropogenic large-scale, and anthropogenic small-scale. While natural disturbances and large-scale anthropogenic disturbances have been studied extensively, there is a paucity of research on the effects of small-scale anthropogenic disturbances. The purpose of this study was to determine the effects of a small-scale clearcut on terrestrial vertebrate populations. Amphibian, reptile, bird, and mammal surveys were conducted before and after clearcut of a 0.5 acre plot, and a reference plot was also surveyed. Shannon's diversity index showed that overall species richness and diversity significantly decreased in the experimental plot. Amphibians and reptiles were found to be close to non-existent on the study plots. Bird and mammal species most affected were those that were already rare in the plot to begin with or those that are dependent on the habitat that was lost. Therefore, this senior study is an excellent baseline data set to conduct future faunal comparisons in the Maryville College Orchard.

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Acknowledgements

First of all I would like to thank Andy McCall and the Physical Plant staff for helping me tackle this project, like driving my equipment and me back to the study plots when needed. It was greatly appreciated. I would also like to thank my family and friends for the support and encouragement throughout the study. I want to thank Dr. Bay and Dr. Ennen for helping me determine what statistical analyses were needed. Last but certainly not least, I want to thank my thesis advisor Dr. Crain for taking me and this senior project on even though his specialty is animal physiology. It turned out quite well.

CHAPTER I

INTRODUCTION

Ecosystems and the communities within are naturally dynamic with densities and relative abundance changing over time (Sousa 1984). Community dynamics are commonly seen through succession, which is defined as a change in species composition in a community over time. Succession involves the colonization and extinction of species in a community after its perturbation due to abiotic and biotic agents (Cain et al. 2008). For example, succession is illustrated in the reestablishment of seedlings after a wildfire or the colonization of species after a volcanic eruption.

The dynamics of change within an ecosystem is determined by the presence or absence of species. Populations of species in a community can be measured by relative abundance, richness, and diversity. Relative abundance of a species measures the abundance of a species in comparison to the other species present in the community, species richness is simply the number of species within a community, and species diversity combines both richness and abundance compared with one another (Cain et al. 2008). These three measurements are used to characterize the structure of a biotic community, ergo they are indicators of change as well.

Sometimes abundance, richness, and diversity are altered abruptly by a disturbance that could be natural or anthropogenic. These natural or anthropogenic disturbances can be large or small in nature. The effects of each type of disturbance ranges from slight to devastating decreases in populations of species. Different types of disturbance are listed with examples of their effects in Table 1.

Table 1: Disturbance types and examples of their effects on populations

			References
Natural Disturbance	Large-scale	Hurricanes	(Waide 1991)
		Wildfire	(Esque et al. 2003)
		Earthquakes	(Losey 2005)
	Small-scale	Tornadoes	(Peterson 2000)
		Drought	(Gould, Sussman and Sauther 1999)
Anthropogenic Disturbance	Large-scale	Climate Change	(Thompson and Ollason 2001)
		Deforestation	(Zipperer, Burgess and Nyland 1990)
	Small-scale	Species Introduction	(Enge et al. 2004)
		Habitat Fragmentation	(Debinski and Holt 2000)
		Clear-cutting	(Petranka, Eldridge and Haley 1993)

Effects of disturbance on terrestrial vertebrates

Natural, large scale

Disturbances are natural occurrences in ecosystems. Such perturbations can have large-scale, long-lasting effects on the environment and the terrestrial fauna living there. Hurricanes are one large-scale natural perturbation on the eastern and southern coastlines of the United States. Devastating large tracts of land, hurricanes kill massive quantities of fauna and flora. This can redirect successional movement, increase species turnover, and alter species regeneration (Dale et al. 2001). Hurricanes also bombard barrier islands and the coastal plain causing erosion, scouring, and sediment and wrack deposition (McFalls et al. 2010). There was a large absence of terrestrial vertebrates following hurricane Hugo at North Inlet, South Carolina in 1989. Birds were the first vertebrates to return shortly after the hurricane, and a small abundance of amphibians and reptiles returned after six months (Gardner et al. 1992).

Wildfire is another natural, large-scale disturbance impacting vertebrate communities. Like hurricanes, wildfire affects terrestrial vertebrates indirectly by killing trees and producing harmful smoke (Dale et al. 2001). Direct impact was observed in a burned site in Pennsylvania, when small mammals were found to be significantly less abundant in the burned areas. On the contrary, there was a higher abundance of amphibians at the burned site (Kirkland et al. 1996). Indeed certain species of plants and trees need periodic burns to regenerate (Frissell 1973). An alteration in plant composition is likely to result in a change in species composition.

Earthquakes are natural disturbances that have a limited immediate impact on ecosystems. Earthquakes may cause widespread damage, but they are low-intensity. A study from an earthquake in New Zealand revealed that there was 100 percent tree mortality occurring on only 7 percent of the 20x 20m plots studied, suggesting that the direct effects of earthquakes are not as severe as the indirect effects. For example, about 74 percent of the tree mortalities in New Zealand were from earthquake-induced landslides (Allen et al. 1999). The more severe effects of earthquakes are due to the tsunamis they can produce. The 2004 tsunami that hit the South Pacific left a 0.5m layer of sand in the inundation zone, which buried former soil. It is believed it will remain in the geological record. Also the inland waters were salinated and deposited with bioavailable heavy metals and arsenic (Szczucinski et al. 2006). Tsunamis have an immediate effect on terrestrial vertebrates and then a lasting impact with all the deposits it brings with it.

Natural, small scale

On a smaller scale, tornadoes are another natural disturbance to the environment. Although the average size of a tornado is 500km compared to the average 1000km hurricane, tornadoes make up for it with wind speeds up to 400kph. Tornadoes are more violent compared to hurricanes, but do not cover as much area merely due to size. Unlike hurricanes, tornado funnel clouds are not always touching the ground, so their paths of destruction are usually patchy. Nevertheless, tornadoes have the power to uproot trees and completely alter an ecosystem (Foster et al. 1998).

Drought is another small scale, natural disturbance that is seen in most forest ecosystems. An ecosystem responds to drought by reducing productivity and water usage. In extreme drought conditions, species may even die (Dale et al. 2001). Species that are well adapted to wet conditions, have lower reproductive rates, and/or have limited mobility are more susceptible to drought. During the drought of 1991 and 1992 in Beza-Mahafaly Special Reserve, of southwestern Madagascar, ring-tailed lemur infant mortality reached 80% and female mortality reached 20.8% (Gould, Sussman and Sauther 1999). Thus, drought decreases species abundance and an ecosystem's biodiversity (Archaux and Wolters 2006).

Anthropogenic, large scale

As illustrated in the aforementioned natural disasters, change is a natural occurring phenomenon within animal communities. Anthropogenic disturbances are considered unnatural and negative towards the environment not because they are anthropogenic, but because of the immensity and frequency of their occurrences. Humans expedite change, as illustrated by accelerated climate change. Climate change affects temperature and precipitation. Through wide-scale release of sulfur dioxide, carbon dioxide, methane, nitrous oxide, and other greenhouse gases, humans have accelerated on the natural rate of climate change, and in doing so, have increased and magnified natural disturbances such as hurricanes, fires, storms, landslides, and ice-storms (Dale et al. 2001). The impacts of a change in temperature are just now being observed and are mostly seen in Arctic species. Caribou and polar bear numbers are in decline due to habitat changes resulting from changes in temperature. Seabirds and long-range migrants are also being affected by the temperature changes, which are altering wintering grounds (Lebreton 2011). This accelerated climate change is also increasing the frequency and intensity of drought. In turn, accelerated climate change therefore increases the frequency and intensity of the effects of drought such as decreased productivity within an ecosystem, decreased water usage, decrease in species abundance and diversity (Archaux and Wolters 2006).

Another damaging anthropogenic disturbance is deforestation. As the human population grows and with it the demand for more space and resources, the acreage of forest decreases. Deforestation in the area now composed by the Great Smoky Mountains National Park experienced tremendous population shifts. For instance, white-tailed deer were plentiful in the area in the early 1800s (Dunn 1988), but deforestation resulting from near exclusive use of wood as a fuel and building material lead to near extirpation of deer by the early 1900s (Linzey 2008). By the mid 1950s, preservation of large tracts of land (GSMNP) and wildlife management programs allowed white-tail deer populations to increase, despite the Park Services pessimism (Linzey 2008). Today, deforestation is eradicating species, replacing them with crops and cattle or for development. The prime example for large, scale clearing today is Brazil, with 837,000 km^2 of forest being cleared by 2001. Brazil averaged 18,100 km^2 of deforestation (Malhi et al. 2008). By 2008 the global deforestation rate reached 18 million ha/year (Chazdon et al. 2008).

Anthropogenic, small scale

One example of a small-scale, anthropogenic disturbance is species introduction. Introduced species alter native species composition and affect native communities through competition, predation, gene pool, and transmission of pathogens (Dale et al. 2001). For example, the brown treesnake (*Boiga irregularis*), introduced to the island of Guam around 1950, drove many small vertebrates into extinction. Vertebrates such as bats, birds, and some reptiles were driven to extinction in most forested areas of the island (Fritts and Rodda 1998). The introduction of mammals into New Zealand had detrimental affects on endemic shorebirds. Rats and feral cats have driven several species to extinction on the main island and driven three of the six extant into threatened status (Dowding and Murphy 2001).

Habitat fragmentation due to urban development is a relatively small scale, anthropogenic disturbance (although regional fragmentation grids can be on a large scale). By definition, habitat fragmentation is the "breaking up of a once continuous habitat into a complex matrix of habitat patches" (Cain et al. 2008). Although habitat fragmentation can occur naturally through wildfire and windfall, its frequency has increased dramatically through intense anthropogenic development and is now commonly assigned a human disturbance (Andrén 1994).

Fragmentation affects the biodiversity of habitats, sometimes causing a species to go locally extinct if resources such as food, shelter, or nesting sites become scarce due to the disturbance (Cain et al. 2008). Species that are sensitive to fragmentation are ecologically specialized. These species are highly adapted to their environment and alterations to that environment can result in extinction (Henle et al. 2004). Examples of fragmentation-sensitive species are the woodland amphibians of southern Connecticut. Woodland frog and spotted salamander populations went locally extinct in patches with less than 30 percent forest cover, and red-spotted newt populations failed to persist in patches with less than 50 percent (Gibbs 1998). However, some species may flourish due to the new structure of the habitat. For example, the brown-headed cowbird (*Molothrus ater*) thrives off of the edge effect that fragmentation causes. An edge in ecology is classified as a boundary that separates two dissimilar patches of habitat (Cain et al. 2008). Brown-headed cowbirds in Boulder County, CO were found to be in abundance near urban/woodland interfaces (edges) and that abundance decreased further into the woodland (Chace et al. 2003).

Habitat fragmentation often results from clear-cutting, a technique used by the logging companies since the 1800s (Linzey 2008). Today clear-cuts are mostly used by forestry agencies for wood production or for urban development such as roads (Keenan 1993). As afore mentioned, fragmentation and the resulting edges have a negative influence on forested species such as the ovenbird, which has experienced a lower reproductive success rate around small clear-cut areas in New Hampshire (King 1996).

Clear-cutting, aside from the indirect effects of fragmentation, also has direct affects on terrestrial vertebrate populations. Removal of trees changes the temperature of the area and the composition of leaf litter/organic layer. The removal of canopy cover and the reduction in leaf litter can negatively affect certain species. For example, the abundance of salamanders of the genus *Plethodon* and the genus *Desmognathus* were found to be significantly lower in sample clear-cut plots in the Southern Appalachia Mountains (Knapp 2003). Small mammals such as deer mice, voles, and shrews are absent right after clear-cutting and have low densities during early succession. Partially harvested areas seem to contain similar abundance numbers of a mature forest. It could then be speculated that the predators that prey on mice, voles, and shrews would follow the same pattern (Fuller, Harrison and Lachowski 2004).

Faunal Surveys

The effects of disturbances cannot be determined without knowing relative abundance, species richness, and diversity before the disturbance. These population measurements recorded before the disturbance can then be compared to the population measurements after disturbance, thus assessing the effects of the disturbance.

Surveying is the most common method for determining relative abundance, species richness, and species diversity. These surveys can monitor changes in biodiversity and ecosystems, assess potential impacts on the environment, and better understand ecosystem function (Wessels et al. 1998). Successful wildlife management depends on quality data collected from faunal surveys. For example, wildlife managers of the Great Smoky Mountains National Park measure black bear populations using bait station surveys, and black bear management plans are based on the data from these surveys (Clark et al. 2005). Faunal surveys also aid in the prevention of species extinction by providing timely population counts. For instance, Australia established 15 dugong protection areas in the Great Barrier Reef as a result of aerial surveys that indicated a decrease in numbers between 1962 and 1999 (Marsh et al. 2005). The conservation of this species began with determining where dugong habitats were located.

There are many types of terrestrial vertebrate surveys, each designed to specifically identify certain species. Mammal, bird, reptile, and amphibian surveys all utilize different methodologies. Strategically placed live traps are used to catch and assess mammal populations ranging from small rodents to raccoons. Larger mammal populations are either just observed or determined by methods such as bait stations (Clark et al. 2006). Aerial surveys are not only used to measure marine mammal populations, but terrestrial vertebrates such as African ungulates (Jolly 1969) and white tailed deer as well (Rice and Harder 1977).

Point count methods are the most common surveys used to measure bird populations. In these surveys, points are established along transects across the study area. At these points an observer identifies birds by physically spotting them and by listening to their calls and songs. The number of points, the time spent at each point, and the distances between them vary depending on the size of the study area (Hamel et al. 1996). There are some species of birds that are not very vocal and/or very cryptic, and thus are rarely seen. Some researchers, therefore, prefer to catch birds in mist nets. These are fine mesh nets standing from the ground about 2 to 3 meters. This allows researcher's to positively identify birds and even band them for recapture rates. Bird banding and mist netting are a good tool for measuring year to year abundance, especially in migrating passerines (Remsen and Good 1996).

There are several standardized methods for surveying reptiles and amphibians. Funnel and pitfall traps along a drift fence are ideal for trapping skinks, lizards, snakes, frogs, and some salamanders (Bury and Corn 1987). Cover-boards such as sheets of tin are used to attract snakes and other small reptiles. These tin sites are usually set weeks in advance to allow time for reptiles to discover it (Fitch 1992). Some reptiles and amphibians cannot be trapped due to small habitat range and movement. Therefore foraging and actively searching for them is an effective method (Corn and Bury 1990).

Purpose

The purpose of this study is to examine the effects of small-scale disturbance on terrestrial vertebrate abundance and territoriality. While numerous studies show clear influence of large-scale disturbances on vertebrate populations, data on the effects of small-scale disturbances are scarce. This study examines the effect of a small-scale clearcut on amphibian, reptile, bird, and mammal populations.

CHAPTER II

MATERIALS AND METHODS

Study Sites

Maryville College in Maryville, TN consists of 320 acres with 118 of those acres included in a Stewardship Forest. The northeastern portion of the Maryville college woods was once kept as hay field until 1992 when the college stopped mowing (Andy McCall, pers.com.). Thus, the northeastern portion of the woods consisted of late, twenty-year-old field succession with a few small trees. Two small plots within this area were to be clear-cut by the college to establish orchard plots (see Gibson Fund Proposal in Appendix 1), and this study examines vertebrate fauna on these plots before and after clearing. The reference plot and experimental plot consisted of 0.5582 and 0.6422 acre respectively with the center of the reference plot at N 35^{0} 45.176’ and W0 83^{0} 57.303’ and the center of the experimental plot at N 35^{0} 45.105’ and W0 83^{0} 57.355’. Both plots exhibited late field succession characteristics having mostly brush and brambles with few small to medium trees.


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E
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Pavilion

Figure 1: Aerial photo, pre-disturbance, of northeastern portion of Stewardship Forest (a), reference plot (b), and experimental plot (c).

Surveys

This study consisted of two surveys: a pre-disturbance survey and a post-disturbance survey. The pre-disturbance survey was from 7 May 2011 to 4 June 2011 and the post-disturbance survey was from 9 July 2011 to 6 August 2011. Prior to the post survey on June 8, the experimental plot was cleared to the ground, while the reference plot was left untouched to act as a control/reference. Surveys were conducted twice a day everyday during the survey periods, one in the morning beginning at 8 a.m. and one in the evening starting at 7 p.m. Prior to each survey, temperature and weather conditions were recorded. On days with inclement weather such as heavy rain and thunderstorms, mammal traps and funnel traps were checked, but bird observations were not conducted.

For each plot, surveys for amphibians, reptiles, birds, and mammals were conducted along a gradsect. Gradsects are imaginary lines that transect a sampling area based on an environmental gradient (Gillison 1983). Environmental gradients include changes in soil type, elevation, temperature, rainfall, etc. Gradsects were used in this study instead of much simpler linear transects because studies have shown that sampling around gradsects, environmental gradients, produces higher number of species and therefore a more accurate sample (e.g., Wessels et al. 1998).

Reptile and Amphibian surveys

Reptiles and amphibians were surveyed using several methods. Snakes and amphibians were surveyed using tin sites. Each tin site contained 5 pieces of 3x 4 ft of tin, and placed on the southeastern sides of the two plots for optimal sun exposure. The pieces were placed in a row curving along the gradsect. These sites were checked everyday during the evening surveys. A silt drift fence 12 feet in length was placed on the northwestern side of each plot. The drift fences curved along the gradsect with a mesh funnel trap on both sides of the fence. The funnel traps were kept flush to the ground using 3 inch nails on the corners. These funnel traps were used in hopes of catching lizards, ground skinks, and small snakes. Although visual surveys for reptiles and amphibians were not conducted, any that were encountered were caught and recorded.

Bird surveys

Bird sampling was performed by using a modified version of Hamel's point count method (Hamel et al. 1996). Three observation points were established evenly around the gradsect for each plot. Observation time at each point was for five minutes with about a one-minute travel time between points. Upon arriving at each point, observation was delayed one minute to allow birds to resume normal activity after observer intrusion. Birds were identified by sight and song/call, and if a bird was not identifiable by sight or sound, it was not recorded. Observations were recorded on Hamel's 360^0 bulls-eye data sheet. (See Appendix 3) The first circle was marked as 25 m and the second 50 m due to the small areas of the two sample plots. A compass was used to determine the orientation of the bulls-eye data sheet. On the sheet, zero was set as North. Birds whether identified by sight or sound were recorded as such and at their estimated position on the bulls-eye.

Mammal surveys

Mammals were sampled by live cage trapping and observation. Each plot contained 3 medium and 4 small Havahart traps placed evenly along the gradsect. Small traps were baited with a 1 centimeter cube of processed cheese coated in peanut butter, and the medium traps were baited with a 2 centimeter cube of processed cheese coated in peanut butter. The traps were strategically placed in grasses and brush so mammals would not overheat and to also conceal the traps from the public. Before releasing captured medium-sized mammals such as opossums and raccoons, pictures of faces, ears, and tails were taken in order to help distinguish between individuals for abundance measurements. Mice were marked on their light underside with a black sharpie during the pre-disturbance survey to establish a recapture rate, but the sharpie did not last the entire 4 weeks. During the post-survey, the mice were shaved on the rump, just above the base of the tail for identification. Shaving lasted the entire length of the post-survey. Any mammals observed while out conducting surveys at the plots were recorded as well.

Statistical Analysis

Overall species diversity was measured using Shannon's diversity index and Pielou's species evenness. Shannon's index was calculated by plugging in equation 1 into excel:

$$H' = -\sum_{i=1}^{S}(p_i \ln p_i) - [(S-1)/2N] \qquad \text{Equation 1}$$

Where H' is the diversity index, *S* is the number of species, *N* is total number of individuals, n_i is the number of individuals in the species, and p_i is the relative abundance of each species, n_i/N (Shannon 1948). Pielou's species evenness was then calculated by plugging in H' into equation 2.

$$J' = \frac{H'}{H'_{\max}} \qquad \text{Equation 2}$$

Where J' is the species evenness measurement and H'_{max} is the maximum diversity index possibly, calculated by equation 3 (Pielou 1966).

$$H_{\max} = -\sum_{i=1}^{S} \frac{1}{S} \ln \frac{1}{S} = \ln S. \qquad \text{Equation 3}$$

A one-tailed t-test was performed on individual species counts to determine if there were significant differences among the species counts between pre- and post-disturbance surveys.

CHAPTER III

RESULTS

Species richness/diversity

The overall survey observed a total of 39 species: 33 bird, 4 mammal, and 2 reptile species. Species richness and diversity is compared between plots and the before and after disturbance surveys in Table 1. Recaptures were very rare: only 1 mouse, 2 raccoons, and 2 opossums were recaptured over the 29-day sampling period. No reptiles were recaptured.

Table 1: Species richness, evenness, and Shannon's Index for both reference and experimental Plots for Pre- and Post-disturbance surveys

		Richness	Evenness	Shannon's Index
Reference Plot	Pre-Disturbance	30	0.86	2.77
	Post-Disturbance	24	0.83	2.64
Experimental Plot	Pre-Disturbance	23	0.75	2.33
	Post-Disturbance	14	0.69	1.82

Amphibians and Reptiles

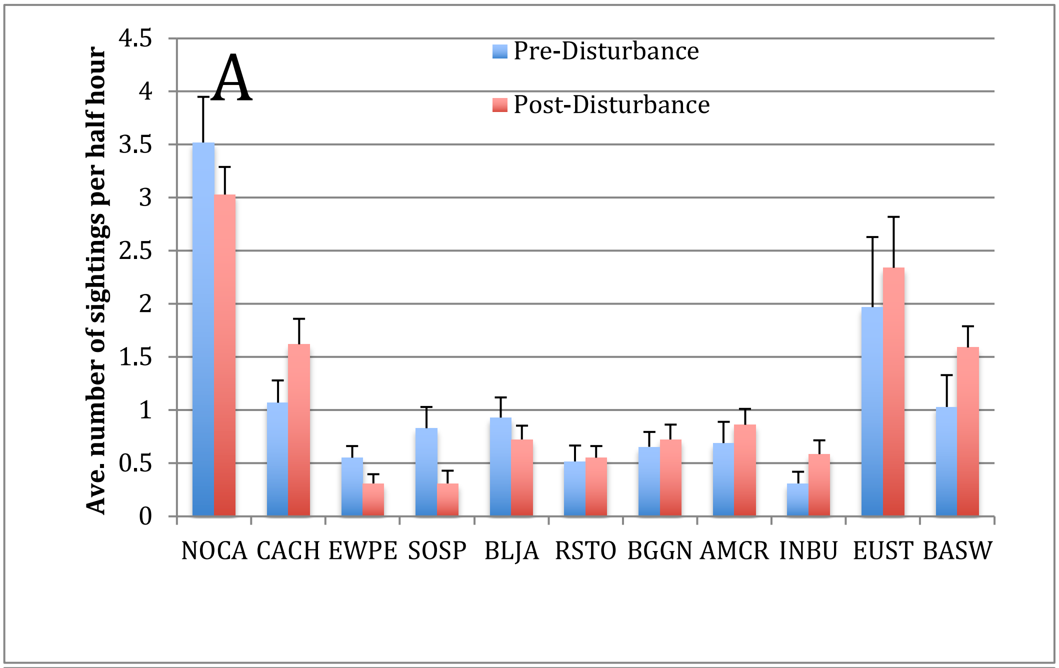
Pantherophis obsoletus was one of two species of reptilia found in this survey. Two *P. obsoletus* were caught along the path in Plot B during the pre-disturbance survey while none were observed during the post-disturbance survey. These two snakes were caught in the early afternoon of two sunny days that did not exceed 75^0F. *Terrapene carolina*, the Eastern Box Turtle, was the only other species of reptilia found. Four individual box turtles (none recaptures) were found during this survey, two of them found traveling through the reference plot during pre-disturbance and the other two traveling through the experimental plot post-disturbance. In the experimental plot, one of the box turtles was caught in one of the large mammal Havahart traps. These turtles were caught on days varying in conditions. Some were caught on sunny days while the others were caught on slightly overcast days. The temperatures ranged from 65^0 -75^0 F. There were no species of amphibia caught or observed in either plot.

Birds

Abundance

33 bird species were recorded, with some species unique to each plot. Species only found in the reference plot were SOSP, EUST, BASW, AMGO, YSFL, BHCO, EAKI, EAPH, BRTH, CONI, GBHE, WEVI, and YBCH, whereas species only found in experimental plot were MODO, CAWR, HAWO, DOWO, AMRO, GCFL.

The Northern Cardinal was the most abundant species for both plots and remained fairly the same post-disturbance. The experimental plot had 9 species that were not seen after disturbance (see Figure 3, A and B).



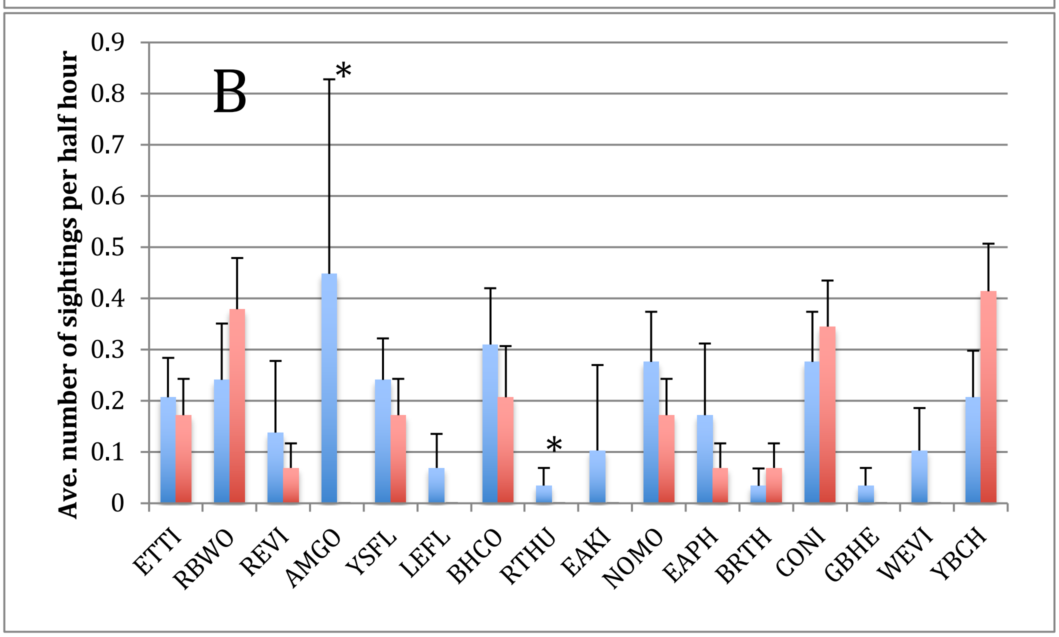


Figure 2: The average number (+1 SE) of sightings per observation half hour for abundant and common birds in the reference Plot during the Pre- and Post-Disturbance Surveys (a). The average number of sightings per observation half hour for fairly common and rare birds in the reference Plot during the Pre- and Post-Disturbance Surveys (b). (* indicates significant difference for $p<0.05$)

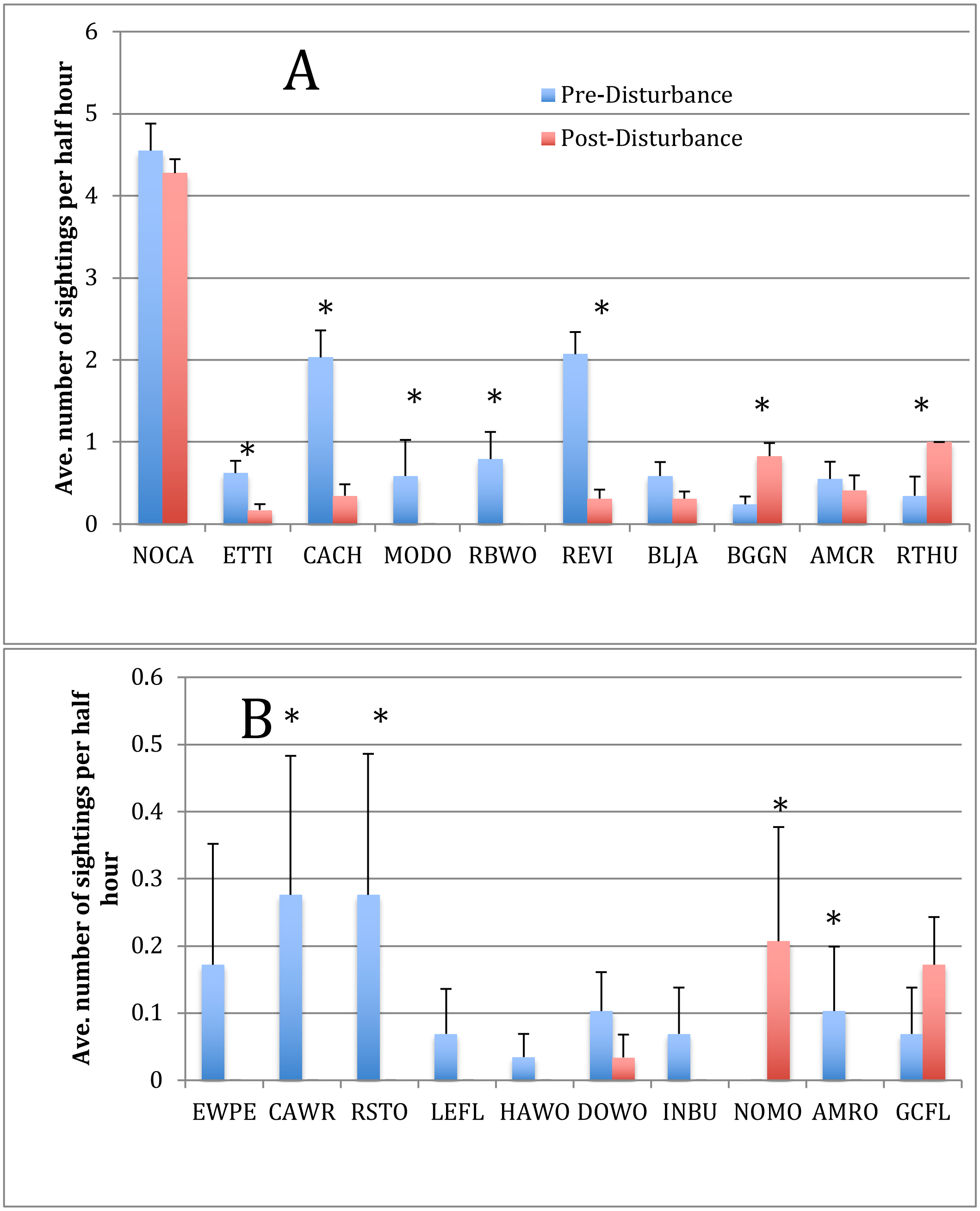


Figure 3: The average number (+1 SE) of sightings per observation half hour for abundant and common birds in the experimental Plot during the Pre- and Post-Disturbance Surveys (a). The average number of sightings per observation half hour for fairly common and rare birds in the experimental Plot during the Pre- and Post-Disturbance Surveys (b). (* indicates significant difference for p<0.05)

NOCA Pre-Disturbance REVI Pre-Disturbance INBU Pre-Disturbance

NOCA Post-Disturbance INBU Post-Disturbance REVI Post-Disturbance

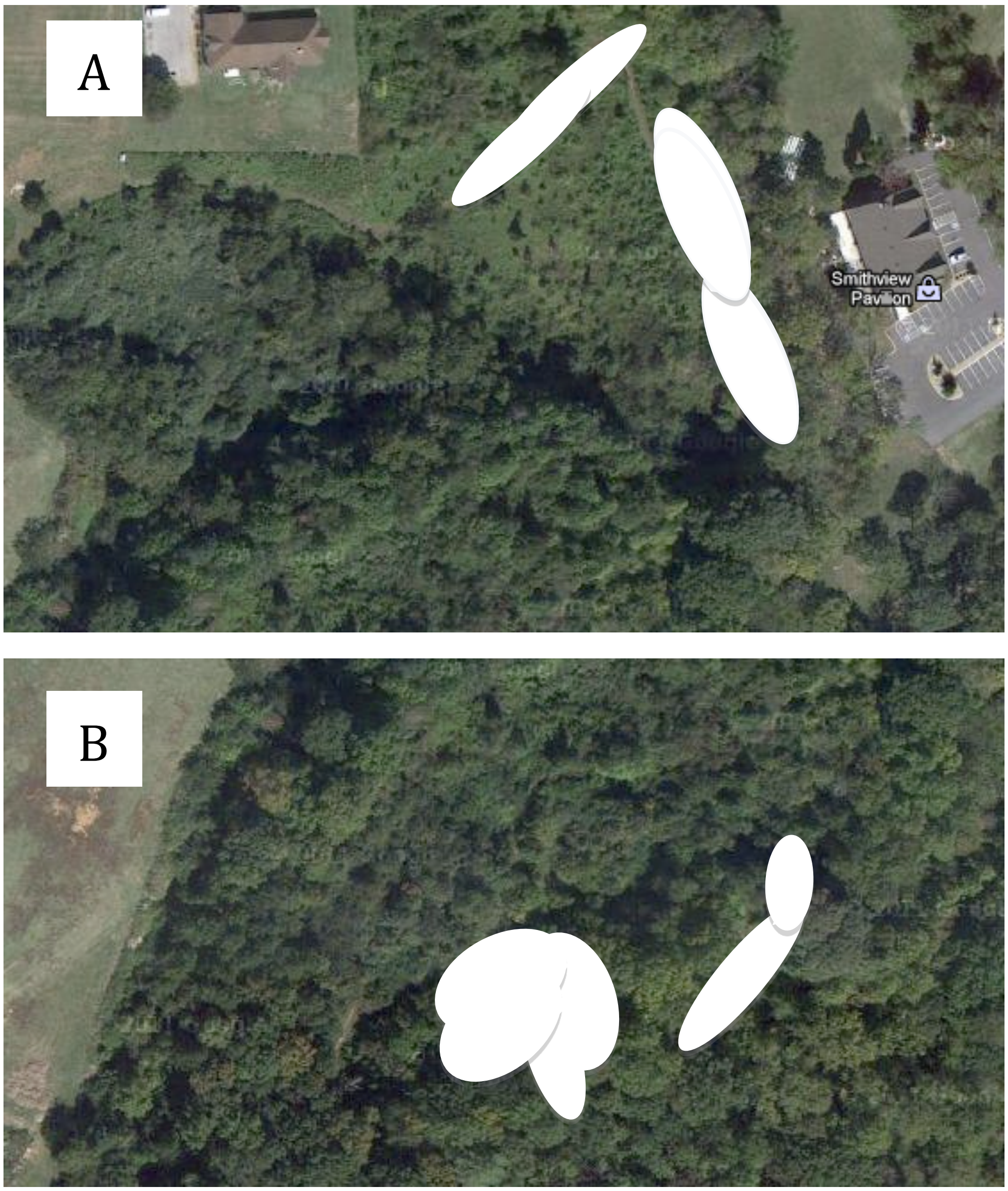


Figure 4: Comparison of pre- and post-disturbance territory areas of NOCA and INBU for the reference plot (a). Comparison of pre- and post-disturbance territory areas of NOCA and REVI for the experimental plot (b).

Mammals

Mammalian species observed were the white-footed mouse (*Peromyscus leucopus)*, Eastern raccoon (*Procyon lotor lotor*), Virginia opossum (*Didelphis virginiana*), Eastern cottontail (*Sylvilagus floridanus*), and Eastern shrew (*Blarina carolinensis*) (see Table 2). Raccoons, opossums, and cottontails were captured in the large Havahart traps, whearas white-footed mice were caught in the small Havahart traps. Eastern shrews were found under tin sites.

Table 2: Average number (+1 SE) of species caught per week in reference and experimental plots during the Pre- and Post-Disturbance Surveys. (* indicates significant difference p-value <0.05)

	Species	Pre-disturbance	SE	Post-disturbance	SE	P-value
Reference Plot	*Peromyscus leucopus*	8.96	0.23	13.034	0.14	0.035*
	Procyon lotor lotor	0.238	0.034	1.204	0.071	0.09
	Didelphis virginiana	0	0	0.483	0.033	0.08
	Sylvilagus floridanus	0.2415	0.0345	0	0	0.161
Experimental Plot	*Peromyscus leucopus*	7.7	0.2	2.17	0.087	0.001*
	Procyon lotor lotor	0.238	0.034	0.238	0.034	1
	Didelphis virginiana	0.966	0.065	1.932	0.084	0.202
	Blarina carolinensis	0.238	0.017	0	0	0.16

CHAPTER IV

Discussion

Small-scale (0.5 acre) clearcutting did affect populations of the experimental plot. A significant decrease in species abundance and diversity was seen after post-disturbance in the experimental Plot. Species richness dropped from 23 to 14 in the experimental plot, and Shannon's Index of diversity dropped from 2.33 to 1.82, indicating a significant decrease in the diversity of species post-disturbance. The experimental Plot also showed a drop in the evenness of species, which means the proportion of species relative to one another became more uneven. This may indicate that certain species either increased or decreased to create this unevenness and in this case after examining the counts, it is the latter. It is clear that the experimental plot was greatly affected by the clearcut when compared to the reference plot, which exhibited relatively no change between surveys.

Reptiles

Statistical analysis was not performed on the reptile data since only two species were observed and their abundance so scarce. Since reptiles seemed virtually absent from these study sites, the effects of small-scale clearcuts was therefore inconclusive for this taxa.

Birds

Bird species (except for the white-footed mouse) were affected most by the clearcut. Out of the 20 species of birds observed at the experimental plot, 11 showed a significant difference in abundance from pre- to post-disturbance. The reference plot only exhibited two species with significant differences between pre- and post-surveys. Overall, it is evident that the clearcut indeed affected bird species in the experimental plot.

As expected, most of the bird species showed a decrease in abundance. Species such as the Eastern Tufted titmouse, Rufous-sided towhee, Carolina wren, and Carolina chickadee exhibited a significant decrease post-disturbance. These species prefer scrubland/overgrown farmland as their habitats where they feed mostly on insects (Elphick et al. 2001). The experimental plot, being an overgrown field that had not been mowed for about 20 years, was prime habitat for these species pre-disturbance. After the clearcut, nothing was left but an abrupt edge that went from freshly cut field straight to mature forest. It makes sense that these species would decline with the absence of their resources.

Red-bellied woodpeckers and red-eyed vireos declined significantly, which was slightly unexpected because they were found to be along the edge of the study site where clearance did not occur. It is possible that the noise of the clearcut caused emigration and they did not return during the 4 weeks that I observed. Yahner showed that while some bird species are unaffected by clearcutting, the red-eyed vireo was more sensitive to the disturbance (1993). The decline may be a result of sampling method, as these two species were identified mostly by song. The post survey was performed from mid-July to early August, meaning they may have stopped singing and calling by then, thus giving the impression of a population decline.

Blue-gray gnatcatcher and ruby-throated hummingbird abundance actually increased post disturbance. The RTHU increase is easily explained because 1 male hummingbird was always seen perched in a tree. He was easily seen more often during the post survey because of the clearance of foliage. The blue-gray gnatcatchers were seen more for the same reason as well. Both were inhabiting the edge and covered by experimental plot foliage.

The Northern Cardinal was relatively unaffected by the clearcut. Sightings stayed above 4 per half hour before and after. The cardinals were mostly seen around the edge of the plot, but were also commonly seen just inside of the plot area. It might have been expected that this species would not be affected due to its generalized diet and habitat along the edge (Elphick 2001). Also, the NOCA was the most abundant species observed in both plots during both surveys. It is curious that the species most affected by the clearcut were observed 2 times or less per half hour. Granted, the NOCA was the only species with abundance higher than 2 sightings per half hour.

While abundance was clearly affected by clearcutting, territoriality was not as affected. NOCA and INBU territories showed a slight shift in the reference plot, which was probably just due to seasonality changes. NOCA and REVI territories shifted a little more than the species of the reference plot. The NOCA and REVI territories shifted with the edge. Their territories were on the former edge during the pre-survey and then shifted back to the current edge after the clearcut. It is sensible that a species' territory will shift to preferred habitat, which in this case was edge. This data further supports previous research on successional edge species being denser on edges than forest interior and showing maximum density along clearcut edges (Strelke and Dickson 1980).

Mammals

Mammal populations were unaffected by the clearcut except for the white-footed mouse population, which was greatly reduced almost to zero in the experimental plot. This is a very significant decrease, especially since the reference plot had a significant increase. This increase was more than likely due to the fact that the mice had to find the baited traps during the pre-survey and not during the post-survey since the traps were never removed and remained in the same locations. The significant decrease of the mouse population in the experimental plot supports Anderson's findings that *P. leucopus* prefers habitat with dense vegetation and cover. Edge or interior had no affect as long as the habitat was dense with vegetation (Anderson et al. 2003). With the loss of the heavy scrub and bush vegetation, the white-footed mouse species lost food, shelter, and cover from predation.

Raccoons and opossums did not seem affected by the disturbance. There were no significant changes in abundance from pre- to post-disturbance, although numbers were not that large to begin with. However, raccoons do show a preference for edge habitat, while opossums show no consistent discretion for either edge or interior habitat (Dijak and Thompson 2000). This helps explain why populations of raccoons and opossums went unaffected in the experimental plot. Raccoons still had an edge although its location was changed, and opossums show no preference.

Conclusions

Small-scale clearcuts do affect vertebrate populations, but it seems to mostly affect species whose abundance is relatively scarce to begin with. Bird species that were significantly decreased were sighted 2 times or less per half hour pre-disturbance. The Northern Cardinal, which was the only bird species clearly unaffected by the disturbance, was sighted 4+ per half hour during the pre-survey. However, further studies need to be conducted on small-scale clearcutting affects on birds because Derleth and Alum (1989) found that species actually increased after disturbance and edge creation. Land type needs to be taken into consideration before comparing abundance affects. Derleth's plots were hardwood and coniferous forests in Maine with some mixed growth, while this study's plots were 20 year old overgrown fields. Consistent land types must be studied to establish accurate abundance and diversity measurements.

Small-scale clearcuts also affect species that depend on the brushy, shrub-like habitats such as the white-footed mouse and the ETTI, CACH, CAWR, and RSTO bird species. All these species went extinct in the experimental plot or came very close to it. These bird species were already low in abundance so it is hard to tell if their numbers decreased due to habitat loss or low abundance. The white-footed mouse, however, was very abundant pre-disturbance and nearly went extinct post-disturbance due to habitat loss. This is a distressing issue since habitat loss effects far outweigh the effects of other habitat disturbances such as fragmentation (Fahrig 1997). Species that are displaced from their habitat must find a new habitat, which means either displacing others or competing with others in a new habitat.

Further studies should be conducted on the effects of small-scale clearcutting as well as other small-scale disturbances because they are few to non-existent and do have an affect on species. Effects of disturbance also need to be comprehensively studied and monitored (Brawn et al. 2001). This study as well as others cited in this paper analyzed the immediate effects of disturbance. The abundance and diversity of species will change as the disturbed plot continues to change. Therefore, this senior study is an excellent baseline data set that can be further utilized and compared to as the experimental plot becomes an orchard. Comprehensive monitoring will show what species the orchard brings and/or displaces.

Appendix 1

Gibson Fund: MC Orchard and Berry Plots Proposal

Drew Crain[1], Bruce Guillaume[2], and Andy McCall[3]

February 22, 2011

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Summary

This proposal outlines a joint venture between academic affairs, student development, and physical plant to establish three orchard plots and three berry plots on the Maryville College campus, and one orchard plot at Penrose Farm during the spring of 2012. These replicated plots would be used (1) in Science 150 and possibly other science courses to examine productivity in plots with different soil nutrients and sunlight exposure and (2) by Mountain Challenge to illustrate the benefits of locally-grown, healthy fruits. In addition, members of the Maryville College community would be able to harvest fruits.

Specific Plans:

Three small orchard plots will be planted on the MC campus, and one plot will be established at Penrose Farm (the farm used by the MC Equestrian team). Each plot will be identical and will consist of four apple trees (two trees each of two varieties) and two pear trees (two trees of the same variety). All varieties of fruit trees will be naturally disease resistant. Heirloom varieties of apples will be planted (choices include Freedom, Liberty, and Gold Rush; final decision of the two varieties will be made after consultation with other east Tennessee orchard growers), and pear varieties will be either Potomac or Magness (both European varieties).

Plot locations for the orchard plots will be finalized with Physical Plant upon funding, but current prospective locations of unutilized land on the MC campus include (a) the hill on the MC woods side of the tennis courts, (b) a portion of the Maryville College Garden beside Crawford House, (c) the abandoned hay field next to Brown's Creek, and (d) the late-succession bramble field at the end of the MC woods dirt road. These plots have distinct soil profiles (ranging from creek bottom to amended recreational area), and would provide excellent long-term data collection plots for tree growth and subsequent fruit productivity. The Penrose Farm plot will provide another distinct habitat type, actively used pasture.

Two of the aforementioned prospective apple/pear tree plots will require clearing prior to establishment. A portion of abandoned Brown's Creek hay field will need to be cleared with a bush-hog, disked, and planted in native grasses prior to the planting of apple trees. The late-succession bramble field may need to be cleared with a bulldozer and planted in native grasses prior to planting. Approval of locations for plots and all land-use modifications will be sought from EFAC prior to any work.

In addition to the four distinct orchard plots, three other plots will consist of blackberry and raspberry bushes. These plots will include a single variety of blackberry and raspberry, with each having three plants each (each plot will have 6 plants). The blackberry variety will be Apache, a large and hardy blackberry that can be harvested in mid-summer. The Raspberries will be Autumn Bliss, which have berries in the early fall, a time when students can both quantify and enjoy the harvest. The berry plots will be placed on the edge of the MC woods or existing fences, in areas currently not utilized for any purpose. Both birds and humans will benefit from the berries, and these berry plots will also serve as aesthetically-pleasing landscaping.

Ongoing care of the orchards will be a joint venture. Pruning and tree/bush monitoring will be overseen by Drew Crain and Bruce Guillaume, both of which will recruit students to assist. A Bonner internship position focusing on "urban and suburban gardening" will also accept responsibilities (overseen by DC and BG)[1]. Physical plant will mow between the apple and pear trees.

Once trees and bushes begin bearing fruit, a committee co-chaired by DC and BG and including an EFAC representative and Mountain Challenge students will make decisions about fruit use and distribution.

Evidence of scholarly or professional promise

For decades, Maryville College has been known for its unique programming in outdoor recreation. Through Mountain Challenge, every MC student has the opportunity to experience outdoor adventures and challenges, and our students are better as a result of this programming. In addition, all students at Maryville College take science courses to illustrate the scientific method. However, in both outdoor recreation activities and the science courses, many students fail to see tangible applications of these activities to their future lives. With the establishment of the MC Orchard and Berry Patches, we seek to expand both our student development and academic programming to include "local agricultural wellness." In doing so, we will expand our professional interests at the same time as benefiting Maryville College students, faculty, and staff.

If funded, this project will directly promote scholarly and professional growth of DC, BG, and AM by providing a link among concern for the environment, effective knowledge and skills relative to fruit production, actual fruit production, and broader individual actions. Simply put, this project will turn intellectual or emotional concerns into constructive and responsible actions, actions that likely will generalize into other areas. In summary, the orchard and berry patches have the promise of producing better citizens, and we look forward to the individual professional growth that will occur from spearheading this endeavor.

This proposal will result in both senior study projects and future publications. The replicated nature of the plots will provide ample opportunity for Biology senior study projects for many years in the future, and after approximately a decade of data collection, we anticipate several publications that will address the effectiveness of the plots in promoting both science education and wellness.

Make an outstanding contribution to Maryville College

Central to effective leadership and good citizenship are two concepts, personal wellness and care for the environment. These concepts are complex and multi-faceted, and this proposal addresses key elements of wellness and the environment.

While wellness is multi-dimensional, good nutrition is at the heart of effective personal wellness efforts. Engaging students in the process of growing and producing some of their own fruit would provide several lifelong lessons about food and health.

One component of environmental stewardship is wise land use decisions. Use of small, existing plots of unused, unutilized land for this project clearly demonstrates good decisions about land use. The plots will be illustrations for students and community members for how fruit trees and berry bushes can be incorporated into domestic landscapes. In addition, the MC campus would continue to be beautified through establishment of aesthetically-pleasing berry hedges and mini-orchards.

[1] Preston Fields is excited about the inclusion of the MC Orchard and Berry Plots in future Bonner Internships.

The recent MC agreement for use of Penrose Farm as an equestrian facility and learning lab provides a unique opportunity to compare fruit productivity in a heavily used pasture. Addition of a small orchard plot to Penrose Farm provides a wonderful educational experience for our students at the same time as providing welcomed links between MC and our community.

Combining smart decisions about where and how to grow and produce some of their own fruit would provide students with invaluable lessons – and some good fruit.

Distinctiveness

This proposal combines the efforts of academic affairs, student development, and physical plant to promote wellness and environmental stewardship through planting and maintaining orchard and berry plots. Such a project is unique, and we are unaware of any such replicated orchard and berry plots at any other academic institutions. Many academic institutions have orchards, but these orchards only serve (1) as an educational component for agriculture students or (2) as a cash-flow stimulus through you-pick fruit sales. The Maryville College orchard and berry plots will be distinct in providing long-term data collection on replicate orchard plots at the same time as promoting wellness.

Currently, Maryville College does little to promote local, healthy food as a component of wellness. Through these new plots, hundreds of MC students each year will be exposed to using environmentally-sound practices to produce a sustainable fruit crop. It is hoped that this will still be true of the plots in the year 2062, fifty years after the plots are established.

Timeline for Use of the Orchard and Berry Plots

If funded, the planning and site preparation for this project will begin during the summer of 2011. Planting of the orchard and berry plots will not occur until February of 2012.

Summer 2011: Site identification, soil analyses, holes dug and prepared.[2]

Early Spring 2012: Planting of fruit trees and berry bushes.

Subsequent Springs: Pruning of apple and pear trees will be incorporated into science laboratories and Mountain Challenge Events.

Summers: Harvest of blackberries by members of the MC community.

Falls (Mid August to mid October): Harvest of apples, pears, and raspberries will occur during the fall. Science students will be challenged to develop a means of quantifying growth and productivity of apple and pear trees, as well as berry bushes.

[2] KT week volunteers will be recruited to assist in this.

Budget

Apple Trees[3]:	$27.95 each x 16 =	$447.20
Pear Trees[3]:	$27.95 each x 8 =	$223.60
Apache Blackberry bushes[4]:	$12.95 each x 9 =	$116.55
Autumn Bliss Raspberries[5]:	$19.95 each x 9=	$179.55
Shipping costs for bushes:		$120.00
Site Preparation:		$500.00
Pruning shears:	$30.00 each x 10 =	$300.00
Soil Analyses and Amendments:		$300.00
	Total:	**$2,186.90**

Long-term Financial Implications

The orchard and berry plots will promote wellness and provide plots for scientific comparisons with nominal long-term financial needs. The plant varieties selected are based on their natural disease resistance (and therefore lack of need for pesticides). Physical Plant already manages the areas where the plots are to be located, so there is no added labor involved in long-term plot maintenance. Pruning and fertilization will be incorporated into Science 150 Laboratories and Mountain Challenge activities, so this will not be a burden on the MC Physical Plant. In addition, a Mountain Challenge student will have the responsibility to monitor and care for the plots.

Presentation of Results to the MC Community

The MC community will receive routine updates on the project. After the orchard and berry plots are established, a presentation will be delivered at an appropriate venue. After Sci150 classes collect several years of data, these data will also be shared with the MC community.

3 http://www.acnursery.com/; shipping cost included
4 http://springhillnursery.com/
5 http://www.baylaurelnursery.com

Appendix 2

A. B. A. Bird Banding Abbreviations

NOCA- Northern Cardinal

CACH- Carolina Chickadee

EWPE- Eastern Wood Peewee

SOSP- Song Sparrow

BLJA- Blue Jay

RSTO- Rufous-sided Towhee

BGGN- Blue-gray Gnatcatcher

AMCR- American Crow

INBU- Indigo Bunting

EUST- European Starling

BASW- Barn Swallow

ETTI- Eastern Tufted Titmouse

RBWO- Red-bellied Woodpecker

REVI- Red-eyed Vireo

AMGO- American Goldfinch

YSFL- Yellow-shafted Flicker

LEFL- Least Flycatcher

BHCO- Brown-headed Cowbird

RTHU- Ruby-throated Hummingbird

EAKI- Eastern Kingbird

NOMO- Northern Mockingbird

EAPH- Eastern Phoebe

BRTH- Brown Thrasher

CONI- Common Nighthawk

GBHE- Great Blue Heron

WEVI- White-eyed Vireo

YBCH- Yellow-breasted Chat

MODO- Mourning Dove

HAWO- Hairy Woodpecker

DOWO- Downy Woodpecker

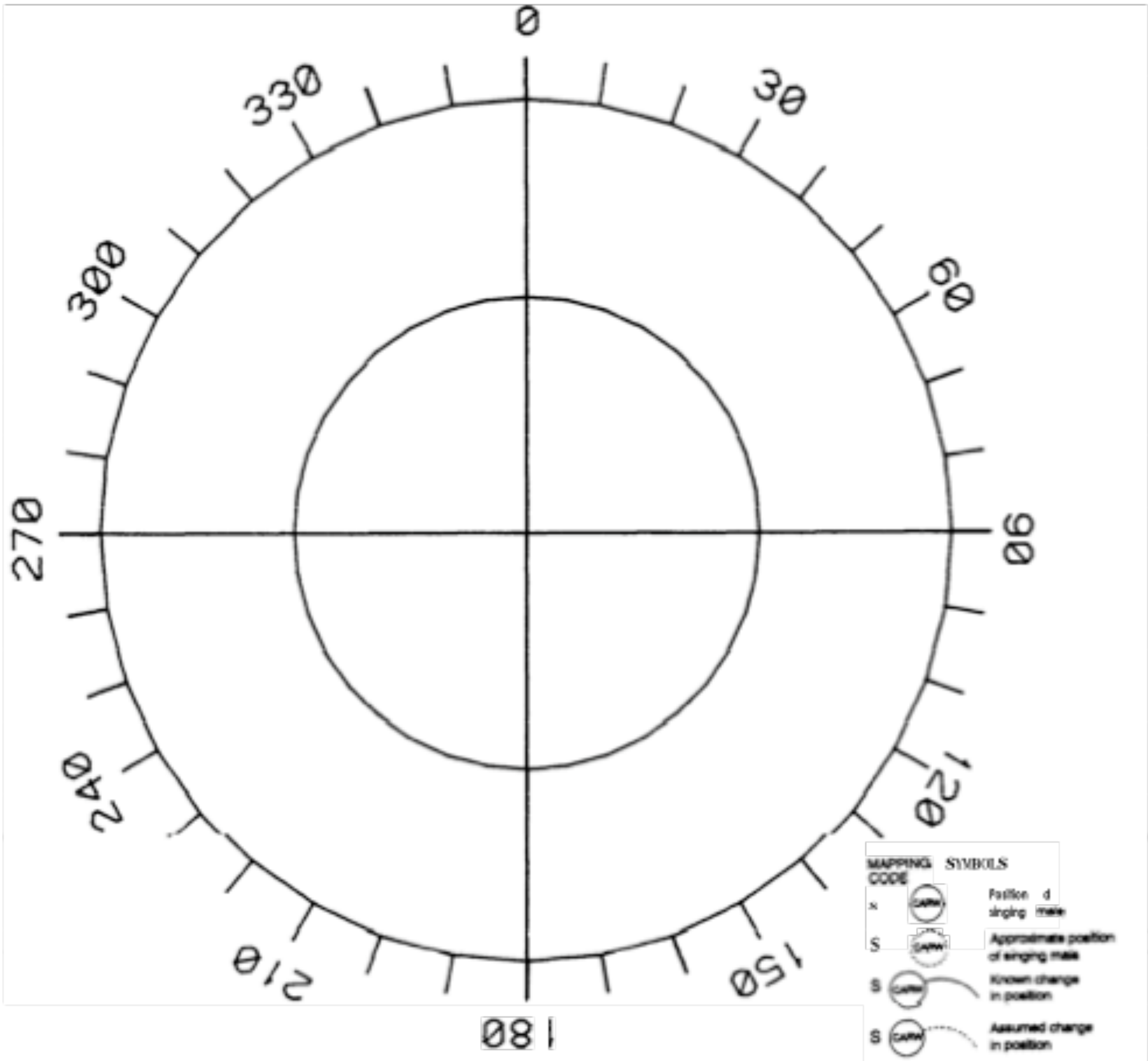
AMRO- American Robin

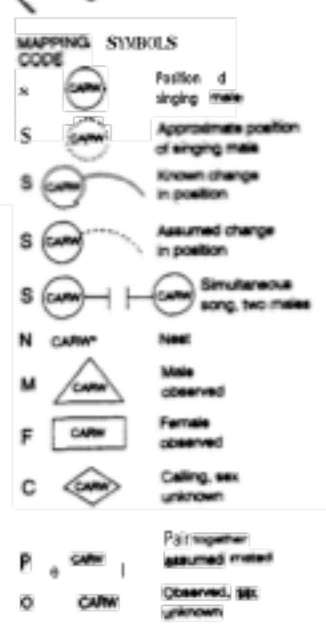
GCFL- Great Crested Flycatcher

Appendix 3

State Virginia station Point # Visit # Year Month Day Time

Observer Temp °C Wind Sky Habitat Forest type Stage Zone N-S coordinates E-W coordinates
Geographic coding: Zone=0 for lat-long, else UTM Zone





Flyovers:

Remarks

Figure L-Blank bull's-eye data sheet.

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