"An Evaluation of Capture Methods and Habitat Preference of Fisher (*Pekania pennant*) in Clarion County, PA"

An Honors Thesis

by

Laken Ganoe

California, Pennsylvania

2017

California University of Pennsylvania

California, Pennsylvania

We hereby approve the Honors Thesis of

Laken Ganoe

Candidate for the degree of Bachelor of Science

Date	Faculty
11/29/17	Carol Bocetti, PhD Honors Thesis Advisor
11/29/17	David Walter, PhD Second Reader
11/29/17	Craig Fox, PhD Honors Advisory Board Associate Director, Honors Program
29 November 2017	M. G. Aune, PhD Director, Honors Program

Laken Ganoe

Environmental Science: Fisheries and Wildlife Science

Dr. Carol Bocetti, Dr. W. David Walter, Dr. Craig Fox

Keywords: fisher, wildlife, mustelid, hair snare, techniques, habitat selection, pekania pennant, wildlife biology

ACKNOWLEDGMENTS

There are many individuals with whom I would like to share my deepest gratitude for assisting me in creating and completing this project. First of all, I would like to acknowledge the University Honors Program for pushing my limits and offering the opportunity to research a topic that is very important to me, as well as my thesis committee for the time they have taken out of their busy lives to serve on my committee. I would also like to thank the Pennsylvania Game Commission and the Pennsylvania Department of Conservation and Natural Resources for working with me to complete permit applications and allowing me to use their lands and equipment for this study. I would specifically like to acknowledge the efforts of Dr. Matt Lovallo (PGC) and Dr. Jeff Larkin (IUP) for sharing their vast knowledge of fisher in Pennsylvania, lending supplies, and for their patience with me throughout the process. I would be remiss if I did not share my most sincere gratitude for Dr. David Walter who has made the conscious effort to work with a passionate young wildlife student that just really wanted to do research on fishers even though it was not in his expertise. I am so glad that this connection we made has grown into a research partnership and will continue to blossom as I become his advisee in the Spring of 2018. The second to last individual I would like to acknowledge is Dr. Carol Bocetti. Since my first days at Cal U, she has been the woman I have looked up to most in my professional career. Without the guidance she has given me at conferences, during class, and even in personal conversations, I would not be where I am today. I have the utmost appreciation and respect for her and am extremely grateful that our paths have crossed. Thank you for believing in me and pushing me to pursue my greatest passion, I will always remember what you have done for me. Finally, I would like to thank my parents. My mom and dad have been the greatest supporters in my life, from my ups to my downs, and they have always been there for me. Whether they know what I'm talking about when I get home and go off about in-depth research projects, they still support me either way. I am very thankful to have them in my life and for their willingness to go out into the field with me. This project would not have been the success it was without their help. I love both of you, and I hope to make you proud.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

Title: An evaluation of capture methods and habitat preference of fisher (*Pekania pennanti*) in Clarion County, PA

Author: Laken Samantha Ganoe

Thesis Chair: Dr. Carol Bocetti

Thesis Committee Members: Dr. David Walter, Dr. Craig Fox, and Dr. Loring Prest

I. ABSTRACT

Fisher (*Pekania pennanti*) have been thriving in Pennsylvania since their reintroduction in the late 1990's. Efforts to mark their presence and absence across the state have been conducted by the Wildlife Conservation Officers from the Pennsylvania Game Commission. The purpose of this study was to determine the feasibility of using hair snares to determine the presence of fisher and to describe the habitat characteristics of locations where fisher presence was detected. I identified 40 fisher detections during a single summer session from 60 hair snares and trail cameras that were sampled over three time periods. Habitat characteristics of sampling locations that detected fishers were not significantly different from the locations that did not detect fishers. The habitat description of fisher locations in my study supports the wider niche description of the species as previously described in Pennsylvania. This study demonstrates the repeatability of hair sample collection in Clarion County which is the first criteria for development of a remote mark-recapture method for estimating population size for this species.

II. INTRODUCTION

FISHER ECOLOGY

The fisher (*Pekania pennanti*) is a member of the weasel family, Mustelidae. The genus can be broken down into three subspecies that are distinguished by ranges within North America: *P. p. columbiana* (northwestern and central areas), *P. p. pacifica* (western areas), and *P. p. pennanti* (northcentral and northeastern areas) (Hall 1981). Fishers are dark brown, furred, arboreal mesocarnivores with tails that encompass almost a third of their body length. Some individuals have dark brown to almost black-tipped tails and may also display white patches on their chest (Douglas and Strickland 1987). They are also sexually dimorphic with males being generally larger than females, weighing from 3.5 to 5.5kg and from 2.0 to 2.5kg, respectively (Powell 1993). Although they are one of the largest members of their family, fishers have a lean body mass with only about 2.4 to 4.6% extractable fat (Leonard 1980).

To maintain their lean body weight, the diet of a fisher consists mainly of small rodents, but will occasionally include carrion and even small birds. Fishers also are one of the main predators of porcupine. The fisher populations found in the eastern U.S. are believed to have a more diverse diet than those found elsewhere (Zielinski et al. 1999). The species is crepuscular in nature, and thus hunts during the twilight hours. Although they are an arboreal mesocarnivore, they spend most of the time hunting on the ground. According to a study done by Buskirk and Powell (1994), fishers tend to only spend the minimum time necessary in open habitats when foraging. They also use a predation approach, similar to other species in Mustelidae, that requires them to utilize temporary refugia while stalking prey (Buskirk and Powell 1994). For reasons primarily unknown, fishers will use tree cavities or brush piles as rest sites. There is speculation that fishers will visit the nearest rest site post-feeding to sleep (Gilbert et al. 1997).

As with rest sites, fishers will use similar structures for denning and raising their young. They will den in brush piles and downed logs, but prefer tree cavities for rest sites and den sites. The study conducted by Gess et al. (2013) found that fisher in Pennsylvania preferred structures that were cavities or broken tops of black cherry trees (*Prunus serotina*). The breeding season for *Pekania pennanti* occurs between March and May. Fisher will become sexually mature at about one year of age depending on nutritional status (Wright and Coulter 1967). The average litter size is between two and three, but can be as many as six altricial kits (Powell 1993, Powell et al. 2003). The kits will stay with their mother and littermates from three to five months. Once on their own, fishers have a lifespan of about eight years in the wild (Weckworth and Wright 1968).

The historic range of this animal covered most of Canada and across the northern United States. Due to overharvest and habitat loss, this range has been modified and fragmented in recent years. There have been differences displayed between *P. p. pennanti* and the other two subspecies when it comes to habitat preference. *P. p. pennanti* has been known to be the more adaptable subspecies that is found in varying forest types. The initial habitat suitability index for the fisher by Allen (1983) predicted individuals would select primarily large diameter trees in stands with 50—90% conifer composition. In the west, *P. p. pacifica* and *P. p. columbiana* display the preference described by Allen (1983) for mixed coniferous forests with high vegetation and downed woody debris on the forest floor (Lancaster et al., 2008). There is some controversy in the literature about fisher habitat selection between Powell (1994b) and Weir and Harestad (1997). The former described fishers as selecting true conifer habitats, whereas Weir and Harestad did not find any difference in habitat preference. In a more recent article, *P. p. pennanti* were found to occupy not only the traditional coniferous stands, but also fully deciduous stands (Powell et al. 2003).

PENNSYLVANIA HABITAT

The state of Pennsylvania has five different distinct forest types across the state: beech-maple forest, Appalachian oak forest, northern hardwood forest, hickory-oak-pine forest, and mixed mesophytic forest (Fig. 1). The two late-succession forest types relevant to the study area in Clarion County are northern hardwood forest and Appalachian oak forest. The northern hardwood forest contains mostly conifers but also some hardwoods, including black cherry (*Prunus serotina*), beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), and birch (*Betula spp.*). The understory is comprised of witch-hazel (*Hamamelis spp.*) and mountain holly (*Ilex mucronate*). Appalachian oak forests make up most of the state and consist of oaks (*Quercus spp.*), red maple (*Acer rubrum*), tuliptree (*Liriodendron tulipifera*), and hickories (*Carya spp.*). Black huckleberry (*Gaylussacia baccata*) and mountain laurel (*Kalmia latifolia*) are abundant in the understory (Rhodes and Block 2005).

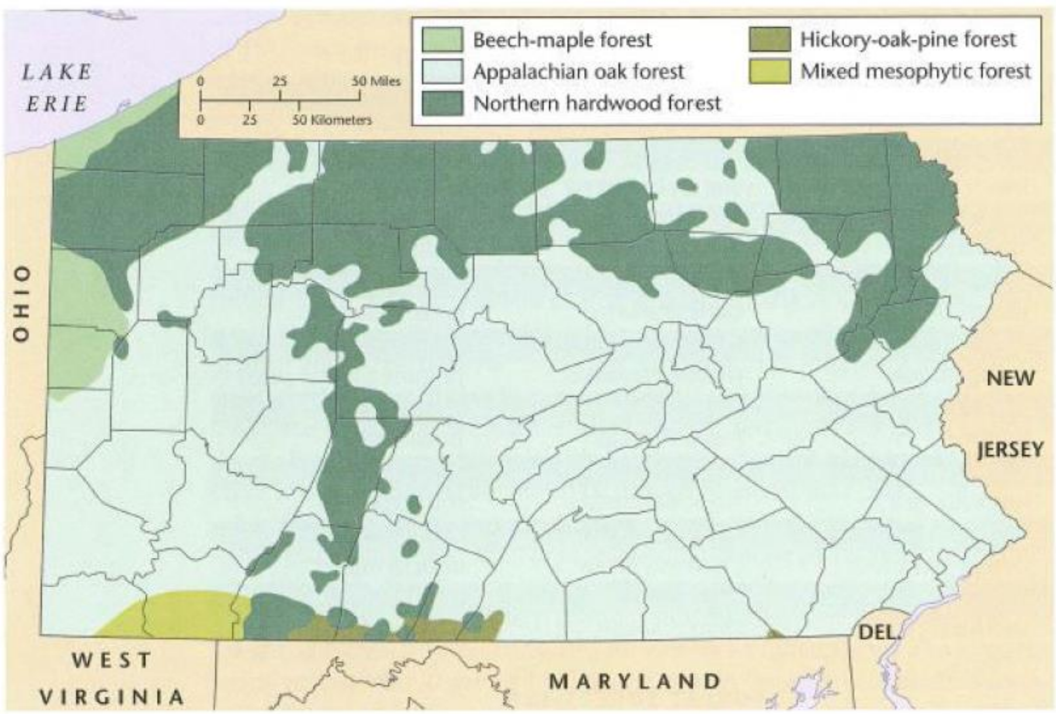


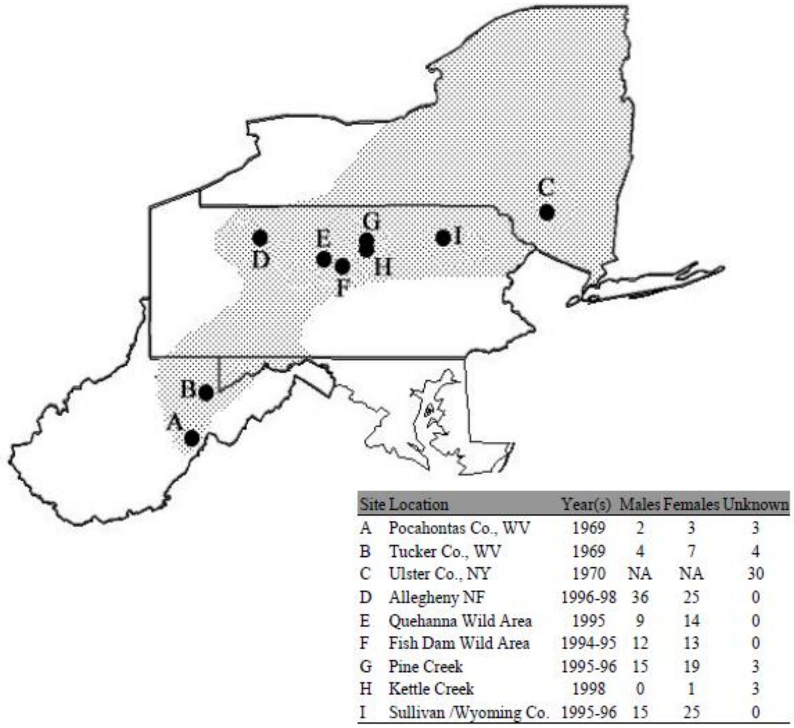
Figure 1: Map of the tree association found in Pennsylvania from Trees of Pennsylvania: a complete reference guide (Rhodes and Block 2005)

The majority of the study area was at one time impacted by the coal mining industry. Most of the mining sites in Clarion County were surface mines. Surface mining (also known as strip mining) is a mining practice where the entire biomass of an area is cleared out and moved aside to allow access to the coal layers below the earth's surface.

Coal mining hit a peak in Pennsylvania in the 1950's, and it was not until 1977 when the federal government created the Surface Mining Control and Reclamation Act (SMCRA) [30 U.S.C. 1258] that regulations were put in place on the proper reclamation of mine sites. The original SMCRA did not give much in the form of guidelines for the types of vegetation that could be planted on reclamation sites, and therefore, companies planted whatever plants would grow in the compacted soils. The neglect of environmental consideration that occurred during replanting resulted in the spread and colonization of many invasive and non-native species. Therefore, many of the habitats at sites in this study reflect the consequences of land management of that era.

FISHER STATUS IN PENNSYLVANIA

The fisher was once a thriving species in the eastern United States. Due to the high demand for their fur and drastic urbanization in the early 1900's, overharvesting, along with loss of habitat led to the extirpation of the fisher in Pennsylvania. In the years 1994 to 1998, a reintroduction project led by the Pennsylvania Game Commission (PGC) in cooperation with several agencies and biologists occurred within the state to re-establish the species (Fig. 2). During the project 190 individuals were reintroduced into six different sites within the state on available public land, such as State Forest Land (SFL) and State Game Lands (SGL).



Site	Location	Year(s)	Males	Females	Unknown
A	Pocahontas Co., WV	1969	2	3	3
B	Tucker Co., WV	1969	4	7	4
C	Ulster Co., NY	1970	NA	NA	30
D	Allegheny NF	1996-98	36	25	0
E	Quehanna Wild Area	1995	9	14	0
F	Fish Dam Wild Area	1994-95	12	13	0
G	Pine Creek	1995-96	15	19	3
H	Kettle Creek	1998	0	1	3
I	Sullivan /Wyoming Co.	1995-96	15	25	0

Figure 2: Reintroduction sites in New York, Pennsylvania, and West Virginia (Lovallo, 2008)

In 2008, PGC Furbearer Biologist Matt Lovallo created a post-reintroduction monitoring program for fisher in Pennsylvania in which he outlines the results of on-going monitoring projects and recommends potential future management through 2017. The fisher population has become very well established and is steadily rising each year to a self-sustaining population. Current methods of population estimation include the combination of four different monitoring approaches: 1) incidental fisher captures, 2) fisher observations, 3) fisher mortality reports, and 4) harvest reports. Wildlife Conservation Officers (WCO) are required to fill out a report at the end of each year that includes fisher observations seen personally and that are reported by the public, reported incidental captures, and reported harvests from trapping within their respective management units. They are also required to report the number of fisher mortalities observed and the causes of each. Most mortality is caused by vehicle collisions in the state of Pennsylvania. In fact, in 2007, there were over 30 reported fisher mortalities that were vehicle-caused (Lovallo, 2008). Twenty percent of all furtakers are sent a similar annual survey that asks them to report the number of incidental captures and sightings of fishers they have experienced over the year.

In 2007, the number of WCO's reporting fisher within their districts, based on the combination of approaches above, was at 75%. Pennsylvania is split into 23 different Wildlife Management Units (WMU), and according to the same survey results, 14 of them have reported presence of fishers. There is no doubt that the population has expanded successfully across the landscape. This success has led to the PGC opening a trapping season for fishers in Pennsylvania in 2010. During the 2011 trapping season there were 138 harvest reports, and an estimated 1,632 fishers that were captured and released throughout the year. The current harvest limit is one fisher per furtaker with mandated permit each year (Lovallo and Hardisky, 2012). The most recent reports on harvest and population estimates have not been released.

PURPOSE AND OBJECTIVES

With the fisher population in Pennsylvania expanding since the reintroduction of the species in the 1990's, it is time for additional research to develop better population estimation methods and to understand dispersal and use of habitat by fisher. This study was created to take a genetic mark-recapture method that has had success in the western United States and bring it to Pennsylvania in order to examine the potential for its use on *P. p. pennanti* on the east coast. The Pennsylvania Game Commission was intrigued to see if the use of hair snares would be successful in repeatedly collecting DNA samples from individual fishers and what the appropriate site design would be to insure the greatest recapture success with the least amount of effort.

This study took place in central Clarion County, Pennsylvania between the towns of Shippenville and Strattenville from west to east, and Clarion and Cooksburg from south to north, encompassing an area of 80km^2. In total, there were 60 snares strategically placed across my sample grid. The objectives of the study were to 1) determine the occurrence of fisher in central Clarion County, 2) serve as a pilot study to determine the feasibility of the remote sampling method of hair snares to collect repeated samples of fisher hair, 3) analyze the effort efficiency in order to determine the appropriate hair snare density, and 4) Compare habitat characteristics at snare locations where fisher were detected against those where they were not to improve sampling site selection for fisher in future studies.

III. METHODS

SAMPLING DESIGN

After researching the history and distribution of fisher in Pennsylvania, as well as taking into account my own personal experiences out west and in Pennsylvania, I selected Clarion County as the location of my study. I reside in this area, and there have been sightings of fisher within the county. I began by creating a sampling grid in ArcGIS (Appendix A). Each grid cell was 4km^2 and roughly resembles the size of a female fisher home range (Ellington 2010). I strategically placed my grid so that it included as much possible SGL and SFL as possible while remaining continuous. Within each cell (referred to hereafter as a “unit”), I placed the first snare site in forested habitat insuring it was at 500m from the forest edge. I also took into consideration my own ease of access when selecting snare sites, but made sure no snares were placed within 100m of a heavily travelled road. I then located an additional two snare sites at least 500m from the first, making sure they were also at least 500m apart from each other, with the same conditions as above. I labeled each unit A-T going from the northwest corner to the southeast (Appendix B). Within a unit, snare sites were labeled 1-3 according to their spatial arrangement from west to east (for example, the snare placed farthest west in unit B, is B1) (Fig. 3).

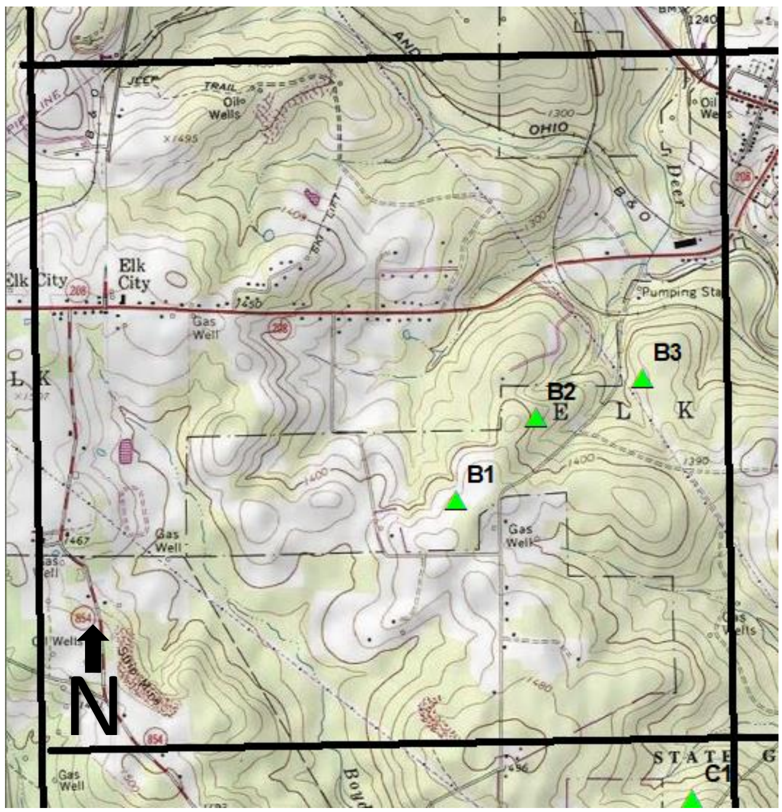


Figure 3: Close up of Unit B from map in Appendix A. North is indicated by the arrow.

Snares were made of 60cm long, 24cm diameter black corrugated drainage pipe with a rubber cap on one end. Three, .30-caliber gun brushes were attached with T-nuts approximately 20cm from the open end of the tube (Fig. 5). A small patch of cloth dipped in gusto, was placed at the capped end of the snare. Gusto is a pungent long-distance scent lure used by many trappers and biologists to attract carnivores. Due to the limited amount of available trail cameras, only 7 working cameras were placed randomly across the sampling units at sites I predicted to have fisher. Cameras were placed approximately 20cm off the ground facing the open end of the snare. Physical placement of snares depended on location and available cover. When downed logs or large boulders were present, snares were wedged beside the structures. If no large objects were at the predesignated site, then the snare was butted up against a larger tree with the capped end against the trunk (Fig. 4). Regardless of placement, large sticks were laid across the snare (Fig. 4) to weigh it down to ensure it would not move when an animal attempted to enter.

Figure 4: Site B1 hair snare set-up

Figure 5: Inside of snare from entrance with display of equidistant hair snares.

TIMELINE

Installation of units began at the end of May 2017 and were checked at three-week intervals for a total of 16 weeks. The schedule ran on a three-week rotation for feasibility of installing and checking units with limited assistance. Units A-I (27 snares) were all installed in week one, M, O, P, and R-T (18 snares) were installed in week two, and the rest (15 snares) were installed in week three. Following installation, a series of three sampling periods occurred in the same schedule as above (Appendix C). Hair samples were taken to Dr. David Walter's lab at Pennsylvania State University (PSU) intermittently throughout the summer.

SAMPLE COLLECTION AND MICROSCOPY

Upon arrival at a snare during each sampling period, the trail camera (if present) was checked for battery life and the SD card was removed and replaced with a cleared SD card. If the snare had been disturbed/moved from its original location, it was noted. Gun brushes were checked for hair samples using a flashlight and white paper. If hair samples were present, all gun brushes were removed, placed in an envelope, and replaced with clean gun brushes. Gusto was reapplied to the existing cloth patch, or replaced with a new patch if absent. Prior to leaving the site, the snare was replaced and weighed down with sticks, and the camera (if present) was turned on.

Following field collection, samples were analyzed using microscopy to determine if it contained the target species. Hair samples were removed from the gun brushes with caution using a fine-tipped pair of tweezers, then they were placed on an adhesive notecard with caution to avoid contact between the adhesive and the follicle. Hair scale casts were created from the hair samples by 1) painting a layer of clear nail polish on a blank microscope slide, 2) gently laying the edge of a hair on top of the still wet nail polish while being careful not to have the follicle encounter the polish, then 3) gently removing the hair from the slide using fine-tipped tweezers. A compound light microscope was used at 400x magnification to view the hair scale casts. Two known samples were used as reference slides for comparison: one from a fisher pelt, and one from a raccoon (Fig. 6). If the hair sample suggested fisher presence, those samples were flagged to be sent to the lab for genetic amplification. Amplification is the process of using the polymerase chain reaction technique (Mullis and Faloona 1987) to create many copies of a specific section of DNA.

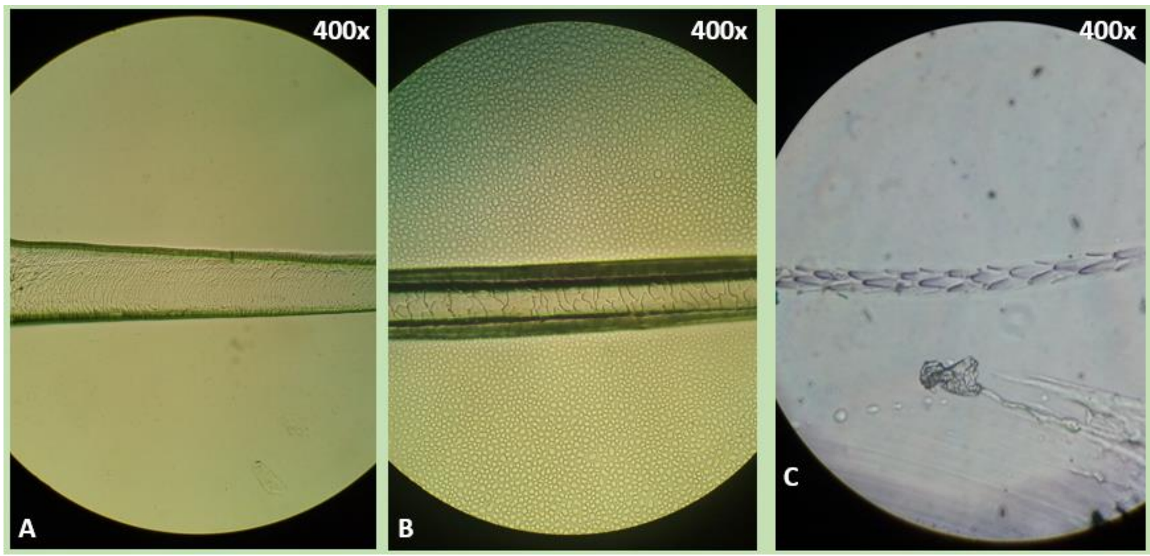


Figure 6: Microscopy analysis of hair samples. A) Fisher guard hair, B) Raccoon guard hair, and C) Fisher underfur

SAMPLING DESIGN EVALUATION METHODS

Snare sites were given a numbered designation a-priori to data collection to determine the ideal sampling site density. The cumulative number of fisher hair samples will be used to evaluate the detection efficiency of 1, 2, or 3 snare sites per unit. For example, the number of detections in the following three scenarios will be compared: a) when only snare 1 was used, b) when snares 1 and 2 were used, and c) when snares 1, 2, and 3 were used.

HABITAT SAMPLING

Seven different habitat variables were measured from which three additional habitat variables were derived at each snare site to use in the analysis of ten habitat characteristics. A 17.8m-radius plot was set-up at each snare site using the snare as the center point (Fig. 7). Within the boundaries of the plot, every tree was recorded with its species identification and diameter at breast height (DBH). The species identification consisted of a four-letter code abbreviation of the scientific name (e.g. *Tsuga canadensis* = tsca). Species richness was derived from tree data, and is the total number of species that were found within the plot surrounding each site. Tree density refers to the number of trees per hectare based on a .10-hectare plot used in this study. Percent Appalachian Oak and percent Northern Hardwood refers to the percentage of trees within a plot that belonged to each respective group. Appalachian Oak species include: all oaks, tuliptree, red maple, hickories, and American Chestnut (*Castanea dentata*). Northern Hardwood species include: beech, birch, hemlock (*Tsuga canadensis*), sugar maple, white pine (*Pinus strobilus*), black cherry and witch-hazel. Some sites did not add up to 100% when totaling the two categories due to the presence of alternate species that were introduced (Appendices D and E).

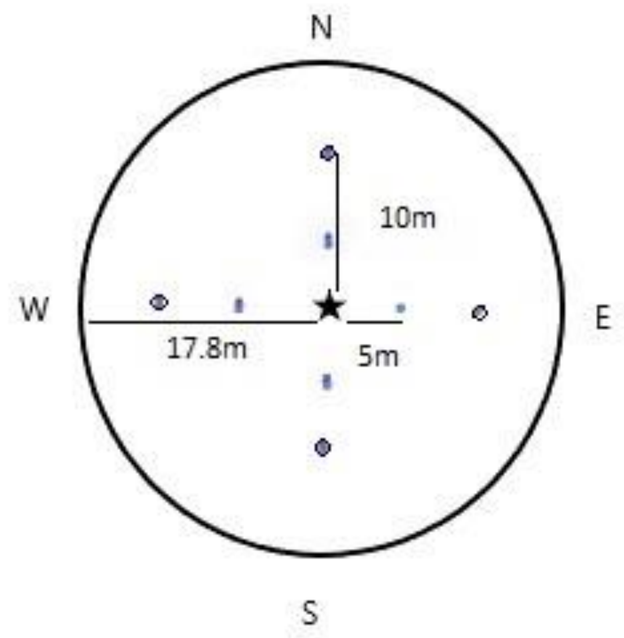


Figure 7: Diagram of 17.8m plot used. Snare displayed as star, and blue dots represent points 5 and 10m from the snare in each cardinal direction that canopy and ground cover measurements were taken. Vertical cover measurements were taken at the 10m mark indicated by the open circle.

At 5m and 10m from the plot center in each cardinal direction, hit-miss readings for canopy and ground cover were taken using a densitometer (Fig. 7). At each snare site, the average percentages for canopy and ground cover were calculated by taking the sum of hits (indicated as a 1) and dividing by 9, which is the total number of opportunities. The grand means for these two vegetative cover variables were then calculated across all snare sites that were used by fisher, and across those that were not used by fisher.

At the 10m mark in each direction, a 2m x 20cm vertical cover board (with 20 painted 20cmx20xm squares) made of canvas was held to collect percent vertical cover. A square was considered a hit if 50% or more was covered by vegetation. The sum of the number of hits from all cardinal directions was divided by the total number of squares available in all directions (160) to determine the percent vertical cover at each snare site. Each measurement of cover type occurred during the second sampling period.

Distances from the snare to roads and streams were calculated using the “Near” function in ArcGIS. Only high traffic areas, defined by paved roads, were considered. The layers PA_StateRoads and PAHistoricStreams given to me by Larkin at Indiana University of Pennsylvania were used in the calculation. Only the distance to the nearest stream and high-traffic road were used for each site.

In the data described below, habitat that is considered “used” is any snare site where fishers were detected via genetic analysis from hair sample, or from photos taken by a trail camera. A site is considered “unused” if genetic analysis of samples came back negative, and if there were no photos of fishers in the area on trail cameras. P-values were calculated using a two-tailed t-test.

IV. RESULTS

FISHER DETECTION

In total, I collected 148 hair samples over the entire project. From these samples, 62 of them were identified as potentially belonging to fisher via microscopy. In addition to the microscopy, the trail cameras confirmed the presence of fisher for 5 of the 62 hair samples. All potential fisher hair samples were sent to the lab at Pennsylvania State University for genetic analysis. Within the 62 samples sent for analysis, 38 were returned with positive fisher identification (Table 1). The remaining hair samples that did not return positive fisher identification were not further evaluated to determine the species captured.

Table 1: The number of fisher and non-fisher hair samples collected across the three sampling periods of the study.

	Positive Fisher Hair Samples	**Non-Fisher Hair Samples**
Period 1	10	33
Period 2	19	30
Period 3	9	47
Overall	38	110

Detection is not only based on the number of hair samples, but camera photos of fisher as well. Upon looking at the positive hair samples for fisher and correlating them with their locations, fishers were detected at 32 sites within 18 units (Table 2). Out of the 32 sites, fisher were detected via trail cameras at four of the sites in four different units. Two snare sites that had detected fisher at the camera during the second sampling period did not return positive results from the genetic analysis of the associated hair samples. These two camera sites that picked up fisher were included in the total detections for habitat analysis since they were identifiable on camera as fisher being present at the site. Units L and Q never detected a fisher at any snare site during any sampling period (Table 2). Other non-fisher detections from camera photos include opossum (*Didelphis virginiana*), porcupine (*Erethizon dorsatum*), raccoon (*Procyon lotor*), black bear (*Ursus Americana*), white-tailed deer (*Odocoileus virginianus*), gray fox (*Urocyon cinereoargenteus*), coyote (*Canis latrans*), long-tailed weasel (*Mustela frenata*) , mice (Muroidea), squirrels (*Scuirus spp.*), flying squirrel (*Glaucomys volans*), chipmunk (*Tamais striatus*), birds and groundhog (*Marmota monax*).

Table 2: Locations of fisher detections across three sampling periods. H indicates fisher hair sample collected, C indicates fisher was caught on camera.

Unit	Site	Period 1	Period 2	Period 3		Unit	Site	Period 1	Period 2	Period 3
A	1			H		K	1	H		HC
	2						2		H	
	3						3		H	
B	1		C			L	1			
	2						2			
	3			H			3			
C	1					M	1	H		
	2		H				2			
	3	H					3			H
D	1	H	H			N	1		C	
	2			H			2			
	3						3		H	
E	1					O	1		H	
	2		H				2			
	3						3			
F	1					P	1			
	2	H	HC	HC			2		H	
	3		H				3		H	
G	1	H	H			Q	1			
	2	H	H	H			2			
	3	H					3			
H	1		H			R	1			
	2						2		H	
	3						3			
I	1	H				S	1		H	
	2						2			
	3		H				3			
J	1		H	H		T	1			H
	2	H					2		H	
	3						3			

SAMPLING DESIGN RESULTS

As the number of sampling sites were added to each unit, the number of fisher hair samples increased. However, as the number of sites added increased, the rate of increase in the number of fisher hair samples was diminishing (Table 3).

Table 3: The cumulative number of fisher hair samples collected across all units as snare sites are added to units.

#sites/unit	Period 1	Period 2	Period 3	Total
1	5	6	4	15
2	8	14	7	29
3	10	19	9	38

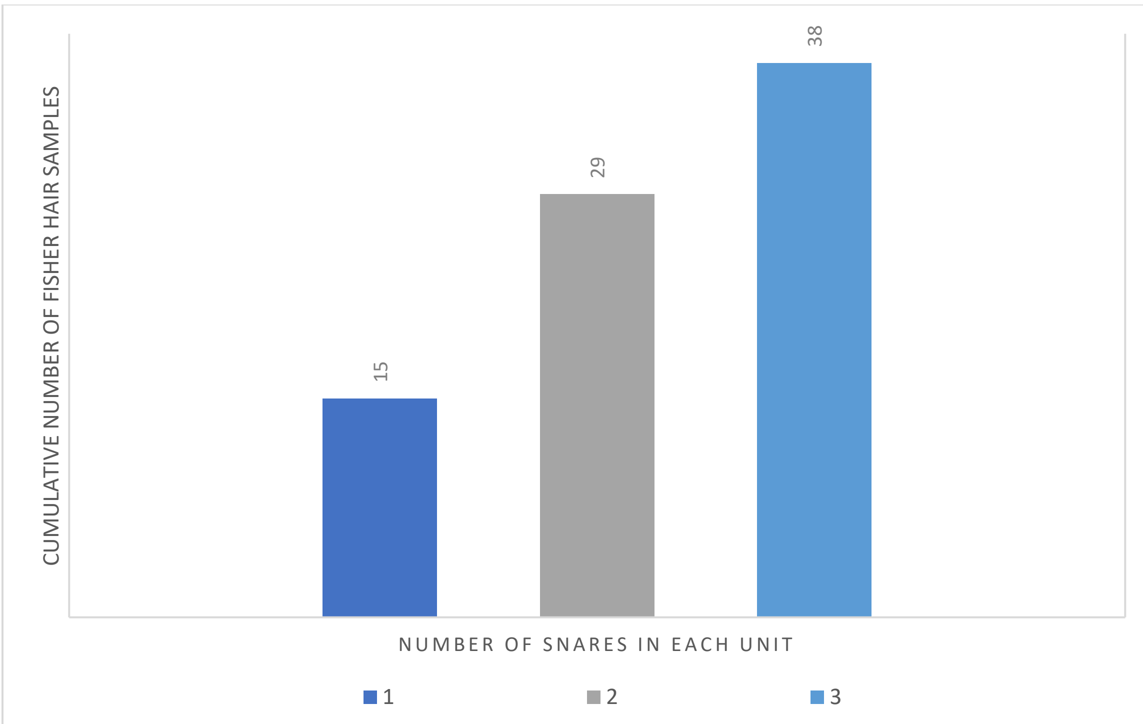


Figure 8: Efficiency of three different snare densities based on cumulative number of fisher hair samples collected at each unit.

HABITAT DATA

For all of the habitat variables, none of the statistics were significant, and there was no difference in the habitat variables in used and unused areas (Table 4).

Table 4: Habitat characteristics for sampling locations (either via hair samples or camera photos) that detected fisher compared to location that did not detect fisher.

	Unused by Fisher		**Used by Fisher**		
Variables	**mean**	**se**	**mean**	**se**	**p-value**
%Canopy Cover	71.43%	0.029	73.96%	0.029	0.543
%Ground Cover	57.54%	0.045	54.17%	0.040	0.578
% Vertical Cover	55.31%	0.054	44.90%	0.043	0.131
Ave. DBH (cm)	22.67	1.476	24.50	1.389	0.373
Species Richness	5.41	0.274	5.84	0.229	0.223
Tree Density	397.14	43.23	421.25	33.27	0.653
% Appalachian Oak	41%	0.05	46%	0.05	0.471
% Northern Hardwood	49%	0.05	42%	0.05	0.317
Stream Distance (m)	176.62	32.89	231.01	29.56	0.222
Road Distance (m)	494.54	81.06	613.20	92.84	0.340

V. DISCUSSION

Hair snares were indeed successful at collecting fisher hair. Using the camera photos and the hair sample detections, fishers were found evenly dispersed across the sampling sites at all but two units (L and Q). These two sites were extremely close to the Clarion River, which is frequented by water sport enthusiasts. Although units K, J, and N had fisher detections and were also along the Clarion River, they were located a bit farther from high-impact areas. Unit L was located where the Clarion River begins to back up and become Piney Lake. Therefore, there is more motor boat traffic in this area than near the other units along the river where the depth is between 1-3 feet. Few people travel the river between N and K since it is extremely shallow and only used for canoeing, kayaking, fishing, and horseback riding (on designated trails). Unit Q is sequestered from the river bank by a well-travelled road. This might suggest that fisher have moved farther back into the forest in that area to avoid interactions with humans.

In the analysis of the feasibility and repeatability of remote sampling, the lab was successful extracting DNA from the hair samples and returned positive fisher identifications for 38 of the hair samples. The detection rate for fisher was 22% across all 60 snares for the combined sampling periods. Multiple sites returned hair samples from more than one sampling period that were positively identified as fisher hair. The method is very feasible to capture hair from the target species over the course of the study. Objective 2 is met with positive enforcement from conducting this study. As a non-invasive technique that requires little man-power, the time and effort spent conducting the field surveys were reasonable for a sample size of this magnitude, and was completed by 1-2 individuals.

The effort efficiency is determined by snare density that results in the most hair samples with the least effort. As expected, the number of fisher detections increased with each additional snare within a unit. When only snare one was used, there were 15 detections over the course of the study. With both snare one and two being used, there were 29 detections. The third scenario represents the overall detection number of 38 fisher. There seems to be a diminishing return on the probability of capture between the use of two and three total snares. Final conclusions on the appropriate snare density cannot be made at this time due to the fact that individual fisher identification needs to be considered. Two units (G and K) had fisher detections at all three snares, with G2 having a detection every sampling period. There is a high probability that many of these detections at G were of the same individual fisher due to the proximity of the snare sites within the unit. Knowing the identification of the fisher at each detection would greatly help in the analysis of the snare density.

As mentioned above about unit Q, the habitat data suggests that fishers do try to avoid busy roadways whenever possible. Although none of the statistics were significant, there was a general difference between the averages for distance from the snare to a road. In areas where fishers were detected, the average was 613.20m as compared to 494.54m in unused areas (Table 3). There is a lot of noise in the data as can be seen by comparing the used (48.21m – 1628.90m) and unused (58.46m – 1083.24m) area ranges for road distance. The used area has the biggest range (1580.69m, Appendix D and E). The used areas also encompass both extremes across all road distance data, suggesting there are indeed multiple variables involved in fisher habitat selection, and that one factor might not be more of an influence over another. I hypothesized that fisher would be using areas with a high minimum distance from roads since they are characterized as extremely elusive creatures and would want to remain in the forest interior (Allen 1983). With the wide range in distance data, the hypothesis would need to have further sampling points to make a conclusive judgement. One suggestion for the presence of fisher near roads is access to easy food items, such as roadkill carrion.

Another distance variable that was considered as possible criteria for fisher habitat selection is distance from the snare to a stream. The average distance from snares in unused areas to a nearby stream was 176.62m, as compared to 231.01m in used areas (Table 3). This was an interesting statistic in the analysis, because I was expecting the distance to the nearest stream to be closer in used areas versus unused areas because a prime resource in an animal's territory is water. If a fisher is out hunting, I expected them to want to remain close to a water source since prey items will go there to drink and the fisher itself may prefer to remain close to a water source, but this did not seem to be the case. The snare closest to water (03 at 9.76m) was actually in an unused area (Appendix D). The farthest snare from water was 699.82m away, and it was used by fisher (Appendix E). A possible explanation for this intriguing finding is interspecies competition between fisher and river otter. As fisher in Pennsylvania have been shown to have a very diverse diet (Zielinski et al. 1999) and would therefore be more likely to use alternate food sources before risking confrontation with river otter, this avoidance could explain the further distance of “used” fisher sites from streams. However, along the Clarion River, I documented several latrine sites for river otter and where they were in proximity to nearby snares. I found latrines on the bank of the river below sites N1 and K1. Both of these sites had fisher detections, so I do not believe they are being deterred by river otter, but this could be an interesting research topic in the future.

Three types of vegetation cover were investigated: ground, canopy, and vertical. Once again, none of the result were significant, and the means of used and unused sites were very similar. For instance, the average percent vertical cover was the closest to being significant, but the means for used (55.31%) and unused (44.90%), do not display any ecological significance (Table 3). The vertical cover estimate is very subjective and does not really accurately represent the vertical cover presence of the sites. For instance, a large leaf could cover half of two different squares, and instead of counting that as only one square, the result would be both squares get counted toward the total since 50% or more of each square was covered. In the future, I would like to change the method to taking a photograph of the coverboard at each survey point and calculating the actual cover once I returned home from the field. I believe altering this method would result in more accurate data and potentially better results. The results for the cover variables were not much different when taking fisher presence into consideration. I expected there to be a preference for high canopy cover, high vertical cover (leaning logs, boulders, etc), and medium to low ground cover (grass, ferns, etc) to fit the previous studies performed on fisher habitat preference (Allen 1983). The lowest canopy cover (33%) was at a site where fishers were detected. The range for used areas for ground (11-89%) and vertical (8-100%) were extremely broad (Appendix E). These results suggest that fishers in Clarion County are not selective when it comes to cover percentages.

The final habitat variables assessed pertain to the tree composition at each site. In much of the literature, fishers are described as preferring mature, coniferous stands, so I predicted the fisher would use areas that had conifers present over the fully deciduous stands. The results indicated no preference for mature forests (trees with larger DBH), or for the northern hardwood forest that includes the coniferous species found in Pennsylvania. The distribution of used and unused sites was practically equal in both the Appalachian Oak forest and the Northern Hardwood forest (Table 3). This implies that the fishers in the area have adapted to thrive in forested stands of a variety of age and composition. The average DBH was almost the same for areas where fishers were detected and areas where they were not (Table 3). There are several ecological implications of these findings. One is that fishers have become highly adaptable and are not being partitioned to certain successional stages or types of forest stands. Since the lure in this study creates a scenario where a fisher is going to come in contact with the bait due to being on the prowl, it implies that fishers are using a variety of different habitats when hunting. Previous studies that implied fishers prefer coniferous stands were based on the locations of rest-sites and dens but not on the preference of hunting grounds. This may indicate a gap in the knowledge of alternate habitat preference when hunting.

In conclusion, the fisher population found in central Clarion County is extremely adaptable to the current environment. The fishers displayed no significant habitat preference that would expressively aid us in improve fisher detectability in future studies. Additional sampling seasons may be required to better answer questions surrounding the habitat preference of fisher in Pennsylvania. There were no specific cover types, forest age, or forest composition that was more or less likely for a fisher detection to occur.

With the majority of the land where sampling occurred being reclaimed coal mine sites, the fishers seem to have recolonized these disturbed areas without hesitation. This study concludes that of this hair snare design can repeatedly capture fisher non-invasively and has the potential to be used in future years to monitor the presence and habitat use of fisher in Clarion County or in the state of Pennsylvania.

I would suggest if this study design is to be used, that no more than three snares be placed within a unit as the effort put into adding a snare may not reap the benefits of more detections. This project was very feasible for one or two people to conduct over the course of a summer season, and it was relatively inexpensive compared to other methods of monitoring such as radio telemetry. I would highly recommend this type of genetic presence/absence monitoring for elusive creatures such as fisher.

SUGGESTIONS FOR FURTHER RESEARCH

There is much yet that the scientific community needs to investigate for *Pekania pennanti*. Once the lab has finished processing the hair samples fully, I intend to use the individual identifications of fishers to evaluate the number of recaptures. From this information, I hope to be able to estimate the population size from the probability of detection which would be a novel method for fisher population estimation in Pennsylvania. There is a possibility that recaptures have occurred at 10/20 units which should roughly represent 10 different individuals. Although it is expected to be successful, if the results do not return multiple recaptures, this would be important information for future projects involving hair snares and may lead to alterations of the study design.

Another suggestion is the analysis of fisher use of reclaimed mine sites, and their hunting ground habitats. From this study, I have found that fishers have moved into reclaimed mine sites and seem to be prospering, while other species have not moved back into those areas. Pinpointing what the fishers use within reclaimed mine areas, may help other reclamation sites in the future. I also believe it would be interesting to conduct a study on the habitats where fishers hunt. In this study, I used a long-distance lure that mimicked a prey item to bring fisher to the area. The nature of the lure may have manipulated a fisher's normal hunting patterns, so perhaps using a different method to track fishers while they are hunting could give insight to a different habitat need other than those already known for den and rest sites.

Lastly, I have been in contact with many fisher researchers who use both the long-distance lure (gusto) and a bait (chicken) when conducting studies on fisher. There is not much information on the effectiveness of gusto and/or bait on detection probability. In previous studies and personal experience, when using gusto and chicken bait there was success in detecting fisher, but many of the sites were altered or destroyed by bear. When conducting this study, I only used gusto and was also successful detecting fisher. The interesting thing I found was I had a total of three occasions where bear interfered with the hair snares, and only one of them the bear made the snare inoperable for one sampling period. I would like to continue this study, but include sites with bait and sites without to compare bear interference at each. This would help answer a larger question that fisher researchers have been asking, and if bait is indeed unnecessary, could save research projects funds that they could use elsewhere.

LITERATURE CITED

Allen, A.W. 1983. Habitat Suitability Index (HIS) Models: Fisher. U.S. Fish and Wildlife Service Biological Report 82, Washington, D.C., USA.

Buskirk, S.W., and R. A. Powell. 1994. Habitat ecology of fishers and American martens. Pages 283-96 *in* S.W. Buskirk, A.S. Harestead, M.G. Raphael, and R. Powell, editors. Martens, sables, and fishers: Biology and conservation. Cornell University Press, Ithaca, New York, USA.

Douglas, C.W., and M.A. Strickland. 1987. Fisher. Pages 511-30 *in* M. Novak, J.A. Baker, M.E. Obbard, and B. Malloch, editors. Wild furbearer management and conservation in North America. Ontario Ministry of Natural Resources, Toronto, Canada. (511-30).

Ellington, E. H. 2010. Developing habitat models to predict fisher occupancy in Pennsylvania. Indiana University of Pennsylvania, Indiana, Pennsylvania, USA

Gilbert, J.H., J.L. Wright, D.J. Lauten, J.R. Probst. 1997. Den and rest-site characteristics of American marten and fisher in northern Wisconsin. Pages 135-145 *in* Martes: taxonomy, ecology, techniques, and management. Provincial Museum of Alberta, Edmonton, Alberta, CAN.

Gess, S.W., E.H. Ellington, M.R. Dzialak, J.E. Duchamp, M. Lovallo, and J. L. Larkin, 2013. Rest-Site Selection by Fishers (*Martest pennanti*) in Eastern Deciduous Forest. *Wildlife Society Bulletin*, 37(4): 805-814.

Hall, E.R. 1981. The mammals of North America. Second Edition. Volume 2. John Wiley and Sons, New York, New York, USA.

Lancaster, P.A., J. Bowman, and B.A. Ford. 2008. Fishers, farms, and forests in eastern North America. Environmental Management 42(1): 93-101.

Leonard, R.D. 1980. Winter activity and movements, winter diet and breeding biology of the fisher in southeast Manitoba. Thesis, University of Manitoba, Winnipeg, Canada.

Lovallo, M. J. 2008. Status and Management of Fisher (Martes pennanti) in Pennsylvania 2008-2017. Pennsylvania Game Commission, Harrisburg, Pennsylvania, USA.

Lovallo, M.J., and T.S. Hardisky. 2012. Pennsylvania Game Commission Bureau of Wildlife Management Project Annual Job Report. Furbearer Population and Harvest Monitoring. Pennsylvania, USA.

Mullis, K.B., and F.A. Faloona. 1987. Specific synthesis of DNA in vitro via a polymerase catalyzed chain reaction. *Methods in Enzymology*, 155: 335-350.

Powell, R.A. 1993. The Fisher: life history, ecology, and behavior. Second edition. University of Minnesota Press, Minneapolis, USA.

Powell, R.A. 1994. Effects of small scale on habitat selection and foraging behavior of fishers in winter. Journal of Mammalogy 75: 349-56.

Powell, R.A., S.W. Buskirk, and W.J. Zielinski. 2003. Fisher and marten. Pages 635-649 *in* Wild mammals of North America: Biology, management and economics. G.A. Feldhamer, B.C. Thompson, and J.A. Chapman, editors. Second edition. John Hopkins University Press, Baltimore, Maryland, USA.

Rhodes, A.F., and T.A. Block. 2005. Trees of Pennsylvania: a complete reference guide. The University of Pennsylvania Press, Philadelphia, PA, USA

Weckworth, R.P., and P.L. Wright. 1968. Results of transplanting fisher in Montana. Journal of Wildlife Management 32: 977-80.

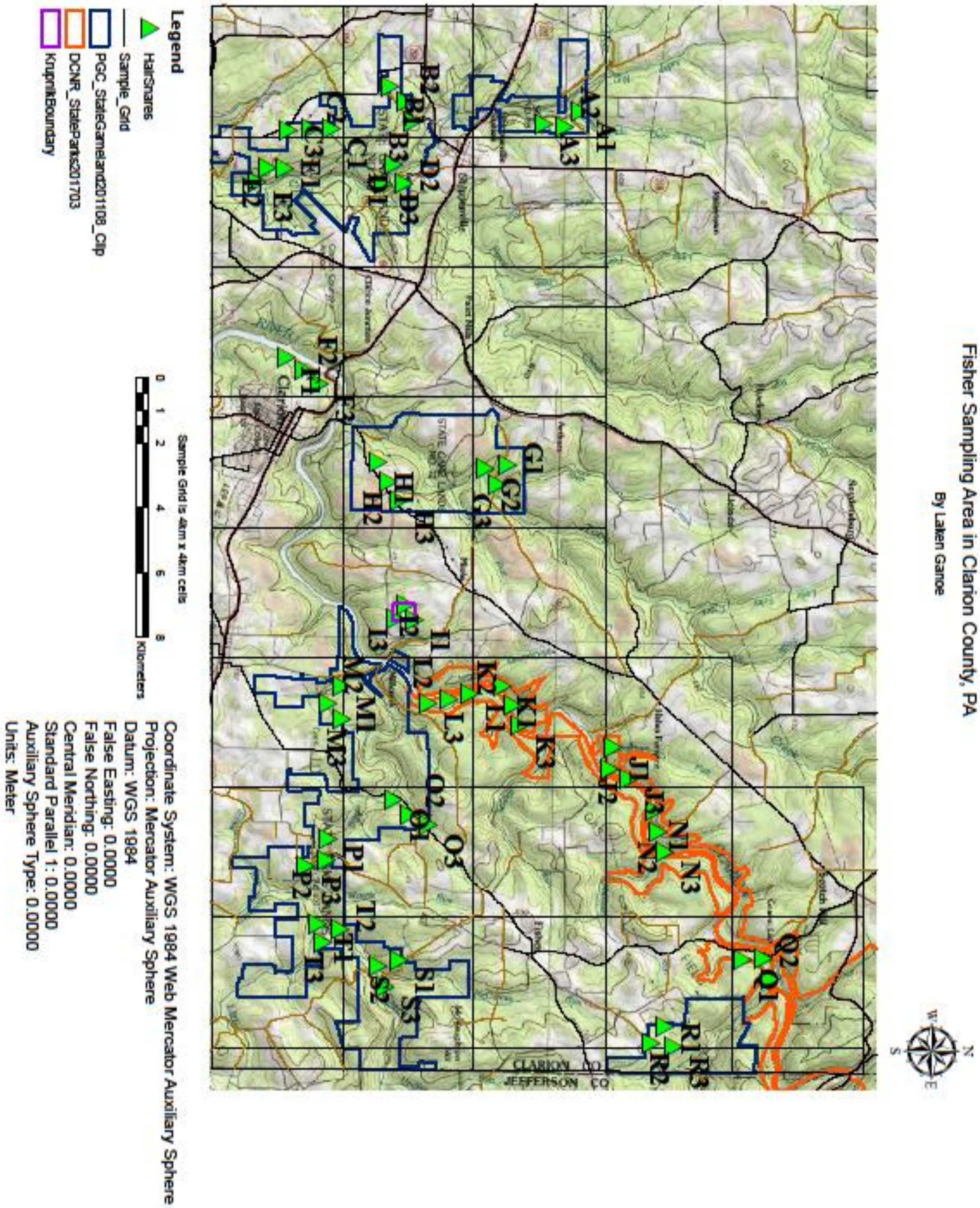
Weir, R.D., and A.S. Harestad. 1997. Landscape-level selectivity by fishers in south-central British Columbia. Pages 252-264 *in Martes*: taxonomy, ecology, techniques, and management. G. Proulx, H.N. Bryant, and P.M. Woodard, editors. Provincial Museum of Alberta, Edmonton, Alberta, Canada.

Wright, P.L., and M.W. Coulter. 1967. Reproduction and growth in Maine fishers. Journal of Wildlife Management 31: 70-87.

Zielinski, W.J., N.P. Duncan, E.C. Farmer, R.L. Truex, A.P. Clevenger, and R.H. Barrett. Diet of fishers (*Martes pennanti*) at the southernmost extent of their range. Journal of Mammalogy 80: 961-71.

30 USC 25: 1201-1309b.

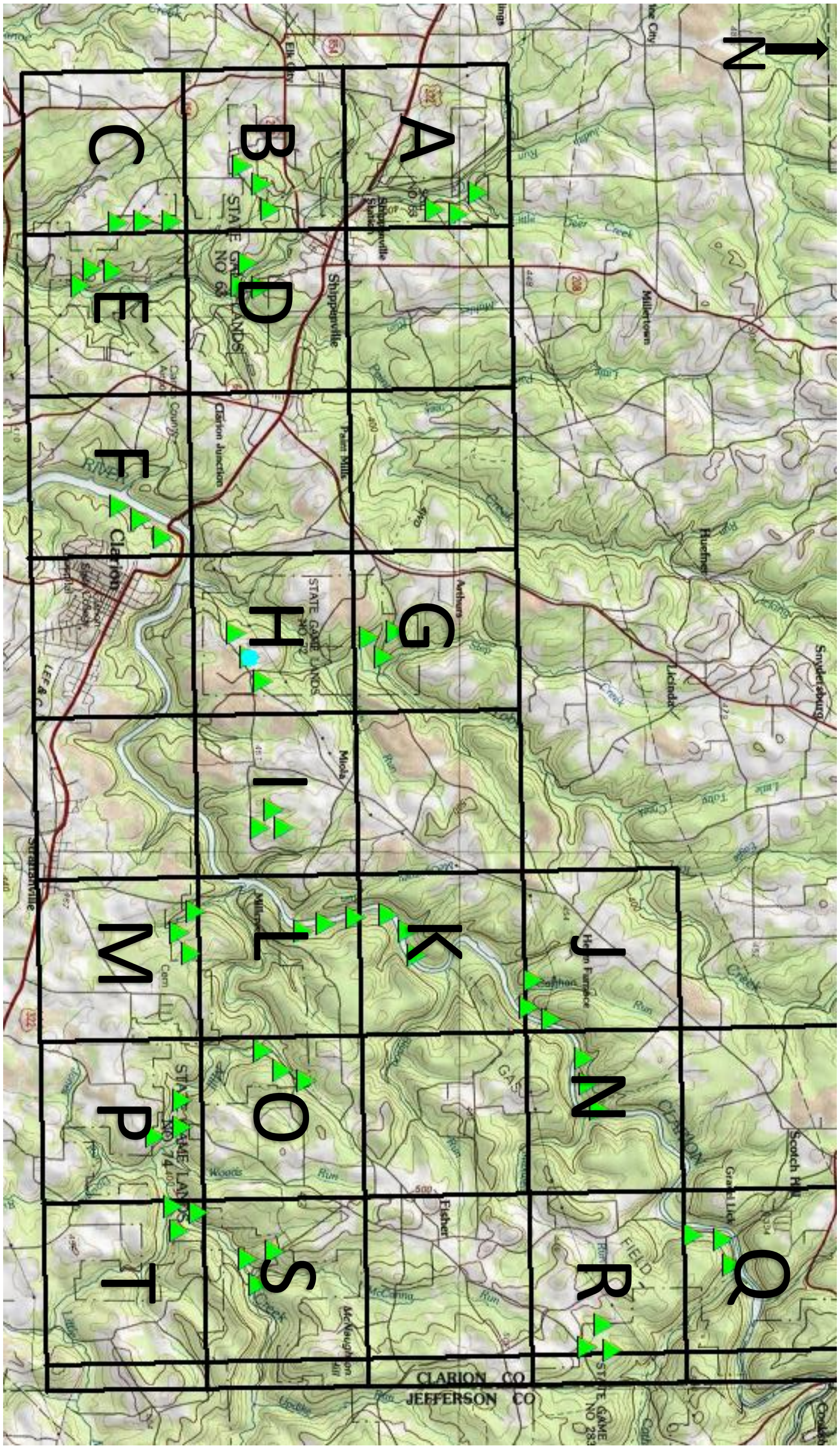
APPENDIX A



Fisher Sampling Area in Clarion County, PA
By Laken Ganoe
Legend
HairSnares
Sample_Grid
PGC_StateGameland201108_Clip
DCNR_StateParks201703
KrupnikBoundary
Sample Grid is 4km x 4km cells
0 1 2 4 6 8 Kilometers
Coordinate System: WGS 1984 Web Mercator Auxiliary Sphere
Projection: Mercator Auxiliary Sphere
Datum: WGS 1984
False Easting: 0.0000
False Northing: 0.0000
Central Meridian: 0.0000
Standard Parallel 1: 0.0000
Auxiliary Sphere Type: 0.0000
Units: Meter
CLARION CO
JEFFERSON CO

APPENDIX B

Demonstration of labeling units A-T based on columns. North is represented by the arrow.



APPENDIX C

Detailed view of schedule for this project broken down into phases.

Phase	Dates	Units
Snare placement	MAY 29-31	A-I
	JUN 5-7	M,O,P,R-T
	JUN 12-14	J-L,N,Q
Sampling Period 1	JUN 19-21	A-I
	JUN 26-28	M,O,P,R-T
	JUL 3-5	J-L,N,Q
Sampling Period 2	JUL 10-12	A-I
	JUL 17-19	M,O,P,R-T
	JUL 24-26	J-L,N,Q
Sampling Period 3/Removal of snares	JUL 31 – AUG 2	A-I
	AUG 7-9	M-O,P,R-T
	AUG 14-16	J-L,N,Q

APPENDIX D

Data from sites consider unused by fisher. Note: E3 was located on the edge of a severe drop off where tree data could not be collected for one quadrant due to possible dangers associated with area.

SnareID	%Canopy	%Ground	%Vertical	Ave. DBH	total spec	total trees	density	stream_dist	road_dist	%App. Oa	%N. Hard
A2	78%	56%	42%	7.11	6	76	760	339.2606264	262.6892	22.37%	68.42%
A3	67%	44%	28%	19.87	6	33	330	269.1397605	147.532	78.79%	21.21%
B2	78%	78%	87%	19.65	9	37	370	194.6218038	185.1367	48.65%	51.35%
C1	100%	78%	51%	7.83	4	124	1240	147.7332878	826.7798	54.84%	41.94%
D3	78%	67%	73%	22.75	4	40	400	98.0830167	1377.792	15.00%	35.00%
E1	89%	89%	35%	15.04	7	59	590	166.9758526	856.1581	22.03%	71.19%
E3	44%	78%	99%				0	51.56129663	966.638		
F1	100%	33%	30%	23.88	4	32	320	188.2283121	678.86	28.13%	68.75%
H2	56%	33%	57%	22.62	5	31	310	750.639242	136.223	3.23%	48.39%
H3	67%	56%	23%	22.01	3	35	350	674.8914075	90.71265	11.43%	77.14%
I2	67%	100%	59%	26.41	5	24	240	36.45988703	398.484	75.00%	20.83%
J3	78%	56%	57%	27.79	6	34	340	70.4242742	1555.274	32.35%	67.65%
L1	56%	67%	63%	17.58	6	52	520	103.0939896	1036.922	53.85%	1.92%
L2	89%	33%	93%	20.15	7	61	610	84.52418793	577.672	59.02%	9.84%
L3	89%	22%	97%	22.00	6	42	420	135.2710455	281.0506	52.38%	9.52%
M1	56%	11%	11%	27.12	5	52	520	42.23981173	228.4205	25.00%	75.00%
N2	67%	56%	40%	25.15	8	43	430	26.60401364	1083.244	46.51%	44.19%
O2	67%	44%	64%	25.27	3	30	300	155.4564886	89.77458	43.33%	56.67%
O3	44%	11%	4%	27.06	4	39	390	9.761617942	93.11561	5.13%	94.87%
P1	67%	44%	100%	22.30	5	21	210	52.89227269	325.7336	76.19%	23.81%
Q1	78%	78%	19%	37.27	7	20	200	157.0689379	58.46288	75.00%	25.00%
Q2	67%	89%	28%	42.73	5	19	190	213.2487244	92.55511	21.05%	78.95%
Q3	67%	56%	45%	30.59	5	27	270	207.174374	120.6944	14.81%	85.19%
R1	67%	33%	64%	20.68	6	42	420	12.72151195	557.746	33.33%	61.90%
R3	89%	78%	87%	12.39	6	53	530	256.8959329	537.281	18.87%	81.13%
S2	89%	67%	47%	23.65	5	28	280	165.142703	204.4943	57.14%	39.29%
S3	44%	89%	100%	15.58	4	26	260	80.83561245	157.506	100.00%	0.00%
T3	67%	67%	47%	27.74	5	32	320	254.4442316	920.2599	31.25%	68.75%

APPENDIX E

Data associated with snares in areas considered used by fisher.

SnareID	%Canopy	%Ground	%Vertical	Ave. DBH	total spec	total trees	density	stream_dist	road_dist	%App. Oa	%N. Hard
A1	78%	67%	53%	19.48	5	41	410	74.66403116	243.7134	29.27%	36.59%
B1	89%	56%	42%	21.36	5	60	600	510.2723039	209.2785	16.67%	13.33%
B3	44%	78%	44%	15.67	5	38	380	206.7040439	97.81455	44.74%	55.26%
C2	78%	67%	27%	18.52	4	58	580	399.7804415	418.5731	72.41%	0.00%
C3	67%	56%	68%	43.49	4	17	170	378.423051	74.37233	100.00%	0.00%
D1	78%	78%	55%	22.18	7	48	480	173.4398631	1164.748	14.58%	37.50%
D2	78%	56%	41%	8.42	7	81	810	266.3959229	1019.737	34.57%	61.73%
E2	67%	56%	49%	11.67	4	107	1070	174.0817387	676.4571	57.94%	42.06%
F2	78%	22%	92%	19.23	7	42	420	251.093529	541.333	69.05%	2.38%
F3	89%	78%	80%	22.99	7	31	310	359.1200033	371.4821	48.39%	45.16%
G1	89%	44%	88%	15.09	6	40	400	294.385468	107.2204	0.00%	77.50%
G2	89%	44%	51%	26.77	8	36	360	15.01671149	298.6066	27.78%	72.22%
G3	89%	11%	16%	30.94	4	34	340	170.3998661	95.95578	32.35%	67.65%
H1	67%	67%	28%	25.10	5	41	410	577.2399607	195.4646	97.56%	2.44%
I1	56%	89%	24%	19.10	6	49	490	298.3546061	364.283	34.69%	63.27%
I3	100%	56%	34%	20.99	8	52	520	228.8072128	175.813	46.15%	48.08%
J1	89%	22%	22%	21.90	7	38	380	123.6688355	1100.39	57.89%	34.21%
J2	78%	67%	23%	25.85	7	32	320	134.0514076	1513.873	68.75%	12.50%
K1	89%	56%	93%	29.03	5	20	200	72.59806287	1474.63	20.00%	60.00%
K2	78%	44%	30%	30.74	7	34	340	67.57134814	1628.896	35.29%	58.82%
K3	89%	44%	45%	30.51	6	36	360	93.02929513	1593.412	38.89%	58.33%
M2	67%	67%	63%	37.78	5	18	180	260.6262421	585.442	38.89%	61.11%
M3	78%	67%	34%	37.21	5	20	200	699.819246	776.2355	15.00%	70.00%
N1	89%	67%	75%	22.15	8	50	500	13.88427504	1002.253	46.00%	20.00%
N3	56%	89%	74%	38.36	7	15	150	32.88215057	1287.14	13.33%	80.00%
O1	67%	11%	8%	27.66	6	61	610	104.0835367	99.93174	21.31%	77.05%
P2	33%	67%	61%	19.15	6	40	400	133.1353813	101.3046	55.00%	20.00%
P3	89%	33%	14%	20.95	6	56	560	254.6800306	203.5601	19.64%	78.57%
R2	44%	89%	16%	23.11	5	23	230	475.6244143	80.526	95.65%	4.35%
S1	44%	56%	18%	28.98	4	37	370	249.1195176	48.21284	75.68%	24.32%
T1	67%	22%	36%	30.02	7	41	410	73.7706618	1037.288	43.90%	56.10%
T2	78%	11%	33%	19.57	4	52	520	225.4727661	1034.465	98.08%	1.92%