PENNSYLVANIA GAME COMMISSION
BUREAU OF WILDLIFE MANAGEMENT
PROJECT REPORT

PROJECT CODE NO.:06310

TITLE: Snowshoe Hare Research/Management

JOB CODE NO.:31001

TITLE: Comparison of methods analyzing response of snowshoe hare (*Lepus americanus*) to habitat management in Pennsylvania.

PERIOD COVERED: 1 January 2013 to 30 June 2016

WORK LOCATION: Monroe County

PREPARED BY: Emily S. Boyd

DATE: 2 June 2016

ABSTRACT Snowshoe hare (*Lepus americanus*) winter track surveys were conducted on the in Monroe County, Pennsylvania during winters from 2013-2016. Transects for snowshoe hare tracks were used to determine snowshoe hare relative abundance in response to habitat treatments. Similar to the findings of Gigliotti (2016), snowshoe hares were found to avoid areas that were managed using mowing and prescribed fire from 2009-2015. I recommend continuing transects for snowshoe hare tracks to determine when hares move back into treated areas.

OBJECTIVES

1. Determine relative abundance of snowshoe hares.
2. Determine cover types, stand age, and management history where snowshoes are most abundant.

INTRODUCTION

The snowshoe hare was listed as a species of maintenance concern on Pennsylvania's 2005 State Wildlife Action Plan due to sensitivity to habitat alteration, apparent decline, and potential importance of Pennsylvania's population for gene flow between states to the north and south. Currently, the distribution is thought to be limited to mountainous sections of the northern half of Pennsylvania (Merritt 1987) and small, isolated populations in higher elevations of southern parts of the state (Boyd 2015) in areas where suitable habitats exist (Diefenbach et al. 2005).

Considering the vast range of snowshoe hares throughout North America, vegetative composition of habitat used by hares in different regions can vary greatly. However, hares rely on a few basic habitat characteristics regardless of location. They are typically found in areas with dense vegetation that provides food, thermal cover, and protection from predators especially

during winter (Barta et al. 1989, Belovsky 1984, Berg et al. 2012, Boonstra et al. 1998, Rohner and Krebs 1996, Sievert and Keith 1985, Wirsing et al. 2002a). Vegetative structure is more influential in hare habitat use than vegetative composition (Carreker 1985) and thermal advantage (Gigliotti 2016). The primary threat influencing the existence of snowshoe hares in Pennsylvania likely is loss of suitable habitat and a corresponding lack of suitable habitat connectivity. Early successional habitat is ephemeral by nature and has been decreasing for decades in Pennsylvania (Alerich 1993). The decrease of suitable habitat has led to an increase in fragmentation which has dramatic negative implications for Pennsylvania's snowshoe hare populations.

The length of time that it takes hare populations to become re-established in forests after disturbance is associated with the regenerative capacity of the landscape which is influenced by topographic relief, moisture, and mineral and organic content of the soil (Baumgartner et al. 1984, Koch 1996). Within a harvested stand, conditions for hares often follow a general pattern: 1) initially cover is low and hares are absent; 2) after a few years (around 5 years in Pennsylvania) woody shrubs and small trees regenerate and hares begin to reoccupy stands; 3) hare density peaks when trees are large enough to provide cover and food even during deep snowy winters; and 4) forests mature and hare populations decline as the understory decreases (Abele 2004, de Bellefeuille et al. 2001, Brocke 1975, Conroy et al. 1979, Darveau et al. 1998, Ferron et al. 1994, Ferron et al. 1998, Forsey and Baggs 2001, Gashwiler 1970, Griffin 2004, Litvaitis et al. 1985, Monthey 1986, Newbury and Simon 2005, Potvin et al. 1999, Potvin et al. 2005a, Scott and Yahner 1989, Sullivan and Moses 1986, Telfer 1974, Wolfe et al. 1982).

A recent study in Monroe County, Pennsylvania (Gigliotti 2016) found that snowshoe hares selected for areas of conifers and areas of decadent scrub oak near the edge of stands. Previous research has not found scrub oak to be an important determinant of snowshoe hare habitat use, but this habitat type is not found throughout the majority of snowshoe hare range, nor is it widespread throughout the Commonwealth. Regardless of species, dense shrubs offer visual protection from predators and a source of forage. The importance of a dense understory is highlighted by the fact that the only significant predictor of winter habitat use in a fine-scale analysis was understory cover, with hares avoiding areas with < 20% visual obstruction (Gigliotti 2016).

Regardless of season, Gigliotti (2016) found that hares did not select for open areas, including areas that underwent prescribed burns in the past 1 – 6 years, likely because these areas did not offer beneficial resources to hares. Open areas lacked any sort of visual obstruction from predators and did not have high amounts of forage. Similarly, hares selected against hardwood stands in the winter. During winter hardwood trees do not have foliage which limits the canopy cover and increases avian predation risk. The understory of the hardwood stands were variable but usually only contained smaller ericaceous plants such as blueberry (*Vaccinium spp.*) and sheep laurel (*Kalmia angustifolia*) which do not provide high abundances of winter forage. In contrast, once trees and understory plants leaf out in spring and summer hardwood stands offer greater canopy cover as well as green forage, likely leading to increased use in summer.

Winter track counts have been used to index snowshoe hare habitat use and relative abundance, particularly in the southern range, where densities are low and habitat requirements are poorly understood (Hartman 1960, Litvaitis et al. 1985, Byrne 1998, Murray 2003). However, winter track counts are restricted to periods of snow cover and may suffer from the effects of

weather or other factors influencing track observability (Godbout 1999). Winter track counts are also limited to relaying information about winter habitat use by snowshoe hares.

This study was designed to detect response of snowshoe hares to habitat management treatments including mowing, burning and various silvicultural practices. Knowing how snowshoe hare populations are affected by habitat management practices will improve approaches to habitat management for snowshoe hares.

METHODS

Global Information System (GIS) software was used to randomly create 30 points from which 25 were selected for transect placement. 15 of these transects occurred in areas where habitat treatments of mowing and burning to create scrub oak had been completed and were designated as "optimal" transects and 10 were placed in areas where no habitat management had been completed recently (i.e., mature larch, spruce, and decadent scrub oak) and were designated as "poor" transects. "Poor" and "optimal" designations were used because areas that received habitat treatments will theoretically be better suited for hares once they've regenerated than areas that received no treatment. Of the untreated transects, 5 occurred within decadent scrub oak stands and 5 occurred in mature hardwood stands.

Line transects were one meter wide, followed a 45 degree azimuth, had a minimum length of 100 meters, and were a minimum of 160 meters from neighboring transects. Track surveys were conducted along established transects following fresh snows. When possible, surveys occurred within 24 hours of snows and all transects were surveyed the same day. Annual sampling consisted of 2 sample periods in which all transects were surveyed. The number of sample units per transect was determined by multiplying the length of each transect by the number of surveys conducted each year and dividing by 100. A measure of relative abundance was derived by counting the number of tracks per sample unit ($100m^2$) crossing each transect. Snowshoe hare tracks were counted when they crossed the one meter wide transect perpendicularly. When tracks paralleled but did not cross the transect; only one set of tracks per 160 m was counted. Dolbeer and Clark (1975) found that the approximate diameter of one snowshoe hare's home range, if it was circular shaped, would be approximately 160 m. For all analyses, the numbers of crossing and parallel tracks were combined to give the total tracks per sample unit. Coordinates of hare track encounters were recorded by Global Positioning System (GPS).

Study Area

The study area was in Monroe County, Pennsylvania (Figure 1). The majority of the study area was dominated by xeric oak stands, however, historical changes in fire regimes also resulted in areas of a mosaic of mesic till barrens dominated by decadent scrub oak (*Quercus ilicifolia*) >2 m tall and pitch pine (*Pinus rigida*). Dominant understory species included blueberry (*Vaccinium spp.*), rhodora (*Rhododendron canadense*), teaberry (*Gaultheria procumbens*), and sheep laurel (*Kalmia angustifolia*). Planted stands of mature Norway spruce (*Picea abies*), red pine (*Pinus resinosa*) and European larch (*Larix decidua*) made up a small portion of the study area (Figure 1; Gigliotti 2016).

Portions of the study area have been involved in a prescribed burn program which began in 2009. The majority of the burning occurred in the summers of 2012, 2013, and 2014 with burn acreage consisting of 190 ha, 241 ha and 162 ha, respectively. The resulting burned patches were dominated by low scrub oak <1 m tall, blueberry, and bracken fern (*Pteridium aquilinum*) and contained very few trees >5 m tall (Gigliotti 2016).

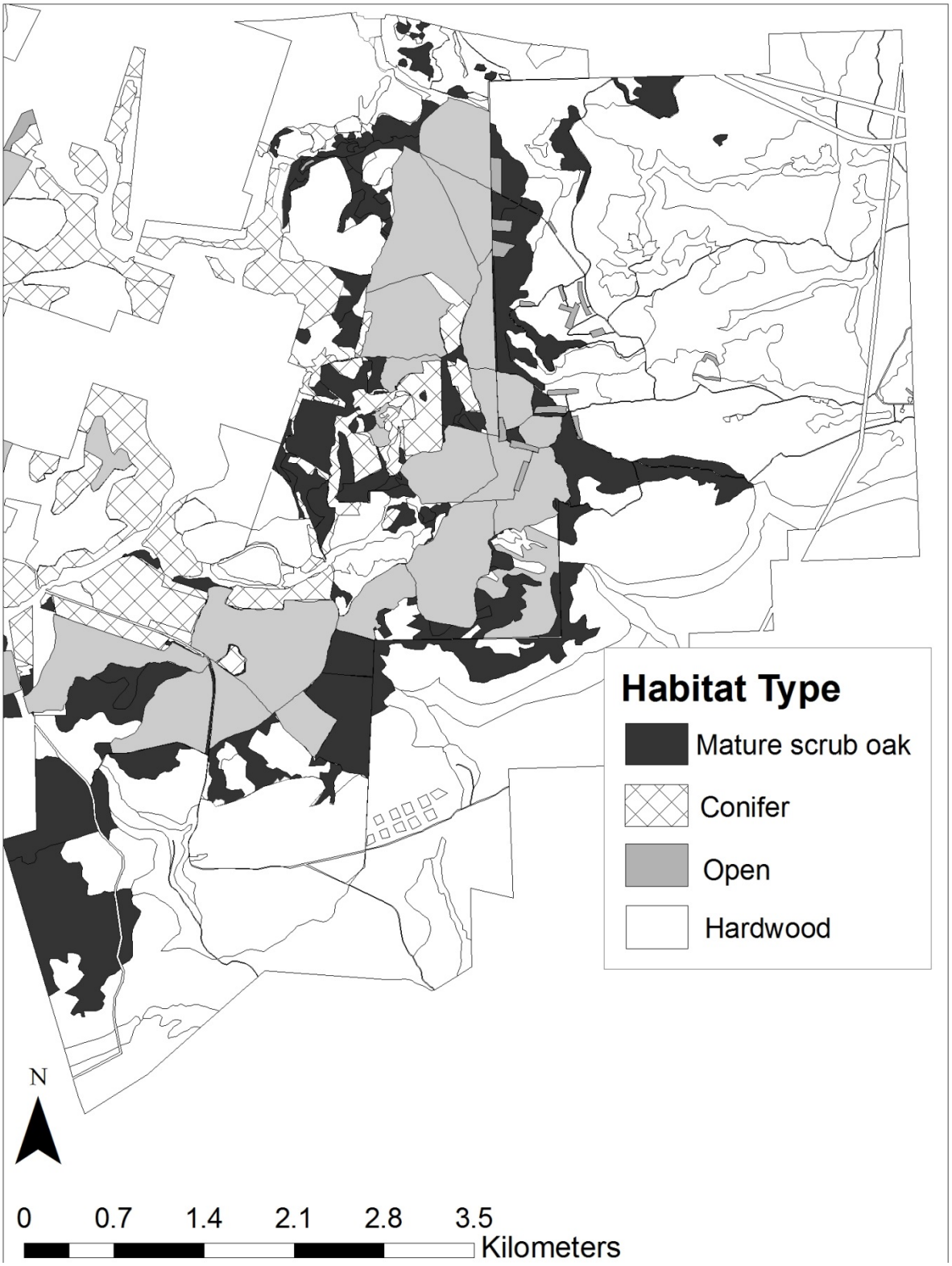

Figure 1: Map of dominant habitat types within the snowshoe hare study area, Monroe County, Pennsylvania (Gigliotti 2016).

RESULTS

Transects were conducted twice per winter season from 2013-2016. A total of 5,000m^2 was sampled per year resulting in 20,000m^2 sampled to date. Every attempt was made to conduct transects as soon as possible after a snow event, but always within 48 hours. Snow conditions consisted of fluffy fresh, packable, or crusty and were 0-12+ inches in depth. The number of snowshoe hare tracks crossing transects was combined to give the total tracks per sample unit by transect.

The highest relative abundance has occurred on poor transects (average RA = 0.25tracks/m), in areas that did not receive habitat management treatments in all years except 2013 (Figure 2). The highest relative abundance (RA = 0.475tracks/m) occurred in 2016 on poor transects. The lowest relative abundance (RA = 0.0167 tracks/m) occurred in 2014 on optimal transects. The average relative abundance for optimal transects over the four years was (RA = 0.1 tracks/m).

Of the 3 cover types where transects exist, relative abundance of snowshoe hares was highest overall in decadent scrub oak stands (RA=0.425), followed by burn units (RA=0.125), while mature hardwoo d stands had the lowest RA (RA=0.075; Figure 3).

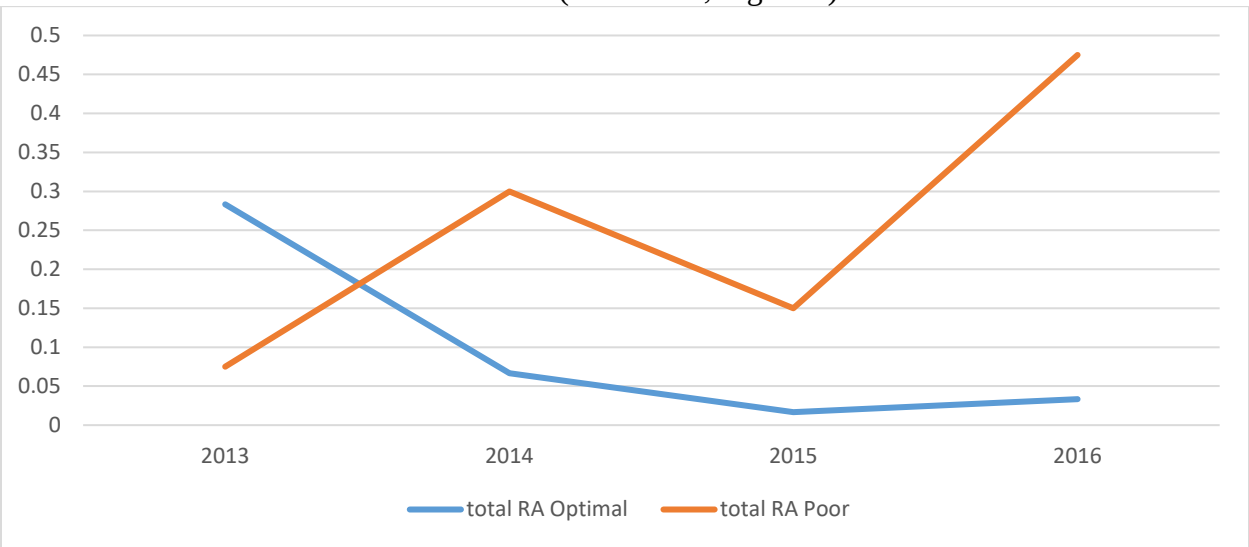

Figure 2: Relative abundance of snowshoe hares in managed (optimal) and unmanaged (poor) stands in Monroe County, Pennsylvania.

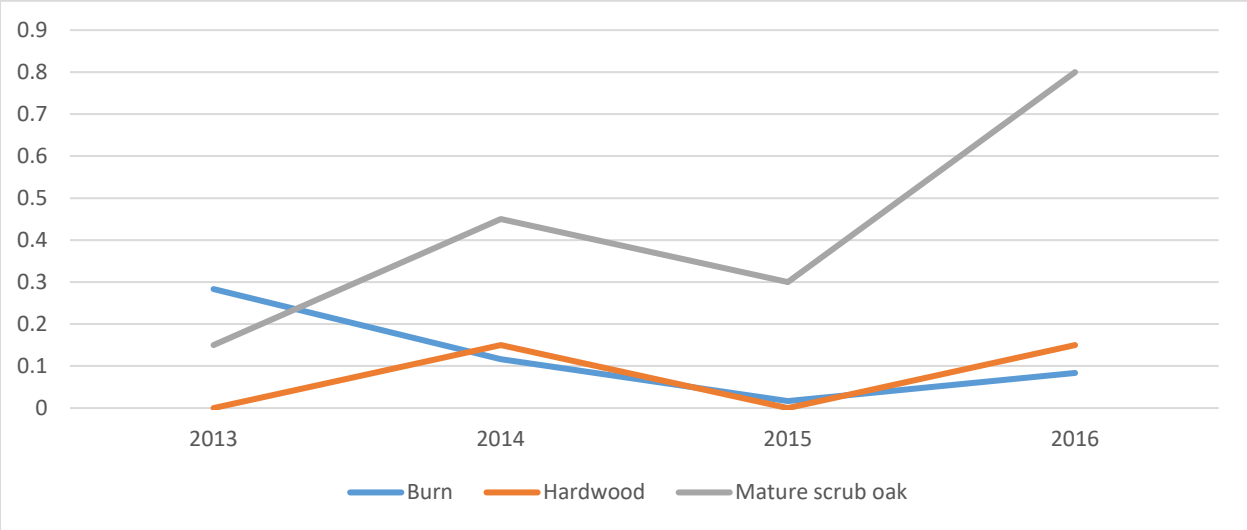

Figure 3: Average relative abundance of snowshoe hares in each cover type by year in Monroe County, Pennsylvania.

DISCUSSION

The finding that hares do not prefer open habitats is similar to hare habitat preferences found by Gigliotti (2016) as well as in other areas of the hare's range (Pietz & Tester 1983; Lewis *et al.* 2011). Regardless of the general habitat type, open areas do not provide substantial forage and protection from predators, especially in the winter. Predation rates on snowshoe hares have been found to be higher in areas with low understory density compared to areas with dense understories (Sievert & Keith 1985). The burned scrub oak is still in the process of maturing and does not yet provide sufficient overhead cover to offer concealment from predators.

Gigliotti (2016) found that in both winter and summer, snowshoe hares did not use open areas, including areas that have recently undergone prescribed burning. Although these large areas were burned to provide early-successional habitat for hares and other early-successional associated species, after 6 years they are still not being used by snowshoe hares due to the lack of dense understory vegetation. The lack of use in recently burned areas agrees with research conducted at northern latitudes showing that hares do not use stands immediately after fires and might not significantly re-occupy burned areas up to several decades post burn (Allard-Duchêne et al., 2014; Cheng et al., 2015). The success of any future prescribed burns need to be examined on a longer time scale to evaluate the effectiveness of burns in creating preferred hare habitat.

In a habitat matrix including decadent scrub oak and conifers, hares are able to benefit from the forage and understory cover of scrub oak as well as the dense canopies of conifer stands. In addition, movement between habitat types might be linked to diel cycles, because hares have been found to select for areas with dense vegetation during the daytime when they are typically less active (Feierabend & Kielland, 2014).

A similar transect study has been conducted during the winters of 2013-2016 in the northwest region of Pennsylvania. A different classification of optimal and poor transects was used. Stands that contained a basal area (BA) $\geq$ 80 square feet were categorized in the following

size classes: size 1 (dominant and co-dominant trees > 18” Dbh (diameter at breast height) and > 50% stocked), size 2 (12-18” Dbh and > 50 % stocked), size 3 (6-12” Dbh and > 50% stocked), and size 4 (<6” Dbh and >50% stocked). Stands that contained a BA < 80 but > 48 were categorized as size 5, if >18” Dbh and < 50% stocked (indicative of a shelterwood harvest). Hoppe (2016) established three transects in all strata except size 2 and size 1, in which he established four and five respectively (due to different sizes of forest stands). Optimal transects at this site are those that occur in timber size class 3 and smaller. Previous analysis in Warren County found that hares had the highest relative abundance in those timber size classes. Likewise, transects that occurred in areas with highly dense woody stem vegetation, classified as optimal at this study site, experienced higher relative abundance of snowshoe hare tracks than transects that had been classified as poor (Figure 4).

The results of these transect studies contribute to a greater understanding of snowshoe hare habitat relationships throughout the extent of their range. Even though snowshoe hares occupy different forest types and exhibit different population dynamics based on their geographic location, populations usually select for areas with high vegetation cover, indicating the range-wide importance of this habitat factor. By concentrating on structural determinants of optimal hare habitats rather than general forest type or dominant species, management strategies can be developed over the diversity of forests types throughout the extent of the hare’s range to create and maintain habitat for this species in the future.

RECOMMENDATIONS

1. It would be beneficial to continue to monitor snowshoe hare habitat use in response to habitat management treatments. The habitat treatments are still regenerating. Continuing the transect study will allow managers to have a better understanding of how long it takes for hares to begin using treated areas again post treatment enabling them to create the most beneficial habitat management matrices for hares. Although research has been conducted on post-fire snowshoe hare habitat use in other areas of the country, the scrub oak-pitch pine habitat is unique to the northeastern United States and likely regenerates differently, leading to differences in post-fire habitat use. Some State Game Land plans allow for only a 5 year treatment cycle for scrub oak and pitch pine which these studies have found to be too short for suitable snowshoe hare habitat. These treatment regimens should be lengthened to at least 15 years in areas that are managing for snowshoe hares.

2. Currently no transects exist in conifer cover types, the cover type which is often cited as most predominantly used by hares. Placement of 5 transects in this cover type would provide valuable insight into the relative abundance of hares in cover types across the landscape as well as create equal sample sizes between transects that occur in treated and untreated areas.

3. Further studies using transects will be helpful in learning more about the spatial arrangement of future habitat treatments. Gigliotti (2016) found that hares preferred areas near stand edges and utilized several different habitat types, indicating that interspersion of small habitat patches are important for hares. Future research could focus on creating different treatment patch sizes and monitoring subsequent snowshoe hare habitat use to determine the optimal habitat configuration that could inform the size and placement of prescribed burns or timber harvesting. Gigliotti (2016) found canopy cover to be an important predictor of snowshoe hare habitat use for some hares in both winter and summer, even when the scrub oak has reached maturity there may

not be enough canopy cover for preferential use by hares due to the lack of taller trees. It would be beneficial to approach future prescribed burns in an experimental framework by altering the amount of basal area retained as reserve trees in separate burn units and assessing snowshoe hare habitat use in relation to canopy cover as the understory regenerates.

4. Creation of a similarly designed transect study in McKean, Cameron, and Elk Counties of Pennsylvania would provide additional insight into the habitat use of snowshoe hares. This area has been identified and recognized as having thousands of acres of variously aged timber management regimes. Snowshoe hare populations in this area are thought to be expanding versus the possible sink population that exists in Warren County.

LITERATURE CITED

Abele, S.L. 2004. Premature thinning, where do the hares go? Responses of snowshoe hares to pre-commercial forest thinning. M.S. Thesis. University of Idaho, Moscow, ID.

Alerich, Carol L. 1993. Forest Statistics for Pennsylvania-1978 and 1989. Resource Bulletin NE-126. U.S. Department of Agriculture. Forest Service, Northeastern Forest Experiment Station. Radnor, Pennsylvania, USA.

Allard-Duchêne, A., Pothier, D., Dupuch, A. & Fortin, D. 2014. Temporal changes in habitat use by snowshoe hares and red squirrels during post-fire and post-logging forest succession. Forest Ecology Management. 313, 17–25.

Barta, R.M., L.B. Keith, and S.M. Fitzgerald. 1989. Demography of sympatric arctic and snowshoe hare populations: An experimental assessment of interspecific competition. Canadian Journal of Zoology 67:2762-2775.

Belovsky, G.E. 1984. Snowshoe hare optimal foraging and its implications for population dynamics. Theoretical Population Biology 25:235-264.

Berg, Nathan D., Gese, E. M., Squires, J. R., and Aubry, L. M. 2012. Influence of forest structure on the abundance of snowshoe hares in western Wyoming. The Journal of Wildlife Management 76(7):1480-1488.

Boonstra, R., D.Hik, G.R. Singleton, and A. Tinnikov. 1998. The impact of predator-induced stress on the snowshoe hare cycle. Ecological Monographs 79:371-394.

Boyd, Emily S. 2015. Snowshoe hare and cottontail rabbit research/management. Wildlife Management Annual Report. Pennsylvania Game Commission, Harrisburg PA.

Brocke, R.H. 1975. Preliminary guidelines for snowshoe hare habitat management in the Adirondacks. Transactions of the Northeast Fish and Wildlife Conference 32:46-66.

Byrne, G. 1998. A Colorado winter track survey for snowshoe hares and other species. Colorado Division of Wildlife, Glenwood Springs.

Carreker, R. G. 1985. Habitat suitability index models: Snowshoe hare. U.S. Fish Wild1ife Service Biology Rep. 82(10.101). 21 pp.

Cheng, E., Hodges, K.E. & Mills, L.S. 2015. Impacts of fire on snowshoe hares in Glacier National Park, Montana, USA. Fire Ecology. 11, 119–136.

Conroy, M.J., L.W. Gysel, and G.R. Dudderar. 1979. Habitat components of clear-cut areas for snowshoe hares in Michigan. Journal of Wildlife Management 43:60-690.

Darveau, M., J. Huot, and L. Bélanger. 1998. Riparian forest strips as habitat for snowshoe hare in a boreal balsam fir forest. Canadian Journal of Forest Resources 28:1494-1500.

de Bellefeuille, S., L. Bélanger, J. Huot, and A. Cimon. 2001. Clear-cutting and regeneration practices in Quebec boreal balsam fir forest: effects on snowshoe hare. Canadian Journal of Forest Resources 31:41-51.

Diefenbach, D.R., S. Rathbun, and J. K. Vreeland. 2005. Distribution and coarse-scale habitat association of snowshoe hares in Pennsylvania (State wildlife grant final report). Pennsylvania Game Commission, Harrisburg, Pennsylvania.

Dolbeer, R. A., and W. R. Clark. 1975. Population ecology of snowshoe hares in the central Rocky Mountains. Journal of Wildlife Management 39:535-49.

Feierabend, D. & Kielland, K. 2014. Movements, activity patterns, and habitat use of snowshoe hares (Lepus americanus) in interior Alaska. Journal of Mammaology. 95: 525–533.

Ferron, J., F. Potvin, and C. Dussault. 1994. Impact < court terme de l'exploitation forestiPre sur le liPevre d'AmJrique en forLt boreJale. MinistPre de l'Environnement et de la Faune, Servie de la faune terrestre, Quebec.

Ferron, J.F., F. Potvin, and C. Dussault. 1998. Short-term effects of logging on snowshoe hares in the boreal forests. Canadian Journal of Forest Research 28:1335-1343.

Forsey, E. S. and E. M. Baggs. 2001. Winter activity of mammals in riparian zones and adjacent forests prior to and following clearcutting at Copper Lake, Newfoundland, Canada. Forest Ecology and Management 145:163-171.

Gashwiler, J.S. 1959. Small mammal study in west-central Oregon. Journal of Mammalogy 40:128-139.

Gigliotti, L.C. 2016. Ecology, habitat use, and winter thermal dynamics of snowshoe hares in Pennsylvania. M.S. Thesis. Pennsylvania State University. University Park, PA.

Godbout, G. 1999. Determination de la presence d'um cycle de population du Lièvre d'amerrique (Lepus americanus) au Quebec et des methods de suivi applicable a cette espece. Faune et Parcs, Quebec City, QC.

Griffin, P.C. 2004. Landscape ecology of snowshoe hares in Montana. Ph.D. Dissertation. University of Montana, Missoula, MT.

Hartman, F.H. 1960. Census techniques for snowshoe hares. M.S. Thesis, Michigan State University, East Lansing, MI.

Hoppe, Timothy T. 2016. Snowshoe hare research/management. Wildlife Management Project Job Report. Pennsylvania Game Commission, Harrisburg PA.

Lewis, C.W., Hodges, K.E., Koehler, G.M. and Mills, L.S. 2011. Influence of stand and landscape features on snowshoe hare abundance in fragmented forests. Journal of Mammalogy. 92: 561–567.

Litvaitis, J. A., J. A. Sherburgne, and J. A. Bissonette. 1985. Influence of understory characteristics on snowshoe hare habitat use and density. Journal of Wildlife Management 49:866-873

Merrit, J.F. 1987. Snowshoe hare. Pages 129-133 *in* Guide to Mammals of Pennsylvania. University of Pittsburgh Press, Pittsburgh, Pennsylvania, USA.

Monthey, R.W. 1986. Responses of snowshoe hares, *Lepus americanus*, to timber harvesting in northern Maine. Canadian Field Naturalist 100:568-570.

Murray D. L. 2003. Snowshoe hare and other hares. Pages 147-175 *in* Wild Mammals of North America, Vol II. G. A, Feldhamer and B. Thompson, eds. Johns Hopkins University Press, Baltimore, Maryland, USA.

Newbury, T.L. and N.P.P. Simon. 2005. The effects of clearcutting on snowshoe hare (*Lepus americanus*) relative abundance in central Labrador. Forest Ecology and Management 210:131-142.

Potvin, F., R. Courtois, and L. Belanger. 1999. Short-term response of wildlife to clear-cutting in Quebec boreal forest: multiscale effects and management implications. Canadian Journal of Forest Resources 29:1120-1127.

Potvin, F., L. Breton, and R. Courtois. 2005. Response of beaver, moose, and snowshoe hare to clear-cutting in a Quebec boreal forests: a reassessment 10 years after cut. Canadian Journal of Forest Resources 35:151-160.

Pietz, P.J. and T.R. Tester. 1983. Habitat selection by snowshoe hares in north central Minnesota. Journal of Wildlife Management 47:686-696.

Rohner, C. and C.J. Krebs. 1996. Owl predation on snowshoe hares: consequences of antipredator behaviour. Oecologia 108:303-310.

Scott, D.P. and R.H. Yahner. 1989. Winter habitat and browse use by snowshoe hares, *Lepus americanus*, in a marginal habitat in Pennsylvania. Canadian Field-Naturalist 103:560-563.

Sievert, P.R. and L.B. Keith. 1985. Survival of snowshoe hares at a geographic range boundary. Journal of Wildlife Management 49:854-866.

Sullivan, T.P. and R.A. Moses. 1986. Demographic and feeding responses of a snowshoe hare population to habitat alteration. Journal of Applied Ecology 23:53-63.

Telfer, E.S. 1974. Logging as a factor in wildlife ecology in the boreal forest. Forest Chronicle 50:186-189.

Wirsing, A.J., T.D. Steury, and D.L. Murray. 2002. A demographic analysis of a southern snowshoe hare population in a fragmented habitat: evaluating the refugium model. Canadian Journal of Zoology 80:169-177.

Wolfe, M. L., N. V. Debyle, C. S. Winchell, T. R. McCabe. 1982. Snowshoe hare cover relationships in northern Utah. Journal of Wildlife Management 46:662-670.

APPENDIX

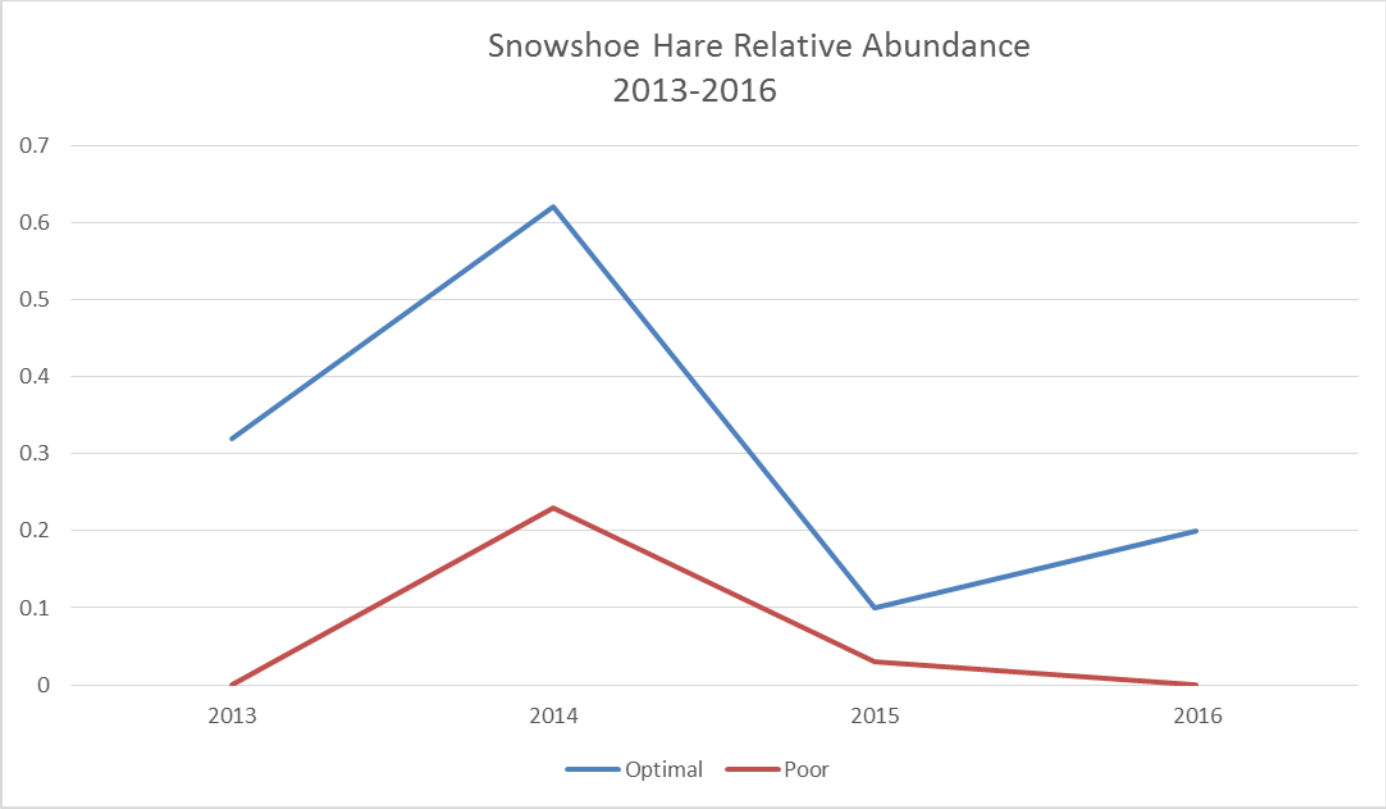

Figure 4:Relative abundance of snowshoe hares in Warren County, PA. Optimal transects occurred in timber size class 3 and smaller. Timber stands greater than size 3 were classified as poor.