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Northern Saw-whet Owl (Aegolius acadicus) Abundance and Distribution in the Southern

Appalachian Mountains of Northeast Tennessee

A thesis

presented to

the faculty of the Department of Biological Sciences

East Tennessee State University

In partial fulfillment

of the requirements for the degree

Master of Science in Biology

by

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August 2014

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ABSTRACT

Northern Saw-whet Owl (*Aegolius acadicus*) Abundance and Distribution in the Southern Appalachian Mountains of Northeast Tennessee

by

John P. McCormick

Little is known about the distribution, abundance, or life histories of the Northern Saw-whet Owl (*Aegolius acadicus*) in the Southern Appalachian Mountains of Northeast Tennessee. This study relied upon the Pennsylvania Protocol of audio playback of a Northern Saw-whet Owl call to monitor for owl presence at various areas above 3,500 feet in elevation. Owls were found at multiple areas in Northeast Tennessee, including Roan Mountain, Unaka Mountain, Rocky Fork, and the Pond Mountain Area. Statistical analysis revealed that these owls were not limited by habitat, showing equal presence in Hardwood habitats along with Spruce and/or Fir habitats. Data also revealed that the owls showed a statistical preference for higher elevations at the surveyed sites. The habitat and elevation preferences, coupled with the locations where owls were detected, allow for a greater understanding of the life histories and population distribution of the Northern Saw-whet Owl in the Southern Appalachian Mountains.

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CHAPTER 1

INTRODUCTION

Background of Northern Saw-whet Owl

While it may seem uncommon to the casual observer, the Northern Saw-whet Owl (*Aegolius acadicus*) is a well-established species in North America. These small owls are common in the forests of the Northern United States and in Southern Canada. Saw-whets can be distinguished by the brown upper parts of their body streaked with white. Similarly, the underside of the bird is white with heavy brown streaking in the feathers. Their facial disk is anchored by golden yellow eyes above a black bill in adults (Peterson 2010). The juvenile owl can be confused with a juvenile Boreal Owl (*Aegolius funereus*). However, the Boreal Owl's range does not extend south of Canada into the Eastern United States, making any perplexing juveniles most likely a Northern Saw-whet Owl (Alsop 2002). One of the most distinguishing features of the owl is its relatively small size. The Saw-whet Owl is one of the smallest owls in North America, comparable to the American Robin (*Turdus migratorius*). It exhibits reverse sexual size dimorphism with females' average weight being 100 grams while the males weigh in at 75 grams. Both sexes measure an approximate length of 20 cm (Carpenter and Carpenter 1993; Cannings 1993).

Saw-whets actively hunt throughout the night. These birds become active approximately one half hour after sunset until one half hour before sunrise. During daylight hours, the owl roosts in tree cavities, trees, and shrubs with thick cover (Forbes and Warner 1974). These owls hunt from low perches, looking for small rodents, birds, or available insects (Alsop 2002). The primarily nocturnal behavior, small size of the owl, and the dense foliage of roosting sites makes

any appearance of a Saw-whet rare to the casual observer. Indeed it is difficult to obtain any substantial record of Northern Saw-whet Owl presence without directly targeting and searching for this species. This secluded nature of owls also creates many difficulties when it comes to the identification of the owl's presence in an area. Compounding the difficulties of locating the Sawwhet Owl is the fact that they restrict calls to the breeding season—late winter into spring. The call is a unique and monotonous "toot-toot" vocalization that can carry upwards of half a mile depending upon surrounding terrain. The singing decreases later in the breeding season after a mate has been attracted to the area (Alsop 2002). While polygyny has been recorded in the Northern Saw-whet Owl, the occurrences of a male raising two clutches with separate females are rare (Marks et al. 1989). Once mating has occurred, the frequent calling becomes more sporadic as the males increase their attention on hunting and providing for their young. Mated males do exhibit a reduced response to soliciting calls making it increasingly difficult to access an owl's presence in a given area. Even with its relative abundance in the north, the solitary nature of the owl leaves much to be learned about the intricacies of the owl's habits and biology (Cannings 1993). New behaviors of Saw-whets are continually being discovered in the void of knowledge that currently exists regarding the species (Boyd 2009).

Breeding Box Usage

The Northern Saw-whet Owl is known to roost and nest in abandoned woodpecker nesting cavities, primarily those of the Pileated Woodpecker (*Dryocopus pileatus*) or the Northern Flicker (*Colaptes auratus*) (Cannings 1993). Saw-whet Owls are forced to compete for these secondary cavity nests with various woodpecker species as well as with Red Squirrels (*Tamiasciurus hudsonicus*) that also use the available cavities (Barb 1995). Saw-whet Owls will

accept artificial nest cavities for the purpose of rearing of chicks when there is a lack of secondary cavity nesting sites. The nesting boxes used for this purpose have the same approximate dimensions as those commonly used for wood ducks (Alsop 2002).

Mark Barb, an East Tennessee State University graduate student, conducted a study in 1995 that involved the placement and monitoring of nesting boxes for Saw-whet Owls placed on trees on Roan Mountain and Unaka Mountain. Thirty-nine nesting boxes were used throughout elevations higher than 3,500 feet on the two mountains. Of these 39 boxes, three confirmed nestings of Saw-whet Owls occurred during the second year of the study (Barb 1995). Similarly, there an ongoing project that incorporates nesting boxes for Saw-whets at Big Bald on the Tennessee/North Carolina border (Big Bald Banding 2011). Of the 28 boxes placed at Big Bald, there has been evidence that two boxes may have been used by Saw-whet Owls for nesting. In both experiments, no results were seen in the first year of the nesting box project. These past experiences show that the Southern Appalachian population of Saw-whet Owls will accept established artificial cavities for nesting.

Northern Saw-whet Owl Range

One solid area of knowledge regarding the Northern Saw-whet Owl is their range (see Figure 1). The Northern Saw-whet Owl can be found as a wintering resident in a majority of the continental United States (Ridgely et al. 2003). They can also be found as a permanent resident along most of the United States and Canadian border, branching southward along the higher conifer zones of the Rocky Mountains and extending from the southeastern edge of Alaska down through the western states of North America into Mexico (Ridgely et al. 2003). Aside from the continuous range, there are two pockets of year-round residency in the Eastern United States. The first location is in the Allegheny Plateau along the West Virginia border. The second extends through the Southern Appalachian Mountains along the Tennessee and North Carolina border, extending northwards into the southern tip of Virginia. Northern Saw-whet Owls are sympatric with several other owl species throughout this range, notably with Eastern Screech-Owls (*Megascops asio*). There is slight segregation between saw-whets and screech-owls due to habitat preference as the Eastern Screech-Owl prefers a more southern-type forest edge (Swengel 1987a). However the range of the owls does overlap and the two species will respond to vocalizations of the other.

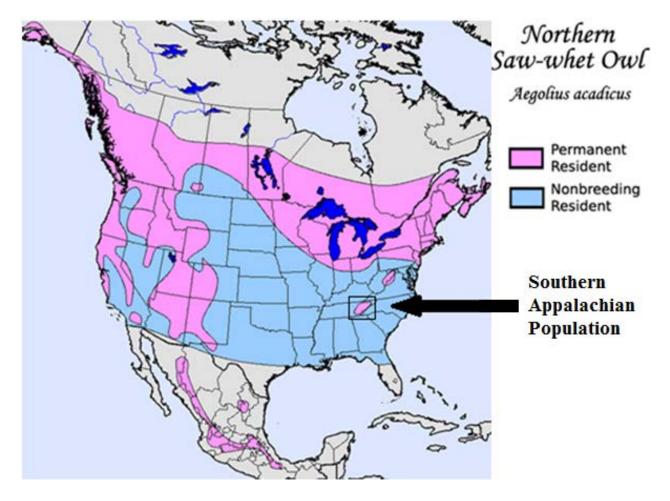


Figure 1. Distribution of the Northern Saw-whet Owl throughout North America (adapted from Ridgley et al. 2003). This figure also indicates the disjunct Southern Appalachian Population.

Southern Appalachian Population

The Southern Appalachian "island" is the southernmost range of the Northern Saw-whet Owl east of the Mississippi River. It has been hypothesized by Tamashiro (1996) that these two islands are the glacial relicts of a time when the Southern Appalachian Mountains mirrored the environment that can be seen in the northern range of Saw-whets today. Indeed, it has been noted that the Saw-whet Owls of this Southern Appalachian disjunct are morphologically distinguishable from the other populations of Saw-whets (Tamashiro 1996). Tamashiro went as far as to hypothesize that the Southern Appalachian Saw-whet might be a genetic reservoir in respect to the other populations of Saw-whet Owls. A recent study also showed migrating Sawwhets flying south to their wintering ground usually avoid the Southern Appalachian Mountain range, preferring to use a corridor along the Atlantic coast (Beckett and Proudfoot 2011). This potential lack of breeding, coupled with Tamashiro's hypothesis of the Southern Appalachian population being a genetic reservoir, leads to an interesting question as to how much importance should be assigned to studying the present owl population in Southern Appalachia.

Even with the interesting queries raised by the Southern Appalachian population of Sawwhets, little research has been conducted on the Southern Appalachian population. A majority of the work published regarding Saw-whet Owls are studies that have occurred in the Northern United States and Canada where these owls are more abundant. This work has shown that Sawwhets accept a wide variety of habitats in the North and Western ends of their range (Cannings 1993). The owls can be found in most woodland habitats and in most forest types throughout their range (Johnson and Anderson 2003). The owls can be found in coniferous forests by riparian zones in the western United States. This preference for coniferous forests is also shown by higher bird density in coniferous forests at moderate elevations and latitudes (Cannings 1993).

The preference for coniferous forests has been associated with the Saw-whet Owls in the Southern Appalachian population. The current consensus among birders in the Southern Appalachian region is that a person must travel to the higher elevations to the Spruce-Fir habitat in order to encounter a Northern Saw-whet Owl during its breeding season (Alsop 1991; McGuiness pers. com.; Somershoe pers. com.). This sentiment seems to be verified as a majority of the encounters with Saw-whets during the early spring months occurs at elevations that exceed 4,500 feet. Almost all of the work conducted on Saw-whet Owls in the Southern Appalachians has been focused on a few areas: namely Unaka Mountain and Roan Mountain on the Tennessee/North Carolina border as well as Grandfather Mountain, Mount Mitchell, the Black Mountains, and the Balsam Mountains of North Carolina (Barb 1995; Cockerel 1997; Milling et al. 1997; Tamashiro 1996; Williams 2003).

The lack of study locations can be partly attributed to the previously mentioned notion that Saw-whet Owls are constrained by their habitat preference. The owls have seemed to limit their breeding range to the spruce-fir habitat through the spruce-fir/upper northern hardwood habitat. Extensive spruce-fir forests of this region are almost exclusively above 1,500 m (5,000 feet) (Simpson et al. 1972). There are also Northern Saw-whet Owls that have been recorded breeding in northern hardwoods with no spruce-fir component (Somershoe pers. com.) A comprehensive study conducted by Milling et al. (1997) found no Saw-whet Owls below 4,000 feet throughout the mountains of North Carolina despite the study focusing over 25% of its time on lower elevation sites.

There have been unconfirmed reports by timber crews of encounters with Northern Sawwhet Owls as low as 3,500 feet in the summer (McGuiness pers. com.). Other sightings of Sawwhets below 3,500 feet are attributed to winter migrations from higher latitudes. One noteworthy

confirmed Northern Saw-whet Owl occurred on 3 May 2014. This bird was identified by Joe McGuinness during the spring bird count of 2014. The bird was located on a gap near the headwaters of Irishman's Branch, a stream located to the east of the city of Unicoi (McGuinness pers. com.). This bird was heard at an elevation of 2,640 feet, almost 900 feet lower than any other confirmed Saw-whet during their breeding season. At the time of this writing, there is still no explanation as to why this owl was in an area that was much lower than expected. Aside from this anomaly, past research supports the idea that during the breeding season, Saw-whets appear to be confined to higher elevations.

Habitat Loss in the Southern Appalachian Mountains

One of the chief concerns for the Southern Appalachian population of Saw-whet Owls is a potential reduction in owl numbers caused by to habitat loss. Indeed, the Southern Appalachian Mountains have historically experienced habitat loss from logging. In the 1950s, the introduction of the balsam woolly adelgid (*Adelges piceae*) led to another risk factor. In the subsequent years, major tracts of conifer woods have been devastated by this insect (USDA 2006). The study of Milling et al. (1997) compared their data collected in mid-1990 with surveys from the 1970s and showed that Saw-whet Owl populations did not seem to be greatly impacted by the adelgid presence. However, it has been over 15 years since the publication of Milling's data. The question arises that the combination of adelgid with factors such as global climate change and air pollution (including habitat loss from ozone and acid rain) has had any effect on the Saw-whet population in Appalachia.

Project Goals

There are worries that the Northern Saw-whet Owl population in the Southern Appalachian Mountains has been declining due to a habitat reduction from logging, climate change, air pollution, and tree deaths from adelgids (Milling et al. 1997; Somershoe pers. com.). There exists a pressing need for more information regarding Saw-whet Owl populations along the entire eastern edge of Tennessee. As shown by the range map, the Southern Appalachian population is one of two disjunct populations in the Eastern United States and this population is the lowest latitude that Northern Saw-whet Owls can be found east of the Mississippi River. This seclusion coupled with the lack of major interactions between the Southern Appalachian population and owls migrating from the north of the range lead to a population that may become more genetically distinct. The possibility that the Southern Appalachian population is a genetic reservoir for Saw-whet Owls motivates the need for more complete information regarding this species in Tennessee.

Due to loss of habitat (from the balsam woolly adelgid and the relegation of conifer tree line to higher elevations due to climate change), less of the Saw-whets' preferred habitat of Spruce and/or Fir and spruce is available to them. In this study I intend to show that the Northern Saw-whet Owl population of the Southern Appalachians is being forced to change its habitat to include the northern hardwood habitat areas overtaking its historical habitat. If no transition away from their reduced habitat is being made, then the owl may be subjected to increased pressures due to higher competition for resources and nesting sites. This project presents information regarding what habitat the Saw-whet Owls are occupying and at what elevations the current Saw-whet Owl population has been detected.

Hypotheses

1. Northern Saw-whet Owls will be present in a multitude of areas in Eastern Tennessee over 3,500 feet in elevation.

In this study I sought to incorporate all accessible and suitable habitats in the Appalachian Mountains of Tennessee to provide a clear picture of Northern Saw-whet Owls and their location throughout the state. In the past, efforts have been made to document this owl's presence in the state of Tennessee. However, these efforts have mainly focused upon searching areas that have had confirmed records of Northern Saw-whet Owls. No effort has yet been made to see the total distribution of Northern Saw-whet Owls throughout suitable areas in Tennessee. By recording all spots surveyed, including those with and without previous evidence of owl presence, this study will indicate the distribution of owls across all survey sites.

2. Northern Saw-whet Owl presence will be influenced more by elevation than by habitat type.

In this study I sought to discover the distribution of Saw-whet Owls throughout the differing habitats along Appalachian Mountains in eastern Tennessee. Past efforts have mainly found owls located in Spruce-Fir or Spruce habitats. However, there have been numerous accounts that also place Saw-whets in Northern Hardwood habitats. Northern Hardwoods with no Spruce or Fir component will be assessed along with the Spruce and/or Fir habitats that have been studied in the past. The Northern Saw-whet Owl distribution among these habitat types will provide information upon the habitat preference of the owl.

CHAPTER 2

MATERIALS AND METHODS

Project Study Area

In light of the fact that most of the previous information gathered has been geographically limited, this project's main purpose was to gather baseline information on the presence of breeding Northern Saw-whet Owls in the mountains of Tennessee. This information will contribute to the understanding of abundance, population size, distribution, and habitat usage of the Southern Appalachian population of Northern Saw-whet Owls.

This study was a part in a statewide survey commissioned by the Tennessee Wildlife Research Agency (TWRA) in order to determine the presence or absence of Northern Saw-whet Owls throughout the state of Tennessee. The study encompassed areas that have already been surveyed, notably Roan Mountain and Unaka Mountain, while also including additional areas in the North and South Cherokee National Forest. A list of these new locations can be found in Table 1 below.

In order to cover such an expanse of land, the overall project was broken into different sections. The South Cherokee National Forest areas were covered by Danielle Floyd at University of Tennessee Chattanooga. My research focused upon the North Cherokee National Forest Areas (areas 1 through 7 in Figure 2 below). This area ran from the Northeastern tip of Tennessee down south through Greene County (indicated by the shaded row in Table 1). The Great Smoky Mountain National Park area was scheduled to be covered by various birding groups in the Great Smoky Mountain area. However, a collaborative effort with these groups was not able to be organized in time for this two-year project.

Areas of Interest	Potential Specific Areas	Counties	Figure 2
	-Shady Valley Area	- Johnson	- 1/2/3
	-Holston Mountain	- Sullivan/Carter	- 2
North Cherokee	-Pond Mountain Area	- Carter	- 4/5
National Forest	-Unaka Mountain	- Unicoi	- 5/6
	-Roan Mountain	- Carter	- 5
	-Rocky Fork	- Unicoi	- 6/7
Great Smoky	-Suitable elevations	-Cocke, Haywood,	- 8,9,10,11
Mountain National Park	-Suitable elevations	Blount, Swain, Sevier	
	-Whigg Meadow	- Monroe	- 12/13
	-Cherohala Skyway	- Monroe	- 12/13
South Cherokee	-Beaver Dam Bald	- Monroe	- 12/13
National Forest	-Wauchessi Mountain	- Monroe	- 12/13
	-Little and Big Frog	- Polk	- 14
	Mountain Wilderness Area		

Table 1: List of areas focused on in research

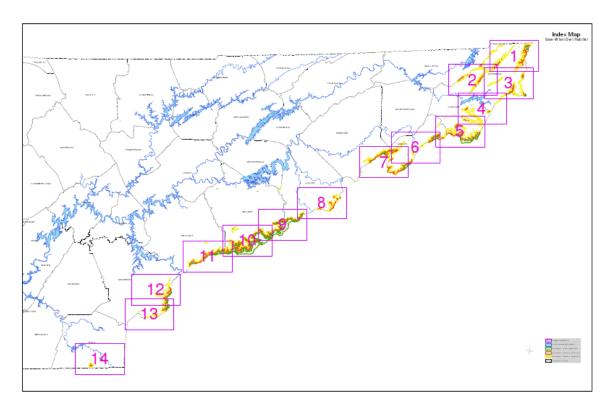


Figure 2: Reference map of East Tennessee areas surveyed (provided by TWRA)

Additional topographic maps for the specific sectors in Figure 2 are located in Appendix A.

GIS and topography maps supplied courtesy of Tennessee Wildlife Resource Agency (TWRA) and the United States Forest Service (USFS) were used to determine areas north of Cocke County, Tennessee, suitable to be surveyed during this project (see Appendix A). The areas that were surveyed encompassed elevations above 3,500 feet. This minimum elevation had been determined because it is the lowest elevation where Northern Saw-whet Owls are expected to be during their breeding season. Milling's study in 1997 found no Saw-whet Owls below 4,000 feet in elevation. Special attention was given to areas above 4,500 feet in elevation during the 2013 field season, while the 2014 field season sought to expand this focus to areas that ranged from 3,500 feet to 4,500 feet.

Nightly surveys were conducted to determine the presence of Northern Saw-whet Owls throughout Tennessee. These surveys were conducted by following the Pennsylvania Protocol of audio playback recording to determine the presence of Saw-whets. Efforts were made to conduct surveys on a vast majority of suitable nights, preferably clear moonlight nights with minimal wind, in all areas that are accessible for researchers.

Pennsylvania Protocol Observation

There are numerous detection methods for Saw-whet Owls. These include listening for calls, locating the whitewash of excrement that indicate a roosting site, searching for pellets, and locating a Saw-whet's cached prey (Swengel 1987a). Given the relative difficulties and unreliability of many of these methods, this project mainly focused on following the Pennsylvania Protocol set forth for by Lanzone and Mulvihill (2006). This protocol focuses on gathering information about the presence of Saw-whet Owls by having the owls respond to a taped audio lure. This survey technique is similar to the survey procedure used by Milling et al. in 1997.

The Pennsylvania Protocol consists of using audio playback of a set series of Saw-whet Owl calls. The purpose of the audio playing is to elicit a response from any Saw-whet Owls within auditory range, approximately one half mile from the playback's source. This range can be limited by weather conditions as well as geographic features that can limit the range or muffle the call. Before conducting the survey for Saw-whets, information that was recorded for each route included: observer name, date, a code for weather, temperature at the beginning and end of route, wind speed and direction, and lunar phase. At each stop the observer included: the stop number, start time, a GPS reading, the habitat, and any excessive noise that occurred at the time of survey. Of the six areas that were surveyed, the habitat type by stop was categorized into one of three bins: mainly Spruce and Fir present, mainly Northern Hardwood, or an approximately equal mixture of Spruce and/or Fir and deciduous trees. All of this information was recorded in the field on a uniform printed sheet (see Appendix B).

Routes throughout areas with suitable elevation were determined based upon the conditions of the roads present. For each route stops were to be within at least 10 meters of a suitable wooded area for Saw-whets. Points upon the road were chosen so that they were clear of any excessive noise interference in the area. Excessive noise was normally regarded as running water or wind that made it too difficult to hear Northern Saw-whet Owls calling in the area. If any point that fell one half mile after the previous point was determined unacceptable, then the next point surveyed was at the next suitable point along the route.

The Pennsylvania Protocol consists of driving along a predetermined mapped route through an area deemed suitable for Saw-whet Owls. Areas were deemed suitable when they met

the criteria of being over 3,500 feet in elevation. These areas, ranging from a Northern Hardwood habitat to a Spruce and/or Fir habitat, were then classified into accessible routes. At approximately half mile intervals along the route, the observers stop the vehicle at a predetermined point. The half mile interval was based off of the male Northern Saw-whet Owls range. These owls are territorial and have a range that is approximately 1 km² (Cannings 1993). If a male Northern Saw-whet Owl is detected at a given stop, then any other Saw-whet vocalizations heard at other stops along route can be inferred as another male. At each predetermined point the observer plays a track of Saw-whet Owl vocalizations (courtesy of the Pennsylvania Breeding Bird Atlas) (see Table 2). Throughout the 11-minute track the observers note and document any responses from any owl species on their printed handout sheet. The audio track is transmitted using an mp3 audio player broadcasting the Saw-whet Owl soundtrack using miniature portable speakers. While small, the portable speaker effectively transmits the audio track. Personal experience in the field showed that the track could still be distinguished humans at a distance of up to 0.2 miles away from the source. It can reasonably be inferred that owls could hear the track at distances greater than those a human could hear. All responding bird vocalizations throughout the 11-minute track were recorded.

After playing the Saw-whet Owl soundtrack at a stop, the observer then drove to the next determined point along the route. Here the protocol was repeated. The routes consisted of as many stops that meet the criteria laid out in the section above (conditional on what areas along the route are deemed suitable). At the end of each route all information was then saved to be compiled later. At the end of each breeding season, all the data recorded and information from all the survey sites in Tennessee were included for analysis purposes. This allowed for the analysis to include all the regions surveyed.

In order to gain access to areas where Saw-whet Owls were likely to breed, service roads on mountains were used. Forest service roads at the higher elevation are difficult to maintain. Due to the unstable terrain that constituted a majority of the roads used, a high clearance fourwheel drive vehicle was used, especially in the early part of the breeding season when the possibility of snow in the upper elevation areas to be surveyed was the highest. An effort was made to use a team of at least two people surveying together for the majority of nights. This was done to limit the risks that can be encountered at the sites surveyed as well as to increase the accuracy of identifying any owl responses. A group of undergraduate students and volunteers helped with the placement of nesting boxes and the nightly monitoring of owls.

To ensure that all data collected were uniform, each group surveyed an area using the same methods for attracting Saw-whet Owls and for recording their presence or absence per area (Table 2). By the end of the two-year study period, a wide section of the Southern Appalachian Mountains were covered and surveyed for Saw-whet Owls.

Table 2: A section listing of the different periods that are a part of the Pennsylvania

Protocol. (Lanzone and Mulvihill 2006)

Time	Period	Туре	Activity	
0:00	1	Listen	Press play and then Listen	
2:00	2		Calling period	
2:00	2.1	Playback	Tape of vocalization (15 seconds)	
2:15	2.2	Listen	Quiet. Short listening period (25 seconds)	
2:40	2.3	Playback	Tape of vocalization (15 seconds)	
2:55	2.4	Listen	Quiet. Short listening period (25 seconds)	
3:20	2.5	Playback	Tape of vocalization (15 seconds)	
3:35	2.6	Listen	Quiet. Short listening period (25 seconds)	
4:00	2.7	Playback	Tape of vocalization (15 seconds)	
4:15	2.8	Listen	Quiet. Short listening period (25 seconds)	
4:40	2.9	Playback	Tape of vocalization (15 seconds)	
4:55	3	Listen	Listen for longer period of 2 minutes.	
6:55	4	Playback	Calling period : Vocalization for 2 minutes (15 seconds of calling followed by 2-second breaks).	
9:00	5	Listen	Listen (The final listening period)	
11:00	End		Termination of play & listening session : Fill out remaining sections on the data sheet for that stop, travel to next stop.	

Thirteen trips were made into the field in 2013 and are expressed in Table 3. The first year of the field season was limited by unfavorable weather conditions as well as the lack of reliable transportation. This year also focused a majority of effort on surveying high elevation sites found on Roan and Unaka Mountain. The Roan Mountain route began at the Rhododendron gardens above Carver's Gap and continued down the Tennessee side on Highway 143. The Unaka Mountain route ran along the Unaka Mountain Road and Red Fork Road. The Shady Valley Area consisted of two separate areas: McQueen Gap on the west side of the valley and on Highway 421 along the east side of the valley. The Holston Mountain route ran along Panhandle Road as it followed the ridge leading to Holston High Point.

2013 Field Season				
Trip	Date	Location		
1	14 March 2013	Unaka Mountain		
2	19 March 2013	Roan Mountain		
3	28 March 2013	Shady Valley Area		
4	2 April 2013	Unaka Mountain		
5	3 April 2013	Roan Mountain		
6	8 April 2013	Shady Valley Area		
7	9 April 2013	Holston Mountain		
8	10 April 2013	Unaka Mountain		
9	16 April 2013	Roan Mountain		
10	18 April 2013	Unaka Mountain		
11	20 April 2013	Unaka Mountain		
12	13 September 2013	Roan Mountain		
13	20 September 2013	Roan Mountain		

Table 3: Dates and locations surveyed in 2013

The second year of the research project had 27 trips that also included areas not surveyed for during 2013 (see Table 4). This included the low elevation sites of Rocky Fork and the Pond Mountain Area. Rocky Fork's route consisted of the USFS property at the higher elevations of Rocky Fork. The Pond Mountain Area followed Laurel Fork Road, down Little Stony Creek Road until it was below the minimum elevation, and then along Walnut Mountain Road. These areas were added to the previous four sites that were surveyed throughout 2013.

	2014 Field Season		
Trip	Date	Location	
1	4 March 2014	Holston Mountain	
2	5 March 2014	Shady Valley Area	
3	7 March 2014	Roan Mountain	
4	8 March 2014	Pond Mountain Area	
5	9 March 2014	Shady Valley Area	
6	10 March 2014	Holston Mountain	
7	11 March 2014	Pond Mountain Area	
8	17 March 2014	Holston Mountain	
9	18 March 2014	Pond Mountain Area	
10	20 March 2014	Shady Valley Area	
11	26 March 2014	Rocky Fork	
12	27 March 2014	Unaka Mountain	
13	30 March 2014	Rocky Fork	
14	31 March 2014	Pond Mountain Area	
15	1 April 2014	Roan Mountain	
16	2 April 2014	Unaka Mountain	
17	3 April 2014	Holston Mountain	
18	8 April 2014	Rocky Fork	
19	9 April 2014	Roan Mountain	
20	10 April 2014	Unaka Mountain	
21	16 April 2014	Rocky Fork	
22	17 April 2014	Pond Mountain Area	
23	18 April 2014	Shady Valley Area	
24	21 April 2014	Rocky Fork	
25	22 April 2014	Roan Mountain	
26	23 April 2014	Unaka Mountain	
27	29 April 2014	Pond Mountain Area	

Table 4: Dates and locations surveyed in 2014

The stops that were surveyed during both the 2013 and the 2014 field season were then transferred into Google Earth (Google Inc. 2009) for the purpose of creating a visual representation of the different areas that were surveyed. This mapping program was also used to plot the different sites where Northern Saw-whet Owls were found to be present.

Audio Recording Devices

Aside from listening for Saw-Whet Owls along mountain roads, another aspect of the project was to include audio recording devices. The Pennsylvania Protocol for identifying the presence of Saw-whet Owls has an observer only present at each site for less than 15 minutes. By using wildlife acoustic recorders, an observer was able to set the recorder and then collect it at a later date. This was done with the intention to greater coverage at a given site. Three acoustic recorders were loaned to ETSU for this project courtesy of Kevin Hamed from Virginia Highlands Community College. In addition, three other acoustic recorders were purchased before the start of the 2014 field season. These were placed at sites determined according to topography maps provided by the Tennessee Wildlife Resource Agency.

Song MeterTM SM1 and SM2 digital audio field recorders made by Wildlife Acoustics, Inc were used. Both types of boxes had nearly identical casings surrounding the equipment and were painted a dull brown color to better blend in with the trees. The recorders have two external microphones placed on top of the housing unit powered by regular D cell batteries. The recorders were set to record only during hours that the owls were active, from the approximate time of sunset through approximately one half hour before the following morning's sunrise. All the recorded data were stored upon a 32 GB SD/MMC memory card located inside the recorder's casing. Recorders were set to record at a sample rate of 32,000 samples per second. This was chosen as it was the closest setting available to the setting recommended by the Wildlife Acoustics Company for recording high pitched calls like those of the Northern Saw-whet Owl (Song Meter User Manual 2009).

The digital audio information was analyzed by computer to find the Saw-whet Owl vocalization pattern (the monotonous "toot-toot" call). The software used for this project

was Song Scope Software (Wildlife Acoustics 2010). The pattern of owl vocalization is unlike any other animal vocalizations in the area and has a known pitch of approximately 1,100 Hz (mean of 1,104.7, standard deviation of 59.5) (Cannings 1993). A track of a known Northern Saw-whet call was annotated and saved as a "recognizer" in the SongScope program. The section was then used by the program to compare the audio track recorded in the field against the known Northern Saw-whet Owl vocalization. The SongScope software then analyzed the track and marked which sections were most similar to the known vocalization.

Breeding Box Placement

As well as identifying where Northern Saw-Whet Owls are distributed throughout Tennessee, nesting boxes were incorporated into this study. Efforts were made to find the nesting boxes that were placed in a past study by Mark Barb (Barb 1995). Unfortunately, the field notes were inadequate for locating the boxes. Only two of the 39 nesting boxes from a past project were located and were in such disrepair that they had fallen off of their respective trees. New nesting boxes were constructed and placed at the study sites.

These boxes were constructed with the aid of the undergraduate students and with materials provided by TWRA. The boxes were built on the campus of ETSU and were then distributed throughout the study area. When constructing Saw-whet Owl boxes, the following conditions were met. The height of the Saw-whet Owl boxes was approximately 17 inches with floor dimensions that were 8 inch 8 inch squares. Four drainage holes were drilled into the floor of the box. The entrance to the box was a circular hole 3 inches in diameter that was located 10 to 12 inches above the floor of the box. The lid to the boxes was constructed to be angled downward with ventilation holes on each side of the box. The tops were equipped with an

eyehook and latch so that the lids were secured from the wind. Once the boxes were constructed, the tops were waterproofed using Thompson's Water Seal. The final process before placement was to provide two to three inches of sawdust to act as nesting material substrate in the bottom of each box.

Once boxes were constructed, they were hung upon trees located on Roan Mountain and Unaka Mountain. Sites for the boxes were chosen as trees that were at least 50 feet away from any major trails so to reduce human disturbance of any nesting owls. An effort was also made so that boxes were set faced away from any trails to reduce their visibility. Once a suitable tree had been found, a researcher then climbed the tree using a belt and tree spikes similar to those used by utility line repairman. Once in the tree, the boxes were nailed in trees approximately 15 feet from the forest floor. They were placed so that there was at least a 10 foot flyway for the birds so they can enter and exit the box without navigating through obstacles. Each nesting box had its GPS location taken along with a description of its tree. Other information included was a description on how to find the tree from a main road or trail. This was done because the Garmin Rino 530 GPS used was only accurate within +/- 20 feet. The box locations and a description of the area can be found in Appendix B.

The boxes were monitored near the middle of the owl's breeding season to ascertain if any owl was using the site. If it appeared that a squirrel had been using the box, the nesting material placed by the squirrel was removed from the box. The only time that the material was not removed was in the cases where it was possible that a Northern Flying Squirrel (*Glaucomys sabrinus*) was using the box. This information was passed along to the USFS as well as Corinne Diggins, a PhD candidate based out of the Virginia Polytechnic Institute and State University who is currently studying the flying squirrels of the Southern Appalachian Mountains.

CHAPTER 3 RESULTS

Nesting Success in Breeding Boxes

The nesting boxes that were placed for this project were checked for owl presence in 2013 and 2014. Both of the times the boxes were monitoring occurred at least 45 days after the anticipated start of the Northern Saw-whet Owl mating season. An initial monitoring of the boxes in 2013 yielded no presence of owls as well as no indication that the boxes were being used by any other species.

The boxes were monitored again in April of 2014. Box 20 on Roan Mountain showed signs that it was being used by an owl for the purpose of prey caching on 12 April 2014. This stocking of three small rodents agreed with documented behavior that male Saw-whets will cache prey to attract a female to the site (Swengel 1987; Cannings 1993). This box was monitored with tree climbing equipment on 4 May 2014. A female was present in the box and remained until a volunteer began to climb the tree. Once the box had been opened, four newly laid eggs were found in the box (see Appendix C). Another monitoring trip on 29 May 2014 showed that three of the chicks were still present in the nesting box.

Lack of Acoustical Recorder Success

Acoustical monitors were employed in the field at various locations throughout the two field seasons of the project. All the recordings that yielded analyzable data can be found on Table 5 below. The 2013 field season yielded no results that could be successfully analyzed due to corrupted data files and theft of a box. The 2014 field season recorded data was analyzed with SongScope software after it had been retrieved from the field. Analysis was not able to determine the presence of any Northern Saw-whet Owls on any of the digital recordings that were gathered.

Area Box Located	GPS Coordinates	Dates Box Recorded
Shady Valley	N- 36.509028	5 March- 8 March 2014
	W- 81.906056	
	Elevation- 3500'	
Holston	N- 36.44875	10 March- 16 March 2014
	W- 82.109361	
	Elevation- 4193'	
Holston	N- 36.435972	10 March- 16 March 2014
	W- 82.126222	
	Elevation- 4205'	
Unaka	N- 36.133389	28 March- 1 April 2014
	W- 82.305194	
	Elevation- 4796'	
Rocky Fork	N- 36.073083	27 March – 30 March 2014
	W- 82.570972	
	Elevation- 4314'	
Rocky Fork	N- 36.073083	31 March – 8 April 2014
	W- 82.570972	
	Elevation- 4314'	
Rocky Fork	N- 36.076139	31 March – 8 April 2014
	W- 82.566139	_
	Elevation- 4171	

Table 5: Areas surveyed with acoustical recorders

Owl Presence as Determined by Pennsylvania Protocol

The most consistent results that were produced came from the Pennsylvania Protocol method of eliciting owl response to an audio track. A complete record of the data gathered during the Pennsylvania Protocol surveys can be found in Appendix D. The 2013 season yielded a total of 107 surveyed stops from a total of 13 trips into the field (see Table 3). The 2014 season yielded an additional 286 surveyed stops during a total of 27 trips into the field (see Table 4). This yielded a total of 393 surveyed stops for the combined two-year research period. A graph

showing a breakdown of stops by location surveyed can be found in Figure 5 below. Throughout these 393 stops, a total of 44 Northern Saw-whet owls were identified. Twenty of the Northern Saw-whet Owl detections came from spontaneous calling, defined as the owls call being detected without being solicited by the audio track. The 44 owls were found on Roan Mountain, on Unaka Mountain, throughout the Pond Mountain Area, and at Rocky Fork. There were no signs of any Northern Saw-whet Owls at either Holston Mountain or the Shady Valley Area. Maps showing the locations of all surveyed sites and the sites that had Saw-whets present are represented below in Figures 3 through 14. Of the 44 Northern Saw-whet Owls that were identified, 12 were located on Roan Mountain, 13 were located at the Pond Mountain Area, 9 were located at Unaka Mountain, and 10 were located at Rocky Fork. This was in addition to a total of 52 Barred Owls (*Strix varia*) that were identified across all the sites. There were no Eastern Screech-Owls (*Megascops asio*), no Great Horned Owls (*Bubu virginianus*), and no Eastern Whip-poor-wills (*Antrostomus vociferus* that were identified above 3,500 feet during either of the years this research project spanned.

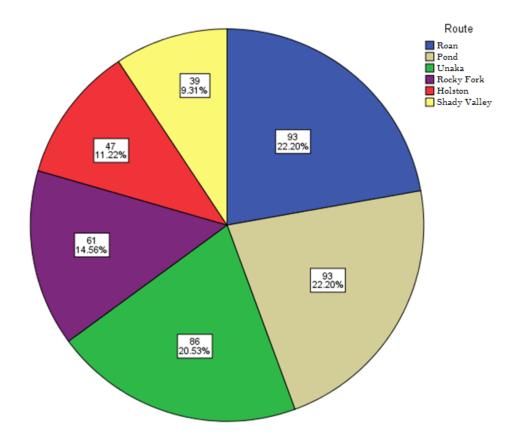


Figure 3: Survey stops by location



Figure 4: Map of survey sites by location



Figure 5: Roan Mountain sites that were surveyed



Figure 6: Roan Mountain sites that had a Northern Saw-whet Owl present



Figure 7: Pond Mountain Area sites that were surveyed



Figure 8: Pond Mountain Area sites that had a Northern Saw-whet Owl present



Figure 9: Unaka Mountain sites that were surveyed



Figure 10: Unaka Mountain sites that had a Northern Saw-whet Owl present

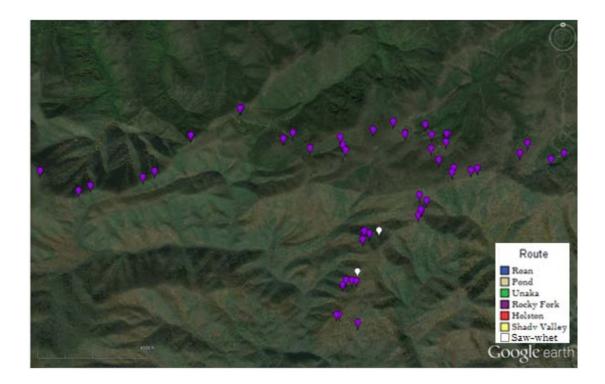


Figure 11: Rocky Fork Area sites that were surveyed



Figure 12: Rocky Fork Area sites that had a Northern Saw-whet Owl present



Figure 13: Holston Mountain sites that were surveyed

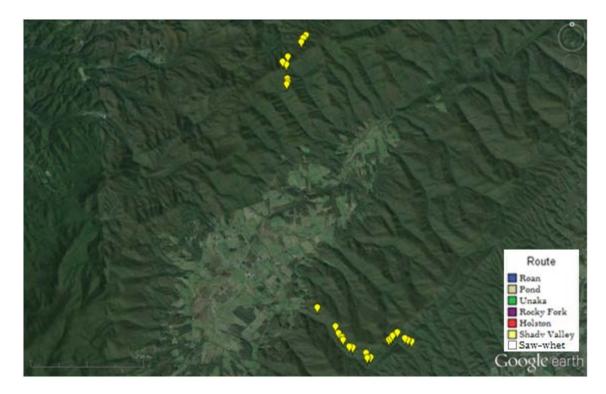


Figure 14: Shady Valley Area sites that were surveyed

Examination of Data Gathered from Pennsylvania Protocol

Of the 44 Northern Saw-whet Owls identified, 12 were located on Roan Mountain, 13 were located at the Pond Mountain Area, 9 were located at Unaka Mountain, and 10 were located at Rocky Fork. A graph showing the locations of the birds recorded can be seen in Figure 15. The count of the different bird codes found in Figure 15 exceeds the number of stops that were done by location. This was caused by situations when one of the surveyed stops would have multiple owls identified at it.

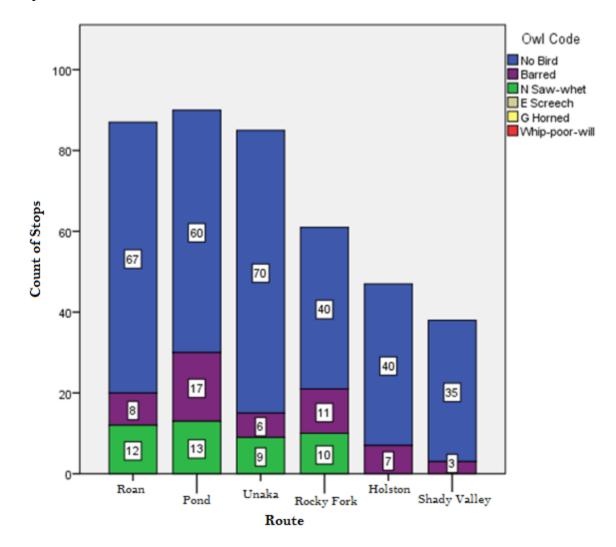


Figure 15: A listing of owls by location surveyed

The habitat concentration varied by the areas surveyed. Figure 16 shows how the different classifications were distributed by location. It should be noted that while the Pond Mountain Area shows some mixed habitat along its route, this was influenced by conifer trees that appear to be planted by local landowners. The Pond Mountain route follows a public road that winds through private land and some of the private land has had conifer trees planted for economic or aesthetic reasons.

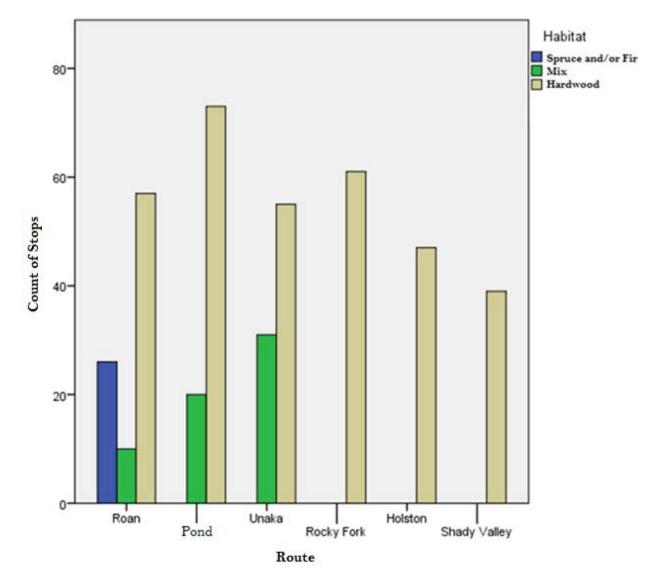


Figure 16: Habitat type frequency by location

The differing habitat types by location can be partially explained by the effect that elevation can have upon habitat. This is shown in Figure 17. The lower elevation sites surveyed had more of a hardwood component while the higher elevation sites surveyed included all three habitat types. This is consistent with the findings of Milling et al. in 1997. Milling also did not find a true Spruce and/or Fir component below 5,000 feet. This finding was supported by this study.

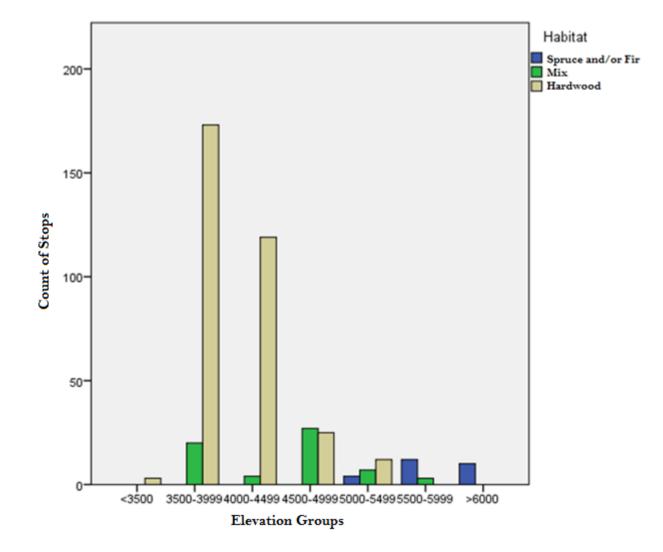


Figure 17: Habitat type by 500 foot elevation group

Northern Saw-whet owls were found throughout all three habitat types during the twoyear study period. The current thinking is that while Northern Saw-whet Owls are habitat generalists in the northern part of their range (Cannings 1993), they are habitat specialists on spruce and fir in the Southern Appalachian Population. This study found a majority of the Northern Saw-whet Owls were detected in hardwood habitats instead of the Spruce and/or Fir habitat (as seen in Figure 18).

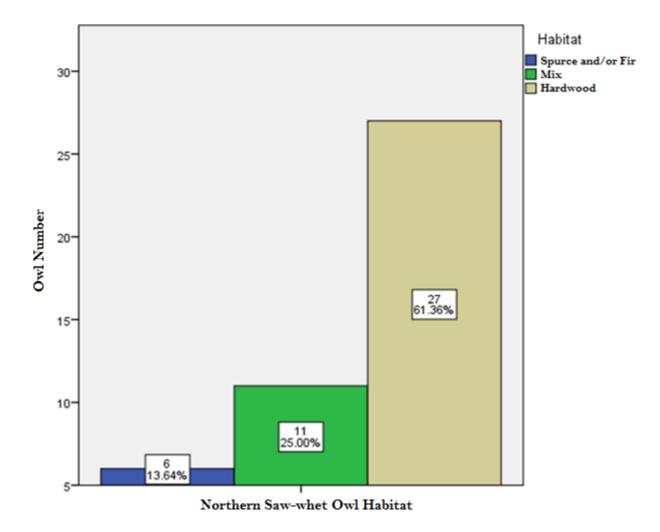


Figure 18: Northern Saw-whet Owl by habitat type

A Chi-Square Test was used on grouping of owls. The chi square statistics test if the owls were evenly distributed across different categories of habitat group (Table 6). The null hypothesis is that the owls would not be found in one categorical type of habitat more or less than the other types.

The expected proportions were calculated from the percentage of locations (Figure 19). It was not possible to survey each of the categories with the same frequency. Categories like hardwood habitats and lower elevations were surveyed more than the other groups. So the groups surveyed more could be expected to yield more owls. To avoid having the expected numbers be the same for all the categories (because they were not monitored with the same frequency), the expected frequencies were calculated from the number of times that each category was surveyed. The proportion of trips to each of the different categories was then used to generate the expected number to take into account that the categories were not surveyed with the same frequency. The expected count was generated by the percentage of times a group was surveyed multiplied by the number of owls that were observed while the observed count came from the data gathered from the field research.

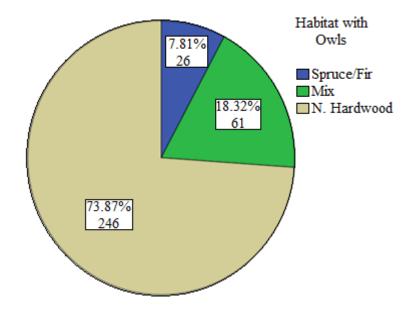


Figure 19: Habitat proportion of the areas surveyed that had Saw-whet presence

Table 6: Chi-Square Analysis on Saw-whet by proportion habitats surveyed

Habitat				
	Observed	Expected	Residu	
	Ν	Ν	al	
Spruce and/or	б	3.4	2.6	
Fir				
Mix	11	8.1	2.9	
N. Hardwood	27	32.5	-5.5	
Total	44			

__ .

Test Statistics

	Habitat
Chi-Square	3.916 ^a
Df	2
Asymp. Sig.	.141

a. 1 cells (33.3%) haveexpected frequencies less than5. The minimum expected cellfrequency is 3.4.

This result indicates that the difference between the observed numbers of owls by habitat type does not significantly differ from the expected numbers. This supports the null hypothesis that Saw-whets had an even distribution across habitats surveyed. This indicates that the Northern Saw-whet Owls detected did not show a statistical preference for habitat type.

Northern Saw-whet Owls were also found across a variety of elevations. This ran opposite of the findings of Milling et al. (1997). In that previous study, only one Northern Sawwhet Owl was heard below 4,500 feet and no Saw-whets were recorded below 4,000 feet throughout the mountains of North Carolina despite those elevations being surveyed over 25% of their study. In this study, a majority of the owls' presence was recorded below 4,500 feet with a large portion falling between 3,500 feet and 4,000 feet (Figure 20 and Figure 21). No owls were recorded above 6,000 feet or below 3,500 feet but these elevations were only surveyed a combined 13 times throughout the two-year period.

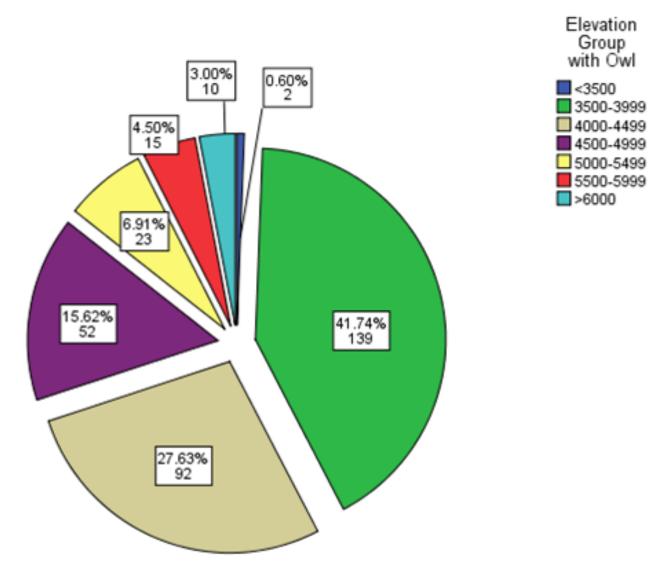
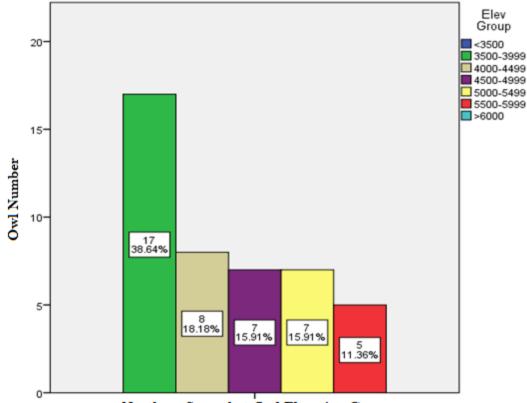
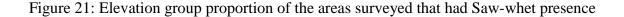


Figure 20: Northern Saw-whet Owl by elevation group



Northern Saw-whet Owl Elevation Group



The proportions of the different elevation groups that were surveyed with owls can be found in Figure 20. These proportions were then used to find the expected values in Table 7 below to see if there were any deviations from what was to be expected had there been no influence from the elevation groups.

A Chi-Square Test was again run on the grouping of Northern Saw-whet Owls. The chi square tests were chosen to test if the owls were evenly distributed across different categories of elevation group. The null hypothesis is that the owls are not found in one categorical type of elevation in a different number than the other types. The chi square test should reveal if the Northern Saw-whet Owls show an even distribution across the varying categories. The expected proportions were calculated from the percentage of elevation groups surveyed that had Northern Saw-whet Owls present (Figure 20). It was not possible to survey each of the elevation groups with the same frequency. The lower elevation categories were surveyed more than the other groups. So the groups surveyed more could be expected to yield more owls. To avoid having the expected numbers be the same for all the categories (because they were not monitored with the same frequency), the expected frequencies were again calculated from the number of times that each category was surveyed. The proportion of trips to each of the different categories was then used to generate the expected number to take into account that the categories were not surveyed with the same frequency. The chi square test was not run on the percentages. Rather the expected count was generated by the percentage of times a group was surveyed multiplied by the number of owls that were observed while the observed count came from the data gathered from the field research. There were no Northern Saw-whet Owls that were recorded at the sites surveyed below 3,500 feet or at the sites surveyed that were above 6,000 feet. This only comprises 3.6% of all the stops that were surveyed. Table 7: Chi-Square Analysis on Saw-whet by proportion of elevation groups

	Observed N	Expected N	Residual
3500-	17	19.1	-2.1
3999			
4000-	8	12.6	-4.6
4499			
4500-	7	7.1	1
4999			
5000-	7	3.2	3.8
5499			
5500-	5	2.1	2.9
5999			
Total	44		

Elev Group by 500

Test Statistics

	Elev Group
	by 500
Chi-	10.825 ^a
Square	
Df	4
Asymp.	.029
Sig.	

a. 2 cells (40.0%) have expected frequencies less than 5. The minimum expected cell frequency is 2.1.

The results from the Chi-square analysis indicate that the observed number significant deviate from the expected number of owls. This does not support the null hypothesis that the owls can be found in the different elevation groups with the same frequency. It indicates that the lower elevation sites contained fewer owls than were expected while the higher elevation sites contained more owls observed than would be expected if there was an even distribution. This suggests that the owls may prefer higher elevation because they were found in the higher elevations more than expected.

Another factor that could influence the number of Northern Saw-whet Owls that had been recorded is the time of the breeding season the owl is surveyed. The field season that was used for surveying the owls ran primarily from the start of March through the end of April. This time period was broken into two-week periods. These periods consisted of early March, late March, early April, and late April. The cutoff points were the first of the month and the fifteenth. The number of stops for each two-week period can be found in Figure 22.

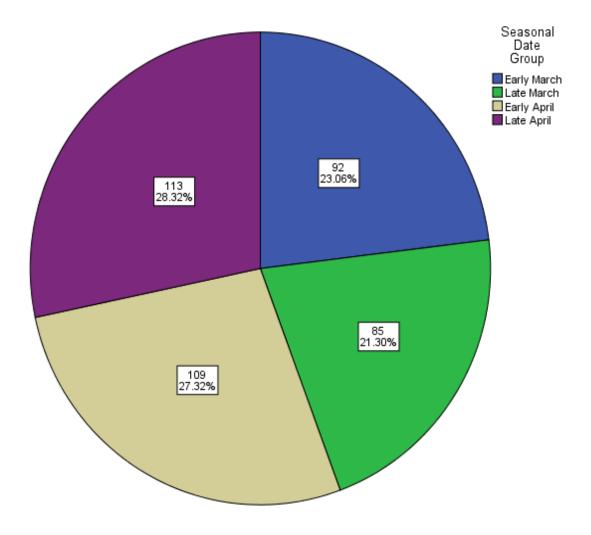


Figure 22: Number of trips by time period during the field season (during breeding season)

Northern Saw-whet Owl presence was recorded throughout the entire length of the field season. This was then set into the categories created by the two week periods from the Start of March through the end of April (Figure 23). There were no Northern Saw-whet Owls identified by the nightly surveys throughout this study during any other time frame.

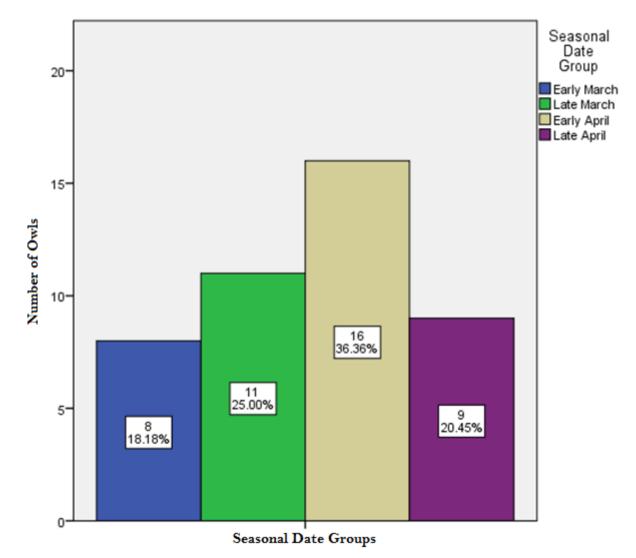


Figure 23: Number of Northern Saw-whet Owls by time period during the field season

A third Chi-Square Test was run on owl presence to see if the owl distribution was equal across the varying time frames described in Figure 22 (see table 8). The expected proportions were calculated from the percentage of date groups surveyed that had Northern Saw-whet Owls

present (Figure 23). As with the previous chi square analysis, it was not possible to survey each of the date groups with the same frequency. To avoid having the expected numbers be the same for all the categories, the expected frequencies were calculated from the number of times that each category was surveyed. The proportion of trips to each of the different categories was then used to generate the expected number to take into account that the categories were not surveyed with the same frequency. The expected count was generated by the percentage of times a group was surveyed multiplied by the number of owls that were observed while the observed count came from the data gathered from the field research. The null hypothesis is that there is no date group that yielded a significantly different number of owls.

Table 8: Chi-Square Analysis on Saw-whet by proportion stops conducted in varying periods

Date Grouping				
	Observed N	Expected N	Residual	
Early	8	10.1	-2.1	
March				
Late March	11	9.4	1.6	
Early April	16	12.0	4.0	
Late April	9	12.5	-3.5	
Total	44			

Date Grouping

Test Statistics

	Date
	Grouping
Chi-Square	3.015 ^a
Df	3
Asymp.	.389
Sig.	

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 9.4. This result indicates that the difference between the observed numbers of owls by date group does not significantly differ from the expected numbers. This supports the null hypothesis that the Saw-whets had an even distribution across date groups surveyed.

While there was no difference in number of Northern Saw-whet Owl by time period, observers could not access some of the higher elevation areas at the start of the field season due to inclement weather. This led to lower elevation sites being surveyed earlier in the field season since they were accessible while the higher elevation sites started being surveyed later in the field season (see Figure 24).

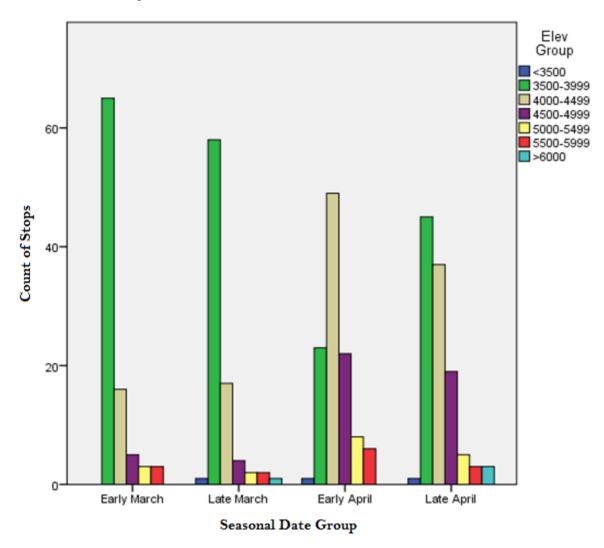
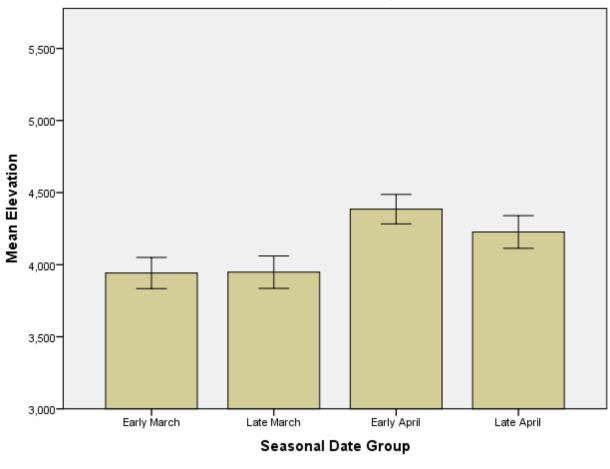


Figure 24: Elevation groups that were surveyed across the different date groups

The difference of the elevations surveyed by date is reflected by the mean elevation of the stops. Figure 25 shows that there is a significant difference between the elevation surveyed in the months of March and April. April's elevations are greater because more of the higher elevation sites became accessible and began to be surveyed for owls.



Mean Elevation for All Stops

Error Bars: 95% CI

Figure 25: Mean elevation of all stops by the seasonal period

These differences are further corroborated by an independent samples Kruskal-Wallis test. These test results indicate that the distribution of the sites surveyed is not the same across the four seasonal date groups (Table 9 and Table 10).

Table 9: Mean elevation of all sites that were surveyed for Northern Saw-whet Owls

Elevation				
Seasonal Date	Mean	Ν	Std.	
Group			Deviation	
Early March	3942.27	91	520.584	
Late March	3948.22	85	521.232	
Early April	4385.23	109	537.433	
Late April	4226.73	113	608.585	
Total	4145.62	398	580.897	

Report

Table 10: Independent Samples Kruskal-Wallis Test results on all the sites surveyed

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Elevation is the same across categories of Seasonal Date Group.	Independent- Samples Kruskal- Wallis Test	.000	Reject the null hypothesis

As mentioned above, the surveyed site elevation changed with each date group as more areas became accessible. This change was reflected in the elevations where Saw-whets were found to be present. Figure 26 shows the elevations where Saw-whets were heard. Early in the field season, a majority of the Saw-whets were heard at lower elevations. Later the mean elevation with birds followed the trend of increased surveys of higher elevations (Figure 27).

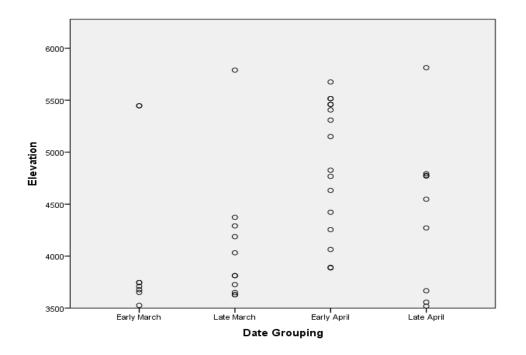
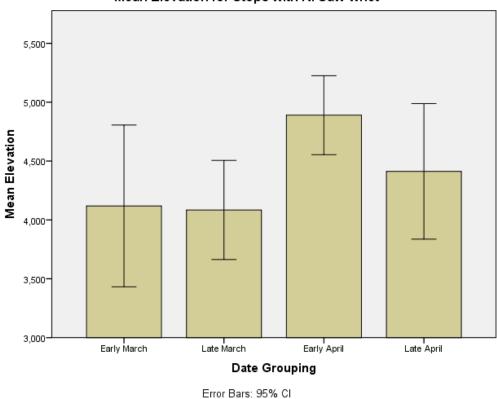


Figure 26: Individual elevations of sites with Northern Saw-whet Owl presence by time period



Mean Elevation for Stops with N. Saw-whet

Figure 27: Mean of different elevations for sites with Northern Saw-whet Owl

An independent samples Kruskal-Wallis Test was run to see if there was any difference

in the elevations where Northern Saw-whet owls were found (Table 11 and Table 12).

Table 11: Mean of the elevations with Northern Saw-whet Owls by different time period

Elevation				
Date	Mean	Ν	Std.	
Grouping			Deviation	
Early March	4118.50	8	822.317	
Late March	4084.36	11	626.663	
Early April	4889.44	16	629.703	
Late April	4412.44	9	749.122	
Total	4450.43	44	755.599	

Report

Table 12: Results of Kruskal-Wallis test on elevations containing Saw-whets by time period

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Elevation is the same across categories of Seasonal Date Group.	Independent- Samples Kruskal- Wallis Test	.014	Reject the null hypothesis

This test indicated that the distribution of elevation where Northern Saw-whet Owls were found is different across the different time periods. It indicates that the early time frame had lower elevation owls while late had owls at higher elevations. This follows the pattern that was seen by all the sites surveyed.

CHAPTER 4

DISCUSSION

The data show the distribution of Northern Saw-whet Owls throughout the northeastern edge of Tennessee. Owls were found at sites that had been surveyed in the past as well as at sites that had never been actively checked for Northern Saw-whet Owls. For the previous sites, Northern Saw-whet Owls were found at Roan and Unaka mountains. This is consistent with the past studies (Barb 1995; Tamashiro 1996; Cockerel 1997; Milling et al. 1997; Williams 2003) as well as with the current notion of where one should look for the owls. However, the owls were also found at sites where they were not expected to be present. The Pond Mountain Area runs along a ridgeline that stays between 3,500 feet and 4,000 feet. Similarly Rocky Fork stays below 4,500 feet. By having these two new areas surveyed, it now appears that the Northern Saw-whet Owl is indeed present in a multitude of areas above 3,500 feet.

The nightly surveys using the Pennsylvania Protocol were able to successfully locate owls. However this method does not allow for a complete statement as to where the owls are located because an observer is only present at a location for less than 15 minutes. Future work needs to include a more systematic use of acoustical recorders that can record all sounds at a given location for multiple nights. While this project did incorporate such recorders, they were not able to record any owls. It is not clear if this lack of identifiable owls was due to inadequate recorder settings, improper use of analysis software, poor recorder placement on trees that created acoustical shadows, or a lack of vocal owls at chosen locations. Recommendations for future work using acoustical recorders should ensure that the recorders' settings are able to pick up the owl vocalizations and that the analysis software used can identify the calls. Work also needs to be conducted in the field to find the range that the acoustical monitors can cover. This

should allow for a more conclusive statement about the presence or absence of owls at areas beyond what can be generated with nightly surveys alone.

It was hypothesized that habitat would not be the most important indicator of Northern Saw-whet Owl distribution. While owls were found in the Spruce and/or Fir habitats of higher elevations, Rocky Fork is almost exclusively hardwood while the conifer component along the Pond Mountain Area is mostly man-made. Yet both of these areas had substantial Saw-whet presence. Of the 44 Northern Saw-whet Owls, a majority were located in a hardwood habitat (Figure 21). This presence holds true even when the proportion of habitat surveyed is taken into account. While tests show that the owl is found in all three habitat types in roughly the same proportions, it is worth noting that the Southern Appalachian population has been thought to be specifically located in the Spruce and/or Fir habitat. But comparing the habitats of the Northern Saw-whet Owl population in the Southern Appalachian Mountains with the habitats of other populations in northern America, it does not seem that the Southern Appalachian population is any more of a habitat specialist than the other populations found in the northern and the western parts of the owls' range. It would be difficult to generate a specific habitat type to act as an indicator of where the Southern Appalachian owls could be found. While the owls observed in the Spruce-Fir habitat did occur more than was expected, this result is was not significant enough to warrant it as the best indicator of owl presence. So by being consistently found in the Hardwood habitats throughout the study period, this study suggests that the Northern Saw-whet Owl of the Southern Appalachian Mountains may be more of a habitat generalist than was previously thought. This helps substantiate previous anecdotal claims of owls being heard in Northern Hardwoods with no Spruce-Fir component.

A better indicator of Saw-whet presence may be the elevations at which the owls were detected. The Northern Saw-whet Owls detected during this project were not restricted to any one elevation class. Owls were found at elevations that ranged from below 3,500 feet to above 5,500 feet. Despite being at all elevations, it appears that the Northern Saw-whet Owls distribution is affected by elevation. Northern Saw-whet Owls were found at higher elevations more than what the number of trips to that elevation would lead to be expected. Taking into account the number of elevation groups surveyed, this preference indicates Saw-whets significantly prefer higher elevations (Figure 22; Table 9). This supports the idea that these owls can be found more at the higher elevations one would find on Roan or Unaka mountains the higher elevations appear be the best source to find these owls. However, it is important to note that the lower elevation areas should not be discounted. A majority of the Saw-whets detected by this project were found below 4,500 feet (Figure 22). Even with the prevalence of surveys at these lower elevation sites (Figure 23), the owl is not constrained to the higher elevations as most may think. So while there may be a better chance of seeing owls at the higher elevations in Northeastern Tennessee, people seeking the owls should not completely discount the lower elevations they pass through as they seek the owls at the higher elevations.

Birders seeking the Northern Saw-whet Owl should also note that the time of year, ranging from early March through Late April for this project, did not fully account for the detections of the owl. The birds were detected with equal abundance in all of the date groups. One trend involving the date groups that needs to be addressed is the apparent correlation between time of year and the elevation that the owls were found. While the data and the analysis run on the elevation with Northern Saw-whet Owl presence indicated that the owls are likely to move to higher elevations later in the season, this result is most likely an artifact due to the

observers' sampling effort. This trend is due to the higher elevations being inaccessible until after winter's ice and snow had melted.

News that the Northern Saw-whet is more of a generalist may be important for the future of the area's population. Due to the problems this population faces such as logging, climate change, air pollution, and tree deaths from adelgids, it is vital that any species be able to use multiple habitats as their historical habitats are overtaken by warmer climate trees. Being able to use multiple habitats should decrease the pressures due to competition for resources and nesting sites. Over the past 15 years since the publication of Milling's data in 1997, the owl has appeared to inhabit more of a wider swath of habitat. The 1997 publication did not find owls to be lower than 4,000 feet. If anything, this project's findings suggest that owls can be found during the breeding season at 3,500 feet with the potential to be slightly lower. While a change in elevation where owls were found may be a modest finding, it does suggest that the owls can survive as elevations see a shift in habitat.

Finding owls at the new areas (Pond Mountain Area and Rocky Fork) may be beneficial for the conservation of the Southern Appalachian population of Northern Saw-whet Owls. The Pond Mountain Area had a vast majority of its sites located in private landholder's property. This area was the most interesting of the project because it consistently had owls from early March through late April. Likewise, the area was unique because it did not fit the criteria normally listed for breeding Saw-whets: high elevation stands of Spruce and/or Fir trees. While the early March birds may have been migrants heading towards more northern locations, it is very likely that the birds that were still there later in the breeding season had nest sites available. Without a suitable nest site, the male owls move to set up a new territory that would be acceptable for the females. Three calling Northern Saw-whet Owls were recorded on 17 April 2014, well into the breeding

season. Indeed, the area has numerous trees that should be suitable for having cavities that the owls could use for nesting. If this site does hold multiple nesting Saw-whets, it would be prudent to ensure that no major man-made habitat changes occur along that area.

Like the Pond Mountain Area, Rocky Fork was a site that did not fit the normal standard for Northern Saw-whet Owls. This area had a calling Northern Saw-whet Owl on 21 April 2014, still well into the breeding season. This suggests that Rocky Fork may also have owls using the area for breeding. Rocky Fork is similar in habitat composition to the Pond Mountain Area. Rocky Fork is higher in elevation than the Pond Mountain area. But the major difference between the two areas is that Rocky Fork is mainly owned by either the state of Tennessee or the United States Forest Service. There is currently a discussion to put in a campground near the entrance of Rocky Fork. Due to the high number of owls in this location, it may be beneficial to ensure that any disturbance is kept minimal.

Little is still known about the Northern Saw-whet Owl in eastern Tennessee. New information is gathered every year on this population's dynamics, such as an owl being identified at 2,640 feet late during its breeding season, as well as this study's finding that owls may be habitat generalists unlike previously thought. Until more is known about its life history and breeding behaviors, care should be taken to ensure that the population is not put through unwarranted stress. The possibility that the Southern Appalachian population is a genetic reservoir for Saw-whet Owls (Tamashiro 1996) increases the need for more complete information regarding this species in Tennessee. Even though this paper has helped to further the knowledge about the owl's distribution, more research regarding the life histories and population dynamics of this Southern Appalachian population is needed to ensure the presence of this small and reclusive owl.

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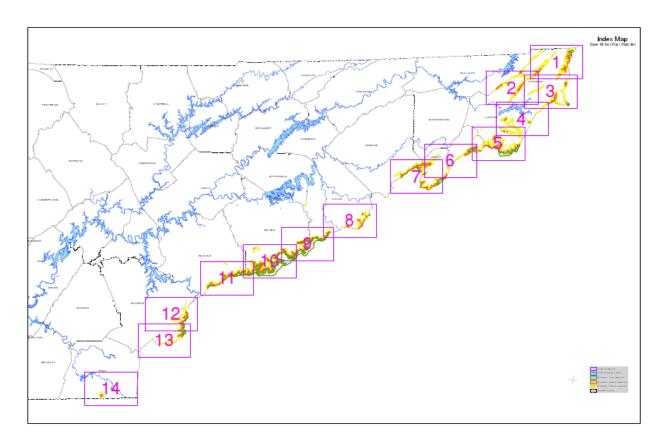
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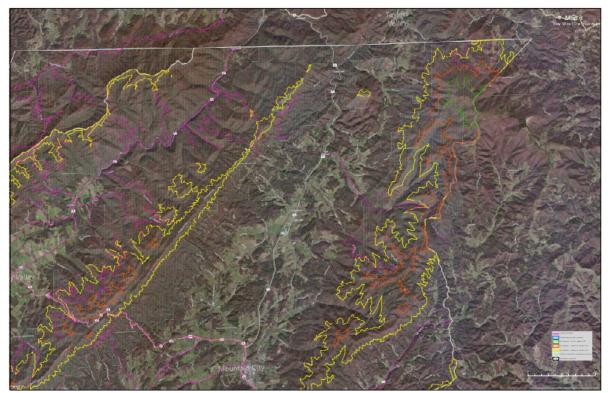
APPENDICES

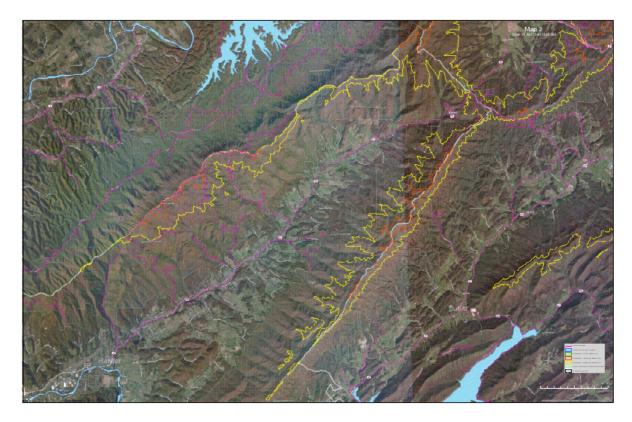
Appendix A

Area Maps Provided by the GIS Department of the TWRA

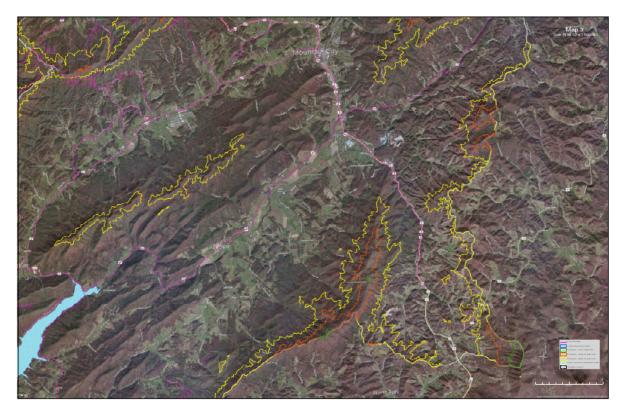


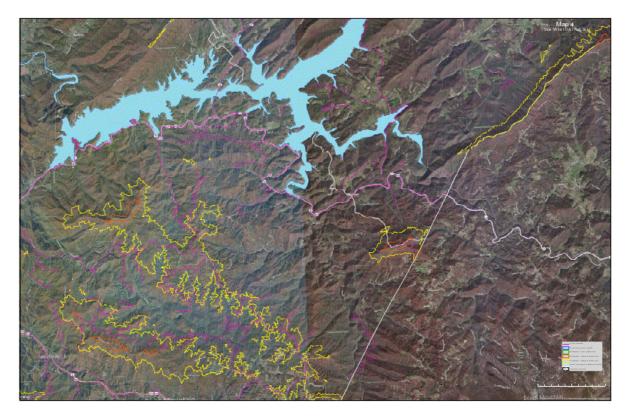
Reference map of locations surveyed

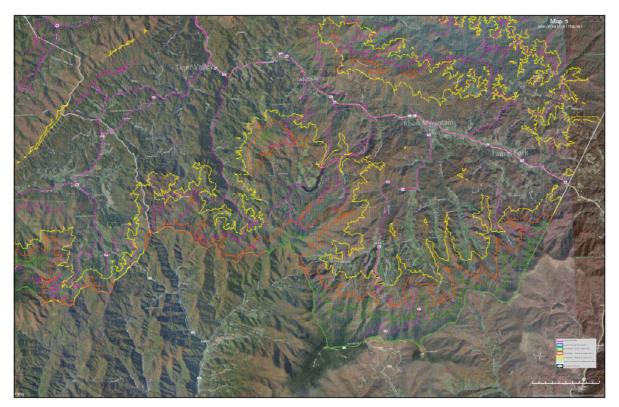


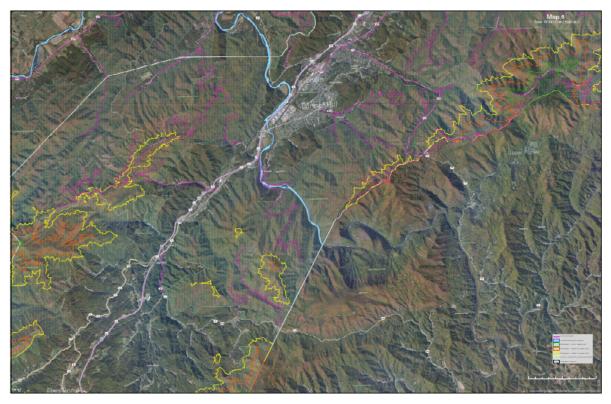


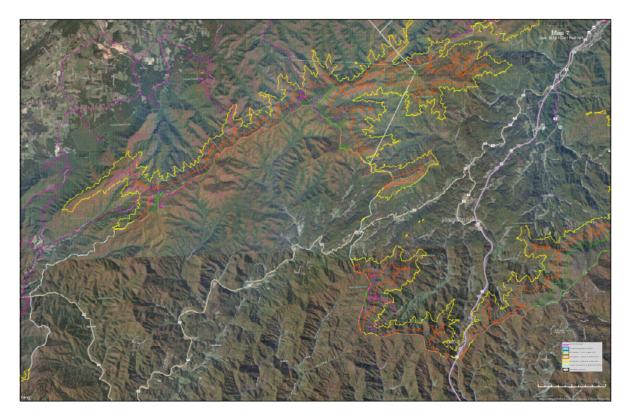












Appendix B

Box 04 -	N 36.135278	Old AT @ switchback on 107 side (front)
	W 82.283222	Located down slope on white pine ~20 ft up
	Elevation 4314	Box on downslope side
Box 05 -	N 36.127722	AT @ switchback on Beauty Gap Side (back)
	W 82.307333	Box ~ 100 yards upslope from AT
	Elevation 4698	On Hardwood tree in rock field
Box 06 -	N 36.127944	Located to E of box 05
	W 82.306333	Surrounded by rocks
	Elevation 4698	Box on Hardwood tree with thick fork in tree
Box 07 -	N 36.129194	Box to N of box 06 (~.1 mi)
	W 82.304806	Hardwood tree strand E of silver pine
	Elevation 4783	Box down slope (E)
Box 08 -	N 36.128389	Box W of Box 05
	W 82.308333	Box located on E of Hardwood
	Elevation 4750	Box on upslope fork Ò≁
Box 09 -	N 36.126583	Box upslope of road on B Gap side
	W 82.310667	Up rock wash at bend right near bottom
	Elevation 4301	Upslope on HW to N of wash, tree forks at 30'
Box 10-	N 36.126583	Located on opposite side of road from Box 09
	W 82.312056	Down slope on large oak w/ fork @35'
	Elevation 4163	Box on W side – down slope
Box 11 -	N 36.132306	On AT near peak- past Rhododendron thickets
	W 82.298389	@ Evergreen patch, head to the E
	Elevation 5129	Box on Fir tree facing E (down slope)
Box 12-	N 36.132194	AT after boulders- $\sim \frac{1}{4}$ mile below 011
	W 82.303278	After boulders, head W through undergrowth
	Elevation 4913	Box on Spruce facing upslope (E)
Box 13 -	N 36.130417	On AT before boulders on trail
	W 82.302972	Box located to E (right when going up), ds
	Elevation 4883	On Black Oak tree
Box 26 -	N 36.144000	On main road coming from Unicoi Side
	W 82.291361	~200 feet before saddle, large Spruce
	Elevation 4688	Box on small spruce slightly ds (facing ds)
Box 27-	N 36.141556	In longest straight-away section of road ~450'
	W 82.297278	before 2 nd pull off
D 10	Elevation 4932	Box upslope on beech at edge of rhod
Box 28 -	N 36.143111	2nd pull off, take trail until rocks end (~0.2mi)
	W 82.302111	After last big boulder, turn left and head ds
	Elevation 4750	Box is facing upslope on thick spruce tree

Nesting Box Descriptions and Locations in Northeastern Tennessee

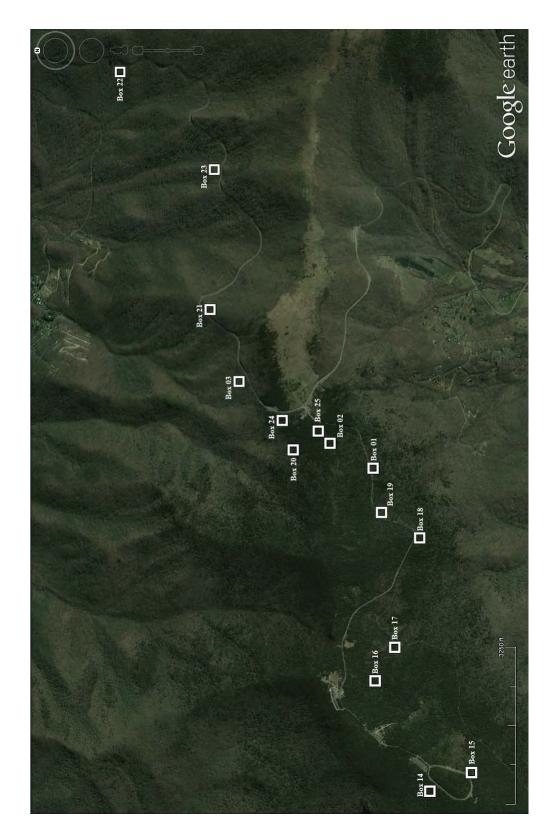
Nesting box locations on Unaka Mountain



Map showing nesting box locations on Unaka Mountain

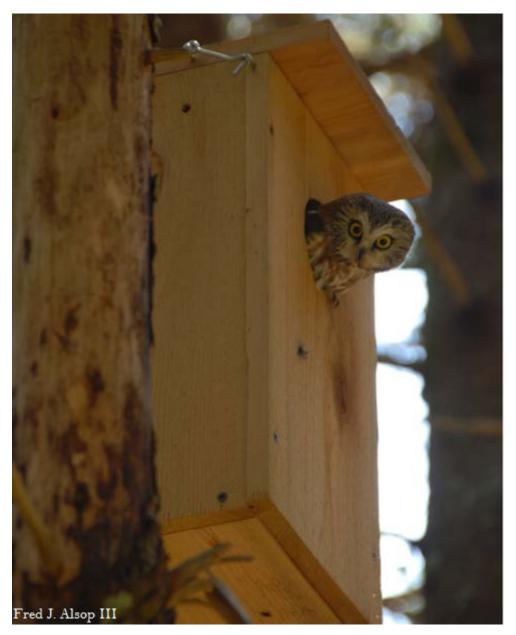
Box 01 -	N 36.101972	Roan High Knob Gated Road off of 143
DONUL	W 82.115111	~mile up the road, a large rock on S of road
	Elevation 5682	Cedar with box on NW side (visible from road)
Box 02 -	N 36.104694	Trail <1/4 mile up roan road on upslope
DON	W 82.113167	Go up trail until AT- head upslope ~50 yards
	Elevation 5708	Cedar Tree with box on upslope side (W)
Box 03 -	N 36.110472	Box off of Hackline Road (off 143)
2011 00	W 82.108278	@ first switchback, box is located down slope
	Elevation 5262	Hardwood with box on uphill (E) side
Box 14-	N 36.098639	Box near Rhod. Gardens, on bus gravel road
	W 82.139556	Back on right circle- large boulder on R
	Elevation 6105	Downslope (200')past growth on Fir (NE side)
Box 15-	N 36.096083	Box on same road as Box 14 on back of loop
	W 82.138139	Culvert on R, go past 10 yards
	Elevation 6085	Box down slope through rhod. on Fir (SE side)
Box 16-	N 36.101972	Gated Rd below top- gravel rd. to pump house
	W 82.13125	~50 ft south of clearing before stream
	Elevation 6003	Box on E side of tree (away from summit)
Box 17-	N 36.100694	Road 130A- follow gravel until red-roof shed
	W 82.128861	2 nd waterfall (before shed) fir on left of creek
	Elevation 5872	Tree 100' from rd, next to stream. Box upslope
Box 18 -	N 36.099083	Box near gravel turn (high side of gravel end)
	W 82.120500	Box down slope ~40 yds. on Cedar (~10" dbh)
	Elevation 5734	Box on down slope side (S)
Box 19-	N 36.101472	Box b/t box 18 and box 01
	W 82.118528	@ 3^{rd} culvert, box down slope ~ 100 feet
	Elevation 5751	Box on W side of Fir, visible walking towards
Box 20 -	N 36.107000	Parking area- follow AT until upslope curve
	W 82.113694	Go straight, perpendicular to AT's curve
	Elevation 5613	After runoff stream, box ~100'from AT on N
Box 21 -	N 36.112333	Coming down TN side of 143
	W 82.102556	2 nd gravel pull off to right (upslope side)
	Elevation 5347	Go upslope ~ 75 yards, HW w/ box on E (up)
Box 22-	N 36.118583	Box on 143 pull off
	W 82.082361	Downslope stands a solitary boulder
D 44	Elevation 4600	~50 SW of boulder is a mossy oak with large Y
Box 23 -	N 36.112167	Off 143 pull off
	W 82.090917	DS of pull off there are 2 large sunken boulder
D. 24	Elevation 4943	DS of boulders there is a beech (box on NW)
Box 24 -	N 36.107694	Follow AT near outhouse area <u>downslope</u>
	W 82.111389	At 3 plank bridge, go downstream
D 25	Elevation 5450	Where 2 streams meet, box on Spruce (East)
Box 25-	N 36.105417	Follow AT near outhouse area <u>upslope</u>
	W 82.112222	At first bridge, follow stream downslope ~100'
	Elevation 5600	Box on Fir, facing back towards outhouse area

Nesting box locations on Roan Mountain



Map showing nesting box locations on Roan Mountain

Appendix C



Northern Saw-whet Owls Found on Roan Mountain

Female Northern Saw-whet Owl in nesting box on 4 May 2013



Clutch of Saw-whet Owl eggs seen through box entrance on 4 May 2014



Northern Saw-whet Owl chicks seen on 29 May 2014

Appendix D

The Data Template Used During the Nightly Surveys

			Ν	or	th	ern	S	av	v-V	W	he	t O	w	S	ur	ve	eys	5						
County	R	out	e/R	oad	5	Obse	rve	r		Da	ate				w	eat	her			Te	mp	erat	ture	
											/	/20			Sta	art:	1	End:		Sta	art:		End	:
Wind Speed					w	ind Dir	ecti	ion					Lu	nar	Сос	le (d	only p	osition w	ill ch	ange)			
Start: End:					Sta	art:		6	End:						Star	t:			End	:				
					Sh	aded co	olun	nns 1	L <mark>,3</mark> a	and S	5 are	quiet	peri	ods.										
Start Time (24 hr)																								
Stop #				1						2						3						4		
Periods	1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total
N Saw-whet Owl																								
E. Screech Owl																								
Barred Owl																								
G. Horned Owl																								
Whip-poor-will																								
Interruptions																								
Excessive Noise																								
Comments																								
Habitat																								
Elevation																								
GPS (deg.dec)																								
NAD83																								
Start Time (24 hr)																								
Stop #				5						6						7						8		
Periods	1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total	1	2	3	4	5	Total
N Saw-whet Owl																								
E. Screech Owl																								
Barred Owl																								
G. Horned Owl																								
Whip-poor-will																								
Interruptions																								
Excessive Noise																								
Comments																								
Habitat		•														•				•		•		
Elevation																								
GPS (deg.dec)																								
NAD83																								
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Appendix E

Key to Code	as and Abbravi	ations Used in	Nightly S	urvoving
Rey to Cour	es and Abbrevi	ations Used in	inging of	in ve ynng

Information Gathered	Abbreviation	Code	Description of Code
Weather at start of night	We_S/E	0	Clear with few clouds, 0-10% cloud coverage
		1	Partly cloudy, scattered 10-50%
		2	Cloudy or overcast, 50-100%
		3	Fog or Smoke
		4	Drizzle- No Survey
		5	Rain- No Survey
Temperature at start/end (in F)	T_S/E	0	<1 mph
Estimated wind at start/end	Wi_S/E	1	1-3mph
		2	4-7mph
		3	8-12mph
		4	13-18mph
		5	19-24mph
		6	>25mph
Wind Direction at start/end of protocol	D_S/E		
Phase of moon	М	F	Full
		Т	(3/4)
		Η	(1/2)
		Q	(1/4)
		Ν	New
Moon position in sky at start/end	M_S/E	L	Low: 0-30 degrees or 150-180 degrees
		М	Mid: 30-60 degrees or 120-150 degrees
		0	Overhead: 60-120 degrees
		U	Unknown or not visible

Information gathered at each general route assessed during nightly surveys

Information Gathered	Abbreviation	Code	Description of Code
GPS coordinates taken in NAD 83	GPS N/W		
Habitat Type	Habit	SF	Spruce-Fir
		MIX	Mixture
		HW	Northern Hardwood
Species of Bird	Code	0	No bird
		1	Northern Saw-whet Owl
		2	Eastern Screech-Owl
		3	Barred Owl
		4	Great Horned Owl
		5	Eastern Whip-poor- will
Number of Owls	Num		
Period in ''Pennsylvania Protocol'' audio playback	Per		
Excessive noise	N	1	Wind
		2	Water
		3	Noise
Any interruptions	Ι	1	Car

Information gathered at individual stops assessed during nightly surveys

Appendix F

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M_S	Г								0										г					þ										þ			
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Е	NW								W										0					W										W			
D_S	0								M										0					ΜM										M			
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Elex	4712	4650	4543	4394	4248	3950	3776	2667	6033	5789	5573	5383	5123	4789	4655	4297	3815	3520	3809	3549	3690	3776	3625	4173	4422	4763	4812	4724	4632	4475	4209	4028	3809	5869	5692	5515	5219
.±	SF		ΜH	ΗW	ΗW	ΗW	ΜH	HW	SF	XIIV	SF	ΜH	ΜH	HW	ΗW	ΗW	НW	ΗW	ΗW	HW	ΜH	ΜH	ΗW	ΜH	ΗW	HW	MIX	ΗW	ХШХ	ΜH	НW	ΜH	ШW	SF	SF	SF	ХIМ
	82.289917	82.292639	82.288500	82.283722	82.281639	82.274083	82.273000	82.274389	82.126167	82.119944	82.111417	82.106861	82.095778	82.082056	82.085500	82.084694	82.096139	82.102389	81.916750	81.915417	81.880139	81.890278	81.897917	82.311472	82.308806	82.306861	82.299778	82.293806	82.289611	82.285056	82.283861	82.275639	82.274028	82.122056	82.115000	82.110583	82.102778
N deg.dec	36.142639	36.144500	36.139278	36.135111	36.138639	36.138778	36.137528	36.133833	36.103250	36.099528	36.105167	36.110444	36.109361	36.115861	36.112278	36.122528	36.124417	36.130056	36.573139	36.568861	36.502500	36.497250	36.501222	36.127000	36.129972	36.134028	36.140306	36.144056	36.141417	36.139111	36.140000	36.137861	36.136694	36.100000	36.102167	36.108333	36.112667
Time	19:35	19:53	20:21	20:43	21:08	21:19	21:34	21:51	20:01	20-25	20:57	21:10	21:25	21:30	21:48	22:02	21:19	22:40	20:56	21-22	22:13	22:27	22:42	19:51	20:31	20:51	21:08	21:19	21:39		I .	I	22:41	20:15	20:40	20:58	21:13
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Route	Unaka	Roan	S. Valley	Unaka	Roan	Roan	Roan	Roan																													
Date	3/14/2013	3/14/2013	3/14/2013	3/14/2013	3/14/2013	3/14/2013	3/14/2013	3/14/2013	3/19/2013	3/19/2013	3/19/2013	3/19/2013	3/19/2013	3/19/2013	3/19/2013	3/19/2013	3/19/2013	3/19/2013	3/28/2013	3/28/2013	3/28/2013	3/28/2013	3/28/2013	4/2/2013	4/2/2013	4/2/2013	4/2/2013	4/2/2013	4/2/2013	4/2/2013	4/2/2013	4/2/2013	4/2/2013	4/3/2013	4/3/2013	4/3/2013	4/3/2013

Data Gathered from Nightly Surveys

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82.095917	82.082194	82.086028	82.085194	82.916917	81.915333	81.880111	81.894722	81.899083	82.137250	82.131528	82.127000	82.120139	82.116028	82.107861	82.102861	82.095333	82.311972	82.308806	82.306889	82.299972	82.293694	82.287472	82.283306	82.276417	82.271417	82.273083	82.139472	82.135000	82.127333	82.119972	82.114083	82.110583	82.104389	82.095861	82.082028	82.085861	82.085222	000000000
36.109361	36.115806	36.127750	36.121250	36.573139	36.568000	36.502500	36.498778			36.436639	36.438306	36.440583	36.447167	36.451333	36.456417	36.459333	36.125389	36.130028	36.134111	36.139167	36.144083	36.140972	36.136056	36.137583		5			36.103639	36.099417	36.102250	36.108139	36.111000	36.109278	36.115889	36.127694	36.121139	120101 20
21:26	21:44	21:59	22:13	20:58	21:16	22:04	22:19	22:36	20:15	20:29	20:46	21:00	21:14	21:30		22:04	20:52	21:08	21:27	21:41	21:53	22:10	22:26	22:43	22:56	23:12	20:20	20:33	20:46	21:00	21:20	21:36	21:48	21:52	22:05	22:19	22:32	22.42
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4678	4806	4845	4534	4320	3943	4602	4792		4826	4744	4560	4370	4271	3996	3795	6112	6181	6118	5505	5416	5114	4819	4471	4271	3877	6151	6190	6076	5478	5328	5154	4747	4412	4268	3913	4215	4291	4107	4130
ХШХ	MIX	MIX	HW	HW	НW	НW	ХШХ		MIX	MIX	MIX	MIX	ΗW	ΗW	ΗW	SF	SF	SF	SF	ΜH	HW	HW	HW	HW	HW	SF	SF	SF	SF	НW	HW	HW	HW	ΗW	НW	HW	НW	HW	HW
82.307639	82.304222	82.296056	82.286417	82.283833	82.270389	82.308750	82.306806		82.299778	82.294083	82.288500	82.283222	82.283861	82.273250	82.274083	82.139667	82.135056	82.129028	82.110556	82.106778	82.095889	82.084639	82.085583	82.084722	82.096111	82.139750	82.135028	82.129028	82.110556	82.102778	82.095861	82.082167	82.085944	82.085278	82.096083	82.137333	82.131667	82.126972	82.120056
36.129861	36.135306	36.142694	36.139389	36.140028	36.140389	36.127583	36.134028		36.139472	36.143806	36.139139	36.135694	36.140000	36.139083	36.136139	36.096139	36.101972	36.104028	36.106639	36.110583	36.109361	36.112806	36.129000	36.122556	36.124528	36.096167	36.102083	36.103944	36.108222	36.112694	36.109333	36.115806	36.127750	36.120917	36.124333	36.432389	36.436417	36.438333	36.440694
20:30	20:45	21:03	21:20	21:36	21:51	20:33	20:47		21:02	21:14	21:28	21:40	21:54	22:08	22:22	20:25	20:37	20:51	21:08	21:13	21:27	21:43	21:57	22:10	22:23	19:50	20:07	20:20	20:39	20:52	21:04	21:19	21:32	21:45	21:54	18:58	19:15	19:32	19:48
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ΗW	ΗW	ΜH	ΗW	ΗW	ΗW	ΗW	ΗW	ΜH	HW	HW	HW	ΗW	HW	ΜH	ΗW	ΜH	ΜH	ΗW	HW	НW	ΗW	HW	ΗW	ХIМ	HW	WH	HW	HW	ΜH	HW	ΜH	HW	ΗW	ΗW	ΗW	ХШ	ХIМ	HW	ΛΠΛ
82.045306	82.05075	82.057222	82.064778	82.06975	82.076417	82.082806	81.905917	81.900028	81.894528	81.888806	81.88225	81.876556	81.910833	81.915694	82.134722	82.127139	82.117167	82.117167	82.111389	82.10475	82.097806	82.089167	82.091111	82.0935	82.086722	82.079722	82.073972	82.067667	82.060472	82.054694	82.047611	82.0445	82.041417	82.033528	82.027361	82.021806	82.012361	82.005583	00 002022
36.256472	36.261472		36.263083		36.26825		36.508833	36.504	36.498611	36.496139	36.501056	36.500361	36.578333	36.5725	<u> </u>	36.435528	36.440139	36.444361	36.449083	36.454056	┣	<u> </u>	36.454139	36.263083		•	-		36.262111					-		36.232222	$\left \right $	36.224278	121010 20
20:43	20:58	21:14	21:29	21:45	21:59	22:13	19:30	19:55	20:13	20:26	20:40	20:54	21:40	21:55	20:09	20:24	20:38	20:55	21:10	21:24	21:38	21:52	22:07	19:35	19:52	20:08	20:22	20:39	20:54	21:08	21:22	21:36	21:49	22:03	22:17	22:30	22:44	22:57	72-17
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3/8/2014	3/8/2014	3/8/2014	3/8/2014	3/8/2014	3/8/2014	3/8/2014	3/9/2014	3/9/2014	3/9/2014	3/9/2014	3/9/2014	3/9/2014	3/9/2014	3/9/2014	3/10/2014	3/10/2014	3/10/2014	3/10/2014	3/10/2014	3/10/2014	3/10/2014	3/10/2014	3/10/2014	3/11/2014	3/11/2014	3/11/2014	3/11/2014	3/11/2014	3/11/2014	3/11/2014	3/11/2014	3/11/2014	3/11/2014	3/11/2014	3/11/2014	3/11/2014	3/11/2014	3/11/2014	2/11/01/1

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4173	4402	4071	4156	4074	4169	3894	3956	3776	3510	3664	3733	3526	3704	3858	3825	3635	3559	3510	3658	3677	3569	3664	3559	3789	3891	3648	3538	4137	4291	4373	4187		3812		3471	4826	4612	4383	3766
ΗW	ΗW	ΜH	ΜH	ΜH	ΜH	ΜH	ΗW	ΗW	ΜH	ΗW	ΜH	ΜH	ΜH	XIIV	ΗW	HW	ХШХ	ΗW	XIIV	XIIV	ΜH	ΗW	ХШ	ΗW	ΗW	HW	ΗW	HW	ΗW	ΗW	ΜH		ΜH		ΜH	ХIМ	MIX	ХШ	ΗW
82.137833	82.131472	82.126917	82.119333	82.115778	82.107917	82.10225	82.093639	82.090667	82.088722	82.083167	82.077444	82.071333	82.0655	82.058361	82.051667	82.0455	82.033778	82.039222	82.030667	82.025639	82.020028	82.008667	81.876389	81.881611	81.889917	81.897639	81.899472	82.889111	82.563222	82.571028	82.57625		82.579056		82.581472	82.303111	82.289972	82.28325	82.276111
36.431444	36.436472	36.438667	36.440861	36.447306	36.451111	36.456972	36.459222	36.4575	36.451806	36.265222	36.268556	36.265472	36.264528	36.263694	36.261528	36.256583	36.250444	36.245028	36.241417	36.236167	36.230028	36.226639	36.500389	36.501667	36.495889	36.500583	36.500778	36.079111	36.075889	36.073	36.069139		36.064556		36.059639	36.136083	36.138944	36.135972	36.134083
19:40	19:56	20:11	20:25	20:41	20:55	21:11	21:25	21:40	21:54	19:50	20:05	20:20	20:35	20:50	21:04	21:19	21:35	21:46	21:59	22:12	22:19	22:27	20:28	20:44	20:58	21:13	21:27	19:51	20:09	20:26	20:52		21:11		21:32	20:07	20:29	20:45	21:12
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Holston	Pond	S. Valley	R. Fork	R. Fork	R. Fork	R. Fork		R. Fork		R. Fork	Unaka	Unaka	Unaka	Unaka																									
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82.566861 HW	82.566861 HW	HW	++	3986	000		00		++	0	0	40	36	2	5	NE	SW	z		D
OU IN	+	36.075472	82.566583 82.566583	WH	4140 4248	• •	0 0		00	00								+	-	
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21:25	36.(82.578167	HW	4032	-	1	ε	0	0										
21:45	-	36.063528	82.579194	ΗW	3807	0	0	0	-	0										
22:00	+	<u>۳</u>	82.581861	ΗW	3513	0	0	•	+	0							+	+	_	
19:56	-	_	82.086833	ΗW	3507	0	0	0	_		-	48	37	1	0	NW	0	z	þ	р
<u></u>		36.267556	82.079972	HW	3756	0	0	0	0 (0										
<u>e</u> 2 -		36.266111	82.073222	MH	3608	0	0	0	2 (0										
19 P	20:44 36.2	36.265528	82.066972	ΜH	3650	-	1	σ	0	0										
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	20:58 36.2	36.262167	82.060556	ΜH	3940	0	0	0	0	0										
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	\vdash	~	82.051139	ΗW	3769	e	2	m	0	0										
	<u> </u>	36.2565	82.045389	ΗW	3612	0	0	0	0	0								\vdash		
	\vdash	36.250806	82.045306	MIX	3559	0	0	0	ر ۳	0								\vdash		
	22:33 36.2	36.245389	82.039472	ΗW	3553	0	0	0	0	0										
	22:47 36.2	36.241778	82.032472	MIX	3759	3	-	5	0	0										
		36.237639	82.026833	MIX	3599	0	0	0	0	0										
1.1.1		36.231528	82.021417	MIX	3687	3	1	3	0	0										
- T	23:28 36.2	36.227528	82.011861	HW	3628	-	1	-	0	0										
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7.	23:41 36.2	36.223556	82.004917	HW	3726	1	1	1	0	0										
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17	0:14 36.2	36.211583	82.000361	ΜH	3599	0	0	0	9 8	0										
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1.75	20:45 36.	36.10813	82.11062	SF	5459	1	1	-	0	0										
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131	-	36.11262	82.10275	MIX	5308	-	1	1	0	0										
		36.10932	82.09581	MIX	5134	0	0	0	2 (0										
- A -		36.11328	82.08606	ΜH	4871	0	0	0	5	0										
	21:38 36.	36.11850	82.08173	ΗW	4694	3	1	ς	0	0										
	\vdash	36.12899	82.08550	ΗW	4422	3	-	4	\vdash	-1										
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	22:19 36.	36.12430	82.09599	HW	3910	0	0	0	0	0								_	_	

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ΜH	ΜH	MIX	ΗW	ΗW	MIX	ΗW	MIX	MIX	ΜH	ΗW		ΜH	ΗW	ΗW	HW	HW	HW	HW	HW	ΗW	ΜH	ΗW	MIX	ΗW	ΜH	ΗW	ΗW	HW	ΗW										
82.04533	82.04305	82.03608	82.02858	82.02394	82.01886	82.01141	82.00485	82.00303	81.90929	81.91529	81.91562	81.87528	81.88165	81.88990	81.89763	82.62131	82.61655	82.60799	82.60158	82.59481		82.58785	82.58121	82.57451	82.57000	82.56718	82.55297	82.55639	82.56410	82.57005	82.57753	82.57980	82.11055	82.10673	82.09583	82.08603	82.08176	82.08577	82.08479
36.25534	36.24838	36.24435	36.24076	36.23477	36.22874	36.22718	36.22355	36.21660	36.58018	36.57453	36.56748	36.49991	36.50172	36.49598	36.50056	36.07562	36.07359	36.07494	36.07949	36.08253		3607981	36.07841	36.08088	36.08070	36.07880	36.07691	36.07864	36.07568	36.07242	36.06882	36.06358	36.10666	36.11051	36.10934	36.11329	36.11855	36.12858	36.12259
22:03	22:18	22:31	22:44	22:58	23:11	23:26	23:41	23:55	20:15	20:30	20:44	21:33	21:49	22:02	22:16	20:11	20:28	20:42	20:57	21:13		21:27	21:42	21:57	22:12	22:27	22:49	23:04	23:19	23:36	23:52	0:08	20:08	20:11	20:25	20:30	20:44	20:57	21:11
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4/22/2014 Roan 8 21:25 36	4/22/2014 Roan 9 21:39 36	4/23/2014 Unaka 1 20:22 36.	4/23/2014 Unaka 2 20:35 36.	4/23/2014 Unaka 3 20:49 36.	4/23/2014 Unaka 4 21:03 36.	4/23/2014 Unaka 5 21:16 36.	4/23/2014 Unaka 6 21:29 36.	4/23/2014 Unaka 7 22:03 36.	4/23/2014 Unaka 8 22:17 36.		4/23/2014 Unaka 9 22:32 36.	4/23/2014 Unaka 10 22:47 36.	4/23/2014 Unaka 11 23:00 36.	4/23/2014 Unaka 12 23:15 36.	4/23/2014 Unaka 13 23:29 36.	4/29/2014 Pond 1 20:18 36	4/29/2014 Pond 2 20:33 36	4/29/2014 Pond 3 20:48 36	4/29/2014 Pond 4 21:02 36	4/29/2014 Pond 5 21:17 36	4/29/2014 Pond 6 21:31 36
36.12436 82.09611	36.13034 82.10054	36.121250 82.318280	36.126090 82.313360	36.131080 82.308120	36.130380 82.306950	36.134780 82.305190	36.141910 82.299330	36.143470 82.291100	36.139500 82.287220		36.137390 82.282890	36.137120 82.278760	36.140580 82.270450	36.134300 82.275160	36.137110 82.268280	36.26543 82.08206	36.26806 82.07689	36.2651 82.06982	36.26207 82.06057	36.26947 82.05495	36.27307 82.05698
MH	HW	HW 4	HW	HW 4	7 XIW	7 XIW	ХIW	7 XIW	ΗW		HW 4	HW 4	HW	HW	HW	HW	HW	HW	HW	HW	HW
3940 0	3687 0	4261 0	4166 0	4432 3	4688 0	4776 1	4770 1	4714 3	4547 1	3	4337 0	4160 0	3946 3	3749 0	3522 0	3553 0	3651 3	3608 0	3831 0	3625 0	3566 0
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VITA

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