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Migration Dynamics of the Northern Saw-whet Owl in the Piedmont, Mountain, and Coastal Plain Provinces of Virginia

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Abstract

The Northern Saw-whet Owl (*Aegolius acadicus*) is a small common owl of which little is known. The saw-whet's migration dynamics are particularly shrouded in mystery due to the secretive nature of this owl. This study examined data obtained by capturing owls with mist nets in order to better understand volume, timing, sex differences and age differences in migration in the Piedmont province of Virginia for 2002-2007. Comparative owl capture data from two other physiographic regions (Mountain and Coastal Plain) were also examined.

Migration flight volume was highest in the Mountain province and lowest in the Coastal Plain, while movements were earliest in the Mountain province and latest in the Coastal Plain. Females dominated samples, suggesting differential migration between sexes and/or the existence of an audio lure bias. Samples were typically dominated by adult owls except for in 2007, a year characterized as an invasion year.

Migration Dynamics of the Northern Saw-whet Owl in the Piedmont, Mountain, and Coastal Plain Provinces of Virginia

Introduction

The Northern Saw-whet Owl (*Aegolius acadicus*) is a small common northern owl of which little is known in comparison to many other birds. Males measure about 19 cm in length and have an average mass of 75 grams, while females measure about 21 cm in length and have an average mass of 100 grams. Their feathers are a mixture of different shades of brown and white with small, isolated areas of black. The adult Northern Saw-whet Owl's back, tail, and wings are mostly brown marked with some white spots. The breast, underparts, and underside of the wing are white with brown streaks, the legs are feathered in white, and the face is light brown marked with both darker brown and white streaks. Juveniles differ in appearance from adults by and have having an unmarked brown breast, in lacking the adult's white markings except for on their tail and wings, and in having a darker brown colored face. Overall, the bird is heavily insulated with feathers, has a black bill, yellow eyes, and a large, roundish head (Cannings, 1993; National Geographic Society, 1987).

This predator's diet consists largely of deer mice, but it also preys on many other small mammals such as other types of mice, voles, shrews, and occasionally even small birds. To a lesser extent, the Northern Saw-whet Owl also feeds on insects and other invertebrates. Using its extremely sensitive hearing, the Northern Saw-whet Owl hunts primarily just after sunset to just before sunrise, using perches generally one and a half to

three meters in height in woods or along wood edges. Once located, prey is caught with the talons and ingested in pieces (Bent, 1938; Swengel & Swengel, 1992).

Several unique vocalizations have been described for the Northern Saw-whet Owl. The advertising call is predominantly produced by the male, although during courtship females produce a slightly different version of it. This call consists of a sequence of repetitive notes whistled at a rate of approximately two notes per second and is used primarily to attract mates. Territorial males will respond with a lower pitched and more rapid version of the advertising call. Another call very similar to this response call is the visiting call, which is given by males when they approach their nest with food. It consists of soft, quickly whistled notes (Cannings, 1993).

In contact situations, a longer whining call characterized by pitch and volume changes is given. There is another, more aggressive call made during contact situations that consists of a sequence of three keen squeak-like calls. Both of these calls can be heard in response to advertising calls. Another response to the advertising call is unique to females and consists of a high-pitched *tssst*. This call may be used by females to induce the male to breed or to offer food (Cannings, 1993).

Other vocalizations include a brief call characterized by a buzzing sound, a twittering call, and the begging calls of nestlings. Northern Saw-whet Owls also produce a non-vocal alarm sound by snapping their bills closed (Bent, 1938; Cannings, 1993).

While it can be found in variety of forests and woodlands, the Northern Saw-whet Owl's favored breeding habitat is coniferous forest, and it prefers a significant canopy formed by trees at least two to four meters in height (Cannings, 1993; National

Geographic Society). This owl's breeding range is concentrated in the northern portion of North America, including Canada, the upper Mid-Atlantic region, the upper Midwest, and New England (Whalen et al., 1997). Further south and in the Southwest breeding takes place only in mountainous areas of high elevation (Bent, 1938). Although it is a rare event, there are two breeding records for Virginia (Pagels & Baker, 1997). One was a failed breeding attempt documented in 1989, and the other was a successful attempt in 1995 (Pagels & Baker). Adult birds do not seem to nest in the area of their birth, but do routinely return to previous breeding sites (Cannings, 1993). Two breeding male birds tracked using radio telemetry had home ranges covering 142 and 149 hectares respectively (Cannings).

In winter the Northern Saw-whet Owl lives in a variety of habitats, all of which are characterized by dense cover, although this habitat can vary in vegetation type, latitude, and altitude. It can be found wintering all across its normal breeding ranges, although a large number of them migrate further south for the winter. Radio telemetry of a wintering male indicated a home range size of 115 hectares (Cannings, 1993).

The Northern Saw-whet Owl is usually monogamous, sometimes polygynous, and perhaps also occasionally polyandrous. Males begin courtship by issuing the advertising call to attract mates in late winter to early fall and receptive females will approach and respond with the high-pitched *tssst* call. Breeding pairs are not known to continue together longer than one season. Once paired, the female chooses a suitable nesting site in the hollow of a tree that is usually formed by a woodpecker. Females lay clutches of four to seven eggs and are entirely responsible for incubating the eggs and brooding the

young, only briefly leaving the nest-to defecate or regurgitate pellets. Males are responsible for supplying all of the food for both mother and young throughout the egg laying, incubation, and brooding stages. The incubation period is approximately twenty-seven days long and there is seventy-five percent successful hatch rate. The female will continue brooding until the youngest bird is approximately eighteen days old at which point she will leave the nest. Females may leave entirely or help the male continue to feed the young. The female may also leave the young and original male to brood a second time, finding a second nesting site and new mate (Bent, 1938; Cannings, 1993).

The young hatch with closed eyes and have a mass of approximately 7.5 grams. They open their eyes around 7-10 days after hatching and gain mass for 20 days, reaching a maximum mass of about 110 grams before dropping to 96 grams by around day 28. The young are capable fliers upon leaving the nest and typically stay together for approximately one month while the male continues to feed them (Bent, 1938; Cannings, 1993).

Northern Saw-whet Owls migrate south for the winter season. Until 1911, however, it was commonly believed and widely published that the owl did not migrate at all or if it did, it made only small scale movements at the extreme boarders of its breeding range. Taverner and Swales (1911) first noted evidence of migratory movement. In 1906, at Lake Huron in Ontario, 1845 birds of many species were found dead along the lake's shore. A particularly strong storm had caught the birds in the midst of their migration resulting in their demise. Among these birds were 24 Northern Saw-whet Owls, which were considered to be rare in that area. Previously, in this same area in 1903, a ship's

captain had also reported seeing what appeared to be Northern Saw-whet Owls land on his ship while crossing the lake. These instances, in conjunction with Taverner and Swales own studies at Point Pelee, Ontario, led to the conclusion that the owls were indeed exhibiting extensive migratory behavior. Most likely the owl's secretive, nocturnal behavior was responsible for masking their migrations. Also, contributing to the delay in recognizing their migratory behavior, owls inhabiting northern regions replace owls leaving southern regions, thus offsetting what would have been a noticeable lack of Northern Saw-whet Owls in the area (Taverner & Swales).

Despite these early observations, the migration patterns of the Northern Saw-whet Owl continued to be largely unknown and debated for decades. Bent (1938) claimed, "The movements of the saw-whet owl are too erratic to be considered as true migration, and it will be observed that there is little difference in the breeding and wintering ranges outlined" (p. 241). It was not until 1965 that the first study providing solid evidence for saw-whet migration was published. Mueller and Berger (1967) began mist netting operations in 1956 at Cedar Grove Ornithological Station on Lake Michigan's western shore and published migratory data collected from the falls of 1962, 1963, and 1964.

The Northern Saw-whet Owl has since become the most commonly banded owl in North America, with around 2500 banded each fall migration in the Great Lakes region alone (Erdman & Brinker, 1997; Erdman et al., 1997). Mist netting has been the prominent method of capture. This largely passive method of capture requires a large number of nets in order to obtain significant capture rates. However, in 1986 Erdman and Brinker employed an audio lure that broadcasted varying series of saw-whet calls through

audio speakers with the hopes of luring more owls into their nets. The result was a more than tenfold increase in the number of owls captured. Without the audio lure, the seasonal mean was 57 owls captured. With the audio lure, the seasonal mean was 636 owls captured. This represented a significant breakthrough in saw-whet banding. Using an audio lure allows researchers to operate fewer nets and still catch more owls. This greatly reduced the amount of time and effort needed by researchers to collect significant amounts of data on migrating saw-whets.

A network of Northern Saw-whet Owl banders, Project Owlnet was established in the 1990s for the purpose of increasing research and communication about Northern Saw-whet Owls migration patterns. Developed by David Brinker, Project Owlnet (2004) has three main goals: “Support expansion of a network of migrant owl banding stations, advocate the use of relatively comparable netting protocols, and improve communication and coordination between owl banding stations in the North America” (¶ 2). The project has been joined by owl banding stations in a number of states such as New Jersey, Maryland, Pennsylvania, Maine, Massachusetts, and West Virginia among others. Project Owlnet not only provides protocols for banding and increased communication between banding stations but also provides useful age and sex determining criteria.

Increased Northern Saw-whet Owl banding efforts have broadened knowledge of the owls’ migration dynamics. Weir et al. (1980) reported that fall migration of saw-whet owls is a yearly phenomenon. They also found some timing variations between sexes and between age groups. For example, in 1977 significantly more juvenile birds migrated earlier than adults, while in 1976 and 1978 significantly more females migrated earlier

than males. It was speculated that timing variation between sexes was the result of the larger females suffering more from lack of resources than males, thus inducing females to migrate earlier.

Weir et al. (1980) also commented on the intermittent irruptive nature of the Northern Saw-whet Owl's migration. Occasionally, significantly more saw-whets are observed migrating in a particular year; this is termed an "invasion year." Weir et al. (1977) speculated this variation of migration magnitude was the product of an unusually successful breeding year. More breeding would result in high numbers of owls competing for resources. As resources become increasingly strained, the owls are forced to migrate in search of new resources. Whalen et al. (1997) suggested that breeding success alone is not the cause of invasion years and argued that prey cycles may be the most responsible factor. In years characterized by high prey availability, breeding success is higher due to the relative ease with which the owls can secure food. This causes an increase in the overall number of saw-whets. However, years of high prey availability are often followed by a year of low prey availability, resulting in a shortage of food for the owls. Thus, low prey availability combined with the increased number of owls results in large scale migrations as the owls seek new resources.

Invasion years are characterized by significantly different migration dynamics compared to non-invasion years. Whalen and Watts (2002) analyzed Northern Saw-whet Owl capture data covering 1994 to 2000. Within this period, 1995 and 1999 were invasion years with many more owls caught compared to other years. Their study showed age, stopover time, and body mass differences between invasion and non-invasion years.

Significantly more immature owls were captured during invasion years than in non-invasion years. During invasion years 82% of captures were immature birds whereas during non-invasion years only 38% of captures were immature birds. The median stopover time for invasion years was only five nights and few individual owls were recaptured. Median stopover times for non-invasion years were twice as long (ten nights) and the number of recaptures was much higher than in invasion years. Owls captured during invasion years also had lower body masses showing poorer body conditions than owls in non-invasion years.

Banding stations documenting migrating Northern Saw-whet Owls are concentrated in the eastern United States and Canada, especially in southern Ontario, New England, Pennsylvania, Maryland, and West Virginia. The migration dynamics of the Northern Saw-whet Owl farther south such as in Virginia have not been well studied. Except for on the Coastal Plain of Virginia at the southern tip of the Delmarva Peninsula (Whalen et al., 1997; Smith et al., 2008) there have been no published studies of the Northern Saw-whet Owls migration dynamics for Virginia. In 2001 a banding station was established in the mountain region of Virginia in Rockingham County to begin documenting saw-whet migration in this region, and in 2002 a banding station was established in the inner Piedmont region at Candler Mountain in Campbell County near Lynchburg.

Objectives

The objective of this study was to collect and examine baseline data on the magnitude and seasonal timing of the Northern Saw-whet Owl's migration in Virginia's

central Piedmont region, and to compare this with the Mountain and Coastal Plain provinces of Virginia. Sex and age related aspects of the saw-whet's migration dynamics were also examined for the Piedmont and again compared with these other two regions.

Materials and Methods

Study Area

Owl netting in the Piedmont region of southern central Virginia was conducted in Campbell County at the southern base of Candler Mountain (37° 20' 35" N and 79° 09' 40" W) for the years 2002-2007. The netting site is located on land owned by Thomas Road Baptist Church and the site is characterized by a moderate understory typical of an eastern deciduous forest mixed with some evergreens.

Comparative data from two other Virginia sites were also utilized. Netting in the Coastal Plain region was begun in Northampton County on the southern tip of the Delmarva Peninsula in 1994 by the College of William and Mary's Center for Conservation Biology (Smith et al., 2008). Here the forest contains a moderate understory and is composed of a mixture of pines and hardwoods. The study site has three banding sites operated simultaneously covering 10 km^2. Netting in the mountain region of Virginia began in 2001 in Rockingham County at Highland Retreat Camp (38° 20' 35" N and 78° 54' 00" W). The banding station here is run by Clair Mellinger and Charles Zeigenfus of Eastern Mennonite University in Harrisonburg, Virginia. Both the Coastal Plain and Mountain sites utilized trapping protocols similar to the Piedmont site, allowing comparison of data among all three sites.

Trapping

Owls were captured using five 61 mm mist nets (dimensions 12 m long and 2.6 m high). These nets were placed end to end in a continuous east to west line on a ridge in the woods. An audio lure was used to attract the owls and increase capture rates. The lure consisted of a battery connected to two loud speakers and an MP3 playing device. This audio lure played a continuous loop of three male Northern Saw-whet Owl's advertising calls with five second pauses between each call and twenty second pauses between each series.

The nets were operated nightly from late October to mid December from about 6-11 PM. Nets were checked each hour and closed at the end of the night's netting. Extenuating circumstances such as rain or heavy wind and leaf fall sometimes necessitated closing the nets early or occasionally canceling operations for that night.

When an owl was captured it was removed from the net and bagged for transport to a nearby office at Camp Hydaway. Once in the office the individual owl was banded with a uniquely numbered U.S. Fish and Wildlife Service (USFWS) aluminum tarsal band. Information about the owl was also collected and recorded including band number, capture date and time, wing molt data, mass, tail and wing length, and subsequent release time. Tail and wing lengths were measured to the nearest half millimeter, and the owls were weighed using an electronic scale accurate to the tenth gram.

Age was determined by comparing wing molt patterns of captured owls to a molt pattern developed from a study of owls of known age provided by the USFWS. An ultraviolet light was shone on the ventral side of the owl's wings causing a pigment

called porphryin that is present in fresh, growing feathers to fluoresce a bright pinkish red. If both the primary and secondary flight feathers were of uniform color, the owl was a hatch-year owl (HY) born that summer. If the flight feathers were not uniform, the owl was an after-hatch-year owl (AHY), older than one year old.

Sex was determined using a wing-mass discriminant function provided by Project Owlnet. A comparison of the individual owl's mass and wing length was compared to a table discriminating sex according to the wing size-mass relationship. This method is claimed to have an accuracy of 95% and relies on the larger average size of females relative to males. There is a small percentage of overlap between the two sexes, and owls falling within this overlap were classified as unknown.

Once the owl had been banded and all the data collected, it was prepared for release. It was placed outside in a cage in the dark for approximately ten minutes so that its eyes could readjust to the low light conditions. The owl was then released near the cover of trees so that it could quickly seek protection from predators.

Data Analysis

Comparison of migration volume was conducted by standardizing capture rates of owls per 100 net hours. This was done for each of the three sites and for each year by dividing the number of hours the mist nets were open during the sampling period by 100 and then dividing that quotient into the number of owls in the sample. Statistical analyses were conducted using SPSS 15.0 for Windows. Distributions were tested for normality using the Kolmogorov-Smirnov and Shapiro-Wilkes tests. Sex and age ratios among study sites were normally distributed and were tested using independent sample *t* tests.

All other distributions such as migration timing among locations for a year, migration timing between years for each location, and age ratios at each location for a given year were not normally distributed and were tested using the non-parametric Mann-Whitney U test.

Results

Volume

At the Piedmont site, the numbers of owls captured per year ranged from 7-71 and the number of trap nights per year ranged from 21- 47 (Table 1). The largest number of owls caught was in 2007 (Table 1). There was an increase in trapping nights and net hours beginning in 2005 and extending through 2007 (Table 1). This was the result of students from Liberty University helping operate the nets. Capture rates in 2005 and 2006, 0.9 and 1.4 owls per 100 net hours respectively, were considerably lower than in other years (Table 1). At the Mountain site owls captured per year ranged from 52-188 with the number of trap nights per year ranging from 12-29 (Table 2). The highest number of owls captured was also in 2007. The Coastal Plain site captured between 21-460 owls each year, and the highest number caught was again in 2007 (Table 3). The number of trap nights per year ranged from 37-48.

The Coastal site captured 2-10 times as many total owls per year compared to the Piedmont site, but the standardized values of owls per 100 net hours were generally lower for Coastal Plain site versus the Piedmont site (Tables 1, 3). This was the result of the Coastal site operating three banding stations all night, compared to the Piedmont which operated only one banding station until 11:00 PM. Trapping efforts at the Mountain site

were more comparable to the Piedmont site; however, standardized values for the Mountain site were 3-6 times higher than for the Piedmont site and 10-20 times higher than for the Coastal site. In general, each site showed appreciable variation in numbers per year, but when these numbers were standardized as owls per 100 net hours, variation within each site per year did not exceed 2-3 times the lowest values.

Table 1

Trapping Effort and Capture Results of Northern Saw-whet Owl Mist Netting in the Piedmont of Virginia, 2002-2007

	2002	2003	2004	2005	2006	2007
Trap nights	21	26	26	38	40	47
Banding Period	10/26-12/14	10/27-12/9	10/30-12/14	10/28-12/11	10/24-12/8	10/20-12/14
Net hours	540	640	610	805	870	1090
New owls	39	38	52	7	12	71
Owls/trap night	1.9	1.5	2.0	0.2	0.3	1.5
Owls/100 net hours	7.2	5.9	8.5	0.9	1.4	6.5

Table 2

Trapping Effort and Capture Results of Northern Saw-whet Owl Mist Netting in the Mountains of Virginia, 2002-2007

	2002	2003	2004	2005	2006	2007
Trap nights	12	18	19	26	26	29
Banding Period	10/23-11/27	10/23-12/9	10/25-12/4	10/31-12/5	10/29-12/4	10/27-11/30
Net hours	226	417	444	766	739	486
New owls	52	87	168	158	114	188
Owls/trap night	4.3	4.8	8.8	6.1	4.4	6.5
Owls/100 net hours	23.0	20.8	37.9	20.6	15.4	38.7

Table 3

Trapping Effort and Capture Results of Northern Saw-whet Owl Mist Netting for the Coastal Plain of Virginia, 2002-2007

	2002	2003	2004	2005	2006	2007
Trap nights	37	43	46	47	41	45
Banding Period	10/23-12/15	10/23-12/15	10/22-12/15	10/25-12/15	10/25-12/15	10/27-12/14
Net hours	7287	8279	8559	7421	7704	8576
New owls	137	119	151	75	21	460
Owls/trap night	3.7	2.8	3.3	1.6	0.5	10.2
Owls/100 net hours	1.9	1.4	1.8	1.0	0.3	5.4

Timing

Figure 1 provides an overview of migration timing for each year at the Piedmont site. The median dates of migration timing for Northern Saw-whet Owls at this site ranged from November 8 to November 20 (Figure 1, Table 4). Comparison of migration timing among sites allows for roughly characterizing each yearly migration at a site as being early (November 1-7), moderate (November 8-14), or late (November 15-30) with respect to the median migration period. The Piedmont site had four moderate migration years (2002, 2004, 2005, and 2007) and two late years (2003 and 2006) (Table 4). Migration timing did not differ significantly among the four moderate years (Table 5). However, the two late years did differ between each other, $U(48) = 122.00$, $p = 0.015$. Both late years differed significantly from all of the moderate years except for 2003 and 2005, $U(43) = 84.50$, $p = 0.126$.

Figure 2 summarizes migration timing for each year at the Mountain site. Median migration dates varied from November 2 to November 20 (Figure 2, Table 4). Years

2002, 2004, and 2007 were early years while 2003 and 2005 were moderate years, and 2006 was late (Table 4). Neither the early nor the moderate years differed among each other. All early years differed from both moderate years, and the single late year differed from all other years (Table 6).

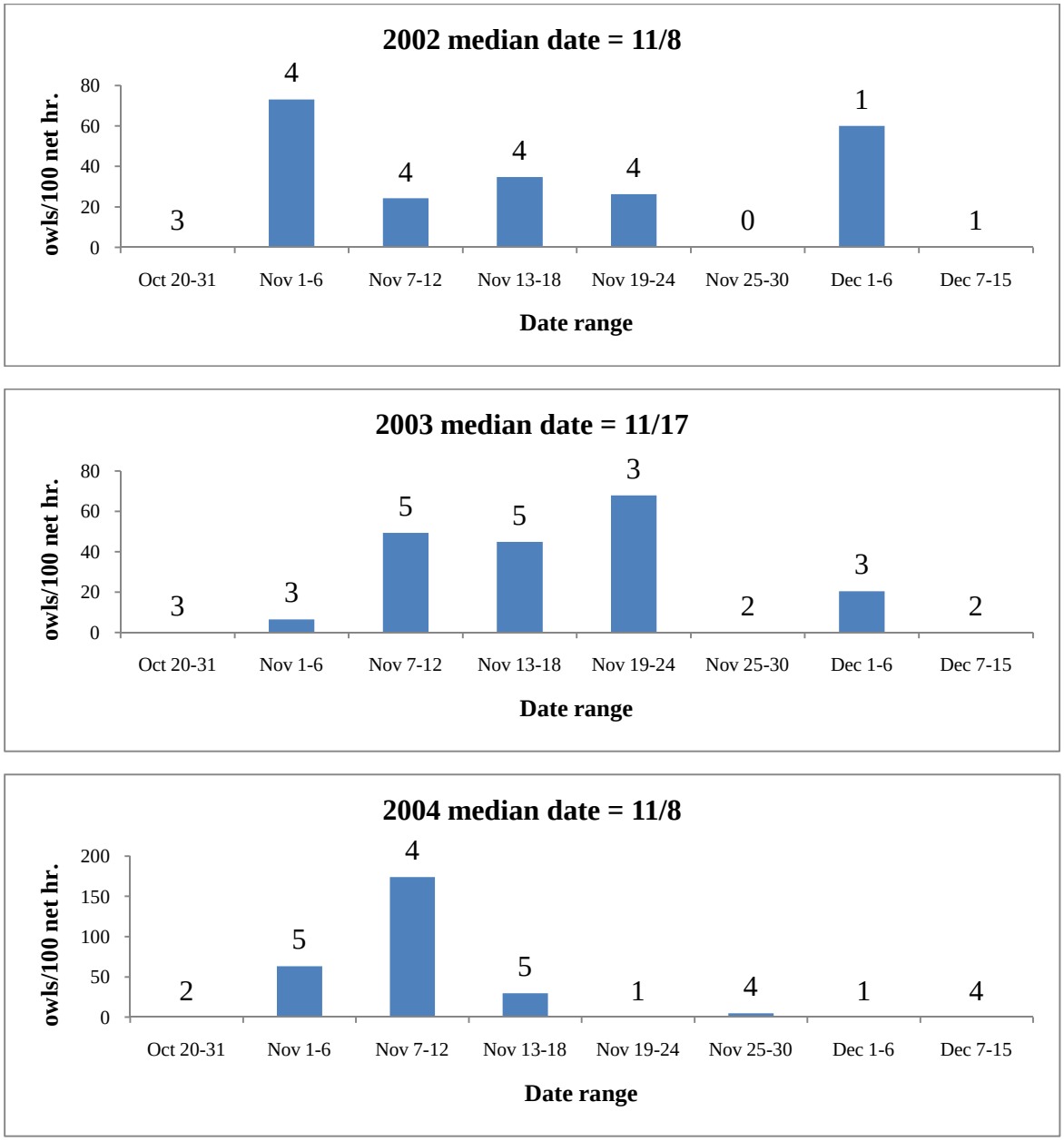
The Coastal Plain site migration timing is summarized in Figure 3. Median migration dates ranged from November 8 to November 25 (Figure 3, Table 4). Three years were moderate (2004, 2005, and 2007) and three years were late (2002, 2003, and 2006) (Table 4). Among the moderate years, 2004 differed significantly from both 2005 and 2007, U (224) = 4005.50, p = <0.001 for 2005 and U (609) = 30100.00, p = 0.014 for 2007. However, 2005 and 2007 did not quite differ, U (533) = 14986.00, p = .0068. Among late years 2003 and 2006 did not differ, U (138) = 985.00, p = 0.122; 2002 and 2003 did not quite differ, U (254) = 7075.50, p = 0.068; but 2002 and 2006 did differ, U (156) = 977.00, p = 0.018. All late years differed from all moderate years except for 2002 and 2005, U (210) = 4633.00, p = 0.237 (Table 7).

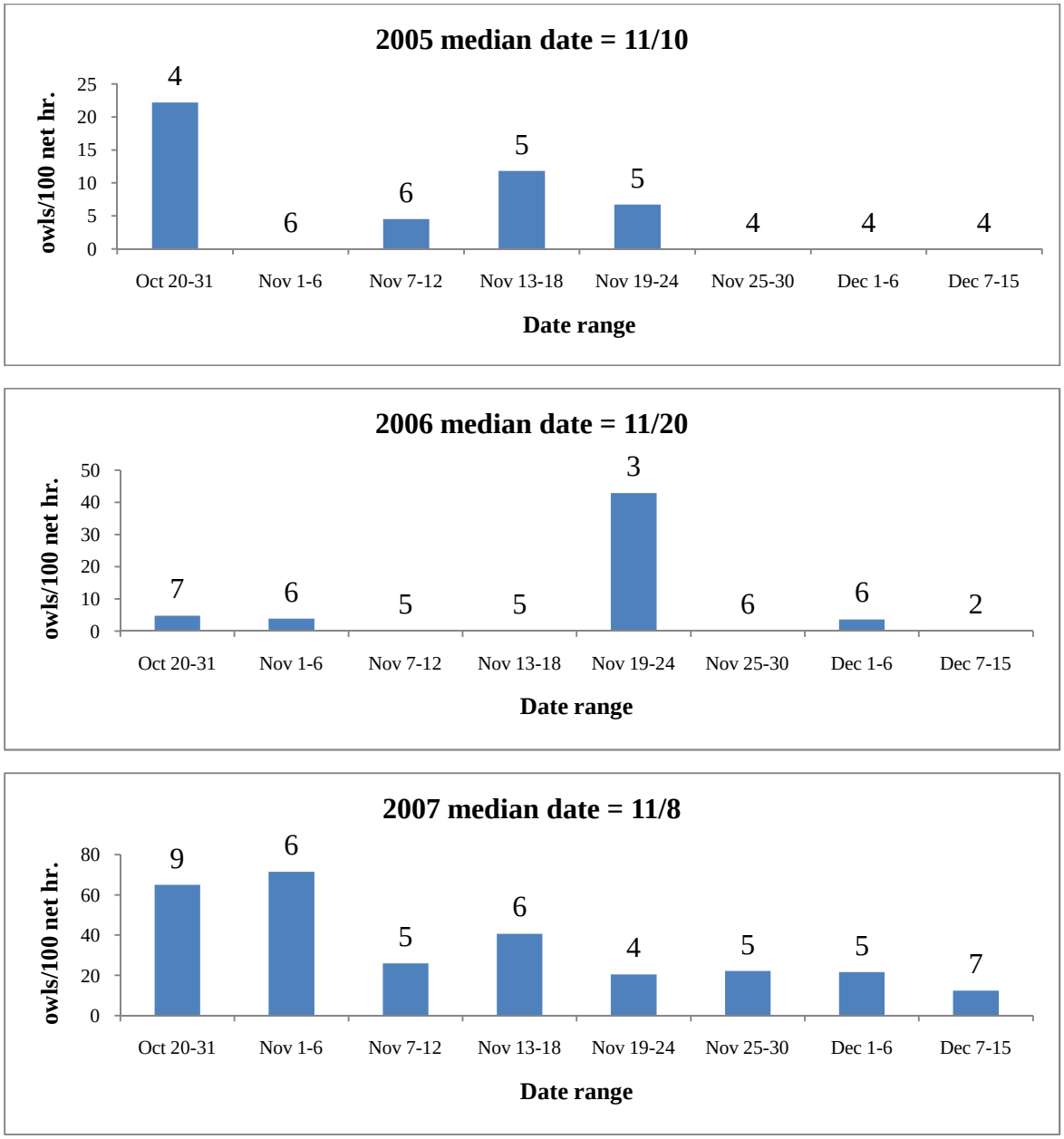
Migration timing was also compared among each site for each year (Table 4). The median dates for each site and year showed a general timing pattern of owls migrating earliest in the mountains, later in the Piedmont region, and latest on the Coastal Plain (Table 4). The only contradiction to this pattern was in 2005 when the Piedmont site had a median migration date one day earlier than the Mountain site (Table 4); however, the sample size was very low for the Piedmont site in 2005 (n = 7) (Table 1). Additionally, there was no statistically significant difference in migration timing between the Mountain and Piedmont sites in the year 2006, U (124) = 648.50, p = 0.767 (Table 8). There was

also no statistically significant difference between the Piedmont and Coastal sites for the years 2004-2007, U (201) = 3343.00, p = 0.108 for 2004; U (80) = 183.50, p = 0.188 for 2005; U (31) = 113.50, p = 0.637 for 2006; and U (529) = 15491.00, p = 0.485 for 2007 (Table 8). The remaining twelve comparisons among sites for each year were significantly different. Moreover, if migration timing was earlier or later in a year for a site, that same pattern tended to be manifested at the other sites for that year as well (Table 4).

Figure 1

Seasonal Timing of Northern Saw-Whet Owl Migration for the Piedmont of Virginia, 2002-2007

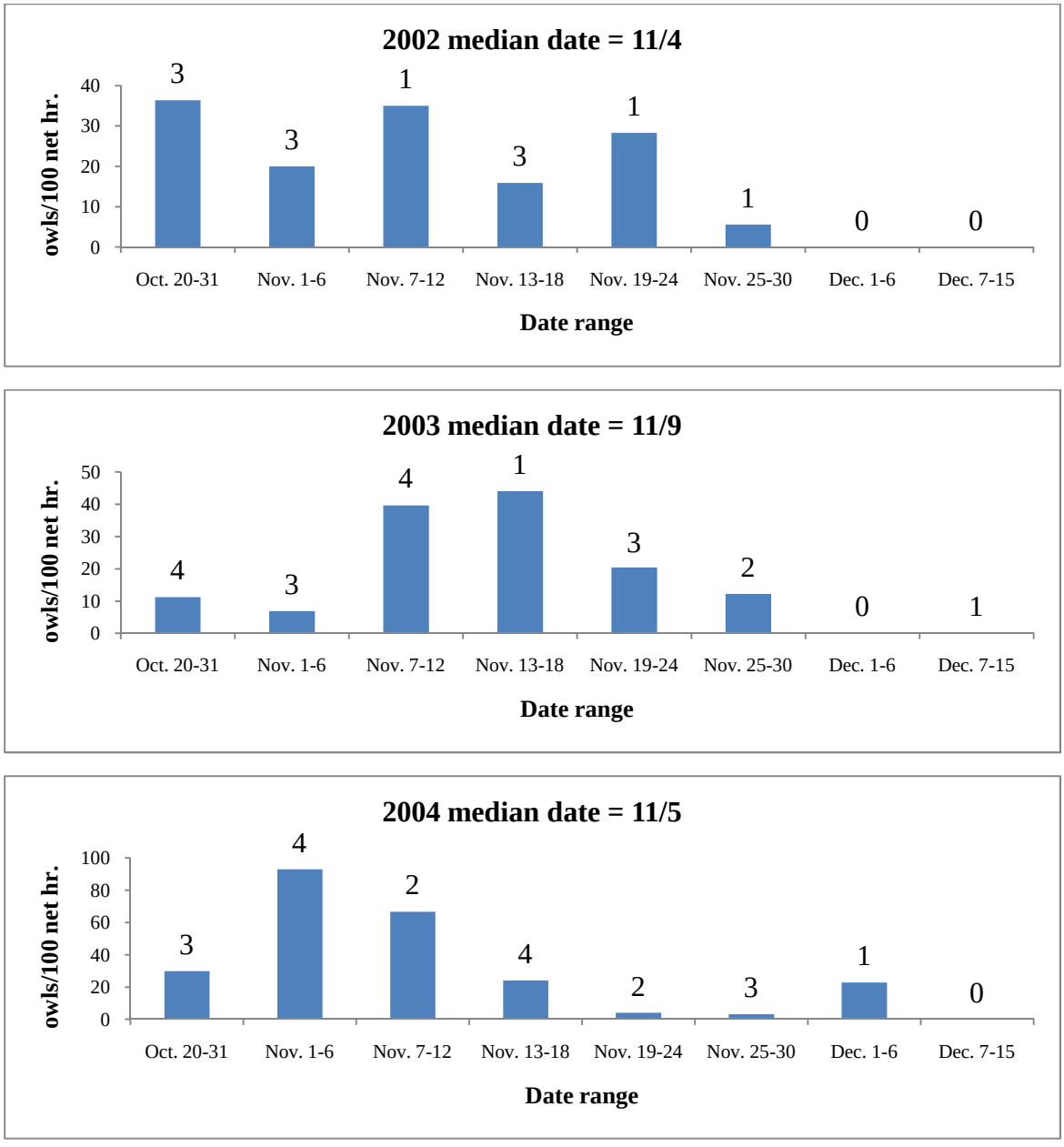


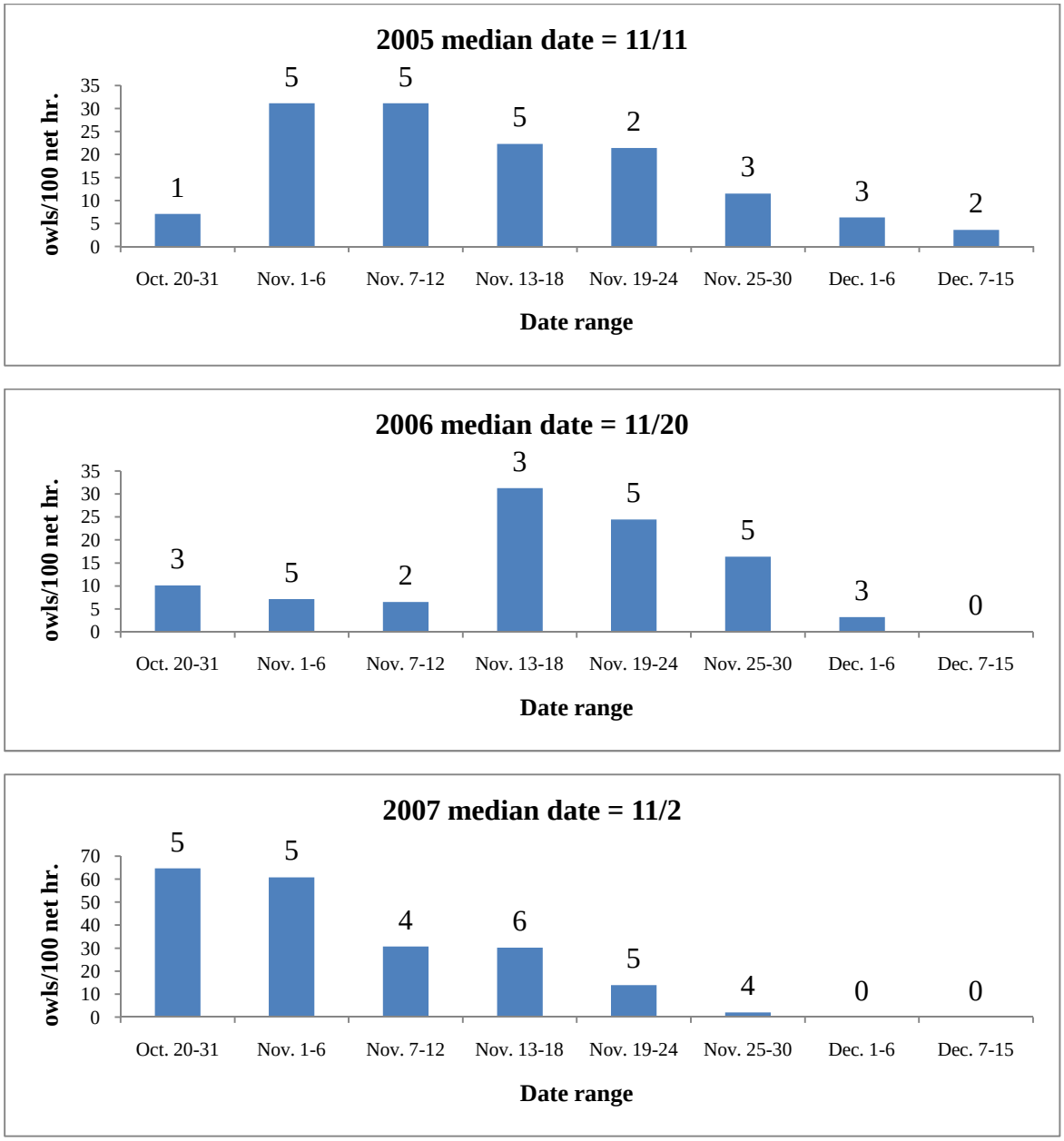


Note. Numbers above column indicate number of trap nights for that date range. Also, scale of Y axis changes from year to year.

Figure 2

Seasonal Timing of Northern Saw-Whet Owl Migration for the Mountains of Virginia, 2002-2007

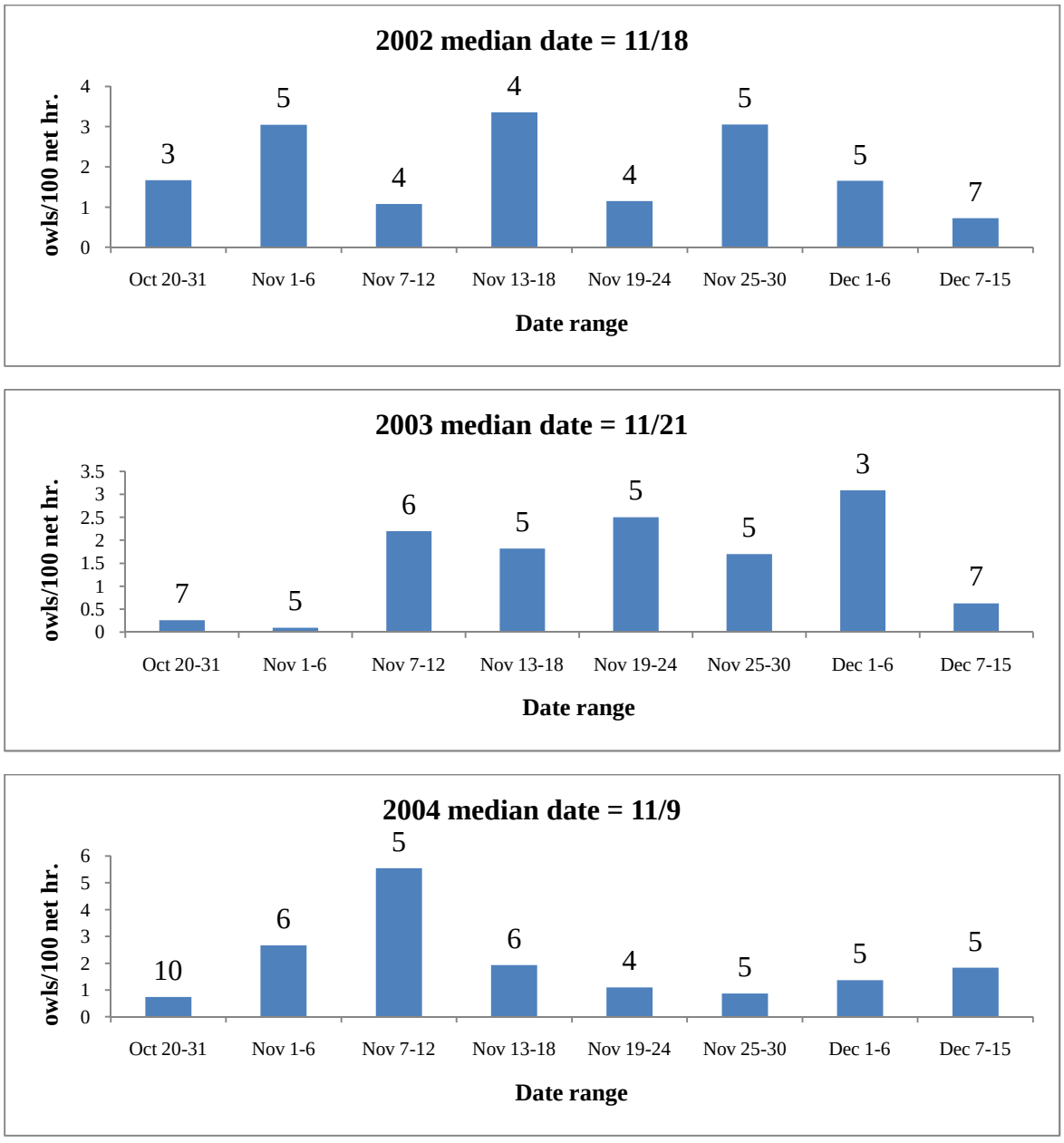


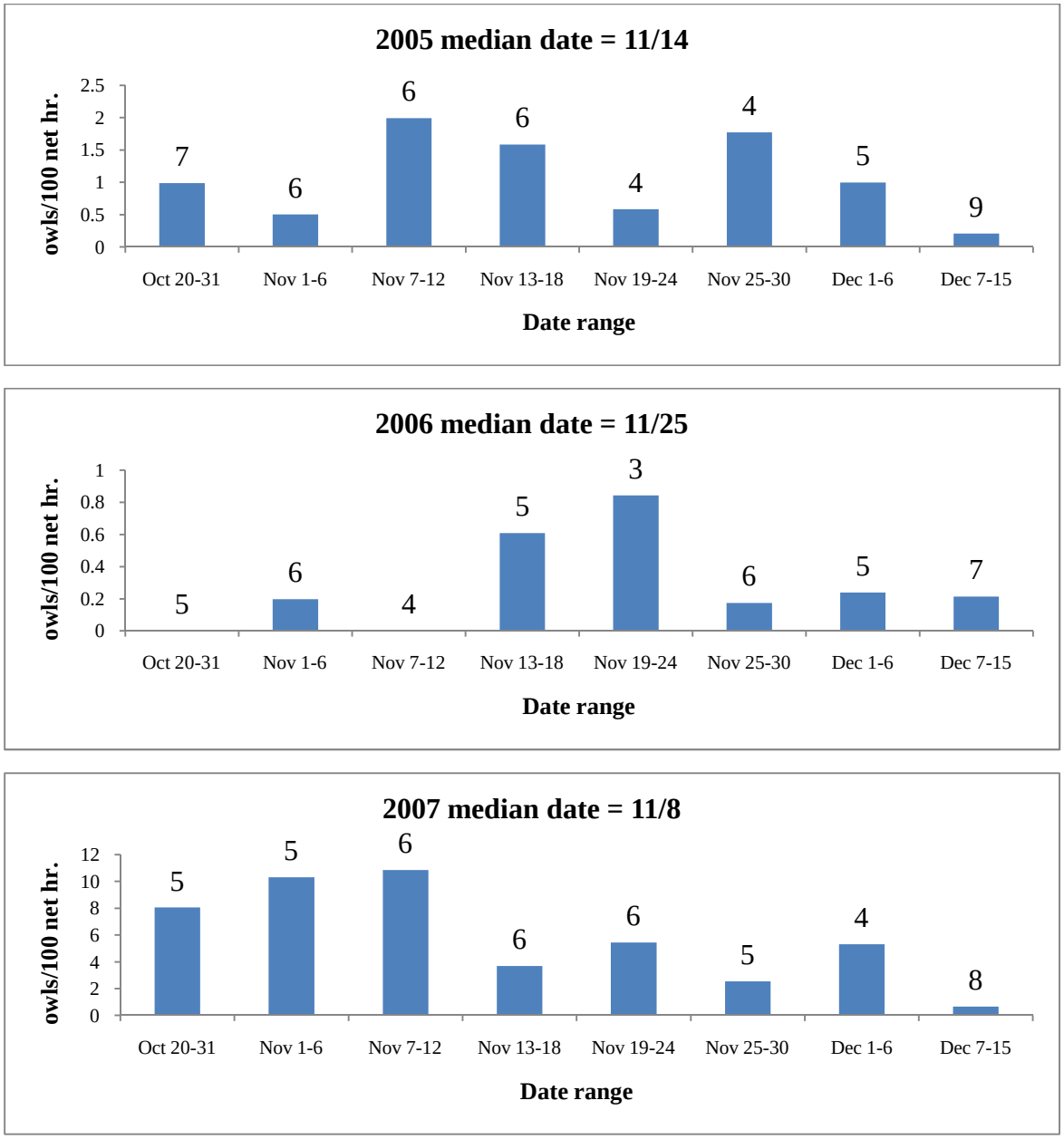


Note. Numbers above column indicate number of trap nights for that date range. Also, scale of Y axis changes from year to year.

Figure 3

Seasonal Timing of Northern Saw-Whet Owl Migration for the Coastal Plain of Virginia, 2002-2007





Note. Numbers above column indicate number of trap nights for that date range. Also, scale of Y axis changes from year to year.

Table 4

Median Fall Migration Dates for 2002-2007 for Three Physiographic Regions of Virginia

Site	2002	2003	2004	2005	2006	2007
Mountain	4-Nov	9-Nov	5-Nov	11-Nov	20-Nov	2-Nov
Piedmont	8-Nov	17-Nov	8-Nov	10-Nov	20-Nov	8-Nov
Coastal	18-Nov	21-Nov	9-Nov	14-Nov	25-Nov	8-Nov

Table 5

Significance Values from Mann Whitney U Tests Comparing Migration Timing for the Piedmont of Virginia, 2002-2007

Year	2002	2003	2004	2005	2006	2007
2002	----					
2003	0.001*	----				
2004	0.460	<0.001*	----			
2005	0.480	0.126	0.757	----		
2006	0.001*	0.015*	<0.001*	0.007*	----	
2007	0.420	0.045*	0.203	0.186	0.027*	----

Note. All values given are p values.
* Indicates significant difference between years.

Table 6

Significance Values from Mann Whitney U Tests Comparing Migration Timing for the Mountains of Virginia, 2002-2007

Year	2002	2003	2004	2005	2006	2007
2002	----					
2003	0.022*	----				
2004	0.930	<0.001*	----			
2005	<0.001*	0.242	<0.001*	----		
2006	<0.001*	<0.001*	<0.001*	<0.001*	----	
2007	0.290	0.001*	0.924	<0.001*	<0.001*	----

Note. All values given are p values.
* Indicates significant difference between years.

Table 7

Significance Values from Mann Whitney U Tests Comparing Migration Timing for the Coastal Plains of Virginia, 2002-2007

Year	2002	2003	2004	2005	2006	2007
2002	----					
2003	0.068	----				
2004	<0.001*	<0.001*	----			
2005	0.237	0.011*	<0.001*	----		
2006	0.018*	0.122	<0.001*	<0.001*	----	
2007	0.005*	<0.001*	0.014*	0.068	<0.001*	----

Note. All values given are p values.
* Indicates significant difference between years.

Table 8

Significance Values from Mann Whitney U Tests Comparing Migration Timing for Three Physiographic Regions of Virginia, 2002-2007

2002

	Coastal	Piedmont	Mountain
Coastal	----		
Piedmont	0.003*	----	
Mountain	<0.001*	0.033*	----

2003

	Coastal	Piedmont	Mountain
Coastal	----		
Piedmont	0.004*	----	
Mountain	<0.001*	0.001*	----

2004

	Coastal	Piedmont	Mountain
Coastal	----		
Piedmont	0.108	----	
Mountain	<0.001*	<0.001*	----

2005

	Coastal	Piedmont	Mountain
Coastal	----		
Piedmont	0.188	----	
Mountain	0.024*	0.287	----

2006

	Coastal	Piedmont	Mountain
Coastal	----		
Piedmont	0.637	----	
Mountain	0.091	0.767	----

2007

	Coastal	Piedmont	Mountain
Coastal	----		
Piedmont	0.485	----	
Mountain	<0.001*	0.001*	----

Note. All values given are p values.
* Indicates significant difference between sites.

Sex ratios

Samples at all three banding locations were chiefly composed of females (Table 9). Ratios of females among all three sites differed significantly. The percentage of males for the Coastal Plain site was approximately three times larger than the percentage of males for either the Piedmont or Mountain sites (Table 9). The ratios of males for 2002-2007 at the Coastal Plain site were significantly higher than the ratios of males for both the Mountain and Piedmont sites, t (10) = -7.87, p = <0.001 for Coastal-Mountain and t (10) = -6.55, p = <0.001 for Coastal-Piedmont. The ratios of males did not significantly differ between the Piedmont and Mountain sites, t (10) = 0.63, p = 0.541.

Table 9

Average Percentages of Male and Female Owls Reported for Three Physiographic Regions of Virginia

	Male	Female	Unknown
Mountain	4.1	86.5	9.4
Piedmont	5.5	74.0	20.5
Coastal	15.7	58.7	25.6

Age ratios

Adults made up 60% or more of the samples for each year in the Piedmont and Mountain sites except for in 2007 (Tables 10, 11). For 2002-2006, the average sample percent of adults was 82.9% for the Piedmont site and 64.4% for the Mountain site. Percentages of adults differed significantly between the Piedmont and Mountain sites, t (8) = 2.77, p = 0.024. In contrast, only 39.4% of the Piedmont sample and 45.2% of the Mountain sample were adult birds in 2007. The Coastal Plain site had a significantly lower proportions of adults than the other two sites each year, t (8) = 4.04, p = 0.004 for

Coastal-Piedmont and t (8) = 2.60, p = 0.032 for Coastal-Mountain. From 2002-2006, the average sample percent of adults for the Coastal Plain site was 46.6%; however, in 2007, only 18.5% of the sample was composed of adults (Table 12).

Table 10

Number (and Percent) of Juvenile and Adult Owls for the Piedmont of Virginia, 2002-2007

Year	HY	AHY	Unknown	Total
2002	11 (28.2)	28 (71.8)	0 (0.0)	39
2003	10 (26.3)	26 (68.4)	2 (5.3)	38
2004	6 (11.5)	43 (82.7)	3 (5.8)	52
2005	0 (0.0)	7 (100.0)	0 (0.0)	7
2006	1 (8.3)	11 (91.7)	0 (0.0)	12
2007	42 (59.2)	28 (39.4)	1 (1.4)	71
Total	70 (32.0)	143 (65.3)	6 (2.7)	219

Note. HY = Hatch Year, AHY = After Hatch Year, and values outside parentheses represent number of owls while values inside parentheses represent sample percentages.

Table 11

Number (and Percent) of Juvenile and Adult Owls for the Mountains of Virginia, 2002-2007

Year	HY	AHY	Unknown	Total
2002	17 (32.7)	35 (67.3)	0 (0.0)	52
2003	32 (36.8)	50 (57.5)	5 (5.7)	87
2004	59 (35.1)	103 (61.3)	6 (3.6)	168
2005	40 (25.3)	115 (72.8)	3 (1.9)	158
2006	42 (36.8)	72 (63.2)	0 (0.0)	114
2007	102 (54.3)	85 (45.2)	1 (0.5)	188
Total	292 (38.1)	460 (60.0)	15 (1.9)	767

Note. HY = Hatch Year, AHY = After Hatch Year, and values outside parentheses represent number of owls while values inside parentheses represent sample percentages.

Table 12

Number (and Percent) of Juvenile and Adult Owls for the Coastal Plains of Virginia, 2002-2007

Year	HY	AHY	Unknown	Total
2002	58 (42.3)	79 (57.7)	0 (0.0)	137
2003	71 (59.7)	48 (40.3)	0 (0.0)	119
2004	77 (51.0)	74 (49.0)	0 (0.0)	151
2005	57 (76.0)	18 (24.0)	0 (0.0)	75
2006	8 (38.1)	13 (61.9)	0 (0.0)	21
2007	373 (81.1)	85 (18.5)	2 (0.4)	460
Total	644 (66.9)	317 (32.9)	2 (0.2)	963

Note. HY = Hatch Year, AHY = After Hatch Year, and values outside parentheses represent number of owls while values inside parentheses represent sample percentages.

Discussion

Volume

There were appreciable differences in migration volume among the three study sites. The Coastal Plain site had the lowest standardized number of owls captured, the Piedmont site had a moderate capture rate, and the Mountain site had the highest capture rate. This suggests migration flight volumes are highest in the mountains and lowest on the coast. However, there are several caveats to this conclusion.

Anecdotal evidence suggests that some differences among sites in capture rates can be the product of microhabitat influences related to the placement of the mist nets. For example, at the Coastal Plain site. Three banding stations were operated within 10

square kilometers of each other. Of these three stations, one station was responsible for 15-20% of Northern Saw-whet Owl captures while the other two stations each account for approximately 40-50% of captures, a difference of 2-3 times the other station's capture rate (Smith et al., 2008).

Capture rates may also be biased due to non-continuous banding efforts at the Piedmont and Mountain sites from 2002-2004. During these years both sites were sampled more rigorously during peak migration periods. When continuous coverage began at the Piedmont site, capture rates for 2005 and 2006 were lower than in previous years (Table 1). However, capture rates were also lower for these years in both the Mountain and Coastal Plain sites (Tables 2, 3), while in 2007, capture rates at the Piedmont site returned to normal despite continuous coverage (Table 1).

Finally, migration flight volumes at the Coastal Plain site may not be represented by independent samples because the three banding stations are located in close proximity together. Banding station placement here was designed to increase the number of recaptures in order to better study stopover dynamics of the Northern Saw-whet Owl. This marginal overlapping of sampling efforts may have decreased overall capture rates and thus not entirely reflected the true migration flight volume for this area.

Despite these qualifications, the magnitude of the volume differences among sites indicates migration flight volume is likely higher in the Mountain province than in the Piedmont or Coastal provinces. This same pattern has also been reported in Maryland (D. Brinker, personal communication). The Mountain province may have more dependable stopover habitat and be consequently used more heavily as a flyway. Data suggest the

Piedmont province experiences a higher migration volume than the Coastal Plain although this difference was not as pronounced in 2007 (Tables 1, 3). A more definitive comparison requires additional data.

Migration flight volumes at the Piedmont site were relatively consistent throughout 2002-2004 and 2007 (Table 1). As noted earlier, 2005 and 2006 capture rates were lower. While this could be related to the beginning of continuous coverage, it is more likely related to some other environmental factor, because capture rates were also lower for the Mountain and Coastal sites. Banding stations further north of Virginia reported relatively normal capture rates for 2005 and 2006, which suggests the migration did not extend as far south in 2005 and 2006 as in other years.

Data for 2007 indicate it was an invasion year. Banding stations to the north also reported significantly higher capture rates than normal. The Coastal Plain site's standardized capture rate increased approximately 2.5-3 times the normal rate compared to 2002-2004 (Table 3). The Mountain site saw an increase in capture rates as well, although not as significant as at the Coastal Plain site, and there was no appreciable difference in capture rates for 2007 at the Piedmont site, although non-continuous coverage in 2002-2004 may have skewed the comparison.

These comparisons among the Mountain, Piedmont, and Coastal Plain sites also imply that migration dynamics may vary geographically. For example, although migration volumes in 2005 and 2006 in the Piedmont and Coastal Plain were lower than the preceding three years, this was not appreciably so for the Mountain site. Factors such

as prey availability and competition for resources may influence this geographic variation in migration volume (Cohen, 1967).

Timing

Two consistent patterns emerge when median dates of migration are compared. First, comparison of median migration dates between years for each location shows that if migration occurred either later or earlier relative to another year, the same pattern was reflected at the other two locations for that year. For example, in 2007 the median migration for the Mountain site was November 2, significantly earlier than 2006's median migration date of November 20 (Table 4). The median migration dates for the Piedmont and Coastal sites were also significantly earlier in 2007 than in 2006 (Table 4). This type of pattern is expected if migration timing is influenced by broad-scale meteorological factors such as the onset of cooler temperatures or other related factors such as leaf fall. These kinds of factors can affect the availability of roosting cover and thus may moderate migration timing. Second, comparing median migration dates among sites for a particular year suggests migration is occurring earliest in the Mountain province, slightly later in the Piedmont province, and latest in the Coastal province. This pattern also suggests the Northern Saw-whet Owl is responding to climatic or climatic related factors. The Coastal province, being characterized by a milder climate due to the moderating effects of the ocean, is expected to have the latest median migration date, while as the climate becomes increasingly cooler further inland, away from moderating influence of the ocean, migration would be expected to occur progressively earlier.

Sex Ratios

The proportion of males at both the Piedmont and Mountain sites were quite small, 5.5% and 4.1% respectively. This is considered a typical result for saw-whet banding stations (Brinker et al., 1997) and there are two possible explanations. First, differential migration between sexes may exist, with males not migrating as far as females as males seek to return more quickly to breeding grounds and establish breeding territories (Cannings, 1993). This would account for the large percentages of females being captured in Virginia which is located relatively far south. Second, the audio lure may be biasing the results either by attracting more females or deterring males. Whalen and Watts (1999) found smaller birds exhibited lure shyness and tended to be captured further from the audio lure, which might suggest a sex bias exists, as males tend to be smaller bodied than females. Also, Duffy and Matheny (1997) found that the use of an audio lure increased the sample percentage of females from 65% without the lure to 80% with the lure, implying that females maybe be preferentially attracted to the lure. Either or both of these hypotheses may explain the difference in sex ratios.

Among study sites, the Coastal Plain site had a significantly higher proportion of males than did the Piedmont and Mountain sites (Table 9). Brinker et al. (1997) reported finding a similar trend in the Middle Atlantic and northeastern United States. This may suggest differences between sexes in migratory route selection.

Age Ratios

Samples were predominantly composed of adult owls in 2002-2006 at the Piedmont and Mountain sites which is typical of non-invasion years (Tables 10, 11).

However, in 2007 juveniles dominated these samples (Table 10, 11); this is consistent with an invasion year, which other more northern banding locations experienced. While not definitively known, the cause of an invasion year is thought to be related to high prey availability the previous breeding season (Whalen et al., 1997). The wide availability of prey increases reproductive success and size of the owl population (Whalen et al.; Cote et al., 2007). Lowered prey availability the following fall then forces many owls south, particularly the juveniles from the successful breeding season. This would produce an invasion year with a higher proportion of juveniles (Whalen et al.).

The Coastal Plain site had significantly lower numbers of adult birds than the other two sites, with most years' samples being composed chiefly of juveniles (Table 12). The reasons for this trend are unclear; however, differences in migratory routes are known to exist in other species of birds (Woodrey & Chandler, 1997) and this may be the case for Northern Saw-whet Owls as well. For example, juvenile Sharp-shinned Hawks are known to migrate in greater numbers along the coast (Clark, 1985; Goodrich, 1989). This trend is further supported by research at another coastal owl banding station in Cape May, NJ, which also reported high percentages of immature Northern Saw-whet Owl captured (Duffy & Kerlinger, 1992).

Conclusion

This was the first long-term study to examine Northern Saw-whet Owl migration dynamics in the Piedmont province of Virginia, and the first to compare three physiographic regions across Virginia. This study's findings suggest migration volume of the Northern Saw-whet Owl is highest in the Mountains and lowest on the Coastal Plains.

It appears that migration timing is earliest in the Mountains, slightly later in the Piedmont, and latest on the Coastal Plains. Also, inter-year migration timing differences at one site were consistently reflected at other sites. Females dominated samples, suggesting differential migration between sexes and/or the existence of an audio lure bias. Samples were also typically dominated by adult owls except for in 2007, a year characterized as an invasion year.

Ultimately, banding efforts in the Mountain and Piedmont provinces are still relatively new, but are now beginning to shed light on saw-whet migratory movements in Virginia away from the coast where longer-term studies have been conducted. Continued study combined with improvements in cooperation and communication between banding stations could greatly enhance current understanding of the Northern Saw-whet Owl's migration dynamics.

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