# Autumn Migration of Northern Saw-whet Owls (*Aegolius acadicus*) in the Middle Atlantic and Northeastern United States: What Observations from 1995 Suggest

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Abstract.—During the autumn of 1995 more than 5,900 migrant Northern Saw-whet Owls were banded in eastern and central North America. Though typical numbers of owls were banded at most Great Lakes stations during 1995, a record number were netted at Hawk Ridge, near Duluth, Minnesota and, when compared with more normal years, a remarkably disproportionate 40 percent of the total were banded at 5 stations in New Jersey, Maryland, and Virginia. The movement occurred throughout the eastern U.S. and may have been comparable to that of 1965 when unusually high numbers of Northern Saw-whet Owls were netted at songbird banding stations throughout the northeastern U.S. In the Mid-Atlantic states, the 1995 movement was comprised largely of immature females, with the proportion of males decreasing as latitude decreased. Many owls migrating through the Mid-Atlantic states probably wintered south of Virginia. None of our banded owls were recovered as northbound spring migrants along the southern shores of the Great Lakes. Interstation retraps and other autumn recoveries present a pattern that suggests that the forests of the southeastern United States may be an important wintering area for a portion of the eastern continental population of Northern Saw-whet Owls.

Each autumn many Northern Saw-whet Owls (*Aegolius acadicus*) leave their breeding range at northern latitudes and migrate to wintering areas (Holroyd and Woods 1975, Weir *et al.* 1980). This movement has been well documented by banding at stations in the Great Lakes area (Mueller and Berger 1967, Weir *et al.* 1980, Erdman *et al.* 1997, Evans 1997). Movement of Northern Saw-whet Owls along the Atlantic coast and in the Northeast has received much less attention, with only Cape May in operation from 1973 to 1990 (Duffy and Kerlinger 1992).

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Beginning in 1991, additional stations began operations in the Mid-Atlantic and each had captured < 200 Northern Saw-whet Owls each autumn. During 1995, the Mid-Atlantic stations witnessed a surprisingly large movement of owls: 2,596 Northern Saw-whet Owls were captured at five stations in New Jersey, Maryland, and Virginia. Analysis of the owls captured in 1995 revealed details on the origin of the flight, the speed of movement between stations, and the age and sex composition of migrants. From these data we will suggest what we can about the characteristics of this unusually large movement of Northern Saw-whet Owls during the autumn of 1995.

## STUDY AREAS AND METHODS

### Coastal Banding Stations

Cape May Point, NJ

(38°50' N, 74°50' W, elevation 1 m, see figure 1) Eleven single height mist nets were operated at a site in South Cape May Meadows, a Nature


Figure 1.—*Location of banding stations mentioned in the text where autumn migrant Northern Saw-whet Owls were banded during the 1991-1996 period.*

Conservancy preserve, approximately 75 m behind the primary dune for 19 nights from October 24 through November 19, 1995. Surrounding habitats consisted of a wet meadow of marsh elder (*Iva frutescens*), groundsel bush (*Baccharis halimi-folia*), scattered red cedar (*Juniperus virginiana*) and a woodlot of mixed deciduous trees with a dense understory of poison ivy (*Toxicodendron radicans*). Ten additional single height nets were located 150 m north between a dense stand of red cedar and a salt marsh. A second station in the Higbee Beach Wildlife Management Area, 3 km north, consisted of eight single height mist nets and was operated on 7 nights from November 4-18. Nets were placed in a cultivated field of mixed forbs adjacent to a hedgerow thicket of Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*) and Virginia creeper (*Parthen-ocissus quinquefolia*).

Assateague Island, MD

(38°10' N, 75°10' W, elevation 2 m, see figure 1) Seven mist nets were operated within a loblolly pine (*Pinus taeda*) forest on an old dune system approximately 650 m west of the Atlantic Ocean shoreline in Assateague Island National Seashore. Mist nets were arranged as a line of six nets with a seventh perpendicular net on the north side of the line at its mid point. The four central nets of the line and the perpendicular net were two nets high and the two outermost nets of the line were one net high. The station was operated nightly from October 22 through December 2, 1995.

Cape Charles, VA

In a 10-km$^2$ area at the southern tip of the Delmarva Peninsula near Cape Charles (fig. 1), three net locations were operated nightly from October 21 through December 13, 1995. At each site a line of six single height mist nets was used. One set of nets was located in the Eastern Shore of Virginia National Wildlife Refuge near the southern tip of the Delmarva Peninsula (37°00' N, 75°50' W, elevation 1 m). Nets at this site were approximately 50-100 m from beaches on the bayside to the west, salt marsh to the east, and the mouth of the Chesapeake Bay to the south. The vegetation consisted of loblolly pine forest with a dense understory of wax myrtle (*Myrica pennsyl-vanicus*). The second net site was in the Gatr Tract/Mockhorn Island Wildlife Management Area along the oceanside of the peninsula approximately 3 km north of the first site (37°10' N, 75°50' W, eleva-tion 2 m). Nets were approximately 100 m west of the salt marsh in a loblolly pine forest with a moderate under-story of various woody shrubs. The last set of nets was located in Kiptopeke State Park on the bay side of the peninsula approximately 3 km north of the first site (37°00', 75°50' W, elevation 10 m). The nets were approximately 100 m east of the beach in a forest dominated by oaks (*Quercus* sp.) with scattered loblolly pines and a sparse understory of American holly (*Ilex opaca*).

### Inland Banding Stations

Turkey Point, MD

(39°20' N, 76°00' W, elevation 24 m, see figure 1) This station was located in Elk Neck State Park near the tip of the Elk Neck Peninsula at the upper end of the Chesapeake Bay. Four mist nets, two nets high, were placed in a roughly straight line at the edge of a small clearing in second-growth deciduous forest approximately 500 m north of the tip of the point. This site was operated on most nights from October 22 through November 25, 1995.

Casselman River, MD

(39°30' N, 79°10' N, elevation 780 m, see figure 1) The banding station was located on the Appalachian Plateau in a broad shallow valley along the upper reaches of the North Branch of the Casselman River 40 km southwest of Cumberland, MD. Seven mist nets, two nets high, were arranged in a relatively straight line through a small clearing in an eastern hemlock (*Tsuga canadensis*) forest. Nets were operated nightly from October 7 through November 26, 1995.

### Net Operation and Banding

All stations used audiolures (Erdman and Brinker 1997) that produced sound pressure levels of 100-110 dB at 2 m and identical tapes to enhance capture rates. Mist nets at all stations were generally 12 m long, 2 m high, 61 mm mesh; some larger and smaller mesh sizes were used at Cape May and Cape Charles. Nets were opened at dusk, checked every 1-2 hours and closed about dawn. At all stations except Cape May, nets were opened on every night with acceptable weather between the opening and closing dates given above. Nets were not operated during precipitation or on extremely windy nights. Captured owls were fitted with U.S. Fish and Wildlife Service leg bands, weighed, measured, and aged. Owls with one generation of wing feathers were classified as immatures (HY=hatch year); owls with more than one age of wing feathers were aged as adults (AHY=after hatch year) (Evans and Rosenfield 1987). The pattern of retained old feathers was recorded for most adults.

### Sex Determination

Weir *et al.* (1980) first published criteria for determination of sex in Northern Saw-whet Owls from wing chord measurement; other authors have commented that the criteria were flawed because observed sex ratios differed from 1:1 (Mueller 1982, Evans and Rosenfield 1987, Slack 1992). The wing chord method of determining sex for Northern Saw-whet Owls does not work reliably and for this analysis it was not used to assign sex to individual owls. A discriminant function (DF) was developed that relied upon a combination of wing chord and mass to assign sex to owls (see Appendix). The DF assigned sex to more than 90 percent of the owls. Solely for the purpose of this analysis, the DF was considered adequate and much more reliable than using wing chord to determine sex.

## RESULTS

During the autumn of 1995, five owl banding stations in New Jersey, Maryland, and Virginia netted 2,596 Northern Saw-whet Owls (table 1). The Turkey Point, MD station, which was only operated during 1995, netted 324 Northern Saw-whet Owls. The five-station total represented more than 40 percent of the Northern Saw-whet Owls banded in the Eastern U.S. during the autumn migration of 1995. During more usual years the total number of owls banded in this portion of the U.S. is at most several hundred. Correcting for effort, the capture rate (owls/10 $m^2$ net/100 hours) during the years 1991-1994, varied from a low of 0.211 at Assateague during 1992 to a high of 2.83 at Cape May during 1993. In comparison, capture rates during 1995 varied from 2.00 to 6.61 (table 1). Although more comparable than total number of owls netted, catch per unit effort values are still not directly comparable, primarily because of differences in the timing and duration of capture efforts between stations each year.

During 1995 there were 31 direct interstation recoveries between the banding stations at Cape May, Assateague, and Cape Charles (fig. 2). Five owls banded at Cape May were subsequently retrapped at Assateague. Fifteen owls

Table 1.—*Northern Saw-whet Owls captured with an audiolure and mist nets, nights of netting effort, and adjusted capture rates at four Mid-Atlantic banding stations from 1991-1996.*

| **Station** | | **Year** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** |
| Cape May, NJ | owls netted | 82 | 24 | 187 | 73 | 637 | -[1] |
| | nights open | 23 | 17 | 28 | 23 | 20 | - |
| | owls/ 10 $m^2$ net/ 100 hours | 1.48 | 0.70 | 2.83 | 1.00 | 6.61 | - |
| Assateague Island, MD | owls netted | 65 | 29 | 63 | 27 | 332 | 21 |
| | nights open | 32 | 43 | 29 | 33 | 38 | 36 |
| | owls/ 10 $m^2$ net/ 100 hours | 0.486 | 0.211 | 0.614 | 0.220 | 2.59 | 0.168 |
| Casselman River, MD | owls netted | -[1] | 44 | 148 | 89 | 296 | 63 |
| | nights open | - | 38 | 45 | 44 | 38 | 55 |
| | owls/ 10 $m^2$ net/ 100 hours | - | 0.375 | 0.802 | 0.459 | 2.00 | 0.287 |
| Cape Charles, VA | owls netted | -[1] | - | - | 52 | 1,007 | 106 |
| | nights open | - | - | - | 32 | 44 | 42 |
| | owls/ 10 $m^2$ net/ 100 hours | - | - | - | 0.314 | 4.43 | 0.502 |

[1] The banding effort at Cape May during the autumn of 1996 was significantly different than during previous years and is not comparable with effort during the 1991-1995 period. At other stations the - represent years for which no data is available.

banded at Cape May were later retrapped at Cape Charles. An additional 11 owls banded at Assateague were retrapped at Cape Charles. Two of the owls banded at Turkey Pt. were retrapped at other banding stations as direct recoveries. One owl went to Cape Charles (banded November 5, 1995, recaptured November 18, 1995) and the other was renetted at an owl banding station near Halifax, North Carolina (36˚10' N, 77˚30' W) on November 25, 1995 (banded October 30, 1995). One Saw-whet Owl from Cape May, banded on November 16, 1995, was also renetted at Halifax, NC, on December 3, 1995. Finally, one owl banded at Assateague on November 12, 1995 was recaptured on the campus of the College of William & Mary (37˚10' N, 76˚40' W) on February 14, 1996. No owls banded at the Casselman River station were retrapped or recovered during the autumn-winter of 1995-96 (fig. 2). None of the owls banded at our five stations during the autumn of 1995 were retrapped as northbound migrants at stations along the southern shores of the Great Lakes during the spring of 1996.

Several owls banded outside the region were renetted or recovered in the Mid-Atlantic region during autumn 1995 (fig. 2). Two owls banded on October 26 and 27, 1994 near Wells, ME (43˚10' N, 70˚30' W), were renetted within a few nights of each other, on November 13, 1995 at Cape May, NJ and on November 16, 1995 at Turkey Pt., MD. A Northern Saw-whet Owl banded at Little Suamico, WI, (44˚40' N, 87˚50' W), on September 29, 1995 was renetted at Halifax, NC on November 8, 1995 (T. Erdman, pers. comm.). This owl represents the first direct recovery of a autumn migrant Northern Saw-whet Owl from the Great Lakes region that crossed the Appalachian Mountains. Another owl, banded at Hawk Ridge, MN (46˚50' N,

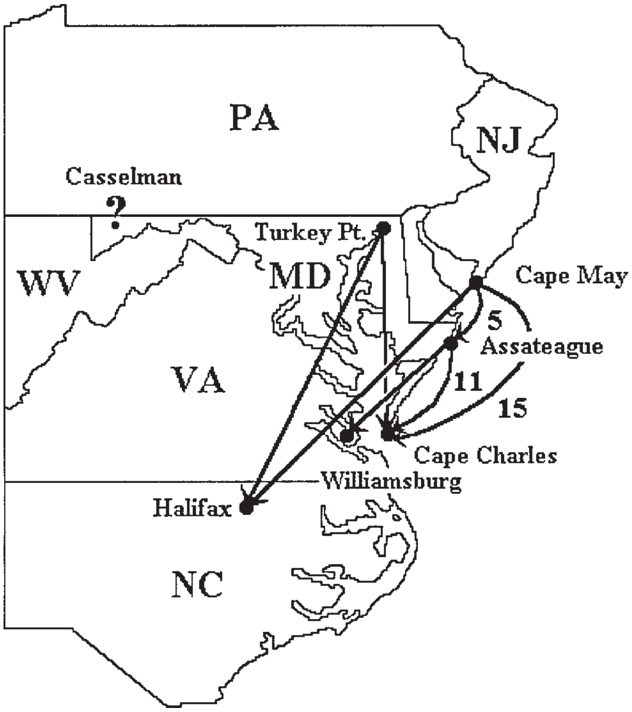


Figure 2.—*Between banding station movements of Northern Saw-whet Owls in the Mid-Atlantic states during the autumn of 1995. No owls were retrapped moving north, and no owls from Casselman River were retrapped.*

92°00' W) during the autumn of 1995 was recovered near East New Market, MD (38°30' N, 75°50' W) during March 1996 (D. Evans, pers. comm.).

During 1995 Northern Saw-whet Owls moved rapidly into and/or through the Mid-Atlantic region (table 2). One immature, released at Cape May near dawn (05:15) on November 17, was recaptured at Assateague Island, 88 km south, 3 hours after darkness (21:00) on the same day, for a minimum speed of nearly 30 km/h of darkness. Traveling from Cape May directly south to Assateague involves a 19 km crossing of Delaware Bay; obviously forced to make this crossing non-stop, this over water flight required less than 40 minutes. When released at Cape May, this owl's mass was 100 g; when recaptured at Assateague it weighed 99 g. Three other owls traveled from Cape May to Assateague within 3 nights. These three owls traveled an average of 29 km per night, nearly as fast as the owl that went from Little Suamico to Halifax, NC (average nightly movement, 32 km). The two interstation recaptures of owls banded at Turkey Point traveled an average distance of 13 and 18 km per night.

While two Northern Saw-whet Owls journeyed from Cape May to Cape Charles within 4 nights (average nightly movement, 56 km), eight other individuals took from 6 to 15 nights and six owls took more than 20 nights (27-65 nights) to make the trip. The shortest recapture interval between Cape May and Cape Charles yielded a minimum speed of 5.6 km/h of darkness. The Cape May owl recaptured in North Carolina traveled an average distance of 20 km per night. Data from owls banded at Assateague and retrapped at Cape Charles are similar (table 2). The shortest interstation interval between Assateague and Cape Charles yielded a minimum speed of 3.1 km/h of darkness. As the distance between stations increased the estimated average rate of migration decreased (table 2).

The autumn 1995 Northern Saw-whet Owl movement was characterized by a high proportion of immature owls (table 3). During the 1991-1994 period, the proportion of the owls that were adults varied considerably between stations and years, ranging from 10 to 63 percent. In any given year, age ratios during the 1991-1994 period showed more disparity between stations than in 1995 when all stations netted few adult owls.

Females were the most frequently netted Northern Saw-whet Owls during 1995 (table 3). Overall the DF assigned sex to 91 percent of the 3,263 owls for which both wing chord and mass measurements were taken (table 3). Along the coast, the proportion of the netted owls that were male increased with latitude, from 14 percent at Cape Charles to 18 percent at Cape May. The percent of the netted sample classed as unknown sex also increased with latitude. Females comprised 83 percent of the Northern Saw-whet Owls netted at the Casselman River in 1995 (table 3). At all stations, adult males were the least frequently captured individuals. Adult males were similarly rare during the 1991-1994 period (table 4).

Northern Saw-whet Owls netted during 1995 were in noticeably poorer body condition than those netted during 1991-1994. Many owls carried little or no fat in the furcular depression. This was in marked contrast to other years when furcular fat was frequently

Table 2.—*Nights between initial capture and subsequent recapture for Northern Saw-whet Owls moving between three Mid-Atlantic banding stations during the autumn of 1995. Values are the number of owls that took the indicated number of nights to travel between banding stations.*

| Number of nights | Cape May to Assateague Island[1] | Assateague Island to Cape Charles[2] | Cape May to Cape Charles[3] |
|---|---|---|---|
| 1 | 1 | 0 | 0 |
| 2 | 1 | 0 | 0 |
| 3 | 2 | 1 | 1 |
| 4 | 0 | 1 | 1 |
| 5 | 0 | 0 | 0 |
| 6 | 0 | 0 | 1 |
| 7 | 0 | 2 | 0 |
| 8 | 0 | 2 | 1 |
| 9 | 0 | 1 | 0 |
| 10 | 1 | 0 | 2 |
| 11 | 0 | 0 | 0 |
| 12 | 0 | 1 | 1 |
| 13 | 0 | 3 | 1 |
| 14 | 0 | 0 | 1 |
| 15 | 0 | 0 | 1 |
| >15 | 0 | 0 | 6 |
| Mean (nights) | 3.8 | 8.8 | 16.0[4] |
| Mean km/night | 23.1 | 15.6 | 14.1[4] |

[1] Cape May to Assateague Island is 88 km.
[2] Assateague to Cape Charles is 137 km.
[3] Cape May to Cape Charles is 225 km.
[4] Two retraps after 15 Dec. were excluded from the mean.

observed (Brinker, Erdman, pers. observ.). Mean body mass by age and sex class is summarized in table 4. At all stations with more than 3 years of data, immature females during 1995 weighed less than those netted at the same stations during any earlier year. Other than the overall low mass of female owls netted during 1995, there was no readily discernible pattern in mean weight variation among years, age classes, or sexes.

## DISCUSSION

### Origin of the Owls

Data on the origin of Northern Saw-whet Owls migrating through the Mid-Atlantic is limited by the lack of any significant banding effort to the north. We suspect that the bulk of the owls observed in the Mid-Atlantic States during autumn 1995 originated in eastern Canada and the northeastern U.S. This is inferred primarily from observations reported regionally (see Audubon Field Notes). Other support is provided by the two owls from Maine recaptured at Cape May and Turkey Point, by an owl banded on October 24, 1995 at Casselman River that was retrapped on October 17, 1996 in southeastern Maine (39°30' N, 79°10' W), and by two recoveries in southern Ontario during 1996 of owls banded on Assateague Island during the autumn of 1995. Interstation retraps of Northern Saw-whet Owls are much more likely than recovery of dead individuals. Had there been more banding effort in eastern Canada and the northeastern U.S., more interstation recoveries would have been available for review. Additional support for a northeastern origin comes from the greater magnitude of the flight in the Mid-Atlantic compared to what was observed in Wisconsin and Minnesota (see below). Had most of the owls originated farther

Table 3.—*Northern Saw-whet Owl age and sex composition at four Mid-Atlantic banding stations from 1991-1996. Age and sex values are percent of sample size (n). Only owls of known age with both mass and wing cord measurements were included, therefore, sample sizes may sometimes be less than the total number of owls captured in a given year.*

| Station | | Year | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 |
| Cape May, NJ | n | 81 | 24 | 187 | 72 | 637 | -[1] |
| | Adults | 56 | 58 | 10 | 38 | 14 | - |
| | Females | 81 | 83 | 76 | 86 | 69 | - |
| | Males | 12 | 17 | 13 | 10 | 18 | - |
| | Unknown | 7 | 0 | 11 | 4 | 13 | - |
| Assateague Island, MD | n | 63 | 29 | 60 | 26 | 324 | 21 |
| | Adults | 29 | 38 | 15 | 20 | 12 | 71 |
| | Females | 76 | 90 | 92 | 96 | 72 | 90 |
| | Males | 16 | 3 | 8 | 4 | 16 | 10 |
| | Unknown | 8 | 7 | 0 | 0 | 12 | 0 |
| Casselman River, MD | n | -[1] | 43 | 147 | 89 | 296 | 63 |
| | Adults | - | 53 | 39 | 45 | 24 | 76 |
| | Females | - | 93 | 94 | 94 | 83 | 95 |
| | Males | - | 0 | 1 | 3 | 8 | 3 |
| | Unknown | - | 7 | 5 | 3 | 9 | 2 |
| Cape Charles, VA | n | -[1] | - | - | 52 | 980 | 102 |
| | Adults | - | - | - | 63 | 17 | 86 |
| | Females | - | - | - | 85 | 75 | 87 |
| | Males | - | - | - | 12 | 14 | 6 |
| | Unknown | - | - | - | 4 | 11 | 7 |

[1] The banding effort at Cape May during the autumn of 1996 was significantly different than during previous years and age/sex class data was not considered comparable with that from the 1991-1995 period. At other stations the - represent years for which no data is available.

west, greater numbers of owls should have been netted in the western Great Lakes. However, an unknown proportion of the Northern Saw-whet Owls that were found in the Mid-Atlantic and southeastern states during 1995 did come from the western Great Lakes. This is in contrast to more normal years when owls from the western Great Lakes are thought to be much less frequent. The two owls that reached Maryland and North Carolina from Hawk Ridge and Little Suamico were the first direct recoveries of western Great Lakes banded Northern Saw-whet Owls east of the Appalachian Mountains. All previous Midwest to Mid-Atlantic recoveries have been indirect (at least one breeding season intervened between the original banding and the subsequent recapture) and were in the Appalachian Mountains, not the Coastal Plain.

### Magnitude of the Movement

The number of Northern Saw-whet Owls in the Mid-Atlantic states during the autumn of 1995 was exceptional. Capture rates during 1995 were several times greater than in previous years (table 1). The increase in the East was much larger than in the western Great Lakes (fig. 3), where Hawk Ridge exceeded its highest previous season by only 27 percent. At Little Suamico, 28 percent fewer owls were banded during 1995 than in the previous high season in 1988 and the numbers in both 1993 and 1994 were slightly higher than in 1995.

It is difficult to compare the size of the 1995 Mid-Atlantic Northern Saw-whet Owl movement with flights prior to 1989, the year when an audiolure was first used at Cape May.

Table 4.—*Mean mass by age and sex class of Northern Saw-whet Owls captured at four Mid-Atlantic banding stations from 1991-1996. Values are in grams and sample sizes are in ( ). Only owls of known age with both mass and wing cord measurements were included, therefore, sample sizes may sometimes be less than the total number of owls captured in a given year.*

| **Station** | | **Year** | | | | | |
|---|---|---|---|---|---|---|---|
| | | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** |
| Cape May, NJ | Adult Female | 94.0 | 94.7 | 94.1 | 96.9 | 93.7 | -[1] |
| | (n) | (44) | (11) | (14) | (23) | (63) | |
| | Adult Male | 81 | 77.0 | 75 | 79.0 | 77.3 | - |
| | (n) | (1) | (3) | (1) | (3) | (3) | |
| | Immature Female | 94.3 | 94.9 | 94.9 | 96.5 | 93.8 | - |
| | (n) | (22) | (9) | (128) | (39) | (326) | |
| | Immature Male | 76.1 | 78 | 79.1 | 80.5 | 77.7 | - |
| | (n) | (8) | (1) | (23) | (4) | (139) | |
| Assateague Island, MD | Adult Female | 97.1 | 95.4 | 96.7 | 91.2 | 94.7 | 95.5 |
| | (n) | (16) | (10) | (9) | (6) | (26) | (14) |
| | Adult Male | 79 | 70 | -[1] | - | 80.5 | 78 |
| | (n) | (1) | (1) | | | (6) | (1) |
| | Immature Female | 97.5 | 95.9 | 97.3 | 95.9 | 94.3 | 94.0 |
| | (n) | (32) | (16) | (46) | (18) | (207) | (5) |
| | Immature Male | 78.9 | - | 78.0 | 80 | 78.4 | 74 |
| | (n) | (9) | | (5) | (1) | (47) | (1) |
| Casselman River, MD | Adult Female | -[1] | 94.7 | 95.3 | 94.6 | 94.1 | 96.4 |
| | (n) | | (21) | (56) | (38) | (65) | (47) |
| | Adult Male | - | - | - | 81.0 | 78.5 | 83 |
| | (n) | | | | (2) | (2) | (1) |
| | Immature Female | - | 97.4 | 96.6 | 95.1 | 94.4 | 98.1 |
| | (n) | | (19) | (82) | (46) | (182) | (13) |
| | Immature Male | - | - | 78.0 | 82 | 76.8 | 78 |
| | (n) | | | (2) | (1) | (21) | (1) |

[1] The banding effort at Cape May during the autumn of 1996 was significantly different than during previous years and mass data was not considered comparable with that from the 1991-1995 period. At other stations the - represent age/sex classes for which no data is available.

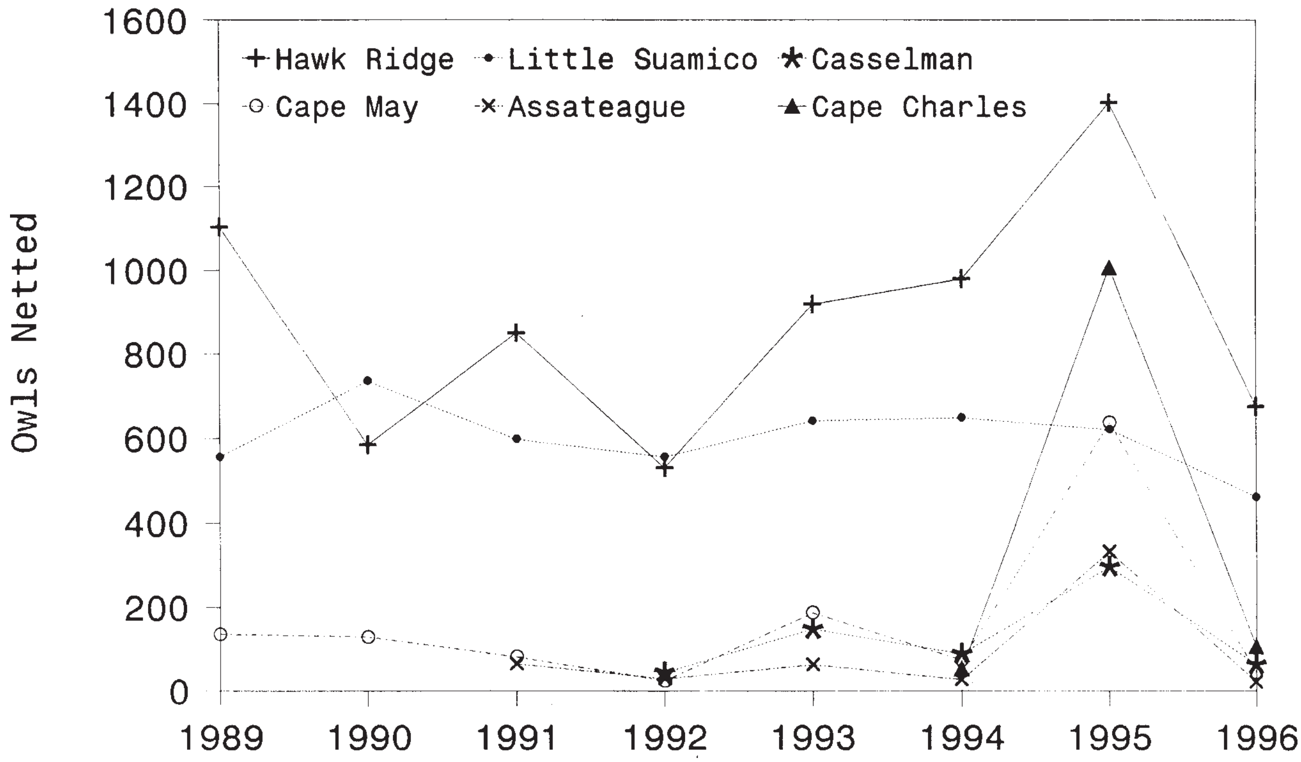


Figure 3.—*Number of Northern Saw-whet Owls captured during autumn migration at two Western Great Lakes and four Mid-Atlantic banding stations from 1989-1996.*

Audiolures increase capture rates from 4 to 10 times (Erdman and Brinker 1997). Without the use of an audiolure, previous high years at Cape May were 1980 and 1981, when 115 and 109 saw-whet owls were netted, respectively (Duffy and Kerlinger 1992). If an audiolure had been used in 1980 and 1981, captures at Cape May may have been comparable to 1995.

The only other year when an exceptionally large migration of Northern Saw-whet Owls was noted in the eastern U.S. occurred in 1965. During the autumn of 1965 large numbers of owls were captured at many songbird banding stations (Davis 1966). For example, on the morning of October 17, 1965, 29 saw-whet owls were passively netted at Kent Point, MD (38°50' N, 76°20' W) (Reese 1966). In an attempt to put the 1965 move-ment into perspective, Bird Banding Laboratory records of Northern Saw-whet Owls banded at all songbird banding stations in Maryland from 1957 through 1985 were reviewed. Banding efforts directed specifically toward migrant Northern Saw-whet Owls were initiated in Maryland during 1986 and data from songbird banding stations after 1985 are overwhelmed by the targeted efforts. The pre-1986 data show that during most years fewer than 10 owls were banded statewide. More than 11 were banded during only 3 years; 1965, 1968, and 1973. Except for 1965, the maximum banded in any one year was 26; during 1965, 65 Northern Saw-whet Owls were banded in Maryland.

The 1995 movement began early, a characteristic that was also observed during 1965 (Davis 1966). For example, the normal autumn migration period in eastern Maryland is October 25-November 15, while during 1965 the passive netting of 29 owls at Kent Point occurred on October 17 (Reese 1966). During 1995 the only station to open early was Casselman River, which opened on October 7. By October 25, 127 Saw-whet owls had been netted, 43 percent of the Casselman's 1995 season total. The other stations opened on their usual schedules and immediately netted significant numbers of owls.

Despite the observations accumulated during 1995, there is no definitive way to compare what we observed during the autumn of 1995 to 1965. Thus, the relative size of the two movements cannot be fairly judged at this point in time.

### Age and Sex Composition

Our observations from 1995 suggest that differential migration, as has been reported for the Tengmalm's Owl (*Aegolius funereus*) in Finland (Korpimaki 1987), may be an important part of the life history of this species. The autumn 1995 migration of Northern Saw-whet Owls into and through the Mid-Atlantic States was comprised mostly of immature females (fig. 4). However, during most years immature females are the predominant age-sex class and the only years when immature females do not predominant are low years, when adult females predominate (table 3). During 1995, the next most predominant age-sex class was immature males. The most infrequent age-sex class was adult males. These results are not entirely surprising as years with higher numbers captured are characterized by larger proportions of immature owls (table 3) (Weir *et al.* 1980, Duffy and Kerlinger 1992). The decline in males with latitude that we observed is probably real. In the only other North American owl that differential migration has been reported for, adult female Snowy Owls *(Nyctea scandiaca*) winter the farthest north and immature males the farthest south (Kerlinger and Lein 1986).

### Interstation Movements

Recaptures of three banded Northern Saw-whet Owls (one each from Assateague, Cape May, and Turkey Point) provided evidence that movement of at least some individuals continued south of Cape Charles. The latter two of these owls went to North Carolina and the other was retrapped in Williamsburg, VA.

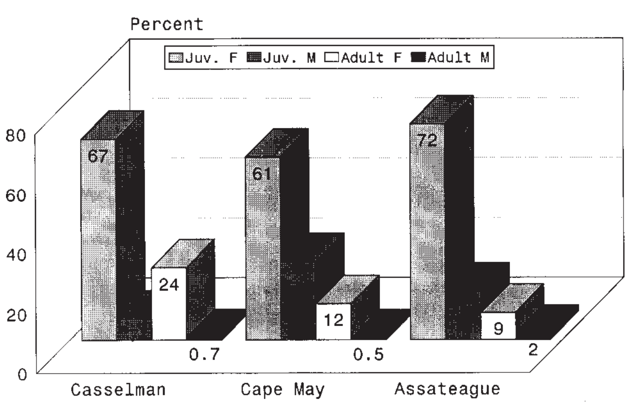


Figure 4.—*Age/sex class composition of autumn migrant Northern Saw-whet Owls at three Mid-Atlantic banding stations during 1995.*

Movement deep into the southeastern U.S. is not unusual. At their farthest known extent south, Northern Saw-whet Owls have been found in northern Florida two times (Lesser and Stickley 1967, Miller and Loftin 1984). Movements south to Florida even occur in years when few Northern Saw-whet Owls migrate into the Mid-Atlantic States. For example, during 1996, when few Northern Saw-whet Owls migrated into the Mid-Atlantic States, a live immature female was found near Pensecola, FL (Woolfenden, pers. comm.).

After reaching Cape May Point, at the southern tip of New Jersey, some owls moved in a northerly direction. Three Northern Saw-whet Owls banded at Cape May were found as road kills less than 8 km north of the banding location 9 (one owl) and 30 (two owls) days after banding, while another was found as a road kill 90 km north of the banding site 38 days after banding. Northward movement may result from a reluctance to cross Delaware Bay or from an abundance of suitable wintering habitat north of Cape May. Four of the five banding stations, particularly the coastal stations, are located in, or in close proximity to, suitable wintering habitat. During 1995 substantial numbers of owls remained in the Mid-Atlantic area for the winter. In a mark-recapture experiment designed to estimate the density of wintering owls on Assateague Island, 56 percent of the 59 individuals netted during January-March 1996 had been banded on Assateague during the autumn of 1995 (Brinker, unpubl. data). There also may have been additional facultative movements of owls during the winter of 1996 in response to unusually severe winter weather with significant snow accumulations along the East Coast. During the mark-recapture experiment waves of unbanded individuals were netted when radio-marked owls disappeared (Brinker and Churchill, unpubl. data).

Lack of interchange between Casselman River and the other four stations suggests that Northern Saw-whet Owls captured at Casselman River may have different origins, migratory paths, and/or wintering areas than those captured at the four Coastal Plain stations. Since banding was initiated in western Maryland during 1986, 901 Northern Saw-whet Owls have been banded and the only retrap or recovery away from western Maryland was the owl retrapped in Maine during the autumn of 1996. In western Maryland, there have been three indirect recoveries of owls previously banded in the western Great Lakes, one each from Hawk Ridge, Little Suamico, and Whitefish Point, MI (46°40' N, 84°50' W).

### Theoretical Framework

After 30 years of collective work and over 50,000 owls banded, can a hypothesis be put forth that attempts to unify what we know of Northern Saw-whet Owl migratory movements in eastern North America? Possibly. In this section we attempt to formulate a working hypothesis that can be used to organize and direct future research on Northern Saw-whet Owl migration.

Northern Saw-whet Owls are relatively small, with an average female mass of about 95 g and an average male mass of about 77 g. This species may have difficulty maintaining body condition and/or temperature in the face of food stress during cold or snowy winters, when acquiring prey may be difficult. Korpimaki (1987) summarized life history traits for Tengmalm's Owls that revolve around body size, sexual dimorphism, and ability to capture prey during winter. An important part of Korpimaki's model of Tengmalm's Owl winter ecology involved differential geographic movement, where females were more migratory than males. Male Tengmalm's Owls remain farther north to facilitate quicker repossession through territoriality of a significant rare resource, nest cavities. This life history model may also apply to Northern Saw-whet Owls in North America and could be an important part of any working hypothesis designed to explain the owls migration and wintering in the East.

In most of eastern North America, the breeding range of Northern Saw-whet Owls is characterized by winters with consistent, often deep, snow cover and long periods when temperatures remain well below 0° C. Capturing small mammal prey under these conditions is sufficiently difficult that some populations of Northern Saw-whet Owls may have developed a strategy where females migrate to areas with a milder winter climate, less frequent continuous snow cover and therefore better prey accessibility and potential for owl survival. Theoretically, all species of migratory birds migrate for access to more abundant food. As with Tengmalm's Owl (Koprimaki 1987), more agile and experienced adult male Northern Saw-whet Owls may remain near breeding territories and an important rare resource, nest cavities, to better compete for territories in early spring.

Northern Saw-whet Owls are also frequently preyed upon by larger owls, especially Barred Owls (*Strix varia*) and Great Horned Owls (*Bubo virginianus*) and seem to prefer habitats containing dense thickets where the risk of predation is less. Thus, when deciduous trees lose their leaves each autumn the cover available to Northern Saw-whet Owls in potential wintering areas in the northern and central U.S. decreases dramatically. Coincidentally, at most latitudes in the east, the peak autumn movement of this species usually occurs just as autumn leaf fall is completed. These factors may make migration to coniferous or evergreen shrub habitats an attractive survival strategy for some definable proportion of Northern Saw-whet Owl populations.

Where in eastern North America is there habitat with good cover, mild winter climate, and abundant prey populations? The approximate distribution of the major areas of coniferous forest in eastern North America is illustrated in figure 5. Northern coniferous forests generally coincide with the breeding habitat of Northern Saw-whet Owls. South of the breeding forest lies an area that may represent an ecological desert of farmland and deciduous forest that has little cover during winter. Before settlement, most of this area was either tall grass prairie or mature deciduous forest and thus potentially unsuitable or marginal wintering habitat for this species. Much of this area also has frequent snow cover and regular cold periods. Upon reaching the southern boundary of northern coniferous forests, it is possible that choices to go farther south or remain at the southern edge of the breeding range affect age and sex classes differently. In contrast, the southeastern coniferous forest represents an area that provides cover, food, and a relatively mild, generally snow free climate. Southeastern forests also have understories that contain evergreen shrubs such as laurels (*Kalmia* sp.), various rhododendrons (*Rhododendron* sp.), American Holly, bayberries (*Myrica* sp.) and magnolias (*Magnolia* sp.) that provide cover not present in northern forests during winter. Based upon Holroyd and Woods (1975) and a review of more recent recoveries in the Bird Banding Laboratory data base, most long distance recoveries terminate in the southeastern coniferous forests. Wintering in the south-

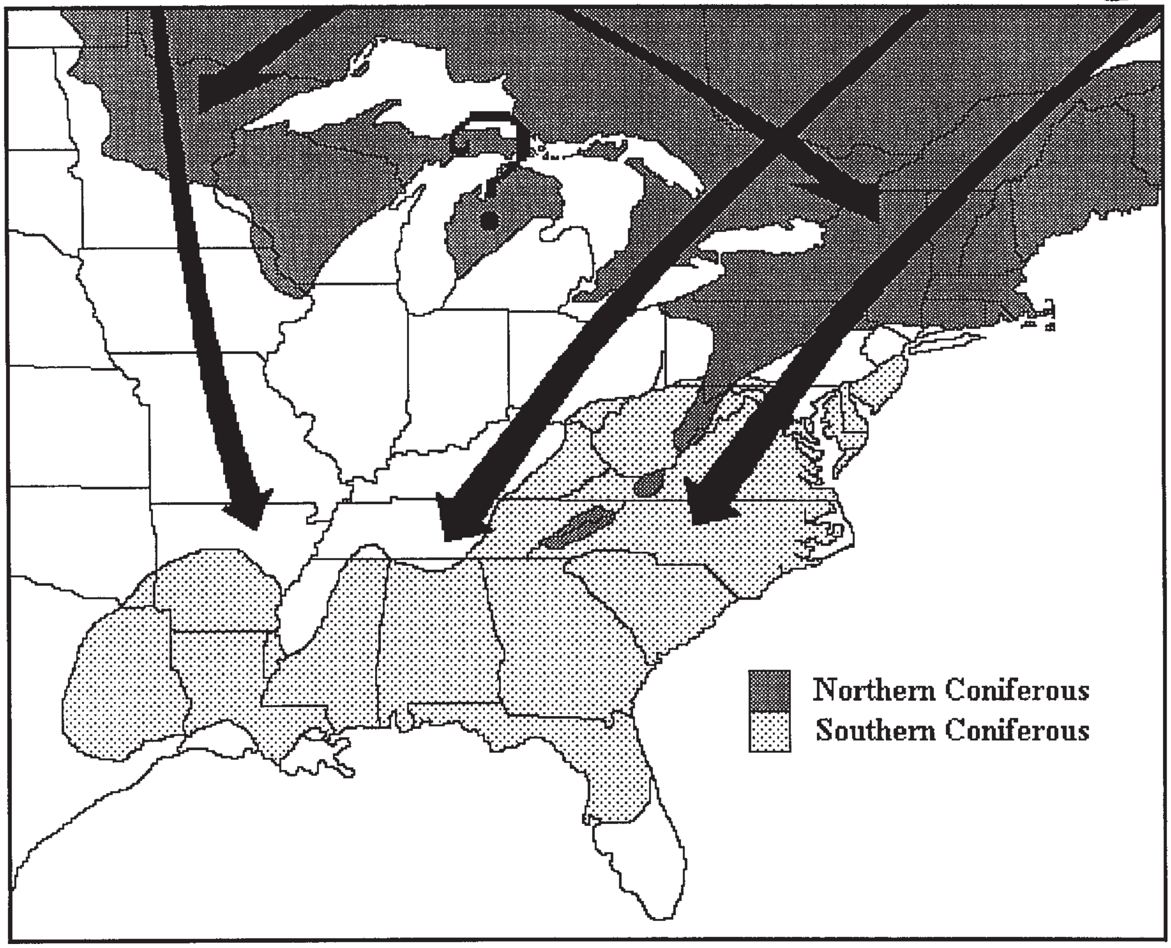


Figure 5.—*Distribution of northern and southern coniferous forest in eastern North America and postulated movement patterns of autumn migrant Northern Saw-whet Owls. Breeding range corresponds closely with the distribution of northern coniferous forest. Wintering individuals have been found as far south as northern Florida. Owls encountered south of 40° north latitude (approximate latitude of Philadelphia, PA) are primarily females. The complex movement patterns around and across the Great Lakes have not yet been described and are represented by a ?.*

eastern forests might represent a successful strategy for female Northern Saw-whet Owls.

Possible pathways between breeding areas in the north and wintering habitat in the southeast are illustrated in figure 5. The movement out of the northeastern U.S. and eastern Canada agrees with recoveries reported in Holroyd and Woods (1975), review of more recent recoveries, and our observations from 1995. Movements from central Canada through the north central U.S. are complicated by the Great Lakes and considerable work remains to be done to better define migratory pathways through the Great Lakes region.

Does this represent a functional hypothesis unifying the observations accumulated over the years that explains some aspects of Northern Saw-whet Owl migration? Only many more years of work from a much expanded network of banding stations will provide the answer.

## CONCLUSION

Over the years more than 56,000 Northern Saw-whet Owls have been banded, more than any other owl species in North America, yet we have no unifying framework that summarizes migration as it relates to the life history of the species. Some of this is because of a lack of basic knowledge, such as criteria for determination of sex, and an inadequate network of banding stations. Other questions also beg for answers. What role did prey abundances play in 1995 reproductive success and subsequent autumn migration? Was the early winter weather in central and eastern Canada during 1995 influential in precipitating the Northern Saw-whet Owl flight? Because of these and other knowledge gaps, it is difficult to provide anything more than speculative explanations of the 1995 movement that was documented in the eastern U.S. Without more active banding stations working together throughout the East, it will be difficult to piece together the puzzle of migration mysteries for this intriguing little owl. With recent advances, such as audiolures and a possible method to determine sex in migrants, cooperative regional studies have the potential to begin testing pieces of theoretical frameworks that might describe migration in Northern Saw-whet Owls.

It is time to ask more directed questions of studies on migrant Northern Saw-whet Owls. One place to start would be to see if Korpimaki's model of wintering in Tengmalm's Owls might also apply to the Northern Saw-whet Owl migration and wintering areas in North America. We should begin to test questions related to differential migration. The many Northern Saw-whet Owl banding stations should begin more cooperative analysis of recoveries, retraps and other data from the thousands of owls already banded, as well as the 2,000-5,000 newly banded owls each year.

The ability to effectively conserve any species depends upon adequate knowledge of its life history. Much remains to be learned of Northern Saw-whet Owl migration and winter ecology.

## ACKNOWLEDGMENTS

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## APPENDIX

### Determination of Sex in Northern Saw-whet Owls

Since Weir *et al.* (1980) first published criteria for determination of sex in Northern Saw-whet Owls from wing chord measurements, other authors have commented that the criteria were flawed because observed sex ratios differed from 1:1 (Mueller 1982, Evans and Rosenfield 1987, Slack 1992). During the winter of 1995, blood samples were obtained from eight owls to determine the sex of individuals for a telemetry study of wintering owls on Assateague Island. Using the criteria of Weir *et al.* (1980), as modified by Buckholtz *et al.* (1984), the sample represented three males, four unknown sex individuals, and one female. Blood analysis of DNA (Fleming *et al.* 1996) revealed that the sample actually consisted of eight females (Brinker, unpubl. data). The probability of drawing a random sample of eight individuals of the same sex from a population with a 1:1 sex ratio is 0.0039 and thus we would expect eight females from less than 1 in 100 samples of eight individuals. As has been long suspected and argued, the wing chord method of determining sex for Northern Saw-whet Owls obviously does not work reliably. For this analysis a new approach was pursued to assign sex to individual owls.

A discriminant function (DF) was developed that relied upon a combination of wing chord and mass to assign sex to owls. The training data set consisted of mass and wing chord measurements from 17 live known sex Northern Saw-whet Owls, 6 males and 11 females. Seven were breeding individuals from

Garrett County in western Maryland. One was a female with a brood patch that was captured in a nest box. Two were breeding season males mist-netted during late June and neither possessed a brood patch. Four (two females, two males) were breeding individuals mist-netted at nest boxes. These four were blood sampled to verify use of DNA analysis for sex identification (Fleming *et al.* 1996); the males lacked brood patches and the females possessed brood patches. The remaining 10 were mist-netted in eastern Maryland outside breeding range, during autumn migration of 1996 (two owls) or as winter residents on Assateague during 1996 (eight owls). The sex of these 10 individuals was determined from blood samples. The DF used the within covariance matrix rather than the pooled covariance matrix because the variance structure was significantly different (ä = 0.05) between males and females.

Testing the DF by resubstitution, there were no errors. A better test of the accuracy of the DF was with a second set of data from 20 different known sex individuals, 7 males and 13 females. This set consisted of four breeding owls from the mountains of Tennessee (Barb 1995), 11 road kills collected near Cape Charles during the autumn and winter of 1995-1996 that were sexed internally, and five wintering (1997) Northern Saw-whet Owls from Assateague that were sexed from blood samples. The DF correctly assigned sex to 18 individuals. The two errors were males classified as females. Probability of class membership was used to improve the DF. When probability of membership for both sexes was less than 0.9, the individual was considered unknown sex. This resulted in one of the incorrectly assigned males being assigned to the unknown category and no others changed. The distribution of all training and test owls is shown in figure 6.

The DF performed much better than the old wing chord criteria, which should no longer be used to determine sex in Northern Saw-whet Owls. As an additional test of the DF, consider mass and wing chord data from 35 Northern Saw-whet Owls netted at two eastern Maryland stations during the autumn of 1996 (Brinker, unpublished data). When plotted, there were two distinctly obvious groups of points (fig. 7). The smaller group of points was the lower mass and shorter wing chord group. Two individuals from this group were sexed from blood samples and they were males. If the assumption that

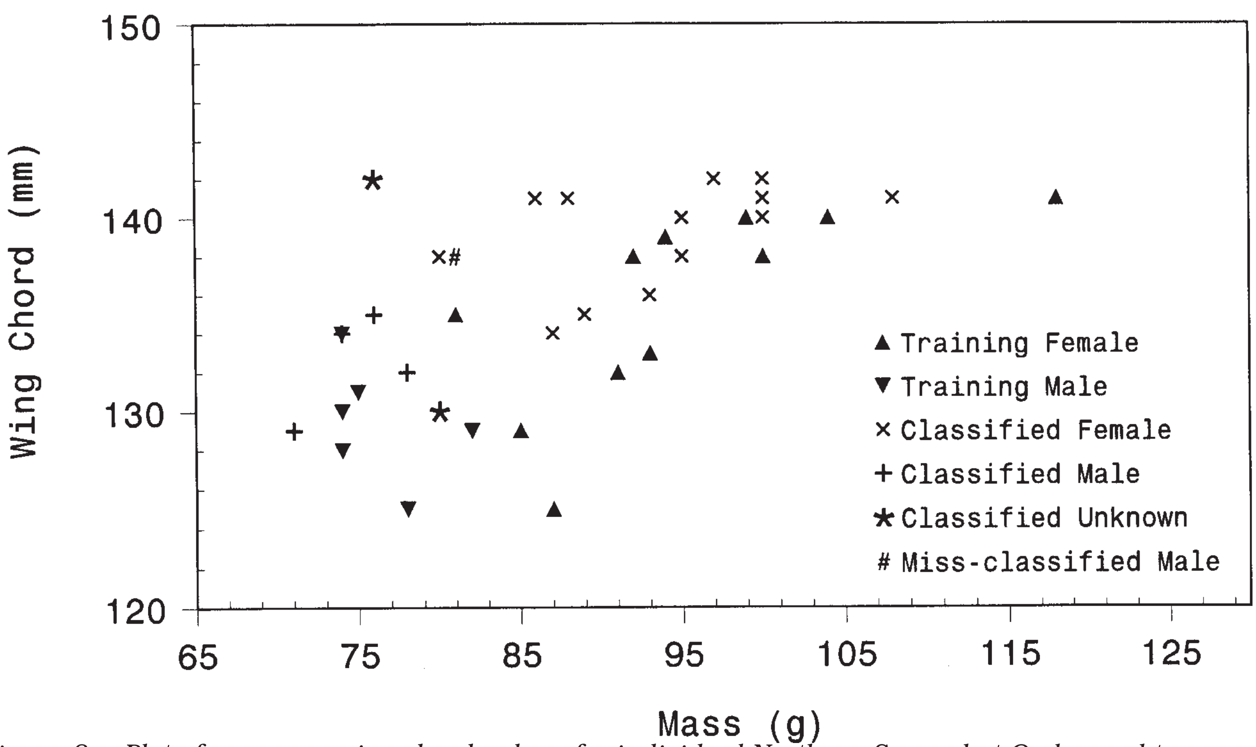


Figure 6.—*Plot of mass vs. wing chord values for individual Northern Saw-whet Owls used to develop and test the discriminant function used to determine sex. Triangles (n=17) represent individuals used for training the DF. All other symbols (n=20) were test individuals.*

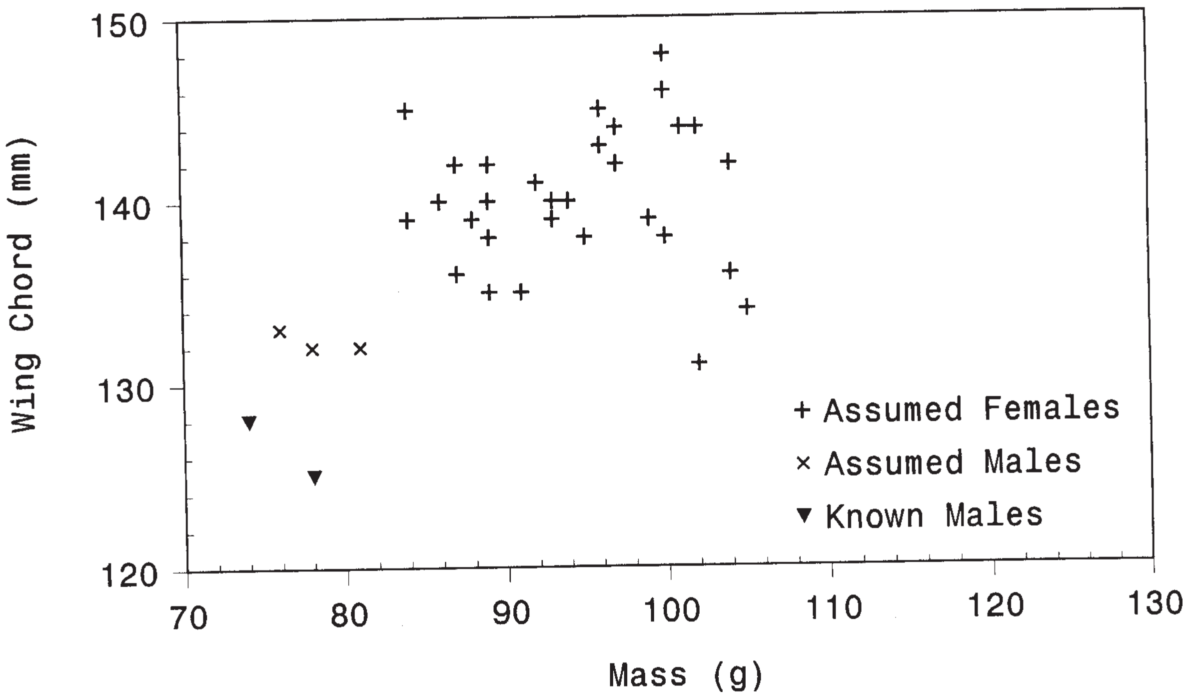


Figure 7.—*Plot of mass vs. wing chord for 35 individual Northern Saw-whet Owls netted during the 1996 autumn migration at two stations in eastern Maryland. The two triangles represent individuals whose sex was determined from blood analysis. In order to test the discriminant function, the sex of all other individuals was assigned. Individuals with masses over 81 g were assigned to female, masses of 81 g or less were assigned to male.*

the two groups represent males and females is pursued further and these data are used to test the DF, all owls are assigned a sex (i.e., using the 0.9 rule no unknowns were assigned) and no assigned sexes deviated from the assumed sex. We state this only to bolster confidence that, for this analysis, the DF is a valid approach to assigning sex.

The female owls that were netted during 1995 were lighter than during more normal years. This is supported by the observation that among all stations and years, the mean mass of immature females was lowest in 1995. Except Assateague, the same was true for adult females. The unusually low mean mass for adult females at Assateague during 1994 may simply be the result of a small sample. For the lighter than usual 1995 females the DF identifies more females as unknowns. However, we do not believe the DF to have erred much in assignment of sex to males and all owls considered females were most certainly correctly classified.

Solely for the purpose of this analysis, the DF was considered adequate and used to assign sex to owls. Those individuals with probabilities of membership for both sexes less than 0.9 were assigned to sex unknown. When more data become available, the use of discriminant analysis to determine sex in Northern Saw-whet Owls will be published elsewhere. Anyone seeking additional information on using this DF for assignment of sex to Northern Saw-whet Owls should contact the senior author.