Studies of Nesting Northern Saw-whet Owls in Northwestern South Dakota

Rocky Mountain Bird Observatory

Tech. Report # SC-SDOWLBAND-03

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***Vision**: Native bird populations are sustained in healthy ecosystems*

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2. ***Education** is critical to the success of bird conservation.*
3. ***Stewardship** of birds and their habitats is a shared responsibility.*

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- ***Studying** bird responses to habitat conditions, ecological processes, and management actions to provide scientific information that guides bird conservation efforts.*
- ***Monitoring** long-term trends in bird populations for our region.*
- ***Providing** active, experiential, education programs that create an awareness and appreciation for birds.*
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- ***Creating** informed publics and building consensus for bird conservation needs.*

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***Cover Photo**:* Clockwise from upper left: nestling N. Saw-whet Owl; mouse prey found in nest; N. Saw-whet Owl female peering from nestbox; weighing an owl. Photos by Nancy Drilling.

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SUMMARY

Northern Saw-whet Owl *Aegolius acadicus* (NSWO), the most common owl in coniferous forests of western South Dakota, have readily bred in owl nestboxes placed in Custer National Forest, Harding County since 2003. This research explores three aspects of NSWO breeding biology in the Harding County nestbox project: nestling sex-ratios, movements of adults and fledglings within and among subunits of Custer National Forest, and correlations between prey abundance and reproductive success. Research methods included banding all nestlings and as many nesting adults as possible, operating banding stations to try to recapture banded birds, monitoring of all nestboxes and nests, and small mammal trapping.

In 2012, NSWO attempted to nest in 11 nestboxes; seven nests (64%) ultimately fledged at least one owlet. Of the 39 total eggs laid in 2012 nests, 30 hatched and 22 owlets fledged. Number of eggs laid in full clutches in 2012 ranged from three to five eggs, with an average clutch size of 3.8. Although reproductive success was slightly lower in 2012, there was no significant difference among any of the years of the nestbox project (2004-2012) in average clutch size, average brood size, or average number that fledged. However, there was reduced hatching success in three years (2008-2010) and reduced fledging success in 2009. Combined with a high variability among years in number of nesting attempts, differences among years in reproduction suggests differences among years in conditions necessary for successful nesting. The main 'condition' probably is prey abundance, but it will take several years of study to determine whether there is a correlation between prey abundance and owl reproductive success in Custer National Forest.

One male and six females were caught at six of the nests that hatched eggs. One pair was already banded; they had been caught and banded October 30, 2011 at a fall migration banding station 0.4 mi (0.7 km) away from the nestbox. Both birds were caught in the same net at the same time in October, suggesting they were already an established pair at that time. The other five females were unbanded when caught on the nest. None of these birds were caught later during the fall 2012 migration banding season. Eighteen nestlings from six nests were banded and blood samples were taken from 14 of these. Results of the nestling sex-ratio analyses should be finished by June 2013. Two birds banded as nestlings were recaptured after they fledged. One was caught 100 days after banding and 0.4 mi (0.7 km) from her nestbox , while the second bird was caught 136 days after initial banding and 7.1 mi (12.4 km) from its nestbox. This suggests that some fledglings do not undergo post-fledging dispersal but rather stay in or near their natal territory until fall migration.

The Harding County nestbox project offers a unique opportunity to study many questions about NSWO breeding and movements. We will continue to monitor nests and increase our attempts at small mammal trapping. We also plan to continue to band adults and nestlings, which in the long-term will also contribute to our understanding of between-year site fidelity, residency status, and migration patterns of these owls.

ACKNOWLEDGMENTS

The 2012 field work for this project was made possible through a Wildlife Diversity small grant from South Dakota Department of Game, Fish, and Parks.

I thank the staff at Custer National Forest's Sioux Ranger District for their approval of the owl nestbox project. Dr. David Swanson, University of South Dakota, kindly allowed me to band nestlings under his permit and taught me how to draw blood. Dr. Glenn Proudfoot, Vassar College in Pennsylvania, gave very helpful advice on the nestling sex ratio project and is performing the DNA analysis gratis. Jamie Balk, Bill J. Unzen, and Caity Reiland-Smith assisted with checking nestboxes and catching and banding birds. Most of all, this project is only possible through the dedication, hard work, and enthusiasm of Charlie Miller, who started the nestbox project many years ago and continues to keep it going.

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INTRODUCTION

Northern Saw-whet Owl *Aegolius acadicus* (NSWO) is the most common breeding owl in the coniferous forests of North America, including in western South Dakota (Cannings 1993, Peterson 1995, Drilling 2010, U.S. Forest Service 2009). Despite this, little research has been conducted on this species during the breeding season, especially concerning more advanced topics such as within- and between-season movements, nestling sex ratios, and relationships between prey abundance and reproductive success (Cannings 1993, Rasmussen *et al.* 2008). No such research has occurred in South Dakota or the Great Plains (Johnson and Anderson 2003, Rasmussen *et al*. 2008).

One reason for the lack of research is because finding enough natural nests for a population study is very difficult and there are few nestbox projects (Project Owlnet online, unpubl. data). Most nestbox projects that do exist either have too few boxes or too low of an occupancy rate to produce an adequate sample size for many research questions. Fortunately in South Dakota, there is an ongoing owl nestbox project that does not have these problems. Begun in 2003 by Charlie Miller, there are now 100 nestboxes in the five subunits of Custer National Forest located in Harding county: the North Cave Hills, South Cave Hills, Slim Buttes, East Short Pines and West Short Pines. Over the years, between 3.5% - 57% of the boxes are used by NSWO in a breeding season (Miller 2010, Miller *pers. comm.*). In 2011, 43 successful nests produced approximately 204 fledglings (Miller unpubl. data). This relatively large sample size provides an opportunity to address gaps in our knowledge of NSWO biology.

Throughout its range, including in western South Dakota, one knowledge gap concerns NSWO movements. In South Dakota, is this species, which can be found year-around in appropriate habitat, resident, partially migratory, or migratory (Backlund and Dowd-Stukel 2006, Rasmussen *et al*. 2008)? A related question is the degree to which NSWO move between forest 'islands' across large expanses of grassland during the season, such as the fragmented habitat found in the five subunits of Custer National Forest in Harding county. Movements might occur if an adult tries to renest after a failed nesting attempt or starts a second nest within the breeding season. This question may be unique to South Dakota - most breeding populations occur in more contiguous and extensive forest habitats (Rasmussen *et al*. 2008). Concerning fledgling movements, Drilling (2012) caught an unusually high proportion of hatch-year birds in Custer National Forest after a very successful breeding season during the 2011 fall migration season. Did these owls hatch at the site or were they migrants from elsewhere? Finally, NSWO nest-site and natal-site fidelity varies among years and populations (Rasmussen *et al*. 2008). What are the rates in Custer National Forest? To answer any of these questions, both adults and fledglings need to be individually marked.

A second topic about which nothing is known concerns NSWO sex ratios. During autumn migration banding efforts, most banding stations catch more female NSWO than males (e.g., Priestley *et al*. 2010). Of 134 fall banding station summaries submitted to the Project Owlnet online database, only one station reported capturing more males than females (Project Owlnet online database, unpublished data). Two suggestions have been put forward as to why more females are caught: 1) females may be more migratory than males who may stay on their territories through winter rather than lose them or 2) females are more likely to be attracted to the

broadcasted call. However there are other possible explanations such as an unequal sex ratio at fledging or differential juvenile or adult mortality between the sexes. Determining the sex ratio at fledging will clarify the issue. If the sex ratio at fledging is female biased, then this may explain female-biased sex ratios at migration banding stations. However, if the sex ratio is approximately equal or male-biased, then other factors need to be explored. Of the few current nestbox projects operating in North America, none have enough boxes or a high enough occupancy rate to produce an adequate sample size for the sex-ratio analysis. The Harding county nestbox project usually does have an adequate number of nests and offers a unique opportunity to address this question.

Rasmussen *et al*. (2008) note that NSWO populations probably are slowly declining because of habitat loss and degradation. However we do not really know continent-wide NSWO population trends nor the reasons for trends that are occurring. Certainly in western South Dakota, NSWO's coniferous habitat is under pressure by a multitude of natural (fire, pine-bark beetle outbreaks, climate change) and anthropogenic (urbanization, timber management practices, mining) stressors. Thus it is important to understand what factors limit Northern Saw-whet Owl populations. One possible factor is prey abundance (Marks and Doremus 2000, Côté *et al.* 2007, Rasmussen *et al*. 2008). NSWO primarily eat white-footed mice (*Peromyscus leucopus*) and deer mice (*Peromyscus maniculatus*) (Cannings 1993), whose populations can fluctuate randomly among years (Bowman *et al*. 2009). Miller (2010, unpublished data) found that NSWO reproductive success varies among years in the Harding county nestbox project. In his study, hatching success varied between 40 - 100% while fledging success varied between 25 - 87%. In the closely-related Boreal Owl (*Aegolius funereus*), reproductive success is positively correlated with abundance of voles, their main prey (Hayward and Hayward 1993). The relationship between prey abundance and reproductive success has not been explored for NSWO (Rasmussen *et al*. 2008). If there is a relationship, then any factors, such as habitat changes, that affect prey populations will also affect NSWO.

PROJECT OBJECTIVES

1. Band all NSWO nestlings and as many breeding adults as possible to:
    a. Detect within-season movements of adults and fledglings among the five forested buttes of the South Dakota portion of Custer National Forest
    b. Determine how long adults or juveniles stay in the area (i.e., residency status of SD owls),
    c. Determine level of nest-site or natal-site fidelity in subsequent breeding seasons
    d. Understand post-breeding movements and migration pathways in the Great Plains
2. Determine the sex ratio of NSWO broods
3. Determine relative prey abundance to:
    a. Determine whether prey abundance correlates with reproductive success
    b. Determine whether prey abundance and reproductive success vary or co-vary among subunits of Custer National Forest

METHODS

Nestbox Construction and Study Area

Nestboxes are made of wood with a detachable lid. On the inside, boxes are 8" square and front and back panels are 20"and 21" high, respectively. The top of the 3" circular opening is 2" below the lid. Below the opening on the inside are a series of 1/4" shallow saw curves to allow the birds to easily climb out of the box. The bottom has three or four 1/2" drainage holes while several 1/2" ventilation holes are drilled near the top.

Nestboxes are located on the scattered tablelands which arise 100-200 m above the surrounding grasslands in Custer National Forest, Harding County, South Dakota (Figure 1). Of the 100 boxes, nine are in the East Short Pines unit of Custer National Forest, two are in West Short Pines, eight in North Cave Hills, nine in South Cave Hills, and the remaining 72 are in Slim Buttes. Nestboxes are mounted on tree trunks approximately 2.5 – 3 m high.

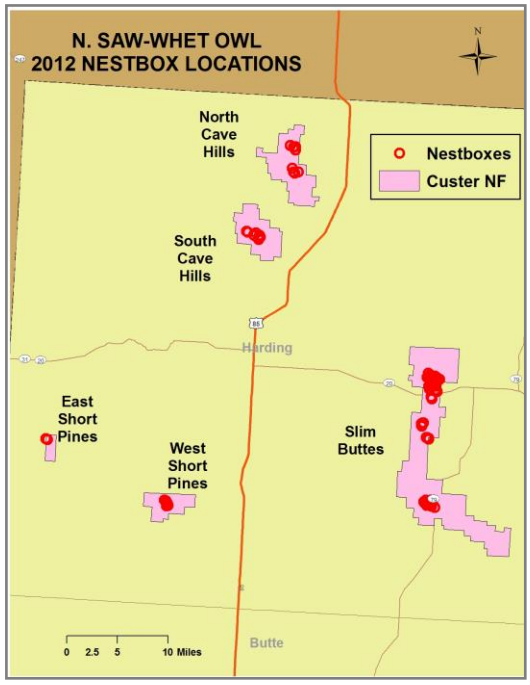

Figure 1. Map of Northern Saw-whet Owl nestbox locations in 2012 in Custer National Forest, Harding County, northwestern South Dakota.

Many boxes are placed in wooded ravines, dominated by Green Ash (*Fraxinus pennsylvanica*) and Chokecherry (*Prunus virginiana*). Some boxes are in Ponderosa Pine (*Pinus ponderosa*) stands which occur on upland areas and slopes. Other major woody vegetation species include Skunkbrush (*Rhus aromatica*), Western Snowberry (*Symphoricarpos occidentalis*), Creeping Juniper (*Juniperus horizantalis*), and in drier areas, Rocky Mountain Juniper (*Juniperus scopulorum*) (Hansen and Hoffman 1988).

Small mammal traps were set up in grassland areas adjacent to forest, areas the edge-loving owls usually forage in (Rasmussen *et al.* 2008). These grasslands are dominated by Needle and Thread (*Stipa comata*), Threadleaf Sedge (*Carex filifolia*), Sun Sedge (*C. inops* subsp. *heliophila*), Little Bluestem (*Schizachyrium scoparium*), Western Wheatgrass (*Pascopyrum smithii*), and Kentucky Bluegrass (*Poa pratensis*).

Banding and Marking Adults.

Female owls were caught in the nestbox while they brooded their young, during the first 15 days after hatching. We waited to attempt capture until after the nestlings hatched to avoid the chance that the female would abandon her nest (Cannings 1993). We captured the brooding female by covering the entrance hole with a long-handled fishing landing net into which she flushed when she heard noises. The male is only at the nestbox at night when he brings food for the female and owlets. Because of this behavior, we were able to catch the male after dark as he flew in with food in a a mist net placed in front of the nestbox (Marks and Doremus 2000).

Once extracted from the nestbox or net, each owl was taken to a nearby processing area for banding, measuring, and aging. Each unbanded owl received a uniquely numbered federal aluminum band on the right leg. All owls were weighed and measured. Measurements included relaxed wing chord and tail length. During the breeding season, only the female has a brood patch. If a bird did not have a brood patch, sex was determined using a regression equation that utilizes mass and wing chord measurements (Project Owlnet 2001b). All adult owls were aged by wing feather molt pattern (Pyle 1997).

In order to determine whether birds are moving among subunits of Custer National Forest and the residency status of NSWO in the area, we planned to set up mist nets with an audiolure two nights a month in each of the subunits from May through November. The net setup would be identical to that utilized during migration (Project Owlnet 2001a) and was to be located at least ¼ mile away from any active nestboxes or nests. Any unbanded birds were to be banded and measured as described above. However, because we found so few owls away from Slim Buttes, we did not attempt to catch owls in other subunits in 2012.

Adult owls were banded under the the Rocky Mountain Bird Observatory federal Master permit #22415, administered by RMBO biologist Nancy Gobris in Brighton, CO. All protocols, including animal safety guidelines and the Bander's Code of Ethics, are written into a Field Protocol manual and kept in the Field Banding Notebook. The Field Notebook also has copies of all permits and project proposals. This Field manual for netting, banding and processing owls is available upon request.

Nestling Banding and Sex Ratios.

Nestlings were banded, weighed, and blood samples collected (see below) when they were adult-sized, at approximately 28-35 days old. During processing, which took place next to the nestbox, nestlings were kept in a covered bucket with rags. Nestlings were banded with a uniquely-numbered aluminum band distributed by the U.S.G. S. Bird Banding Laboratory. Because most

of the owlets were near fledging age, we blocked the entrance hole with a wadded sock for 5-10 minutes after we put the owlets back into their nest. This allowed the birds to calm down and prevent premature fledging. Nestling owls were banded, and blood collected, under federal Master banding permit #22199, administered by Dr. David Swanson, and under Collection Permit #24-2012 from South Dakota Dept. of Game, Fish and Parks

The sex of nestlings will be determined using a simple PCR (polymerase chain reaction) test for two different CHD genes found on the sex chromosomes of birds (Griffiths *et al*. 1998, Fridolfsson and Ellegren 1999). The CHD-W gene is found only in females while both sexes have the CHD-Z gene. To obtain the necessary DNA for the test, approximately 0.05 cc (~ 200 µl) of blood was drawn from each bird's tibiotarsal femoral vein. Each blood sample was stored in a Longmire's solution 2 ml bar-coded cryogenic tube. The DNA analysis will be conducted by Dr. Glen Proudfoot at Vassar College in Poughkeepsie, NY. These results are expected by June 2013.

Relative Prey Abundance.

To obtain an index of relative prey abundance, we planned to live-trap small mammals for two consecutive nights per month for the months of April - July (Ministry of Environment 1998). Grids of Sherman traps (2 x 2.5 x 6.5" folding galvanized traps) were established in grasslands near occupied and unoccupied nestboxes. Traps were located every 10 m and marked with orange flag stakes. Traps were opened and baited with peanut butter-oatmeal balls around sunset and checked the following morning, starting before sunrise. Each captured small mammal was to be identified to species, weighed, temporarily marked by clipping fur at the base of the tail, and released. The temporary mark is to identify individuals that are recaptured at a later date. This is necessary to adjust the prey abundance index to reflect the number of individuals an owl would encounter, not the number that reenter traps (Ministry of Environment 1998). Relative prey abundance will be defined as the number of individuals captured per grid per night (Bowman *et al.* 2009).

Reproductive Success.

Before the nesting season, all nestboxes were cleaned out, and fresh wood shavings added by Charlie Miller of Buffalo, SD. Nestboxes were monitored for nesting activity between mid-March and late June 2012. Before May, checks consisted of walking by a box; the female usually looks out if she is present. Starting the second week of May, all boxes were opened. If a box had a nest, we recorded number of eggs and nestlings, number of stored prey items visible and approximate age of nestlings. After the owls fledged, the prey mat at the bottom of the box was examined for unhatched eggs, nestling remains and prey remains. From these checks, clutch size, number of eggs hatched (hatching success), and number of fledged owls (fledging success) was calculated.

Measures of reproductive success were compared for years 2004 - 2012. A one-way Analysis of Variance was used to compare clutch size, brood size and number fledged among years. The *G*

statistic was used for among year comparisons of percent nestboxes used, percent nests that hatched, percent hatched nests that fledge at least one owl, and percent successful nests. If any of these among-year analyses were significant, I did a simultaneous unplanned test of homogeneity, utilizing a G_H statistic with a critical χ^2 value of 15.507 (with 8 degrees of freedom and α=0.05) to determine which year(s) were significantly different from one another (Sokal and Rolf 1981).

RESULTS

Reproductive Success.

In 2012, Northern Saw-whet Owls attempted nests in 11 nestboxes (Figure 2). In one of these, one egg was laid and then abandoned. Percent of all nestboxes used differed significantly among years 2004 – 2012 (G=109.9, df=8, $p<0.001$) (Table 1, Figure 3). Percentages of nestboxes used in 2007 and 2011 were significantly higher (G_H =51.4, $p<0.001$) than those in all other years.

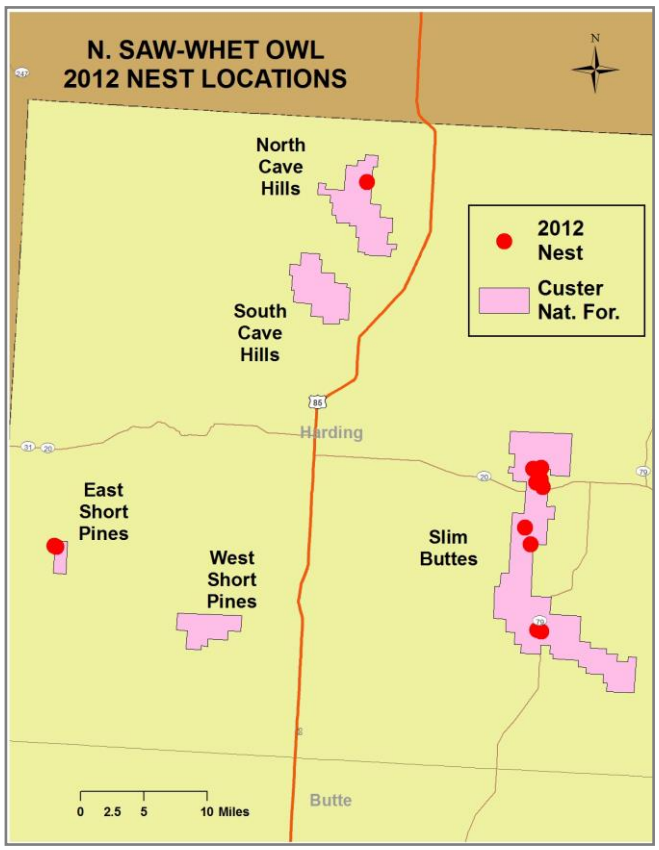

Figure 2. Locations of Northern Saw-whet Owl nest attempts in 2012 in Custer National Forest, South Dakota.

Table 1. Summary of 2012 Northern Saw-whet Owl reproductive success in nestboxes in Custer National Forest, South Dakota, compared to 2004-2012 combined data.

	2004-2012	2012
Median percent nestboxes used per year	15	11
Percent attempted nests that were successful	75.4	63.6
Percent of eggs in full clutches that hatched	83.6	76.9
Percent of hatched eggs that fledged	83.3	73.3
Average clutch size (full clutches only)	5.2	3.8
Average brood size (hatched nests only)	4.8	3.8
Average number of fledglings per hatched nest	4.4	3.1
Total number of fledglings produced per year (range)	2 - 204	22

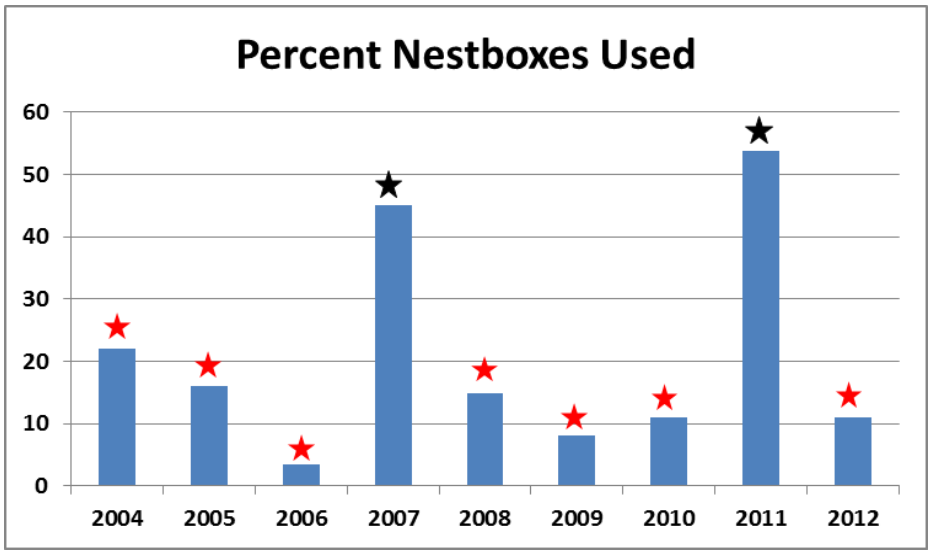

Figure 3. Percent of available nestboxes used by Northern Saw-whet Owls by year in Custer National Forest, South Dakota. Number of nestboxes available ranged from 36 boxes in 2004 to 100 boxes in 2012. Years represented by bars with same-colored stars were not significantly different from one another.

Of the 39 total eggs laid in 2012 nests, 30 hatched and 22 owlets fledged. Number of eggs laid in full clutches in 2012 ranged from three to five eggs, with an average clutch size of 3.8. This was the lowest average clutch size of any year since the beginning of the project (Appendix A); however there was no significant difference in clutch size among years ($F_{8,116}$= 0.01, $p>0.9$). There was a significant difference among years in the percent of eggs in full-clutch nests that hatched ($G=51.8$, $df=8$, $p<0.001$) (Figure 4). Eggs in 2008 – 2010 had significantly lower hatching success than those in other years (G_H =16.6, $p<0.05$). In 2009 and 2010, the reduction in percent eggs hatch was because of many nest failures, not because few eggs hatched per nest (i.e., clutch size approximately equal to brood size) (Appendix A). In 2008, reduced hatching

success was both because of entire nest failures and of some eggs not hatching in ultimately successful nests.

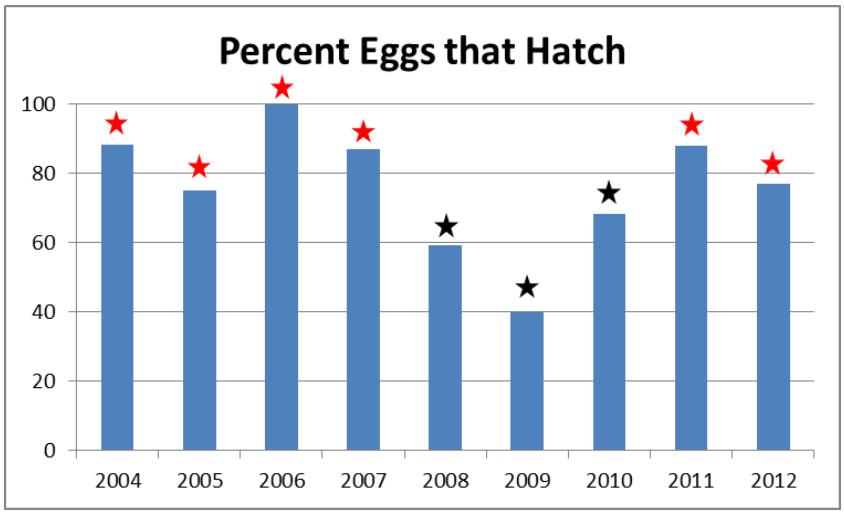

Figure 4. Percent of Northern Saw-whet Owl eggs that hatched in full-clutch nests in Custer National Forest, South Dakota between 2004 - 2012. Years represented by bars with same-colored stars were not significantly different from one another.

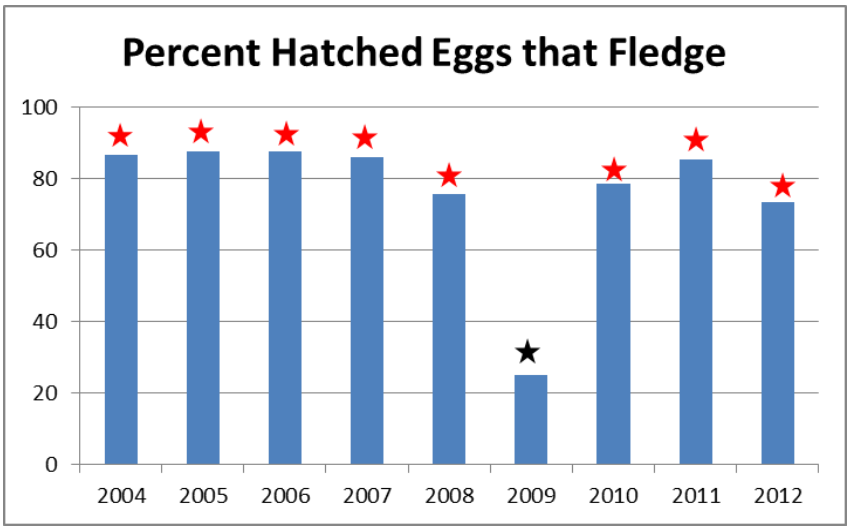

Figure 5. Percent of Northern Saw-whet Owl hatchlings that fledged in Custer National Forest, South Dakota by year. Years represented by bars with same-colored stars were not significantly different from one another.

Because of the low average clutch size in 2012, average brood size and average number of owlets fledged in 2012 also were lower than the all-year average (Table 1). However once again, there was no significant difference in brood size ($F_{8,103}$= 0.01, p>0.9) or number fledged per nest ($F_{8,92}$= 0.01, p>0.9) among years. In 2009, a significantly lower proportion of hatchlings went on to fledge compared to all other years (G =18.8, df=8, p<0.025) (Figure 5). The signifcant reduction in fledging success in 2009 was because many died in nest, not because entire nests failed (Appendix A graph).

Overall, there was no significant difference among years in the percent of attempted nests that fledged at least one bird (G=11.7, df=8, p>0.10) (Figure 6).

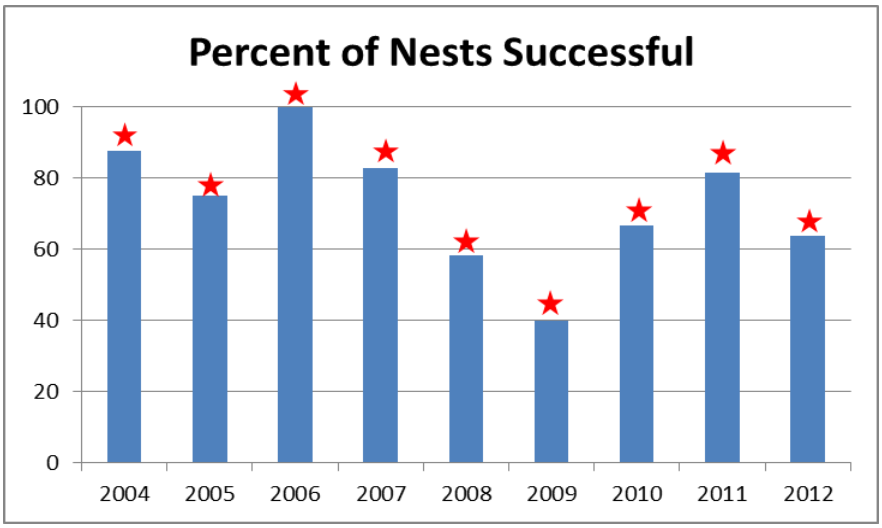

Figure 6. Percent of attempted nests by Northern Saw-whet Owls that fledged at least one owlet each year in Custer National Forest, South Dakota. Years represented by bars with same-colored stars were not significantly different from one another.

Adult and Nestling Banding

One male and six females were caught at the nine nests that hatched eggs. One pair, the male and female at nestbox 20 in Slim Buttes, was already banded. They had been caught and banded October 30, 2011 at a fall migration banding station 0.42 mi (0.68 km) away from the nestbox. Both birds were caught in the same net at the same time in October, suggesting they were already an established pair at that time. The other five females were unbanded when caught on the nest. None of these birds were caught later during the fall 2012 migration banding season. Of the three nests where we did not catch any adults, we attempted but missed the female at one nest and subsequent efforts to catch her failed. The other two nests were too close to fledging when we commenced our efforts to catch adults and we did not want to disturb the nest and risk premature fledging.

Eighteen nestlings from six nests were banded (Table 2). Three owlets had already fledged from nestbox 61 by the time we arrived and only one remained to be banded. Blood samples were taken from all nestlings except those in the N. Cave Hills nest. All 18 banded nestlings fledged successfully.

Table 2. Summary of 2012 Northern Saw-whet Owl nestling banding in Custer National Forest, South Dakota.

Date	Area	Nest Box #	Number Nestlings Banded
5/28/2012	N. Cave Hills	9	4
5/31/2012	Slim Buttes north	20	3
5/31/2012	Slim Buttes north	98	2
5/31/2012	Slim Buttes north	61	1
5/31/2012	Slim Buttes central	96	4
7/26/2012	Slim Buttes central	70	4

Two birds banded as nestlings were recaptured after they fledged. One female was caught in September, 100 days after banding and 0.4 mi (0.7 km) from her nestbox (#20). The second bird, unidentified sex, was caught in October, 136 days after initial banding. We caught it in the Deer Draw area of Slim Buttes 7.1 mi (12.4 km) from its nestbox (#96) which was located in the central part of Slim Buttes.

Because there were so few nests and owls present during the breeding season, especially in National Forest subunits outside of Slim Buttes, no attempt was made to catch owls away from nests until September. Thus we were unable to test whether birds were moving among subunits during the breeding season.

Small Mammal Trapping

Of the 200 small mammal traps set out in Slim Buttes, 100 were set up in four grids near unoccupied nestboxes while 100 were set up in four grids near occupied nestboxes (Figure 7).

We set traps for two nights in mid-May 2012 but did not catch any animals. Because of drought and schedule conflicts, we did not attempt to trap small mammals again in 2012.

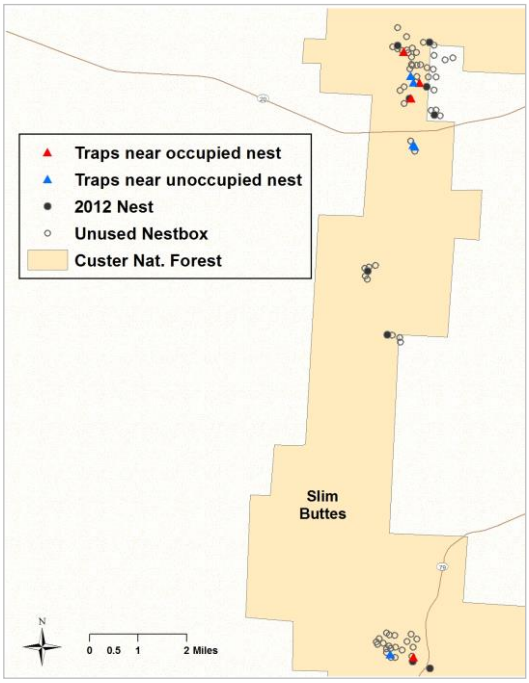

Figure 7. Location of small mammal trap grids in 2012 in Slim Buttes, Custer National Forest, Harding County, South Dakota.

DISCUSSION

Reproductive Success

Northern Saw-whet Owl reproductive success in the Custer National Forest nestbox project is very similar to that of owls in other studies (Table 3). Thus this species appears to have quite consistent average reproductive success over a large area (western North America) and time period (studies range from the early 1980's to the present). Even within the present study, average reproductive success, as defined by mean clutch size, brood size, and number fledged per nest, was similar across years. However, 'average' metrics mask the considerable amount of variation among years in some measures. A more nuanced look at the data reveals that in some years, nest failure is higher, even though the averages were the same as other years. In three years (2008-2010), most nest failures occurred before hatching. In 2009, which had the lowest reproductive success of any year during this study so far, many hatchlings did not fledge. This suggests that, of all the years of this project, conditions were the worst in 2009; not only were there few attempted nests, the few that were attempted lost both eggs and nestlings before the end of the nesting attempt. Only two nests were attempted in 2006 but they both did very well, suggesting two possibilities. First, conditions were bad during winter, when nest sites are being selected, but improved in spring and summer. Or, perhaps for some reason almost no owls were present that year but the small number that nested found good conditions. Finally, 2007 and 2011 not only had huge spikes in numbers of nests, but hatching and fledging success also were high. This suggests that conditions were very good before and during the nesting season. Thus 'conditions' seem to vary among years but what those condition(s) are remain unknown. The

Table 3. Comparison of published Northern Saw-whet Owl reproductive success measures, with sample sizes, to those of this study in Custer National Forest, SD (last row) .

Location	Mean Clutch Size (*n*)	Mean Num Fledge, Successful Nests (*n*)	Mean Num Fledge, All Nests (*n*)	Pct Nests Fledge	Notes
North America	5.5 ± 0.24 SE (13)				Rasmussen *et al*. 2008
British Columbia	5.7 ± 0.15 SE (36)	3.5 (17)	2.7 ± 0.09 SE (22)		Rasmussen *et al*. 2008
Alberta		5.5 ± 0.50 SE (4)	4.4 ± 1.17 SE (5)		Rasmussen *et al*. 2008
Oregon	5.2 ± 0.79 SE (12)		3.6 ± 0.60 SE (9)		Rasmussen *et al*. 2008
Oregon	5.8 (22)	4.4 (20)		80%	Nightingale *et al*. 2013 1 year of data
Idaho	5.8 (14)	5.3 (?)	3.6 (?)		Rasmussen *et al*. 2008
SW Idaho		4.8 (29)	3.3 (42)	69%	Marks & Doremus 2000 13 yrs of data
South Dakota	**5.2± 0.12 SE (127)**	**4.4± 0.16 SD (104)**	**3.4 ± 0.20 SE (136)**	**75.4%**	**This study** **9 yrs of data**

most logical 'condition' to affect nest settlement and success would be prey abundance. One study has shown a weak correlation between mouse abundance and numbers of nesting owls (Marks and Doremus 2000). We will be assessing the impact of prey abundance on NSWO nesting in Custer National Forest over the next few years to evaluate whether there is a relationship in this area.

During the nine years of this nestbox project, the single most important factor dictating the number of owls produced in Custer National Forest was the number of breeding adults that attempt to breed (Figure 3). In general the project has 5 – 15 nest attempts a year (Appendix A),

but in 2007 and 2011, number of nest attempts jumped by an order of magnitude. Because reproductive success was approximately the same each year in this study area and in other regions and years, it seems unlikely that the spikes in 2007 and 2011 were because of local spikes in a critical resource, such as their mice prey. If there had been a local super-abundance of a resource to attract that many breeding birds, we would expect an increase in reproductive success, which we did not see. There is evidence that the dramatic increase in numbers every four years is a large-scale phenomenon in this species (Swengel and Swengel 1995, De Ryuck *et al*. 2012). Banders at fall migration banding stations have noted that dramatic spikes in owl numbers occur every four years (Whalen and Watts 2002, Stock *et al.* 2006, Brittain *et al.* 2009). Usually the spike consists of hatch-year birds, which has led to two possible explanations. First, reproductive success was especially high and/or juvenile mortality exceptionally low in those 'irruption' years. A second explanation is that approximately the same number of owls are produced each year, but in some years, larger numbers of hatch-year birds migrate south. Data from breeding populations are needed to clarify the cause of these four-year cycles. In Custer National Forest, large numbers of fledglings were produced in 2007 and 2011, which would explain high numbers of hatch-year birds that were caught at the 2011 Slim Buttes fall banding station compared to 2012 (Drilling, unpublished data). However we do not have an explanation yet for why so many owls showed up to breed in Custer National Forest in those two years, compared to the other years of the study. Hopefully, continued banding, prey availability studies, and documenting reproductive success will increase our understanding of this phenomenon.

Movements and Residency

Because so few banded birds are recaptured typically, understanding movement and residency patterns takes many years. However, we had an excellent start with four recaptures in Slim Buttes in 2012. An adult pair, first banded together in October 2011, nested less than 0.5 mi from the banding station in spring 2012. Although we cannot be certain, most likely this pair spent the winter at Slim Buttes rather than migrating elsewhere and then returning. To our knowledge, this is the first ever documentation of fall-banded NSWO nesting in the same area the following spring. In general, nest-site fidelity is quite low in this species, with studies documenting a 14% return rate (n=36) in British Columbia and 2% rate (n=52) in Idaho (Rasmussen *et al.* 2008). Continued banding of nesting birds in Custer National Forest will reveal whether either of these two owls, or any other of the breeders return to breed.

Although we did not catch either of these adult birds during subsequent migration banding efforts, we did recapture one of their banded offspring in late summer, again less than 0.5 mi from the nestbox. Saw-whet Owl broods stay together in the natal territory and are fed by adults for at least one month after fledging (Rasmussen *et al.* 2008). Nothing is known about when young NSWO become independent, but based on other species, the guess is 6-8 weeks (Rasmussen *et al.* 2008). We recaptured the offspring 100 days after banding, or approximately 95 days after she fledged. She probably was fully independent by that time but still remained near her natal territory. Because we do not know anything about post-fledging movements in this species, it is difficult to know if this observation is an anomaly. Another fledgling, from a nestbox in the central part of Slim Buttes, was recaptured 136 days after banding or approximately 130 days after fledging. We caught this bird at the Deer Draw fall migration

banding station seven miles from its nestbox. It clearly was no longer on its natal territory but was still in its natal 'forest'; there is almost continuous forest between the nestbox and banding station. Assuming that neither of these young birds left Slim Buttes and then came back, it appears that there is little post-fledging dispersal, at least for some individuals during the first 3-4 months and at this location. It could be argued that the low dispersal is because these birds hatched on a small forested island in a large sea of grasslands and sagebrush. When an owl leaves Slim Buttes, it must fly over at least 25 miles of grasslands before encountering another forested patch. Thus the young owls may choose to stay in the forest patch where they hatched. These results may be different in large continuous forested areas such as the Rocky Mountains or the boreal forests of Canada.

Future Work

Long-term datasets on individual species are rare but vital to understanding animal populations (Clutton-Brock and Shelton 2010). The Harding County owl nestbox study is a unique opportunity to understand owl breeding – no one else has this sort of dataset. The nine years of data have shown a possible four-year breeding cycle which seems to corroborate observations at fall banding stations. We plan to continue monitoring the nests to determine if this is actually a repeatable cycle. In addition, we plan to continue studies that evaluate the reasons behind the patterns we see, especially the relationship between reproductive success and prey abundance. Finally, the first year of nestling and breeding adult banding gave us new information on how long these owls stay in the area. Additional banding hopefully will build on this.

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APPENDIX A.

Statistics by year of Northern Saw-whet Owl reproduction in Custer National Forest nestboxes, South Dakota, including mean clutch size ± SE of nests with full clutches, mean brood size ± SE of nests with at least one hatched egg, mean number of fledglings per nest ± SE for all hatched nests and for only nests that successfully produced at least one owl, and N, the number of nest attempts that year. These data are represented graphically below the table.

Year	Mean Clutch Size (range)	Mean Brood Size (range)	Mean Number Fledge, Successful Nests (range)	Mean Number Fledge, All Nests (range)	N
2004	6.0 ± 0.29 (5-7)	5.4 ± 0.45 (4-7)	4.7 ± 0.63 (2-7)	4.1 ± 0.78 (2-7)	8
2005	4.0 ± 0.18 (3-5)	3.4 ± 0.40 (2-5)	3.5 ± 0.31 (2-4)	2.6 ± 0.58 (2-4)	8
2006	4.0 ± 0.71 (3-5)	4.0 ± 0.71 (3-5)	3.5 ± 1.06 (2-5)	3.5 ± 1.06 (2-5)	2
2007	5.6 ± 0.21 (4-7)	5.2 ± 0.29 (1-7)	4.8 ± 0.28 (1-7)	4.0 ± 0.41 (1-7)	29
2008	4.3 ± 0.37 (2-6)	3.6 ± 0.47 (2-5)	3.1 ± 0.31 (2-4)	1.8 ± 0.48 (2-4)	12
2009	4.0 ± 0.40 (3-5)	4.0 ± 0.71 (3-5)	1.0 ± 0.00 (1-1)	0.4 ± 0.22 (1-1)	5
2010	4.6 ± 0.45 (2-6)	4.7 ± 0.45 (3-6)	4.4 ± 0.61 (2-6)	2.4 ± 0.82 (2-6)	9
2011	5.7 ± 0.18 (3-8)	5.2 ± 0.21 (2-8)	5.0 ± 0.23 (2-8)	4.1 ± 0.33 (2-8)	52
2012	3.8 ± 0.19 (3-5)	3.8 ± 0.15 (3-4)	3.1 ±0.43 (1-4)	2.0 ± 0.53 (1-4)	11
All Years	**5.2± 0.12 (2-8)**	**4.8± 0.14 (1-8)**	**4.4± 0.16 (1-8)**	**3.4 ± 0.20 (1-8)**	**136**