2009
South Dakota Department of Game, Fish and Parks – State Wildlife Grant Program
FINAL REPORT

Name: David L. Swanson **Date**: 31 October 2009

Affiliation: University of South Dakota, Dept. of Biology **Position**: Professor

Mailing Address: Department of Biology, University of South Dakota, 414 E. Clark Street, Vermillion, SD 57069-2390

FAX: 605-677-6557 **E-mail**: david.swanson@usd.edu **Phone**: 605-677-6175

Project Title: Breeding Ecology of American Three-toed Woodpeckers in the Black Hills

Principal Investigator: David Swanson, Department of Biology, University of South Dakota

Co-PIs: Dr. Hugh Britten, Department of Biology, University of South Dakota
Amanda Ervin, Ph.D. student, University of South Dakota

Stated Objectives:
A. Survey white spruce habitat for resident American Three-toed Woodpeckers (*Picoides dorsalis*)
B. Characterize white spruce habitats and other habitats used by American Three-toed Woodpeckers
C. Locate nests and monitor production
D. Band American three-toed woodpeckers with standard FWS bands
E. Use radio transmitters to track movements of a subset of banded birds
F. Collect information on foraging behavior and attempt to relate this to habitat
G. Record presence and nesting of sympatric avian species inhabiting white spruce habitats and evaluate competition
H. Collect DNA samples from the Black Hills population of American Three-toed Woodpeckers and sequence mitochondrial and/or microsatellite DNA

Project Methods and Results

Playback Surveys – For playback surveys, we used random transects in white spruce forest that were established by Rocky Mountain Bird Observatory (Panjabi 2003). Each transect was roughly linear, following spruce habitat, and consisted of 15 points, except for a few transects in which the spruce habitat ended before 15 points were reached, with individual points separated by 250 m. We conducted surveys in early morning (0445-0930 MST) from 24 May-3 July 2005, which is within the major drumming/calling period (both on a daily and seasonal basis) for American Three-toed Woodpeckers (Leonard 2001). We did not conduct surveys on days with rain or high winds. We counted all woodpeckers seen or heard at each point using a 5-minute survey period with a playback procedure of American Three-toed Woodpecker drumming and calls. The playback procedure consisted of an initial 1 min of listening, followed by 30 sec

playback, followed by 30 sec listening. The alternating 30-sec playback/listening periods were repeated until the 5-min survey period was complete. We used the Peterson Audio Field Guide as the source for the woodpecker drumming and calls and broadcast sounds from a personal CD player through a Radio Shack electronic blow-horn. This allowed sufficient broadcast of drumming and call notes to attract woodpeckers from a considerable distance (> 200 m).

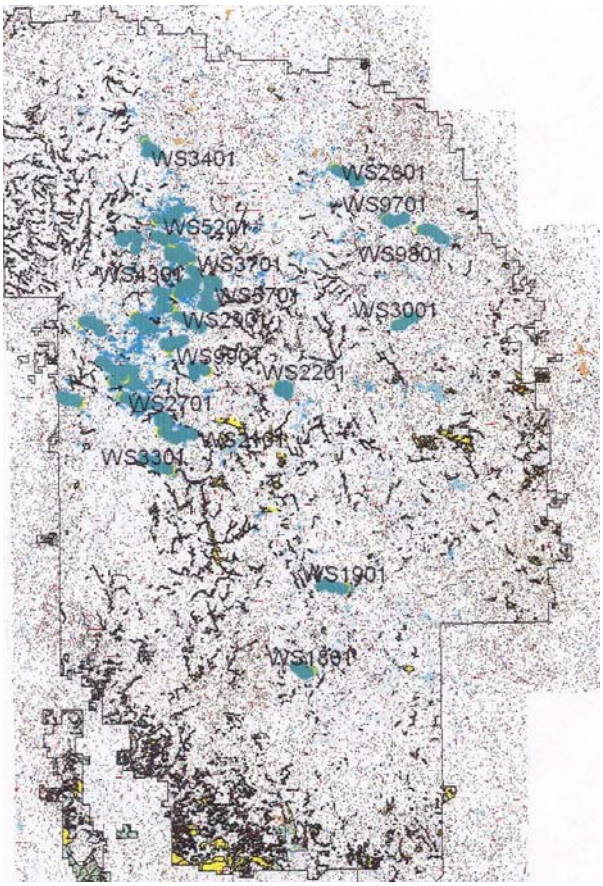

Fig. 1 – Transects completed (green shading) in white spruce habitat in the Black Hills of South Dakota during the breeding season of 2005.

We completed surveys on 28 transects (411 total points) during the breeding season of 2005 (Fig. 1). We observed a total of 78 three-toed woodpeckers, for an overall relative abundance of 0.19 birds per point (2.85 birds/transect). On some transects, we detected as many as 9-10 individuals, so maximum relative abundance on these transects was in excess of 0.6 birds/point. Thus, we detected generally higher abundance of three-toed woodpeckers than on standard (i.e., non-playback) surveys of the same spruce transects (e.g., 2003 = 36 total observations; highest abundances of about 0.3 birds/point) (Panjabi 2003). Thus, American Three-toed Woodpeckers were detected at higher levels than on standard transects and appear to be relatively common in these spruce forest habitats in the Black Hills.

We recorded other woodpecker species within the white spruce habitat, but did not generate relative abundance estimates for these species. Hairy Woodpecker (*Picoides villosus*) and Red-naped Sapsucker (*Sphyrapicus nuchalis*) were both relatively common in these habitats. We found several nests for both Hairy Woodpecker and Red-naped Sapsucker; Hairy Woodpecker nests were most often located in ponderosa pine and aspen, whereas those of sapsuckers were invariably in aspen, and most often in aspen groves. We only observed two instances of aggression between Hairy and American Three-toed woodpeckers. In one instance, a foraging female three-toed aggressively pursued and drove away a Hairy Woodpecker from the dead spruce snag upon which she was foraging. In the other instance, a Hairy Woodpecker was scolding and diving at a foraging American Three-toed Woodpecker, who appeared to essentially ignore the actions of the Hairy Woodpecker. These anecdotal observations do not allow firm conclusions to be drawn about competition among co-habiting woodpeckers in white spruce forests in the Black Hills, but the occurrence of all three species as regular residents in this habitat suggests that there is relatively little competition among these species, perhaps due to habitat partitioning. Firm conclusions regarding competition and any potential habitat partitioning among these three species will require further research.

Nest Monitoring and Nest Site Selection – We searched for American Three-toed Woodpecker nests in areas where woodpeckers responded to playbacks or in areas with evidence of woodpecker foraging (i.e., dead spruce trees with scaled bark) by following observed birds and by systematically examining spruce snags, pine snags, and living and dead aspen trees in these areas. Using these methods, we located 3, 8, 10, and 7 nests during the breeding seasons of 2005, 2006, 2007, and 2008, respectively, for a total of 28 nests. We checked these nests every 3-5 days until fledging or failure with a Sandpiper Technologies Wireless TreeTop Peeper 4 Video Monitor System, which allowed us to view nest status inside the nest cavities. Nests were considered successful if they fledged at least one young bird. For each nest site, we performed a vegetation analysis in the nest area (see Fig. 2 for sampling protocol description). Vegetation data measured consisted of number, species and size (two categories: small [< 23 cm Diameter and Breast Height, DBH] and large [> 23 cm DBH]) of living trees, number, species and size of snags, number and size of downed logs and number of shrubs. We counted all living trees, small snags, and downed logs in four 6 m X 50 m strip transects in each of the cardinal directions, with the transect origin centered on the nest. Large snags were counted on four 20 X 50 m strip transects centered on the nest. Shrubs of at least 20 cm in height were counted in three 4 m-radius subplots centered on the nest and at 50 m from the nest to the north and south. In addition to vegetation analyses at nest sites, we performed identical analyses at 30 random sites in white spruce habitat. Random sites were centered on randomly selected points from the playback survey transects that we conducted in 2005. We used Student's *t*-tests, with a sequential Bonferroni adjustment of alpha-levels for multiple tests (Rice 1989), to compare vegetation variables between nest and random sites to determine if nest sites differed from random sites for any of the vegetation characteristics.

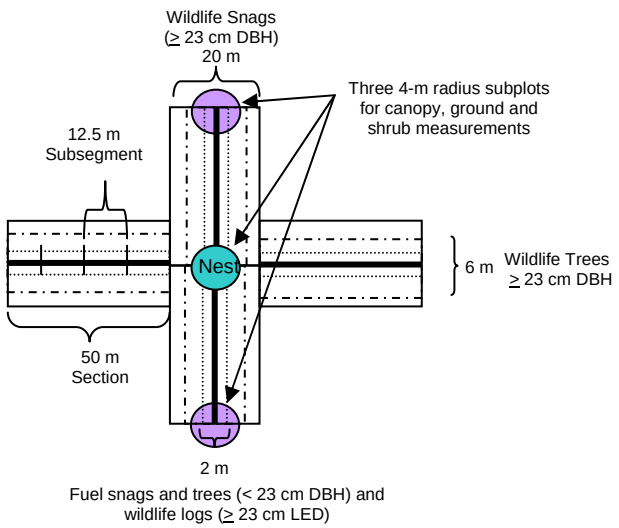

Figure 2. Vegetation sampling design surrounding nest trees.

Of the 28 total nests located, 12 successfully fledged young, providing an apparent overall nest success rate of 42.9%. Mayfield daily nest survival rate (DSR, Mayfield 1961, 1975) was 0.9662. Extrapolating this DSR over the entire incubation and nestling period of 38 days (Baicich and Harrison 1997) gives an overall nest success rate of 27.1%. We also calculated nest success with recent maximum likelihood approaches using Program MARK (Dinsmore et al. 2002, Rotella et al. 2004). For the simple model where daily survival rate was assumed to be constant across nests and dates, DSR was 0.945, which results in an overall nest success rate of 25.3%.

Nesting success in this study (overall nest success rate = 27% and 25% by Mayfield and maximum likelihood methods, respectively) was lower than that for three-toed woodpecker nests in Oregon (53%, apparent nest success) and Idaho/Montana (79%, Mayfield nest success) (Leonard 2001). Nesting success for three-toed woodpeckers in our study is also lower than that documented for other woodpecker species in recent studies of burned or pine-beetle killed habitats in the Black Hills. Gentry and Vierling (2007) documented an overall Mayfield nest success rate of 90% (n = 55 nests) for Lewis's Woodpeckers (*Melanerpes lewis*) nesting in old ponderosa pine burns in the Black Hills. Black-backed Woodpecker (*Picoides arcticus*) nesting success in areas of pine-beetle killed forest in the Black Hills ranged from 41 to 78% (maximum likelihood nesting success) in different years (Bonnot et al. 2008).

Precise reasons for the low nesting success of three-toed woodpeckers in spruce habitats in the Black Hills are not known. However, we did document several potential mammalian nest predators at active woodpecker nest cavities with Cuddeback Excite 2.0 heat/motion-activated

Figure 3. Potential predators at American Three-toed Woodpecker nests in the Black Hills documented with a Cuddeback Model digital game camera mounted several meters away from active nests. (A) Failed nest where we documented predation by a red squirrel (*Tamiasciurus hudsonicus*). (B) Successful nest where we documented several potential mammalian predators approaching the nest cavity (clockwise from top left: red squirrel; northern flying squirrel [*Glaucomys sabrinus*] – marked by red oval; least chipmunk [*Tamias minimus*]; least chipmunk).

remote digital game cameras that we erected within 3 meters from the nest cavity. We deployed game cameras at two nests in 2007 and one nest in 2008. Potential mammalian predators documented at these nests included red squirrels (*Tamiasciurus hudsonicus*), least chipmunks (*Tamias minimus*), and northern flying squirrels (*Glaucomys sabrinus*) (Fig. 3). We did not document any other birds at nest cavities, although three-toed woodpeckers were regularly detected by the game cameras, so we suggest that mammals may be important predators at nests

of American Three-toed Woodpeckers in the Black Hills. In addition, in two separate nest cavities, both in aspen, flying squirrels had usurped three-toed woodpeckers from completed nest cavities when we returned to the cavity to check on nest progression. In both of these cases, the nest cavity was complete, or nearly so, but no eggs were yet present on the prior nest check.

Of the 28 nests, six occurred in spruce snags, two in living spruce with dead sections, three in ponderosa pine snags, nine in living aspen and eight in aspen snags. Thus, nesting substrates are quite variable in this population. The 61% of nests occurring in aspen or aspen snags is a higher incidence of aspen nesting that in other portions of the species' range (Leonard 2001). Nest cavity height ranged from 3-12 m, with the exception of one nest in a spruce snag that was at least 15 m high, and nest cavity entrances appeared to be oriented in random directions.

Nest sites differed from random sites in several respects. Nest sites (mean ± SE) had significantly more wildlife (> 23 cm dbh) aspen trees (Nest = 5.4 ± 1.8, n = 29; Random = 0.5 ± 0.2, n = 30; $P = 0.002$) and wildlife aspen snags (Nest = 2.7 ± 1.7; Random = 0.4 ± 0.2, $P = 0.007$). Nest sites also showed a tendency to have and fewer small pine snags (Nest = 3.3 ± 2.3; Random = 4.0 ± 1.4, $P = 0.051$) and fewer small spruce trees (Nest = 71.9 ± 10.9; Random = 95.2 ± 9.0; $P = 0.077$), although neither of these differences were significant. No other significant differences between nest and random sites were detected. In general, nest sites contained higher numbers of large aspen trees and snags, similar numbers of large spruce and pine trees and snags, and fewer small spruce and pine trees and snags. Along with the high incidence of nests occurring in aspen trees and snags, these data suggest that spruce forest with relatively high numbers of aspen may serve as preferred nesting habitat for American Three-toed Woodpeckers in the Black Hills.

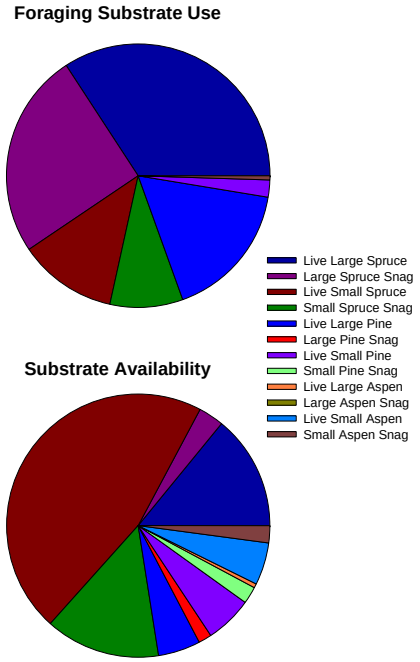

Fig. 4. Foraging substrate used vs. substrate availability in 2007 and 2008 for American Three-toed Woodpeckers in spruce forests in the Black Hills.

Foraging Observations: We collected foraging observations from 19 individual birds (110 total observations) in 2006, from 23 individual birds (115 total observations) in 2007, and from 11 individual birds (83 total observations) in 2008. We collected foraging data by following individual foraging woodpeckers and recording tree species, status (living or dead), and size of the tree (small or wildlife, as defined above; 2007 and 2008 only) on which they foraged. We also timed each foraging bout on individual substrate trees, but have not analyzed time sequence data yet. We used Chi-square tests, with sequential Bonferroni adjustment of alpha-levels, to compare foraging use of trees and snags with tree and snag availability (determined from 30 random samples as described above). In 2006, we did not record the tree size category for foraging observations. During 2006, three-toed woodpeckers spent 72% of their total foraging bouts on spruce trees, with 45% on dead spruce and 27% on living spruce, 20% on living and dead ponderosa pine, and 8% on aspen. Three-toed woodpeckers foraged on dead spruce in greater proportion than its availability ($P < 0.001$), and foraged on live spruce in lower proportion than its

availability ($P < 0.001$). Other trees and snags were used in proportion to their availability. During 2007 and 2008, we also included tree size category in the analyses, and found that woodpeckers spent 59.2% of foraging bouts on wildlife size category spruce, living or dead, and 80.1% of foraging bouts on spruce trees and snags of any size (Fig. 4). Chi-square tests revealed that live wildlife spruce, wildlife spruce snags, and live wildlife pine were used in higher proportion than their availability ($P < 0.001$ in all cases). Live small spruce ($P < 0.001$) and live small aspen ($P = 0.004$) were used in lower proportion than their availability. No other foraging substrate differed significantly between use and availability. These data suggest that three-toed woodpeckers prefer large spruce, living or dead, and large pine for foraging, and tend to avoid small living spruce and aspen.

Radio-tracking and Home Range Size – We attached transmitters to the back (2005) or the base of the upper tail (2006-2008) to a total of 27 birds during the 2005-2008 field seasons. We detected transmitter signals from radio-tagged woodpeckers with Yagi 3-element handheld antennas and ATS receivers. We recorded locations (UTM coordinates and bearing of the signal) of radio-tagged birds for use in triangulation to establish precise positions several times each week once the transmitters were attached. We obtained sufficient sample sizes for home range analysis ($n \geq 30$ locations) for 7 of the 27 birds, as many these birds were able to work the transmitters free before we could collect 30 individual locations. For the seven birds with sufficient sample sizes, we calculated home range size by three different methods; minimum convex polygon, fixed kernel and adaptive kernel (Table 1, Fig. 5). Mean (± SE) 95% fixed kernel home range size was 136.4 ± 38 ha. This was 18% smaller than similar estimates from American Three-toed Woodpeckers in Oregon (Goggans et al. 1989) and 56% larger than similar home range estimates for the closely related Eurasian Three-toed Woodpeckers (*Picoides tridactylus*) in Germany (Pechacek 2004, Pechacek and d'Oleire-Oltmanns 2004).

We used ArcGIS and rank matrix tests to examine how habitat occupancy from radio-tracking locations varied with available habitat. For determination of available habitat, we identified 82 random plots (of 91 ha each) within the study area. We then compared available habitat in random plots with habitat-types present within 95% fixed kernel home ranges by rank matrix test. Ponderosa pine was the most abundant habitat in the study area, comprising 86.3% of available habitat. Other habitats available, on a percentage basis, included aspen at 5.8%, grasslands at 3.3% and white spruce at 3.0%. American Three-toed Woodpeckers occupied aspen habitats, relative to their availability, significantly more than they occupied grassland and white spruce habitats, and occupation of the latter two habitats did not differ significantly from occupation of ponderosa pine habitats (Table 2). The preferential occupation of aspen habitat according to ArcGIS data is consistent with the nest site selection data, where aspen was present in higher densities in nest site study plots than in random study plots in white spruce habitats. This strongly suggests a preference for aspen within home ranges for three-toed woodpeckers within the Black Hills. Such a preference for aspen has not been documented for three-toed woodpecker populations in other locations in North America (Leonard 2001). The occurrence of grassland habitat within three-toed woodpecker home ranges is somewhat surprising, given their general preference for spruce-dominated habitats (Leonard 2001), but aspen/spruce forests abut against parklands throughout the Black Hills, and woodpeckers regularly nest in trees near the grassland-woodland border, so these sites are likely classified as grassland in ArcGIS.

Table 1. Home Range Size (ha) of American Three-Toed Woodpeckers in the Black Hills, SD

	MCP[a]		FK[b]		ADK[c]	
Bird ID	50%	100%	50%	95%	50%	95%
6	0.9	10.1	2.9	14.1	2.5	21
7	84.3	205.4	91.7	336	79	386
13	2.2	19.5	12	69	4	37.7
20	34.1	101.1	46.5	158.9	43.4	172.1
21	6.6	72.7	22.5	139.1	17	237.6
23	13.7	59.8	27.2	106.1	24.1	125.9
26	30	93.9	30.1	131.4	46.2	200.6
Mean	24.5	80.4	33.3	136.4	30.9	168.7
SE	11.1	24.6	11	38	10.3	47.3

[a] Minimum Convex Polygon
[b] Fixed Kernel
[c] Adaptive Kernel

	Grassland (GRA)	Ponderosa Pine (TPP)	White Spruce (TWS)	Aspen (TAA)	Willows (SWI)	Rank
GRA		+	---	+++	-	2
TPP	+		---	+	-	2
TWS	-	-		+	+	2
TAA	+++	+	+++		---	5
SWI	-	---	+	---		1

Table 2. Ranking matrices based on comparing proportional habitat within 95% fixed kernel home ranges with proportions of habitat available within 82 random 91-ha plots within the study area. Positive or negative symbols indicate the direction of the comparison and triplicate positive or negative symbols represent significant differences between home range and random plots.

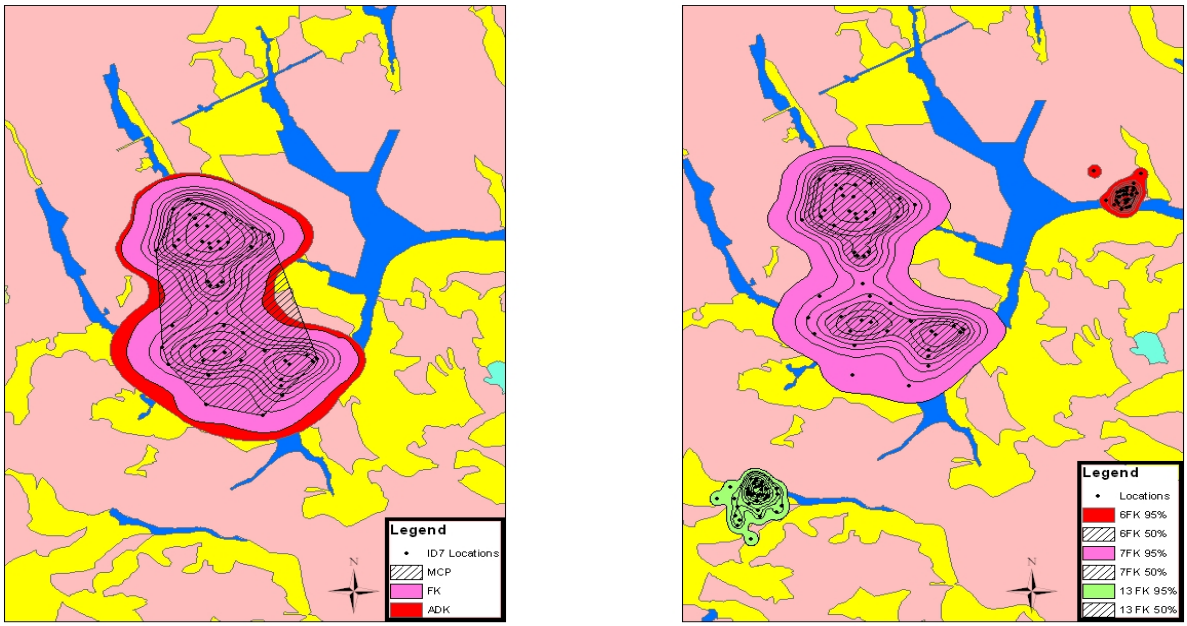

Figure 5. Home range size in American Three-toed Woodpeckers in Long Draw, Lawrence Co., South Dakota. The left panel shows the radio transmitter locations and home ranges calculated by the three different methods (100% minimum convex polygon, 95% fixed kernel, and 95% adaptive kernel) for bird 7. The right panel shows locations and 50% and 95% home range sizes by the fixed kernel method for bird numbers 6, 7 and 13. The background colors represent habitat types classified by ARC-GIS. Blue represents aspen, yellow represents white spruce, pink represents ponderosa pine, and pale green represents grasslands.

Genetics – Due to the geographic isolation and sedentary nature of the American Three-toed Woodpecker in the Black Hills we hypothesized that the Black Hills population is genetically differentiated from Rocky Mountain populations and there is very limited or no gene flow between the sampled populations. The specific objectives of the genetic portion of this project are to: 1) determine if the populations are structured geographically, 2) determine if there is gene flow between the sampled populations, and 3) elucidate the extent of the variation (if present) within and between the populations.

We obtained blood or tissue samples from 42 American Three-toed Woodpeckers from collecting sites in the Black Hills, South Dakota and western Montana, as well as tissue samples from museums. Total samples from different locations in North America were: northern Black Hills, South Dakota (n=21); LoLo National Forest, Montana (n=11); Washington (n=4); Alaska (n=2); and Alberta, Canada (n=4). We successfully extracted DNA from all samples and have completed genetic laboratory work.

For initial analyses of mitochondrial DNA we used 1,936 base pair sequences from 4 genes: (COI 424bp, CytB 474bp, ND2 820bp, ND3 218 bp; Zink et al. 2002) using 5 screener samples: (2 Black Hills, 2 Montana, 1 Alberta, and 1 Alaska). Visual inspection revealed little to no

genetic structure in COI, ND2 and ND3 in the screener samples. However, CytB displayed some variation and therefore we amplified the remainder of the samples. We successfully amplified the forward and reverse strands of 36 of the remaining 37 samples using standard PCR methods and aligned each sequence with Sequencher 4.5 (Fuchs et al. 2004) and Se-Al v 2.011 (Rambaut 2002). Analyses of mitochondrial DNA conducted to date have revealed little evidence for consistent genetic variation among populations of American Three-toed Woodpecker in western North America.

Consequently, we turned to microsattelite analyses to examine variation among Black Hills and western Montana populations for which we had sufficient blood samples. For microsatellite analyses, we used 14 microsatellite loci that proved to be polymorphic in the Eurasian Three-toed Woodpecker (Valimaki et al. 2008). We amplified 42 samples using the 14 loci, and amplification was successful in 11 of these loci. The 3 unsuccessful loci were due to non-specific amplification or failure to amplify. We analyzed 20 Black Hills samples and 11 Montana samples. We used the computer program Structure 2.2 (Pritchard et al. 2000) to make inferences regarding population structure by using genotype data. We estimated the number of populations (K) using input values of K=1 to K=4. After each run, we estimated alpha (low alpha values suggest structuring), ln probability (low values suggest that the genotypes are associated with specific populations) and the Q value (the probability that individuals can be assigned to a cluster). From these estimates (Table 3), we inferred that there are most likely 2 or 3 populations based on Black Hills and Montana samples (Figure 6). It appears that there is some admixture with the Montana population moving into the Black Hills population. Based on the results for K=3 there also may be some sub-structuring within the Black Hills population.

Alpha and Likelihood analyses		
K	alpha	ln
1	0	-1098.4
2	0.11	-1076.1
3	0.1072	-1127.2
4	0.1356	-1214

Table 3. Values for K, alpha and ln probability for microsattelite DNA analyses of Black Hills and Montana populations of American Three-toed Woodpeckers.

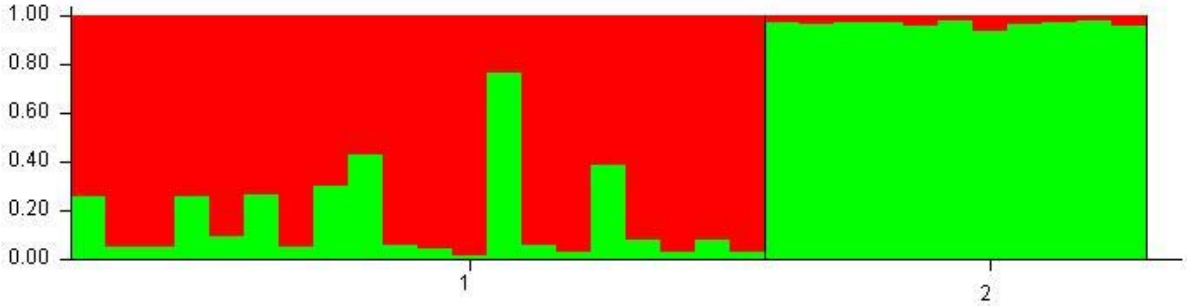

Figure 6. Plot of Q estimates based on K= 2. Population 1 is Black Hills, Population 2 is Montana. Each bar represents an individual and is proportional to the inferred K cluster. Note that birds from the Montana population all show Q estimates greater than 0.90, whereas no birds from Black Hills populations have Q estimates exceeding 0.80, with all but one bird below 0.50.

Conclusions

American Three-toed Woodpeckers occur in good numbers in spruce forests in the Black Hills. Average relative abundances of woodpeckers were about twice those for non-playback samples of the same transects (Panjabi 2003). It is difficult to make precise comparisons of bird density among sites and studies because of differences in sampling protocols and detectabilities of birds, but such comparisons can still be constructive for establishing estimates of relative abundances among sites. Panjabi (2003) documented an average density of three-toed woodpeckers in white spruce forest in the Black Hills as 0.04 birds/ha, which is lower than some studies in Montana and Colorado, especially in burned areas, but similar to those for other North American locations (Leonard 2001). In addition, the overall average abundance (birds/point) that Panjabi (2003) detected was roughly similar to the average relative abundance at other sites in the northern Rocky Mountains. Given that our abundance estimates were about twice those for Panjabi (2003), these data suggest that American Three-toed Woodpeckers in the Black Hills occur at abundances roughly similar to those for other sites in the Rocky Mountains.

Overall nesting success for the Black Hills population of American Three-toed Woodpeckers (43% apparent nest success; 27% Mayfield nest success; 25% maximum likelihood nest success) was lower than that for American Three-toed Woodpeckers in other portions of their range (53% apparent nest success in Oregon and 79% Mayfield nest success in Idaho and Montana; Leonard 2001) and also lower than that for other woodpeckers in the Black Hills (e.g., Gentry and Vierling 2007; Bonnot et al. 2008). Causative factors behind the low nest success for three-toed woodpeckers in this study are not known, but we did document the presence of potential mammalian nest predators, including red squirrels, least chipmunks and northern flying squirrels at active nest cavities. We also documented one instance of a Red Squirrel preying on a nestling, although it is possible that the nestling may have been dead prior to the appearance of the squirrel. We did not detect the presence of avian nest predators at cavities, so these data suggest that mammalian nest predators (principally Sciurids) are likely the primary predators on three-toed woodpecker nests in the Black Hills.

Nest site selection was quite broad with dead or dying spruce, dead ponderosa pines, and living and dead aspen used for nest cavities. Such nest site substrates have all been recorded previously for this species, but the relatively high incidence of aspen use for nesting cavities was somewhat unexpected (Leonard 2001). Three-toed woodpeckers preferred nest sites in spruce forest with higher numbers of large aspen and aspen snags compared to random sites, suggesting that some habitat selection for nesting does occur and that areas with higher abundance of large aspen within spruce forests are preferred. In addition, foraging woodpeckers preferred large spruce, both living and dead, which suggests that spruce habitats with large trees and snags are important for foraging in this species.

Mean home range size in three-toed woodpeckers in the Black Hills falls within the reported range for other populations of American and Eurasian three-toed woodpeckers. Breeding-season home ranges in this study contained a higher proportion of aspen relative to its availability than spruce or pine. This is consistent with the relatively high proportion of aspen in nest vegetation comparisons and with the high incidence of aspen as a nesting substrate, and highlights the importance of aspen to Black Hills three-toed woodpecker populations.

Inter-population comparisons of mitochondrial DNA in three-toed woodpecker populations from western North America generally revealed only minor variation, suggesting little genetic divergence among populations. However, comparisons of microsatellite loci allowed separation of Black Hills and Montana populations, suggesting some genetic divergence between populations, but evidence also suggest some gene flow from Rocky Mountain populations into Black Hills populations. Additional microsatellite analyses should further illuminate comparative population structure between Rocky Mountain and Black Hills populations of American Three-toed Woodpeckers.

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