

**NESTING ECOLOGY OF THE NORTHERN GOSHAWK  
IN THE BLACK HILLS OF SOUTH DAKOTA  
REPORT FOR THE 2009 NESTING SEASON**

Prepared by:

Craig J. and Pamela R. Knowles  
FaunaWest Wildlife Consultants  
POB 890  
Townsend, MT 59644

Prepared for:

South Dakota Game, Fish and Parks  
523 East Capitol Ave. - Foss Building  
Pierre, SD 57501

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# NESTING ECOLOGY OF THE NORTHERN GOSHAWK IN THE BLACK HILLS OF SOUTH DAKOTA REPORT FOR THE 2009 NESTING SEASON

**ABSTRACT:** The nesting ecology of northern goshawks (*Accipiter gentilis*) was studied in the Black Hills of western South Dakota from 2003 to 2009. Goshawk nest territories were found by broadcasting alarm calls, intensive searches of potential nesting habitat, and visiting historic nesting territories based on information from the U.S. Forest Service (USFS). During this 7- year period, 30 active goshawk nesting territories were studied. There were 53 nesting attempts sufficiently monitored to establish that 35 nests fledged young (66% successful). Among these monitored nests, there was an average of 1.1 chicks fledged per nesting attempt and 1.6 chicks fledged per successful nest. Goshawks frequently used alternative nests from one year to the next, and we were not always successful at finding new alternative nests. Alternative nests ranged from 50 yards to 0.7 miles apart. The average number of alternative nests found per nesting territory was 2.2, and in 1 territory there were 6 nests. Ponderosa pine (*Pinus ponderosa*) was the preferred nest tree with 65 goshawk nests in pine trees and 1 nest found in a white spruce tree (*Abies glauca*). The average diameter (dbh) of nest trees was 16.8 inches dbh. Nest stand characteristics were measured at 21 nest tree sites. Average nest stand dbh was 10.2 inches, average nest stand tree density was 266 trees per acre, and the average nest stand basal area was 128 sq. ft. per acre.

## INTRODUCTION

The Black Hills in western South Dakota are an island mountain range surrounded by prairie grasslands. Due to their location in the northern Great Plains, the Black Hills represent a unique configuration of habitats. The predominant tree species in the Black Hills is the ponderosa pine (*Pinus ponderosa*), and this species forms extensive areas of forested habitat. Ponderosa pine seems to be well adapted to the climate and soils of the Black Hills, and grows extremely well. Consequently, the Black Hills are intensively managed for timber production. Among the diurnal raptors in the Black Hills is a small population of the northern goshawk (*Accipiter gentilis*) (Bartelt 1977, Erickson 1987). However, there is no estimate of the number of goshawks in this population. Moreover, it is unknown if these goshawks are migratory or if they are year-long residents of the Black Hills. The goshawk is of considerable interest because it is a U.S. Forest Service (USFS) Region 2 sensitive species whose nesting habitat is old growth and mature ponderosa pine forests. Its selection of old growth and mature pine stands for nesting habitat makes it sensitive to forest management practices. Over a 3-decade period, the USFS has accumulated records of over 70 goshawk nesting territories within the South Dakota portion of the Black Hills (Steve Hirtzel, USFS pers. comm.). Surveys by Bartelt (1977) and Erickson (1987) found only a few of these territories occupied in any given year. The goshawk is reported to be sensitive to human activity and disturbances associated with logging, mining, and

recreation. Abandonment of nests and nesting territories due to these disturbances is possible. In addition to forest management practices (timber harvest, thinning), wild fire has the potential to degrade goshawk nesting habitat over an extended period (50 years or more), and mountain pine beetle can also cause localized reduction in conifer cover within goshawk nesting stands.

Outside of the 2 Master thesis studies on goshawks (Bartelt 1977, Erickson 1987), systematic surveys for goshawks in the Black Hills have been limited to information gathered by the USFS on goshawks prior to proposed logging. However, these surveys have been highly localized to timber sale sites, and widely spaced both temporally and spatially (Steve Hirtzel, USFS, pers. comm.). Since about 2000, the USFS has attempted to monitor known goshawk nest territories (Cara Staab, USFS biologist, pers.comm.). Some raptor surveys have also been conducted in conjunction with mining activity in the northern Black Hills, but typically the survey areas are later destroyed through mining operations. In 2003, South Dakota Game, Fish and Parks initiated a study of goshawks in the Black Hills (FaunaWest 2003, 2004, Knowles and Knowles 2005, 2006, 2007, 2008). This report provides additional information on goshawk nesting in the Black Hills collected during the 2009 nesting season. Special emphasis is placed on a detailed account of each active nesting territory found during the 7 survey years.

## STUDY AREA AND METHODS

This study of goshawks was conducted in the South Dakota portion of the Black Hills, and within this area, only Federally-owned land was surveyed. This represented an area about 60 miles long (north to south) and 30 miles wide (east to west), or approximately 1,000,000 acres. Three major rock formations, limestone (sedimentary), schist (metamorphic), and granitic rocks (igneous) comprised the Black Hills within the study area. Drainage basins composed of limestone rock were porous and overall appeared to have fewer flowing streams than the other 2 rock types. This difference is noted because the presence of springs and flowing water appeared to be important to goshawk nest site placement. There were outlying areas of sandstone and shale rock formations located on private lands at lower elevations that were not surveyed that appeared to provide good nesting habitat for other diurnal raptors. Although the elevational range within the study area was 3,700 to 7,100 feet, most of the survey work was conducted between 4,000 and 6,500 feet.

Ponderosa pine was the dominant tree species in the Black Hills, and appeared to grow equally well within the 3 strikingly different geologic formations. Elevation may have influenced the growth of ponderosa pine, with trees above 6,500 feet occurring in denser stands and having a more pole-like growth form. White spruce (*Picea glauca*) was also a common tree species in the northern half of the Black Hills. This species was found at intermediate and higher elevations, and was generally restricted to drainage bottoms and slopes with northerly exposures. At lower elevations (below 4,500 feet), burr oak (*Quercus macrocarpa*) appeared with increasing abundance growing in association with ponderosa pine. Quaking aspen (*Populus tremuloides*) was locally abundant at intermediate and higher elevations, especially at sites with recent fire

events.

The majority of the Black Hills has been subjected to forest management practices. This activity has taken place for over a century, and most pine stands exhibit evidence of past harvest. Logging roads, maintained and un-maintained, were generally situated at 0.25-0.50 mile intervals. In addition, the Black Hills were systematically crossed by a series of maintained gravel and paved roads, which followed nearly all major drainages and ridges. Shelterwood and seed-tree cuts appeared to be the common logging practices, but pre-commercial thinning was also frequently observed. Forest fires in the Black Hills have been aggressively suppressed for over a century and it appeared that ponderosa pine has greatly increased in abundance and distribution as a result of this activity. However, due to intensive timber harvest there are not necessarily more large trees in the Black Hills (Brown and Cook 2006). There were several large blocks of naturally occurring grassland areas within the Black Hills managed for livestock grazing. Much of the privately-owned land in the Black Hills was located in valley bottoms and the northern mining district around Lead and Deadwood, with most of this land being developed for housing or mining. Private lands were not surveyed for goshawks.

Our surveys for goshawks consisted of 3 distinct phases. The first phase was to visit all previously recorded goshawk nesting territories and determine the proportion that were active in 2003. The second phase was to conduct systematic surveys for goshawks in suitable habitat, and the third phase was to monitor known active nesting territories.

In 2003, the USFS had records of 72 previously recorded goshawk nesting territories within the South Dakota portion of the Black Hills. Each of these nesting territories had UTM coordinates for one or more nests, and in April and May 2003, each of these nest territories was checked for goshawk presence. This involved driving to a nearby location and walking about 0.25-1.0 mile to the nest coordinates. Trees in the general area of the coordinates were then searched for stick nests. If a nest was found, the tree species, size of tree, and nest condition were noted, and an UTM coordinate for the nest tree was obtained with a GPS unit. Following this search effort, a recorded goshawk alarm call was played as a series of alternating calls and listening periods. The calling sequence took approximately 9-10 minutes. The calls were played from CD and minidisk players, and were amplified using a Radio Shack Powerhorn (electronic megaphone). The megaphone was rotated through several directions during the calling period to assure that calls were well projected in all directions. If a goshawk responded to the calls and a nest was found, information (tree species, approximate diameter, slope, elevation, and UTM coordinates (NAD 27)) was gathered on the nest tree and the surrounding area. Starting in May 2004, all locational data was recorded as Latitude/Longitude coordinates/NAD 83. In addition, South Dakota Game, Fish and Parks provided us with a map that depicted known goshawk nests found in the mid-1970s. Although many of these nest sites corresponded with the USFS supplied goshawk nesting territories, there were some unique sites and these were visited in 2004 and 2005. These sites were searched in an identical manner as described for USFS supplied nest sites. Some goshawk nesting territories visited in 2003 that appeared to be in good goshawk habitat, but found to be inactive, were surveyed again from 2004 - 2009.

The second phase of the study was to conduct systematic goshawk surveys. During each survey year, roads and trails were driven and walked within suitable goshawk habitat stopping at about 0.25-0.5 mile intervals along these roads and trails and broadcasting recorded goshawk alarm calls as described for the nesting territory survey. For each calling station, date, start time, and UTM or latitude/longitude (decimal degrees) were recorded with a GPS unit. All wildlife species responding to the calls were noted. These systematic surveys were conducted in May and June in 2003, May through July 2005 and 2006, May through early August in 2004 and 2007, and July in 2008 and 2009 .

During 2003, all active nests found during the April/May surveys were visited a second time during late June to determine the fate of the nesting attempts. At this time, a minimum number of young birds in the nests was determined, and it was assumed that these birds would likely fledge. During subsequent years, all nesting territories that were known to be previously active during this survey work were visited during mid to late May to determine which nests were active. Active nests were visited again in mid to late June to determine which active nests successfully produced chicks and to get a minimum count on the number of chicks in the nest. (Generally, chicks in a goshawk nest could be seen by standing on an elevated site in the nest vicinity and viewing the nest with binoculars. This method yields a minimum count since it is possible to overlook chicks when they are small and downy. As chicks approach fledging, they frequently stand in the nest making them much easier to count.) A third visit to active nests was made in early to mid July to determine the number of nests successfully fledging chicks and the number of chicks that fledged. Nest territories that were found to be inactive during the May visit, were visited again in June to verify the absence of goshawks. During these visits, the area around known nest sites (0.25 to 1.0 mile) was systematically surveyed to look for alternative nests. These surveys included both visual inspection of potential nesting habitat and broadcasting goshawk alarm calls. In some cases, a third visit was made to inactive territories in July, and a similar survey effort was made in the nest vicinity.

In September 2006, we attended a meeting with USFS personnel at the Black Hills National Forest main office in Custer, SD. In this meeting it was decided that the USFS would monitor nests in the Hell Canyon Ranger District (southern portion of the Black Hills) while we would continue to monitor the nests that we found in the Mystic and North Hills Ranger Districts. The nest territories affected by this decision were Carroll Creek, Sourdough Draw, Needles, and Camp Remington.

## **RESULTS AND DISCUSSION**

### **SUMMARY OF 2009 GOSHAWK NEST MONITORING**

In 2009, we visited 47 nests located in 24 territories and found goshawks or evidence of goshawks at 10 territories. Northern Hills Ranger District biologists visited 2 additional nesting territories (Beaver Gulch and Crow Creek) each with 1 year of recorded use since 2003, and both territories (and nests) were inactive. The Hell Canyon Ranger District provided information on 5

nesting territories (Camp Remington, Carroll Creek, Upper Needles, and Sourdough) that we had previously monitored and 2 of these were reported as active (Camp Remington and Carroll Creek).

### **OVERVIEW OF THE GOSHAWK NEST SURVEY EFFORT**

The systematic goshawk calling effort resulted in recorded calls being played at 227 sites in 2003, 290 sites in 2004, 348 sites in 2005, 201 sites in 2006, 215 sites in 2007, 42 sites in 2008, and 137 sites in 2009. In 2003, goshawks responded at 9 sites (4.0%) which led to the discovery of 8 active nests. In 2004, goshawks responded to calls at 6 sites and a goshawk was observed flying at a seventh site. At these 7 sites (2.4%) with goshawk observations, an active nest was found at only 1 site (Spring Creek). However, 2 stations with responses were probably associated with the Spring Creek and Reno Gulch nest sites, and 2 stations with responses were associated with an active nest territory on private land where we did not attempt to locate the nest. Also, 1 response came on 1 August when adults may not have been defending the actual nest site. In 2005, goshawks responded to calls at 13 sites (3.7%), and we found 3 new active nests as a result of this effort (Edelweiss Nest 3, Benner Gulch Nest 2, and Sourdough Nest 1). In 2005, all the goshawk responses came in the vicinity of known nesting territories. At 1 of the 13 calling stations with a goshawk response or observation, a goshawk was observed to fly but did not respond vocally. Also in 2005, we had 3 observations of goshawks flying across roads and perching in trees, but these birds failed to respond to recorded calls when given the opportunity. In 2006, goshawks responded to calls at 6 (3%) of the 201 calling stations. However, these 6 responses all came within known nesting territories (32 call stations were conducted in known nesting territories). This resulted in 3 new active nests being found (Edelweiss Nest 4, Reno Gulch Nest 2, August Nest 1). Two new additional nests were found in active territories by systematically walking through nesting territories. At the 169 calling stations conducted in areas without recently documented goshawk nesting in 2006, there were no responses. In 2007, goshawks responded to calls only at 1 site out of 215 calling stations. This response came on the June visit to the Elk Creek nest territory, which had been found inactive during the May visit. The goshawk called several times, and then flew to and remained in the vicinity of Nest 2, but no active nest was found. (In 2008, an active alternative nest was found in the vicinity of where the bird was initially calling in 2007. This is described in detail later in Appendix B of this report.) In 2008, we did not conduct systematic surveys outside of known goshawk nesting territories, because the initial survey of known territories in May found all but one of the known nests to be inactive, and our survey effort was focused on finding alternative nest sites in these territories. In July 2008, we had 42 calling stations within and adjacent to known goshawk nesting territories. This resulted in 2 responses (5%) and the discovery of 2 new active alternative nests (Elk Creek Nest 3 and Custer Peak Nest 2). In 2009, we conducted 122 calling stations within known nesting territories and had 4 responses (3%) and there were 15 calling stations outside of known nesting territories with no responses. The calling effort in 2009 allowed us to determine that Elk Creek and Wilson Draw nest territories were occupied and that the Custer Peak nest territory was occupied and successful at fledging 1 juvenile goshawk although we were not able to find the active nest.

Thirteen goshawk nests have been found by systematically walking through known goshawk nest

territories and looking for nests in trees. We generally walk with 2 to 3 people walking 50-100 feet apart, and use a GPS unit to map and maintain parallel routes following hillside contours. Seventeen nests have been found through broadcast calling of goshawks. This includes the discovery of 2 previously unrecorded goshawk nest territories. There have also been 8 nest territories found through logging operations and their associated activities. Overall, during the 7 survey years, playing recorded goshawk alarm calls resulted in detection of goshawks at 3.2% of 1,316 calling stations.

During the 7 survey years, we were involved with monitoring 30 nesting territories that had at least 1 nesting attempt. (Note: These were not all the known active goshawk nesting territories in the Black Hills. The USFS biologists were also monitoring other active nest territories.) Some territories like Carroll Creek, Edelweiss, and Elk Creek, were active most years, while other territories seemed to have lesser use. We found evidence of goshawks using these 30 territories on 90 occasions (territory year checks) out of a possible 158 occasions (57%)

During the 7 survey years we were able to monitor 53 nesting attempts and 35 (66%) of these successfully fledged young. This would be a maximum success rate since there were 18 instances where a territory had 1 or 2 adult goshawks near the nest, but they were not incubating eggs in the nests. Our initial nest checks in spring were timed to correspond with late incubation and nest failures occurring early in incubation would not be detected. Birds remaining in the nest area after a nest failure is not uncommon and these territories would have been recorded as occupied. We found that nest failure occurred throughout the nesting period. We documented nests to fail during incubation, when chicks were small and downy, and when chicks were larger and feathered. Causes of the nest failures were not determined. However, disturbance due to human activity in the nest vicinity (logging, power line removal, traffic) may have contributed to 3 nest failures. Predation (great-horned owls, (*Bubo virginianus*) or red-tailed hawks (*Buteo jamaicensis*)) was suspected in another 4 nest failures, but for the majority (11) of nest failures there was no obvious cause. The average number of young to successfully fledge from successful nests was 1.6., and the average number of young to fledge from all monitored nests was 1.1. Table 1. provides a summary of nest territory status by year for each of the nest territories that we monitored. Table 3 provides a summary of 7-years of goshawk nesting territories that we monitored.

Maps in Appendix A show the general location of the nest territories that we have monitored. Appendix B, Table 1 provides a summary of information on each goshawk nest found during the 7 survey years, and Appendix B, Table 2 lists the status of nests checked in May, June and July during 2009. Appendix B also contains a detailed account of nesting history, observations of goshawks, and observed impacts for each nesting territory found during the 7 survey years. This is a summarization of our field notes.

Table 1. Summary of status (Ia = inactive, A = Active, O = occupied) and number of chicks produced at goshawk nesting territories found from 2003 through 2009 in the Black Hills, South Dakota.

Territory	2003	2004	2005	2006	2007	2008	2009
August	-	-	-	2	2	Ab	I
Bear Town	Ia	-	Ia	Ia	Ia	Ia	Ab
Beaver Gulch	-	-	-	A	Ia	-	Ia
Benner Gulch	2	Ia	2	O	Ab	Ia	Ia
Bloody Gulch	Ia	-	-	-	-	1?	3
Boxelder Creek	2	3	Ab	O	1	O?	A
Buskala Creek	1	Ia	O	O	Ia	Ia	Ia
C. Remington	1	Ab	Ia	Ia	Ia	Ia	A
Carroll Creek	A**	A**	2	2	2	Ia	A
Clayton	-	-	-	A**	A	1	O
Crow Creek	Ia	A	Ia	Ia	Ia	Ia	Ia
Custer Peak	-	-	-	A	2	2	1
Edelweiss	1	A*	1	1	Ab	2****	1
Elk Creek	-	A	A**	Ab	A	1	O
Flynn Creek	-	-	Ab***	Ia	Ia	-	-
Gudat Creek	1	Ab	O	Ia	Ia	Ia	Ia
Horsethief	-	-	-	A	O	O	Ia
Jenny Gulch	-	-	-	-	A**	Ab	O
Lena Gulch	-	-	-	-	-	-	O
Keough	Ia	-	Ia	O	O?	Ia	Ia
Lyons Draw	Ab	A**	O	Ia	Ia	Ia	Ia
Needles	1	Ab	Ia	Ia	Ia	Ia	Ia
Patterson Creek	-	-	-	-	-	-	1
Reno Gulch	-	A	1	1	Ia	O?	Ia
Sourdough	Ia	-	2	Ab	2	A	Ia
Silver City	Ia	-	-	Ia	Ab	Ia	Ia
Spring Creek	A**	3	Ia	Ia	Ia	Ia	Ia
Tigerville	2	Ab	I	1	Ab	I	Ab
Victoria Dam	Ia	-	A	A	2	O?	Ia
Wilson Draw	Ia	-	-	Ia	Ab	Ia	O

\* based on sign at nest site

\*\* based on information from the USFS

\*\*\* based on information from CSP

\*\*\*\*1 of the 2 chicks removed for falconry

## **IMPACTS OF TIMBER HARVEST ON GOSHAWK NESTING TERRITORIES**

Timber harvest has played a significant role in nesting ecology among the goshawk nest territories that we have monitored during the past 7 years. We have documented logging impacts at 16 goshawk nesting territories. This is over half of the monitored nesting territories (N=30) receiving some type of logging impacts during a 7 year period. Three nest trees were cut in 2 territories, and nest stands were cut at 5 nesting territories. Adjacent stands were cut at 10 territories and logging roads were bulldozed next to 3 nest trees. Nest stands or adjacent stands were thinned at 5 nesting territories. In some cases, multiple impacts occurred to a nesting territory. For example, at Lyons Draw, one of the nest trees was cut, the nest stand was cut, and an adjacent stand was thinned.

During 2003, when we visited historic nest sites we found that disturbance by past logging was apparent at 9 of 28 (32%) nesting territories where we evaluated timber management. The level of logging disturbances documented at the monitored nest sites during the past 7 years certainly equals or exceeds what we found at these historic nest sites. There is no indication that timber management in relation to goshawk nesting ecology has changed in the past decade as compared to timber management from the 1970s through the 1990s. Both Bartelt (1977) and Erickson (1987) described goshawk nesting territories in the Black Hills being impacted by logging during the 1970s and 1980s. Bartelt (1977) reported on 1 nest that was abandoned about 30 days into incubation after logging trucks parked next to the nest tree. Examination of data sheets from the 1970s documenting goshawk nests in the Black Hills revealed that tree harvests were occurring in close proximity to active nests, and in one case the nest tree was left surrounded by harvested land. This is similar to what we have observed the past 7 years. Axelson (2009) reported similar impacts of logging on goshawks in northeastern Minnesota, and on the recent steps taken to mitigate logging impacts. These included protecting 50 acres around nest sites and only allowing selective logging within a 500 acre area around nest sites such that 60% of the habitat remained suitable for goshawk nesting (i.e. tall trees and partially closed canopy).

Crocker-Bedford (1990) studied goshawk nest re-occupancy rates in the Kaibab National Forest at logged and unlogged sites and reported that re-occupancy dropped by 80% at logged sites where small (3-6 acres) and large (40-494 acres) buffers were left around the nest tree. Moreover, nestling production dropped by 94% when compared to unlogged sites. Crocker-Bedford estimated that logging in the Kaibab National Forest from 1972-1988 resulted in a 50% decline in nesting pairs of goshawks. Logging opened the forests to other raptor species better adapted to early successional stages, and species such as red-tailed hawks, great-horned owls, and long-eared owls typically occupied former goshawk nests (Crocker-Bedford 1990). Greenwald et al. (2005) reviewed all goshawk radio telemetry studies that addressed habitat selection within home-ranges, as well as studies relating territory occupancy and productivity to habitat features. These studies encompassed a variety of forest types including coniferous, mixed coniferous, hardwood, boreal and temperate rain forests. Their conclusion was that goshawks selected for forest structure characterized by mature to old growth forests with large diameter trees and high canopy closure. Many other goshawk researches have also concluded that goshawks select for mature and old growth timber stands (see Daw et. al. 1998).

Similar results have been reported for goshawks in Europe. Research on goshawk breeding densities in southeastern Norway where much of the forest has been converted to farmland and urban areas, found regional goshawk breeding densities were positively correlated to the percentage of mature forest (Selas et al. 2008). These authors concluded that establishing buffer zones around nest sites would not be sufficient to maintain goshawk populations if the proportion of mature forests is reduced at a landscape level. When timber harvest altered more than 30% of stand structure, 88% of goshawks nesting in 2 study areas in France and Italy moved away from the original nest stand to the nearest mature stand (Penteriani and Faive 2001). These authors concluded that goshawks can tolerate some levels of timber harvesting within the nesting stand, as long as the cover reduction does not exceed the threshold of about 30%. In the Black Hills, timber harvests frequently reduce cover by more than 30%.

In our monitoring of goshawks in the Black Hills, it is difficult to determine the fate of goshawks following timber management impacts because goshawks are not marked nor do we have any means of tracking individuals. However, in the following discussion we attempt to disclose timber management impacts to goshawk nesting territories (summarized in Table 2), and summarize what we have observed with goshawks at these sites.

August: A large timber harvest came within 0.25 mile of Nest 1 in 2007. Nest 1 was successful that year, but Nest 2 was abandoned in 2008 and the territory was inactive in 2009.

Beaver Gulch: An adjacent stand was logged to within less than 0.1 mile of nest stand. Nest 1 and nest stand destroyed by wind event or snow loading. This cut also came to about 0.1 mile of Nest 2. Following these events, the nest territory was recorded as inactive in 2007 and 2009.

Benner Gulch: Nest 1 stand was thinned in 2005. In our opinion, the stand was rendered unsuitable for goshawks and we have not documented any use of the stand since 2003.

Benner Gulch: Nest 2 stand was harvested to within 0.17 mile of the nest in 2007. The 2007 nesting attempt was abandoned and there has been no documented nesting in this area since. Motor sport activity in this area is also a factor, but much of this activity is related to logging roads and areas cleared by logging.

Bloody Gulch: USFS logged a large area to within 0.25 mile of the nest in 2007, and also placed 2 large slash piles within 0.25 mile of the nest. The nest stand on private land was logged to within 100 yards of the active nest during early summer 2008. Remains of 1 feathered goshawk chick was found near the nest in July 2008. The nest was used again in 2009 and was successful.

Buskala Creek: Nest 1 was active and successful in 2003, but the territory has not been active since. Thinning of adjacent stands occurred in 2005. Trees were cut within 100 yards of Nest 2 and 0.1 mile of Nest 1. This thinning occurred within a large area logged 20-30 years ago.

Camp Remington: Bottomland stands along Iron Creek were thinned in 2003 and 2004 about 0.1 mile from Nests 1 and 2. Nest 2 was abandoned in 2004 and goshawks have not been

observed since. A new nest was found in 2009 along Iron Creek north of Nests 1 and 2.

Clayton: A large area was cut within 0.1 mile of Nest 1 possibly around 2006. The goshawks appeared to successfully nest 2006-2008, but the nesting attempt apparently failed in 2009.

Custer Peak: There was thinning of an adjacent stand to within 100 yards of Nest 1 between July 2007 and June 2008. The birds built a new nest and successfully fledged 2 chicks in 2008. In 2009, the goshawks built a new undocumented nest at least 0.25 mile west of Nests 1 and 2 and fledged at least 1 juvenile.

Edelweiss: While not a logging operation, a double pole power line was removed in 2007 and equipment and cut poles passed right below the Nest 3 tree which was active. This caused abandonment of the original nesting attempt and abandonment of a re-nesting attempt.

Elk Creek: Adjacent stands were harvested in 2005 and 2006 and a portion of the nest stand was cut in 2007. The 2006 nesting attempt ended with the remains of a feathered chick below the nest. The 2008 nesting effort was successful despite trees being cut within 20 yards of the Nest 3 tree. However, there appeared to be an abandoned nesting attempt at Nest 2 or 3 in 2009.

Flynn Creek: This nest stand at the Flynn Creek nest in Custer State Park was harvested in 2005 while goshawks had young in the nest. There was a main haul road and 2 large slash piles within 50 yards of the nest. The nest tree was left standing but the surrounding large trees were cut. This was extreme disturbance at a critical time, and the nest failed. The nest was not used when checked in 2006 and 2007.

Gudat Creek: A portion of the nest stand was cut in 2003 about 330 yards from Nest 1 prior to nesting. This nest successfully fledged a chick. This cut was less than 150 yards from Nests 2 and 3. Nest 1 was abandoned in 2004 and there have been no nesting attempts in this territory since. The nest stand was largely destroyed by logging in 2008 including the cutting of 2 nest trees (Nest 2 and 3). Additional cutting of trees in this area occurred in 2009.

Horse Thief: Nest 1 was active in 2006 and located next to a logging road that was used to access a thinning project during May (goshawk incubation period). The female was on the nest at least 42 days minimum, and probably more realistically she was on the nest around 60 days before abandoning the nest. Disturbance was the likely cause of this abandonment. The female was probably off the nest too long during incubation and the eggs got cold and died. Goshawks have been present in the territory in 2007 and 2008, but the 2 known nests have not been active. Additional thinning of the nest stand took place between the 2008 and 2009 visits. All trees less than 8 inches dbh were removed from the nest stand except in the area immediately surrounding the nests.

Lena Gulch: This nest was found in March 2009 apparently as a result of a logging operation in an adjacent drainage. The territory was occupied at this time, but was abandoned by 14 June 2009. The logging operation came within 0.1 mile of the nest.

Lyons Draw: This territory was active in 2003 and 2004. The Nest 1 tree and stand were harvested after the 2004 nesting season. This territory was occupied in 2005, but there was no nesting attempt at Nest 2, and the territory has been inactive 2006-2009. Additional timber harvest occurred on a remaining strip of the nest stand prior to the 2009 site visit.

Needles/ Norbeck: Nest 1 was active in 2003 and fledged a chick. Following the nesting season, the nest stand was cut to within 150 yards of Nest 1. This cutting unit was large (1 square mile or more) and surrounded Nest 1 on all sides and included several adjacent stands. Roads were dozed through the nest stand at 14 yards and 100 yards from Nest 1. This nest was abandoned early in the 2004 nesting effort, and great-horned owls used the nest in 2007. The nest was inactive in 2006, 2008 and 2009.

Reno Gulch: The Nest 1 stand was cut in 2004 and 4 of the cut trees were within 20 yards of the nest when the goshawks had a chick in the nest. After the fledging period, a road was dozed right next to the nest. In 2005, this nest was again active and fledged 1 young goshawk. In 2006, the goshawks moved 0.3 mile and built a new nest. This nest successfully fledged 1 of 2 chicks. These 2 nests were inactive in 2007 - 2009, but a great-horned owl used Nest 1 in 2009.

Sourdough Draw: This nest stand was about 200 yards from the terminal edge of the Jasper Fire. The Bear Mountain Road ran between the Sourdough nests and the burned area. Trees along the edge of the burn became severely infested with bark beetles and in 2006 all trees west of the Bear Mountain Road were cut and slash piles burned before nesting. Fire from the burning slash crossed the road and burned a small portion of the nest stand. This reduced the buffer between the nests and the burn by about half. At the same time, less than 600 yards away on private and USFS lands, there was an extensive logging project. The Nest 1 tree had died from bark beetles in 2006 and the goshawks constructed a new nest in the same stand. Nest 2 failed in 2006. However, goshawks returned to Nest 1 in 2007 and fledged 2 chicks. The territory was active again in 2008, but was inactive in 2009. Firewood cutters took about a dozen old growth pine trees at the historic nest site in 2005.

Spring Creek: A portion of the nest stand was cut in 2003 when Nest 2 was active. The cut came within 30 to 50 yards of the nest. The fate of the nest in 2003 was not known. In 2004, the goshawks built a new nest (Nest 1) about 200 yards away from the cutting unit, and successfully fledged 3 chicks. These nests have been inactive since 2005.

Tollgate: Although this is probably a broad-wing hawk nesting territory, it is considered a historic goshawk territory. This area was extensively logged 20-30 years ago rendering the site unsuitable for goshawks. The area was slowly returning to larger diameter trees when in late 2008/early 2009 this entire area was subjected to a second harvest leaving the nesting area as an isolated patch of regenerating ponderosa pine forest. This second harvest extends along the ridge for a mile or more both north and south of the nest stand.

Wabash Spring: This was not a nest that we normally monitored, but in 2007 we visited the nest site and found that this nest fledged 1 chick. However, adjacent stands within 100-200 yards of

the nest tree had just been recently cut. This nest was in an area with extensive older harvest units. In 2008 and 2009, this territory was reported by the USFS as inactive.

Although the response of goshawks to timber harvest in the nest vicinity has been variable, it appears that when nest stands are cut, goshawks ultimately abandon their nesting territory 1 or 2 years post cut. In addition, disturbances during nesting (especially during incubation) can cause nest failure (Flynn Creek 2005, Horse Thief in 2006 and Edelweiss in 2007 are good examples of disturbances). Potentially, goshawks can move around within their territories and construct new nests, but this assumes that there are stands of ponderosa pine with sufficient density of larger diameter trees that cover a suitably large area to meet their nesting requirements. Certain abiotic characteristics of the stand must be met as well. This includes a source of flowing water close to the nest stand, and tree stands on land with slopes generally less than 20%. Hargis et al. (1994) stated that water features up to 2 miles from the nest can be used by goshawks, but that nests were significantly closer to water than random points and that location of water influences configuration of the home range. Iverson et al. (1996) reported that 70% of their radio relocations of goshawks were on gentle slopes. Hargis et al. (1994) also recommended that mature forests be retained around water sources.

Current FS regulations call for protecting 180 acres around goshawk nests. These 180 acres are based on stand configurations drawn on aerial photos, but apparently there is no minimum distance from a nest to a harvested stand. Consequently tree harvests have come very close to goshawk nests, and in a few cases nest trees have been cut. The problem with this approach is that the USFS can and does incrementally remove mature and old growth forests around a goshawk nest stand which can and does force the abandonment of the nesting territory because habitat conditions in the area are no longer suitable for successful nesting (see examples above). Forest Service guidelines allow for 7 years of non-use of a goshawk nest territory before it is considered abandoned. After this time, the nest stand can be harvested. Based on this scenario, the USFS is slowly managing itself out of suitable goshawk habitat. Compounding the timber harvest problems are mountain pine beetle infestations, exceptional snowfall events during spring incubation, competition with red-tailed hawks and great-horned owls, catastrophic wildfires, and disturbances due to human activities like off-road motor sports. Certainly, there are more goshawks in the Black Hills than what we have documented, but we have monitored a sufficient number of nesting territories that our survey effort is reflective of what is happening to goshawks in the Black Hills. That is: high nest failure rate, and a low number of young fledged per nesting attempt. Both are indicators of a stressed population.

Our survey effort has not addressed other big issues with goshawk ecology such as: What is the total population in the Black Hills; What are the population dynamics of this population? Is this an isolated population or does it receive immigrants from other populations?, and Can birds displaced by logging successfully establish a nesting territory elsewhere? Answers to all of these questions require a much greater level of research. However, without answers to these important questions, it is impossible to know if the management guidelines are sufficient to maintain a robust goshawk population in the Black Hills. Based on our monitoring effort, it appears that when timber harvest occurs within a 0.25 mile of the a nests, the site is ultimately abandoned. It

is recommend that all timber stands within 0.25 mile radius of a nest trees be protected from harvest until there is sufficient information available on goshawk population trends in the Black Hills to know if current management guidelines are adequate. This moratorium on logging within a 0.25 mile radius of goshawk nests should be extended to all historic nests and not just recently active nests, since these historic sites probably include unique abiotic features such as flowing water, gentle topography, and shelter from prevailing winds. A 0.25 mile buffer around goshawk nests represent about 125 acres of protected land. This is 55 acres less than what USFS guidelines currently propose to protect. From a quarter mile to half mile from a nest, timber harvest could be permitted, but it must be designed to facilitate goshawk hunting activities and develop future old growth stands. There is certainly a need to gather more information on goshawk nesting ecology in the Black Hills as it relates to timber management.

Table 2. Summary of logging activity that has occurred within a quarter mile of active goshawk nests monitored from 2003 to 2009.

Territory	Nature of logging activity
August	adjacent stand cut to within 0.25 mile of the nest
Beaver Gulch	adjacent stand cut within 0.1 mile of nest, nest stand collapses
Benner Gulch	nest stand thinned, adjacent stand cut to within 0.17 mile of the nest
Bloody Gulch	adjacent stand cut less than 100 yards away on private land, FS land cut within 0.25 mile of the nest
Buskala	adjacent stands thinned less than 100 - 200 yards away
Custer Peak	adjacent stand thinned less than 100 yards away
Elk Creek	adjacent stands cut, portion of nest stand cut to within 20 yards of nest tree
Flynn Creek	nest stand cut, slash piles and haul road within 50 yards of nest tree, CSP
Gudat	2 nest trees cut, nest stand cut
Horse Thief	nest stand and adjacent stand thinned, logging traffic under nest tree
Lena Gulch	Adjacent stand cut within 0.1 mile of the nest
Lyons Draw	1 nest tree cut, nest stand cut, adjacent stand less than 100 yards thinned
Needles/Norbeck	adjacent stands cut within 150 yards of nest, roads dozed at 14 & 100 yards of nest tree
Patterson Creek	Nest stand severely thinned.
Reno Gulch	nest stand cut, road dozed next to nest tree
Sourdough	adjacent stand cut less than 150 yards of nest tree, slash piles burned fire spreads to nest stand, firewood cutting in nest stand
Spring Creek	adjacent stand cut less than 50 yards of nest tree
Tigerville	nest stand subjected to firewood harvest
Wabash Spring	adjacent stand cut within 100-200 yards of nest tree

## **SUMMARY OF GOSHAWK PRODUCTIVITY**

During the 7 survey years, we have been able to monitor the fates of 53 nesting attempts (Tables 1 and 3). Only 35 (66%) monitored nesting attempts have led to fledged young or young likely to fledge. These 35 successful nests produced 56 chicks or 1.6 chicks per successful nesting attempt. For all monitored nesting attempts, there have been only 1.1 chicks produced per nesting attempt. This would actually be a best case scenario since some of the territories listed as occupied (that is adults were in the nest area when the nest territory was checked during late incubation, but they were not on the nest) probably represented failed nesting attempts. We had 19 cases where a territory was recorded as occupied but an active nest was not found (Table 1). Since our survey effort documented nesting during late incubation we cannot account for nest failures during early incubation. The number of young produced for all nesting attempts, number of young fledged for successful nests, and nest success in the Black Hills appear to be low when compared to goshawk monitoring efforts in other areas (Table 4). The goshawk productivity averages for data from the 16 other studies shown in Table 4 (this spans a wide range of areas, time and climates, and contains a large sample size) is 1.9 young fledged for all nests, 2.2 young fledged for successful nests, and 83% nest success. These data suggest that the number of goshawks fledged from all active nests and from successful nest in the Black Hills is about 40% lower than an average for goshawks in other regions of western North America, and the percent of nests successful at fledging young in the Black Hills is about 20% lower than for other areas. The population of goshawks studied by Ingraldi (1999) over a 5 year period had slightly greater productivity than what we have recorded for the Black Hills, and he estimated lambda at 0.84 (lambda less than 1 is a declining population, lambda of 1 is a stable population, and lambda greater than 1 is an increasing population). This would be a declining population, and population viability analysis suggested mean time to extinction would be 29 years if it were a closed population. He suggested that the goshawk population that he studied was a biological sink within a larger population of unknown stability. A similar situation may exist in the Black Hills where productivity is low and the population is maintained through immigration.

Table 3. Summary of goshawk nesting efforts by year for the Black Hills National Forest from 2003-2009.

	2003	2004	2005	2006	2007	2008	2009	Total
Tot. act. nests monitored	9	6	7	7	11	7	6	53
Successful nests	8	2	5	5	6	5	4	35
Chicks fledged	11	6	8	7	11	7	6	56
Territories monitored	19	14	19	25	26	26	28	157
Territories active	11	12	12	15	16	12	12	90

During the 7 survey years, we have documented 30 nesting territories where goshawks have been found during at least 1 year (we have actually checked on many other historic territories, but have not found evidence of goshawks). Thus, there is some reasonable expectation that the territory contained during all or part of the monitoring effort, some habitat suitable for nesting goshawks. For these territories, our survey effort has resulted in 157 territory years of monitoring effort, and

there have been 90 (57%) territory years where we have documented at least some use of the territory by goshawks.

Table 4. Summary of goshawk productivity in various North American regions as compared to goshawk productivity in the Black Hills, South Dakota.

Region	No. Nests	Young Fledged/ Nest Attempt	Young Fledged/ Successful Nest	% Nests Successful	Source
Alaska	21	1.8	2.3	78	McGowan 1975
Yukon	19	1.9	2.5	73	Doyle and Smith 1994
California	127	1.7		91	Bloom et al. 1986
California	84	1.9		87	Woodbridge and Detrich 1994
New York	36	1.4		80	Speiser 1992
Arizona	83	1.9	2.2	87	Reynolds et al. 1994
Arizona	22	2.4	2.6	84	Boal and Mannan 1994
Arizona	273	1.6	1.9	82	Reynolds and Joy 2005
Arizona		1.3	1.9	70	Ingraldi 1999
Nevada	36	2.2			Younk and Bechard 1994
Nevada	212	2.3	2.6	91	Fairhurst and Bechard 2005
Oregon	50	1.4			DeStefano et al. 1994
Oregon	12	1.2	1.4	83	Bull and Hohmann 1994
Oregon	48	1.7		90	Reynolds and Wight 1978
Idaho	46		2.1	80	Hanauska-Brown 2003
Montana	18	2.6	2.9	88	Clough 2000
South Dakota	53	1.1	1.6	66	this study

**TREE SIZE AND DENSITY MEASUREMENTS FOR GOSHAWK NEST TERRITORIES**

In late July and early August 2007, we measured tree density, dbh and basal area at 6 nest trees after goshawk chicks had fledged. Similar measurements were recorded at 15 additional goshawk nest trees in July 2008 (Table 5). The measurements were taken within a 60-foot radius of the nest tree. This is approximately a quarter acre area (0.26 acre). Standing dead trees were measured but were noted as dead, and tree species was also noted. Only trees 4-inch dbh and larger were measured. The following is a summary of these measurements.

At the 21 nest sites examined, the nest tree dbh was considerably larger than the average dbh for the nest stand. Nest trees averaged 16.5 inches dbh while the average dbh for the nest stands was 10.2 inches. Goshawk nest trees were usually the largest tree in the nest stand or close to being the largest. Others have reported similar results (Bent 1937, Reynolds et al. 1982, Speiser and Bosakowski 1989). Tree density averaged 266.3 trees per acre, and ranged from a low of 84.6 trees per acre to a high of 600 trees per acre. Thirteen of the 21 nest stands examined had more

than 200 trees per acre. The Wilson Draw Nest Territory had the lowest tree density and had been subjected to a previous timber harvest perhaps 15-20 years ago where about half of the large diameter trees were cut. Basal area ranged from 86.6 sq. ft. per acre to 174.7 sq. ft. per acre, and averaged 128.0 sq. feet per acre. Again, Wilson Draw stands out as the lowest basal area for goshawk nest sites. The dominate tree at all but one nest site (Elk Creek - discussed below) was ponderosa pine. Most nest sites had dead trees in the stand, but at Victoria Dam Nests 2 and 3, almost a third of the trees were dead, and at Tigerville Nest 1 a quarter of the trees were dead. Bark beetle infestations were the probable cause for the dead trees.

Table 5. Summary of nest tree dbh (inches), average stand dbh (inches), number of trees per acre, basal area (square feet per acre), percentage of trees in nest stand that were ponderosa pine, and the percentage of standing trees that were dead within a 60-foot radius of the nest tree for 21 goshawk nest sites.

Nest Territory	Nest Tree dbh	Ave. dbh	Trees/ac	Basal area	% PIPO	% dead
August	16.8	8.7	380.7	157.5	100	1
Boxelder Creek 2	12.4	9.9	326.9	174.7	99	5
Clayton 1	16.6	9.7	315.4	161.6	100	10
Custer Peak 1	17.3	11.0	253.8	167.7	100	14
Edelweiss 1	18.3	11.8	153.8	117.3	100	0
Edelweiss 2	14.2	11.9	134.6	104.4	100	0
Edelweiss 3	17.6	10.7	219.2	135.7	100	4
Edelweiss 4	21.4	10.7	184.6	115.2	100	8
Edelweiss 5	22.8	12.9	138.5	126.4	100	0
Edelweiss 6	15.0	9.0	280.8	122.7	100	1
Elk Creek 2	17.5	8.5	257.6	101.5	9	13
Horse Thief 1	16.2	12.9	115.4	105.4	100	0
Reno Gulch 1	14.2	11.3	168.8	119.3	100	0
Reno Gulch 1	14.2	11.2	153.8	105.4	100	0
Reno Gulch 2	10.1	8.8	353.8	150.8	99	3
Spring Creek 1	14.6	7.6	323.1	102.1	92	14
Tigerville 1	13.3	8.3	423.1	157.6	100	25
Tigerville 3	16.5	7.2	600.0	169.0	100	10
Vitoria Dam 2	19.4	9.6	261.5	132.7	87	31
Vitoria Dam 3	14.7	9.1	350.0	156.9	97	31
Wilson Draw	22.0	13.7	84.6	86.6	100	0
Average	16.5	10.2	266.3	128.0	94	9

The Wilson Draw nest site (inactive in 2003, lost its chick in 2007, was used by great-horned owls in 2008, and was occupied in 2009) stands out as being considerably different from the other nest

stands. This site was logged possibly 15-20 years ago, and all measured trees were unharvested trees and not regeneration (the level of pine regeneration at this site was low and all new trees were less than 4 inch dbh). It was apparent that the logging reduced the number of trees per acre, the basal area, but it increased the average dbh of the nest stand. The density of trees (84.6 per acre) and basal area (86.7 sq. ft. per acre) at this site should be considered as minimums that goshawks can nest in the Black Hills. It should also be noted that the 85 trees per acre remaining post harvest at this nest site was well above the 6-12 trees per acre remaining in a typical seed tree cut.

When our Black Hills nest stand data are compared to nest stand data in various North American regions (Tables 5 and 6), they fit well into the range reported for basal area, average nest stand dbh, trees/acre and nest tree dbh (Table 6). This is in contrast to the productivity data which is clearly below the reported goshawk productivity. Based on data contained in Table 6 and results of our nest stand analysis in the Black Hills, good goshawk habitat appears to be sites with basal area at least 100-200 sq. ft. per acre, average nest stand dbh of at least 10 inches with some trees available in the stand with 16-inch dbh or greater, and a tree density of at least 200 trees per acre. It is clear that nest stands subjected to seed-tree and shelterwood cuts where tree density drops below 10 trees per acre and basal area falls below 50 square feet per acre, are not suitable for goshawks and probably will remain unsuitable for several decades. Reentry into these stands to remove seed trees such as at the Tollgate Nest Territory will guarantee that the stands will never be suitable goshawk habitat.

Logging occurred at the Reno Gulch Nest 1 in 2004. A 12-foot wide road was bulldozed right next to the nest tree and timber harvest occurred to the north of the road that nearly bisected the 60-foot radius circle where we measured stand characteristics. In the harvested portion of our 60-foot diameter sample area, 4 trees were cut. Based on stumps, these trees averaged 12.5 inches in diameter and represented a loss of at least 13.8 sq. ft. per acre of basal area. Table 5 shows nest stand characteristics both before and after harvest. However, this does not represent the actual harvest level because only about a quarter of the sample area was harvested and trees removed by the bulldozer during road construction could not be counted. In addition, our visual impression was that a greater percentage of the trees were removed in the remainder of the cut than close to the nest tree. This may have been due to the defensive behavior of the goshawks. Reno Gulch Nest 1 was successfully used in 2005 following the cut, but it has not been used by goshawks since then. Both the Clayton and Boxelder Creek nesting stands had trees thinned quite a few years ago (possibly 20 years - blue paint was faintly visible on standing trees at the Clayton site). At the Clayton nest site, possibly up to 100 trees per acre were cut and dropped. Both these sites still had high tree densities (326.9 and 315.4 trees per acre) despite the thinning.

The Elk Creek nest site was unusual in that the Nest 1 tree died from bark beetles as well as most of the surrounding pine trees. This forced the goshawks to move to a spruce dominated stand in the drainage bottom below the Nest 1 stand. Twenty-eight percent of the new nest stand was comprised by white spruce and 63 percent of the stand was birch and aspen. This was completely different from all other known active goshawk nest stands that we have encountered during the 7 survey years. The goshawks only used this stand for 2 years and then moved to an adjacent pine

dominated stand that was subsequently impacted by logging.

Table 6. Northern goshawk nest stand characteristics from various North American regions as compared to nest stand characteristics in the Black Hills, South Dakota.

Area	No. Stands	Basal Area (sq.ft.)	Ave. Stand DBH (in.)	Trees/ac	Nest Tree DBH (in)	Source
Arizona	10	174	10.7			Spencer 1995
California	12		10.7	303	29.2	Saunders 1982
California	12	392	22.8	113	35.8	Hall 1984
Idaho	26	124	12.2		16.9	Patla 1997
MT-ID	17	177		459	19.6	Hayward and Escano
New Mexico	11		8.7	388	22.5	Kennedy 1988
New York	12	109			18.1	Allen 1978
NY-NJ	16	140	10.6	182	12.7	Basakoski et al. 1992
Oregon	7		10.8	195	32.4	Reynolds et al. 1982
Oregon	34	226	8.7	407		Moore and Henny 1983
Utah	25		9.3		13.2	Hennessy 1978
Utah	10		10.8	291	16.9	Fischer 1986
Wyoming	39	221			12.4	Squires and Ruggiero 1996
BC	8	155	8.9	284	14.0	Basakowski and Rithaler 1997
Alberta	17		7.8		12.0	Schaffer 1998
Montana	18	186		310	14.8	Clough 2000
South Dakota	14	173	10.1		17.0	Erickson 1987
South Dakota	21	128	10.2	266	16.5	this study

### **GREAT-HORNED OWL USE OF GOSHAWK NESTS**

Great-horned owls have the potential to significantly influence goshawk nesting ecology by pirating nests and by preying upon juvenile and fledged goshawks. Great-horned owl predation on goshawks has been noted by other researchers (Boal and Mannan 1994, Woodbridge and Detrich 1984, Rohner and Doyle 1992). Boal and Mannan (1994) identified great-horned owl predation as the principal cause of nestling mortality (46%) and the likely factor in unidentified causes of death (36%). Great-horned owls have nested in goshawk nests 8 times during the 7 survey years. Nests used by owls were Crow Creek Nest 1 in 2003, Edelweiss Nest 2 in 2007 and 2009, Needles Nest 1 in 2007, Gudat Creek Nest 1 in 2007, Reno Gulch Nest 1 in 2009, Victoria

Dam Nest 2 in 2009 and Wilson Draw in 2008. In 2007 and 2009, the Edelweiss goshawks nested in Nest 3 about a quarter mile west of Nest 2. Failure of Edelweiss Nest 3 in 2007 was probably due to disturbance from power line deconstruction rather than great-horned owls. With the exception of Edelweiss Nest 2, all these nests were in stands that were adjacent to logged areas. However, Edelweiss Nest 2 was adjacent to a major county road and a subdivision which represented openings in the forest. Most of our observations of great-horned owls in the Black Hills during the 7 survey years have been in logged areas. Logging probably benefits great horned owls by creating open foraging habitat, and by increasing prey density.

Remains of goshawk chicks have been found below nest trees at Tigerville Nest 1 in 2004, Elk Creek Nest 2 in 2006, Silver City Nest 1 in 2007 and Bloody Gulch in 2008 (Patti Lynch USFS biologist, pers. comm.). Patti Lynch (USFS biologist, pers. comm.) also reported finding remains of a goshawk chick more than a 100 yards from Victoria Dam Nest 2 in 2006. Most likely these are avian predation events and great-horned owls are a likely predator. We also have had many other nests that have failed where we have not found remains of chicks, but the nest failure certainly could have been due to a predation event. There is also Reno Gulch Nest 2 in 2006 that contained 2 chicks on 24 June and 2 days later there was only 1 chick in the nest with no trace of the other chick in the nest vicinity. Other avian predators that might take goshawk chicks include the red-tailed hawk and turkey vulture. We have seen 2 encounters of goshawks with turkey vultures (Reno Gulch and Carroll Creek), and in both instances, the goshawks behaved very aggressively towards the turkey vultures. At Carroll Creek, a turkey vulture made 2 close (2-3 yards) passes at the goshawk nest with chicks. Although turkey vultures normally feed on carrion, there are records of turkey vultures taking live young from other bird species nests.

#### **UNIQUE WEATHER EVENTS WITH POTENTIAL TO IMPACT GOSHAWK NESTING**

Two major spring snowstorms have occurred during the 7 survey years. From 19-22 April 2006, a spring snowstorm produced 60-72 inches of snow in the Lead area of the northern Black Hills. A Snotel station on North Rapid Creek (N44° 12', W 103° 47'), at 6,130 feet elevation recorded 3.2 inches of water equivalence precipitation. The other major spring snowstorm occurred from 30 April to 3 May 2008. Lead recorded 54.5 inches of snow fall and 4.64 water equivalence precipitation. Deadwood received 29.9 inches of snowfall. The North Rapid Creek Snotel recorded 2.8 inches of water equivalence precipitation. The 2006 snowstorm may have occurred just prior to initiation of goshawk nesting, but the 2008 storm probably occurred right at the start of goshawk incubation. In 2008, nests appeared to be abandoned at August, Boxelder, Reno Gulch, and Victoria Dam. The 2008 Clayton nest, which was about 1 month behind a normal nesting sequence, was probably a re-nest attempt which appeared to be successful. Horse Thief 2006, Edelweiss 2007, and Boxelder 2009 (described in detail in Appendix B) were probably re-nesting attempts too. The Edelweiss and Horse Thief re-nesting attempts failed, and the Boxelder birds were still incubating eggs on 17 July 2009 at the end of our survey effort. Goshawk re-nesting in response to catastrophic nest failure is possible, but it appears that it has minor population consequences. Others have reported reduced goshawk productivity in relation to cold wet spring weather (Bloxtton 2002, Fairhurst and Bechard 2005 ).

## SUMMARY AND CONCLUSIONS

This is the first long-term study of goshawks in the Black Hills. We have gathered information on goshawk nesting ecology for 7 years and enough data have been gathered to conclude that goshawk nest site selection is consistent with what is reported in the literature, but goshawk productivity is well below other reports in the literature. Based on this low productivity, it is likely that the Black Hills goshawk population is decreasing or if it is stable, it is maintained through immigration. The low productivity recorded in this study appears to be related to a variety of factors including but not limited to forest management, off-road motor sports, great-horned owl predation, competition with red-tailed hawks, catastrophic weather events, and mountain pine beetle.

Based on 7 years of monitoring goshawk nests in the Black Hills, it appears that:

- 1) Goshawks generally select for larger ponderosa pine trees for nest placement. The average diameter of goshawk nest trees was 16.8 inches and ranged from 9 inches to 24 inches dbh.
- 2) The preferred nest tree is ponderosa pine. Only 1 of 65 goshawk nest trees was not in a ponderosa pine. The single exception was a nest in a white spruce with a broken top.
- 3) Goshawks nested in mature and old growth ponderosa pine stands. Tree density in these stands averaged 266 trees per acre, basal area averaged 128 square feet per acre, and average dbh was 10.2 inches.
- 4) All of the historic nests (except Wilson Draw) we have examined that were subjected to timber harvest have been abandoned. It may take many years for tree density, average dbh, and basal area to increase sufficiently to provide suitable goshawk habitat. The fate of goshawks displaced by loss of nesting habitat due to timber harvest is unknown. Relocating displaced goshawks has proved to be difficult due to their cryptic nesting habits and unreliable survey techniques.
- 5) Nesting goshawks subjected to disturbances have shown variable response from nest abandonment (Flynn Creek - logging, Horse Thief - recreation/vehicle traffic, Edelweiss - power line deconstruction, Tigerville firewood cutting) to successful nesting (Reno Gulch - logging, Tigerville - National Guard Camp). Surprisingly, a high percentage of goshawk nests seem to be subjected to some disturbance during the nesting season.
- 6) In cases where goshawk nest trees were killed by bark beetles (Elk Creek, Sourdough, and Horse Thief - latter case is presumed), goshawks have moved to a nearby site and constructed a new nest. (Note that all 3 new nests failed in 2006.)
- 7) Thirty-five of 53 (66 %) nesting attempts monitored over the 7 surveys years successfully fledged chicks. Nests were abandoned both during incubation or early brooding of chicks, and also after chicks become feathered. Although exact causes of abandonment were not determined, predation and disturbances may have be the likely causes in some cases.

8) The average number of chicks fledged per all nesting attempts was 1.1 chicks per nest, and the average number of chicks fledged per successful nest was 1.6 chicks per nest. Nest success and fledging rate for Black Hills goshawks is well below the range and average reported throughout North America.

9) Goshawks in the Black Hills appear to have courtship in April, lay eggs in late April or early May, hatch eggs in late May or early June, and fledge chicks in July. However, in some years this sequence may be delayed by 1 or 2 weeks. Goshawks may re-nest if a nest fails early in incubation, but this appears to be an infrequent event with minor population consequences.

10) A major spring snowstorm from 30 April to 3 May 2008 appeared to cause considerable nest abandonment. A significant loss of reproductive effort in 2008 may have population consequences in future years. A similar spring snowstorm from 19 to 22 April 2006 did not appear to cause a high rate of nest abandonment possibly because the storm largely occurred before most goshawks initiated incubation.

11) Broadcast alarm calls may or may not result in a response from nesting goshawks. Although the response rate to broadcast alarm calls over the 7 survey years has only been around 3%, it is much higher in known active nest territories and has been useful at locating new alternative nests. The response rate to broadcast alarm calls in suitable habitat without documentation of recent goshawk nesting has been very low, but it has resulted in discovery of new nesting territories. Through a combination of intensive ground searches and broadcast alarm calls, we have been successful at finding alternative nests in goshawk nesting territories. However, the survey techniques employed in this study are so inefficient that negative survey results should never be considered as evidence that goshawks are not in an area.

12) Goshawks generally have more than 1 nest in a territory (average 2.3 nests, maximum 6 nests - so far), and frequently alternate nests from 1 year to the next. Alternative nests have been 50 yards to 0.7 miles apart. Finding the alternative nests within nesting territories has been a challenge.

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