

Two Decades of Research and Monitoring of the Northern Spotted Owl on Private Timberlands in the Redwood Region: What do We Know and What Challenges Remain?

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Abstract

Surveys for northern spotted owls on Green Diamond Resource Company's (formerly Simpson Timber Company) ownership in coastal northern California were initiated in 1989. The following year, a long-term demography study was initiated that has continued to the present time. A Habitat Conservation Plan was developed for the species in 1992 and numerous habitat studies followed. The extensive dataset generated was used to estimate the trend in owl numbers, develop resource selection functions for nighttime activity and nesting habitat, and analyze the factors influencing spotted owl survival, fecundity and habitat fitness (i.e., ability of the habitat to support a stable population of owls). Important conclusions generated to date include that habitat heterogeneity (i.e., juxtaposition of young and older stands) is critical to both survival and fecundity, as is precipitation during the early nesting season. A landscape projection of current and future habitat indicated an abundance of high quality habitat that has the potential to support an increasing population of owls. Demographic analysis found the owl population was stable from 1990 to 2001, but has declined in recent years. The decline coincided with an apparent increase in barred owls. Growing evidence including barred owl removal experiments indicate that the invasion of barred owls into northern California is responsible for the decline. Preliminary results of the recently initiated removal experiment suggest that control of barred owls is feasible, and that spotted owls respond rapidly and favorably where barred owls are removed.

Key words: northern spotted owl, habitat fitness, habitat conservation plan, demography, barred owl removal experiment

Introduction

There has been extensive research on northern spotted owl (*Strix occidentalis caurina*) habitat requirements over the years. The majority of these studies have been conducted in landscapes with significant amounts of mature or old forests, which are the principal habitats for this species in most areas where it has been studied (Courtney et al. 2004). However, almost nothing was known about the northern spotted owl on private managed timberlands until the Northern Spotted Owl Status Review Supplement was published on April 21, 1989 by the US Fish and Wildlife Service (FWS). This review concluded that listing the northern spotted owl as a threatened species throughout its entire range was warranted, which we observed to have unleashed a flurry of spotted owl surveys on private lands in northern California. Included in this survey effort was the initiation of spotted owl surveys

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across Green Diamond Resource Company's (formerly Simpson Timber Company) in north coastal California.

Contrary to expectations, we found large numbers of spotted owl on Green Diamond's (GDRC) ownership, which put the company on a collision course with the federal Endangered Species Act (ESA) when the owl was listed in 1990. In response, GDRC launched a long-term research and monitoring program on spotted owls that still continues today, they developed and got approved the first Habitat Conservation Plan (HCP) for spotted owls in 1992 and are in the process of developing a new HCP for spotted owls along with coverage for fishers (*Martes pennanti*) and tree voles (*Arborimus longicaudus* and *A. pomo*). Here we report the major findings of 2 decades of research and monitoring on spotted owls and describe the new challenges that threaten the long-term viability of this iconic species of the Pacific Northwest.

Methods

Each year, we attempted to locate all individual territorial spotted owls within the entire study area. Surveys were initiated each year beginning 1 March using protocols initially adapted from Forsman (1983) and further modified to support GDRC's approved spotted owl HCP. Owls were initially located primarily at night using vocal imitations or recordings of their calls. Daytime surveys were used primarily to locate roosts and determine the status of owls at sites where they had been previously located or where nighttime responses had been heard. Once an owl was located, it was typically offered live mice to determine its identity (if previously captured and marked), paired and reproductive status (Forsman 1983). Most nests were initially located by following the male back to the nest where the male would commonly attempt to deliver the mouse to the female. Once a nest was located, it was revisited one or more times after the typical period for fledging (late May through early June) to determine the status of the nesting attempt.

Most owls were captured with a snare pole and marked with a unique numbered FWS band attached to one tarsus and a plastic color band attached to the other tarsus. For the radio telemetry study, we fitted owls with tail-mounted radio transmitters (Holohil, model RI2C 6 g) equipped with either a 1- or 2-year battery (total mass = 5.5 or 7.5 g, respectively). We attached radio transmitters to the proximal portion of the rachis of the two central rectrices using small zip-ties and epoxy (#332 Titan Corp., Lynnwood, WA). The time that transmitters remained attached to individual birds ranged from 1 to 15 months (mean ≥ 7 months) until the rectrices were molted. Owls fitted with radio transmitters were tracked with a two-element, hand-held directional H-antenna (Telonics model RA-14) and portable receiver (Telonics model TR-4). We radio tracked owls during all seasons, from April 1998 through September 2000. Triangulations were attempted on two to four birds per night from roadside locations throughout the study area, with subsequent visual sightings if possible. When located, a bird was followed for 4 to 8 hours or until lost. Locations were recorded when the bird changed roosting sites, or every 30 minutes, whichever came first.

Results

Distribution

The first surveys of northern spotted owls on GDRC's ownership in 1989 did not cover the entire ownership, but it did demonstrate that spotted owls occurred throughout the majority of the ownership and their population density was unusually high in some regions. Surveys of all the main contiguous blocks of GDRC's ownership occurred every year since 1989 and the pattern that emerged indicated that spotted owls were located throughout the ownership, but there were substantial differences in the density of owl sites. In general, owl densities were highest in regions with a mixture of mature second growth and young regenerating stands, and few owls were found in homogeneous stands of second growth. There was also a pattern of high density of owl sites distributed lower on the slopes along rivers and major creeks. A study based on surveys from 1990 to 1997 indicated that two regions (Korbel and Mad River) produced the highest estimates of crude densities for northern spotted owls, but there have been few statistically rigorous attempts to estimate population density throughout its range (Diller and Thome 1999).

Habitat

GDRC's original 1992 HCP was developed when there had been little spotted owl research in the coastal redwood region and only 3 years of site-specific owl surveys and research in the study area. As a result, only simplistic definitions of habitat existed and suitable habitat for spotted owls was defined as forest stands >30 years old, because at least some stands in this age class were known to be used by spotted owls for foraging, roosting, and nesting (Folliard 1993). At the time, it was assumed that recently regenerated stands (0 to 5 years) had no direct value to owls. Stands 6 to 30 years were known to be woodrat habitat (Hamm 1995) and therefore potential spotted owl foraging habitat. Foraging, roosting, and occasional nesting occurred in stands 31 to 45 years old, and forest stands >45 years old were considered to be prime nesting and roosting habitat as well as foraging habitat.

To describe and quantify the unique site-specific habitat used by spotted owls on a managed forest in the redwood region, GDRC used the extensive research and monitoring to develop a more sophisticated and spatially explicit definition of spotted owl habitat. Determining what habitat spotted owls used during their period of nocturnal activity was the first step. To gather data on what habitat spotted owls used at night, we conducted a radio telemetry study from 1998 to 2000 that included 28 total owls that were followed all or a portion of that time. The resulting data was used to construct 95 percent kernel distributions based on what owls used versus a random selection of available points within the same area. These data were used to develop a resource selection function (RSF) for spotted owl nighttime activity. The top model indicated that owls tended to be found low on the slope in areas composed of approximately 70 percent age class 41+ years with a high percentage of hardwood. Furthermore, selection was highest if the nearest stand to the owl's location was either 6 to 20 or 21 to 40 years, and lower if the nearest stand was either 0 to 5 or 41+ years. In other words, when active at night, spotted owls on GDRC's ownership were most likely to be found in older more complex forest stands that were in close proximity to younger stands that have high densities of woodrats (Diller et al. 2010).

To further refine spotted owl habitat, we conducted an analysis of the habitat selected for nesting by spotted owls on GDRC's timberlands. Based on the locations of 182 successful nests (fledged at least one young) from 1990 to 2003, we estimated a RSF to characterize the habitat of an 'average' successfully nesting spotted owl. The top model for managed timberlands indicated that the relative probability of

locating a successful nest increased with age of the stand and ‘edge density’ within a 600 m radius of the nest. ‘Edge density’ was calculated as m of edge (line between any two age classes) per ha, or in other words, the amount of stand age heterogeneity. In addition, selection was greatest in stands with approximately 55 percent basal area of residual older trees, 30 percent hardwood basal area and a large amount of good nighttime activity habitat within a 400 m radius of the nest. This indicated that for nesting, spotted owls were selecting older more complex stands that were in fairly close proximity to areas that had a high potential as foraging habitat (Diller et al. 2010).

Habitat fitness

‘Fitness’ (i.e., ability to survive and reproduce) has traditionally been considered an individual attribute, but the quality of the habitat occupied by a particular individual also influences its fitness. Therefore, the quality of the habitat relative to its impact on the fitness of individuals occupying that habitat can be defined as ‘habitat fitness’ (Franklin et al. 2000). Combining the influence of habitat on both survival and reproduction provides the ultimate measure of habitat quality such that areas with high habitat fitness are capable of supporting a stable or increasing ‘source’ populations while areas of low habitat fitness are associated with habitat ‘sinks.’ GDRC’s long term demographic study along with geographically referenced and relatively detailed forest stand information on all parts of its ownership made it possible for us to directly relate habitat characteristics with survival and fecundity to estimate site-specific habitat quality (i.e., habitat fitness) for spotted owls.

To estimate the impact of habitat on survival, we utilized capture-resight data from 1990 to 2003 and we used nesting information from the same time period to analyze the impact of habitat on fecundity. We included both habitat and non-habitat covariates such as regional precipitation and mean air temperature in the analyses along with some covariates related to the 1992 spotted owl HCP conservation program. The HCP allowed harvesting of a limited amount of occupied owl habitat (i.e., ‘take’ of the owl site), which provided a unique opportunity to assess the direct impacts of timber harvesting on spotted owls. We also analyzed the effect of 39 no-harvest set-asides totaling 10,331 ac that were designated as part of the spotted owl conservation strategy in the HCP.

Increased days of precipitation during the early nesting entered with a negative coefficient the top survival and fecundity models. In contrast, increased temperatures during early nesting entered the top survival model with a positive coefficient. Positive effects on survival were also associated with increased nest site selection values (i.e., areas good for nesting conferred higher survival probabilities). Four habitat covariates were associated with higher fecundity, but collectively they were representative of areas having higher habitat heterogeneity. Harvesting or take of an owl site did not enter the survival model, but it did have a negative effect on fecundity. The effect of set-asides was complex with the highest survival and fecundity associated with areas near ($< \frac{1}{2}$ mile) but not inside set-asides (Diller et al. 2010).

From the average survival and fecundity at a specific location, the largest Eigenvalue of the Leslie projection matrix was computed and defined to be the habitat fitness of the site. Relative to other categorical variables, habitat fitness was most sensitive to the location of the nest site/activity center relative to a set-aside.

Habitat fitness values were highest in the ½ mile buffer surrounding a set-aside with all other covariates being realistically equal. While considerably lower relative to the magnitude of the effect, take (i.e., harvesting an owl site) was the second most important categorical variable relative to habitat fitness. Relative to continuous variables, habitat fitness was most sensitive to changes in precipitation during the early nesting period such that increases in the total number of days of measurable precipitation within the early nesting period caused habitat fitness to decline. The second most important continuous variable was edge density, where increases in this variable resulted in higher values of habitat fitness. Relative to latent variables (i.e., variables generated from other models), habitat fitness was most sensitive to changes in survival followed by changes in fecundity and nesting habitat (Diller et al. 2010).

Using anticipated harvest plans in the next 10 years and projected harvests derived through a newly developed harvest schedule model, we were able to project spatially explicit stand conditions into the future. Assuming important non-habitat variables (e.g., weather and barred owls) remain at the median values from the past, we were able to project spatially explicit estimates of habitat fitness on GDRC's study area at 10 year intervals from 2010 to 2060. The changes in habitat fitness across GDRC's ownership were dynamic at the sub-basin level with specific areas waxing and waning in their relative habitat value for owls. However, the overall proportion of the ownership in the highest category of habitat fitness (i.e., habitat capable of supporting an increasing population of spotted owls) increased from 35 percent in 2010 to 64 percent of the ownership in 2060. In 2060, a total of 87 percent of GDRC's ownership is projected to be in the two highest categories of habitat fitness, which is projected to be capable of supporting a stable or increasing populations of spotted owls if other non-habitat variables (e.g., weather and barred owls) remain within acceptable limits (Diller et al. 2010).

Based on a sensitivity analysis of habitat fitness, the habitat variables that most likely contributed to this trend were edge density and the proportion of older stands (41 to 60 years) adjacent to younger stands (6 to 20 and 21 to 40 years). Implementation of GDRC's aquatic HCP that was approved in 2007 will create a future landscape in which an estimated 20 to 25 percent of the landscape will be in older stands associated with protected riparian or geologic reserves. Along with smaller clearcut openings mandated by the California Forest Practice Rules, the net affect will be much greater overall open edge density and a higher overall level of habitat heterogeneity, which appears to be highly beneficial to spotted owls in GDRC's ownership. In summary, current models based on site-specific habitat data indicate a strong positive trend in habitat quality for spotted owls on GDRC's ownership.

Population trend

Mark-recapture studies were initiated throughout GDRC's ownership in 1990 to estimate key demographic parameters and trends in the population. Along with other range-wide demographic studies of northern spotted owls, GDRC participated in three previous meta-analyses in 1998, 2004 and 2009. Results from the most recent meta-analysis that analyzed GDRC data from 1990 to 2008 indicated that mean apparent annual survival probabilities of adult spotted owls on GDRC land were 0.851 and 0.853 for males and females, respectively, while estimated mean annual fecundity for adult spotted owls on GDRC land was 0.305. The estimated rate of spotted owl population change ("lambda RJS") on GDRC land was 0.972, which is

similar to but slightly lower than the two nearby Willow Creek and Hoopa study areas. The trend in estimates of the realized population change indicated that the population of spotted owls on the GDRC study area was apparently stable or increasing until 2001 after which the population began an apparent downward trend. The barred owl covariate entered the top model for both survival and fecundity, which suggested that barred owls were the most likely cause for the recent decline of spotted owls on GDRC's study area (Forsman et al. in press).

Potentially, this downward trend was reversed with a 26.6 percent increase in the number of occupied owl sites on GDRC's density study area in 2009 followed by a 3.0 percent increase in 2010. Factors that may have contributed to this increase included modifications (i.e., using high quality digital callers and including a greater variety of recorded calls) of the survey protocol in 2009 to increase spotted owl detection rates, which resulted in locating banded resident spotted owls in historical sites that had appeared to have been abandoned in recent years. In addition, the lower Mad River Tract has large areas of third growth that apparently were just now reaching suitable habitat attributes for colonization by spotted owls. GDRC also initiated a barred owl removal experiment in 2009, which involved removing all barred owls from treatment areas (i.e., approximately half of the total study area). Barred owls were removed from historical spotted owl sites, which allowed these sites to be re-colonized by spotted owls and these treatment areas could be colonized by spotted owls free from interference from this expanding competing species (see preliminary barred owl results below). Therefore, the recent improved trend probably was a combination of improving survey techniques, increasing amounts of suitable habitat, and freeing approximately half of the study area from barred owls.

Response of spotted owls to experimental removal of barred owls: preliminary results

In 2006, Green Diamond assisted the California Academy of Sciences (CAS) in obtaining a small collection of barred owls in California. These initial collections provided an opportunity to do preliminary "removal case studies" that would document the response of individual spotted owls to the removal of barred owls. Seven barred owls were collected from four different historical spotted owl sites during May and June 2006 on GDRC's ownership in Humboldt County. Although based on just four "case studies", these results suggested that spotted owls were quick to re-colonize their former territories following removal of barred owls.

As part of the implementation of the recovery plan, a Barred Owl Work Group (BOWG) was formed to consider implementation of a suite of barred owl removal studies (USFWS 2008). The BOWG provided full support for a study on GDRC's ownership that was designed to be complementary to other removal experiments that were being proposed for public lands in Washington, Oregon and California. Still working under CAS scientific collecting permits that allowed removal of 20 additional barred owls, a preliminary barred owl removal experiment was initiated on a portion of GDRC's spotted owl demographic study area in 2009. The study was designed to determine the impact of barred owls on site occupancy, survival and fecundity of spotted owls using paired treatment and control areas where barred owls were removed in treatment areas, while they were allowed to increase 'naturally' in control areas. The additional collections in 2009 also allowed for added removal case studies of the response of individual spotted owls to the removal of barred owls from sites that were previously known to be occupied by spotted owls.

The results of our early barred owl removal work were encouraging, but the sample sizes were still too small and the time interval too short making conclusions preliminary. In response, we were granted the authorization from the FWS and California Department of Fish and Game to fully implement a barred owl removal study within the GDRC spotted owl demography study area in 2010. The authorization allowed for a total of 70 barred owls to be taken over 3 years with a maximum of 30 individuals in any year. To account for geographic variation in habitat and both spotted and barred owl population densities, GDRC's demographic study area was subdivided into three treatment (Salmon Creek, Korb/Mad River/Little River and Wilson/Hunter/Terwer Tracks) and three control areas (Ryan Creek, Redwood Creek and Bald Hill/County Line Tracts).

One of the valuable findings from these initial removal efforts was that using a lethal method (i.e., adult territorial individuals were attracted to within 20 to 30 m using recorded calls and shot with a 20 gauge shotgun), barred owls could be collected humanely, efficiently and with relatively little effort and cost. For example, in late winter early spring of 2009, one field person made a total of 16 visits to six territories with a mean of 1 hour 23 minutes per visit (not including vehicle travel time) to collect 100 percent of the known (11) territorial barred owls in the Korb/Mad River treatment area. This equated to approximately 2 field hours per barred owl removed, which has been repeated in 2010 and 2011. By far, the biggest cost associated with the barred owl removal study is the initial surveys of the study area, but this is also needed for the spotted owl monitoring program so the barred owl removal study adds little additional cost above GDRC's existing commitments.

To date, nine historical spotted owl sites meet the criteria for a removal case study (i.e., barred owls removed from a historical spotted owl nest site or activity center). All of the sites have been re-occupied by spotted owls with the time for re-occupation ranging from a minimum of 13 days to a maximum of 1 year. Four of the sites were re-occupied by the original resident spotted owls, including one female that had not been seen for 7 years, and the remaining sites were re-occupied by new or unknown individuals. The spotted owls were again displaced at three sites by re-occupation of barred owls: one the following year, one after 3 years and one after 4 years.

The barred owl removal experiment has been too limited in time and scope to assess the impact on spotted owl fecundity and survival rates, but we have been able to assess preliminary changes in spotted owl occupancy rates for a portion of the study area. All the known barred owls (16) were removed from the Korb/Mad River area in 2009, and in 2010, all of the barred owls (eight individuals) that recolonized this area were removed. The control area (i.e., no barred owl removal) immediately adjacent to the Korb/Mad River treatment area occurred in the Redwood Creek watershed. Although there has not been enough time to fully investigate differences in occupancy rates between these two regions, we did a preliminary cursory analysis of the trend in the number of occupied spotted owl sites for the Korb/Mad River treatment versus immediately adjacent Redwood Creek control area. The year 1998 was selected as a reference point, which was the year prior to when barred owl numbers began to rapidly expand in our study area. *Figure 1* below shows the recent trend in occupied spotted owl sites between the control and treatment area.

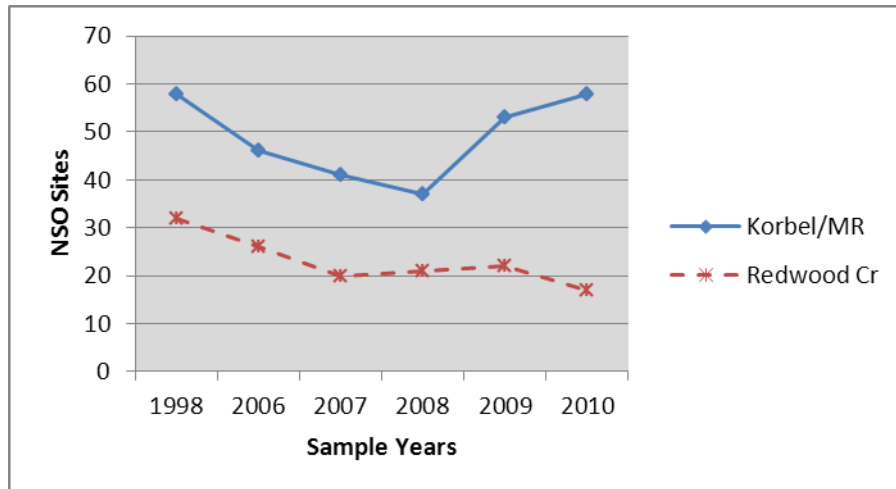


Figure 1—Trend in occupied Northern Spotted Owl (NSO) sites on two adjacent tracts of land on Green Diamond Resource Company's ownership in coastal northern California. Barred owls were removed from "Korbel/MR" in 2009 and 2010, but no barred owls were removed from "Redwood Creek."

The apparent dramatic 43 percent increase in the number of occupied spotted owl sites in the Korbel/Mad River area from 2008 to 2009 was not due exclusively to historical spotted owl sites being "freed" of barred owls, because the number of newly occupied sites (16) greatly exceeded the number of sites (6) from which barred owls were removed. It probably was a combination of removing barred owls from historical spotted owl sites, improving survey techniques and increasing amounts of suitable habitat that led to the increase in occupied spotted owl sites in the treatment area. However, the lack of a similar increase in the Redwood Creek tract suggested that removal of barred owls in the Korbel/Mad River area may have had a synergistic effect on all of these factors. Specifically, creating an area free of barred owls may have increased the probability that resident spotted owls that previously were silent would now be more inclined to respond to surveys and it would make colonization of the area more likely when floater spotted owls were not being rebuffed by resident barred owls. The negative impact of barred owls in some stretches along Redwood Creek that historically had high densities of nesting spotted owls is quite dramatic. The spotted owls appear to have been almost totally replaced by barred owls, although some spotted owls because of their high adult survival are likely to still persist in these areas. However, every attempt to survey for them results in an aggressive response from a barred owl, which precludes any further attempts to locate spotted owls.

When this study is complete, we will also be able to estimate impacts of barred owls on apparent survival and fecundity of spotted owls. Currently, we lack even preliminary estimates on these demographic parameters, but there is little doubt that if the trend in occupancy between treatment and control areas continues, there also will be dramatic differences in apparent survival and fecundity.

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