Response of Wildlife and Aquatic Resources to Even-Aged Management in Coastal Northern California

Lowell Diller, Ph.D., TWS Certified Wildlife Biologist

To achieve compliance with the FSC-US national standard, even-aged silviculture may not be employed unless certain conditions are met. Specifically, as described in Indicator 6.3.g.1.b, even-aged silviculture may be employed where: 1) native species require openings for regeneration or vigorous young-stand development, or 2) it restores the native species composition, or 3) it is needed to restore structural diversity in a landscape lacking openings while maintaining connectivity of older intact forests. To clarify "Part 3" of the indicator, the following draft guidance language was developed:

> *Where assessments (see below) indicate the historical existence of a distribution of openings within all or a portion of the assessment area and a current landscape lacking representative openings, managers can use even-aged silviculture to re-create openings in those areas. The resulting distribution of openings should be guided by considerations of historical natural disturbance regimes and maintenance of functional wildlife habitat for native species or maintenance of ecosystems of conservation concern, including HCVF. The intent is largely, but not exclusively, about restoration of habitat diversity to historical conditions.*
>
> *Conformance with Part 3 of the Indicator should include:*
>
> 1. *Assessments of natural disturbance regimes and associated distribution of openings at the watershed or planning unit level. Generally, the spatial scale of assessments should be within 10,000 – 20,000 acres.*
>
> 2. *Justification for the scale and configuration of the assessments. This should include consideration of the purpose of restoration and goals of restoring habitat heterogeneity (e.g. the suite of target species that benefit from habitat openings). Departures from the 10,000 – 20,000 acre size range are justified by ecological conditions or historic events.*
>
> 3. *A review of the assessment by independent qualified experts (e.g. wildlife biologists or landscape ecologists who are not biased because of past or present affiliations with the land owner/manager or other interested stakeholders) to confirm the findings. The adequacy of the assessment should be based upon the quality of input into the assessment, and may include expert opinion and literature.*

From an ecological prospective, Indicator 6.3.g.1.b Part 3 indicates that the prohibition of even-aged silviculture was established at least in part, because of the potential for even-aged silviculture to not mimic the pattern, form or frequency of historical disturbance regimes and thereby reduce the native species composition. Potentially this could occur

because even-aged silviculture may create more, larger or less structurally diverse openings relative to historical openings. This would create a forested landscape lacking continuity, structural diversity and eliminate connectivity of older intact forests.

The following discussion addresses how Green Diamond Resource Company, California Operations has maintained native biodiversity, and how its primarily an even-aged management system compares to historical disturbance regimes. However, before launching into this discussion, it is essential to establish the extent to which Green Diamond has investigated and monitored the various terrestrial and aquatic resources that occur within its ownership.

Green Diamond has been engaged in numerous research and monitoring projects on their timberlands in coastal northern California for over two decades. The northern spotted owl (*Strix occidentalis caurina*) was the focus of the first studies initiated in 1990 on Green Diamond's (originally Simpson Timber Company) ownership. Intensive studies on spotted owls has continued with annual property-wide surveys, mark-recapture demography studies, two master's theses on habitat associations and a telemetry study to quantify nighttime activity. Since 2007, this work has been expanded to monitor the expansion of the barred owl (*Strix varia*) and its the interactions with spotted owl. Collectively, this work has resulted in the single largest mark-recapture dataset on spotted owls in existence (>1,800 captures and >4,000 capture/recapture events) and the data has been included in nine peer-reviewed scientific papers and reports.

Following the spotted owl, the terrestrial species most intensively studied on Green Diamond's ownership has been the dusky-footed woodrat (*Neotoma fuscipes*) with two master's theses on abundance and habitat associations, a study on their population response to commercial thinning versus clearcutting and property-wide population monitoring since 2004. Similar levels of work have been directed on the fisher (*Martes pennanti*) with two master's theses (habitat associations and population density) and four property-wide surveys. Other terrestrial wildlife species with extensive studies include the marbled murrelet (*Brachyramphus marmoratus*), black bear (*Ursus americanus*) red and Sonoma tree voles (*Arborimus longicaudus* and *A. pomo*) and Del Norte salamander (*Plethodon elongates*). Finally, species with less extensive monitoring include bald and golden eagles

Research and monitoring also has been conducted on aquatic systems since 1993. The initial focus was on coho and Chinook salmon (*Oncorhynchus kisutch* and *O. tshawytscha*), steelhead (*O. mykiss*), cutthroat trout (*O. clarki*) with annual monitoring of juvenile populations in key watersheds throughout the ownership. Monitoring of outmigrant smolt populations was added on selected streams in 1999. Among herptiles, the southern torrent salamander (*Rhyacotriton variegatus*) and coastal tailed frog (*Ascaphus truei*) were also extensively and intensively studied and monitored since 1993. Other herptiles less extensively monitored were the western pond turtle (*Clemmys marmorata*), northern red-legged frog (*Rana aurora aurora*) and foothill yellow-legged frog (Rana boylii). Green Diamond has also conducted extensive assessment and

monitoring of aquatic habitat and water quality on key fish bearing streams since 1993. In addition, since 2001, Green Diamond has done complete floristic surveys as part of all timber harvest plans. There has also been extensive forestry related research on Green Diamond's ownership, but that work is covered in a separate discussion.

In addition to all the studies directly supported by Green Diamond or conducted "in-house" with the company's large biological staff, the company has engaged in over 15 cooperative studies with various academic and federal scientists. Examples of these cooperative studies of terrestrial wildlife species include the following:

- Marten (*Martes americana*) distribution and habitat associations (USDA Forest Service, Pacific SW Research Station and Department of Wildlife, Oregon State University)
- Mountain lion (*Puma concolor*) habitat and movements (Department of Wildlife, Humboldt State University, Department of Wildlife, University of Idaho)
- Use of residual structure by forest bats (USDA Forest Service, Pacific SW Research Station)
- Passerine abundance and composition in forest stands (Department of Wildlife, Humboldt State University)
- Olive-sided flycatcher (*Contopus cooperi*) habitat associations (Department of Wildlife, Humboldt State University)
- Varied thrush (*Ixoreus* naevius) nesting ecology (Department of Wildlife, Humboldt State University)
- Water economy in two species of plethodontid salamanders (Department of Wildlife, Humboldt State University)

Incidental to other designed surveys and as part of timber harvest assessments, Green Diamond's biological and trained forestry staff have also collected property-wide data for the past 20+ years on the distribution and relative abundance of a variety of species. Data were collected for wildlife species such as the peregrine falcon (*Falco peregrinus*), bald eagle (*Haliaeetus leucocephalus*), golden eagle (*Aquila chrysaetos*), osprey (*Pandion haliaetus*), northern goshawk (*Accipiter gentilis*), Cooper's hawk (*Accipiter cooperii*), sharp-shinned hawk (*Accipiter striatus*), flammulated owl (*Otus flammeolus*), Vaux's swift (*Chaetura vauxi*), great blue heron (*Ardea herodias*) rookeries and a variety of amphibian and reptile species. In summary, we believe this property is unprecedented in terms of the number and extent of the studies and monitoring on a large industrial ownership. In addition to the conservation plans described below, the studies and monitoring have lead to over 30 scientific publications and master's theses. Possibly only a few experimental forests such as the 16,000 acre H. J. Andrews Experiment Forest in the Oregon Cascades have been more intensively studied.

Collectively, most of the studies and monitoring have either been used for the development of, or as part of long term monitoring for multiple conservation plans. The first plan was a habitat conservation plan (HCP) for northern spotted owls developed with the US Fish and Wildlife Service and implemented in 1992. This was followed in 2005 with a Deadwood Management Plan that was developed in cooperation with California Department of Fish and Game. In 2007, a second HCP covering six listed or sensitive aquatic species with dual jurisdictions was developed with and approved by the US Fish and Wildlife Service and National Marine Fisheries Service. The floristic surveys led to a Sensitive Plant Conservation Plan in 2005 that was developed in cooperation with California Department of Fish and Game, and in 2009, the department also approved an incidental take permit for the Trinity bristle snail that includes special conservation measures and monitoring. Finally, a new forest HCP (FHCP) is near completion with an anticipated signing in 2013. The FHCP will include updated conservation measures for the spotted owl including management of the barred owl threat and it will also cover the fisher and two species of tree voles.

All of these studies along with published scientific reports have allowed us to characterize species into the following basic tiers on Green Diamond's ownership:

1. *Compatible with or dependent on even-aged timber management:*
   Species in this category include those that select early seral stages or require openings, and therefore readily utilize stands regenerated from even-aged management. This group also includes species that select mid successional (pole to mature stands) forests, but they are compatible with even-aged management because they have the ability to readily recolonize managed forests (e.g., Cooper's and sharp-shinned hawks and many Passerine birds)

2. *Generally believed to be incompatible with even-aged timber management, but able to be sustained with special harvest prescriptions or mitigation:*
   Species in this group include those that either because of special habitat requirements or limited ability to recolonize areas have the potential to be reduced or completely eliminated from a managed landscape.

3. *Incompatible with timber management with no known mitigation possible:*
   This group currently only includes the marbled murrelet which is only known to persist in unmanaged old growth forests.

Species that belong in the first category require no special attention during timber harvest planning and may actually be more abundant in an even-aged management system. For example, bird species such as the olive-sided flycatcher and purple martin require openings for their perches or roosts and benefit by the openings created by even-aged management. Passerine birds benefitting from even-aged management is not an anomaly, a graduate study on Green Diamond's ownership documented that landbirds had the greatest diversity and abundance in stands <20 years relative to mature second growth

and old growth stands in Redwood National Park (Hazard and George 1999). This result was consistent with a regional study that showed bird abundance and richness increased with increased levels of disturbance in highly productive west-side systems in the Pacific Northwest (McWethy et al. 2009). However, McWethy et al. (2009) showed the reverse pattern relative to disturbance and bird abundance and richness in less productive east-side systems, which illustrate the need to evaluate disturbance on a site-specific basis.

We do not have site-specific data on overall small mammal response to even-aged management, but there have been several studies done on the dusky-footed woodrats, the primary prey for the northern spotted owl and fisher in this region. This important prey species was found to be most abundant in young stands <20yrs (Hamm 1995 and Hughes 2005), which relates to the significance of habitat heterogeneity as described in more detail below.

It is the second category of species for which Green Diamond's management must be most critically assessed relative to the FSC even-aged management indicator noted above. Probably the most telling assessment of Green Diamond's success relative to this group is simply the distribution and abundance of these species that are generally not associated with managed forests. Despite the fact that the landscape consists mostly of second and third growth forests, the summation of the extensive studies and monitoring have demonstrated a high diversity and abundance of wildlife and fish that occur on Green Diamond's ownership in California. Possibly the most noteworthy are spotted owls and fishers because these are species that are generally thought to be associated with old growth or late seral forests (USFWS 1990; Courtney et al. 2004; Powell and Zielinski, 1994; Carroll et al., 1999; Zielinski et al., 2004). The estimated density of spotted owls is the highest reported in the scientific literature (Diller and Thome 1999) and fisher densities were estimated to be equivalent to the highest reported in North America (Thompson 2008). Tree voles also are generally believed to be associated with mature and old growth forests (Meiselman and Doyle 1996; Dunk and Hawley 2009), but their unique adaptations and life history characteristics have thwarted attempts to characterize their population dynamics. We have documented that tree voles can be locally abundant (Thompson and Diller 2002) and analysis of spotted owl food habits indicated that tree voles were well distributed, but highly variable across Green Diamond's ownership (unpublished report).

In addition to the well-known mature and old growth associated wildlife species described above, there are lesser known amphibian species purported to be associated with late seral and old growth coniferous forests in the Pacific Northwest. The Del Norte salamander, a terrestrial species associated with rocky substrates and two headwater amphibian species, the southern torrent salamander and coastal tailed frog, have all been described as being primarily associated with mature and old growth forests (Carey, 1989; Welsh, 1990; Welsh and Lind, 1991; Bury and Corn 1988; Corn and Bury 1989). All of these amphibian species have been shown to be well distributed and abundant on Green Diamond's ownership (Diller and Wallace 1994; Diller and Wallace 1996; and Diller and

Wallace 1999). All of the salmonid species that occur in the region (i.e., coho and Chinook salmon, steelhead and cutthroat trout) are also thought to be sensitive to even-aged timber harvest and most abundant in streams in undisturbed mature and old growth forests. The numerous fish surveys on Green Diamond's ownership revealed that all the historical salmonid streams continue to support populations of these fishes and several of the streams have runs of the federally and state listed coho salmon that are equivalent to some of the best runs anywhere in California (Green Diamond, Aquatic Habitat Conservation Plan 2011 Biennial Report).

This abundance of wildlife and fish raises the obvious question of why this would occur on Green Diamond's ownership when so many other studies have demonstrated that these same species are rare or absent from managed forests and in particular those that are managed using even-aged silviculture. To answer this apparent contradiction, we need to examine what these purported late seral or old growth associated species require that is typically missing or in limited supply in forests managed using even-aged silviculture. A key conclusion from our own studies along with numerous studies on other landscapes indicates the importance of late seral habitat elements for the terrestrial species such as spotted owls and fishers. These late seral elements include large diameter snags and green wildlife trees with cavities and other types of decadence. These same green wildlife trees and snags eventually are recruited as downed logs and coarse woody debris, which are also important to some late seral wildlife species. In addition to late seral habitat elements, structural complexity in terms of the stand layers (i.e., shrub, intermediate canopy and overstory canopy) and the diversity of tree species is important. In particular, conifer stands with a mix of hardwood species tend to be important to selected species of wildlife.

With repeated rotations using even-aged management, it seems likely that the late seral habitat elements and stand diversity would be lost or severely reduced. The fact that this has generally not occurred on Green Diamond's ownership is partly due to the logging history and partly due to current conservation planning efforts. One key factor that led to the initial retention of older habitat elements on Green Diamond's land was the change of merchantability standards over the years. When the original harvesting of the old growth stands occurred, numerous individual trees exhibited undesirable defects such as large fire scares, extensive rot indicators and overall decadency. At the time of original harvest, these trees had little or no economic value and therefore were left on the landscape. In addition, individual or groups of old growth trees were left on the landscape due to the feasibility or cost of extraction using older harvesting equipment. Finally, many large old growth trees were left on the landscape simply because they were too dangerous or difficult to fall. These and other factors led to the retention of individual "legacy trees" across the landscape, which numerous studies have shown to provide critical structure for many species of wildlife. Having demonstrated the value of this legacy or residual structure, Green Diamond has developed multiple conservation plans that target this structure for retention. This started with the spotted owl HCP in 1992 and was followed by the development of the Terrestrial Deadwood Management Plan in 1999. This plan for

retention and recruitment of late seral habitat elements (large green wildlife trees and snags) has been revised to better conserve habitat elements for fishers and tree voles and will be included as a conservation element of the FHCP. The approval of the aquatic HCP (AHCP) in 2007 was particularly important, because it will result in preserving approximately 25% of the ownership in riparian and geologic reserves that will develop into late seral stands.

The fact that Green Diamond's managed stands are not simplified "monocultures", but tend to contain a diversity of conifer and hardwood species is mostly an attribute of the tree species richness that occurs in this area. In particular, there are a variety of evergreen hardwood species such as tanoak, (*Lithocarpus densiflorus*), California bay (*Umbellularia californica*), and Pacific madrone (*Arbutus menziesii*) that exhibit coppice growth making them virtually impossible to eliminate from conifer stands. The result is that stands developing from even-aged silviculture tend to show high structural and species diversity in a manner similar to the attributes of late seral forests. The managed stands on Green Diamond's ownership simply do not show the typical monoculture look of many plantations associated with even-aged silviculture in other regions in the Northwest. Finally, the mild climate, abundant rain and rich soils in coastal California lead to very high primary productivity and stands that are only 30-40 years old can already show attributes of a mature forest stand.

In addition to the important structural characteristics of forest stands on Green Diamond's ownership, there is an important species, the dusky-footed woodrat, which could be termed a "keystone species" because it has a large impact on the abundance of important late seral species in the region. As noted before, the dusky-footed woodrat tends to be associated with early seral shrub and pole-staged stands and they can reach high densities (i.e., represent a high amount of total biomass) in these stands (Sakai and Noon 1993, Hamm 1995, and Hughes 2005). To sustain a mosaic of early seral stands within a forest environment, it is necessary to create openings through some form of stand-replacing disturbance. Historically, this was produced by natural disturbance events, primarily fire, which has been replaced largely by even-aged management.

As noted earlier, the northern spotted owl and fisher have adapted to take advantage of this abundant prey species. The northern spotted owl was listed in 1990 primarily due to loss of old growth habitat on which it was assumed to depend (USFWS 1990). Throughout much of its range in Washington and Oregon, the owl roosts and nests in older forests and feeds primarily on flying squirrels that are also found most abundantly in older forests (Courtney et al. 2004). In areas where spotted owls feed primarily on flying squirrels, suitable habitat requires relatively large tracts of old forests. However, as noted above, the highest reported densities of northern spotted owls occurred in what was described as "highly fragmented" forests on Green Diamond's ownership in coastal California (Diller and Thome 1999). Similar high owl densities were reported in forests with a history of even-aged management to the east in the Hoopa Reservation (Higley, pers. comm.) and Willow Creek Study Area (Franklin et al. 1990). Initially, this appeared

to be a contradiction with the studies previously done in Oregon and Washington, but it was soon discovered that the dusky-footed woodrat was responsible for this apparent contradiction.

Understanding the difference in the primary prey of the northern spotted owl provided a logical explanation for why forest landscapes with frequent openings leading to apparent forest fragmentation might be unsuitable for spotted owls in one region and beneficial in another. The spotted owl still roosts and nests in older forests in coastal California, but its primary prey is found in young forests. Long-term demographic studies of spotted owls using mark-recapture data have shown that a mosaic of young and older forests (termed "habitat heterogeneity") is critical to maintaining spotted owls in this portion of their range (Franklin et al. 2000; Diller et al. 2010; M. Higley, pers. comm.). Given that fire has largely been eliminated from managed forests in the redwood region, creating openings through even-aged management is a critical element of maintaining habitat for spotted owls.

Although it is now well established that habitat heterogeneity is beneficial where the northern spotted owl's range overlaps the range of the dusky-footed woodrat (Klamath Province in southern Oregon southward along the California coast), there has been little work on the effects of selection harvesting versus even age management in this region. However, Green Diamond acquired a large tract of timberlands in the Little River Drainage that had been subjected to extensive thinnings for approximately 20 years. This provided the opportunity for a retrospective study on the impact of thinning versus clearcut harvesting on woodrat abundance. The study involved trapping woodrats in young stands regenerating from clearcuts and stands with various levels of thinning. The conclusion was that woodrats did not colonize stands until they reached a level of thinning that was equivalent to clearcutting standards in California (Hamm and Diller, 2009).

The key to providing woodrat habitat appears to be having sufficient sunlight to promote the growth of early seral plant species that are fed on by woodrats. Under lower light levels associated with thinnings, the unpalatable shade tolerant shrub species such as salal (*Gaultheria shallon*), evergreen huckleberry (*Vaccinium ovatum*) and Pacific rhododendron (*Rhododendron macrophyllum*)) persist. In this portion of their range, our data indicate that spotted owls are not only compatible with even-age management as practiced by Green Diamond, but high quality habitat capable of maintaining a viable population only occurs in areas where creation of openings through even-aged management maintains habitat heterogeneity (Diller et al. 2010). This phenomenon may change in more southern portions of the spotted owl's range in coastal California (e.g., southern Humboldt and Mendocino Counties), which has a warmer and dryer climate. Although there have been no published studies, anecdotal observations on managed timberlands in Mendocino County indicate the woodrats are found in thinned stands (R. Douglas, pers. comm.), but this observation has not been confirmed with any designed studies.

Historically, stand-replacing wildfires presumably were the primary mechanism that maintained varying amounts of early seral stands that supported a variety of early seral-associated species such as the dusky-footed woodrat in coastal California. While it may not apply to the redwood region in California, it was estimated that over the last 3,000 years in the Oregon coastal forests, the proportion of old growth forests at the province scale varied from 25-75%, but the variation increased at the smaller watershed scale from 0-100% (Wimberly et al. 2000).

We are unaware of any estimates of the historical levels of old growth versus early seral stands in coastal California, but pre-European natural disturbance in redwood forests was characterized as frequent but predominantly of low to moderate severity and extent, and resulting in uneven-aged forest (Lorimer et al. 2009). However, the fire history and ecology of the redwoods does not accurately characterize the impact of fire and other disturbance factors in the coastal redwood region, because the predominately redwood forests generally only occur in the fog influenced low elevation areas near the coast and in the stream and river valleys. The higher elevation ridges that parallel the river valleys and interdigitate with and fragment the redwood forests give way to predominately Douglas-fir and hardwoods. On many of the south-facing slopes generally above 2,000 feet, the conifer forests are replaced by oak-prairie woodlands. These non-redwood ridges that are typically oriented northwest to southeast experience the seasonal extremes more typical of interior locations. From north to south in coastal California, the extent of these oak-prairie woodlands increases and their proximity to the coast decreases. In the northern portion of Green Diamond's ownership in Del Norte County the non-redwood ridges reach to within 5-8 miles of the coast (Figure 1), but south of the Eel River Drainage, prairie ridges extend all the way to the river valleys and the coast (Figure 2).

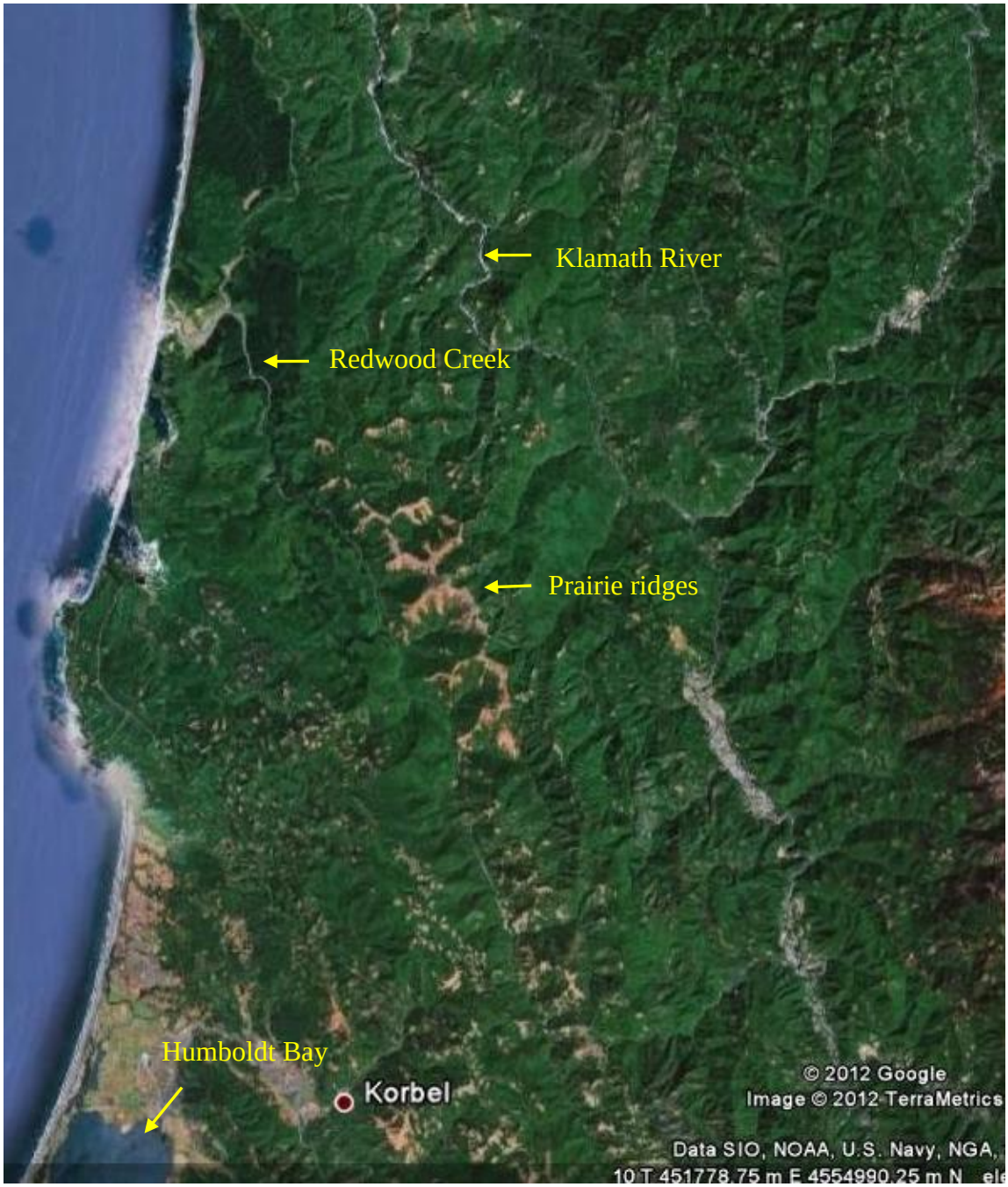

Figure 1. Google Earth view of the landscape from Humboldt Bay north to the Lower Klamath River. Note the prairies and oak woodlands along the ridge east of Redwood Creek.

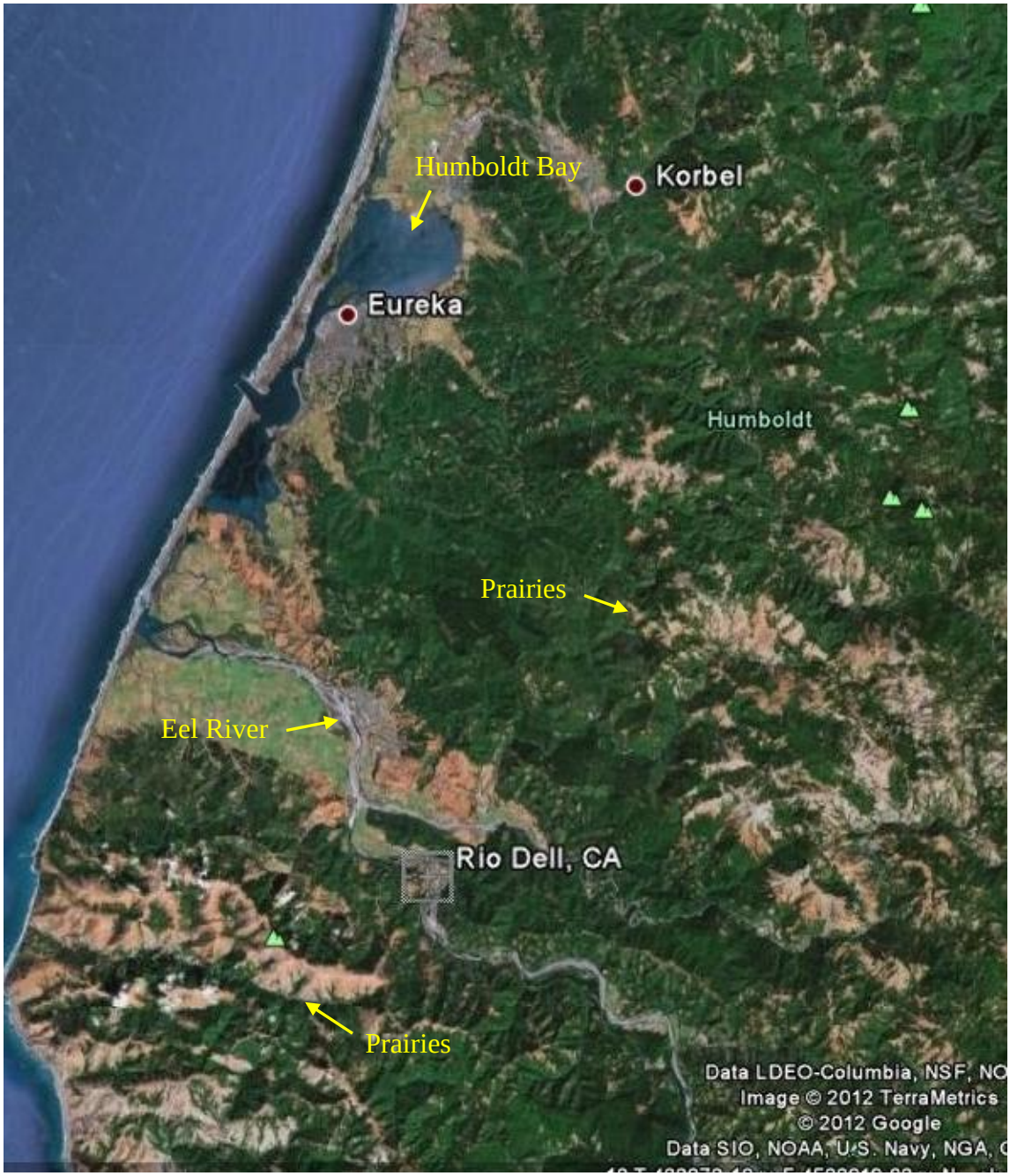

Figure 2. Google Earth view of the landscape from Humboldt Bay south to the Lower Eel River Drainage. Note the extensive prairies and oak woodlands throughout the area including ridges that extend to the coast southwest of the Eel River Drainage.

The coastal prairies that occur primarily on the ridges and south-facing slopes in the redwood region are part of the California coast grassland that was ranked as one of the most endangered ecosystems in America (Noss and Peters 1995). It is generally believed that fire was the primary mechanism to create and maintain the oak-prairie woodlands. According to the Redwood National and State Parks Fire Management Plan (2010), fires were set in northwestern California by American Indians to increase acorn production, providing basketry materials and to encourage new growth of grasses and browse favored by deer and elk. European settlers that came into the area after 1850 also set fires to create pastures for livestock and to encourage growth of browse for elk. When fire suppression became a national policy and priority in the 1930s, ecological conditions were fundamentally changed and Douglas-fir forests began replacing the oak-prairie woodlands. Although we are unaware of any regional quantification, anecdotal observations by numerous foresters and biologists have noted substantial changes in recent decades in the amount of openings associated with prairies and oak woodlands. Redwood National and State Parks is using prescribed burns and selective removal of Douglas-fir stands in an attempt to restore and maintain this vital ecosystem.

Stephens and Fry (2005) hypothesized that the frequent anthropogenic fires ignited in surrounding grasslands or oak savannahs were also responsible for fire in the coast redwood trees. Some prairie fires would naturally extinguish themselves because of the differing fire environments at the coast redwood ecotone and only a subset of those fires burned through the redwood forest. As noted above, this probably resulted in frequent but predominantly low to moderate severity fires in the redwood forests, but some these same prairie fires likely resulted in some stand replacing fires in the higher elevation Douglas-fir forests. These fires likely created a highly dynamic ecotone between prairies, Douglas-firs and redwood forests, which would have been the primary source of early seral forests. Over time with climatic changes in wet and dry cycles, the ecotones surrounding the ridgelines presumably also waxed and waned with varying amounts of early seral forests. With the exclusion of wild fire from this ecosystem, not only are natural openings associated with prairies and oak woodlands being lost, but of equal importance, the process that generated early seral forests has been lost.

In summary, except for the low elevation coastal strip, the redwood region was historically highly fragmented by a high density of ridges with open prairies, woodlands and Douglas-fir forests separating stream and river with old growth redwood forests. Presumably, it was in these highly dynamic areas associated with ridges and south-facing slopes where spotted owls evolved this relationship with dusky-footed woodrats and selection for areas with high habitat heterogeneity. Although fishers tend to utilize a more diverse prey base than spotted owls, coastal California is the only region in which woodrats constitute a major portion of the fisher's diet (K. Slauson, unpublished report). Similar to the spotted owl, there is a high density of fishers on Green Diamond's ownership, which is likely at least partially due to their relationship with woodrats in this historically structurally diverse region.

As noted above, the value of habitat heterogeneity is not limited to the structurally diverse redwood region, but extends inland to the western portion of the Klamath Province. This illustrates that the adaptations shown by purported late seral associated species such as the northern spotted owl and fisher occur over a much larger scale than the redwood region. We know from Green Diamond's mark-recapture study over the last 22 years that juvenile spotted owls readily disperse to and from Green Diamond's ownership to the Eel River drainage to the south, north into southern Oregon and to the Hoopa and Willow Creek study areas to the east. Clearly, the local breeding population of spotted owls extends over millions of acres. A study of the genetic structure of spotted owls confirmed genetic exchange throughout coastal California and the Klamath Province including haplotypes from the California spotted owl in individuals on Green Diamond's ownership (Haig et al. 2004). This would suggest that spotted owls in this region are not adapted to local conditions, but exist as a population that encompasses millions of acres in southern Oregon and northern California.

We do not have the extensive mark-recapture data for fishers, but presumably their abilities to disperse are much more limited than a bird that can readily fly over ground barriers such as large rivers and non-forest habitats. However, we have documented a fisher moving from Hoopa to Green Diamond land. Presumably, there are no barriers for genetic exchange within the coastal redwood region and western Klamath Province and a locally adapted population of fishers would encompass all the coastal river drainages from southern Oregon to the Eel River.

Spotted owls and fishers are two species with large home ranges that would be unlikely to have unique adaptations associated with redwood forests, but are there less vagile species that may be uniquely adapted to redwood forests? Although the possibility exists for some uniquely adapted undiscovered non-vertebrate species, there are no known vertebrate species or sub-species that are unique to redwood forests. The purported Humboldt marten subspecies (*Martes americana humboldtensis*) is the closest to being considered a redwood forest specialist, but the genetic data do not support it being distinct from coastal martens in Oregon and the historical range of the subspecies extends into the western Klamath Province. This lack of species uniquely adapted to the redwood forests provides strong evidence for the dynamic and structurally diverse nature of the redwood region and indicates that conservation assessments should include the entire redwood region and adjacent western Klamath Province.

Although there are no data available to quantify the extent to which historical disturbance events such as wildfire created and maintained prairie openings and early seral stands, we can reasonably assume that these historical openings and early seral forests varied dramatically both spatially and temporally. The high variability in natural systems illustrates the arbitrary nature of our current definitions of silvicultural systems. Various types of timber harvesting characterized as uneven-aged silviculture from single tree selection to the maximum opening size for group selection are assumed to provide a diversity of tree sizes and ages for various forest wildlife species. Above an arbitrary

opening size, the silvicultural prescription is characterized as “even-aged” and the concern is that a diversity of trees of different size and age will not have available wildlife. However, this is a function of the mobility of the wildlife species in question and not the arbitrary limits on the size of openings. For example, spotted owls and fishers have large home ranges and can move about rapidly so that Green Diamond’s ownership with its small maximum clearcut size and a very high density of watercourses with substantial riparian retention would not be perceived as “even-aged.” In contrast, from the perspective of a Trinity bristle snail, single tree selection may essentially create an “even-aged” home range. Although Green Diamond’s predominate silvicultural prescription is defined by California’s forest practice rules as even-aged, we believe that it is effectively uneven-aged at the landscape level relative to most of the species of conservation concern. For those species with more limited vagility and sensitivity to timber harvest such as some of the amphibian species, the extensive riparian reserves have been demonstrated to meet their habitat needs.

At the landscape level, we believe Green Diamond’s application of even-aged silviculture actually provides for greater habitat and structural diversity than application of an uneven-aged silvicultural prescription such as individual tree selection. The two pictures below of recent timber harvesting illustrate this point. The picture on the left (Figure 3.A) is of an “uneven-aged” selection harvest, which if applied extensively across the landscape would result in within stand diversity, but very little stand diversity at the landscape level. This same landscape would be perpetuated indefinitely with repeated entries at intervals of approximately 10-15 years. In contrast, the “even-aged” harvesting on the right (Figure 3.B) may result in little diversity in tree ages at a small scale (<10-20 acres), but at the landscape level, the small clearcuts, riparian reserves and retention of tree clumps within harvest units will provide for much greater overall diversity.

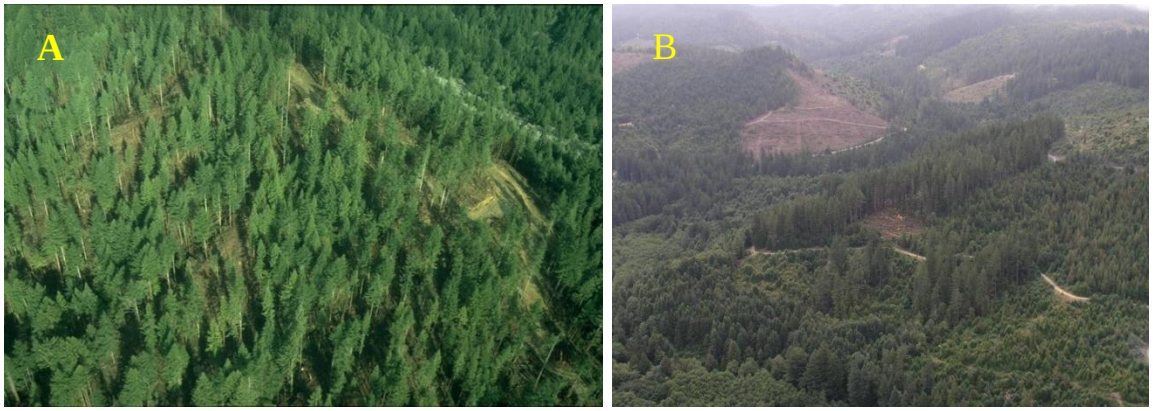

Figure 3. Picture of a selection harvest (A) in a second growth redwood forest near Humboldt Bay and a mosaic of even-aged harvest units (B) in the Little River watershed.

The current application of even-aged harvesting has been evolving on Green Diamond’s ownership over just the last 20+ years, and as a consequence, we do not have examples of

how this silvicultural management will look in the future at the end of a typical rotation within a given sub-basin. The picture of even-aged silviculture (Figure 3.B) may give the impression that the future landscape will be dominated by young seral stages. However, the future managed landscapes created on Green Diamond's ownerships can be predicted by areas of current focused harvesting (Figure 4). At the initiation of the next rotation in approximately 30 years, this sub-basin will be covered by stands regenerated from former harvest units that will be mostly 30-50 years old. Within these stands will be a complex matrix of extensive riparian areas and retention areas (approximately 25%) that will be 80-100 years old. At that point in the future, this particular sub-basin will be a continuously forested area with stands of variable age, while other sub-basins across the ownership will be in the active harvesting stage as pictured below(Figure 4). This process will be repeated across time and space with harvest units continuing to be harvested at the appropriate site-specific rotation age, but the riparian and retention areas will continue to age relative to the harvest units.

Figure 4. LiDAR imagery of the vegetation layer in the Maple Creek watershed. Extensive even-age timber harvesting was initiated in this area in 1999 and it is currently the sub-basin within Green Diamond's ownership with the highest rate of harvest.

The synthesis of the studies of various wildlife species on Green Diamond's ownership also demonstrates the importance of fundamental ecological processes. Natural disturbances of various types (i.e., fires of different intensities, windstorms, floods, disease outbreaks, etc.) have always been part of all forest ecosystems and these disturbances have produced a variety of different seral stages and stand conditions within forested landscapes on both temporal and spatial scales. Species are adapted for these variable conditions in different ways so that there have always been "winners" and "losers" depending on stochastic natural disturbance regimes. This same ecological principle applies equally to human managed systems in that disturbing a forest, or attempting to hold it static, results in some species that benefit (i.e., become more numerous and widespread) and others that are disadvantaged or even locally extirpated. This means there is no single "right way" to manage forests to benefit all terrestrial and aquatic species and natural biodiversity within a region is only maintained through diversity of forest conditions.

The regional relationship between spotted owls, fishers and woodrats also illustrates the importance of site-specific research and monitoring to establish the most appropriate silvicultural system in any given region to maintain selected species of conservation concern. However, we also need to address the larger context of the biodiversity within the entire north coastal region of California. A major portion of Green Diamond's ownership is situated between Redwood National and State Parks on the west and US Forest Service land on the east. Both of these public land bases have substantial areas of old growth and the management plans for both areas will lead to additional old growth in the future. With the possible exception of a rare major stand-replacing wildfire, potentially these areas will be losing much of their openings necessary to create habitat heterogeneity (seral stage diversity), and along with it, some of their biodiversity. Although the old growth along the coast will likely be poor habitat for spotted owls and fishers, it will continue to play a vital role in providing habitat for species of critical conservation concerns such as the marbled murrelet, which as noted above, is not compatible with any type of forest management. The old growth forests of the parks and Forest Service may also play a key role in the recovery of coastal (Humboldt) martens, which may not be able to persist on a managed landscape that has high densities of fishers, a strong competitor/predator of the marten.

Therefore it is our conclusion that when the region is considered in its entirety, Green Diamond with its unique version of even-aged silviculture will maintain a vital link that is required to maintain the native biodiversity of the region. Openings and early seral forests that were historically maintained on ridges and south-facing slopes within the redwood region will gradually be lost, but they will be replaced by a dynamic mosaic of openings on Green Diamond's ownership. While this will represent a westward shift in some areas in the pattern of openings and early seral forests relative to historical patterns, Green Diamond will help maintain the native biodiversity of the region through its application of even-aged management. In essence, the process of frequent fires associated with prairies that maintained openings and early seral forests has been lost and has been

replaced by even-aged management that retains high amounts of late seral elements. We therefore strongly believe that the application of our management practices meet the requirement of (as described in Indicator 6.3.g.1.b Part 3) "restores the native species composition" for both vegetation and wildlife, and "is needed to restore structural diversity in a landscape lacking openings while maintaining connectivity of older intact forests."

Literature Cited

Bury, R. B., and P. S. Corn. 1988a. Responses of aquatic and streamside amphibians to timber harvest: a review. In K. J. Raedeke (ed.), Streamside Management: Riparian Wildlife and Forestry Interactions, pp. 165-180. Univ. of Washington, Institute of Forest Resources, Contribution 59, Seattle.

Carey, A. B. 1989. Wildlife associated with old-growth forests in the Pacific Northwest. Natural Areas Journal 9:151-161.

Carroll, C. R., W. J. Zielinski, and R. F. Noss. 1999. Using presence-absence data to build and test spatial habitat models for the fisher in the Klamath Region, U.S.A. Conservation Biology 13:1344-1359.

Corn, P. S., and R. B. Bury. 1989. Logging in western Oregon: responses of headwater habitats and stream amphibians. For. Ecology Mangmt. 29:39-57.

Courtney, S. P., J. A. Blakesley, R. E. Bigley, M. L. Cody, J. P. Dumbacher, R. C. Fleisher, A. B. Franklin, J. F. Franklin, R. J. Gutiérrez, J. M. Marzluff, L. Sztukowski. 2004. Scientific evaluation of the status of the Northern Spotted Owl. Sustainable Ecosystems Institute, Portland, OR.

Diller, L. V. and R. L. Wallace. 1994. Distribution and habitat of *Plethodon elongatus* on managed, young growth forests in north coastal California. Journal of Herpetology 28(3):310-318.

Diller, L. V. and R. L. Wallace. 1996. Distribution and habitat of *Rhyacotriton variegatus* on managed, young growth forests in north coastal California. Journal of Herpetology 30(2):184-191.

Diller, L. V., and D. M. Thome. 1999. Population density of northern spotted owls in managed young-growth forests in coastal northern California. Journal of Raptor Research 33:275-286.

Diller, L. V. and R. L. Wallace. 1999. Distribution and habitat of *Ascaphus truei* in streams on managed, young growth forests in north coastal California. Journal of Herpetology 33(1): 71-79.

Diller, L., K. Hamm, D. Lamphear and T. McDonald. 2010. Green Diamond Resource Company, Northern Spotted Owl Habitat Conservation Plan, Ten-Year Review Report. Report available from U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata, California. 193 + viii pp.

Dunk. J. R. and J. J. Hawley. 2009. Red-tree vole habitat suitability modeling:
Implications for conservation and management. Forest Ecology and Management 258 (2009) 626–634

Franklin, A.B., J.P. Ward, R.J. Gutiérrez and G.I. Gould, Jr. 1990. Density of Northern Spotted Owls in northwest California. *J. Wildl. Manage*. 54:1-10.

Franklin, A. B., D. R. Anderson, R. J. Gutierrez, and K. P. Burnham. 2000. Climate, habitat quality, and fitness in Northern Spotted Owl populations in northwestern California. Ecological Monographs 70:539-590.

Hamm, K. A. 1995. Abundance of dusky-footed woodrats in managed forests of north coastal California. M.S. Thesis, Humboldt State University, Arcata, CA. 46 p.

Hamm, K. A. and L. V. Diller. 2009. Forest management effects on abundance of woodrats in northern California. Northwestern Naturalist 90:97–106.

Hazard, G. C. and T. L. George. 1999. Landbird abundance and diversity in different-aged stands of coast redwood forests in Northwestern California. Northwestern Naturalist 80:99-109.

Lorimer, C. G., D. J. Porter, M. A. Madej, J. D. Stuart, S. D. Veirs Jr, S. P. Norman, K. L. O'Hara, W. J. Libby. 2009. Presettlement and modern disturbance regimes in coast redwood forests: Implications for the conservation of old-growth stands. Forest Ecology and Management. 258:1038-1054.

McWethy, D. B., A. J. Hansen and J. P. Verschuyl. 2009. Bird response to disturbance varies with forest productivity in the northwestern United States. Landscape Ecol. DOI 10.1007/s10980-009-9437-6.

Meiselman, N., and A. T. Doyle. 1996. Habitat and microhabitat use by the red tree vole (Phenacomys longicaudus). American Midland Naturalist 135:33-42.

Hughes, K. D. 2005. Habitat associations of dusky-footed woodrats in managed Douglas-fir / hardwood forests of northern California. M.S. Thesis, Humboldt State University, Arcata, CA. 40 p.

Noss RF, Peters RL. 1995. Endangered ecosystems: a status report on America's vanishing habitat and wildlife. Washington DC: Defenders of Wildlife. 151 p.

Powell, R.A. and W.J. Zielinksi. 1994. Fisher. Pages 38-73 in L.F. Ruggiero, K.B. Aubry, S.W. Buskirk, L.J. Lyon, and W.J. Zielinski, eds. The scientific basis for conserving forest carnivores: American marten, fisher, lynx, wolverine in the western United States. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO. General Technical Report RM-254.

Sakai, H. F. and B. R. Noon. 1993. Dusky-footed woodrat abundance in different-aged forests in northwestern California. Journal of Wildlife Management 57(2):373-382.

Stephens, S. L. and D. L. Fry. 2005. Fire History in Coast Redwood Stands in the Northeastern Santa Cruz Mountains, California. Fire Ecology 1(1):1-19.

Thompson, J. L. 2008. Density of fisher on managed timberlands in north coastal California. M.S. Thesis, Humboldt State University, Arcata, CA. 40 p.

Thompson, J. L., and L. V. Diller. 2002. Relative abundance, nest site characteristics, and nest dynamics of Sonoma tree voles on managed timberlands in coastal northwest California. Northwest Naturalist 83:91-100.

USFWS (U.S. Fish and Wildlife Service). 1990. The 1990 status review: northern spotted owl: *Strix occidentalis caurina*. USDI Fish and Wildlife Service, Portland, Oregon. 95 pp.

Welsch, H. H., Jr. 1990. Relictual amphibians and old-growth forests. Conserv. Biol. 4:309-319.

Welsh, H. H., Jr and A. Lind. 1991. The structure of the herpetofaunal community in the Douglas-fir/hardwood forests of northwestern California and southwestern Oregon. In L. F. Ruggiero, K. B. Aubry, A. B. Carey, and M. H. Huff (Tech. Coords.), Wildlife and Vegetation of Unmanaged Douglas-Fir Forests, pp. 395-413. USDA , Forest Service, Gen. Tech. Rept. PNW-GTR 285, Portland, Oregon.

Wimberly, J. C., T. A. Spies, C. J. Long and C. Whitlock. 2000. Simulating historical variability in the amount of old forests in the Oregon Coast Range. Conservation Biology 14:167-180.

Zielinski, W.J., R.L. Truex, G.A. Schmidt, F.V. Schlexer, K.N. Schmidt, and R.H. Barrett. 2004. Home range characteristics of fishers in California. J. Mammalogy, 85(4):649–657.