Chapter 8:

WILDLIFE AREAS

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8.1 INTRODUCTION

Wildlife areas are defined herein to include Wildlife Habitat Conservation Areas and the Wildlife Habitat Network. The Wildlife Habitat Network is designated and mapped in King County's Comprehensive Plan. Wildlife Habitat Conservation Areas are those terrestrial areas that include:

- Habitat for federal or state listed endangered, threatened, or sensitive species both within and outside the Urban Growth Area;
- Habitat for Raptors and Herons of Local Importance: osprey, black-crowned night heron, and great blue heron both within and outside the Urban Growth Area, and red-tailed hawk outside of the Urban Growth Area;
- Wildlife habitat networks designated by the County;
- Habitat for candidate species, as listed by the Washington Department of Fish and Wildlife, found in King County outside of the Urban Growth Area;
- Birds of local importance: Trumpeter swan, Tundra swan, Snow goose, Band-tailed pigeon, Brant, Harlequin duck, Blue grouse, Mountain quail, and Western bluebird on lands outside of the Urban Growth Area; and
- Mammals of local importance: marten, mink, Columbian black-tailed deer, elk, and mountain goat on lands outside of the Urban Growth Area.

The Growth Management Act (GMA) defines Fish and Wildlife Habitat Conservation Areas (FWHCAs), from which the above Wildlife Habitat Conservation Areas derive. FWHCAs are lands that are designated and managed for maintaining targeted species within their natural geographic distribution so that isolated subpopulations are not created. Such areas are considered to be critical for the long-term viability and proliferation of certain native fish and wildlife species. GMA includes guidelines that jurisdictions must consider when designating these areas. King County's Comprehensive Plan includes policies for the protection of FWHCAs. To facilitate discussion and assessment of the FWHCAs, they have been grouped into Aquatic Areas (Chapter 7) and Wildlife Areas, which are the subject of this chapter.

This chapter will present a literature review of the best available science (BAS) that relates to wildlife areas. After the literature review, the Critical Areas, Stormwater, and Clearing and Grading Ordinances standards will be assessed to determine their consistency with BAS and any risk to the wildlife areas if the ordinances depart from BAS. Finally, all literature cited in the literature review as well as literature reviewed but not directly cited is listed in the references section.

8.2 REVIEW OF LITERATURE

Wildlife areas are land-based (terrestrial) ecosystems composed of unique interacting systems of soil, geology, topography, and plant and animal communities (Johnson and O'Neil 2001). For the purpose of this discussion of King County's wildlife areas, the best available science concerned with terrestrial conservation is reviewed, including literature that ranges from conservation theory to studies on select terrestrial wildlife species. For this analysis, wildlife areas are defined as those areas in which priority mammals, birds, amphibians, reptiles, and invertebrates of King County are likely to be found.

8.2.1 Conservation Theory

In addition to the conservation framework presented in Chapter 2 – Scientific Framework, other important conservation theory, especially as relates to ecosystems, are presented in this section.

Noss et al. (1997) considers the ecosystem "an appropriate target level for conservation planning and for integrating concerns from other levels of organization." Maintaining viable ecosystems with their respective populations is likely to be a more efficient, economical, and effective conservation strategy than a species-by-species or single-habitat approach (Noss et al.1997). Such a strategy does not suggest that species and their habitats be ignored, but rather that the planning approaches avoid solely focusing on single-species conservation (Noss et al.1997).

Because knowledge of such diverse and complex systems is limited, management must be capable of coping with complexity and uncertainty. Consequently, an increasing number of scientists have eloquently argued that the emerging principles of ecosystem-based management and adaptive management are well suited for this task (Lee 1993; Noss et al. 1997; Baydack et al. 1999; Meyer 1997).

Landscapes, Ecosystems, and Populations

Landscapes are defined as large areas composed of many different kinds of ecosystems that are organized into repeatable patterns of habitats, physical features, and human influences (see Forman and Godron 1986). An ecosystem is defined as a physical system with an associated community of interacting organisms through which energy flows and material cycles. Finally, a population is defined as a group of individuals with common ancestry that are much more likely to mate with one another than with individuals from another such group.

Just as ecosystems are components of landscapes, habitats are components of ecosystems. Habitats vary in size, shape, and distribution, and are multidimensional places where populations or groups of populations live (Noss et al. 1997).

The dynamic development of landscapes, ecosystems, and populations are characteristically unpredictable. Relationships exist between these units at every level of organization and there is a constant flow of energy and materials throughout ecosystems that result in complex patterns of association at many scales of organization. Landscapes, ecosystems, and populations are interconnected through physical and biological processes and structures. Because a strong interrelationship exists among process, structure, and function at these many scales, there is a close correspondence between the characteristics of ecosystems, landscapes, and populations. Collectively, the temporal and spatial scales at which landscapes, ecosystems, and populations function suggest a correspondence between spatial and temporal phenomena that must be considered in conservation.

Ecosystem-Based Adaptive Management

The general goal of ecosystem-based management should be the use of natural resources in a sustainable manner that does not threaten the integrity of the natural ecosystems that provide the resources (Spence et al. 1996; Grumbine 1994; Lee 1993). That is, despite the uses of, or services derived from ecosystems, management is directed toward preserving the resilience of these systems to support ongoing uses and provide the services. Beyond the overall goal of maintaining ecosystem integrity, authors such as Grumbine (1994) agree on five specific goals necessary to achieve sustainability and integrity:

- Maintain viable populations of all native species;
- Represent, in protected areas, all native ecosystem types;
- Maintain evolutionary and ecological processes;
- Manage over time scales to maintain the evolutionary potential of species;
- Accommodate human use and occupancy within the constraints above.

Achieving these goals will require a landscape perspective that takes into consideration:

- All species within the ecosystem, not just those with economic value;
- Interactions among species, not just independent species themselves;
- Time scales of ecosystem processes;
- Ecosystem (and watershed) scale;
- Threats beyond the immediate site boundary;
- All users and benefactors of the resource;
- Adaptive management.

Adaptive management requires that management actions are designed and carried out in such a way that the results of the management increase understanding of the effects of the actions and the operations of ecosystems. Learning how specific actions affect the surrounding ecosystems reduces the uncertainty associated with resource management decisions.

The principles of adaptive ecosystem-based management apply regardless of the degree of past or present human influence. This approach is suitable for intensively urban systems and for wilderness areas; although the goals will be different, a system-based management approach with provisions for adaptively evaluating outcomes is just as useful applied to human communities as to forest communities.

Contemporary Ecology and the Implications for Conservation

The scientific foundation of conservation has historically and traditionally focused on the habitat and species level of organization. This relatively narrow focus was based on the historical notion of “equilibrium” or “balance” in the natural world and led to an interpretation of habitats (and any “unit” of nature) as more or less self-contained and therefore a suitable unit for conservation (Pickett et al. 1992). The equilibrium model has given way to a dynamic view of nature called the nonequilibrium, or “flux of nature,” model (Pickett et al. 1992; Rogers 1997).

- This nonequilibrium model emphasizes that ecosystems: (1) are open to fluxes of materials, energy, and species; (2) exhibit patterns that emerge according to the relationships among process, structure, and function; and (3) exist at multiple spatial and temporal scales of pattern and process. Consequently, in order to understand a particular habitat pattern, the distribution of a species, or a species' abundance and diversity, the patterns, processes, and structures that form landscapes, ecosystems, and habitats must be understood at the appropriate spatial and temporal scales. The landscapes, ecosystems, and populations upon which the processes act are integral and essential in these emerging patterns. Moreover, other units of biological structure—populations, species, and genes—must be considered when interpreting ecosystem and habitat patterns. It is this interaction that establishes the parameters of function for ecosystems and habitats.

The contemporary paradigm[1] arose in response to several empirical and theoretical failures of the equilibrium paradigm (Simberloff 1982). Specifically, natural communities were observed to (1) have multiple persistent states that did not reflect a local climax (Botkin and Sobel 1975); (2) exhibit various pathways of vegetation change that violated the dominant role of the climax state in guiding system dynamics (Pickett 1989); and (3) be considerably more "open" to external forces than predicted by the equilibrium model (White 1979). Although particular ecosystems have distinct characteristics (e.g., aquatic versus terrestrial systems and marine versus lacustrine systems), and ecosystems tend to conserve mass and energy, the structure and function of ecosystems were found to be subject to many external influences. Fires, floods, increases in herbivory, disease outbreaks, and a wide variety of other "outside" factors all were identified as influencing the dynamics of individual ecological systems and their equilibrium state. This array of events affecting the patterns and processes of ecosystem development suggested to ecologists that ecosystems are conditional and that the imprint of past disturbances and patterns is reflected in the present pattern or state of ecosystems (Meyer 1997; Jorgenson and Mitsch 1989). In fact, the structure and function of many ecosystems are disturbance-mediated, and both materials and energy moved more freely across ecosystem boundaries than had been predicted by the equilibrium model.

In summary, the major points of the contemporary paradigm are thus:

1. Natural systems are open to fluxes of materials, energy, and species from outside the system (Whittaker and Levin 1977). The surroundings of the system are important in understanding dynamics and structure. A corollary of this characteristic is that the structure of many ecosystems is mediated by episodic disturbances of varying magnitudes and durations—fires, windstorms, floods, droughts, tidal fluctuations, and disease outbreaks, for example.
2. Process, rather than endpoint, is critical (Vitousek and White 1981); the focus tends to be on how systems behave and the relationship among process, structure, and function. The non-equilibrium paradigm can accommodate equilibrium as a special case or as a functional steady state but not as an invariant stable state.
3. Multiple scales of pattern and influence must be considered. At large scales, a landscape may consist of many patches or components that vary individually in composition over time but

[1] A paradigm is (1) the world view shared by a scientific discipline or community and (2) the exemplars or models for problem development, analysis, and solution within a discipline. The world view can be further explained as the family of broad theories that form the foundation of the discipline while the exemplars include both the models for attacking problems and the considerations of what particular problems are important to the discipline.

together maintain an equilibrium composition across the landscape. This model is often referred to as the "shifting mosaic" model (Bormann and Likens 1979) and can be applied to stream ecosystems as well (Pickett and White 1985; Patrick 1975).

The contemporary paradigm also requires that context is considered in conservation efforts. Many species carry out their life histories across many ecosystems; one system is used for breeding, another for feeding, a third for migration. Collectively, these are required to maintain populations. Many wildlife species have complex life cycles that require various ecosystems and habitats for breeding, feeding, and shelter. For example, most sexually mature pond-breeding Northwest amphibians only migrate to wetlands for a few weeks in spring to breed, and they use uplands almost the entire year for feeding, cover, and resting. Elk and other ungulates also exhibit seasonal elevational migrations to spring breeding, summer feeding, and overwintering grounds.

8.2.2 Wildlife Areas Functions

Large terrestrial areas facilitate homing, migrations, dispersal, and other activities crucial to populations (Blake and Karr 1984; Fahrig 2002; Dawson 1994; Carey et al 1992). Concurrently, these inclusive wildlife areas protect air and water quality and provide other critical ecological processes and functions that contribute to the conservation of healthy habitats and ecosystems (Franklin 1993; Rubec 1997).

The multiple functions of terrestrial areas are in response to a wide variety of natural- and anthropogenic-driven physical and biological factors interrelated on a local, watershed, and regional scale. Consequently, in natural environments, fire, erosion, floods, and other disturbances alter habitat and animal behavior, often on a grand scale. In populated urban and rural areas, farm lands and forest production districts, and other lands, these natural disturbances are usually controlled or minimized. In these areas, humans and their activities determine land cover, displace wildlife, or otherwise influence their ability to retain species and viable populations through outright habitat loss or its alteration and fragmentation (Vitousek et al. 1997). The building of human structures, infrastructure, and other intensive activities has especially decreased habitat function.

Protection of wildlife areas is intended to safeguard state and federally listed species and locally important species, and in doing so, is intended to contribute to native biodiversity in King County. These wildlife areas maintain biodiversity by providing food, water, and cover, the basic needs of wildlife, as well as by protecting breeding, nesting, hibernation, roosting, and other essential areas for population survival.

Human Dominated Landscapes and Variation of Functions Over Time

A less-obvious implication of the contemporary paradigm is that humans are important agents of ecosystem change. Humans are a part of the landscape: they influence and are influenced by ecosystems, are an integral part of ecosystems, and are fully dependent upon ecosystems for their well being (Kaufmann et al. 1994). Natural ecosystems perform fundamental life support services that allow humans to thrive (Daily et al. 1999; Costanza et al. 1887).

Ecologists are beginning to examine the human landscapes as they would any other ecological system—as an arena to test general theory and examine the relationship of structure and function (McDonnell and Pickett 1990). Anthropogenic disturbances are being compared and contrasted with natural ones, and the cumulative effects are being studied for clues to system integrity.

As stated above and in Chapter 2 – Scientific Framework, ecological systems and their processes and functions vary over time. Natural- and human-dominated landscapes differ in the source and type of disturbance, with natural disturbances (e.g., fire, severe flooding) being replaced by human-caused disturbances (e.g., land clearing, habitat fragmentation) in human-dominated landscapes. Human use of the land alters the structure and functioning of ecosystems (Vitousek et al. 1997). Moreover, wildlife populations and home ranges expand and contract over time (Dasmann 1981). Simultaneously, greenbelts, remnant forests, and other urban habitats (Agee 1995) set aside for their protection also transform over time. Historically, and in natural environments, variability of habitat provided a continuous source of environmental replenishment and resources for species. Today, in human-dominated landscapes, sources of environmental replenishment may be limited, especially in smaller and increasingly isolated habitats.

- Marzluff and Bradley (in press) distinguish the interface between urban areas and wildlands as a specific area with its own unique conservation purposes and management considerations. The rural residential areas of King County may be thought of as this interface. Marzluff and Bradley point out that development in such areas can be contentious. They suggest the goal of restoration in the interface should be to buffer the more native areas from the urban areas, and that maintaining ecological functioning within the interface is secondary. Marzluff and Bradley (in press) cite various authors who have discussed the negative effects on biodiversity of development in and adjacent to the interface, by “removing, perforating, isolating, and disturbing native vegetation; simplifying vegetative structural diversity; introducing invasive and nonnative plants and animals; removing large predators; favoring synanthropic species that prey on, compete with, and parasitize native species; creating barriers to dispersal; and disrupting important ecosystem functions such as nutrient cycling, soil formation, and water cycling.” Even though patches of forest are retained, patch sizes are smaller and connectivity is lower, such that the forests are dominated by edge processes (see “Protection Suggested by Literature” below).

The wildlife habitat function within human landscapes may vary significantly with intensity of land-use change and human activity. A study by McDonnell et al. (1997) revealed a complex urban-rural environmental gradient: “The urban forests exhibit unique ecosystem structure and function in relation to the suburban and rural forest stands; these are likely linked to stresses of the urban environment such as air pollution.” Changes in bird communities have been well documented and exhibit trends that include increasing bird relative abundance with decreasing bird species richness (Beissinger and Osborne 1982; Donnelly 2002). Specifically, densities of relatively few dominant urban ground gleaners increase and a concomitant decrease is observed in forest insectivores, canopy foliage gleaners, and bark drillers (Beissinger and Osborne 1982).

When humans alter a natural environment with roads and development, agriculture and logging, the result is a matrix of fragments on the landscape. As a result of fragmentation, remaining populations of native wildlife are smaller (Marzluff and Ewing 2001). Native birds are exposed to a number of threats, including competition with non-native species (e.g., European starlings), exposure to more predators and parasites (e.g., domestic cats), greater disturbance from human activity, and restricted dispersal corridors. Additionally, key resources are often removed, such as snags and logs, ground cover, and shrub patches. Nutrient and hydrological cycles are also negatively impacted by fragmentation (Marzluff and Ewing 2001).

As alluded to above, one serious yet frequently ignored effect of fragmentation on wildlife species is the increased predation on avian species by house cats. Domestic cats were estimated to kill between 7.8 and 217 million birds per year in Wisconsin (Coleman and Temple 1996, as cited in Marzluff and Ewing 2001). A single house cat can decimate entire populations within a patch of habitat.

Wildlife Areas Protection

To protect select wildlife habitat and species, strategies for conservation of terrestrial systems should be crafted at relevant small, medium, and large scales. For example, neighborhood, parcel, and landscape context should all be considered in planning efforts because different factors and components can affect these scales differently, and because wildlife requires conservation at multiple scales (Gutzwiller 2002; Peterson and Parker 1998; Bissonette 1997; Forman 1995). These scales should parallel the needs of wildlife. For example, breeding and nesting requirements of individuals occur at a small scale, and migratory routes occur at large scales.

Marzluff and Ewing (2001) said of avian diversity that in order to restore it, reproduction, survivorship, and dispersal must be maintained, restored, and monitored in fragmented landscapes. The same could be said of any of the priority species. Further, urbanization must be anticipated, and creative ways must be found to increase native habitat and collectively manage it (Marzluff and Ewing 2001).

Existing Habitat and Wildlife Protection

Existing methods of conserving individual wildlife species are diverse and complex, in part because habitat needs vary between vertebrate species and classes and over time (Leopold 1933; Teague 1971; Shaw 1985; Rodiek and Bolen 1991; Magnusson 1994; Morrison et al. 1998). Consequently, programs affecting wildlife protection and management are numerous. In 1971, 550 domestic programs administered by Federal agencies alone already existed (Almond 1971). Numerous state laws and local laws, ordinances, and special provisions also exist that may be used to conserve wildlife and their habitat. However within many urban environments, traditional techniques for wildlife conservation are seldom used, conservation planning for wildlife is fundamentally a fragmented and reactionary process, and no one agency or group sets a high priority on wildlife (McKinnon 1987).

In Washington State, the Washington Department of Fish and Wildlife provides distributions, descriptions, and management guidelines for priority species and habitats, such as inclusive short reports (e.g., Milner 1991) and well-referenced long reports such as those on invertebrates (e.g., Larsen 1995), amphibians and reptiles (e.g., Larsen 1997), snags (e.g., WDFW 1995), and others. However, local agencies influence anthropogenic impacts to habitat and their wildlife through their diverse regulations, including environmental (e.g., air and water quality standards, initially often Federal Standards), natural resource (e.g., resource extraction, agriculture, forestry practices), and development (e.g., comprehensive plans, zoning, critical areas) regulations. In other words, land use is determined by local jurisdictions, but the State provides guidance and information for the regulation of wildlife.

King County addresses terrestrial habitat and species conservation needs directly through actions such as regulations, property acquisition, and purchase of easements, and indirectly through innovative methods such as Current Use Taxation program (CUT), Public Benefit Rating System (PBRS), Forestry Program, and Watershed Planning. For further descriptions of these programs, please see Chapter 1 – Introduction. To specifically target wildlife population, King County has a designated protected Wildlife Habitat Network to facilitate wildlife movement between large habitat patches (i.e., hubs such as publicly protected regional and local parks, large lakes, and rivers). Such a network should enable populations to intermingle and disperse from east to west and north to south using large protected areas within the County. The Wildlife Habitat Network is mapped in the King County Comprehensive Plan and is protected through the existing Sensitive Areas Ordinance (adopted in 1993).

The Maryland Department of Natural Resources (2001:24) summarizes widespread problems in the field of wildlife conservation:

> Most conservation efforts in this country are still reactive not proactive; haphazard not systematic; piecemeal not holistic; single purpose not multifunctional; too focused on the local or project-level scale and not enough on the watershed, regional or landscape scales critical to understanding the environmental context. We seem to dwell on individual pieces of the land development-land conservation puzzle and fail to take advantage of the strategic linkages between resources, tools, programs, and people. Conservation efforts too often result in protected 'islands' too isolated to deliver their promise.

Protection Suggested by Literature

Biologists agree on the importance of protecting actively used critical areas such as nesting trees (for examples, see Rodrick and Milner 1991; Van Horne and Wiens 1991). Equally recognized is the fact that such specific ecosystem and habitat attributes vary in usage and distribution in time and space. For example, bald eagle and red-tailed hawk nesting trees and snags blow down or rot over time. Therefore, these birds must find new trees and snags on a regular basis. To maintain sustainable breeding populations of these priority species, alternate trees, and snags must be available (Thomas 1979; Marzluff and Ewing 2001). Likewise, other breeding and non-nesting critical habitats must be available for occupancy—naturally or through anthropogenic actions—so that all life stage requirements for species and populations are met. Conservation of active breeding, foraging, and sheltering habitats through buffers and other means is essential; however, it is equally important to provide alternative habitats for all these and all other crucial needs, which may be widely dispersed within the varied ecosystems of watersheds and larger landscapes (Gutzwiller 2002; Peterson and Parker 1998; Bissonette 1997; Forman 1995).

There are two approaches to conserving species and their habitat in the literature. The first is to protect species only within clearly identified ecological reserves (i.e., tracts of land, often large in area) that are relatively homogenous in plant composition and structure regardless of adjoining land use (Soulé and Wilcox 1980; Frankel and Soulé 1981; Wright 1998). The second approach attempts to protect species across an entire region by enhancing the quality of existing habitat and by providing for all important wildlife needs (Franklin 1993; Morrison et al. 1998). This second approach is more difficult to implement. Implicit in both approaches, but perhaps not emphasized, is the protection of ecological function, composition, and structure. In urban and some rural environments, such approaches are more difficult to implement than in large forested areas and more natural landscapes. Nevertheless, land use regulation through ordinance rules and zoning and Comprehensive Plan policies guiding habitat restoration, and other short- and long-term actions can minimize detrimental effects to wildlife by providing guidance on area size, locations, configuration, and other characteristics necessary to support populations.

Wildlife habitat protection should be based on several internal (site-specific) and external (contextual) habitat considerations. Internal considerations include:

1. How structurally diverse (vertically and horizontally) is the habitat? Vertical diversity is derived from the amount and distribution of vegetation and other structural elements in various zones ranging from underground to the tops of the tallest trees. Horizontal diversity is determined by the size and distribution of vegetation patches across the landscape. Greater structural diversity generally increases the area's wildlife diversity (MacArthur et al. 1962; MacArthur 1964; Balda 1975; Erdelen 1984; Vivian-Smith 1997; Trevithic et al. 2001). A wetland with a patch of trees or open water is generally more valuable than a uniform stand of Douglas fir in a plantation. A forest with a well-developed understory is generally more valuable than a uniform stand of cattails or spirea, or a dense forest with no understory. Areas with low structural diversity may be enhanced and become more valuable to fish and wildlife through restoration efforts, particularly in areas that have been degraded by humans.
2. What are the "edge" conditions? Edges (ecotones) are used by relatively greater numbers of species, which may be harmful or beneficial to native species depending on the taxa adapted to and occupying the edge (Hansson 1983; Logan 1985; Yahner 1988; Lidicker and Koenig 1996). An area, such as a natural burn area, with a mosaic of habitat types that provide an undulating edge is more valuable to wildlife than an area of equal size but with a linear edge. Increased amounts of edge along wetlands or streams, provided they have adequate buffers, increase the value to wildlife species. In contrast, a terrestrial area adjacent to human habitation and certain land uses (e.g., grazing, farming) may have greater numbers of species, but typically they will be square-edged and contain harmful exotic species and aggressive native species (Richter and Azous 2000; Blair 1996). Edges in human-created and occupied environments, although diverse in species, are often dominated by generalist, competitive synanthropic (human associated, tolerant) edge species and fewer interior core species. Human edges are often straight and abrupt with little transition. In natural environments edges are generally gradual transition zones, non-linear, and characterized by higher species diversity than areas along straight edges (Meffe and Carroll 1994; Yoakam and Dasmann 1971). In aquatic systems, convoluted edges include coves, lobes, and peninsulas that enable better positive interactions between aquatic and terrestrial organisms than straight edges: (1) by increasing the length of beneficial transition habitat (the productive shallow shoreline); and (2) by facilitating the dispersal of organisms that have biphasic life stages (invertebrates, amphibians) between aquatic and terrestrial systems (Meffe and Carroll 1994; Dramstad et al. 1996). Edge processes near human development may include "increased wind; reduced humidity; increased predation on amphibians, birds, and small mammals; increased predation and parasitism on bird nests; increased exposure to invasive plants; and increased clearing, pruning, and trampling of native vegetation" (Marzluff and Bradley, in press).
3. Are snags or large trees present? Snags serve many important functions for wildlife, especially nesting, cover, and food sources for cavity-nesting birds and mammals (see further discussion on snags below in Priority Habitats section). If snags are removed for safety

reasons and stumps are not removed, even decaying stumps only a few feet high can be beneficial to wildlife.

4. Are downed logs present? Logs also serve a number of important functions for some wildlife species, particularly in or near streams and wetlands. Coarse woody debris, including logs, are critical elements of healthy, productive, and biologically diverse forests (Bull 2002). Thomas (1979) identified 179 vertebrate species that use coarse woody debris (snags and down wood) in the Blue Mountains of Oregon and Washington. Loss of rotten-log communities may affect some woodpeckers, such as the pileated woodpecker, because of the resultant decline in carpenter ants (Marzluff and Ewing 2001). Logs may also contain moisture, and the cool microclimate may protect certain species during short-term droughts.
5. Is water present or can it be safely accessed nearby by wildlife? Water is one of the essential components of habitat. Wetlands and riparian areas are especially important for wildlife as they may provide all needs in close proximity to each other (Kaufman et al. 2001). Often they provide year-round surface water. Their often high vegetation productivity of grasses, herbs and shrubs provide food sources for a multitude of invertebrate and vertebrates herbivores. In turn, these animals attract carnivores and omnivores. The diverse vegetation structure of wetlands also provides cover from predators and a unique and benign microclimate that is often warmer in winter and cooler in the summer than adjoining uplands and other terrestrial area. Collectively, these traits are optimum for successful reproduction, and therefore the high number of wetland-associated species. For additional information on Riparian Areas, see Chapter 7 – Aquatic Areas, and for additional information on Wetlands, see Chapter 6 – Critical Aquifer Recharge Areas.

External considerations include:

1. What is the size of the habitat patch? Generally, large patches of a given habitat type are more valuable than small patches. Optimal patch size in western Washington may be around 75-100 acres (30-40 ha). Donnelly (2002) found that areas greater than 75 acres are useful for many native birds, but specific species do have specific thresholds of occurrence that are related to amount and configuration of the forested habitat. Most native forest species were present at sites larger than 42 ha in the urbanizing area around Seattle. However, the case can be made to protect relatively smaller patches (e.g., 5-20 acres, or 2-8 ha) of diverse vegetation that are more widely distributed across the urban landscape, because these areas may be “stepping stones” between larger areas for some birds that persist in smaller patches (Potter 1990; Burel 1989; Fahrig and Merriam 1994). Woodlots, for example, often serve as “island refuges” for species that would otherwise not be found in residential neighborhoods.
2. Does the habitat serve as a link (e.g., corridor) to otherwise isolated natural areas, parks, preserves, open spaces, or large tracts of land designated for long-term forestry? Corridors are valuable in facilitating movement of animals between essential breeding, feeding, and roosting habitat and in minimizing negative attributes (e.g., reduced numbers, inbreeding, greater vulnerability to local extinction) of isolated populations. Although corridors may have negative effects, such as providing a pathway for the transmittal of invasive weeds or diseases (e.g., Hess 1996a), the positive effects of corridors are believed to outweigh the potential negative effects. Riparian areas provide especially important movement corridors in urban-rural landscapes.

3. Does the area serve as a buffer or is it surrounded by a buffer? Buffers are especially important when human activity may affect the area. Buffers may be visual or auditory, and they may also serve to act as a barrier for unwanted species. For example, a buffer would have increased value if were effective in keeping domestic cats away from nesting birds (Simberloff and Cox 1987) or in keeping mice and rats away from bird eggs.
4. What are the surrounding habitat types or land uses? The wildlife in the area may be positively or negatively affected by adjacent habitat or land uses. An area adjacent to an existing park with native vegetation will be more valuable to wildlife than a similar area adjacent to commercial or industrial development.

Wildlife Management in Urban Areas

Wildlife management in urban areas is extremely difficult because of the competing and simultaneous demands on the land. Trading wildlife benefits and urban benefits as well as trading some wildlife species for others are inescapable consequences attributed to this demand. Moreover, not all wildlife and habitat management issues are relevant in urban areas, nor are all wildlife species appropriate for natural habitats although their home ranges may encompass both natural and human-dominated landscapes (Milligan-Raedeke and Raedeke 1995). In urban, rural, and other areas, existing protections of species have been formulated by weighing habitat and wildlife needs along with human and economic needs.

A Puget Sound area study by Marzluff and Donnelly (2002a) revealed that to conserve native forest species in an urban environment:

> (1) policy makers should limit urban development to 52 percent of the landscape; (2) urban planners should keep at least 64 percent of the remaining forest aggregated, creating stands greater than 42 ha wherever possible; and (3) land managers and homeowners should maintain at least 23 percent conifers in the canopy and maintain tree density above an average of 9.8/ha. Tree density in individual yards should vary around this average.

Results from another Puget Sound study by Rohila and Marzluff (2002) suggest that if at least 30 percent of forest is retained in settled areas, and high live-tree density and large tree diameters are maintained, cavity-nesting birds may be maintained for up to several decades. They recommend that forest be retained in the largest patches possible (30 ha or greater), and that the smallest average forest patch size does not fall below 3 ha. Rohila and Marzluff (2002) also provide recommendations for snag retention (see section on Snags below).

Restoration of wildlife habitat should not be underestimated for stemming and reversing the loss of wildlife. Strategic planning, in which temporal patterns of demography and dispersal as well as the spatial distribution of habitat and its conservation of target species are protected, restored, and overall managed, can significantly contribute to the persistence and recovery of certain populations (Scott et al. 2001).

Rare and Indicator Species

When conservation planning, it is important to give consideration to rare ecosystems, habitats, and species[2]; endemic ecosystems, habitats, and species; species that exhibit wide population fluctuations; areas of high native biodiversity; and key habitats and keystone species. Rare and endemic species, habitats, and ecosystems are at greater risk of extinction than those that are widespread and abundant. Additionally, because many scientists recognize the temporal and financial limitations involved in the study and protection of individual species, and they further recognize that protection must incorporate multiple physical and biological needs of target species, they have been devising methods for overcoming these limitations by identifying and protecting indicator species and by modeling species and populations and their respective habitats and needs.

Rare species, habitats, and ecosystems are defined as those that are few in number or are poorly represented in an area. Rare species often lack the capability to resist changes in environmental conditions or lack the resilience to recover after a change. Species, habitats, and ecosystems may be rare because of the following reasons: changing natural conditions have reduced their range, abundance, or distribution; they depend on specific environmental conditions that are not commonly represented in this area (species or habitats at the edge of their range or occurring as relicts); and anthropogenic (human-related) actions have caused habitat loss or severe decreases in range or abundance.

Indicator species are often ecological or social surrogates for species of concern. Indicator species include:

- Keystone Species. Species that exert a major influence on the biological structure of their ecosystems. These species often prevent dominance by a single species and thereby maintain diversity in the community. Loss of a keystone species[3] means loss of a species that plays a significant role in habitat functions and trophic dynamics (exchange of energy). This loss could result in considerable community change and shifts in ecosystems (Paine 1974).
- Endemic Species. A species or other taxonomic group that is restricted to a particular geographic region for reasons such as isolation or response to soil or climatic conditions (Allaby 1999). Endemic species generally have adapted to very specific requirements that are linked to particular habitat or ecosystems that are, themselves, rare. Endemics may be represented by only a few individuals or be confined to small, unique geographic areas. Consequently even small perturbations are likely to cause extinction of endemic species or their limited unique habitats and ecosystems.
- Umbrella Species. A species whose habitat requirements encompass the needs of other species primarily because they have a smaller subset of the same requirements (Simberloff 1998).
- Focal Species. A species that encompasses the structural and functional needs of entire ecological communities. During planning considerations, some scientists use a suite of "focal species," each of which is used to define different spatial and compositional attributes that must be present in the landscape (Lambeck 1997).

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[2] "Species" is used throughout to be inclusive of populations.

[3] Keystone species are defined broadly to include every species "whose impact on its community or ecosystem is large, and disproportionately large relative to its abundance" (Power et al. 1996:609).

Powers et al. (1998) suggest "that if keystone species can be identified in threatened ecosystems, critical areas should be set aside to maintain keystones, rather than focusing management efforts solely on endangered species or 'hot spots' of biodiversity." Simberloff (1998) argues that "the conservation approach most likely to unite the best features of single-species management and ecosystem management is to focus management efforts on keystone species because it involves explicit consideration of the mechanisms that underlie ecosystem function and structure…. Keystones are functionally linked to a suite of other species; thus, management for the persistence of keystone species benefits other species by maintaining key ecosystem functions or structures." Aubry and Raley (2002) suggest the pileated woodpecker is a keystone species.

Endemic species associated with wildlife areas may warrant particular consideration because of their dependence on specific environmental conditions that are not commonly represented in an area. Keystone species are also essential because entire ecosystems are altered if they are extirpated or decrease significantly. Clearly these two groups warrant consideration because of changing natural or anthropogenic (human-caused) circumstances that may have reduced their range, abundance, or distribution.

Modeling

Modeling is another important wildlife conservation tool. When using models, scientists must determine what the most appropriate models are and how to use them effectively. Many types of models exist, each for specialized uses and distinct goals (Starfield et al. 1997; Roloff et al. 2001). For example, there are statistical species-habitat regression models used to describe the survivorship and habitat affinities for species (Verner et al. 1986). There are also more theoretical habitat models for identifying habitat use and species requirements, such as reaction-diffusion (Bevers and Flather 1999). Population and predator prey models are available (Savill and Hogweg 1998) but may be more of heuristic value. A comprehensive survey of models used in wildlife and their application is provided by Roloff et al. (2001).

Developing and using wildlife-habitat relationship models is one of the best tools used in conservation (Robertson 1986). However, such models are only useful if they include an explanation of their processes, assumptions, strengths, and weaknesses to those who apply those models (Thomas 1986). Although the science of modeling wildlife-habitat relationships is progressing in terms of evaluating, predicting, and determining habitat preferences for wildlife, such models are mostly limited to nesting habitat, roosting habitat, and food abundance. These attributes are critical for wildlife, but they do not reflect the full complement of requirements (Verner et al. 1986) that are necessary for species or population survival.

Clearly, models have become important tools to guide decision making and wildlife protection. However, they may be difficult to apply, lack perceived validity, or prove inconclusive (Verner et al. 1986; Roloff et al. 2001). Some models may be especially difficult to apply to urban and rural areas because they have been developed for wildlife management purposes in large relatively pristine or forested landscapes. GAP analysis and other applicable information gathered from case studies of modeling as management tools in wildlife and habitat protection (Quinn and Johnson 2001) may be applied to protecting local species in King County.

Empirically determined areas necessary to maintain species and their interacting populations (i.e., metapopulations) have not been established until recently. Smallwood (1999) provided an analytical tool using existing population estimates to project areas where species may occur.

Case studies have proposed a method for assessing acreage habitat needs for wildlife survivorship (metapopulations) based on five functionally significant demographic units: (1) adult female; (2) reproductive unit; (3) constrained population; (4) unconstrained population; and (5) metapopulation (Smallwood 2001). Currently in King County, there are only a few species, such as bald eagles, peregrine falcons, and pileated woodpeckers, with enough population data to utilize this method to assess acreage required for species-specific habitat functions. Until biologists have more population and metapopulations data for more species, such methods will remain preliminary and not practicable for species and population conservation.

Adaptive Management (see above) is essential to efficient progress in wildlife-habitat modeling where there are still so many unknowns (see Chapter 9 – Wetlands). Specifically, experiments in conservation and protection planning need to be incorporated into fish and wildlife habitat management in lieu of relying on observational studies alone to guide management. It is through well-designed studies of conservation practices that stronger inferences between wildlife, habitat, and our protection actions can be established. However, linking wildlife and habitat responses to management action may take decades or centuries to recognize, and the associated feedback for conservation improvement may be delayed beyond the life of management issues (Roloff et al. 2001).

8.2.3 Protecting Individual Wildlife Species

To conserve species and populations, a comprehensive approach that protects all habitat needs is required. Buffer zones are useful tools for protecting raptors, for example, during periods of extreme sensitivity (Knight and Skagen 1988; Knight and Temple 1995, both as cited in Richardson and Miller 1997). However, protection of a nest tree or some other specific habitat feature is only a small part of that species' survival needs and, consequently, insufficient if other requirements are not met. Moreover, the presence of a species may provide only minimal information about the quality of habitat or the ability of a species or population to persist. The population must be understood within its daily and seasonal home range and greater landscape context. In some instances, species presence may indicate habitat quality, such as specific species of invertebrates in streams or the spotted owl in old-growth forests. Alternatively, the presence of snags and other favorable habitat features may not ensure the site will be otherwise suitable for snag-dependent or other habitat-dependent species.

A site where a species nests or is otherwise observed may be an ecological sink, which is an area that attracts species or populations, but from which the species don't emerge or don't reproduce successfully. Sinks do not represent habitat for sustainable populations. It has been argued by Foppen et al (2000) that under some circumstances, sinks or small landscape elements that are linked by corridors can promote larger overall metapopulation size, and, therefore, prolong the survival of declining metapopulations. However, sinks are generally considered to not contribute to maintaining populations.

The scientific literature discusses a broad range of habitat conditions and other protection needs for the multitude of wildlife found in King County. The King County Comprehensive Plan policy E-170 directs that King County protect habitats for priority species and other specific priority habitats listed by the Washington Department of Fish and Wildlife. The Comprehensive Plan distinguishes between those species and habitat that "shall be protected" and those that "should be protected." Regardless of which group a species or habitat falls into, protection is to be accomplished through regulations, incentives, or purchase. Below is a brief discussion on the life history needs of ten of the wildlife species whose habitats are to be protected as Wildlife Habitat Conservation Areas. After the discussions of the ten species, the remaining species whose habitats “shall” be protected (as per the Comprehensive Plan) are collectively presented in Table 8-1, and the species whose habitats “should” be protected are collectively presented in Table 8-2. Specific priority habitats that should be protected in King County are also discussed below.

Knowledge of life histories is useful for helping predict community responses to landscape change (Hansen and Urban 1992). Marzluff and Ewing (2001) state that a detailed understanding of each species in a community is important for effective management. Individuals of the ten species discussed below may spend a critical portion or all of their life histories in an area of King County that is affected by the County’s proposed CAO. These ten species were singled out for explicit language in the CAO because of one or more of the following reasons: (1) they are federally listed as threatened; (2) they are most easily identifiable; or (3) they are most likely to be encountered in King County nesting in the same location for more than one year.

Each species has essential breeding, nesting, denning, roosting, foraging, hibernation, migration and other living habitats (e.g., jointly referred to as its home range), all of which are characterized by individual and population needs. Nesting, denning, and other breeding areas are strongly defended areas and are acknowledged territories and important to individual reproduction and fitness. Foraging, migration, and other habitats extend beyond defended territories and even home ranges and are required for population health and survival. These extended habitats are essential to dispersal, colonization, gene flow, and other aspects of population demography that benefit the long-term (i.e., evolutionary) success of a species (Bunnell and Harestad 1983).

Spotted Owl

The northern spotted owl is a year-round resident throughout forested portions of western Washington at elevations generally below 5,000 feet (Thomas et al. 1990, 1993). In the Pacific Northwest, this species typically nests in old-growth forest or mixed forests of old-growth and mature trees that are multi-layered with an overstory of large old-growth trees and one or more understory layers of smaller trees (Forsman and Meslow 1986). Within these forests, spotted owls nest almost exclusively in trees in cavities or on platforms made of debris such as sticks and needles; none of the owls build their own nests (Forsman et. al. 1984).

Although the spotted owl may be found in varied structural types and age classes of forests, old-growth forest is considered to provide roosting, nesting foraging, and dispersal habitat for the species. The Washington Administration Code (222-16-085) has defined suitable spotted owl habitat for nesting, roosting, foraging, and dispersal. This habitat consists of the following characteristics: (1) a canopy closure of 60 percent or more and a layered, multispecies canopy where 50 percent or more of the canopy closure is provided by large overstory trees; (2) three or more snags or trees 20 inches dbh or larger and 16 feet or more in height per acre with various deformities such as large cavities, broken tops, dwarf mistletoe infections, and other indications of decadence; and (3) more than two fallen trees 20 inches dbh or greater per acre and other woody debris on the ground.

Spotted owls typically forage at night by sitting on elevated perches and diving on their prey, which includes a variety of mammals (especially arboreal and semi-arboreal), birds, and insects

(Forsman and Meslow 1986). Established pairs typically remain in the same territories from year to year, and foraging areas may exceed 2,470 acres (1,000 hectares) (Forsman et al. 1884; Thomas et al. 1990). Forsman (1980, 1981) documented that foraging areas ranged from 1,350 to 8,350 acres (546-3,379 ha). Territory sizes are 100-340 acres (40-138 ha) with an average of 230 acres (93 ha) (Brown 1985).

Forest management activities, particularly the removal of old-growth forest and disturbance of nest sites, are believed to be the single greatest factor for spotted owl population declines (Forsman et al 1984).

Peregrine Falcon

Hayes and Buchanan (2002) summarize peregrine falcon natural history and population and habitat status in Washington State. The following summary is taken from their report for Washington Department of Fish and Wildlife, and some but not all references were reviewed by King County for accuracy of citation.

Peregrine falcons occur year-round in Washington as either nesting or migrating individuals. Primary nesting locations in Washington include the San Juan Islands, lowlands of the northern Puget Sound, and along the outer northern coast of western Washington. Nesting also occurs in the forested slopes of the Cascade Mountains (Hayes and Buchanan 2002). Within coastal areas of Puget Sound, peregrine falcons typically nest and roost on cliffs that are between 45 feet (15 m) to about 770 feet (235 m) in height, provide unobstructed views of the surrounding landscape, and are in close proximity to water (WDFW 2002). In forested upland regions of Western Washington, the species has been found to nest at elevations exceeding 1,000 feet (Hayes and Buchanan 2002). In urban areas, peregrines will rarely nest on tall buildings and bridges (White et al. 1988, as cited in Hayes and Buchanan 2002), vegetated slopes, and very rarely in trees (Pacific Coast American Peregrine Falcon Recovery Team 1982).

In natural landscapes, foraging habitat for the species includes open areas with a high abundance of potential prey, such as marshes, lakes, meadows, river bottoms, and coastlines (Hayes and Buchanan 2002). In cities they feed on rock doves (pigeons) and other urban wildlife.

Breeding peregrines are most likely disturbed by activities taking place above their nest (Herbert and Herbert 1969; Ellis 1982). In studies that occurred in Arizona, recommended buffer zones of no-human activity around peregrine falcon ranged from 0.8 km to 4.8 km (0.5-3.0 mi.), with wider setback zones recommended for activity above the breeding cliff (Ellis 1992). In Washington, it is recommended that human access along the top of the nesting cliff should be restricted within 0.8 km (0.5 mi.) of the rim from March through the end of June (Hayes and Buchanan 2002). Other factors including human disturbance associated with recreation, such as rock climbing, has also impacted and continues to impact the species (WDFW 2002). Human activities on the face of or immediately below nest cliffs should be restricted within 0.4-0.8 km (0.25-0.5 mi.) of nest during breeding (Ellis 1982). Additionally, power lines, guy wires, or other similar facilities or structures should be routed away from nests. These facilities or structures should not be established within 0.4-0.8 km (0.25-0.5 mi.) of nests (Ellis 1982).

Historically, population declines of the peregrine were mainly caused by pesticide pollution (particularly DDT), which led to eggshell thinning and low hatchling success (Cade et al. 1988; Snow 1972; Peakall 1974). The threat of DDT and other organochlorine pesticides has been largely reduced because they were outlawed in the United States; however, peregrines are still affected by chemical contamination resulting from consuming prey species that winter in countries that use DDT and other organochlorine pesticides (Henney et al. 1982; Stone and Okoniewski 1988). Application of regulated pesticides that could potentially affect passerine birds such as organochlorines, organophosphates, strychnine, and carbonfuran, should not be used around occupied peregrine nests during the breeding season. In addition, wetlands, estuaries, and other potential foraging areas should be preserved, and large trees should be maintained where peregrine falcons feed.

Vaux's Swift

Vaux's swifts are summer residents in Washington, and in this state are found in Douglas-fir forests, especially in old-growth stands (Manuwal 1991). The best variables for predicting Vaux's swift occurrence in NE Oregon were number of dead trees ≥51 cm and number of trees with conks of Indian paint fungus (Bull and Hohmann 1993).

In an Eastern Oregon study, most swifts were found to arrive to nest in late April and early May and depart from mid-August to early October (Bull and Collins 1993b). There is strong breeding site fidelity, with the same birds using the same nest tree for consecutive years (Bull and Collins 1993). Therefore, protecting a nest tree likely will serve to provide nesting habitat for several years if the birds don't abandon the area.

Vaux's Swifts are positively associated with old-growth forest (Bull and Hohmann 1993) and may be the only diurnal bird that depends on old-growth for its continued survival (Manuwal 1991). Nest sites are likely to be critical limiting resource for this species, which are colony nesters (Manuwal 1991). Only large-diameter hollow trees can accommodate swifts (Bull and Blumton 1997), and as such, suitable roost trees are most likely to occur in old-growth stands (Bull 1991).

The average dbh and height of roost trees were 77 cm (range = 47-110 cm) and 26m (range = 9-40 m), respectively, and are entered through pileated holes, other woodpecker holes, or broken tops (Bull and Blumton 1997). A number of roosts are necessary if some of the chambers are not big enough to contain a large number of swifts. Additionally, if a predator is at one roost, the swifts may need to use another (Bull and Blumton 1997).

Swifts are aerial insectivores, and during breeding season, they forage exclusively in the air, pursuing insects on the wing. Important nest stands (tree stands adjacent to the nest) have a high density of insects. Swifts may spend a large portion of their time foraging over aquatic areas and wetlands. Even in areas of relatively little open water, Bull and Beckwith (1993) observed birds spending 27 percent of time over water, though only 2 percent of study area had open water.

Radio-tagged swifts foraged up to 3.4 miles (5.4 km) from the nest. (Bull and Beckwith 1993); however, foraging swifts spend approximately half their time within a quarter mile (0.4 km) of the nest stand (Bull and Beckwith 1993). When using roost trees other than the nest tree, juvenile Vaux's swifts roosted an average of 3.3 km (range = 0.3-9.2) from nest tree and adults roosted an average of 1.5 km (range = 0.1-9.2) from nest tree (Bull and Blumton 1997).

Key management elements for protecting Vaux's swifts are to maintain large diameter hollow trees and snags (e.g., >20 inches, or 50 cm, dbh), recruit future suitable nest and roost trees, and maintain a high density of large live trees (e.g., >39 inches, or 100 cm, dbh). Presence of tree heartrot, fire, woodpeckers, and other ecological components that create tree cavities and nest holes will benefit this species (Bull and Collins 1993).

Marbled Murrelet

Marbled murrelets are small sea birds (weighing about 7 ounces) that nest in old-growth forests. Most murrelets nest within 37 miles (60 km) of saltwater, and no further than 62 miles (100 km) (Hamer 1995; Miller and Ralph 1995). Breeding birds are likely to be in nesting habitats from mid-May through end of July (Bentivoglio et al. 2002).

Important forest attributes in Washington for murrelets are old-growth forest and stand size (Raphael et al. 1995). Murrelets use old-growth (>81 cm dbh) forest (Hamer 1995): mean stand age in Pacific Northwest is 522 years (range of 180-1,824) (Hamer and Nelson 1995), and stand age of 6 trees in Washington ranged from 450-1736 years (mean of 879). However, the structure and processes occurring within stand appear to be more important than stand age (Grenier and Nelson 1995)

The best predictor of stand occupancy in Washington was found to be a measure of potential nest platforms, not tree size (Hamer 1995). Mistletoe blooms, unusual limb deformations, decadence, and tree damage all appear to create a large number of nest platforms, and platforms are generally available when tree diameters exceed 76 cm (Hamer 1995). In Washington, Hamer (1995) found that the quality of a site as nesting habitat for murrelets would be reduced if land management activities reduce or affect the number of potential nest platforms/ha; the composition of low elevation conifers; moss cover on tree limbs; stem density of dominant trees (≥81cm dbh); and canopy closure.

Hamer and Nelson (1995) found the important attributes in old-growth forest in Washington to be nest platforms, moss cover, slopes (in Pacific Northwest, nests located on slopes of moderate gradient, with a mean of 23 percent), and stem density (mean density of large trees [>46cm dbh] of 93.8/ha). The presence of breeding marbled murrelets was most related to "availability of low elevation, unfragmented old-growth forests within the fog zone that were close to highly productive marine areas" (Meyer et al. 2002). In Washington, all records of nests, eggs, eggshell fragments, and downy chicks have been associated with old-growth forests (Hamer and Nelson 1995).

Marbled murrelets are likely limited by availability of suitable habitat; therefore, available habitat is likely already occupied (Ralph at al. 1995). This theory would suggest that if habitat suitable for marbled murrelet nesting remains in King County, murrelets are occupying it. Additionally, although fragmentation and isolation of old-growth forest had an adverse effect on both murrelet occupancy and abundance, the effects of fragmentation were not immediate (Meyer et al. 2002).

Raphael et al. (2002) estimated that murrelets on the Olympic Peninsula use more than approximately 370 acres (150 ha) of nesting habitat per bird; however, it appears some birds may nest closer than that, possibly in relative "clumps." Indeed, Meyer et al. (2002) found that no occupied plots were >6.8 miles (11 km) from another occupied or flyover plot.

Singer et al. (1995) observed that incubating marbled murrelets did not show visible reaction to loud talking, yelling, or passenger vehicle noise. However, human food scraps left by passers-by might attract corvids, which prey upon murrelets.

Townsend's Big-Eared Bat

Townsend's big-eared bats are year-round state-wide residents of Washington, but may according to WDW (1994), they be "the most imperiled species of bat in Washington and may be threatened by extinction within this state (Senger and Crawford 1984; WDW 1991, 1993). Their extreme intolerance to disturbance cannot be overstated (Senger and Crawford 1984; Nieland 1990, 1991)."

Townsend's big-eared bats may roost in caves, mines, buildings, bridges, tunnels (Pierson and Rainey 1998), though most known group hibernating sites are in structurally stable caves. Their colonies in caves may range from a dozen to 200 individuals (Barbour and Davis 1969, as cited in WDW 1994). They hang from walls and ceilings in open areas (Pierson and Rainey 1998), generally 6-9 feet off the ground (Perkins 1990). Their maternity period is between April and mid-September and their hibernating period is November through February (Pierson and Rainey 1998). The bats aggregate in spring at nursery sites and give birth to single young in late spring or early summer (Pierson and Rainey 1998), and nursing colonies are intact until young are independent in late summer or early fall.

Roost criteria in a California study used to evaluate suitability as nursery sites (Pierson and Rainey 1998) included an entrance no smaller than 15 cm high by 31 cm wide, a semi-dark to dark interior large enough for flying forays, with a temperature between 18 and 30 degrees C, within 5 miles (8 km) of water, and free from human disturbance. Most sites are characterized by strong to moderate air flow (Humphrey and Kunz 1976).

In addition to natural caves, abandoned mines are also used. In a Utah study, Sherwin et al. (2000b) found that approximately one-quarter of all abandoned mines surveyed were used as day roosts; therefore, they determined the mines to be "an important resource that may be critical to the long-term viability of local populations."

Colonies appear to have alternative roosts (Pierson and Rainey 1998; Graham 1966) and they also appear to change roosts as the season progresses (Pierson et al. 1991). Pierson et al. (1999) recommend that roosting patterns should be investigated, and all sites used within the maternity season should be protected. Site fidelity is strong: if undisturbed, this species will use the same roosts indefinitely (Sherwin et al. 2000a; Pierson and Rainey 1998; Pearson et al. 1952; Graham 1966). However, mere presence of people causes this species to desert preferred and alternative roosts (Humphrey and Kunz 1976). In a study by Graham (1966), it was observed that as caves were visited by humans, nursery sites were abandoned. And over time, even without subsequent human disturbance after abandonment, the bats did not return.

Microclimate variables "are important determinants of whether a site is appropriate as a roost location for maternity colonies of bats" (Betts et al. 2000). Temperature changes in caves may result from the removal of forested vegetation outside the entrance (Piersen et al. 1999). Perkins (1985) recommends each nursery site and hibernaculum have at least a 450-ft harvest-free buffer in all directions and Piersen et al. (1999) recommend retaining a buffer zone with a minimum of

500 foot horizontal radius maintained around roost entrances, as well as maintaining or improving riparian and wetland habitats within 10 miles of roosts to achieve healthy and diverse structure.

Several authors and experts (as cited in Pierson and Rainey 1998) suggest that movement during the nursery season, either for foraging or shifting to an alternate roost, is confined to within 9 miles (15 km) of the primary roost. Likewise, seasonal movements to hibernacula appear to be limited to the immediate area. The bats may not move more than 1.2-5 miles (2-8 km) between nurseries and hibernacula (Humphrey and Kunz 1976). Dobkin et al. (1995) female big-eared bats in central Oregon used a series of interim roost sites over a period of up to two months between hibernation and moving to their maternity caves.

Hibernacula for Townsend's big-eared bats are caves or cave-analogous structures such as mines. Additional hibernacula requirements (Pierson and Rainey 1998) are that they are L-shaped, which generates a "cold sink" with good air flow (Pierson et al. 1991), and that they are free from human disturbance. The bats often roost near entrances, which make them more vulnerable to disturbance (Humphrey and Kunz 1976). Perkins et al. (1994) similarly found that the bats preferred hibernating roost sites in caves or mines with discernible air flow (usually the result of multiple entrances).

In a coastal California study (Fellers and Pierson 2002), primary foraging habitat appeared to be riparian woodland: "The animals followed densely vegetated gullies when dispersing from the main roost, and spent the majority of their foraging time within a forested habitat."

The big-eared bats forage primarily on moths, and most terrestrial moths lay eggs and feed on shrubs, trees, and flowering plants (Smith pers. comm., as cited in Piersen et al. 1999). Perkins (1985) recommends that aerial spraying of insecticides, herbicides, or any chemical be banned within 1 mile (1.6 km) of caves during any season, because the bats may glean insects from foliage; "If they do glean, herbicide ingestion would be detrimental to maintaining a viable population." However, Fellers and Pierson (2002) note that they did not observe these bats hovering or obviously pausing as would be expected if they were gleaning.

Big-eared bats in a central Oregon study (Dobkin et al. 1995) moved up to 15 miles (24 km) from hibernacula to foraging areas, although the distances moved from interim day roosts to foraging areas were typically 1.2-5 miles (2-8 km) prior to breeding season. Dobkin et al. (1995) note that the "data demonstrate that the actual area of concern for management of individual populations is considerably greater than indicated solely by locations of hibernacula and maternity caves." Despite Perkins' (1985) recommendation to ban aerial insecticides within 1 mile of caves, these data indicate that aerial insecticides should be banned from a larger area of 1.2-5 miles, and possibly as much as up to 15 miles.

Pierson and Rainey (1998) point out that "immediate steps should be taken to protect key maternity sites, particularly on public lands. In many cases adequate protection could be accomplished by gating the roost entrance, using a gate design that excludes people but allows bats to pass through (Pierson et al. 1991). Although appropriate gate design is essential, it is not sufficient. Gates must also be maintained, and human traffic prohibited during the critical maternity or hibernating seasons….Regulatory agencies need to be informed of the extreme importance of both caves and anthropogenic structures, such as mines, as roosting habitat for *C townsendii* and other bat species."

Sherwin et al. (2000a) implores managers to account for the potentially dynamic nature of roosts when attempting to protect actual roosts, because it is possible that critical roosts may not be continuously occupied. They found that in most cases, sites that proved to be actual roosts contained signs of use (guano, discarded moth wings, etc.) even when the bats were not present. Therefore, they propose that researchers should protect sites based solely on 'sign' of use and not 'occupancy at time of survey' (Sherwin et al. 2000a).

In Utah, Sherwin et al. (2000a) found that it took an average of 8.3 surveys during a single season to determine with a 90 percent probability that a given mine was not an actual roost, and it took a minimum of 3.4 surveys to eliminate a mine as a maternity roost. It took 3.2 surveys to eliminate a cave as a roost site, and it took an average of 7.6 surveys before a site could be eliminated as a hibernation roost. These data indicate that one site visit cannot be relied upon to definitively reveal whether bats are using a cave during various stages of their life history.

Osprey

Osprey are relatively large raptors that eat fish almost exclusively. They are summer residents in Washington State (Rodrick and Milner 1991).

Nest site availability might be one of the greatest limiting factors for osprey reproduction (Ewins 1997). Although it appears that osprey usually nest close to water, they may nest in such close proximity not only to maximize foraging opportunities while minimizing energy expenditure, but because some of the only remaining suitable nest trees may be close to water (e.g., trees are left standing along shorelines as visual buffer for recreationists; Ewins 1997).

Nest site selection today seems to depend on the availability of clear aerial access to the nest, strong side branches, proximity to water, avoidance of mammalian predators and bald eagles, and the characteristics of the surrounding stand (Ewins 1997). Osprey tend to select trees that are higher than the surrounding canopy. They often nest in snags or dead-topped trees, and many times, these trees are in wetlands created by beavers. Though it has not been quantified, it is likely that reductions in beaver populations have affected the availability of preferred osprey nest sites (Ewins 1997).

Their home ranges extend 4-6 miles (6-10 km) from their nests (Brown 1985). In an Idaho study, Van Daele and Van Daele (1982) found greater productivity for nests more than 1,500 m from human disturbance.

Swenson (1979) noted that different authors had reported varying results of human disturbance on osprey reproduction. He suggests that the variability in results might in part be due to the degree of osprey's habituation to humans, and that if humans are already present during the onset of nesting, their continued presence might not be detrimental to nesting success. Levenson and Koplin (1984) found that after nesting begins, a substantial increase in human activity such as logging has significant adverse effects on productivity. Because so little is known about how osprey respond to factors associated with timber extraction at different scales and time frames, Ewins (1997) points out the need for a systematic study of nesting ospreys in relation to different forest management activities.

Regarding the effects of human disturbance on nesting osprey, Ewins (1997) says:

> The influence of human disturbance of Ospreys at their nest seems to vary according to whether the birds are already used to human presence or not, whether the disturbance is regular from the onset of the nesting season or if it commences during a sensitive stage such as the incubation or small chick stage (Swenson 1979; Poole 1981; Van Daele and Van Daele 1982; Levenson and Koplin 1984)….reduced breeding success is often experienced by birds disturbed after nesting has begun, particularly in remote areas or where little or no human disturbance has occurred earlier in the season (Swenson 1979; Levenson and Koplin 1984; Poole 1989).

An Osprey Habitat Management Plan that was adopted in California's Lassen National Forest in the 1970s (Garber et al. 1974). Although the plan was written over 30 years ago, it is interesting to note that the writers were aware of the osprey's large-scale requirements. The plan's components included: (1) Leaving timber and snags within 200 feet of water frequented by breeding ospreys; (2) leaving at least 2 snags and 2 dominant live trees per acre within a quarter mile of osprey nests; (3) leaving all suitable broken-top live trees and snags within 2 miles of the nest; (4) leaving 3-5 trees for roosting and potential nest trees within an eighth-mile of a nest; and (5) timbering activities within an eighth-mile of a nest were to be altered to produce the least amount of disturbance from April 1 to August 15.

Rodrick and Milner (1991) present management recommendations for osprey based upon a literature search. The following summary is taken from their review for Washington Department of Fish and Wildlife, and some but not all references were reviewed by King County for accuracy of citation.

- Restrict all human activities within 660 feet (201 m) of any active osprey nest from April 1 to October 1.
- Do not cut trees within a 200-foot (61 m) radius of individual osprey nests. This radius may be reduced to 130 feet if topography or screening vegetation limits visibility of the nest and retains at least one snag or perch site for each pair. Beyond the 200-foot (61 m) no-cut zone, retain 3-5 live or dead dominant trees immediately suitable for nesting or roosting, and some healthy young trees suitable for future roosting or nesting within a 660-foot (201 m) radius of the nest tree (Zarn 1974).
- Where osprey nests are located along a lake or marine shoreline, attempt to retain a 200-foot (61 m) terrestrial buffer around water bodies in which timber and snags are not cut (Zarn 1974; Westall 1986). Beyond the 200-foot (61 m) no-cut zone, maintain at least two dominant live trees and two desirable snags per acre within an additional, restricted-cutting zone of 1,100 feet (335 m) (Zarn 1974; Westall 1986).
- Ospreys unaccustomed to human activities should be protected from disturbance. Roads should be closed between April 1 and September 15 if they are located within 660 feet (200 m) of a sensitive (unhabituated) pair. In remote areas, campsites should not be located within 0.7 mile (1.1 km) of occupied nests and hiking trails should not come within 300 feet (91 m) of the nest tree.
- Manage and protect marine, estuary, lake, and stream and riparian habitat to provide adequate food abundance for nesting ospreys (Vana-Miller 1987).
- Fish control projects using rotenone applications should not be undertaken in waters where ospreys hunt unless temporary alternative food sources are available.

- In urban or rural areas where suitable nest trees are lacking and no suitable structures for nesting occur, consider building artificial nesting platforms for ospreys if abundant and suitable foraging habitat is nearby and no bald eagles are nearby. Nesting structure can be either a temporary solution until shoreline trees regenerate or permanent if competition with eagles prevents the use of suitable trees. Nest platforms can also be an effect means of luring pairs away from problem nest sites (Poole 1989).

Northern Goshawk

Northern goshawks typically nest in old-growth forests. Results from a study on the Olympic Peninsula by Finn et al. (2002b) indicate that goshawk use of the landscape will be maximized where at least 54 percent of their home range is late-seral forest and no more than 17 percent is conifers under 7 years old.

The mean number of nest actually used in a breeding season in a study by Woodbridge and Detrich (1994) was 2.6 (+/-0.42). The reoccupancy rate was low (44 percent from the previous year). Woodbridge and Detrich (1994) found that "reoccupancy of alternate nests was highly variable; at some territories goshawks did not re-use the same nest twice in 4-7 years, whereas others used a single nest for 2-6 years and then moved to or built another." They also observed that 4-6 years of monitoring were required to adequately define the area used for nesting within most territories.

In the same study, goshawks typically used 3-9 alternate nests distributed among 1-5 different forest stands ranging from 10 to 284 acres (4 to 115 ha), and showed low fidelity to individual nest trees or stands (Woodbridge and Detrich 1994). Woodbridge and Detrich observed that "alternate nest sites within most territories appeared as clusters, spatially distinct from nest clusters at neighboring territories." Territories in this study were positively correlated with the larger remaining patches of mature forest, and they suspect that patch size may be an important factor in determining the quality of nesting habitat.

Nest sites in a study by Speiser and Bosakowski (1987) were significantly further from human habitation than random sites (furthermore, random sites within 0.28 miles (1,500 ft; 0.45 km) of human habitation were rejected from their analysis). Goshawks in this same study nested in relatively close proximity to wetlands. Speiser and Bosakowski (1987) observed that the presence of conifers may help determine nest site selection. Conifer presence may be tied to regulation of microclimate within a forest stand. Results from Speiser and Bosakowski (1987) were corroborated with other newer studies (Desimone 1997; McGrath 1997, Squires and Ruggiero 1996, as cited in Finn et al. 2002a) that overstory canopy is an important feature of goshawk habitat. Finn et al. (2002a) found that stand-wide overstory depth was valuable in predicting goshawk nest-stand occupancy.

Reynolds et al. (1992) recommend maintaining 3 suitable goshawk nest areas of at least 30 acres (12 ha) each per nesting goshawk pair's range. In addition, 3 replacement nest areas per home range should be in a development phase to replace stands lost to catastrophic fire or other factors and no harvest should occur in nest stands. In one study, alternate nests were used between years in 17 of 34 territories; mean distance between original and alternate nests was 874 ft (266.4 m) (SD =574 ft; 175 m) (Reynolds 1994).

Crocker- Bedford (1990) found that, between 1985 and 1987, 66 percent of control nests were reoccupied at least once compared with only 12 percent of buffered nests. Occupancy was low in both small (3-6 acres; 1.2-2.4 ha) and large (40-494 ft; 16-200 ha) buffered nests, a result which suggests that the sizes of buffer areas were inadequate.

Alternate nests range from 49-6,778 feet (15-2,066 m) apart (Reynolds and Wight 1978; Woodbridge and Detrich 1994). Mean distance between alternate nests in the southern Cascades of northern California was 896 ft (273 m) (SD= 225 ft; 68.6 m) (Woodbridge and Detrich 1994). Woodbridge and Detrich (1994) also found that goshawks in their study were typically using 3-9 alternate nests distributed among 1-5 different forest stands ranging from 4.1 to 115 ha. Squire and Reynolds (1997) recommend maintaining 1-8 alternate goshawk nests within a nest area.

Post fledging-family areas of 420 acres (170 ha) should be managed to contain a variety of forest conditions and prey habitat attributes for goshawks (Reynolds et al. 1992; Kennedy et al. 1994). Snags, downed logs, and wood debris should be present throughout the area to maintain high prey densities.

Older conifer trees produce more consistent crops of seeds and mycorrhizal fungi, both of which are important food sources for small mammals, which goshawks depend on (Reynolds et al. 1992). Birds are also important prey for goshawks. In addition to forest cover type, other habitat attributes such as stand structure, patch size, landscape features, woody debris, snags, understory vegetation, openings, and canopy closure are important to goshawks and their prey (Graham et al. 1999, as cited in Palis et al. 1999).

Northern goshawk foraging areas are as large as the home range (up to 5,400 acres, or 2,185 ha) and should be maintained with habitat conditions similar to the post fledging-family areas for goshawks but with a more open canopy of 40 percent. Beier and Drennan (1997, as cited in Finn et al. 2002a) reported that goshawks rarely forage near their nests.

Home ranges during nesting season vary from 235-8,649 acres (95-3,500 ha) depending on sex and habitat characteristics (Squires and Reynolds 1997). Home ranges of males are typically larger than those of females (Hargis et al. 1994; Keane and Morrison 1994; Kennedy et al. 1994). Individuals typically enlarge or sometimes shift location of home ranges after breeding (Hargis et al. 1994; Keane and Morrison 1994). Home range of non-breeders is poorly understood but may be larger than those of breeders (Squires and Reynolds 1997).

Timbering activities near nests may cause failure, especially during incubation (Boal and Mannan 1994). Logging activities within 164-328 ft (50-100 m) of nest can cause abandonment, even with 20-day-old nestlings present. Reynolds et al. (1982) recommends leaving a minimum 19.8 acre (8 ha) forest buffer around nests for timber harvest.

Squires and Reynolds (1997) state that “Timber harvest is a primary threat to nesting populations (Reynolds 1989; Crocker-Bedford 1990). Each year nests are destroyed by logging operations, but impacts to nesting populations are unknown; breeding densities may be lowered or individuals may redistribute to adjacent areas….Forest harvest may be compatible with Goshawk management provided that habitat needs are provided at multiple spatial scales (Reynolds et al. 1992). In harvest areas where overstory trees were removed but numerous mature stands were retained, birds still nested approximately two-thirds of the time (n = 14 yr.) and produced typically 2-3 young/nest (Hargis et al. 1994). In California, nesting densities remained fairly high despite fragmentation of mature forests through timber harvest (Woodbridge and Detrich 1994);

however, territories associated with large contiguous forest patches were more consistently occupied compared to highly fragmented stands. In New Jersey and New York, nests were further from human habitation than expected on the basis of available habitat (Speiser and Bosakowski 1987), an observation suggesting that disturbance reduces habitat quality."

Palis et al. (1999) point out that "Habitat patch connectivity is also important to consider. One suggestion is that patches of high quality habitat should not be separated by more than 96 kilometers (recommendation based on known dispersal distances; Graham et al. 1999). Scale is another important consideration. Rather than concentrating on breeding home-ranges, entire ecological units (about 100,000 hectares in extent) need to be managed across vegetation types, land ownership, and political boundaries (Graham et al. 1994). Ecological units need to include a wide variety of forest conditions, from regenerating stands to mature second-growth or old-growth stands (Reynolds et al. 1992)."

To better understand the specific habitat requirements of the goshawk, a variety of additional studies are necessary, such as population size and structure; population trend and rate of population change; age-specific fecundity and survival; life span; mate and territory fidelity; adult and juvenile dispersal; variations in diet composition and prey abundance in various forest types; response of populations to variations in prey abundance; seasonal and annual variations in habitat use (particularly winter habitat selection; Beier and Drennan 1997), in home range size, and in dietary composition; foraging behavior; and activity budgets. In addition, monitoring and inventorying techniques need to be improved, the factor(s) that limit population size need to determined, and forest dynamics, as they relate to maintenance and enhancement of preferred habitat, need to be better understood (Keane and Morrison 1994; Reynolds, et al. 1992).

Great Blue Heron

Great blue herons are state-wide colony nesters. They aggregate in the breeding season to nest in tall trees, regardless of tree species (Quinn and Milner 1999).

Quinn and Milner (1999) present a literature search that describes great blue heron life history, habitat requirements, and management recommendations. The following summary is taken directly from their review for Washington Department of Fish and Wildlife, and some but not all references were reviewed by King County for accuracy of citation.

- To protect colonies from human disturbance, most studies reviewed by Butler (1992) recommended a minimum 984 ft (300 m) buffer zone from the periphery of colonies in which no human activity occurs during the courtship and nesting season (15 February to 31 July). Many authors of these studies, however, make recommendations in the absence of data showing the effects of human disturbance on nesting great blue herons. Moreover, colonies in Washington have been established or continue to persist within 984 ft (300 m) of human disturbance. Following experimental work on the disturbance of nesting great blue herons in Ontario, Canada, Vos et al. (1985) recommended that a 820 ft (250 m) buffer zone (their greatest flushing distance) plus 164 ft (50 m) for a total of 984 ft (300 m) would be suitable to minimize disturbance to nesting great blue herons.
- Quinn and Milner (1999) concur with Butler's (1991) recommendation that activities such as logging or construction should not occur within 3,281 ft (1,000 m) of a colony and no aircraft should fly within a vertical distance of 2,133 ft (650 m) during the nesting season unless those activities can be shown to have no effect on great blue heron fitness.

- Important foraging areas within a minimum radius of 2.5 miles (4 km) of colonies should be protected from development (Hoover and Wills 1987). In addition, each foraging area, particularly those that are intensively used, should have a surrounding buffer zone of at least 328 ft (100 m) (Short and Cooper 1985).
- Buffer zones around great blue heron colonies (984 ft [300 m]) and foraging areas within 4 km (2.5 MI.) of colonies (328 ft [100 m]) should be free of pesticides (Brown 1978; Smith 1987). Suggested buffer widths for insecticide spray application near foraging areas range from 102-1,640 ft (31-500 m) (Kingsbury 1975; Payne et al. 1988; Terrell and Bytnar-Perfetti 1989), but in general buffer widths should increase as the toxicity of the treatment compound increases. Determination of buffer widths should account for pesticide droplet size and volume and meteorological conditions (Kingsbury 1975; Brown 1978; Payne et al. 1988).
- Permanent, year-round minimum protection areas of 984 feet (300 m) from the peripheries of colonies should be established where there are no site specific management plans (Bowman and Siderius 1984; Vos et al. 1985; Buckley and Buckley 1976; Short and Cooper 1985; Parker 1980).
- Large colonies (>50 nests) would likely require more alternative nesting habitat. J. Kelsall (pers. comm.) suggested leaving large nesting trees in the center of an area having 984 ft (300 m) or more of isolation during the breeding season. Several alternative forested stands at least 10 acres (4 ha) in size with dominant trees at least 56 feet (17 m) in height should be left in the vicinity of existing great blue heron breeding colonies (Parker 1980; Jensen and Boersma 1993). Alternative nesting stands should be located 984 ft (300 m) from human activities or development (Quinn and Milner 1999).
- In addition to the information described above by Quinn and Milner (1999), great blue herons were studied in King County by Stabins (2001). Stabins found that the average effective buffer width around active colonies in King County in 2000 was 60 feet (18 m), which is a decline from the mean buffer width in an earlier study by Stabins and Raedeke (1992). In the 1992 study, the mean effective buffer width in King County was 164 feet (60 m). Stabins (2001) ascribes the overall decline to the establishment of new colonies with little or no effective buffers. This finding may suggest that large buffers are not always necessary.

Stabins (2001) found that colonies were more successful if they had more nests, and she surmised that larger colonies are less likely to experience breeding failure. She also found that colony success was affected positively as the proportion of human activity increased. This is a surprising finding that might have to do with the effects of bald eagle predation on the colonies, and a reduced ability of bald eagles to predate upon herons within increasingly urbanized areas. Additionally, it appears that in many cases, heron colonies seem able to habituate to human activity to some degree. Despite the likely increased habituation of herons to humans in King County, no-entry protection of nest stands is still recommended by Stabins (2001).

Bald Eagle

Bald eagles, a state and federally listed Threatened species, breed and winter in Western Washington. They defend breeding territories, which include the active nest, alternate nests, preferred feeding sites, and perch and roost trees (Stalmaster 1987).

Watson and Rodrick (2001) present a literature search that describes bald eagle life history, habitat requirements, and management recommendations. The following summary is taken directly from their review for Washington Department of Fish and Wildlife, and some but not all references were reviewed by King County for accuracy of citation.

- The critical breeding period for Washington's bald eagles begins with courtship in early January and ends with juvenile dispersal in mid- to late-August (Watson and Pierce 1998; S. Zender pers. comm.).
- Maintaining tree and stand structure, and maintaining adequate distances between habitat alterations and nest trees, are the key factors for managing habitat near breeding eagles in Washington. The long-term goal in managing habitat alterations is to maintain suitable nest and perch trees within existing territories to insure their continued occupancy by bald eagles (Stinson et al. 2001).
- Buffers between 330-4,000 ft (100-1,200 m) have been recommended throughout the United States to protect the integrity of nest trees and stands (Mathison et al. 1977; U.S. Fish and Wildlife Service 1982, 1986; Fraser et al. 1985; Anthony and Isaacs 1989; Grubb and King 1991; Grubb et al. 1992). Buffer zones of 800 ft-1,000 ft (250-300 m) have been recommended in perching areas where little screening cover is present (Stalmaster and Newman 1978). Nests and nest trees must be protected year-round, because bald eagles typically use and maintain the same nests year after year.
- The three main factors affecting the distribution of nests and territories are: (1) nearness of water and the availability of food; (2) the availability of suitable nesting, perching, and roosting trees; and (3) the number of breeding-age eagles in the area (Stalmaster 1987). An adequate, uncontaminated food source may be the most critical component of breeding habitat for bald eagles (U.S. Fish and Wildlife Service 1986; Stalmaster 1987). Breeding eagles in Washington primarily consume live or dead marine and fresh-water fishes and also waterfowl and seabirds. Secondary food sources include mammals, molluscs, and crustaceans (Retfalvi 1970; Knight et al. 1990; Watson et al. 1991; Watson and Pierce 1998).
- The maintenance of high tree density and moderate canopy closure are recommended in Washington to visually buffer bald eagle nests from human activities. In Washington, Watson and Pierce (1998) found that complete vegetative screening around nests dramatically reduced the time and frequency of eagles' responses to disturbance. Partial screening had less of a positive effect, although it did reduce response distance. In the same study, eagles nesting in taller trees at heights >47 m (154 ft) had significantly reduced responses to a walking pedestrian compared to nests that were lower in trees.
- The long-term goal in managing habitat alterations is to maintain suitable nest and perch trees within existing territories to insure their continued occupancy by bald eagles (Stinson et al. 2001).Known bald eagle perch trees and potential foraging perches greater than 51 cm (20 in) dbh and within 75 m (246 ft) of the top of a bank or shoreline should be protected.
- Activities that produce noise or visual effects within 120 m (400 ft) of the edges of communal roost trees or staging trees should be conducted outside of the critical roosting period (November 15–March 15). This corresponds to the time when most eagles begin to arrive in eastern and western Washington, with numbers peaking in December and January and declining rapidly by mid-March (Biosystems, Inc. 1980, 1981; Fielder and Starkey 1980; Garrett et al. 1988; Stalmaster 1989).
- Key roost components included core roost stands, buffer trees, flight corridors and staging trees, and prey bases associated with roosts (Stalmaster 1987).
- Grubb (1980) found an average territory radius of 1.6 miles (2.5 km) in western Washington. Home ranges of 50 pairs of bald eagles throughout Puget Sound averaged 4.2 mi^2 (6.8 km^2)

(Watson and Pierce 1998). Ranges included areas occupied during occasional excursions beyond defended territories. Core areas of intense use averaged 1.5 km^2 (0.9 mi^2) in size. On the lower Columbia River, the mean home range size and minimum distance between eagle nests was 22 km^2 (13.6 mi^2) and 7.1 km (4.4 mi), respectively (Garrett et al. 1993). The distance eagles maintain between adjacent, occupied territories may be important for maintaining their productivity when food resources are limited (Anthony et al. 1994).

- Additionally, Stinson et al. (2001) recommends protecting salmon habitat and populations (particularly chum salmon runs) in King County and the Puget Sound region (see Chapter 7 – Aquatic Areas). Chum salmon are the most important source of carcasses present during periods of high densities of foraging eagles. Chum salmon spawn in large numbers in mainstem rivers, attracting large concentrations of foraging eagles. Coho salmon and steelhead also provide large numbers of carcasses in the more widely dispersed tributary and off-channel spawning sites. Lake Washington sockeye are utilized in a limited but increasing fashion by bald eagles (Stinson 2001). Finally, fish control projects using rotenone applications should not be undertaken in waters where the birds hunt unless temporary alternative food sources are available (WDW 1991a).

Red-tailed Hawk

The red-tailed hawk is the most frequently seen large hawk in the Pacific Northwest. Red-tailed hawks occur and breed in every county in Oregon and Washington (Gabrielson and Jewett 1940; Jewett et al. 1953; Larrison and Sonnenberg 1968; all as cited in Jackman and Scott 1975). It is the only large buteo regularly found west of the Cascades and is the most abundant one east of them (Jackman and Scott 1975). However, there are no estimates of population numbers or densities for these regions.

Red-tailed hawks are diurnal raptors that forage by perching quietly on an exposed snag, rock, or some other elevated perch that affords a view of a large area. Power line supports and telephone poles are used as perches in treeless areas (Jackman and Scott 1975). After sighting potential prey such as a small mammal, snake, or bird, (often at distances of 600 ft or more), they swoop down upon it (Jackman and Scott 1975).

Robbins et al. 1986 (as cited in Preston and Beane 1993) report that breeding populations of red-tailed hawks increased during the period 1965-1979 in nearly all regions of North America, especially Ohio, Kentucky, Wisconsin, Minnesota, California, and British Columbia. Red-tailed hawks are permanent residents of the Pacific Northwest, although there are local seasonal movements. Most of the breeding populations west of the Cascades are probably permanent residents. Mild winter weather west of the Cascades results in an influx of birds from other areas in addition to a large number of over-wintering juveniles (Jackman and Scott 1975).

Red-tailed hawks are one of the earliest breeders in the Pacific Northwest. Jewett et al. (1953, as cited in Jackman and Scott 1975) indicate that nesting starts in March and that young are found during the first half of June. Gabrielson and Jewett (1940, as cited in Jackman and Scott 1975) stated that nest building and repair began in late March and early April, with 15 March being the earliest date for eggs and 23 June the latest.

Nest site characteristics for this species vary widely with vegetation and topography. Preston and Beane (1993) note that "common characteristics of all sites include an unobstructed access to nests from above and a commanding view of the adjacent environment." Nest sites are often tall and in open areas and often close to water. They also note that "typically, several nests from previous years are visited by both members of the pair. Two or more nests are often repaired, and greenery may be placed on these before a single nest is finally chosen (Bent 1937)." Janes (1994) found that "red-tailed hawks abandoned areas with perches at moderate densities (0.3-0.6 perch/ha) more often than expected by chance while preferentially retaining areas with greater perch densities."

Janes (1984b) showed that not only is prey abundance a significant factor in reproductive success, but that the arrangement of hunting perches within a territory was also correlated with reproductive success. Preston (1990) concluded from a study in Arkansas (which corroborated other studies) that raptor foraging distribution represents a response to a suite of environmental factors such as habitat characteristics and prey abundance, and not just prey availability, for example. "Models of predator-prey relationships that assume a direct relationship between prey density and prey capture (e.g., Poole 1974) are probably inappropriate for most raptors" (Preston 1990). Preston and Beane (1993) suggest that the two factors most likely to limit red-tailed hawk populations are nest sites and food supply, and that the relative importance of these factors varies with location and year.

Janes 1984a found that red-tails have a high degree of breeding-site territory fidelity, at least among females. In north-central Oregon (Janes 2003, 1984b) territories of red-tailed hawks remained stable over time, even if the occupants changed. Janes (2003) also found that the number of nesting pairs remained stable in the north-central Oregon study, and in Richmond, British Columbia, Runyan (1987) found that 9 of 11 nests used in the period 1983-1985 were used in each of the three years.

Stout et al. (1998) described and compared red-tailed hawk nesting habitat in urban, suburban, and rural locations in southeast Wisconsin. They found that productivity (defined as one or more fledglings that survive to bandable age, or 20-35 days) did not differ among urban, suburban, or rural nest sites used by breeding red-tails. They also found that natural cover within the macrohabitat area (an area of 48.4 acres [19.6 ha], or 820-ft. [0.25-km] radius) averaged 25.5 acres (10.3 ha) for urban, suburban, and rural locations. These authors recommend that at least 16 percent of urban land be left in natural habitat, and that the natural habitat be composed of 40 percent forest and 60 percent herbaceous cover, and that forested areas should be approximately 22.2 acres (9 ha) to provide suitable nesting woodlots.

In a study in a semi-forested area in Snohomish County (in Western Washington, just north of King County), 35 nests in 27 breeding territories were found in an area 56 mi^2 (145 km^2). No nests were found in conifers, and nest trees were the largest deciduous trees for 328 ft (100 m) in all directions only 31 percent of the time. Six of the nest trees were within 328 ft (100 m) of highways; however, no nest trees were found along railroad right-of-ways. Nesting density in this study area was calculated to be 1 occupied nest tree per 2.8 mi^2 (7.25 km^2). The author also observed that red-tailed hawks sometimes nested within 328 ft (100 m) of human habitation when other areas of potential habitat were unused.

Janes (1984b) evaluated the effects of human activity on red-tailed hawks nesting in north-central Oregon by classifying territories as (1) with and without dwellings, (2) with and without paved roads, and (3) with nests placed within 656.2 ft (200 m) of roads, or not so placed. He reported that "normal human activity" (defined as the presence of dwellings or frequently traveled roads) did not affect red-tailed hawk reproductive success, that the presence of dwellings or frequently traveled roads or the location of nests near roads had no significant effects. He did not, however, study the effects of more obtrusive activities such as clearing and grading.

Few studies have documented the response of red-tailed hawks to development, especially in the Pacific Northwest. Runyan (1987) documented a density of one nest per 1.4 mi^2 (3.6 km^2) in the "rural-urban fringe area" of Richmond, British Columbia, which is 7.5 miles (12 km) south of Vancouver. This average density is higher than those reported in most other studies; however, areas without suitable nesting habitat were arbitrarily excluded from these calculations. Four of the nests they observed were within 328 ft (100 m) of major highways.

A study in New York by Minor et al. (1993) showed that nesting densities of red-tailed hawks in an urban/suburban area did not differ statistically from nesting densities in other studies from non-urban areas. Furthermore, there was no significant difference between the mean productivity of the non-urban studies and the mean productivity in this study. The implication of these two sets of statistics is that with adequate nest sites, red-tailed hawks can maintain populations alongside human-made habitat conditions. It should be noted that the trend of reducing hawk habitat while retaining nesting hawks cannot be sustained indefinitely; however, large data gaps exist that if filled would help determined the threshold of minimum habitat requirements for red-tails before densities and productivity rates begin to decline. Furthermore, the studies above assume that prey is not a limiting factor, although it can be as per Preston and Beane (1993).

In a study by White and Thurow (1985), a group of nesting pairs of ferruginous hawks were subjected to daily disturbances that were designed to simulate those associated with land development on western rangelands. The ferruginous hawk is also a Buteo, like red-tailed hawks. However, unlike red-tailed hawks, their numbers have been declining and it is possible they are more susceptible to human disturbance. They found that the adults, despite the brief durations of the disturbances, deserted 33 percent of the disturbed nests. Their cumulative data revealed that adults did not flush 60 percent of the time if their activities were more than 394 ft (120 m) from the nest, and they did not flush 90 percent of the time if they were more than 820 ft (250 m) from the nest This study was in Idaho in a cold desert environment, with sagebrush as the predominant vegetation. It is possible that in forested areas of King County, these distances could be shorter.

An unpublished document by WDFW (199X) recommends preserving the red-tail's nest tree and at least 1 acre (0.4 ha) of forest around it. This recommendation is based on a study in Missouri, and in that study, 59 percent of red-tails nested in woodlots larger than 1 acre, whereas 33 percent nested in woodlots smaller than 1 acre, and 8 percent were in solitary trees. Based upon the fact that the vegetation and topography of the Missouri Ozarks is different from those of King County, and because these numbers are reports of where nesting red-tails occur, not on how they respond to development, there is considerable uncertainty involved in using these numbers as management recommendations for red-tailed hawks in King County.

In that same document, WDFW also recommended that clearing, grading, construction, and other human activities be restricted around the nest site from February 1 through July 31. These recommendations are based upon various nesting studies throughout the United States. Based upon a personal communication (by Michael Kochert of the Bureau of Land Management), they also recommend a buffer of 650 ft (200 m) around the nest during nesting season for clearing, grading, construction, and other obtrusive human activities. They recommend a buffer of 325 ft (100 m) around the nest for daily human activity such as driving and walking.

Unpublished data by an informal King County monitoring study indicate that buffers of 25-150 ft are not adequate to protect nesting red-tailed hawks. Eleven nests were observed prior and subsequent to clearing and grading with buffer establishment. The fate of two nests went undetermined, one nest was destroyed during building, and two nests remained successful where construction plans were abandoned. The six remaining nests were all deserted. In five of these instances, a buffer ranging between 25 and 150 ft was set, and in two of those cases, the actual buffer was significantly smaller (81 versus 150 ft, and 50-75 versus 150 ft). The sixth nest had no development activity within 650 ft; as with the other nests, it is unknown if the construction activities were the sole cause of nest abandonment. It is also unclear at what time frame construction activities were occurring; however, best times for construction tend to coincide with nesting.

Remaining "Shall" Species

Table 8-1 lists the habitat requirements and suggested protection mechanisms for the remaining species that the Comprehensive Plan says shall be protected. The table is grouped into three scales: (1) the breeding, nesting, denning territory; (2) the adjoining water, feeding, roosting, cover area; and (3) the greater home range.

"Should" Species

Table 8-2 briefly indicates the needs of the species listed in the Comp Plan as "should be protected."

Table 8-1. Best Available Science for maintaining Viable Populations of Listed Wildlife Species that Shall be Protected.

Species	IMMEDIATE HABITAT REQUIREMENTS (NESTING, BREEDING, DENNING)	LOCAL AREA REQUIREMENTS (WATER, FOOD, COVER)	WATERSHED/LANDSCAPE REQUIREMENTS (HOME RANGE OF SPECIES)
Black-backed woodpecker *Picoides arcticus*	• Retain large trees and snags in rural King County and where snags are lacking, create new ones. • Nest cavity for black-backed woodpeckers is usually 2-15 feet (0.6-4.6 meters) above ground, in trees averaging 8-9 inches (21-23 cm) dbh, in forest opening or in dense stand, often near water. Nests usually in a conifer such as pine, spruce, fir, or Douglas-fir (Scott et al. 1977). • Black-backeds may use edge habitats for nesting between coniferous forest and burns, bogs, meadows, or logged areas (Kilham 1966; Raphael and White 1984).	• Minimum habitat: 106 acres (43 ha; Black-backed woodpecker) - 600 acres (243 ha; pileated woodpecker) (Brown 1985). • In rural King County, manage patches of remaining forest and woodlots to include patches greater than or equal to 25 acres (10 ha) widely distributed through each basin with a canopy closure greater than 70%, at least 3 trees greater than 26 inches (66 cm) dbh. Also maintain smaller evenly distributed patches of forest and woodlots between 4 and 12 acres (1.6-4.9 ha) in size to serve as stepping stones and foraging habitat for woodpeckers (Vizyova 1986; Dickman 1987; Tilghman 1987; Herson-Jones et al. 1995). • During thinning and cutting, the following types of trees should be left standing where it is safe to do so: dying trees, trees with heartwood rot, insect-invested trees, and trees with distorted shape or wind breakage (Bull 1987). • Because the average Douglas-fir in Washington will not reach the average size for a pileated woodpecker nest tree until after 100 years, manage nesting areas for long rotations (Conner 1979). Nesting areas should be managed to produce >70% canopy closure.	• Home range: 440 yards (m) from nest (Brown 1985). • In Oregon, home range size for three individual black-backeds was 178, 306, and 811 acres (72, 124, and 328 ha); small home range size was associated with abundant mature/old growth timber (Goggans et al. 1989). • Apparently black-backeds range widely outside of the breeding season in response to food availability, so managing habitat on a landscape (or even regional) scale would be important to the viability of the species (Kilham 1966; Raphael and White 1984). • Management recommendations include, (1) establish woodpecker management areas of approximately 1000 acres (405 ha) in appropriate habitat, with no salvage sales allowed; (2) retain all trees with nest cavities; (3) retain snags in harvested areas; (4) retain veteran trees and a mix of healthy and diseased trees for nesting; (5) for foraging, retain dead patches of trees in a variety of decay stages, especially insect host trees, and those susceptible to future insect occupancy; (6) retain some tall hard dead trees for woodpecker drumming; (7) limit insecticide use in forest habitats (Goggans et al. 1989; Rodrick and Milner 1991; Environment Canada 1997).
Pileated Woodpecker *Dryocopus pileatus*	• Retain large trees and snags in rural King County and where snags are lacking, create new ones. • In harvested areas, leave at least 14 snags greater than 20 inches (51 cm) in diameter at breast height/100 acres (40 ha) to maintain nesting habitat (Neitro et al. 1985). • Areas managed for nesting pileated woodpeckers should be within 492 feet (150 m) and preferably within 164 feet (50 m) of water. • Maintain downed wood and stumps in rural forests and woodlots to attract foraging pileated woodpeckers.	• Retain snags by clustering potential nest trees in small areas or dispersing the trees throughout the territory (Neitro et al. 1985). Dispersing the trees throughout the territory reduces loss to wind, fire, and woodcutters (Rodrick and Milner 1991). • Because of the importance of downed logs as foraging sites, Bull and Holthausen also recommended leaving 100 logs/2.5 acres of preferably 15 inches dbh (100 logs/ha of 38 cm dbh). To provide for nest and roost sites and foraging, they also recommended leaving 8 snags/2.5 acres of preferably 20 inches dbh (8 snags/ha of 51 cm dbh).	• Pileated woodpecker home range: 300-600 acres (121-243 ha), up to a 4 mile (km) radius (Brown 1985). • Within every 12,000 acres (4,856 ha) of dispersal area in a managed forest, manage approximately 900 acre/1,500 acres (364 ha/607 ha) for one pair of pileated woodpeckers with a 450 acre (182 ha) old growth or mature nesting area and an additional 450 acres (182 ha) for foraging. Maintain at least 2 hard snags/acre >12 inches (30 cm) dbh within the nesting area and of these 900 snags, 68 should be >20 inches (51 cm) in diameter. A minimum of 2 hard snags/acre >10 inches (25 cm) in diameter should be maintained in the additional 450 acre (182 ha) foraging area (USDA Forest service 1986; Mellen 1987). • In various areas, pileateds reported as requiring forest patch sizes of at least 49-173 acres (20-70 ha), unless other forested areas are nearby (Bushman and Therres 1988). Dispersal distances need to be known and considered when planning any preserve or management area, and data from birds in similar habitats within the region should be used for planning purposes. Dispersal data are scant at present, based on recoveries of banded birds in New York (20 miles, or 32 km, from site of banding) and Alberta (10 miles, or 16 km), and from detailed studies of banded and radio-equipped birds in Oregon in which birds nested from 0.4-5.4 miles (0.7-8.7 km) from their natal site (Bull and Jackson 1995). • Based on home range and habitat use data from the Pacific Northwest, Bull and Holthausen (1993) recommended increasing the size of management areas to 900 acres (364 ha) and increasing the number of management areas per forest.
Golden Eagle *Aquila chrysaetos*	• Construction activities, trail use, camping below active golden eagle eyries, and climbing on nest cliffs should be restricted in a 2,625-foot (800 m) radius around known nest sites during the nesting period of January 15 to July 15 (Rodrick and Milner 1991).	• Golden eagle home range: 4 mile (6.4 km) radius (Brown 1985) • Timber harvest in managed forests should be designed to maintain a distribution of different seral stages within drainage basins, including regions of mature or old-growth timber suitable for eagle nesting. Manage mature forests to provide accessible open-branched trees near known golden eagle nests for alternate nesting platforms (Rodrick and Milner 1991).	• Golden eagle territory size: 5.5-8 mi^2 (8.9-12.9 km^2) (Brown 1985)
Merlin *Falco columbarius*	• Maintain at least a 300 foot (91 m) no-cut buffer around known merlin nest sites when they are discovered. • Human activities, such as development, logging, recreation, camping, hiking, or other disturbances should not occur within 1,200 feet (366 m) of active merlin nests from March 15 through July 30 (Bechert and Ball 1983; WDW 1989).	• Protect important shorebird habitats as a vital source of winter prey for merlins (WDW 1989).	

Species	IMMEDIATE HABITAT REQUIREMENTS (NESTING, BREEDING, DENNING)	LOCAL AREA REQUIREMENTS (WATER, FOOD, COVER)	WATERSHED/LANDSCAPE REQUIREMENTS (HOME RANGE OF SPECIES)
Black Crowned Night Heron *Nycticorax nycticorax*	• Maintain a minimum 984 foot (300 m) buffer zone from the periphery of colonies in which no human activity occurs during the courtship and nesting season (February 15 to July 31) (Butler 1992; Vos et al. 1985; Rogers and Smith 1995; Quinn and Milner 1999; Skagen et al. 2001). • Establish permanent, year-round minimum protection areas of 984 feet (300 m) from the peripheries of colonies where there are no site specific management plans (Bowman and Siderius 1984; Vos et al. 1985; Buckley and Buckley 1976; Short and Cooper 1985; Parker 1980). All human activities likely to cause colony abandonment should be restricted in this buffer between February 15 to July 31 (Quinn and Milner 1999). • Activities such as logging or construction should not occur within 3,281 feet (1000 m) of a colony during the nesting season (Butler 1991; Quinn and Milner 1999).	• Protect important foraging areas within a minimum radius of 2.5 miles (4 km) of colonies from development (Hoover and Wills 1987). Each protected foraging area should have a surrounding buffer zone of at least 328 feet (100 m) (Short and Cooper 1985; Hoover and Wills 1987). Human activities should be minimized in these buffer zones.	• Fish control projects using rotenone applications should not be undertaken in waters where the birds forage unless temporary alternative food sources are available. • The use of organochlorine, organophosphate, and carbamate insecticides should be avoided near great blue heron colonies and upland/wetland foraging habitat (McEwen et al. 1972; Grue et al. 1983; Smith 1987 as cited in Quinn and Milner 1999). Pesticides and herbicides are also toxic to fish and amphibians, which are the primary prey of herons. The use of any insecticide (Smith 1987 as cited in Quinn and Milner 1999) or herbicide (Santillo et al. 1989) should be avoided in great blue heron nesting or foraging habitat unless it has been shown to have no effect on the fitness of great blue herons or their prey species (Quinn and Milner 1999). Buffer zones around heron colonies and foraging areas within 2.5 miles (4 km) of colonies should be free of pesticides (Brown 1978, Smith 1987 as cited in Quinn and Milner 1999). Buffer widths for insecticide spray application near foraging areas should range from 102 to 1,640 feet (31-500 m), depending on the toxicity of the treatment compound (Kingsbury 1975; Payne et al. 1988; Terrell and Bytnar-Perfetti 1989).
Purple Martin *Progne subis*	• Protect any known hollow piling used as nest cavities by purple martins.		
Yellow-billed cuckoo *Coccyzus americanus*	• No longer breeds in Washington (Rodrick and Milner 1991). • Dense foliage, especially within 30 feet (9 m) of the ground is the most important habitat component of yellow-billed cuckoo habitat (Gaines and Laymon 1984), with cuckoos requiring larger patches of riparian habitat than other birds of similar size that use shrubby riparian habitat. • Cuckoos in California are generally found only in riparian habitat over 300 feet (91 m) wide and over 4 acres (1.6 ha) in size (Gaines and Laymon 1984). In California, cuckoos are absent where water is over 330 feet away. Breeding birds in California are usually found in intact riparian woodlands of over 100 (preferably 200) acres (40-81 ha) in size (Laymon and Halterman 1989), however yellow-billed cuckoos have been observed breeding in 55 acres (22 ha) wooded fragments in Mississippi (Hughes 1999). • Breeding habitat for cuckoos may be limited by the availability of suitable nesting trees, because many appropriate sized shrubs and trees do not have the horizontal branches preferred for nesting or provide enough cover for nesting birds (Laymon 1980). Species of willow with horizontal branches, red alder (*Alnus rubra*), cultivated and feral fruit trees, and bitter cherry (*Prunus emarginata*) were probably the preferred species for the construction of nests in western Washington.	• If and when breeding yellow-billed cuckoos are discovered in western Washington, riparian vegetation should not be removed where they occur (Rodrick and Milner 1991). • Riparian buffers in known cuckoo habitat should have a minimum combined width on both sides of a stream of 300 feet (91 m). • Breeding habitat should be at least 100 acres (40 ha) in size and preferably 200 acres (81 ha) to serve as a population source for smaller (sink) patches of riparian shrub/tree habitat. All cuckoo habitat should be within 330 feet (100 m) of water and where possible connected by riparian corridors vegetated densely enough to provide cover for cuckoos moving between foraging areas. • Riparian buffers where cuckoos are found should be managed for areas of dense shrub growth or to have a dense shrub understory. Appropriate small trees and shrubs that provide dense cover and horizontal branches for the placement of cuckoo nests should be planted or riparian vegetation managed for these species. • Cuckoo foraging habitat areas should be a minimum of 10 acres (4 ha) in size (Gaines and Laymon 1984).	• Preserves in the west should include riparian areas with dense stands of cottonwood and willow with an average tree height of 33-49 feet (10-15 meters) (Anderson and Laymon 1989). • Prohibit insecticide spraying in riparian corridors used by cuckoos (USFWS 1985). To avoid accidental wind drift into riparian areas, aerial application of pesticides should not occur on adjacent lands when winds exceed 6 miles/hour (10 km/hour). Insecticides should not be applied between June 15 and August 15 to agricultural sites where yellow-billed cuckoos are known to forage (Laymon 1980). • Pesticides contaminate preferred prey items, particularly lepidopteran larva and some foods, such as frogs, occur in pesticide-laden runoff adjoining agricultural land (Laymon and Halterman).
Gray Wolf *Canis lupus*	• Restrict trail/road access and timber harvest or construction activities within 0.25 miles (km) of an active wolf den site during the denning period or April 1 through June 15 (USFWS 1987).		
Grizzly Bear *Ursus arctos*	•	• Hiding/thermal cover for grizzly bears should be protected within the North Cascades Recovery Area (USFWS 1993, 1997). • Reduce open road density to 1.0 mile/mile^2 (km/km^2) within North Cascades Recovery Area for grizzly bears (USFWS 1997b). • Design all clear cuts within the North Cascades Recovery Area so that no point in a unit is more than 600 feet (m) from effective hiding cover for bears (USFWS 1993, 1997).	• Home range: up to 170 mi^2 (440 km^2; Brown 1985) • Road and trail closures in areas of grizzly bear activity are necessary to create security habitat and minimize the likelihood of grizzlies interacting with humans (USFWS 1993, 1997). • Protect riparian habitat with cover/movement corridors and specify uneven-aged harvest techniques near riparian zones to maintain forage habitat for bears while retaining vegetative cover (USFWS 1993, 1997b).
Lynx	•	•	• Home range in Montana: up to 14 mi^2 (36 km^2; Brown 1985)

Species	IMMEDIATE HABITAT REQUIREMENTS (NESTING, BREEDING, DENNING)	LOCAL AREA REQUIREMENTS (WATER, FOOD, COVER)	WATERSHED/LANDSCAPE REQUIREMENTS (HOME RANGE OF SPECIES)
Lynx canadensis			
Western Gray Squirrel *Sciurus griseus*	• Require mature trees and snags with nest cavities. Nests in holes in trees (winter) and outer branches of hardwoods (summer) (Ingles 1947).	• territory size: 0.3-0.8 acre (0.1-0.8 ha; Brown 1985)	• Home range: 0.5-2.5 acres (0.2-1 ha; Brown 1985)
Fisher *Martes pennanti*	• Maintain and create denning sites by protecting hollow trees, snags, and large broken top conifer trees (Aubry and Houston 1992; Powell and Zielinski 1994).	• Minimum habitat: 3,200 acres (1,295 ha) per population (Brown 1985) • Created openings in core fisher habitat should be no longer than 300 feet (91 m) and should follow land contours (Ingram 1973).	• Home range: up to 15 mi^2 (39 km^2) (Maine) • Maintain travel corridors with continuous canopies through the establishment of adequate stream riparian buffers (Aubry and Houston 1992; Powell and Zielinski 1994). Freel (1991) recommends a riparian buffer travel corridor of at least 600 feet (183 m) in width on both sides of streams in clearcut landscapes. • Manage large blocks at least 100 $miles^2$ (259 km^2) as core fisher habitat below 3,300 feet (1,000 m) elevation as uneven-aged forest stands with at least 80% canopy closure (Ingram 1973). • Minimize forest fragmentation within the mountain hemlock zone by utilizing uneven-aged harvest techniques to reduce the percentage of stand perimeter consisting of clearcut edge (Allen 1983; Aubry and Houston 1992; Powell and Zielinski 1994). • Uneven-aged management and protection of snags, cavity trees, and coarse woody debris provides the diverse structure necessary to provide high populations of forest-floor small mammals required for a fisher prey base (Powell and Zielinski 1994). • Preservation of spotted owl habitat and the creation of late successional reserves in the western hemlock zone of the Cascade Mountains will create more closed canopy forest with a high degree of forest-floor structural diversity (Powell and Zielinski 1994).
Wolverine *Gulo gulo*			• Forest practices in mountain corridors between protected wilderness areas should protect and provide appropriate structures, such as large cavities, coarse woody debris, and old beaver lodges to provide den sites (Banci 1994). • Management objectives for North Cascade grizzly bear recovery area will provide secure habitat with available wolverine habitat in Alpine Lakes Wilderness Area and surrounding open, park-like mountain hemlock forests and alpine habitat (see section above under "Grizzly bear"). Efforts to secure habitat for grizzly bears will also meet the most important limiting factors for wolverines, which are remoteness and protection from human disturbance and poaching.
Larch Mountain Salamander *Plethodon larselli*	• Larch Mountain salamanders depend on cool, moist environments. Nearly all populations of these salamanders have been found on steep talus slopes in forested areas, though they have also been found on steep slopes in old-growth forests, under woody debris on the forest floor or in piles of detritus beneath snags (Corkran and Thoms 1996). • Have been found in caves (Aubry et al. 1987, as cited in WDW 1994). • Where Larch Mountain salamanders occur on steep, forested slopes, downed woody debris of all size and decay classes should be retained.	• Most talus slopes known to be occupied by Larch Mountain salamanders have a mixed overstory of bigleaf maple (*Acer macrophyllum*), Douglas-fir (*Pseudotsuga menziesii*), and sometimes Oregon ash (*Fraxinus oregona*) (Larsen and Schaub 1982; Herrington and Larsen 1985). Suitable talus in Washington generally consists of rocks with a diameter of 1-6 cm (0.4-2.4 in), contains large quantities of decaying plant matter and small amounts of soil, and is often covered by a layer of moss (Herrington and Larsen 1985; Corkran and Thoms 1996). Organic matter is important for sustaining the salamander's invertebrate prey base and for maintaining moisture within the talus. • Avoid impacting talus slopes. • Buffer talus slopes with 90-150 feet (27-46 m) protected area and leave 50% or more of additional uncut forested areas beyond buffer	• A Western-Washington endemic, their range includes extreme eastern King County (Larsen 1997), and a population has been found at a lava tube entrance within the Mount St. Helen National Volcanic Monument (Aubry et al. 1987, as cited in Larsen 1997).
Van Dyke's Salamander *Plethodon vandykei*	• From limited documented cases, Van Dyke's salamanders breed in protected areas under rocks and in logs near headwater streams and often in old-growth stands or groups of old-growth trees. Also, assumed to breed where they occur in colluvial rock near seeps and or moist north-facing rocky habitats in forested areas (Corkran and Thoms 1996; Blessing et. al. 1999). • Talus slopes are occasionally used by Van Dyke's salamander.	• Both juveniles and adults inhabit the splash zones of streams where they can be found under cobbles and woody debris and in cracks in rock faces. Though typically found along stream margins, Van Dyke's salamanders have been found far from water on moss-covered talus slopes and fractured rock outcrops with northerly exposures (Leonard et al. 1993, Corkran and Thoms 1996). Aubry et al. (1987) found Van Dyke's salamanders among loose rocks on the moist floor of a lava tube near Mount St. Helens.	• Range does not include King County (Larsen 1997), however, range indicated is based on known observations, which may not reflect true extent. • This species is also associated to some degree with riparian habitats in mature and old-growth coniferous forests (Jones and Atkinson 1989, as cited in Larsen 1997) where they are thought to use downed logs (Jones and Atkinson 1989, as cited in Larsen 1997; Jones 1989).

Species	IMMEDIATE HABITAT REQUIREMENTS (NESTING, BREEDING, DENNING)	LOCAL AREA REQUIREMENTS (WATER, FOOD, COVER)	WATERSHED/LANDSCAPE REQUIREMENTS (HOME RANGE OF SPECIES)
		• Protect headwater and smaller streams and adjacent buffers where salamanders are found from yarding, heavy equipment and timber harvests. Suggested buffer widths range from 90-150 feet (27-16 m). • They inhabit cool, moist habitats in forested areas. The forest canopy maintains the microclimactic stability required by these salamanders (Larsen 1997). Retain and/or maintain 50% shade along stream banks, seeps, wet talus and other such areas.	
Oregon Spotted Frog *Rana pretiosa*	• Spotted frogs tend to lay their eggs in exposed shallows, usually less than 30 cm (12 in) deep. • Oregon spotted frogs are highly aquatic, inhabiting marshes and marshy edges of ponds, streams, and lakes. Spotted frogs usually occur in shallow, slow moving waters with abundant emergent vegetation and a thick layer of dead and decaying vegetation on the bottom. The frogs take refuge in this layer when disturbed (Nussbaum et al. 1983, Corkran and Thoms 1996). • Minimum habitat: 2 acre (0.8 ha) pond/population (Brown 1985) • Although King County is in the former range of this frog, it is not believed to be extirpated (McAllister et al. 1993, as cited in Larsen 1997).	• Maintain forests adjacent to breeding ponds and wetlands.	• Home range: 2,500 ft^2 (232 m^2; Brown 1985)
Western Toad *Bufo boreas*			• Home range: 175 ft (53 m; Brown 1985)
Western pond turtle *Clemmys marmmorata*	• Found in ponds, rivers, vernal pools, streams, ephemeral creeks, reservoirs, agricultural ditches, sewage treatment ponds and estuaries (Reese and Welsh 1997) • Adult and juvenile turtles favor aquatic habitats with access to areas of deep slow water with underwater refugia and emergent basking sites. Hatchlings are relatively poor swimmers and tend to seek areas with slow, shallow, warmer water, often with emergent vegetation (Ashton et al. 1997).	• Terrestrial habitat requirements are viable throughout the range, but must include basking sites and nesting habitat. Terrestrial basking sites include mud banks, rocks, logs, and root wads on the bank, but never far from the water. The nest site has good exposure to the sun and compact soil (Holland 1994, as cited in Ashton et al. 1997; Reese 1996). • Females deposit their eggs on land, usually above the flood plain, up to several hundred meters from water. For nesting females tend to seek out open areas with sparse low annual vegetation, low slope angle, and dry hard soil (Holland 1994, as cited in Ashton et al. 1997; Reese 1996). Nesting sites are used for over-wintering hatchlings.	• Exhibit relative site fidelity, in both aquatic and terrestrial environments. They utilize a home range on the order of several hundred meters and have moved over 3.1 miles (5 km) within a stream (Holland 1994, as cited in Ashton et al. 1997).
Beetles **Beller's ground beetle** *Agonum belleri* **Hatch's click beetle** *Eanus hatchii* **Longhorned leaf beetle** *Donacia idola*	• Inhabit eutrophic sphagnum bogs associated with lakes below 3,300 ft (1,000 m) elevation (Larsen et al. 1995).	• Urban run-off waters may contain pesticides and other pollutants that could be harmful to adult or larval beetles. Therefore, stormwater run-off from surrounding developments should not be diverted into sphagnum bogs (Larsen et al. 1995).	• Activities that might alter the condition of sphagnum bogs where Beller's ground beetles are known to occur should be prevented. These activities include peat mining, filling, draining or construction within bogs, removing or damaging endemic vegetation, and other perturbations. • Changing the natural water level or flow rate within bogs should also be prevented. Sediment inflow from surrounding land-use activities may affect survival of Beller's ground beetles and should be avoided (Johnson 1986, as cited in Larsen et al. 1995).
Butterflies **Great Arctic Butterfly** *Oeneis nevadensis gigas* **Johnson's hairstreak** *Mitoura johnsoni* **Valley silverspot** *Speyeria zerene bremnerii*	• The Johnson's hairstreak butterfly depends on lowland coniferous forests that contain dwarf mistletoes of the genus *Arceuthobium*. These mistletoes occur mainly on western hemlock (*Tsuga heterophylla*) and occasionally on true firs (*Abies* spp.) (Scott 1987; Pojar and MacKinnon 1994). • The western blue violet *(Viola adunca)* is the only known host plant for the Valley Silverspot butterfly (Larsen et al. 1995).	• The Valley Silverspot butterfly uses open prairies, arctic-alpine tundra, subalpine glades, and midelevation roadsides and clearings (Larsen et al. 1995). • Peak conditions for the Johnson's hairstreak butterfly exist in old-growth and late-successional second-growth, lowland forests. Younger forests that contain dwarf mistletoe may also have the potential to support populations of the Johnson's (mistletoe) hairstreak (D. McCorkle, pers. comm., as cited in Larsen et al. 1995).	

Table 8-2. Best Available Science for maintaining Viable Populations of Listed Wildlife Species that Should be Protected.

Guild/Example Species/ Function/	IMMEDIATE HABITAT REQUIREMENTS (NESTING, BREEDING, DENNING)	LOCAL AREA REQUIREMENTS (WATER, FOOD, COVER)	WATERSHED/LANDSCAPE REQUIREMENTS (HOME RANGE OF SPECIES)
Blue Grouse *Dendragapus obscurus*	• Manage forests in low to mid-elevations to improve blue grouse breeding habitat by creating open areas (Rodrick and Milner 1991). • Retain known winter blue grouse roost areas including mature mistletoe-laden Douglas-fir thickets near ridges (Rodrick and Milner 1991).	• Territory size: up to 11 acres (4.5 ha) (Brown 1985) • Allow the tops of some hills and low productivity sites to remain unplanted, serving as grouse breeding areas (Zwickel and Bendell 1985; Johnsgard 1973).	• Home range: 30-285 acres (12-115 ha) • Where blue grouse occur, use clearcuts smaller than 800 feet (244 m) across and leave at least 16 trees per acre (40 trees/ha) with a minimum 9 inch (23 cm) diameter at breast height on wintering areas (Cade 1985). • Use longer rotations (greater than 60 years) for wintering habitat of blue grouse (Cade and Hoffman 1990). • Include native forbs in seed mixes when reseeding forest lands (Seaburg 1966).
Mountain Quail *Oreortyx pictus*	•	• Breeding territory size: 5-50 acres (2-20 ha) (Brown 1985) • Herbicides that destroy brushy habitat should be avoided in clearcuts that harbor populations of mountain quail (Ware et al. 1999). • Timber harvest that retains slash and/or slash piles and harvested sites that are not subject to broadcast burning have been beneficial to mountain quail (Ware et al. 1999).	• Home range: 2-3 acres (0.8-1.2 ha) per brood • Avoid clearcutting extremely large blocks of forest (>500 acres, or 202 ha) (Ware et al. 1999).
Band-Tailed Pigeon *Columba fasciata*	• Leave 3 trees or snags/acre (2.5/ha) in clear-cuts to serve as perch trees (Rodrick and Milner 1991; Reynolds et al. 1992).	• Territory size: up to 1 mile (1.6 km) radius of nest (Brown 1985) • Manage patches of remaining forest and woodlots to include patches greater than or equal to 25 acres (10 ha) widely distributed through each basin and smaller (4-12 acre, or 4.9 ha, stepping stone habitat patches) distributed through the landscape (Vizyova 1986; Dickman 1987; Tilghman 1987; Herson-Jones et al. 1995). • Nests are usually more than 66 feet (20 m) from openings and more than 1,198 feet (365 m) from human habitations (Glover 1953). Movements between nesting, roosting, and feeding sites have a tendency to follow stream courses (Glover 1953; Kautz and Braun 2000). • Important habitat components include closed-canopy forests for nest sites, open-canopy forests for foraging, and presence of mineral springs and licks (Sanders 1999). Close proximity to free water (< 1,312 ft, or 400 m) is also important (Glover 1953).	• In the Oregon Coast Range, mean home range recorded for radio-tagged adults was 4,500 acres (SD +/- 9,833 acres, N = 70; Leonard 1998) (11,121 ha; SD +/- 24,298 ha). • Create management arrangements with private landowners to protect mineral sources for pigeons during the breeding season. In areas with dense vegetation limiting bird access, vegetation removal is an option. In mineral poor regions, consider providing salt-licks for pigeons containing sodium and calcium salts by bearing the mineral blocks at natural seeps. Maintain perch trees near mineral sites. • Manage forests to produce areas of dense berry producing understories and thickets of red elderberries and cascara in clear-cuts. • Food availability apparently greatly influences breeding and flock movements (Gutierrez et al. 1975), and any management activity that reduces mast production or the availability of fruiting shrubs and other primary foods would be detrimental. • In southern Washington Cascades Douglas-fir forests bandtails were more abundant in mature stands (95-190 years old) than in wet old-growth (250-700 yrs.) or young stands (55-80 years; Manuwal 1991).
Western Bluebird *Sialia mexicana*	• Retain snags greater than 10 feet (3 m) tall and 15 inches (38 cm) dbh around the edges of clear-cuts (Brown 1985). Leave defective trees with heartrot, distortions, or damage as potential nest sites (Jackman and Scott 1975). • Clearings and snags created from forest fires should be left to succeed naturally whenever possible (Rodrick and Milner 1991) • Retain smaller saplings and scattered shrubs for cover and foraging perches in managed forests (Pinkowski 1979). • Provide adequate habitat for primary cavity producers (hairy woodpeckers, downy woodpeckers, northern flickers, and other small to medium sized woodpeckers) (Herlugson 1975).	• At elevation above 600-1,000 feet (183-305 m), bluebirds are able to compete successfully for nesting cavities. In these regions, manage forests to retain snags and retain older, large, and partially dead trees (Herlugson 1975). • Use controlled and natural burns to prevent dense forest growth and overgrowth and overgrowth of open areas in areas inhabited by bluebirds (Herlugson 1975). • Prevent the spread of reed canary grass and research methods of reclaiming open areas overrun with reed canary grass. • Restrict the use of pesticides in bluebird foraging areas.	
American Marten *Martes americana*	• Maintain forested riparian buffers of approximately 330 feet (100 m) on each side of streams or terrestrial corridors at least 600 feet (183 m) wide connecting patches of forest that contain suitable complex physical structure at ground level for martens (Freel 1991; Knutson and Leaf 1997; Small 1982). • Maintain marten habitat patches with a minimum size of 37.5 acres (15.2 ha) and average size of at least 600 acres (243 ha), connected by forested	• Minimum habitat: 640 acres (259 ha) per population (Brown 1985) • Maintain at least 45% of marten core habitat as late successional conifer forest (Buskirk and Ruggiero 1994). • Use uneven-aged timber harvest techniques in marten core habitat areas. • Road building, skidding, and other logging operations should be kept 200 feet (61 m) from riparian areas (Spencer 1981 as cited in Freel 1991).	• Home range: up to 590 acres (239 ha) (Montana)

Guild/Example Species/ Function/	IMMEDIATE HABITAT REQUIREMENTS (NESTING, BREEDING, DENNING)	LOCAL AREA REQUIREMENTS (WATER, FOOD, COVER)	WATERSHED/LANDSCAPE REQUIREMENTS (HOME RANGE OF SPECIES)
	riparian corridors to maintain marten habitat at a landscape scale (Chapin et al. 1998, Bissonette et al. 1991). • Road closure following logging operations may be needed to reduce concentrated trapping pressure or human disturbance (Koehler et al. 1975).	• Maintain complex physical structure at ground level during timber harvest to provide resting habitat for martens in 10 to 40-year-old second-growth forests. Large-diameter coarse woody debris, address many of the needs that martens have for physical structure: predator avoidance, access to subnivean spaces, and thermal protection (Buskirk and Ruggiero 1994). A ground surface covered by downfall ranging from 20 to 50% is assumed to have optimum value (Allen 1982).	
Mink *Mustela vison*		• Mink minimum habitat: 1 stream mile (1.6 km) per pair (Brown 1985) • Maintain a 75% tree, shrub, and/or persistent emergent herbaceous vegetation canopy within a 330 feet (100 m) riparian buffer along streams, marshes, and shorelines (Allen 1984). • Maintain a minimum of 75% tree and/or shrub canopy closure within 330 feet (100 m) of the water's or wetland's edge (Allen 1984).	• Home range: 3 miles (4.8 km) along river
Columbia Black-Tailed Deer *Odocoileus virginianus leucurus*	•	• Manage winter habitat to provide a good mix of thermal cover patches and forage patches adjacent to each other (Rodrick and Milner 1991). • Manage forest succession to produce deer winter range thermal cover at least 40 feet (12 m) tall, with tree canopy cover of at least 70% with four layers (canopy, sub-canopy, shrub layer, and herbaceous layer) and the overstory canopy with trees that average over 21 inches (53 cm) dbh to provide a relatively snow-free, sheltered environment (Brown 1985). • Manage forested habitat to produce a combination of thermal cover adequate for periods of heavy snow and forage areas that are interspersed with a minimum of 40% of a 1-mi^2 (2.6-km^2) area in cover, or which at least half is thermal cover (Rodrick and Milner 1991).	• Home range: 95-272 acres (38-110 ha) (Brown 1985) • Provide riparian buffers to serve as movement corridors between habitat patches, particularly in rural and agricultural/rural lands. •
Elk *Cervas elaphas*	• Elk calving habitat should be protected from disturbance from May 1 to June 30. Calving habitat should be provided within 1,000 feet (305 m) of water on gentle slopes that contain at least 40% of the area in cover patches. Forage opening should occur as small, scattered patches. Cover patches should be at least 200 feet (61 m) wide and have a canopy that exceeds 70% of trees more than 40 foot (12 m) tall (Rodrick and Milner 1991).	• Roads in winter ranges should be closed when snow exceeds 18 inches (46 cm) (Rodrick and Milner 1991). Roads on winter elk range open to public use should be limited to 0.5 mile (0.8 km) of road per one square mile of habitat (Rodrick and Milner 1991). • Foraging areas should have patches of hiding cover that provides screening vegetation that covers 90% of a standing elk, at 200 feet (61 m) or less (Mudd 1975, Brown 1985). • Foraging areas should have patches of hiding cover that provides screening vegetation that covers 90% of a standing deer, at 200 feet (61 m) or less (Mudd 1975, Brown 1985).	• Home range: up to 6,000 acres (2,428 ha; Brown 1985) • Maintain current road management programs and work cooperatively to identify additional winter range road closure opportunities to benefit elk (Spencer 2001). • Establish road closures of winter range during the fall and winter months to buffer the influences of increased human disturbance (WDFW 1999). Roads on winter range open to public use should be limited to 0.5 mile of road per one square mile of habitat (Rodrick and Milner 1991). • Manage forest succession to produce forage areas with less than 60% combined canopy cover where trees and shrubs are more than 7 feet (2 m) tall and there is an understory of shrubs and herbaceous vegetation (Rodrick and Milner 1991). • Develop new road closure management strategies to allow free movement of elk to winter range during the hunting season. • Reduce open road densities to 1 mile/mile^2 (1 km/km^2) on elk winter range (Spencer 2001). Road densities on summer range should not exceed 1.5 mile/mile^2 (3.8 km/km^2) (Rodrick and Milner 1991). • Control noxious weeds on important elk forage sites (Spencer 2001).
Mountain Goat *Oreamnos americanus*	• Retain conifers in an unmanaged condition 300 feet (91 m) directly above and below cliffs used by mountain goats (Rodrick and Milner 1991).	• Maintain cover in travel corridor between cliffs used by mountain goats (Rodrick and Milner 1991). • Retain 20 to 50% of goat summer ranges in escape cover patch of 10-20 acres (4-8 ha) (Rodrick and Milner 1991).	• Home range: 1.2-9.3 mi^2 (3.1-24 km^2) (Colorado) (Brown 1985) • Maintain goat forage areas in vigorous conditions through burning or seeding native herbs. Restrict livestock grazing in goat habitat (Rodrick and Milner 1991). • Retain more than 50% of goat winter range in thermal cover areas of more than 36 acres (15 ha) each and discourage human use and vehicle traffic on and off roads and trails from November 1 to June 30 within 1 mile of winter range (Rodrick and Milner 1991).

8.2.4 Priority Habitats

Wildlife habitats created by geomorphic features lend diversity to environments otherwise largely dominated by plant communities (Maser et al. 1979b). There are three such habitats in King County: caves, cliffs, and talus. These features are characterized by abrupt, relatively stable edges and predictable airflow patterns, and provide relatively secure habitats for wildlife (Maser et al. 1979b). “Removal of forests adjacent to these geomorphic features alters food sources, changes wind currents, affects light patterns and periodicity, removes visual barriers, modifies drainage patterns, and opens the area to increase human harassment, all of which impact the wildlife species utilize these habitats” (Scharpf and Dobler 1985).

These habitats occupy a very small percent of the total area, yet they are disproportionately important as wildlife habitats. Each of these habitats concentrates and supports a unique animal community, and adjacent plant associations provide food sources, microhabitat stabilization, and perches for raptors. Plant communities adjacent to these habitats should therefore be stabilized as much as possible (Maser et al. 1979b). Caves, cliffs, and talus are fragile environments that can be easily destroyed, but not restored.

“Removal of timber adjacent to cliffs or talus slopes, from around the entrances to caves, or from over caves with thin ceilings should be carefully evaluated. Points to consider are how this removal would alter light intensity, wind currents, drainage patterns, humidity, food sources, and in the case of caves, how the transport of nutrients into the cave would be impacted” (Scharpf and Dobler 1985).

Wildlife habitat areas considered in this BAS review are also unique ecosystems that may not be directly associated with a particular species. Rather, they are terrestrial habitat types or elements with unique or significant value to a diverse assemblage of species (WDFW 1999b). Examples include unique vegetation types or dominant plant species (e.g., riparian areas; see Chapter 7 – Aquatic Areas), a described successional stage (e.g., old-growth/mature forests), or a specific structural element (e.g., snags). Some of these ecosystems, such as old-growth forests, are characterized by unique endemics (Welsh and Lind 1988; Spies 1991) such as spotted owl and marbled murrelets, whereas other areas such as riparian zones are noted for their disproportionate use and wide diversity of wildlife (Riparian Habitat Technical Committee 1985; Johnson and O'Neil 2000). Habitat types and elements of the environment that are considered for conservation are discussed below.

Caves

A cave is any naturally occurring void, cavity, recess, or system of interconnected passages that occur beneath the surface of the earth or within a cliff or ledge and is open to the surface; is large enough to permit an human to enter or support priority wildlife species; includes any natural pit, sinkhole, or other feature that is an extension of the entrance; includes vegetation and topographical attributes around the cave entrance that control cave microclimates; and includes any *cave resource* therein (any material or substance occurring naturally in caves, such as animal life, plant life, paleontological deposits, sediments, minerals, speleogens, and speleothems).

Washington Department of Wildlife (WDW; 1994) point out that the caves in Washington state harbor unique communities of organisms, including over 27 vertebrate species, including mammals, birds, reptiles, and amphibians, and nearly 500 invertebrate species, including mollusks, insects, arachnids, and worms. Many of these species are rare, declining, or sensitive, and many of the mammals, for example, contribute organic debris and feces, which provide food resources within caves (Senger 1987; Senger and Crawford 1984, both as cited in WDW 1994). WDW (1994) states that threats to cave ecosystems include road building and development, logging, pesticides and fertilizers, landfills, and parking areas, among others. These human activities lead to the alteration of the vegetation surrounding caves, as well as water flow and quality and air-flow dynamics.

Bats (because they hibernate) and other insects, amphibians, and fish that use caves are often poikilothermic (their body temperatures vary with the external temperature), so they rely on the relative stability of the cave environment to maintain their bodily functions (Scharpf and Dobler 1985). Senger (1987, as cited in WDW 1994) points out that "Most caves support a few bats during some portion of the year and bat feces form the basis of entire food chains in some cave systems." Larch Mountain salamanders, one of the species whose breeding habitat the County is obligated to protect (see Table 8-1), may use cave systems.

Nutrient input into caves comes generally from streams and from those species which use the cave for shelter but feed outside. Streams bring in detritus, bacteria, and some animals. Cave-using species, such as bats, contribute their guano, and if they die in the cave, their dead bodies also contribute to the cave ecosystem. (Barr 1967; McAlpine and Reynolds 1977). Scharpf and Dobler (1985) point out that a cave's ecosystem could be altered by a change in the hydrologic characteristics of its watershed, and that "changes in forest structure and productivity around a cave may influence not only those species moving in and out of the cave, but the obligate cave dwellers as well."

Nieland (pers. comm. 1982, as cited in Scharpf and Dobler 1985) observed a marked decrease in nutrient input into shallow lava tube caves in southwest Washington following timber harvest over them. It is possible that tree roots that penetrate through cracks and hang from the ceiling of these caves provide a nutrient source for invertebrate species. Scharpf and Dobler (1985) suggested that removal of vegetation around the entrance to a cave can alter the light intensity that penetrate the cave. The increased light could affect humidity patterns, enlarge the twilight zone and reduce the dark zone." These changes in light penetration would affect the cave's inhabitants. Removal of vegetation around cave entrances can also change the temperature of the cave. Changes in the environment surrounding the cave will affect species moving in and out of the cave as well as the obligate cave dwellers (Scharpf and Dobler 1985).

Scharpf and Dobler (1985) emphasize that "cave systems can be disrupted to a much greater degree than most other habitat types because of the confined space involved, limited escape routes for species using caves, and the fragile ecosystems within caves." Logging above caves can deplete nutrients available within a cave because of loss of root invasion. Changes in surface vegetation may also impact caves by altering humidity levels. These changes may alter the suitability of a cave for current inhabitants (Senger and Crawford 1984).

If a cave is surrounded by vegetation, USFS (1997) recommends that wind-firm buffers should be left intact. They state: "there is no credible standard buffer distance that will provide the assurance required to protect the systems from blowdown of the forest within a given buffer. Each buffer must be carefully designed considering wind direction patterns, blowdown history, previous adjacent harvest, topography, and stand windfirmness. Delineated lands surrounding such features and systems must be of sufficient size to insure protection even if blowdown occurs."

Washington Department of Fish and Wildlife provide specific recommendations for the protection of caves (WDW 1994) with the caveat that buffers represent minimum distances and may not be adequate in specific instances:

- Logging practices should not be conducted over caves, within 100 feet to the sides of cave passages, or within 200-300 feet of cave entrances. Larger buffers may be required depending on the size, aspect, and location of entrances.
- Roads should not be constructed over cave systems, within 300 feet of cave passages, or within ¼ mile of a visual proximity of a cave. Road construction should not cause erosion, alter water flow or the climate in or around caves (see logging buffer).
- Mining activities are not appropriate in or near caves or within their hydrological settings.
- Grazing should not occur above caves or within their watersheds and entrance buffers.
- Pollution, including sewage, herbicides, and pesticides, should not occur within cave watersheds.
- Caves with suspected water contamination, and those in areas of planned development, should have water sources traced using fluorecein dye. This is especially important for caves that contain wildlife.
- For caves with known or suspected bat use:
  - Caves with maternity colonies should be closed from May 1 to August 31.
  - Caves with hibernacula should be closed from November 1 to April 1.
  - No recreational use should occur within 300 feet of cave systems within these times.
  - Access should be restricted by eliminating or re-routing trails and roads.

Cliffs

A cliff is defined here to be a steep, vertical, or overhanging rock face ≥25 feet in height. Cliffs are a special habitat used by a variety of wildlife species, including swallows, bats, raptors, and small mammals. Certain attributes make cliffs more valuable to wildlife. "Wildlife use increases in direct relation to the size and number of fractures, pockets, and ledges formed on the cliff face" (Scharpf and Dobler 1985). A cliff with both large and small fractures could provide habitat for peregrine falcons, which use large fractures, and American kestrels, swifts, and bats, which use smaller cavities and fractures (Scharpf and Dobler 1985). Additionally, many animals that use cliffs take advantage of the security found in the cracks and ledges to escape predators.

"Cliffs provide [shelter] for wildlife and concentrate a variety of reptiles, birds, and mammals into relatively small but stable environments. Most of the species that use cliffs obtain their food and water nearby….With increasing height, there are more predictable upward-flowing warm air currents, or thermals, which provide conditions necessary for raptors" (Craighead and Craighead 1969 in Maser et al. 1979b). Maser et al. (1979b) points out that "…high cliffs adjacent to or within 0.25 miles (0.4 km) of permanent water are by far the most important for those animals associated with them." "Many raptors prefer cliffs for nesting and roosting, because the height of cliffs aids their hunting by giving them a larger field of view and providing them with predictable updrafts and thermal currents for soaring" (Scharpf and Dobler 1985). Scharpf and Dobler (1985) also note that cliffs in the Cascade Range only below about 5,000 feet in elevation offer much potential for raptor nesting because snow packs at higher elevations limit the forage base for wildlife.

Brown (1985) suggests that the removal of timber adjacent to cliffs be carefully evaluated in terms of how it will alter light intensity, wind currents, drainage patterns, humidity, and food sources. Additionally, he suggests logging activities adjacent to cliffs should be carried out during periods of the year when breeding birds are not present, and recreational activities should be limited to non-critical times of year for raptors. "Forest practices can have both direct and indirect impact upon the use of cliffs by wildlife. The most common direct impact involves blasting and quarrying of cliffs to provide crushed rock for improvement of logging roads….Indirect impacts from forest practices are associated with removal of the forest habitat surrounding the cliff. When the forest is removed, the cliff environment can be altered in several ways. Wind and temperature patterns may be altered, visual barriers removed, and drastic changes will occur in the food availability for most cliff dwellers" (Scharpf and Dobler 1985).

Talus

Talus is an area of dislodged rock fragments accumulated at the base of a steep slope or cliff, where the cliff may or may not still be present. The rocks are homogenous and range in average size of 0.5 to 6.5 feet (0.15 - 2 m) in diameter and are composed of basalt, andesite, or sedimentary rock. The talus slope includes vegetation growing within the talus. Talus "occupies a relatively small portion of the land base yet concentrates reptiles, amphibians, birds, and small mammals" (Scharpf and Dobler 1985).

Maser et al. (1979b) list 56 vertebrate species that use talus for feeding and an additional 35 that use talus for breeding and feeding. Included in the list of species that feed on talus slopes are several birds and mammals that the County is required to protect, including Northern goshawks, peregrine falcons, and Vaux's swifts. Not included on this particular list are two salamanders that are now known to use talus slopes and which the County is also required to protect (Van Dyke's salamander and Larch Mountain salamander). It is likely other special species use talus slopes that have not yet been discovered in that habitat.

"The important structural components of talus include length, depth, width, type and size-class of the rock, and the age and stability of the formation. A large, deep, stable talus of basalt or andesite is much more important as wildlife habitat than is a small talus or one of sedimentary rock" (Maser et al. 1979b). "Talus concentrates vertebrate animals, such as frogs and toads, lizards, snakes, birds, and small mammals, into relatively small areas. The larger a talus, the more stable it is and the more opportunities it provides for wildlife habitat. A talus needs to be large enough to provide living space for a self-sustaining population of the species that is dependent on it." "Depth is important because the animals move up and down inside a talus seeking the right conditions of temperature and humidity. Talus is especially important for the protection of some species during reproduction and hibernation. In addition, talus often supports an edge of herbaceous vegetation that is the food supply for species living within it."

Herrington (1988, as cited in Larsen 1997) surveyed 183 talus slopes in Washington and Oregon and found that nearly 60 percent had been altered by talus removal or deforestation. When talus materials are removed (for road-building materials, for example), the remaining talus may shift to the base of the slope. In these instances, erosion and siltation of the talus often follow, and the movements of small animals, such as salamanders, is inhibited (Harrington and Larsen 1985, as cited in Larsen 1997).

Scharpf and Dobler (1985) suggests that removal of timber adjacent to talus slopes should be carefully evaluated in terms of how removal will alter light intensity, wind currents, drainage patterns, humidity, and food sources. When forest is removed from within and around talus slopes, the microclimate within the talus may become uninhabitable. For example, Herrington and Larsen (1985, as cited in Larsen 1997) studied a site where half a talus field was clearcut and the other half retained a mature forest canopy. They found that Larch Mountain salamanders did not inhabit the cleared area but maintained stable numbers in the forested portion.

Van Dyke's salamanders, one of the species the County is obligated to protect when discovered, use talus slopes (Larsen 1997). As noted above, Larch Mountain salamanders also may use talus slopes. Herrington and Larsen (1985) recommend a buffer of 98-164 ft (30-50 m) around talus slopes when these salamanders are present. Buffer sizes should be evaluated on a site-by-site basis, to ensure that the microclimate created by the present vegetation is not altered after clearing. It is likely that when buffers are adequate for salamanders, they would be adequate for other sensitive species.

Snags

Snags are standing dead trees and are well documented to be important to a large variety of wildlife species (Neitro et al. 1985; Bull 1978; Bull and Meslow 1977; Cline 1977; Mannan et al. 1980). In Washington and Oregon, 93 wildlife species are associated with snags in forest ecosystems, including 4 amphibian, 63 bird, and 26 mammal species. Of the 93 species, 21 are associated with hard snags (decay class 1 and 2), and of those 21 species, 5 species are associated only with hard snags, including the pileated woodpecker (Marcot 2002). Larger diameter snags are typically more valuable to a greater number of species than smaller diameter snags (Bull 2002).

Snags, as well as downed trees (i.e., logs), are critical elements of healthy, productive, and biologically diverse forests (Bull 2002). Thomas (1979) identified 179 vertebrate species that use coarse woody debris (snags and down wood) in the Blue Mountains of Oregon and Washington. Loss of rotten-log communities may affect some woodpeckers, such as the pileated woodpecker, because of the resultant decline in carpenter ants (Marzluff and Ewing 2001).

Ohmann and Waddell (2002) point out that "dead trees are important elements of productive and biologically diverse forests. Dead trees form major structural features with many ecological functions, including habitat for organisms, energy flow and nutrient cycling, and geomorphic processes (Harmon et al. 1986)."

Snag densities are lowest in early successional stages of forests, and they are highest in late stages (Ohmann and Waddell 2002). Regional differences in dead wood abundance have been observed (Ohmann and Waddell 2002). The factors that influence the processes that maintain dead wood within an ecosystem are scale-dependent and incredibly complex (Ohmann and Waddell 2002).

The DecAID model (Marcot et al. In prep.), which uses the best available wildlife and inventory data from Western Washington and Oregon, indicates that an average of 46 snags/ha >25 cm dbh

(18.6/acre >10 in) should be managed for to maintain the snag component in the Western Washington conifer-hardwood lowlands at the 50 percent tolerance level for wildlife habitat, with 20/ha (8.1/acre) of those snags being larger than 50 cm (20 in) dbh. The model also recommends managing "areas with the complete range of snag densities and sizes to provide snags for all species on the curve. To manage for all species, some snags as large as 145 cm (57 in) dbh should be provided for pileated woodpecker roost trees. For all other species snags from 80 to 100 cm (32-39 in) dbh should be provided on the landscape."

From their study in the Puget Sound region, Rohila and Marzluff (2002) provide recommendations for snag retention in urbanizing areas. They suggest that the retention of forest lands should provide cavity-nesting birds with the snags they require, though forest areas with high densities of existing snags (>8 snags ≥ 25 cm DBH per ha), and live trees (318 trees per ha) should be selected for protection. Additional attributes they recommend for cavity-nesting birds include conserving all snags that are large in diameter (minimum of 30 – 40 cm), more decayed, red alder species and coniferous species, taller (≥18 m), with broken tops, a variety of bark remaining (65-84 percent), conk fungus, and snags with other cavities.

Just like managing for an ecosystem such as old-growth, managing for snags means that processes must be in place to sustain creation of more snags over time. In undisturbed stands in Western Oregon and Washington, 30 percent of all snags greater than 10 inches (25.4 cm) dbh fell down over a 10-year study period (Ohmann 2002). Snag fall-down rates were substantially lower for the largest snags: 93 percent of snags over 39 inches (100cm) dbh remained standing during the study period. Also, in undisturbed stands, western redcedar and other conifers such as cedars stood the longest. Hardwoods, Sitka spruce, and true firs fell at the greatest rates (Ohmann 2002).

Ohmann and Waddell (2002) note that although their data is specifically on dead wood abundance, "management actions may best be focused on the ecological processes that lead to development of these forest structures rather than on the structures themselves." And just as the processes that help to create snags should be preserved, so should the needs of the wildlife who use the snags be considered (Ohmann and Waddell 2002). Snags are primarily used by birds and bats, whereas the majority of species using downed trees include small mammals, amphibians, and reptiles (Bull 2002).

Bull (2002) describes how coarse woody debris, including snags and logs, is formed in a variety of ways: "Trees can be killed by fire, insects, decay fungi, flooding, drought, and windthrow. The means by which a tree is killed influences the manner in which it decays, how long the tree will stand, and the rate of deterioration. A strong relationship exists between the kind of decay in a tree and what species can use it, particularly for nesting and foraging."

Marcot (2002) emphasizes that no single wood decay element, such as snags, provides for all wildlife species associated with wood decay. In fact, it may well be that all wood decay elements (e.g., various decay classes of snags, down wood, and other elements such as bark, mistletoe brooms) may be necessary to provide for all associated wildlife species. Marcot (2002) went on to suggest that "down wood can be viewed as the center of a 'functional web' of ecological roles. As such, down wood, or *any of the wood decay elements*, provides at least some of the habitats used by many wildlife species that in turn can influence their environment and other species in diverse and unexpected ways."

Mellen et al. (1992) have suggested that the pileated woodpecker is an indicator species, and therefore "its proper management may aid the viability of other species using similar forest habitats." However, Mellen (1987) warned that "the presence of pileated woodpeckers may not necessarily indicate adequate habitat exists for other species which may have more stringent requirements for mature forest habitats." Tree/snag sizes should be based in large part on the requirements of pileated woodpeckers, as they are the largest excavators, and size of tree/snag will often be limiting factor for their nesting. But density of snags should be based on different species.

Neitro et al. (1985) recommended a minimum dbh of 25" (63.5cm) for pileated nest snags in western Oregon and Washington. "Douglas-fir snags retain most of the bark so tree dbh is routinely measured including bark thickness." Mellen (1987) also recommended this minimum, but asserts that habitat should be managed for means. Mean nest tree dbh from the Mellen study was 69cm. Mean roost tree dbh from the Mellen study was 98cm. "…I suggest that management directed towards providing snags closer to the mean of 70cm dbh from this study would be preferable. This strategy would help avoid managing for suboptimal habitat that may lead to low reproductive success and a gradual decline in pileated woodpecker abundance (Conner 1979)."

Neitro et al. (1985) make the following recommendations for snag retention:

- Leave all hard snags, damaged and dying trees, and defective live trees, except those considered safety hazards
- Retain hard snags in favor of soft snags
- Retain large diameter snags (over 15 inches, or cm, dbh) in favor of small diameter
- Retain tall snags (over 60 feet, or m) in favor of short snags
- Retain snags with greater bark cover in favor of snags with little bark cover
- Leave undisturbed all hardwoods having natural and woodpecker cavities

Old-Growth and Mature Forest

Old-growth forest is defined variously by different authors depending on the use of the definitions (Braumandl and Holt 2000; Marcot et al. 1991). Definitions tend to be based either on timber production criteria or on ecological attributes (Marcot et al. 1991; Franklin and Spies 1991b). Marcot et al. (1991) review the considerations for old growth definitions and inventories made by a number of authors. They illustrate the importance of definition for inventorying (and potentially protecting) old-growth forest, and recommend that inventories are based on attributes, are map-based, and that any adopted definitions be part of a system of classification of various stages of forests.

Thomas et al. (1993) found that 312 plants, 149 invertebrates, 112 stocks of anadromous salmonids, 4 species of resident fish, and 90 terrestrial vertebrates were closely associated with old-growth forest conditions. Lehmkuhl and Ruggiero (1991) performed an extinction risk assessment for 94 vertebrate species dependent on late-successional forest (old-growth and mature forest). They report that 68 of these species have primary dependence on late-successional forest, and the most at-risk species for local extinctions include several species of salamanders and many small mammals such as voles, moles, and squirrels. Also most at risk are bald eagles, northern goshawks, pileated woodpecker, northern spotted owl, Vaux's swift, blue grouse, band-tailed pigeon, fisher, marten, and other bird and mammal species.

Old-growth forests have structural components and stand attributes that are quite different from any other type of forest (Franklin and Spies 1991a). These structural components, such as snags and down wood, and stand attributes, such as multi-storied and deep canopy, foster the distinctive communities found in old-growth forests (Franklin and Spies 1991a). Manuwal (1991) found that old-growth stands have the highest densities of very large snags, and mature stands have the highest densities of large hardwood snags, such as bigleaf maple and cottonwood. (For more information on snags, see above.) Additionally, Manuwal (1991) points out that winter old-growth habitat is particularly important because of the relatively large percentage of permanent residents in Douglas-fir forests.

Much remains unknown about the old-growth ecosystem (Franklin and Spies 1991b), and even more likely remains to be learned about the value of mature forests. Mature forests that have grown up after an old-growth forest was destroyed from natural disturbance (e.g., fire) will have greater complexity associated with it because of legacies from the previous forest, such as snags and down logs, than will a managed second-growth forest (Franklin and Spies 1991b). Consequently, naturally formed mature forests will have greater value for many species of wildlife (woodpeckers, amphibians, etc.), whereas the effects on hydrology, for example, may not be significantly different between types of mature forest.

Wildlife Corridors

Human population growth and associated expanding development has altered the character of the Puget Sound (see Chapter 1 – Introduction) and posed significant challenges for land managers and regulatory agencies who strive to balance land use with species and habitat preservation. The Puget Sound landscape that was historically characterized by a matrix of human development within expansive natural environments in much of the region, is now characterized as natural environments embedded within a matrix of human development. Growth and human development has resulted in the reduction and loss of natural habitats, altered the structure and function of naturally occurring habitats, and fragmented habitats into small isolated habitat patches.

One approach that land managers and regulatory agencies have implemented to alleviate impacts on wildlife habitats and species within human-influenced environments includes the establishment of wildlife habitat corridors. Habitat corridors are defined as contiguous, vegetated, dispersal conduits of variable length and width that connect isolated habitat patches to other patches or larger landscape habitat components.

Although most definitions of wildlife corridors in the literature define corridors as dispersal conduits that link isolated habitat patches (Saunders and Hobbs 1991; Rosenberg et. al.1997), the corridor itself, if wide enough and vegetated, may also provide habitat where resident organisms live and reproduce (Rosenberg et. al. 1997; Noss 1983; Brooker et al. 1999). Corridors can provide a variety of functions for flora and fauna at both the local and regional landscape spatial scale including:

- Providing a means for animals to move between habitats (home range) daily and seasonally (Noss 1983);
- Enabling animals to disperse from one patch to another;

- Reducing species extinction rates by ensuring that populations or individuals are not isolated from others in the landscape (population sink);
- Guarding against detrimental genetic effects (inbreeding depression and random genetic drift);
- Providing increased foraging habitat for a variety of species;
- Providing predator escape cover for animals as they move between patches; and
- Providing an avenue for vegetative communities to maintain reproduction viability and colonize new areas (Tewksbury et. al. 2002; Stephen and Hallett 1999; Rosenberg, et. al. 1997).

Although wildlife corridors provide many beneficial ecological functions, because of the characteristics of corridors, it has been argued that corridors may degrade naturally occurring habitats and populations in some situations (Beier and Noss 1998). For example, when some organisms disperse via corridors, they may spread diseases, non-native vegetation, and non-native insects across the landscape (Hess 1996a). Indeed, the conservation value of corridors has been debated. Simberloff and Cox (1987) explore the various possible negative consequences associated with corridors. Corridors can transmit disease, fire, or predation, and the access they provide can potentially facilitate poaching and predation by domestic animals. Noss (1987) quickly respond to Simberloff and Cox and suggest that disadvantages of corridors could be avoided or mitigated by sound ecological planning. One recurring theme by Noss (1987) is that corridors should be as wide as possible while taking into consideration habitat structure and quality within the corridor, as well as the surrounding habitat, human use patterns, and species expected to use the corridor.

Rosenberg et al. (1995) suggest that much of the recent debate about the value of corridors may stem from differing definitions, including whether a corridor should be only thought of as a dispersal route or both a dispersal route and habitat in its own right. Rosenberg et al. (1995) emphasize that clear, unambiguous criteria are needed to distinguish a linear patch as a corridor.

At a larger (landscape) scale, corridors may decrease the level of genetic variation among populations, or provide a means for fire or other abiotic disturbances to spread within the landscape (Saunders and Hobbs 1991). Although there are potential concerns to corridors in specific landscape situations, in most areas of the natural landscape, habitats were historically connected and many identified potential corridor disadvantages were in effect at that time. Therefore, species evolved and habitats were influenced by some of the potential corridor shortcomings. Corridor establishment attempts to mimic in a managed landscape the natural biologic processes that historically occurred. Beier and Noss (1998) reviewed several studies on wildlife corridors and found that "only about 12 studies allow meaningful inferences of conservation value, 10 of which offer persuasive evidence that corridors provide sufficient connectivity to improve the viability of populations in habitats connected by corridors." Thus, given the constraints of increased human growth and development, corridor establishment has been generally accepted to provide more ecological advantages than disadvantages, and corridors are considered an essential component for promoting ecological processes in landscapes (Dawson 1994).

Much remains uncertain and debated about how to design corridors so they funnel and not trap those species they are intended to serve. Similarly, buffers must be designed so they adequately shield native species from the negative impacts of fragmentation (Marzluff and Ewing 2001). The criteria for establishing corridors and the characteristics of the corridors (length, width, and vegetative type) vary significantly depending on land management and ecosystem objectives. Overall, the larger the corridor, the greater ecological value gained. Because there are often financial and regulatory constraints involved in establishing expansive corridors, however, large corridors are not always practicable. Therefore, because various species have specific life needs and movement patterns, much of the scientific literature supports identifying criteria and characteristics of proposed corridors based on the needs of a specific species or species guild that are in danger of isolation.

To preserve biodiversity in fragmented landscapes, most authors (Davis and Glick 1978; Soule 1991; Shafer 1997; all as cited in Marzluff and Ewing 2001) recommend either establishing corridors among native patches or buffering native patches with native habitat to increase their size and amount of interior area. Marzluff and Ewing (2001) contend that the design and establishment of a system of native vegetation reserves and the maintenance and restoration of ecological function in those reserves are imperative for conserving biodiversity in urban landscapes.

- However, reserves are not enough; they must be large enough to allow a great enough core size so that they are not population sinks (Marzluff and Ewing 2001). Authors such as Davis and Glick (1978), Knight (1990), Soule (1991), and Shafer (1997) "uniformly recommend that (1) the area and numbers of reserves be maximized; (2) the amount of edge and degree of fragmentation within reserves be minimized; (3) the connectivity between reserves be maximized; (4) buffers be maintained around reserves; and (5) the scale of reserve planning be expanded beyond the local area to include entire watersheds and bioregions" (Marzluff and Ewing 2001).

8.3 Conclusion

This Wildlife Areas chapter reviews conservation biology literature to provide background on approaches for protecting wildlife species and the ecosystems in which they live. Life history information is reviewed extensively for each of the ten species specifically addressed with standards in the proposed Critical Areas Ordinance. A shorter review is presented in tabular form for the remaining species the County is required to protect. Additionally, best available science is reviewed for priority habitats. These priority habitats, which may be protected via incentives as codified in the proposed Clearing and Grading Ordinance, often provide shelter and other life needs for the species the Comprehensive Plan requires the County to protect.

A dearth of literature exists for many of the species the County is required to protect. For other species, studies have been conducted in areas different in topography or climate or otherwise than those of King County. Nonetheless, literature applicable to protecting these species, and most specifically their nesting habitat, was reviewed.

It is not uncommon for little information to be known about species that are on protection lists, such as the lists of species the Comprehensive Plan requires the County to protect. It is unfortunate that frequently the species in most need of protection have the least amount of information available toward that end and, in turn, that other species on protection lists are there because so little is known about them.

For some species that have been frequently studied, it is most likely that research occurred somewhere other than in King County, as mentioned above. Still, ranges of protection measures from various studies are available for scientists (and subsequently policy makers) to review to decide where King County's needs likely fit within those ranges. The forest characteristics, for example, of the various nesting sites are reviewed and taken into consideration, as is the precautionary principle.

Upon reviewing the best available science for the priority habitats such as cliffs, caves, and talus, it becomes clear that their importance cannot be overstated. These areas provide many of the life history needs of the species the County is required to protect as well as a host of additional species. And to take this idea a step further, best available science tells us that while it is important to protect specific habitat for individual species when they are rare or endemic, for example, the most effective way to assure conservation of populations and ecosystems is to afford protection of functioning systems at the landscape level. Therefore, although it is important to protect individually nesting or breeding animals, the need to protect the system that creates their nesting, foraging, and other required habitats cannot be overlooked, or it becomes impossible to sustain those populations over time.

In summary, current best available science suggests that:

- Protection of reproductive sites (nest trees, caves) and their buffers, especially during appropriate times of year, is arguably the most important but not a comprehensive strategy for protecting priority species;
- Protection of wildlife corridors, riparian areas, wetlands, and aquatic areas contribute to the conservation of wildlife species;
- Protection of priority habitats may result in conservation of habitat for a range of priority and non-priority species;
- Protection of wildlife habitat using a landscape-level perspective is critical for the sustained conservation of wildlife species and biodiversity.

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