Prepared for:

City of Bellevue
Planning & Community Development
450 110th Avenue NE
P.O. Box 90012
Bellevue, WA 98009

Bellevue Urban Wildlife Habitat Literature Review

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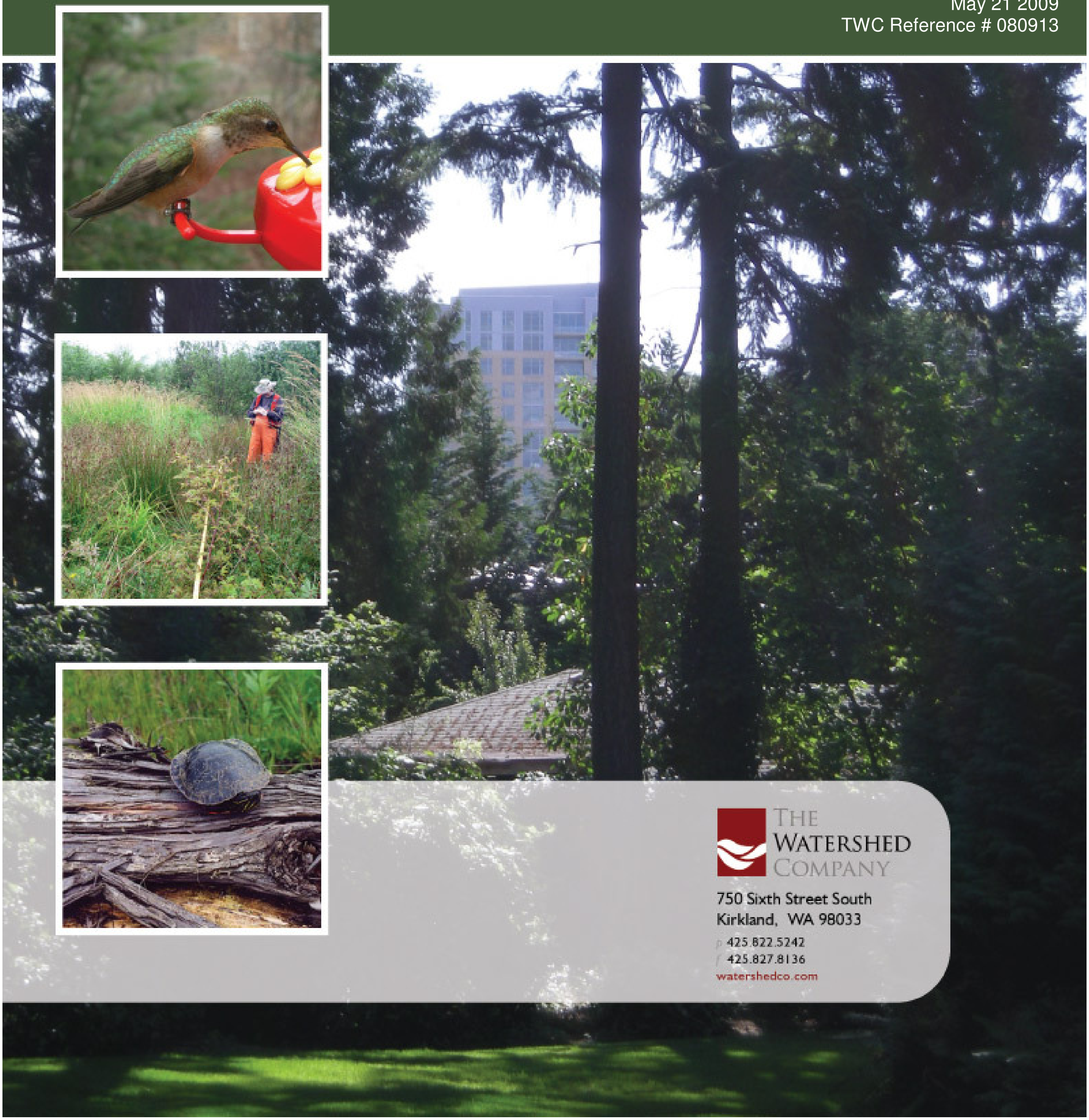

THE WATERSHED COMPANY

750 Sixth Street South
Kirkland, WA 98033

p 425.822.5242
f 425.827.8136
watershedco.com

LITERATURE REVIEW

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The Watershed Company Reference Number: 080913
The Watershed Company Contact Person: Suzanne Tomassi

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BELLEVUE URBAN WILDLIFE HABITAT

1 EXECUTIVE SUMMARY

The City of Bellevue seeks to address the presence, function and value of habitat within its limits. Wildlife use of urban habitat is a relatively new field of study, and presently no standard means of evaluating either wildlife use or the value of urban habitat is widely available. It is generally accepted and well documented that urbanization has a profound impact on wildlife and habitat. A comprehensive review of the scientific literature pertaining to the subject of urban habitat reveals a number of trends, collated and described in the following document. Particular attention is paid to the City of Bellevue's species of local importance, so designated because they are in danger of extirpation; they have special recreation, commercial, tribal or other value; and their continued existence in the City is dependent on protections that are not adequately addressed by other jurisdictions. Results of this literature review are used in support of a standardized means of assessing urban habitat value, the accompanying Functional Assessment Model.

2 INTRODUCTION

2.1 Wildlife Habitat in the Urban Environment

As the United States grows in population and cities, suburbs, and rural areas support greater densities, natural wild areas become fewer and urban natural areas become increasingly valuable to both wildlife and humans. Recent scientific research has responded in kind, and a growing knowledge base confirms what is best captured in the summary: "All urban areas have the potential to contribute to conservation of wildlife diversity" (Marzluff and Rodewald 2008). In the Pacific Northwest, native habitat exists to varying extents within even the most densely developed areas. This document summarizes the best available science addressing the impacts of ongoing human development in urbanizing areas and the interactions among humans, wildlife, and urban natural environs.

2.2 Scientific Justifications for Urban Habitat Conservation

Urbanization, the increase in human settlement density and associated intensification of land use, has a profound and lasting effect on the natural environment and wildlife habitat (McKinney 2002, Blair 2004, Marzluff 2005, Munns 2006), is a major cause of native species local extinctions (Czech et al. 2000), and is likely to become the primary cause of extinctions in the coming century (Marzluff et al. 2001a).

Cities are typically located along rivers, on coastlines, or near large bodies of water. The associated floodplains and riparian systems make up a relatively small percentage of land cover in the western United States, yet they provide habitat for rich wildlife communities (Knopf et al. 1988), which in turn provide a source for urban habitat patches or reserves. Consequently, urban areas can support rich wildlife communities. In fact, species richness peaks for some groups, including songbirds, at an intermediate level of development (Blair 1999, Marzluff 2005).

Protected wild areas alone cannot be depended on to conserve wildlife species. Impacts from catastrophic events, environmental changes, and evolutionary processes (genetic drift, inbreeding, colonization) can be magnified when a taxonomic group or unit is confined to a specific area, and no one area or group of areas is likely to support the biological processes necessary to maintain biodiversity over a range of geographic scales (Shaughnessy and O'Neil 2001). As well, typological approaches to taxonomy or the use of indicators present the risk that evolutionary potential will be lost when depending on reserves for preservation (Rojas 2007). Urban habitat is a vital link in the process of wildlife conservation in the U.S.

2.3 Social Justifications for Urban Habitat Conservation

The U.S. Census Bureau (2005) reports a 6% increase in metropolitan areas between 2000 and 2005, compared to a 3% increase in areas containing fewer and less dense urban clusters and a 1% increase in rural areas. By 2005, 54% of the U.S. population lived in urban areas of one million or more people, and in the western U.S., 90% of residents resided in metropolitan areas. Residents of urban and suburban areas place a higher value on conservation than rural residents (Kellert 1996, Conover and Conover 1997), and in particular, non-pest and less common species may be appreciated to a greater extent than common or pest species (Clergeau et al. 2001). Residents of metropolitan areas in the U.S. show a willingness to spend money and time on wildlife management, both to prevent and solve damage problems and to encourage the presence of wildlife around their homes (Conover 1997). This is evident in the preference of individuals, families, and businesses to locate in cities with abundant natural areas (Kellert 1996).

Evidence that natural areas have more than a simple aesthetic appeal has some physiological and psychological basis (Hartig 1993). Health benefits, including recovery from mental fatigue and stress, may be derived from exposure to a small natural area such as a backyard garden (Kaplan and Kaplan 1989, Ulrich et al. 1991).

Broad public support of programs promoting or mandating conservation is essential to the implementation of conservation initiatives or regulations. Conservation of urban wildlife habitat provides economic, educational, environmental and personal enrichment benefits to urban dwellers. Urbanization without subsequent preservation of natural areas leads to fewer wildlife-human interactions in cities, where residents tend to encounter biological uniformity in their daily lives (Miller 2005), and as a result diminishes the benefits derived from urban natural areas. Although the economic costs of conservation are likely to be high in areas where property has high commercial and residential development value, the returns on conservation investments are also likely to be great because of the great potential for improvement to ecological function and aesthetic value (Wear et al. 2004).

More than two decades of literature document the value that humans place on wildlife and the natural environment in general (Johnson 1988, Stern et al. 1995, Manfred 2008). Couple this with the actual and potential benefits of natural areas to city-bound humans, and it becomes clear that urban conservation is vital to both wildlife and people.

3 DEFINITIONS

3.1 Habitat

The City of Bellevue defines habitat as "the place, including physical and biotic conditions, where a plant or animal usually occurs and is fundamentally linked to the distribution and abundance of species" (Land Use Code [LUC] 20.50.024H). The LUC goes on to state that a species may use a habitat or a structural component of the habitat for all or part of its lifecycle, and may adapt to use various habitats. The definition considers that habitat is scale-dependent and refers to a large geographic area, a species' homerange, a local setting, or a site-specific feature.

Habitat may perform a specific function for a species or multiple species. It may refer to breeding-season range, migration support areas, breeding sites, or travel corridors. Habitats of particular concern in the City of Bellevue are those that occur in limited amounts and are highly vulnerable to disturbance or alteration. Rare and vulnerable habitats include mature native lowland forest, cliffs and caves, snag-rich areas, riparian corridors, heron rookeries, and regulatory critical areas (e.g., streams or wetlands).

Habitat in the urban environment includes both natural and man-made elements. As is the case for all habitat, it is any feature or setting from which a species or individual animal could derive some use or benefit during all or part of its lifecycle. Urban habitat is often isolated, fragmented and degraded, with disrupted water flow and nutrient cycling due to pavement and structures. Cities are commonly accompanied by sprawl, wherein expanses of native vegetation are replaced by highly interspersed exotic ground cover, pavement, roads, and other development (Marzluff 2001). Urban habitat excludes, by definition, some of this area because it does not support wildlife use at any time. Urban habitat may, however, include buildings, gardens, lawns, right-of-ways, invasive vegetation infestations, utility wires and structures, rockeries, and other artificial features. As well, even small patches of native vegetation in an urban setting are potential wildlife habitat. Thus, any vegetated area and all natural and manmade features that may be used by wildlife should be considered potential wildlife habitat. Most properties in the City of Bellevue, with the exception of those in the downtown core that lack a substantial landscaping component or pervious surface, can be expected to contain some habitat.

3.2 Habitat Feature

Habitat features are natural or man-made characteristics of the environment serving a particular use to an animal or species. The term has some overlap with both habitat and habitat type, as features may include ponds, streams, wetlands, or other generally larger-scale part of the landscape, but more often refers to a single structure or character. Habitat features frequently are nest and den sites, prey concentration areas, year-round water sources, and foraging perches. Common habitat features are large snags, downed wood, cliffs, steep banks, vernal pools, caves, brush or rock piles, burrows, and isolated or small stands of mature conifers. In urban habitat, features commonly include man-made structures such as telephone poles and wires, abandoned buildings, eaves, chimneys, bridges, and ledges.

3.3 Habitat Type

The phrase habitat type refers to the "place where an animal or plant lives and which is characterized by a dominant plant form or physical characteristic. A 'Habitat Type' is based on actual conditions and consequently can be mapped, and is assumed to contain all the essential needs for a species' maintenance and viability. Habitat Types are not species-specific because they are based on the similarity of many wildlife species using a suite of vegetation types" (LUC 20.50.024H). In short, habitat types are groups of vegetation types that form land cover, or land use cover types that are not vegetative (O'Neil and Johnson 2001).

3.4 Urbanization

Urbanization is the process describing the increase in human settlement density and associated intensification in land use (Marzluff 2001). Further, it is accompanied by an increase in *per capita* energy consumption and results in systems that depend largely on outside rather than local natural resources (McDonnell and Picket 1990).

3.5 Landscape Terms

A number of studies define the following landscape terms very specifically, using minimum and maximum percentages of vegetative cover, impervious surface, parks, and other land features. In general, the following terms are drawn from studies of wildlife responses to human-influenced landscapes, though they are somewhat broadly redefined herein. The looser definitions are needed so that the terms can be used to refer to a range of studies that each might define the terms with slight differences.

3.5.1 Urban

In this document, urban landscapes are areas where commercial, industrial, or dense residential land uses dominate. Following Donnelly and Marzluff (2004), impervious surface makes up the majority of land cover, although the minimum 60% employed in the aforementioned study may vary somewhat. Green space is minimal in this designation, similar to the 20% or less specified by Marzluff et al. (2001b). It is generally confined to small city parks and residential and commercial landscaping.

3.5.2 Suburban

Suburban landscapes are dominated by single-family homes on residentially zoned lots. Percent cover by impervious and treed surface loosely follows Donnelly and Marzluff's (2004) 20-60% and 25% or greater, respectively, for their "urban forest" designation. Green space is largely composed of parks, riparian corridors, residential landscapes, and critical areas and their buffers.

3.5.3 Exurban

Exurban landscapes include areas that are less than 20% impervious surface and more than 70% trees (Donnelly and Marzluff 2004). Non-treed pervious surface makes up 15% or less. Development is low density, roughly 6 to 25 homes/km^2 (Hansen et al. 2005).

4 EFFECTS OF URBANIZATION ON HABITAT

As human-induced impacts on the natural world become increasingly evident, and as public interest and concern about these impacts grow, science has focused on the measurable effects of urbanization on wildlife and habitat. Recent work addresses changes in and loss of native habitat, and how animal populations and communities change in response. Emerging trends indicate repeatable and predictable changes to wildlife and illustrate the need to address habitat in development planning.

4.1 Vegetation Changes in Urbanizing Environs

Many of the habitat changes that occur with urban development are predictable. Indeed, tree cover reduction is often a defining part of the term urbanization. As buildings and paved surfaces increase, remaining vegetation tends to be maintained. However, as land use transforms along a gradient from wild to urban, a peak in species richness in many taxa, including plants, occurs at intermediate development levels. This peak is likely the result of habitat heterogeneity as components of remaining native habitat are interspersed with varying degrees of human disturbance, which may include artificial feeding, fruiting plants, and garbage (McKinney 2002). The end result, however, is reduced vegetative richness and diversity at the urban core.

Land use changes from contiguous forest to single-family housing on Seattle's fringe resulted in significant declines in native tree and forb diversity as forest was lost in the last quarter of the 20^{th} century (Robinson et al. 2005). Native shrub diversity also showed a downward trend. In this and other studies (Blair 1996, 2001; McKinney 2002), exotic ground cover vegetation increased significantly with development, and this in turn served to simplify and degrade ground cover (Reichard and White 2001), which can impact nest site selection and foraging availability. Both the number and proportion of non-native plant species changed from a few percent or less in rural areas to more than 50% at the urban core in the Midwestern U.S. (Whitney 1985). As the urbanization gradient progresses, the rate at which natural vegetation is lost increases (McKinney 2002). The replacement of native species by common non-native weeds presents the danger of habitat homogenization (Blair 2001). As well, vegetative structural diversity can be expected to decrease as forest is lost, although urbanization in former grasslands can actually increase structural diversity (Marzluff 2001). Scientists in the Pacific Northwest and elsewhere have investigated the impacts of these vegetation changes. These vegetation alterations have been shown to drive changes in animal populations and communities (see Section 5).

4.2 Fragmentation and Connectivity

A major effect of urbanization at both local and landscape levels is habitat fragmentation and loss of connectivity. As structures, roads, yards, and other man-made features perforate the landscape, remaining habitat becomes isolated in patches or fragmented, often to the detriment of wildlife (Marzluff and Ewing 2001). Isolated habitat fragments tend towards degradation and the establishment of non-native habitat (Marzluff 2001). Water flow is obstructed or redirected, nutrient cycling is disrupted, and ecological function may be interrupted or altered. Many wildlife taxa are impacted by fragmentation, as presented in the following sections.

4.3 Other Alterations

4.3.1 Ecological Processes

Human settlement and the development of urban areas impact a number of ecological processes. The alteration of natural fire regimes, including the near-exclusion of fires in developed parts of the arid west, has allowed woody plants to invade native grasslands (Coppedge et al. 2001). On the other hand, controlled burns and increased anthropogenic fire frequencies in developed areas can alter forest structure; promote invasion of non-native vegetation (Keeley 2004); and truncate natural succession, maintaining land in early seral stages (Keeley 2002).

Altered flood regimes, increased and redirected stormwater flow, and changes in stream volumes and locations are all incurred with the construction and development of towns and cities. Subsequent changes in riparian and floodplain vegetation can change vegetative composition and structure in urban habitat. These areas are of particular importance because they tend to support rich wildlife communities (Knopf et al. 1988). Habitat degradation is just one of the impacts of stormwater sediment and pollution (Anthony et al. 1993, 1994), which result from increased impervious surface (NRDC 1999).

Other ecological processes that are impacted by urbanization strongly influence wildlife communities. Habitat changes that occur with urbanization and ongoing development have been shown to alter predator-prey relationships (George 1974, Wilcove 1985, Crooks and Soulé 1999, Marzluff 2001) and brood parasitism (Donnelly and Marzluff 2004). The spread of disease to wildlife resulting from human settlement threatens both biodiversity and people (Daszak et al. 2000). The growing body of research on climate change shows impacts of urbanization at all scales, from local to global (Sax and Gaines 2002).

4.3.2 Direct Human Disturbance

Finally, habitat disturbance by humans results from the influx of people to both rural areas and existing settlements. Noise, vehicular and foot traffic, litter and pollution, lighting, and pets all impact habitat to some extent. The following sections describe how subsequent habitat changes affect wildlife.

4.3.3 The Rural-Urban Gradient

The human-influenced landscape does not occur in discrete units, but in a gradient from least- to most-developed. Physical changes along the rural-urban gradient move toward increases in road and population density, air and soil pollution, ambient temperature, average annual rainfall, soil compaction and alkalinity, impervious surface, and imports of energy and materials (McKinney 2002).

5 WILDLIFE RESPONSE TO URBANIZATION

Extinction of wildlife species results from either land use change itself, or new selective pressures that are a result of land use changes. The vegetation and disturbance impacts described in the preceding sections are the direct evidence of land use change. Selective pressures include modification of climate, changes in predator pressure and competitor communities, and introduction of disease. At a local scale, species diversity has greatly decreased in anthropogenic settings from pre-settlement conditions in the U.S. At this local scale, species diversity is strongly affected by biological and physical interactions, compared to the process of speciation at work on a global scale. Impacts to evenness are even more important at the local scale because distribution of abundances plays a role in possible outcomes regarding wildlife community changes (Sax and Gaines 2003). Thus, these interactions are extremely important on the local scale.

5.1 Trends in Wildlife Responses to Urbanization

Several trends, as well as some opposing findings, emerge from reviews of the literature (Marzluff 2001, McKinney 2002) regarding the general impacts of urbanization on wildlife. Land use by humans had an overall negative effect on biodiversity, attributed to direct habitat conversion. Lower species diversity was observed at urban cores compared to rural areas, and this held true over several plant and animal taxa. When measured along a gradient, some species responded linearly, decreasing in richness and other parameters as development increased. In contrast, non-native plant and animal species richness and population density increased with increasing urbanization. A number of groups showed non-linear declines in urban areas, with a peak in richness in moderately developed landscapes.

5.2 Habitat Availability, Stand Age, and Vegetative Characteristics

Loss of species richness in urban cores has been attributed to reduction in available habitat, measured as number of plants or area covered by plants, particularly in earlier works. Richness of birds (Shugart et al. 1975, Goldstein et al. 1986), mammals, and herpetiles (Dickman 1987) has been correlated with amount of available plant cover. On small study areas, such as urban reserves, wildlife-habitat dynamics are also influenced by factors like juxtaposition of landscape features; locations of structures, roads, and other development; availability of adjacent habitat; presence of corridors; and other landscape-level characteristics. Recently, the role of habitat fragmentation and habitat patch size has been investigated, and more detailed attention is paid to these phenomena in this report (5.6.3).

Stand age and the length of time since development occurred affected bird communities in the Seattle area. The age of suburban sub-divisions played a role in the response of bird richness, which continued to decrease for up to 80 years post-development. Loss was greatest when forest cover declined throughout the period, but still continued, somewhat less extensively, when forested area was stable over time. Species richness decreases with subdivision age were due to losses of typical forest bird species and, over time, those species that colonize the habitats typical of new subdivisions (openings, grasslands, ponds, and deciduous forest) (Marzluff 2005).

The observed increase in non-native plants with urbanization is noted in the preceding section. Such vegetation alterations have been observed to act as mechanisms by which wildlife community changes occur. Nelson and Nelson (2001) demonstrated differences in bird and butterfly species richness and butterfly abundance between natural areas with native trees and shrubs compared to lawn areas. Increased non-native vegetative cover was one of several factors that simultaneously led to reductions in the number and quality of urban songbird nest sites in several studies, and exotic shrub cover accounted for the effects of urbanization on the risk of nest predation (Marzluff 2001). Exotic ground and shrub cover was locally associated with a decrease in forest bird species and an increase in synanthropic species in the Seattle area, although whether these changes were also the result of other concurrent effects of other urbanization characteristics was unclear (Donnelly and Marzluff 2004). Ironically, dispersal of non-native plant species may be facilitated by birds in the urban landscape, leading to the propagation of discrete infestations (Reichard et al. 2001).

Local level vegetative features have a predictive value in bird species richness. Fruit-bearing shrubs, large conifers, and streams were associated with the presence of several "sensitive" species in a study of urban bird population indicators. While shrub and ground nesters were most accurately predicted by landscape level features, both large- and small-scale vegetative features had impacts (Melles et al. 2003).

5.3 Synanthropic Species, Non-native Wildlife, and Anthropomorphic Effects

Promotion of non-native species by urbanization has been demonstrated in animals as well as plants. In a summary of the existing literature, Marzluff (2001) reported that human-driven land use cover changes that occur with urbanization have generally resulted in increases in non-native bird species, increases in species that nest in human structures, increased nest predation, and decreases in forest-interior and ground-nesting species. In many cases, density increased, but decreases in richness and evenness accompanied the increase. Factors favoring increases were primarily increased food, and less importantly, fewer predators, less persecution by humans, and habitat enhancement. Factors that drove declines were decreased available habitat, reduced habitat patch size, increased edge habitat, increased non-native vegetation, decreased vegetative complexity, and increased nest predation. In many cases, relationships were non-linear, with density and richness peaking at intermediate levels of disturbance. This phenomenon often was the result of varying levels of adaptability of species to disturbance. Several studies investigated the changes in wildlife communities by categorizing species based on their ability to adapt to urbanizing conditions.

Bird and mammal studies show that species have different ways of adapting to drastic changes with urbanization. Urban avoiders, in roughly decreasing order of sensitivity, are rare species with low reproductive rates, large mammals, old-growth and mature forest species, insectivorous tree foragers, neotropical migrant birds, and ground-nesting birds (McKinney 2002). These species and guilds are the first to be excluded from urbanizing areas. Many large mammals, and predators in particular, were of course lost to development during the original settlement of the U.S. Blair (1996) noted the loss of native insectivorous birds from built areas in California. Donnelly and Marzluff (2004) reported a similar tendency for some neotropical migrant birds species and native forest species to decline in smaller forested areas.

Species and guilds that are able to adapt to human-induced changes include edge species, omnivores, ground-foragers, seed-eaters, aerial sweepers, tree/shrub/cavity nesters, burrowing mammals, and human food eaters. These “urban adapters” benefit from the interspersion of habitats that residential development often results in, including edges created where open areas or maintained properties meet native forest (Adams 1994). They are able to utilize native resources as well as foods that are available as a result of human presence. These include intentionally provided bird foods, seed- and fruit-producing landscape plants, and garbage. Aerial insectivores probably take advantage of open areas and artificial lights that attract insects; seed-eaters benefit from both landscape plants and birdfeeders; and omnivores, corvids in particular, seem able to exploit garbage sources (McKinney 2002). Species, including some swallows and wrens, that are able to nest in man-made structures find an abundance of nest sites in urban habitat. The availability of human-introduced resources is one of the reasons that abundances of urban-adapters tend to be higher than found in natural situations (Adams 1994, Marzluff 2001).

Because most common mammals lack the mobility of birds, they may not adapt as well to the built environment. Still, some species are able to adapt to urban conditions. Burrowing mammals, such as moles and groundhogs, readily nest beneath lawns. Many squirrel species benefit from birdfeeders and ornamental fruit-producing trees. Eastern chipmunk, red squirrel, and meadow vole all have shown a tolerance for human development (Racey and Euler 1982). Raccoons, skunks and opossums readily inhabit yards, provided some forest cover exists in the vicinity (McKinney 2002), and increases in numbers along the rural-urban gradient have been observed (Odell and Knight 2001).

Finally, some species thrive in developed conditions because of their ability to exploit urban resources. These species may be completely or near completely dependent on these resources (McKinney 2002). These species may be responding to the creeping homogeneity of the developed U.S. (Blair 2001), resulting in similar bird communities comprising few species in high abundances. By far the three most common avian urban exploiters are rock dove, house sparrow, and European starling (Marzluff 2001). Mammalian exploiters are able to take advantage of garbage and shelter; familiar species are house mouse, Norway rat, and black rat. Of course, cockroaches and other insects can also be considered urban exploiters. As demonstrated by the species considered in this group, exploiters tend toward non-native species, which as a whole increase in species richness toward urban cores (McKinney 2002).

5.4 Reproduction, Predator-Prey Relationships, and Brood Parasitism

Several studies have examined how urbanization can impact the reproductive habits and requirements of wildlife. Any disruption to or change in breeding habits and success is vital to species and populations. The long-term viability of a species can be reduced, and a species may cease to be self-sustaining if reproductive success is permanently impacted. This leads to local extinction. Donnelly and Marzluff (2004) found that small forest patches or reserves in urban and suburban areas produced few or, in the most urbanized cases, no successful nests of shrub-nesting birds. Nests had high predation rates, attributed largely to the low native shrub cover and high cover by exotic plant species. Depredation appeared to be primarily by rats. Instead of being directly due to urbanization, these results show that retained large forest patches within urban areas have a greater positive effect on breeding birds than in rural areas. Other findings support this conclusion as well (Marzluff 2005, Blewett and Marzluff 2005).

Nest depredation phenomena in urban areas may be attributed to urbanization exerting pressure on predator-prey relationships. Increases in densities of opossums, raccoons, and domestic cats were detected with increasing urbanization in Tennessee, but no impact on bird nest depredation rates was observed (Haskell et al. 2001). Other studies suggest that predation increases with urbanization (Terborgh 1989) and in association with reduced vegetative structural complexity in managed and maintained developed areas (Jokimäki and Huhta 2000). The use of artificial nests and eggs rather than natural nests in some of the studies may be the greatest factor in this apparent discrepancy (Haskell et al. 2001).

Nesting success is also impacted by brood parasitism by brown-headed cowbirds. A relationship between increased parasitism of native songbirds by cowbirds and both residential development density and agriculture was demonstrated in Montana (Hansen et al. 1999), possibly as a result of supplemental food or decreased predator abundance (Hansen et al. 2005).

It is generally accepted that urbanization increases pet-bird interactions and can affect wild bird numbers (Stallcup 1991). Further, domestic cats may impact raptor hunting success rates in urban areas by reducing through predation the number of small mammals available (George 1974). In contrast, predator reduction in urban areas has also had a positive effect on bird populations (Marzluff 2001, Gering and Blair 2006).

5.5 Ecological Processes

Humans impact a number of natural ecological processes when they settle land or increase development density. In the arid west and other parts of the U.S., for example, humans have excluded fire from developed areas to protect people and infrastructure. Depending on the habitat type in which exclusion takes place, it can result in truncated succession, an overabundance of early seral stages, vegetative compositional homogeneity, non-native species invasions and infestations, and/or reduced vegetative structural diversity. Wildlife communities can respond to these alterations. In Oklahoma, juniper invasion with decades of fire control changed populations of several songbird species, causing declines in some and increased abundance in others (Coppedge et al. 2001). Fire suppression can also result in more structurally diverse forest, although this has not consistently been demonstrated to lead to enhanced wildlife communities (Allen et al. 2006). Species-specific responses are commonly reported and can be either positive or negative.

Increases in impervious surface are a universal result of urbanization and ongoing development. This in turn may increase pollution and sedimentation in stormwater runoff, which typically lowers water quality in aquatic features, where it can impact biotic communities (Garrison and Wakeman 2000). Similar increases in nutrient load can impact the natural environment by promoting the growth of non-native species and lowering biotic diversity (Vitousek et al. 1997). The best-known example of direct impacts of pollution on wildlife is probably the effects of the organochlorine DDT on some bird species. Although banned in 1972, the substance was at least partly responsible for near-extirpation in bald eagles, peregrine falcons, and brown pelicans, and continues to impact populations in some areas (Anthony et al. 1993, 1994; Stokstad 2007).

Introduction and spread of infectious disease to wildlife has been precipitated and aggravated by human settlement. Evidence exists that congregations of birds at feeders encourage the spread of disease (Fischer et al. 1997). The transfer of disease from human-introduced animals, including pets (Daszak et al 2000), captive and feral animals (Reolke et al. 1993), and livestock (Cleaveland et al. 2003), to wildlife is also documented.

Direct human disturbances routinely disrupt wildlife in and near developed areas. Passive and active recreation (Fraser et al. 1985, Stalmaster and Keiser 1998) put varying degrees of pressure on birds and other wildlife. The presence of roads facilitates access and wildlife harassment in addition to road kill (Trombulak and Frissell 2000). The presence of humans along trails has been shown to impact adjacent use of habitat by birds (Miller et al. 1998).

5.6 Landscape Considerations

Study at a fine scale is important for determining local-level factors affecting wildlife; however, the impacts of human settlement in developing areas and of ongoing urbanization in cities and towns cannot be fully understood without considering the greater landscape. Landscape-scale habitat configurations may be as important as habitat on the local scale, but are difficult to evaluate because of the complex urban mosaics encountered in early studies (Melles et al. 2003). Surrounding land uses and habitats may serve as wildlife species sources, provide travel corridors, influence vegetative communities, and otherwise affect natural patches within developed areas. Larger-scale analysis also allows measurement of population and community changes along a gradient, which inevitably occurs in “natural” development situations. Much of the literature cited throughout this document is the result of studies along rural-urban gradients. The following sections explore the impacts of the landscape-scale forces of fragmentation and patch size on habitat.

5.6.1 The Rural-Urban Gradient

Effects of interspersed developed land and green space on wildlife occurrence can be expected to work in both directions: species richness in highly developed areas may be influenced by communities supported in adjacent habitat patches, and areas of native habitat are certainly impacted by encroaching urbanization (from Melles et al. 2003). A body of work has attempted to decipher these effects by assessing wildlife communities along an urban-rural gradient.

Examples of non-linear responses of wildlife to urbanization are mentioned throughout this document. The rural-urban gradient can also be discussed as a landscape-level habitat feature, as it includes, by definition, several land uses (most commonly rural, suburban, and urban) that are recognized independently from one another. Some wildlife responses are best considered across these gradients.

Peaks in species richness over landscapes that include a gradient of rural-suburban-urban development have been demonstrated in many animal taxa, including birds, mammals, butterflies, bees, ants and lizards (McKinney 2002). The explanation is often habitat heterogeneity, fruit and seeding plants found in suburban areas, bird feeders, garbage, and other supplemental resources. In contrast, Marzluff (2001) found progressively lower bird species richness in all settled areas compared to rural in 61% of studies he reviewed (i.e., a linear response along the rural-urban gradient), and the opposite or no demonstrable change in the remainder. In another study, bird species richness declined along a gradient with increasing urbanization, and the remaining community was dominated by highly abundant species, not all of which were non-native (but did include house sparrow, starling, and rock dove) (Melles et al. 2001). In some fish communities, high diversity in intermediately-urbanized areas precedes homogenization (lower diversity) in urban areas, because diversity is first inflated by the presence of both native and non-native generalist species invading from downstream reaches, and followed by the loss of less sediment-tolerant native species (Scott and Helfman 2001).

Bird species richness peaked in the Seattle metropolitan area at housing densities found in single-family residential developments, declined sharply at 80% developed land, and declined as well at the other end of the spectrum with mature, second growth, and coniferous forests of 1 square km scale (Hansen et al 2005). Donnelly and Marzluff (2004) observed the same peak in moderately developed landscapes, with the highest richness estimates occurring where synanthropic species were recruited from diverse surroundings. The results of this study agreed with those of Blair (1996), who showed richness peaking at medium intensity urbanization.

A strong negative correlation occurred between native small mammal abundance in Boulder, Colorado and amount of surrounding suburban development (Bock et al. 2002). Other animal communities that have shown linear richness declines with increasing urbanization are insects (Denys and Schmidt 1998) and amphibians (Lehtinen et al. 1999, Riley et al. 2005). Butterfly abundance decreased with increasing urbanization near Palo Alto, California (Blair 1999). Non-linear responses, like those observed in songbird communities, where richness and/or diversity peaks at moderate levels of development, have been reported in lizards (Germaine and Wakeling 2001), butterflies (Blair 2001), and small mammals (Racey and Euler 2001).

Several studies look at the rural-urban gradient in terms of distance from development. Small mammal communities in the Seattle area changed from native to mostly non-native communities quickly from exurban to suburban/urban (Hansen et al 2005). In a separate study, intact riparian habitat supported lower bird diversity as plots approached roads and buildings; densities of some urban-adapted species increased. However, most species densities were negatively affected by percent cover of roads and buildings (Rottenborn 1999). Occurrence of insectivorous birds (Askins and Philbrick 1989) and neotropical migrants (Friesen et al. 1995) was greater when suburban development was farther away. Similarly, red fox and coyote occurrences increased with distance from houses and bird densities were significantly higher in undeveloped areas compared to residential developments (Odell and Knight 2001).

5.6.2 Landscape Mosaics

Landscapes surrounding urban areas can contain features such as streams, wetlands, parks, and forest stands that impact the wildlife dynamics of the developed areas. When the landscape/features mosaic was considered by Melles et al. (2003), avian shrub and ground nesters were associated with both local- and landscape-level features (streams, deciduous trees, and high level adjacent forest and green space cover). Urban-adapted species increased with decreasing forest cover and were associated with local-level features (conifers, deciduous trees, and shrubs). As impervious surface increased and vegetative cover decreased, communities became increasingly dominated by four or five highly urban species, including two non-natives. The authors were unable to show that landscape-level habitat measures were better indicators of richness, but landscape level forest cover and green space were predictive of presence/absence of four species. Richness was highest when large parks were closest to one another. Results suggest that forest cover and green space along the gradient may have acted as sources for bird species in the study area.

Porter et al. (2001) reported the successful use of an intermediate heterogeneity model to predict species diversity patterns in urban landscapes. Results of Marzluff's (2005) research were consistent with this; landscapes of intermediate development density and forest cover had the highest diversity. This was the result of a mix of retained native forest species and synanthropic species. In native conifer patches in suburban areas, bird richness was strongly correlated with the percentage of native forest, peaking at 50-60% forest in the landscape. Loss of native forest was correlated with loss of native forest birds; colonization by synanthropic species decreased with increasing forest in the landscape. Early successional species peaked at 50-60% forest. Thus, the high richness was a combination of native, edge, opening, and synanthropic birds. Blair (1999) also reported a peak in bird abundance with intermediate urbanization levels.

5.6.3 Fragmentation, Habitat Patches, and Connectivity

Fragmentation is an unavoidable result of urban development. Urbanization causes more persistent and drastic fragmentation than other anthropogenic land uses, such as forestry and agriculture, as fragments are commonly separated by impervious surface, structures, impassable barriers, and infrastructure used by vehicles and people. Subsequent impacts on wildlife and habitat can be extreme. Total habitat area is reduced; dispersal and travel by many wildlife species is altered or obstructed; and the processes of predation, parasitism and interspecies competition are affected (Marzluff and Ewing 2001).

Fragmentation affects species differently depending on the species' sensitivity to patch size, isolation, habitat within the patch, landscape characteristics surrounding patches, and species interactions with other wildlife using the landscape. Even small breaks between habitat patches can deter wildlife travel and, in some cases, directly impact wildlife abundance. Fahrig et al. (1999) documented a proportional increase in frog and toad mortality with traffic intensity on roads, and suggested that mortality contributed to decreased abundance in areas of high-intensity road use. The relatively small gaps from bridges, perhaps coupled with the disturbance of vehicles and noise, were associated with decreases in riparian bird species richness and density (Lens and Dhondt 1994, Machtans et al. 1996). Not surprisingly, urban-exploiters and species that nest in man-made structures increased with the same type of fragmentation and disturbance (Rottenborn 1999).

In a fragmented urban landscape, habitat occurs between and among manmade features. The literature refers to habitat patches (or "reserves") because contiguous, naturally vegetated areas are limited in urban, suburban and often exurban areas. Reserve size has been shown to exert an influence on bird populations. The tendency for species richness to increase with reserve size was demonstrated in the Seattle, Washington area (Donnelly and Marzluff 2004). The study included urban, suburban and exurban landscapes and tested small (mean 2.1 ha), medium (mean 37.4 ha), and large (mean 1471.1 ha) reserves. Although these areas are larger than most non-park land within the City of Bellevue, similar areas occur in the landscape surrounding the City and influence wildlife populations and communities in the City, as they may act as species sources and use within-City habitat for travel or other lifecycle needs.

Long-term viability of avian populations seems to be lowered by reduced quality and abundance of native forest (Donnelly and Marzluff 2004). As well, native forest bird species are the first to be lost from urban areas. Therefore, large forest patches in the greater landscape may be important to adjacent developed areas in that they preserve species that may use urban areas but cannot exist without larger habitat patches in the greater vicinity. In contrast, fragmented habitat matrices are a major influence on urban habitat patches as a source of invasive plants and predators (McKinney 2002). They may eventually become "sinks," unable to support wildlife populations.

Terrestrial habitat islands were predicted from collected literature to support more species as the size of island increases (Adams 1994). This held true for woodland birds, chaparral birds, land vertebrates, flies, and beetles.

Donnelly and Marzluff (2004) looked at habitat patch size impacts on avian species in a landscape context in the Seattle metropolitan area. Their results provide evidence that species richness increases with habitat patch size, as reported elsewhere in the literature, in all landscapes (urban, suburban, and exurban) because large reserves are able to support more species drawn from the regional pool. Large reserves in more developed areas supported greater species richness than large exurban reserves because of their ability to recruit and support synanthropic species that were generally not present in exurban areas. As well, larger reserves can be expected to contain greater habitat diversity and subsequently more niches for species to utilize. As reserve size decreased, those species depending on intact or expansive forest were the first to disappear. The authors attribute the differences in species richness between large and small reserves to local extinctions.

Very large reserves supported most native forest species found in the area, while reserves within landscapes of high (>40%) urban cover supported most of the synanthropic species found here. In summary, forest species occurrence decreased with decreasing habitat patch size, and synanthropic species occurrence increased with the amount of urbanization in the surrounding landscape. Non-native groundcover explained much of this variation: native forest species decreased and synanthropic species increased with the amount of exotic ground vegetation. The complex juxtaposition of habitats in more urban landscapes seems to allow for the occurrence of synanthropic species in urban reserves.

Total bird relative abundance was greater in habitat patches in urban and suburban landscapes than in more rural landscapes. This could not be explained by human-supplied food sources and nest sites because synanthropic species, which would be expected to exploit these features, were not common in the habitat patches. Rather, the authors suggest that density increased because individual forest birds pack into reserves when forest habitat is scarce. Birds are more able to disperse when reserves are bigger, evidenced by the tendency of packing to be less profound in bigger reserves.

The highest shrub nest densities, apart from those in large, exurban reserves, were observed in medium suburban reserves. These considerable (mean of 34.7 ha) habitat patches potentially act as a means of retaining forest species in developing landscapes. This is particularly important because small forest patches in urban landscapes had no value as breeding areas for at least some forest bird species.

One solution to the negative impacts of fragmentation is connectivity (Schaefer 2003). Connectivity refers more to the ability of an animal to traverse an area than any innate condition of the habitat itself. It can refer to the intactness of a patch or expanse of habitat (in contrast to fragmented habitat) or to a travel corridor between larger habitat patches. It is becoming increasingly apparent that landscape configurations are an important factor in species occurrence and distribution (Rodewald 2003), but it follows that different wildlife species perceive and use connectivity differently. Small, terrestrial organisms require separate consideration from more mobile large mammals and birds. Fortunately, many small, less readily mobile species are typically associated with wetlands, streams and riparian zones, and are subsequently afforded some measure of protection by existing regulatory codes in most jurisdictions in Washington State. City of Bellevue Critical Areas requirements are designed to protect both aquatic features and some extent of upland buffer extending from their boundaries.

Less mobile species, such as invertebrates and small mammals, often exhibit a more profound response to urbanization than more mobile species (Hansen et al. 2005), and might be expected to be more greatly impacted by fragmentation. Bird population dynamics may be related to amount of vegetated area available rather than configuration because birds are highly mobile and able to travel between disjunct patches (Marzluff 2005). However, some mobile species (e.g., songbirds) exhibit a preference for traveling between habitat patches through wooded areas compared to open gaps, even when the wooded route was up to three times longer than the gap (Desrochers and Hannon 2003).

Adjacent upland areas, including corridors, are also crucial to the ability of many less mobile species to live, reproduce and travel (Calhoun and de Maynadier 2004). Lehtinen et al. (1999) found that road density in particular was associated with a decline in amphibian species richness. This argues for upland connectivity when preserving wetlands.

6 Species of Local Importance

The City of Bellevue has designated 19 species of local importance (LUC 20.25H.150), excluding fish. Of these species, three are herpetiles, four are bats, and twelve are birds. These species are drawn from a number of taxa and depend upon a variety of habitat types and special features. Not all are documented or likely to occur in the City of Bellevue.

6.1 Reptiles and Amphibians

Western pond turtles were most likely extirpated in Bellevue in the 1980s. Although Meydenbauer Bay supported the species in the 1960s, only a few isolated individuals were observed during extensive surveys in 1991-1992 (Hays et al. 1999). Known breeding populations are presently restricted to Klickitat and Skamania Counties (Nordstrom and Milner 1997a).

Although western toad remains locally common in many areas within its range, rapid declines in the Puget Sound Lowlands have been observed and documented. Richter and Azous (1997) report use of some King County wetlands by breeding western toads, although they observed no breeding or non-breeding individuals in the western part of the County, including Bellevue and immediately surrounding areas. Washington State's Department of Natural Resources Natural Heritage Program reports the extirpation of a Beaver Lake, King County population since 1980, when the existence of only 21 of an historical 86 populations was confirmed (Hallock and McAllister 2005).

Surveys conducted from 1995 to 2005 revealed the presence of Oregon spotted frogs at six locales in Washington in nearly comprehensive surveys (Hayes and Pearl 2005). The authors further noted that populations historically occurring in lowlands drainages west of the Cascade have been disproportionately extirpated. Of three known Washington locations reported by WDFW in 1997 (Nordstrom and Milner 1997b), one was in Thurston County and two in Klickitat County. No populations are known or expected in the Bellevue vicinity.

A GAP (Gap Analysis Program) analysis (Johnson and Cassidy 1997) led by WDFW used satellite imagery, other data, and input from local experts to generate maps of core and peripheral habitat of the three herpetile species of local importance. Using a course-filter approach based largely on vegetation type, GAP analyses tend to over-estimate species occurrence (Smith and Catanzaro 1996). Habitat for none of the species is depicted within City limits, although individual occurrences of western toad are noted in or near the City.

6.2 Mammals

Four mammal species, all bats, are Bellevue species of local importance. GAP analyses were completed for the four mammal (bat) species on the City's list of species of local importance. No records of actual occurrences are depicted on resulting maps for any of the species (Johnson and Cassidy 1997).

The Townsend's big-eared bat's range includes most of the lowland and high montane mixed and coniferous forests of Washington, but their occurrence seems to be limited by the availability of suitable roost sites and, possibly, human disturbance (Woodruff and Ferguson 2005). Suitable roosts for both daytime and nursery roosting are caves, mines, hollow trees, and man-made structures. GAP analysis depicts Bellevue as core habitat for the species.

Some core potential habitat areas for long-eared myotis have been identified in the City of Bellevue. Although it occurs in most forested habitats and roosts in a variety of sheltered areas, including buildings, mid- to high-density development is not considered long-eared myotis habitat (Johnson and Cassidy 1997).

Long-legged myotis core habitat is depicted in the Johnson and Cassidy (1997) GAP analysis in the southern extent of Bellevue city limits and is common in much of its range. It is more often found at elevations of 2,000 to 3,000 m, however.

GAP analysis depicts neither core nor marginal Keen's myotis habitat in King County. The species is associated with old conifer forest. Few records of actual occurrences exist for the state (Johnson and Cassidy 1997).

6.3 Birds

Bald eagles are common nesters in western Washington, and a number of known nests are located within Bellevue city limits. Nesting birds also tend to choose sites close to open water in dominant tall trees of any species, usually providing line-of-sight to nearby water (Watson and Rodrick *et al*. 2004). The species often acclimatizes well to human development, although some individuals respond negatively to new disturbance and development (Stalmaster 1987). In winter, birds congregated at feeding grounds along large rivers and roost sites in dense conifer stands in western Washington. Habitat for established pairs and potential breeding habitat for additional birds exists in Bellevue, and suitable foraging perch trees are present throughout the City. Their diet is primarily fish, both live and dead, as well as ducks, other waterfowl, and carrion.

The peregrine falcon is mainly a cliff-nester, preferring cliffs greater than 45 m in height (Hays and Milner 2004), although man-made structures and occasionally trees are also used, as are existing abandoned nests built by other species. Preferred nest sites are usually near open water (Seattle Audubon Society 2005). Most breeding pairs are near a coast, but the species' range is expanding to encompass cities, including Seattle and Tacoma (Seattle Audubon Society 2005). They occur throughout western Washington in winter, when they often utilize large trees and snags for foraging perches near feeding sites, which are often open wetlands and mudflats but also include developed areas. Bridges and commercial and treed lakeside properties in Bellevue provide potential nesting and foraging locations, and the species is a documented nester in the City. Major prey species include pigeons and starlings in developed areas and ducks and shorebirds near coasts.

The merlin is a rare breeder in western Washington (Seattle Audubon Society 2005) and breeding occurrences are unlikely in Bellevue. However, wintering and migrating individuals commonly use parks, lakes, urban and suburban areas, and coastal regions, and rely less on forest. The species preys on small birds, bats, rodents, reptiles and large insects.

Red-tailed hawks are ubiquitous in western Washington and can be observed in almost any habitat. They usually use tall trees for nesting, but may also build nests on ledges, platforms or buildings (Seattle Audubon Society 2005). They forage mostly on small mammals, but also songbirds, reptiles and large insects, and they often utilize foraging perches near developed rights-of-way, fields, and other open areas in Bellevue.

Ospreys typically live near rivers and other large bodies of fresh or salt water and nest in large trees, snags, or man-made structures and platforms. They forage for fish in water that can support medium-sized fish. Ospreys are migratory and are present in Bellevue from late March through September (Seattle Audubon Society 2005).

Common loons prefer large, secluded lakes for breeding (Lewis et al. 1994, Seattle Audubon Society 2005) and are not likely to be found on any lakes in the City of Bellevue during the breeding season. In winter, the species is most common on the coast and in saltwater bays and inlets, but can occur on freshwater lakes near the coast as well. The open waters of Lake Washington and Lake Sammamish are suitable for non-breeding loons for short periods at any time during the year, but the species is very unlikely to use non-lake property in the City.

Pileated woodpeckers are regularly observed in suburban environs, where they forage and drum on trees, snags, and telephones poles. Despite being commonly referred to as old-growth or mature forest nesters, they will nest in any forest type as long as suitably large trees for roosting and nesting are present (Seattle Audubon Society 2005).

Vaux's swift forages in open skies over forests, lakes and rivers, where insects are abundant. Nesting normally takes place in mature or old-growth forest where large snags, preferably at least 27 inches dbh (Lewis et al. 2002) with cavities of approximately 20 inches in length, are available. The species also nests in broken treetops and chimneys. Sightings of individuals are not uncommon in developed areas, and they can be observed foraging over lakes, wetlands and forested areas in Bellevue. Additionally, remaining tracts of mature forest could potentially support breeding birds.

Purple martins readily nest in man-made boxes and structures, in addition to natural cavities. A colony nested in pilings at the north end of Lake Sammamish until at least 2003 (WDFW 2005). Individuals can be observed foraging on flying insects over any open area, including lakes, wetlands, fields and developed areas. Potential for the establishment of breeding sites, either natural or human-created, exists in the City of Bellevue, particularly in large wetlands and along lakeshores.

Western grebes are common on Lake Washington and Lake Sammamish in winter, where individuals utilize open waters. Breeding birds do not occur on or near other Bellevue lakes. Their diet consists entirely of fish and they are not likely to be found on land in Bellevue at any point in their lifecycle.

Great blue herons are typically thought of as wading birds frequenting wetlands, rivers, ponds and lakes. They are common in these habitats year-round in the Bellevue area. In winter, however, they also hunt on land, foraging on small mammals, primarily voles (Seattle Audubon Society 2005). The species usually nests in tall trees, but may also utilize artificial structures and even shrubs. The availability of suitable nesting sites in proximity to foraging areas may limit the occurrence of the species, and a number of studies also show that human disturbance can affect colony success, although some birds may acclimatize to disturbance (Quinn and Milner 2004).

Green herons depend on wetlands, ponds and streams for their prey, which is primarily small fish, but also includes crustaceans, insects, herpetiles and rodents. They typically nest in trees near water. Although they breed in Bellevue, they are a secretive species and susceptible to disturbance, development and habitat loss (Seattle Audubon Society 2005).

6.4 Habitat Types and Features Associated with Species of Local Importance

Of the species described in the preceding sections, 10 can reasonably be expected to occur within City of Bellevue limits. These are bald eagle, peregrine falcon merlin, red-tailed hawk, osprey, pileated woodpecker, Vaux's swift, purple martin, great blue heron, and green heron. These species and their habitats are subsequently the focus of the following discussion.

Certain aspects and characteristics of habitat in the City of Bellevue are of particular value to species of local importance. The habitat types described by Chappell et al. (2001) that occur within the City limits are Westside lowlands coniferous-hardwood forest; Westside riparian wetlands; herbaceous wetlands; open water (lakes, rivers and streams); agriculture, pasture and mixed environs;

and urban and mixed environs. These categorizations are modified herein to better reflect the actual conditions in Bellevue (see Sections 6.4.1 through 6.4.6).

As a whole, the City of Bellevue can be considered urban and mixed environs, which encompasses a gradient of development densities comparable to the urban, suburban and exurban designations defined in Section 3.5. Densities range from high (>60% impervious surface) to low (10-29% impervious surface) (Chappell et al. 2001). Highest development density occurs along the I-405 and SR 520 corridors and in the downtown areas. Much of the remaining area is moderately developed with single-family residences and parks. A few large blocks of Westside lowland forest and extensive wetlands remain on public property. Because the scope of this work is limited to the City boundaries, a smaller scale is applied and additional habitat types identified within the City's mixed environs. Habitat types encompassed within the City and described below are mixed forest; scrub-shrub; wetlands; lakes, rivers, and streams; agriculture, pasture and herbaceous areas; and mixed urban environs.

6.4.1 Westside Lowland Conifer-Hardwood Forest

Westside lowland conifer-hardwood forest in the City of Bellevue includes stands commonly dominated by red alder and bigleaf maple; western hemlock; Douglas-fir, red alder, and bigleaf maple; and Douglas-fir and western red-cedar. Typical understories range from dense and diverse native shrubs in younger stands to sparse sword fern in more mature forests. Common understory vegetation includes vine maple, osoberry, red alder, red huckleberry, cascara, red elderberry, tall and low Oregon grape, snowberry, salmonberry, evergreen huckleberry, salal, bracken fern, Pacific bleeding heart, Dewey's sedge, trillium, and other shrubs and groundcovers.

This habitat type ranges from mature, intact stands to very small fragments in the City of Bellevue. It is important in all its existing forms. In large stands, it provides nesting and foraging habitat for species requiring greater ranges for nesting or foraging. This may include merlin, red-tailed hawk and pileated woodpecker. Where stands exist near open water or wetlands, they are potential bald eagle, osprey, and great blue heron nesting habitat. Even small stands can potentially provide nest sites for these birds, provided some tall trees are present. Green herons may nest in younger forest as well, provided some water is proximate. When snags are present, Vaux's swift may nest. Forest near open water provides suitable foraging habitat as well for each of these species, and for peregrine falcons.

Because of the highly interspersed nature of habitat in urban areas, forest fragments are often located near openings other than water. Such forest fragments or small stands are of particular value to species that forage in open skies over clearing, such as red-tailed hawk and merlin.

Both intact large forest stands and forest fragments support nearly all species of local importance by providing travel and roosting corridors and locations. The benefits of urban forest cover can be inferred from the impacts of fragmentation and habitat loss described in this document. Protecting remaining forest is crucial to preserving shelter for resting, refuge, and migrating/travel needs.

In addition to providing nesting, foraging and travel habitat, forest stands and groups of trees are vital to maintaining prey populations for species of local importance. Songbirds are a common component of merlin and red-tailed hawk diets, and many songbird species depend on forest for much of their lifecycle. Declines in songbirds with forest cover loss and fragmentation increase, as described in previous sections of this report, can be expected to impact species that depend on them as food.

6.4.2 Scrub-Shrub

If left untouched by both human-induced and natural disturbance regimes, scrub-shrub in the City of Bellevue would succeed toward forest. However, development and other aspects of the urban environment allow for scrub-shrub and young forest to perpetuate. Dense shrub cover provides nesting areas for many songbird species, and the tendency for this type of cover to occur near or within development often means that it has irregular borders and is highly interspersed with other land covers, benefiting the synanthropic species as detailed earlier in this report. Some of these species are of particular value to merlins and peregrine falcons, both of which commonly feed on birds in urban areas. Shrub also provides cover for small mammals, another important prey group. Where dense low cover occurs near wetlands and streams, it supports prey populations of reptiles and amphibians for green herons and great blue herons, as well as directly providing cover for these species.

6.4.3 Wetlands

The value of wetlands as wildlife habitat is well documented. They are essential to great blue herons and green herons for their entire lifecycles. The open areas above wetlands are ideal purple martin foraging habitat, and the species most often selects nesting sites in the vicinity of wetlands. Bald eagles and peregrine falcons regularly forage on ducks and other birds that utilize wetland habitat. Reptiles and amphibians that breed and rear in wetlands are important as primary and secondary prey species to a variety of wildlife, beyond the species of local importance mentioned here. Urban wetlands provide refugia in areas that might otherwise be more highly developed, particularly where vegetated buffers are preserved. The interface between wetland and upland habitat is of great value to wildlife in cities for this reason, as well as for the diversity of life these habitats naturally support.

6.4.4 Lakes, Rivers and Streams

Open water features are a vital habitat component for several species of local importance. Lakes and large rivers provide prey species for bald eagle, osprey, great blue heron, and green heron. They also provide forging areas for Vaux's swift and purple martin. These species all rely on the proximity of these features for some or all of their lifecycle, and the presence of open water in the City of Bellevue is responsible for the ability of the species to live in City limits. Preservation of forest stands, native shrub, and large trees near open water is key to providing potential nesting habitat for these species as well.

Streams provide breeding and foraging habitat for both heron species of local importance, as well as for numerous other birds and for fish, reptiles and amphibians. However, where vegetated riparian zones exist along streams, they become an invaluable resource as travel corridors for birds and mammals. Many studies address the importance of riparian corridors to wildlife, particularly in developed areas (Knopf et al. 1988, Gillies and St. Clair 2008). They are particularly valuable in fragmented urban habitats because they facilitate travel among habitat patches for wildlife.

6.4.5 Agriculture, Pasture and Herbaceous Areas

In Bellevue, remnant agricultural lands of the agriculture, pasture and herbaceous area habitat type primarily comprise berry farms and pasture. Herbaceous areas can include parks and fields, as well rights-of-way and residential land that are not vegetated with trees and shrubs. Open herbaceous areas attract species that prey on small mammals. Red-tailed hawks and merlins in particular often forage over open herbaceous areas. Vaux's swift, purple martin, and other aerial-foraging insectivorous birds can also be spotted utilizing these areas. Waterfowl may congregate in cultivated land outside of the breeding season. As well, the edges formed by these lands when they border other habitat patches attract a variety of generalist and synanthropic species.

6.4.6 Mixed Urban Environs

The category describes the more highly developed areas of Bellevue and incorporates small patches of vegetation among buildings, concrete, and other urban infrastructure. The general landscape includes the spectrum of developed areas described in Section 3.5. The environment attracts highly adaptable species, often non-native pest species, but where it interfaces with more natural environments, synanthropic species appear and diversity can be enhanced, as described in earlier sections of this document. Most of Bellevue's species of local importance require habitat and features not typically present in urban environs, with a few exceptions. Peregrine falcons are increasingly observed to use urban areas for their entire breeding cycles. They readily nest on buildings and bridges and feed on urban wildlife, notably rock doves (pigeons). Merlins use urban areas in winter, when they are mostly likely to be found in the Bellevue area, preying on urban songbirds. Purple martins may be seen foraging over urban areas during the breeding season. These species and others also utilize less densely developed urban environs, including residential areas, parks, and rights-of-way.

7 Management Recommendations and Mitigation

The recommendations and mitigation measures outlined in this section are designed to maximize habitat suitability for a number of diverse terrestrial wildlife species and guilds. They are based on results and trends detailed in this literature review.

Avian species are common in urban areas and are enjoyed by wildlife recreationists. As well, research on the effects of urbanization on birds is being conducted in the Seattle metropolitan area, and is therefore relevant to this work. Most large mammals have been excluded from the Bellevue area; small- and medium-sized mammals are often viewed as pests and urban populations tend to include well-adapted urban exploiters. Habitat of aquatic and wetland species are provided some protection under the existing Critical Areas Ordinance, and they are therefore not the primary focus of this work. As a result, many of the following recommendations are based on the needs of birds that occur in Western Washington. Special attention is paid to species of local importance (LUC 20.25H.150).

Implementation of both recommendations and mitigation should consider existing habitat values and needs on a site-specific basis. Habitat should be quantified and qualified using a functional assessment form (The Watershed Company 2009); resultant scores should guide decisions and actions based on the following management strategies. Highest scoring sites are of the greatest value and management should include primarily preservation and the other recommendations below, while mitigation should be considered only when impacts are unavoidable. Lower scoring sites may have higher potential for improvement, and therefore mitigation might offer greater benefits.

7.1 Habitat Management Recommendations

- **Preserve large patches of native vegetation when possible.** It has been proposed that the most effective and cheapest way to protect species diversity in the long run is to preserve as much natural habitat as possible (McKinney 2002). Habitat patch size is important to avian species richness in all landscapes and to breeding birds in some. Therefore, small- and medium-sized habitat patches alone will not preserve all native species. Evidence suggested that vegetative complexity, and native shrub diversity in particular, contributed to higher richness and less evenness in bird communities in larger habitat patches (Donnelly and Marzluff 2004). Loss of some rarer species that were supported by the greater habitat diversity in the larger patches occurred in smaller reserves. In addition, long-term viability of bird populations seems to be reduced by reduced quality and abundance of native forest, and this seems to be related to the amount of vegetation available (Marzluff 2005). Parks provide an opportunity for preserving relatively large forested areas within urban boundaries, and they should be a priority in urban planning. In particular, maintenance that involves native vegetation removal should be limited where possible to preserve vegetative complexity and exclude human traffic and other disturbances.

- **Limit or control human-introduced disturbances, including pets, hiking, refuse, and noise, in habitat patches.** This may be accomplished with wildlife passable fencing, signage, or, preferably, a dense buffer of native vegetation.
- **Restore native habitat.** Natural succession in natural ecosystems increases the number of plant and animal species that use a residential area following disturbance (McKinney 2002). The same effect can be achieved using native plantings, which also tends to reduce non-native infestations. The benefits of native vegetation in wildlife habitat are evidenced in many of the studies presented in this document. Diversity should be maximized when planning landscapes. Native plant diversity has been correlated with increased diversity of native faunal species.
- **Remove non-native plant species and replace with natives.** Evidence suggests that wildlife population parameters are enhanced by native plant species, particularly groundcover. Groundcover within existing forest should be preserved and enhanced (Donnelly and Marzluff 2004).
- **Preserve and encourage heterogeneity of landscapes to maximize diversity.** This encourages use by synanthropic species, many of which are native, and positively affects bird species diversity. Some species require edge habitat and fragmentation, but a completely fragmented landscape is homogeneous; large, unbroken patches of intact native vegetation should be part of a heterogeneous landscape. Local effects of maximizing habitat heterogeneity will not translate globally, however. Settling all land moderately to achieve the highest species richness does not enhance diversity globally, but rather leads to homogeneity (Lockwood et al. 2000, Sax and Gaines 2003, McKinney 2006). Further, only a few globally distributed species occurred locally and did not drive natives to extinction, as competition for resources was low at this level (Marzluff 2005, Blewett and Marzluff 2005). This does not alleviate the need for large-scale management and preservation.

- **To follow the preceding recommendation, maintaining existing moderately settled land and planning for undeveloped and highly developed areas in the future is an appropriate strategy for the City of Bellevue.**
- **Preserve and encourage recruitment of special habitat features.** Snags, large conifers, downed wood, perches, rockeries, steep slopes, and water features are all valuable wildlife habitat features. Many of them specifically benefit species of local importance.
- **Assess development project areas for their potential to support species of local importance.** If evidence that suitable habitat for any of these species exists, and reasonable potential for recruitment of individuals of the species is noted, a management planned tailored for the species, with consideration given to the management recommendations presented in this section, should be completed.
- **Employ development management practices that limit sprawl.** Despite Washington State's Growth Management Act attempting to concentrate development in dense areas, the primary growth pattern has been wildlands to exurban and from exurban and agriculture to suburban (Robinson et al. 2005). Exurban increased by 193% from 1974-1998. Because Bellevue is young, studies conducted in the area do not reveal whether the commonly observed peak in wildlife species diversity and richness at intermediate levels of disturbance will persist over ecological time (Marzluff 2005). Further support for avoiding intermediate disturbance in some cases is gleaned from the tendency for some wildlife species to respond negatively as distance to development decreases (see 5.6.1). Thus, this non-linear peak should not be used as an excuse to fragment intact landscapes in rural and wild areas. Techniques that promote housing density should be considered in all cases.
- **Plan for and maintain habitat corridors between habitat patches.** In general, a wide swath of native vegetation that includes structure heterogeneity is preferred, but cover should be maintained when this is not feasible.
- **Buffer natural areas and parks with low-intensity development zones.** This creates softer edges and may be necessary for protecting wildlife in existing natural areas (Rodewald 2003).
- **Consider the surrounding landscaping in small-scale planning.** Landscape level impacts cannot be avoided, and planning should couple a broad approach with site-specific decisions.
- **Do not attempt to manage small, inner-urban areas for all species.** Recognize that some species will not occur in some areas, and manage for those species most likely to benefit.

- **In fragmented areas, design small-scale habitat projects to mimic a natural landscape mosaic.** Some degree of fragmentation exists in nature. Native fragments can be mimicked in artificial situations.
- **Discourage open lawn on private properties in favor of more structurally diverse vegetation.** Encourage property owners to replace lawns with structurally diverse landscapes. Backyard habitat programs are essential links in urban habitat management (Schaefer 2003).
- **Provide incentives for single-family lot owners to preserve trees and native vegetation.** Recommended tree density is at least 9.8 trees/ha with at least 23% conifers (Donnelly and Marzluff 2006).
- **Require a variety of green spaces as part of new developments.** Plan diverse spaces to support a spectrum of needs (Marzluff and Rodewald 2008).
- **Assess habitat using a standardized habitat assessment tool in any area where a land use action is proposed.** Employ a combination of subjective and quantitative techniques. Quantitative techniques allow data sets to be shared among users (Shaughnessy and O'Neil 2001), while a qualitative component allows for site-specificity and professional judgment.
- **On a city-wide scale, plan for a maximum of no more than 52% urban landcover and more than 64% total forest cover.** Limit grading and clearing and promote native growth protection areas. Do not allow for subsequent development on previously developed properties to circumvent these goals (Donnelly and Marzluff 2006).
- **Encourage public participation and appreciation of natural environs.** The success of urban habitat management is contingent upon public support. New approaches for promoting public involvement and education should be considered.

7.2 Mitigation Measures

Whenever the needs of both the natural environment and the expanding human population must be considered, some impact may be unavoidable. If all possible measures have been taken to avoid and minimize habitat impacts and the preceding recommendations are planned, the following measures will help mitigate potentially detrimental effects of development.

- Replace disturbed or destroyed native habitat with appropriate native plant species in high structural and compositional diversity. Plan carefully so that plants provide wildlife forage year-round.
- Avoid temporal impacts of habitat loss by providing plant cover in or adjacent to disturbed areas before and during disturbance.

- Plan construction activities outside of the spring and summer breeding and rearing seasons.
- Provide additional habitat features to altered landscapes to encourage wildlife use. These may include snags, downed wood, rock piles, year-round water features, and nesting platforms or boxes.
- Control and limit disturbance by humans to natural areas by fencing the areas, excluding pets, limiting invasion to trails, pointing lighting away from natural areas, limiting or excluding night lighting, limiting noise, and providing trash receptacles to discourage littering.
- Consider the long-term effects of development and mitigation by planning for natural succession to proceed on the property.

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GUIDANCE

Using the Bellevue Urban Wildlife Habitat Functional Assessment Model

City of Bellevue

Prepared for:

City of Bellevue Development Services Department
450 110th Avenue NE
P.O. Box 90012
Bellevue, Washington 98009

Prepared by:

THE WATERSHED COMPANY

750 Sixth Street South
Kirkland . WA 98033
p 425.822.5242
f 425.827.8136
watershedco.com

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USING THE BELLEVUE URBAN WILDLIFE HABITAT FUNCTIONAL ASSESSMENT MODEL

EXECUTIVE SUMMARY

The City of Bellevue Functional Assessment Model was developed to provide a standardized, reproducible means of evaluating habitat in an urban or urbanizing setting. The model measures and rates landscape- and local-level habitat parameters, which were selected based on best available science. A comprehensive literature review preceded production of the model to describe the need for such a measurement tool and to provide a basis for parameter selection and classification. This guidance serves to aid users in applying the model.

The model consists of a form that identifies habitat features to be assessed. The form is designed to identify both the ability of a site to perform habitat functions and the level of opportunity that exists in the greater landscape for the site to function effectively. A numerical result representing the site's potential and actual habitat value can be compared to other locations or over time. A five-step process is evaluates and rates the habitat value of a property. The form classifies the property according to existing impervious surface; assesses habitat-based landscape characteristics; identifies and rates site habitat parameters; assigns a score based on the results of the first three steps; through the rating generated and the individual responses to each measurement, determines a site's habitat attributes, deficiencies, and potential to support wildlife.

1 INTRODUCTION AND PURPOSE

This guidance is intended for use with the City of Bellevue Functional Assessment Model. Similar models have been developed for characterizing and rating the value of regulated critical areas such as wetlands and streams. No such model is widely available to evaluate habitat value on a local scale in an urban area. The Bellevue model allows users to rate habitat on a property based on its potential to support species of local importance and other wildlife.

The role and function of wildlife habitat in urban areas is detailed in the May 2009 Bellevue Urban Wildlife Habitat Literature Review. The model is captured in a functional assessment form, a tool developed using the results of the literature review. It measures the value of a property or area to wildlife by assessing existing conditions on the local scale and within a larger landscape context. Parameters measured are habitat features and components that are important to one or more species during some point in their lifecycle. In the City of Bellevue, these parameters are vital to ensuring that wildlife continues to survive in the urban landscape.

2 Overview of the Model

Figure 1 illustrates the three-step process by which a property is evaluated. Habitat parameters measured by the model are separated into landscape- and local-level. At the local level, the presence of habitat and habitat features allows for wildlife to potentially use the area. However, a source of individual animals is needed for actual use to occur. The presence of such opportunity is best measured over the adjacent landscape, the boundaries of which are determined by the present degree of development, which in turn plays a role in the ability of animals to access a site from surrounding areas. If suitable conditions exist at the local scale and a source is present at the landscape, habitat on a property has the potential to support wildlife. Before these parameters are measured, the subject property is classified into one of four zones. All parcels in the City do not start from an equal point; by nature of their location, zoning and present use, some show a higher baseline potential than others and are assessed accordingly. Zone classification is based on impervious surface and is the first measure of whether the potential to support habitat exists on the property. The Bellevue Planning and Community Development Department (PCD) will provide impervious surface data when a determination needs to be made.

Figure 1. Three-step evaluation processes employed by the functional assessment form.

Step 1 – Define property's zone

Zones are determined based on some feature or features of a site or site's vicinity that act(s) as an indicator of the site's potential to provide habitat presently and in light of likely future conditions. The amount of impervious surface presently on the subject property is used in this model to classify the property into one of four zones.

↓

Step 2 – Does the opportunity to provide habitat exist?

A set of questions addresses the landscape surrounding the site. Questions are particular to the urbanization level of the area, and the scope may vary for individual sites depending on the zones applied in Step1. Most of the questions in Step 1 one are answered using aerial photographs and information sources listed in these sections.

↓

Step 3 – Does the opportunity to provide habitat exist?

The next set of questions are answered through measurements and observations on-site and address the site's present ability to support wildlife. These questions are also drawn from current literature and are specific to the jurisdiction or area.

↓

Step 4 – Scoring

Points are awarded based on the scores from Steps 1 through 3. Higher-scoring sites are those that have both greater ability to perform habitat functions and the opportunity, afforded by the surrounding landscape, to do so.

↓

Step 5 – Form results are used to drive permitting decisions, management recommendations, and mitigation

If site development is proposed, the form can be used to assure that specific site features that are important to habitat are preserved. For example, connectivity to critical areas or off-site habitat patches might be addressed by clustering development. Recommendations can be made for managing the remaining habitat. Mitigation for impacts can be planned on a site-specific basis, focusing on both landscape-level ecological processes that may be affected by action on the site and on-site habitat types and features.

3 USING THE FORM

3.1 Landscape-level Parameters

3.1.1 Land Use and Development Density

Obtain the property's land use and development density category from PCD and assign the appropriate score on the form. Categories are based on the percentage of impervious surface on the property. Zone A properties contain 90% or more impervious surface; sites designated as Zone B are made up of 50%-90% impervious surface; Zone C sites comprise from 20% to 50% impervious surface; and Zone D are covered by less than 20% impervious surface.

3.1.2 Occurrence of Habitat Types

Use the zone designation provided by PCD to determine the required area to evaluate (Table 1). The required evaluation area for each zone should be measured as a circle with the subject property at the center.

Table 1. Landscape Attributes circles associated with PCD zones.

Landscape Attributes circle size to use	Zone A	Zone B	Zone C	Zone D
Area (acres)	0.5	5.0	100	250
Radius (feet)	83	263	1,178	1,862

Using publicly available aerial photographs, count the number of different habitat types on the property and within the evaluation area. Consult National Wetland Inventory (NWI) maps and King County Sensitive Areas iMAP online GIS information (iMAP) to determine the existence of known wetlands. Any habitat patch that is wholly or partially within the evaluation area should be counted.

Habitat types, as defined in the Bellevue Urban Wildlife Habitat Literature Review, are based on groups of vegetation types or other features that sustain wildlife. They are structurally based and therefore do not generally differentiate between native and non-native species, with the exception of areas such as golf courses or large lawns that can be discerned at a large scale on aerial photographs. Habitat types found in the City of Bellevue are mature coniferous forest, mixed coniferous-deciduous forest, scrub-shrub, meadow and grassland, ponds and lakes, streams, and wetlands. Wetlands may be further divided into emergent, shrub-shrub, forested, or open water; however, if wetland areas are not apparent from aerial photographs or readily available public resources, they may be categorized by vegetative structure alone as meadow, scrub-shrub, etc.

Do not count wetlands twice (e.g., as both wetland and as forest), but do count different wetlands individually.

3.1.3 Proximity of Critical Areas

Distances categories to critical areas are derived from general knowledge regarding urban wildlife home ranges and modified to account for the presence of travel barriers. Measure the distance from the subject parcel edge to the edge of known critical areas (streams, wetlands, wildlife networks, ponds, Priority Habitat and Species (PHS) polygons (required for Zone D only), and lakes). Consult NWI maps, the Washington Department of Fish and Wildlife (WDFW) SalmonScape online database, and iMAP to determine the location of sensitive areas. If the subject parcel is located within a PCD Zone D, obtain PHS data from WDFW. Distances can be measured using the distance function in the iMAP system, GPS, or aerial photographs. Sites containing a critical area receive an additional point, as do sites containing habitat patches that are contiguous with critical areas on- or off-site, regardless of whether the patch itself is a critical area.

3.1.4 Habitat Connectivity and Corridors

For each patch of habitat on the site, determine connections to off-site vegetated areas using first on-site observation and then aerial photographs. Breaks in connectivity are based on the propensity of wildlife to avoid crossing them. Breaks include gravel roads used by vehicles daily, paved roads, paved multi-use trails that experience daily non-motorized traffic, maintained lawns or fields associated with structures, pasture, mowed rights-of-way, and solid fences or walls. Impervious foot trails, decommissioned or rarely used gravel roads, wildlife-passable fences, and unmaintained rights-of-way are not breaks in connectivity.

Connections must be vegetated with trees, shrubs (native or non-native) or wetlands. Other cover (lawns, ornamental vegetation) may make up no more than 50% of the width of the connecting area at any point. Streams are included as part of the connecting area, but ponds, lakes, and other open water bodies are not.

Parks meriting 3 points are Mercer Slough, Phantom Lake wetland complex, Larson Lake wetland complex, Cougar Mountain Regional Wildland Park, and Weowna Park. In addition, habitat patches connected to mapped King County wildlife networks, obtained from the iMAP system, are awarded 3 points under the conditions stated in the FAM.

3.1.5 Patch Size

Size of habitat patches is measured on-site for patches fully contained within a property, and using aerial photographs for patches extending beyond subject property boundaries. Count all patches in the appropriate area for the property, using the property's PCD zone designated circle size (Table 1), placing the property at the center of the circle. Point allotments for patch sizes are based on species-area curves and modified for relevance to an urban landscape. For the purposes of this question, a habitat patch is the total area of all contiguous cover types defined as habitat in Section 1.2, with the exceptions of manicured lawns and other highly manipulated and maintained areas. Habitat patch boundaries are delineated by the edge of unmaintained low cover, shrubs, water body edge, or tree canopy. Score each patch individually and allot the total points.

3.1.6 Interspersion

This question assesses the variety of habitat available and the amount of edge habitat on a site. Using the appropriate size circle for the property's zone (Table 1), overlay a circle on an aerial photograph with the property in the center. Choose the appropriate score using Appendix A. Include all vegetated areas ≥0.5 ac in size as habitat. Exclude paved areas, gravel, and structures. An additional point is awarded if high-value habitat in the form of a wildlife network or park listed in Section 1.4 is included in the matrix.

3.2 Local Attributes

3.2.1 Size of Native Trees

Points are awarded to sites containing trees likely to be used by wildlife for nesting or foraging. Higher points are given for trees of sizes preferred by or critical to species of local importance. On residential or other small parcels, measure the diameter at breast height (dbh) of the largest trees on the property. Allot points based on the largest tree on-site. Large sites may require a tree survey for some permit applications. In this case, tree sizes can be obtained from the survey.

3.2.2 Coniferous Component

Dominance of coniferous species may be measured by one of several scientifically sound methods. The suggested method is to use aerial coverage in the uppermost stratum. The most abundant species exceeding 50% cover is dominant. Any single species covering 20%-50% of the top stratum is sub-dominant. If conifers on a site fail to meet one of these criteria but are present, the site receives one point for this parameter.

3.2.3 Percent Vegetative Cover

Estimate the percent of vegetative cover on the site using plots, line-intercept, or another appropriate method. Sample only vegetated parts of the property. Include grass and lawns, but note that a point is subtracted if low grass represents more than 50% of the herbaceous layer. Measure cover in three strata: 0-2.3 ft (0-0.07 m), 2.3-25.0 ft (0.7-7.6 m), and >25.0 ft (>7.6 m). Each stratum is scored separately on the assessment form. Plot radii for sampling herbaceous, shrub and tree layers should be 5 ft, 10 ft and 30 ft, respectively. Adequate sample sizes may be calculated using Freese (1962), Stauffer (1983), or a similar method. Alternatively, 30% of <1-ac properties, 20% of <5-ac properties, or 10% of >5-ac properties may be sampled, provided it can be demonstrated that vegetation is adequately represented. Smaller sample sizes may be accepted for highly homogeneous sites, to be justified in an accompanying report and decided on a case-by-case basis.

3.2.4 Vegetative Vertical Structural Diversity

Use a foliage height diversity (FHD) index such as MacArthur and MacArthur (1961) to measure vertical vegetative structure. Other authors have modified this index for ease of use and applicability (e.g., Hays et al. 1981, Berger and Puettmann 2000). The FHD index considers both the number of strata occupied by vegetation and the evenness of vegetation distribution in calculating diversity:

$$FHD = -\sum p_i \ln p_i$$

where p_i is the relative proportion of total foliage in the i^{th} stratum. Use the three strata (0-2.3 ft, 2.3-25.0 ft, and >25.0 ft) in Section 3.2.3, following MacArthur and MacArthur's (1961) recommendations for effective testing of wildlife habitat. See Appendix B for an example of how to calculate FHD using the index above.

Vegetative proportions can be assessed visually in vertical corridors or cylinders, or by using a vegetation profile board. Sample locations may be randomly selected or, on smaller sites, chosen in areas representative of the site. Sample sizes should be calculated using the methods suggested in Section 3.2.3.

3.2.5 Vegetative Species Richness

Count native vegetative species that make up at least 10 sq ft of the property (cumulatively). Do not include species on the King County 2009 noxious weed list (http://www.kingcounty.gov/environment/animalsAndPlants /noxious-weeds/laws/list.aspx) in richness calculations.

3.2.6 Invasive Species Component

Percent cover by invasive species can often be estimated visually, as these species tend to grow in mono-specific patches with clearly defined edges. If invasive species are scattered or dispersed as individual plants, use the methods suggested in Section 3.2.3 to obtain percent cover. Include all species on the King County noxious weed list.

3.2.7 Proximity to a Year-Round Water Source

Categories are based on home ranges and dispersal distances of bird, reptile and amphibian species of local importance. Year-round water sources include perennial lakes, ponds, wetlands and streams, and artificial features such as reservoirs and detention facilities, provided they have vegetated buffers. Artificial water sources with buffers comprising solely low groundcovers or maintained vegetation receive scores reduced by 1 point. Scores of 0 points should not be reduced, however.

3.2.8 Snags

Count all snags at least 4 inches dbh, or estimate average snags/acre on large sites. For sites smaller than one acre, extrapolate snags/acre. Additional points are added for snags of sizes preferred by or critical to species of local importance. Again, extrapolate large snags/acre on sites where a full count is not practical.

3.2.9 Other Habitat Special Features

Features to be awarded points in this category are as follows:

- downed wood at least 6 inches in diameter at any point
- unused structures such as sheds, barns, houses, wells and chimneys
- water-holding features (need not be a year-round source)
- rockeries
- rock piles
- vertical banks
- stumps at least 20 inches in diameter
- trees with large (> 2 inches diameter entrance) cavities
- active nests or dens
- active raptor perches (defined by observation or documentation of use)

4 SCORES

Possible scores range from 0 to more than 50 points. A score of 10 or less is indicative of sites with little or no functional wildlife habitat, and little potential or opportunity for wildlife to use the site. Sites scoring 11 to 25 points are most likely in Zone A or Zone B, and thus, while habitat might be present in the landscape, potential for wildlife to use the property might be low. Sites with scores of 26 to 40 provide both actual habitat and likely the opportunity for wildlife to use the habitat on the site. Scores exceeding 40 point are indicative of high value exurban areas, where wildlife use, including that of species of local importance, can be expected both on the site in the surrounding area.

An individual evaluation of where points were awarded should be performed for each site, as the score for any each provides insight into the particular property's assets and limitations. It is important to first note whether a property receives a landscape-parameters score that indicated that opportunity to support wildlife exists. If little opportunity exists (i.e., the site scores low for landscape questions), local-level parameter scores must then be evaluated in light of this finding. If development is proposed for the site, a detailed review of where the most potential and actual habitat functions exist can guide the actions taken so that the least possible impact is experienced. Similarly, a site-specific evaluation of point distribution can be used to guide mitigation, where appropriate. Both landscape- and local-level features and score should be investigated, as mitigation actions should address the needs of the surrounding area rather than being limited by the site. For example, it may be most appropriate and effective to preserve or enhance a riparian buffer that extends onto the subject property, even if no aquatic feature is itself located on the property. Such review and considerations are vital to protecting the health and value of wildlife habitat within the City.

5 Reporting Standards

A report should accompany all habitat functional assessments. Report content should include, at a minimum, the information in the following sections.

5.1 Property Information

- Supply property address and parcel number.
- Supply project name and contact information of applicant.
- Describe actions proposed for the property.
- List any additional environmental reports or site assessments submitted pertaining to the property.
- Describe existing development on the property, including structures, utilities, impervious surface, and land use.
- Describe the natural environment on and adjacent to the property, including topography, elevation and vegetation.

5.2 Project Personnel

- Supply name and contact information for the landowner.
- Supply names and contact information for architects, developers, project managers, and other personnel (if applicable).

- Supply names and summarize credentials of ecologists or other scientists who worked on the assessment.

5.3 Project Description

- Describe proposed actions for the property, including demolition, construction, vegetation alteration, proposed increases or decreases in impervious surface, and planned uses.
- Explain any proposed deviation from building code, including why it is necessary.
- Detail development schedule, if applicable.

5.4 Functional Assessment Information

- List dates of site visit(s) and report completion.
- List and explain any deviation(s) from the methods described in the functional assessment form and accompanying Guidance.
- Although it is not necessary to submit raw data from the functional assessment form in the report, include all sample sizes and methodologies used for calculations and measurements.
- List references used, including personal communications, in site investigations.
- Note any documentation, evidence, and observation of wildlife use of the property.
- Describe any regulated critical areas on the site and summarize applicable regulations.
- Include a map or aerial photograph overlay depicting locations and extents of habitat and habitat features presented in the FAM.
- Describe expected and possible impacts to habitat from proposed actions on the property.
- Detail proposed mitigation measures (if any), performance standards, and contingency plans.

A detailed assessment of the distribution of points on the form should be included and should drive a discussion of opportunity and ability of the site to perform habitat functions. Special site assets and any weaknesses should be identified. Recommendations may be made for avoiding and minimizing site development, if appropriate. Finally, it should be emphasized that mitigation should be the last approach considered, after avoidance and minimization have been employed to the extent possible. If unavoidable impacts to habitat are to occur, mitigation should be addressed on a landscape scale, as well as at a site level. If habitat deficiencies in the greater landscape can be improved through mitigation on the subject property, mitigation measures should take a landscape approach.

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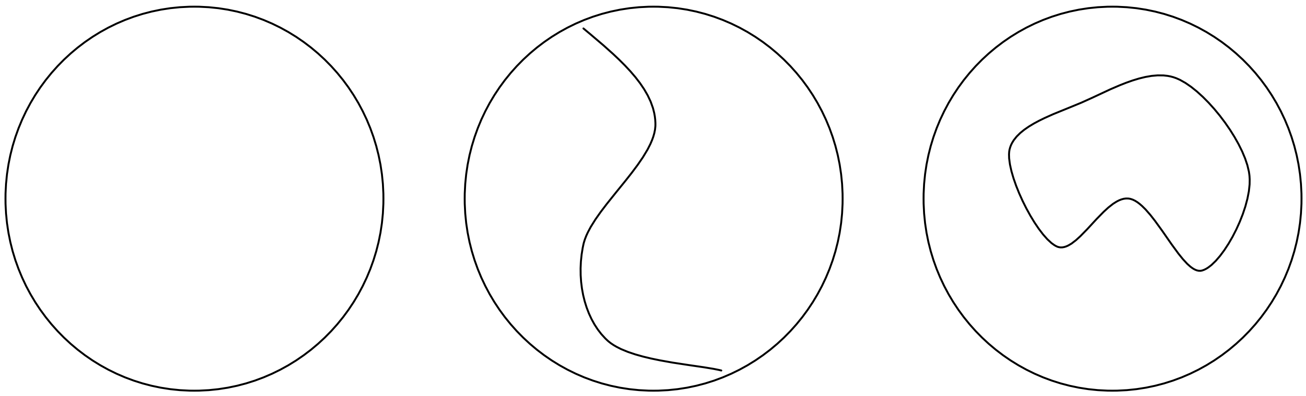
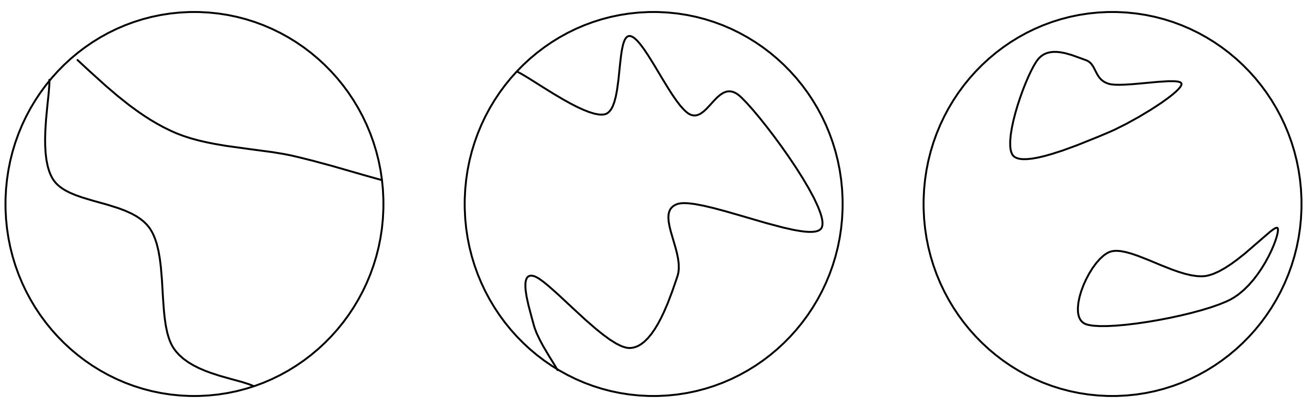
APPENDIX A

Spatial Pattern Chart for Rating Juxtaposition

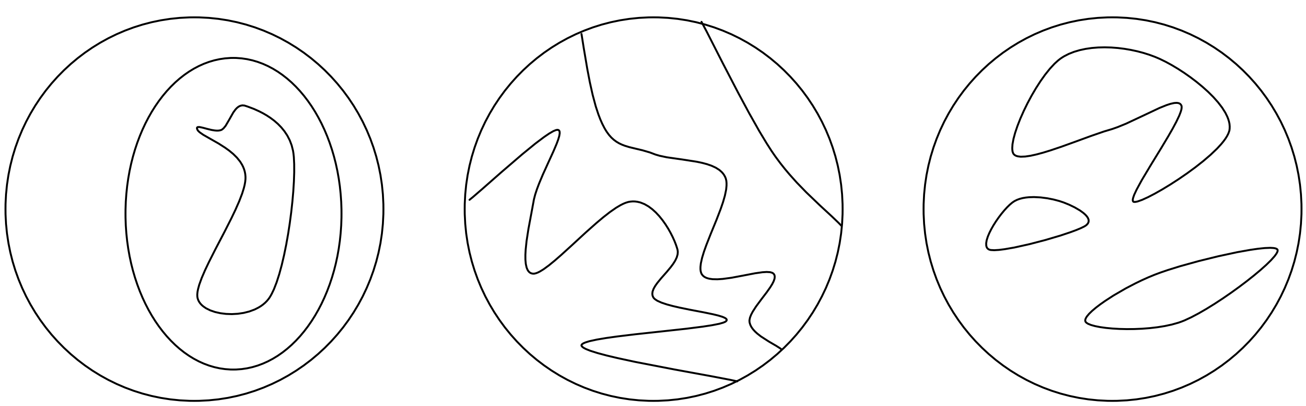
None **Simple/low**



Moderate



Complex/high



APPENDIX B

Foliage Height Diversity (FHD) Example Calculation

An example of FDH is calculated below using the equation:

$$FHD = -\sum p_i \ln p_i$$

In this example, a 3-strata forest has a ground layer of 90 percent cover, a mid-story of 40 percent cover, and a tree layer of 70 percent cover. Thus, i=3 and the sum of cover is 200 percent. To calculate proportions:

Stratum 1: $p_1 = 90/200 = 0.45$

Stratum 2: $p_2 = 40/200 = 0.20$

Stratum 3: $p_3 = 70/200 = 0.35$

Next, calculate $p_i \ln p_i$ for each stratum using the natural log function on a scientific calculator:

$0.45 \ln 0.45 = -0.36$

$0.20 \ln 0.20 = -0.32$

$0.35 \ln 0.35 = -0.37$

Finally, the negative sum of these amounts = FHD:

$-[(-0.36) + (-0.32) + (-0.37)] = 1.05$

City of Bellevue

DRAFT FUNCTIONAL ASSESSMENT TOOL

for Upland Habitat

Property address________________________ Project name ________________________

Location_____ Range_____ Township_____ Section_____ Project contact________________________

Parcel number________________________ Telephone number(_____) -_____ -_____

Property owner________________________ Address________________________

Telephone number (_____) -_____ -_____

Staff________________________ Date(s) of site visit(s)________________________

Washington Department of Fish and Wildlife Priority Habitat and Species (PHS) data obtained? Y/N_________

1.0	PROPERTY DESIGNATION	Zone A	Zone B	Zone C	Zone D		Zone
1.1	**Existing impervious surface**	>90%	50-90%	20-50%	0-20%		
2.0	**LANDSCAPE PARAMETERS**	**No points**	**1 point**	**2 points**	**3 points**	**Additional points**	**Total**
2.1	**Land use/development density**	Zone A	Zone B	Zone C	Zone D		
2.2	***Occurrence (number) of habitat types**	0	1	2	3+		
2.3	****Proximity of known critical areas (distance to edge)**	>2,500 ft	<2,500 ft	<1,200 ft	<100 ft	+1 point if contiguous with critical area	
2.4	**Habitat connectivity and corridors**	No connection to other habitat areas	≥50-foot-wide connection to vegetated areas of at least 1 acre	≥50-foot-wide connection to vegetated areas of at least 50 acres but not listed parks***	≥50-foot-wide connection King County wildlife network or listed parks***	+1 point for ≥150-foot-wide connection King County wildlife network or listed parks***	
2.5	**Patch size**	<0.-1.0 ac	1.0-5.0 ac	>5-10 ac	10-42 acres	>42 acres = 4 points	

City of Bellevue

DRAFT FUNCTIONAL ASSESSMENT TOOL

for upland habitat

2.0	LANDSCAPE PARAMETERS	No points	1 point	2 points	3 points	Additional points	Total
2.6	***Interspersion of habitat patches (excluding patches <1 ac in area)**	No or isolated patch (no others within 0.5-ac circle)	Low	Moderate	High	+1 point if wildlife network or listed park is included	
3.0	**LOCAL PARAMETERS**	**No points**	**1 point**	**2 points**	**3 points**	**Additional points**	**Total**
3.1	**Size of native trees on site**	No significant trees on site	6-12" dbh tree(s) present	12-20" dbh tree(s) present	>20" dbh tree(s) present	+1 point if tree(s) >30" dbh are present	
3.2	**Coniferous component**	No conifers on site	Conifers very sparse or present in understory only	Conifers co- or sub-dominant in overstory	Conifers dominant	+1 point if conifers >30" dbh are present	
3.3	**Percent cover (sample vegetated areas only)**						
	Ground layer (0-2.3 ft) (5-ft radius)	0%	0-25%	25-50%	50%+	+1 point for cover >75%; -1 point if mowed grass is >50%	
	Shrub layer (2.3-25 ft) (10-ft radius)	0%	0-25%	25-50%	50%+	+1 point for cover >75%	
	Canopy (>25 ft) (30-ft radius)	0%	0-25%	25-50%	50%+	+1 point for cover >75%	
3.4	**Vegetative vertical structural diversity (foliage height diversity)**	FHD = 0	FHD < 0.70	FHD = 0.70-0.90	FHD > 0.90		
3.5	**Vegetative species richness**	0-1 species	2-5 species	6-19 species	20+ species		
3.6	**Invasive species component**	>75% cover	25-75% cover	10-25%cover	<10% cover		

City of Bellevue

DRAFT FUNCTIONAL ASSESSMENT TOOL

for Upland Habitat

3.0	LOCAL PARAMETERS	No points	1 point	2 points	3 points	Additional points	Total
3.7	**Proximity to year-round water**	>1.0 mi or artificial feature with maintained /invasive buffer present within 0.3-1 mi	0.3-1.0 mi or artificial feature with maintained/ invasive buffer present within <0.3 mi	<0.3 mi or artificial feature with maintained/ invasive buffer present within patch	Natural water feature present within patch with native buffer		
3.8	**Snags (≥4 in dbh)**	No snags on site	1/ac or fewer	2-6/ac	>7/ac	Add 0.5 point for each >20 in dbh and 1 point for each >30 in dbh	
3.9	**Other habitat features**	None	1	2-4	5 or more		
Landscape parameters points							
Local parameters points							
TOTAL POINTS							

* Use circle of the appropriate size for the property's zone:

Zone A – 0.5 ac
Zone B – 5.0 ac
Zone C – 100 ac
Zone D – 250 ac

** PHS data required for sites in Zone D

***Parks: Mercer Slough, Phantom Lake wetland complex, Larson Lake wetland complex, Cougar Mountain Regional Wildland Park, Weowna Park; King County wildlife network