Chapter 4.
Upland Habitat Conservation Areas

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4.1 Overview

The first part (4.2) of this chapter provides definitions and a general overview of **streams and lakes** of San Juan County (SJC) and then describes impacts to these water bodies and strategies for determining widths of buffers[2] that protect their functions. The second part (4.3) of this chapter provides definitions and a general overview of SJC **upland (terrestrial) habitats**, describes impacts to these, and suggests options for enhancing their protection or management. Except where supported by citation of specific literature, all statements in this chapter are either commonly-accepted, science-based knowledge among ecologists or are the interpretation of the chapter author who is a wetland scientist and wildlife biologist.

The State of Washington requires San Juan County, as well as other counties and cities, to identify and protect the functions and values of "Fish and Wildlife Habitat Conservation Areas" (FWHCA's). This is one of the five types of "Critical Areas" identified in the Growth Management Act (WAC 365-190-080). In WAC 365-190-030(6a), FWHCA's are defined as:

> "areas that serve a critical role in sustaining needed habitats and species for the functional integrity of the ecosystem, and which, if altered, may reduce the likelihood that the species will persist over the long term. These areas may include, but are not limited to, rare or vulnerable ecological systems, communities, and habitat or habitat elements including seasonal ranges, breeding habitat, winter range, and movement corridors; and areas with high relative population density or species richness.

"Fish and Wildlife" is intended to include some plants and invertebrates, as well vertebrates (birds, mammals, amphibians, reptiles, fish). Virtually every square inch of the planet provides habitat for some organism, so priorities must be established. At a state level, the Washington State Department of Fish and Wildlife recommends species

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[2] In general, the term b**uffer** refers to terrestrial areas surrounding a wetland, stream, water body or other area of high ecological, geological, or hydrological importance, and whose purpose is to reduce or prevent impacts to the functions of the protected resource, such as may occur from adjacent land uses. In comparison, **setbacks** are regulatory tools used to protect land from encroachment by structures, but do not generally specify how the setback area must be managed. Like setbacks, buffers are measured a specified distance between a development and the resource being protected. Unlike setbacks, buffers usually are considered off-limits to some activities and land uses which themselves may impact the functions of the wetland. Buffers are often (but not necessarily) configured to completely encircle a wetland, lake or other resource, whereas setbacks are confined to just a direct path between the development and the wetland being protected.

and habitat types they consider to be priorities for extraordinary protection or management in each county. The Washington State Department of Natural Resources (Natural Heritage Program) recommends ecosystems and rare plants they consider to be of highest priority in each county. Not all species and areas recognized or recommended by either department must be singled out and designated by counties and cities for extraordinary protection or management (WAC 365-190-040 4b).

At a minimum, the State of Washington requires counties and cities to protect the following natural resources:

- Shellfish Areas (commercial and recreational)
- Kelp and Eelgrass Beds
- Herring, Smelt and Other Forage Fish Spawning Areas
- Waters of the State as Defined in RCW 90.48.020
- Lakes, Ponds and Streams Planted With Game Fish
- Naturally Occurring Ponds Less Than 20 Acres
- Areas Important to Threatened, Endangered, or Sensitive Species
- Habitats of Local Concern
- State Natural Area Preserves, Natural Resource Conservation Areas and Wildlife Areas

Although this chapter has attempted to include all important data directly relevant to fish and wildlife habitat of streams, lakes, and uplands in San Juan County, there are few or no data describing the locations, abundance levels, local habitat preferences, and trends of nearly all of the County's plants and animals. Even for species and habitats believed to be locally rare, few countywide systematic surveys have been done because of the difficulties of accessing private lands and the time and costs of conducting such work. Despite these limitations, within SJC there regularly occur at least 988 species of vascular plants, 7 amphibians, 7 reptiles, 216 birds, 35 mammals, close to a dozen fish species, and perhaps over a thousand of species of invertebrates (Appendix 4-A).

Despite the county's relatively small area, its vertebrates (amphibians, reptiles, birds, and mammals) comprise more than 26% of those occurring regularly in Washington. Most have a unique set of environmental requirements but those are poorly known for most species (but see Appendix 4-B for a catalog of general habitats used by each terrestrial vertebrate species). For some species, SJC probably supports the largest or only populations or densities in the Puget Sound region, the Pacific Northwest, or the entire United States. These include but are not limited to Black Oystercatcher, Golden Eagle (breeding, formerly), Island Marble Butterfly, Vesper Sparrow (Oregon subspecies, breeding), Sharp-Tailed Snake, Marbled Murrelet (wintering), and several plant species. The following data sources are particularly useful in understanding the status, locations, and needs of individual plant and wildlife species in San Juan County:

- *Floristic Atlas of the San Juan Islands* http://biology.burke.washington.edu/herbarium/resources/sanjuanatlas.php
- *Wild Plants of the San Juan Islands.* (Atkinson & Sharpe 1993).
- *Birding in the San Juan Islands*. (Lewis & Sharpe 1987).
- *Checklist: Birds of the San Juan Islands*. (Jensen 2010).
- *Local Conservation Priorities for Western Washington: Suggestions for Effective Conservation Actions for County, City, and Private Landowners and Managers: San Juan County.* (Cassidy & Grue 2006).
- *Landscape Planning for Washington's Wildlife: Managing for Biodiversity in Developing Areas (A Priority Habitats and Species Guidance Document)*. (Washington Department of Fish and Wildlife 2009)

Relative to its size, the county contains a wide variety of habitats. Many areas by now have recovered from disturbances that occurred within the past 150 years, while others continue to be altered, and still others exist in relatively unaltered condition. The effect of this habitat variety and quality on the richness of species in the greater Puget Sound – Georgia Strait Region is unquestionably positive. This is true despite the fact that, in contrast to many mainland parts of western Washington that are of similar size, SJC's fauna overall is naturally less diverse. That happens for several reasons. The topography of the county spans less than 3000 feet of elevation, creating less climatic diversity than in many mainland counties, and that in turn constrains the diversity of plants and animals. Perhaps more significantly, the island environment limits the ability of many terrestrial species to colonize from adjoining mainland, and to persist in otherwise suitable habitats in the county. That same factor makes the decline of any species in the county potentially a greater concern than a similar decline occurring in mainland counties, because recovery via immigration of new individuals from the mainland is likely to be slower or not occur at all. Species that primarily inhabit extensive forests also may be absent, or are relatively vulnerable to extirpation, partly because historically forested areas in many parts of the county have been fragmented by roads and urban and agricultural development, as well as by natural phenomena. Large mammals such as elk, gray wolf, cougar, and bison were perhaps among the first animals to disappear entirely from the county (probably before the 1900's), if they were present at all, and have never recovered. Species possibly present at one time but now apparently extirpated (absent) include one native game bird (e.g., ruffed grouse), spotted frog, Pacific giant salamander, western pond turtle, and many plant species. A lack of credible and comprehensive countywide surveys, especially during the early years of island occupation by humans, makes it difficult to confirm the disappearance of many plants and animals formerly reported from the county or suspected to have occurred here based on the types of habitats they are known to associate with.

Protecting a broad range of habitats is the first step to protecting biodiversity (the number of species and their genetic variation). Protecting biodiversity is important not only for legal and aesthetic reasons, but also because of the services that myriads of obscure but irreplaceable species silently perform for humans (Cardinale et al. 2006, 2009, Chivian & Bernstein 2008). Yet, thousands of species are now being irreversibly lost from counties, regions, and the planet, at perhaps a faster rate than at any time during co-existence with modern humans.

4.2 Review of Information: Freshwater FWHCA's Requiring Protection

4.2.1 Classification of Fresh Waters

As noted at the beginning of this chapter, the following features are among habitats on a list of Fish and Wildlife HCAs that the State of Washington requires be protected:

- Waters of the State as Defined in RCW 90.48.020
- Lakes, Ponds and Streams Planted With Game Fish by Public Agency
- Naturally Occurring Ponds Less Than 20 Acres With Fish and Wildlife Habitat

These are now discussed in individual sections.

4.2.1.1 Waters of the State as Defined in RCW 90.48.020

This includes "lakes, rivers, ponds, streams, inland waters, underground waters, salt waters, and all other surface waters and water courses" (RCW 90.48.020). It includes areas where surface water is present only seasonally or intermittently, as is the case with many wetlands, ditches, drainageways, and headwater streams. Although this definition is extremely broad, counties and cities have the latitude to assign different levels of protection to different types of water. They may do so by considering the following (for example) as listed in WAC 365-190-130 4f(iii):

- Species present which are endangered, threatened or sensitive, and other species of concern;
- Species present which are sensitive to habitat manipulation (e.g., as listed by WDFW's priority habitats and species program);
- Historic presence of species of local importance;
- Existing surrounding land uses that are incompatible with salmonid habitat;

- Presence and size of streamside ecosystems;
- Existing water rights; and
- The intermittent nature of some waters.

Counties and cities, as a starting point for assigning different levels of protection (e.g., buffer widths) to streams and other surface waters, commonly use the classification system established in WAC 222-16-030 and -031. Three types of flowing waters defined by that classification are present in San Juan County: Type F, Type Np and Type Ns. These have been mapped for Orcas and San Juan Islands, and mapping is currently underway for Lopez Islands. These maps are included in Chapter 8.

Type F. **Fish Bearing Streams** (also called Types 2 and 3). Segments of natural waters which are within the bankfull widths of defined channels and periodically inundated areas of their associated wetlands (or within lakes, ponds, or impoundments having a surface area of 0.5 acre or greater at seasonal low water) and which in any case contain fish habitat, or fall into at least one of the following four categories:

(1) Waters diverted for domestic use by more than 10 residential or camping units or by a public accommodation facility licensed to serve more than 10 persons, where such diversion is determined by the department to be a valid appropriation of water and the only practical water source for such users. Such waters shall be considered to be Type F Water upstream from the point of such diversion for 1,500 feet or until the drainage area is reduced by 50 percent, whichever is less;

(2) Waters diverted for use by federal, state, tribal or private fish hatcheries. Such waters shall be considered Type F Water upstream from the point of diversion for 1,500 feet, including tributaries if highly significant for protection of downstream water quality;

(3) Waters within a federal, state, local, or private campground having more than 10 camping units under certain conditions specified in the WAC;

(4) Riverine ponds, wall-based channels, and other channel features that are used by fish for off-channel habitat, as evidenced by a seasonal or perennial fish-accessible connection to a fish habitat stream.

If fish use has not been documented, two characteristics may be considered indicative of highly significant fish populations (Type 2):

-- Stream segments having a defined channel 20 feet or greater within the bankfull width and having a gradient of less than 4 percent; or

-- Lakes, ponds, or impoundments having a surface area of 1 acre or greater at seasonal low water.

Also, if fish use has not been documented, additional characteristics may be considered indicative of Type 3 in western Washington:

-- Stream segments having a defined channel of 2 feet or greater within the bankfull width and having a gradient of 16 percent or less; or
-- Stream segments having a defined channel of 2 feet or greater within the bankfull width and having a gradient greater than 16 percent and less than or equal to 20 percent and having a contributing area greater than 50 acres; or
-- Ponds or impoundments having a surface area of less than 1 acre at seasonal low water and having an outlet to a fish stream; or
-- Ponds or impoundments having a surface area greater than 0.5 acre at seasonal low water.

Type Np. Non Fish-bearing Perennial Streams (also called Type 4) Perennial streams are flowing waters that do not go dry any time of a year of normal rainfall and include the intermittent dry portions of the perennial channel below the uppermost point of perennial flow.

Type Ns. Non Fish-bearing Seasonal Streams (also called Type 5). These are nonfish habitat streams in which surface flow is absent for at least some portion of a year of normal rainfall and which are not located downstream from any stream reach that is a Type Np Water. For brief periods at least, Type Ns Waters must be physically connected by an above-ground channel system to the ocean or to channels with perennial flow (Type S, F, or Np Waters).

Figure 2. Examples of Type Ns streams, with measuring rod (photos courtesy of Wild Fish Conservancy).
Note the absence or stunting of vegetation along a linear path.

An additional term used only in this report is **drainageway**. This is a scientific term (not a regulatory term) used to denote networks of linear topographic depressions whose existence or flow regime has not been field-verified, but which are readily discernable using laser-based LiDAR aerial imagery (fine-resolution topographic data that screens out the vegetation). As part of this project this imagery was analyzed automatically to delineate "high certainty drainageways" and "low certainty drainageways." Many or most of the former are believed to include all currently mapped streams qualifying as Type F, Type Np, and Type Ns Streams. Many or most of the latter include Type Ns Streams but also include many (but not all) additional areas expected to convey surface or shallow subsurface water for short periods. A new spatial data layer resulted from that LiDAR analysis. Although other investigators have used such analyses to identify unmapped intermittent streams important to fish (Mouton 2005, Wild Fish Conservancy unpublished), our purpose was different. We used LiDAR imagery mainly *to identify approximate paths that runoff and shallow subsurface flow (and the pollutants they potentially carry) are more likely to take* while moving downhill towards streams, lakes, wetlands, and the marine shoreline during the most intense or prolonged storms. Our drainageway maps should be integrated with those from SJC Public Works that provide more detail on locations of drainage lines and culverts along public roads on the major islands. The Public Works maps have been ground-checked to a greater extent, although not comprehensively.

The importance of using GIS and topographic analysis to delineate intermittently-flowing drainageways for the analysis of water quality problems and protection of receiving waters has been demonstrated by Baker et al. 2006, Walsh & Kunapo 2009, and many other scientists during the past few years. The spatial layer (map) we created showing high and low certainty drainageways has not been field checked, but should be. That is because LiDAR imagery, although sensitive to slight (less than 1 ft) differences in ground elevation, is coarser with regard to horizontal precision. Thus, this new layer, although better documented and more complete than any unverified streams layer the County currently has, should (for most uses) be "registered" manually against channels that are visible in color imagery, as well as by using ground-level observations and GPS readings (when satellite reception is sufficient to use GPS to pinpoint locations better than the LiDAR imagery does). If the County is unable to do this comprehensively, then it might be done on a case-by-case basis by building permit applicants or their qualified consultants.

There are four year-round (perennial) streams in San Juan County. Two are found on Orcas Island -- Cold and Cascade creeks. Cold Creek is fed by a large spring and Cascade Creek has Mountain Lake as its source. Two streams on San Juan Island also run all year. These are San Juan Valley Creek, which begins at Trout Lake on Mt. Dallas and converges with the drainage system for the wetlands of the False Bay watershed, and a small creek that begins at the back of Mt. Cady and drains into Garrison Bay. Streams on the remaining islands in the county flow only intermittently (SJC *Water Resource Management Action Plan* 2000).

While few would argue that surface waters as a whole are important to many forms of life, less well known and valued is the role of surface waters that are present only intermittently throughout the year, such as Type Ns streams. Yet, many studies -- both in SJC (Barsh 2010) and in other parts of the Pacific Northwest (e.g., Brown & Hartman 1988, Nickelson et al. 1992, Steiner et al. 2005, Colvin 2005, Wigington et al. 2006) -- have demonstrated routine and perhaps crucial use of such intermittent (also called ephemeral) streams, ponds, and wetlands by some wildlife species and salmonid fish, at least in places where seasonal access is not blocked by impassible culverts or extremely steep gradients.

Especially where intermittent streams exist in ravines, they concentrate fallen leaves, fish foods (terrestrial insects), and wood. Instream wood usually helps maintain pools important to fish, particularly during extremely dry or wet periods. Accumulations of wood and leafy material comprise important shelter for amphibians and for invertebrates important to downstream fish, as well as providing one of several energy sources for marine food webs. Intermittent streams and drainageways also provide sheltered humid environments where amphibians and other wildlife can conduct essential dispersal movements, moving from pond to pond (or wetland to wetland) with less risk of desiccation (Colvin 2005, Olson & Chan 2005, Freeman et al. 2007, Meyer et al. 2007, Olson et al. 2007, Welsch & Hodgson 2008).

In addition, where vegetation along intermittent streams has not been extensively cleared, a relatively large amount of leaf litter, insects, woody debris, and other particulate carbon -- all important to marine food chains -- is transported during storms from headwaters to estuaries via these flow paths (Wipfli et al. 2007, Rykken et al. 2007, Progar & Moldenke 2009). Nonetheless, although large wood and other natural organic matter from intermittent streams is clearly beneficial to individual fish and to salmonid food webs, the degree to which a reduction in its supply or transport might, relative to other factors, limit salmonid *populations* in SJC or regionally is unknown.

In addition to their habitat benefits, low-gradient Type Ns streams and drainageways appear to be among the most important areas (with the exception of wetlands) for treating excess nitrate and some other pollutants from lawns, gardens, crops, and malfunctioning septic systems, before that nitrate can pollute groundwater and other surface waters (Dieterich & Anderson 1998, Peterson et al. 2001, Alexander et al. 2007, Creed et al. 2008, O'Driscoll & DeWalle 2010). They perform that function through a microbially-mediated process called denitrification. That occurs when dissolved nitrogen comes in contact with moist, organic, anoxic sediments, such as where decaying leaves or wood are buried in the bed of a low-gradient drainageway or intermittent stream (Craig et al. 2008). Levels of moisture in the sediment should be at least 70% for optimal denitrification (Hefting et al. 2006). Even when water flows through intermittent drainageways or ditches, if those are well-vegetated it helps maintain the temperature and clarity of downstream waters (Duncan et al. 1987, Gomi et al. 2006).

Resources of Streams and Lakes in SJC

It is estimated that 31 streams countywide are potentially fish-bearing. Surveys of at least parts of most of these streams have been completed in the last several years. There are no known natural Chinook spawning areas in the county. Chum salmon spawn near tidewater but if they still occur in the county, they are barely hanging on. Coastal cutthroat trout are currently well-documented in four streams, and probably occur in several additional streams that have not yet been fully surveyed. Most are landlocked, but anadromous runs exist in at least two streams. Whether these salmonid populations are "natural," as opposed to being planted or introduced, is not a legal requirement for habitat protection. Available information is shown in Table 4-1.

Table 4-1. Distribution of native salmonids in SJC intermittent and perennial streams

sources: SJC Dept. of Health and Community Services 2000, Barsh 2010, Barsh (pers. comm.).

Salmonid Species	**Island**	**Stream** (unofficial names)	**Comment**
Chum salmon	Orcas	Crow Valley stream	only one juvenile reported from 2004-2010 surveys
	San Juan	San Juan Valley creek/ False Bay	recent anecdotal reports, but none found in 2004-2010 surveys
Coho salmon	Orcas	Cascade Creek	seen in sea-accessible reach; most likely planted
	Orcas	Pickett Springs creek	one juvenile seen
Coastal cutthroat trout	Orcas	Cascade Creek	widespread spawning
	Orcas	Doe Bay stream	landlocked and persisting
	Orcas	West Beach stream	small numbers of sea-run
	Orcas	Victorian Valley (Bayhead) stream	apparently extirpated by pond construction, seen until 2007

Table 4-1. Distribution of native salmonids in SJC intermittent and perennial streams			
sources: SJC Dept. of Health and Community Services 2000, Barsh 2010, Barsh (pers. comm.).			
Salmonid Species	**Island**	**Stream** (unofficial names)	**Comment**
	San Juan	Garrison Bay- Mitchell Hill	numerous sea-run and landlocked, genetically distinct from others in islands

Aside from salmonids, native freshwater fish that depend on perennial or intermittent streams in SJC include three-spined stickleback (*Gasterostreus aculeatus*), reticulated sculpin (*Cottus perplexus*), and shiner perch (*Cymatogaster aggregata*). Surveys of SJC streams and lakes have found more non-native fish stocks than native ones. Introduced species with populations that may be self-sustaining in SJC include rainbow trout (*Oncorhynchus mykiss)*, brook trout (*Salvelinus fontinalis*), fathead minnow (*Pimephales promelas*), bluegill (*Lepomis macrochirus*), smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), and probably others. Most of these are" warm water" fish native to the eastern United States. Aquatic invertebrates have also been collected in studies by Barsh (2010) and others, but no comprehensive survey has been conducted to quantify their diversity among SJC's streams, lakes, and wetlands. Two crayfish are known to be present in the county: signal crayfish (*Pacifastacus leniusculus*) on Orcas and Lopez Islands, and white river crayfish (*Procambarus acutus*) on northwestern Lopez (S. Rosenbaum, wetland scientist, pers. comm.).

San Juan County has 11 bodies of fresh water larger than 20 acres, which are traditionally defined as lakes (e.g., Cowardin et al. 1979, and WAC 173-2). In decreasing order of area, the lakes are Mountain, Cascade, Sportsmans, Horseshoe, Spencer, Trout, Zylstra, Roche Harbor, Hummel, Martin, and Woods Lake. The county also has over 1000 ponds, of which at least 27 are larger than 5 acres. San Juan Island has the most ponds and lakes. Relatively little biological or water quality information has been published on the county's 11 lakes. Probably all support both native fish and the introduced (exotic) fish species that compete with them. The WDOE, based on a single visit to Cascade Lake in 1997, categorized it as oligo-mesotrophic, meaning its fertility is poor to moderate. Large seasonal growths of algae, indicative of eutrophic (high fertility) conditions, are apparent in shallow Hummel Lake on Lopez Island, and significant fish kills as a result of the subsequently low dissolved oxygen levels have been reported. However, lakes in SJC have generally been spared the problem of summertime blooms of toxic blue-green algae that many western Washington lakes have suffered. All the county's lakes are important to waterbirds, especially when severe storms and high tides batter the marine shoreline.

4.2.1.2 Lakes, Ponds, and Streams Planted With Game Fish by Public Agency

Neither WDFW nor any other public agency stocks game fish in the county's streams. During 2010, rainbow trout (a game fish) were stocked in four SJC lakes: Cascade, Egg, Hummel, and Mountain. Non-native fish of unknown origin have been reported from Sportsman Lake and the Lakedale Lakes on San Juan Island, and probably have been stocked in dozens of private ponds by landowners.
Stocking of ponds and lakes, especially with predaceous non-native warmwater fish such as bass and bluegill, whether done by agencies or private individuals, can be extremely detrimental to salmonids and native amphibian populations – far more than the presence of predatory bullfrogs (Adams et al. 2003, Pearl et al. 2005). Many introduced fish species prey voraciously on native fish as well as on sub-adults of locally uncommon frogs, salamanders, and turtles. They also may introduce fungal diseases, compete for food, and at the very least reduce the abundance of native species and average size of individuals (Hoffman et al. 2004, Hirner & Cox 2007). Unfortunately, bass have been found in Killebrew Lake, Hummel Lake, Sportsman's Lake, and perhaps elsewhere. Wetlands along these lakes would otherwise provide some of the physically best habitat for native amphibians in the county.

4.2.1.3 Naturally-occurring Ponds Less Than 20 Acres with Fish and Wildlife Habitat

Nearly all such areas in San Juan County are considered to be wetlands in whole or part. Accordingly, measures to conserve the habitat functions of ponds are described in Wetlands (Chapter 2).

4.2.2 Impacts to Freshwater FWHCAs

Home construction and associated impervious surfaces and storm drains, even when occurring at low densities but near drainageways that lead to the same stream or wetland, can dramatically alter the amount, timing, frequency, and duration of flow in streams and water level in lakes and wetlands (Booth et al. 2002, Schuster et al. 2005; Konrad et al. 2005, Poff et al. 2006, Shields et al. 2008); increase pollutant loads and concentrations (Chadwick et al. 2006; Morgan et al. 2007, Cunningham et al. 2009); disrupt channel configurations (McBride & Booth 2005, Colosimo & Wilcock 2007); shift local air and water temperature regimes (Delgado et al. 2007); introduce chronic noise, predators, and other disturbances (Hepinstall et al. 2008); and as a consequence of these and related factors, alter the abundance, diversity, and species composition of fish and wildlife communities (Miltner et al. 2004, Hansen et al. 2005, Alberti et al. 2007, Walsh & Kunapo 2009, Cookson & Schorr 2009). Many studies from other regions have correlated a reduced occurrence of fish and wildlife with increased housing density (even at low densities), without specifying the specific causes (e.g., water pollution, hydrologic alteration from impervious surfaces, vegetation removal, noise, disturbance). For example, a study of multiple watersheds in Tennessee found reduced occurrence of native fish where housing densities exceeded 1 unit per 4 acres (Cookson & Schorr 2009).

These impacts are discussed below, first for areas near streams (riparian habitat) and then for relatively dry uplands.

4.2.2.1 Impacts of Stormwater, Septic Systems, and Water Diversions on Water Quality and Quantity

Over 63,000 synthetic chemicals are in common use in the United States, many of them in households with septic systems incapable of detoxifying them completely. Nationwide, more than 200 of these chemical substances have been found in groundwater, but only where someone has checked (and monitoring most of these chemicals is rare due to high costs for laboratory analysis). Only a tiny fraction of these synthetics has been tested for their possible effects on humans, let alone on the thousands of species of plants and animals occurring in SJC. When testing has been done, it most often has focused only on direct toxicity rather than effects on reproduction and behavior which can be almost equally damaging to populations over the long term. Moreover, common pollutants can arrive simulataneously in the same waterway and the effects of the enormous number of possible *combinations* on aquatic life has only rarely been investigated. Many organisms that are able to physiologically tolerate or adapt behaviorally to a single stress such as low dissolved oxygen are unlikely to survive multiple simultaneous stresses, such as mildly elevated levels of turbidity, pesticides, and metals. Multiple pollutants are common in stormwater runoff.

Potential or actual sources of waterborne pollution within San Juan County include:

- on-site septic systems (bacteria, nutrients, household chemicals)
- ditching of “poorly drained” low spots (sediment, reduced capacity to process runoff)
- soil erosion, as natural vegetation is converted to residential and commercial developments
- dirt roads and unpaved driveways (sediment, hydrocarbons)
- household, garden, and agricultural chemicals including those used for killing moss (zinc roof strips), ants, termites, mice, rats, and weeds.

- untreated stormwater runoff from residential and commercial developments, roads, parking lots, and vehicles (metals, hydrocarbons, nutrients)
- wild and domestic animals (nutrients and bacteria from waterfowl, dogs, livestock)
- agricultural practices (e.g., fertilizer, pesticides, drainage, pond creation, plowing, irrigation)
- forestry practices (e.g., soil disturbance, shade removal, concentrations of decaying vegetation, facilitation of alder establishment)
- marinas and boating activities (hydrocarbons, metals, bacteria, shade)
- excavated ponds (warmed and oxygen-poor outflows)
- golf courses (warmed runoff, nutrients, herbicides)
- solid waste/hazardous waste
- rain carrying pollutants from outside the county (even from across the Pacific Ocean)

Partly as a result of these sources, water quality issues of greatest potential or actual concern, generally or in limited portions of the county, include:

- surfactants (laundry and dishwasher detergents such as nonyl phenols) in all surface waters
- pesticides (especially pyrethroids) and their wetting agents in all waters
- other hydrocarbons (PCB, PAH, etc.)
- other household chemicals and pharmaceuticals from septic system outflows
- excessive nitrate and ammonium in surface and groundwater, from septic system outflows, residential yards, golf courses, gardens, large stands of alder, and lands with domestic animals
- excessive phosphorus from fertilizing of residential lawns and gardens
- excessive sediment (turbidity) in intermittent streams, wetlands, and marine waters with limited circulation
- naturally high levels of arsenic (a potent carcinogen), fluoride, barium, and sodium in aquifers
- intermittently elevated temperature and low dissolved oxygen in the county's few fish-bearing streams
- increasing salinity in aquifers used domestically

Any of these water quality issues can be aggravated when water is diverted for human use from streams and groundwater, or when stream flows and pond levels are regulated by dams or other control structures. Because of the county's lack of snowpack derived water, capturing and storing water during the rainy season for domestic or agricultural use during the dry months has long been practiced by individual landowners and groups in San Juan County. Yet even a simple reduction in the amount of water reaching portions of a stream or wetland can have important ecological consequences. An artificiallly-caused water deficit, rather than polluted water, may be the single most important factor limiting productivity of freshwater habitat in many parts of SJC.

Approximately 40% of the county's population receive their drinking water from surface water systems. On the main islands these areas include the Town of Friday Harbor, Roche Harbor, Eastsound (54% surface water), Doe Bay, Olga, Rosario Resort, Rosario Highlands, and Spring Point. These water systems serve the majority of the high-density growth areas in the county. Trout Lake and Briggs Pond supply domestic water for the Town of Friday Harbor and Roche Harbor, respectively. Rosario Resort draws water from Cascade Lake; the Olga and Doe Bay water systems depend on Mountain Lake; and Eastsound uses Purdue Reservoir as a backup for well water sources (SJC *Water Resource Management Plan* 2004). Orcas Island has the county's largest lakes, and Lopez Island has the least amount of perennial surface water. Roche Harbor and Eastsound are in the process of increasing their storage capacity. There are also many instances of private pond water being used for irrigation, which is illegal under Washington law unless a water right is legally held (San Juan County, *2004 Water Resource Management Plan*).

With lower remaining flows or shallower waters during the late spring and summer, some pollutants become concentrated as water temperatures rise, water evaporates, and networks of pools, ponds, and ditches become disconnected from each other earlier in the spring than usual. This can be lethal for any aquatic life remaining in those areas, especially when accompanied by heat-induced loss of oxygen dissolved in the water. Keeping domestic animals far from ponds and their input channels is additionally important because the nutrients they add tend to rob the receiving waters of dissolved oxygen. In some cases, the natural wetlands that existed where many ponds now occur also may have tended to raise stream temperatures, but probably to a much lesser degree. Artificial ponds have much greater sun exposure than most natural wetlands and probably have less subsurface interflow, resulting in higher water temperatures.

The life cycle of coastal cutthroat trout in SJC necessitates that hatchlings remain in a stream for their first summer. Summer pool conditions therefore determine the survival of each cutthroat generation (Barsh 2010). Many SJC streams remained functionally disconnected for four to eight months after midsummer, which includes most or all of the period within which adult cutthroat trout return in the autumn. Streams in which flow does not begin until late in the autumn had no salmonids or only resident salmonids (Barsh 2010). Thus, concerns about the effects of impervious surfaces, water diversion, and ponds on waters of SJC are not limited just the quality and quantity of water, but also the timing, frequency, and duration of its occurrence in the most ecologically important locations. A guiding principle is that the water regimes that exist in wetlands, streams, and aquifers after development or other regulated actions occur should resemble as closely as possible the pre-development water regimes.

The placement of small dams to create ponds at several points on intermittent streams, or the enlargement of existing instream ponds, has been shown to sometimes diminish the water available to downstream areas during certain seasonal periods. Impoundments also can cause warming of whatever water is present in downstream portions of many receiving streams. Instream ponds that must fill completely before they can spill over into the channel downstream delay flows required by fish during critical periods in the autumn. Some instream ponds also cause stream flows to stop abruptly in early summer, potentially stranding fish in de-watered sections. Pond owners who wish to minimize this problem can modify the control structures on their ponds to provide at least 0.25 cfs (cubic feet per second) summer instream flow, which usually maintains enough water to keep instream pools connected (Barsh 2010). Despite sometimes adverse impacts to native fish, the excavation of many instream ponds in SJC has probably facilitated the expansion of local populations of some native waterbirds that typically shun heavily vegetated wetlands, and has perhaps also provided additional breeding habitat for some salamanders and frogs. Depending partly on their outlet characteristics, instream ponds can either improve or degrade the chemical quality of runoff they receive.

The productivity of estuarine habitats also can be compromised if less fresh water from upland systems (streams and groundwater seeps) is available at critical times, having been diminished by domestic water consumption and increased evaporative losses from ponds. In those estuarine areas, maintaining intermediate salinities during at least part of each day, as well as normal water temperatures and turbidity levels, is essential to salmonids and some other estuarine animals and plants.

Large portions of the county are at a point where water right allocations for groundwater by the State exceed local recharge, and in some areas current use of water exceeds aquifer capacity. Among the major islands aquifer recharge may range from 1.44 inches per year (5% of rainfall) on Shaw to 2.49 in/yr (9% of rainfall) on Lopez (San Juan County, *2004 Water Resource Management Plan*). When groundwater is not adequately recharged, and stormwater runoff is routed to the ocean more quickly through ditches and pipes rather than through natural wetlands, this shortens the duration of flooding or saturation in wetlands as well as the duration of flows in intermittent streams, with major consequences for water quality and aquatic life. On the other hand, in possibly a few densely-populated areas that still have septic systems, water seepage from these systems collectively may extend seasonal flow duration somewhat in drainageways or intermittent streams. Areas designated for high-density growth in the county's comprehensive plan which also may have limited groundwater include Eastsound, Orcas Landing and Deer Harbor. In addition, when groundwater is extracted on landforms such as peninsulas and isthmuses with limited acreage for recharge, this may pose the greatest threat to wetlands and intermittent streams in those areas.

Another problem arises when groundwater is extracted from aquifers for domestic use. At many locations a potential exists for the vacated underground soil/rock pore space to be filled with salty marine waters which can seep laterally into the fresher aquifers, especially when infiltration of surface waters has been reduced by developments accompanied by impervious surfaces that speed the overland movement of water. The result, termed seawater intrusion, can render water in some aquifers unfit for human consumption for long periods. All SJC groundwater is vulnerable to this threat, and there are several places throughout the county where wells have become undrinkably saline or a rising trend in groundwater salinity has been detected. As aquifers become more saline, the wetlands that depend on groundwater discharging naturally to the wetlands may also become more saline, and significant changes are likely to occur in their species and functions. The threat is greatest in areas within 1000 feet of shoreline, glacial underlying deposits, and where nearby wells already have chloride levels greater than about 100 mg/L (San Juan County, *2004 Water Resource Management Plan WRIA 2*).

Compared with contributions from other counties, the contribution of San Juan County to pollution loads in Puget Sound as a whole has been suggested as being *relatively* small because of the county's low population density, low-intensity agriculture, and few commercial or industrial facilities. Indeed, several ecological studies have chosen areas in San Juan County as the least altered benchmark or reference site when compared with other areas in the Puget Sound. However, even low concentrations of some pollutants can interfere significantly with aquatic life.

By State law, all unclassified surface waters that are tributaries to Class AA marine waters are classified as Class AA, meaning they must meet State standards for water quality. Because nearly all runoff in San Juan County flows into marine waters, all SJC streams and drainageways must meet the State standards, and this has been shown to be difficult in some bays with limited water circulation. Except in those areas with limited marine water circulation, once pollutants enter the county's marine waters, there usually is a potential for rapid dilution by the large volume of typically cleaner water associated with local tides and currents. This reduces pollutant concentrations and, perhaps in some cases, the threat to coastal resources from non-persistent contaminants. Nonetheless, before runoff reaches marine waters, evaporation and low summer flows potentially concentrate pollutants in wetlands, deeper pools of intermittent streams, and in ponds, lakes, and lagoons that lack persistent outflows. Animals that live in these areas, drink this water, or find refuge there from summer drought are likely to be exposed to these concentrated pollutants (e.g., Barsh et al. 2010).

In 1997-1999 the County ranked individual watersheds with regard to likely pollution sources (SJC *Watershed Management Action Plan*, 2000) but that effort has not been updated. "Conversion of natural land cover" was ranked as the highest potential source of pollution for Deer Harbor, a small watershed with steep terrain that in the past decade has experienced perhaps the most clearing of forest lands for residential development. Potential contamination from marinas ranked highest for Roche Harbor, the smallest priority watershed, with an extensive resort and marina complex. Potential pollution from stormwater runoff ranked highest for the Friday Harbor watershed, which is the most urbanized part of the county. Agricultural practices ranked highest as a potential source of contaminants in the False Bay and Westsound watersheds. The threat to water quality of failing on-site septic systems was ranked highest for the Westcott/Garrison, East Sound, Fisherman Bay, and Mud/Hunter watersheds. Contamination had been documented or reported in these areas (SJC *Watershed Management Action Plan*, 2000) but more recent monitoring has not found high levels of bacterial contamination.

Currently, no government agency conducts systematic, ongoing, countywide monitoring of critical pollutants in SJC surface water. The County Stormwater Utility is now establishing such a program. Between 1997 and 2008 the County monitored water quality in several gauged streams. This included sampling that was contracted to Huxley College (Wiseman 2000) in 1999 and 2000. The County's monitoring from 2002 to 2008 adhered to a WDOE-approved quality assurance plan, and was done jointly with the San Juan Conservation District and University of Washington Marine Labs . Some water quality measurements have also been made by individuals or organizations supported by short-term grants from state, federal, or private institutions. For the last 3 years the SJC Department of Health and Community Services has managed 2 networks for monitoring groundwater. Overall, knowledge is least complete regarding the concentrations and loads of "emerging" pollutants (new synthetic substances whose toxicity to SJC organisms is uncertain), including pharmaceuticals and some household chemicals. Also, few of the county's wetlands have been sampled.

Little has been documented regarding any actual harm caused by pollutants to SJC's native plants and animals. However, harm (other than sudden acute mortality) is extremely difficult to demonstrate. Harm can be presumed where contaminants are known to exceed legal standards, but harm can occur nonetheless for several reasons. First, dozens of studies have shown that some combinations of chemicals are more harmful together than individually, and chemical-by-chemical legal standards do not recognize this. Second, for most contaminants, the effects on many organisms and life stages, under diverse background environmental conditions, have not been studied at all. Third, no legal standards exist for hundreds of untested household chemicals whose use has become commonplace in recent decades. Because most native species have not had time to gradually adapt their physiology or behavior for coping with these chemicals, it is reasonable to anticipate some adverse effects on reproduction, behavior, and growth – and ultimately on survival as a species.

The following discussion focuses mainly on water quality impacts associated with residential development and public roads (rather than agriculture or forestry), only because those are the impacts which the County is legally most capable of addressing. The discussion also focuses mainly on the substances most likely to harm aquatic life due to their known or presumed extent of occurrence and/or toxicity.

Figure 3. Single-family homes on small lots.
(photo from Camano Island)

Septic Systems

About 75% of the SJC population relies on onsite septic systems; the rest relies on sewage treatment plants serving the communities of Friday Harbor, Roche Harbor, Eastsound, Orcas Village, Rosario, and a portion of Lopez Village. Soil ratings established by the NRCS indicate that very little area in San Juan County is suitable for conventional on-site septic systems, so alternative septic systems designed to provide an additional level of treatment are often used. However, these systems require regular maintenance to insure that they are functioning properly. The County maintains a database of locations of over 8000 septic systems (not all of them active), but the County estimates that locations of perhaps 1000 septic systems are unknown. Even for the known locations, the County does not have sufficient resources to monitor all systems to ensure they are performing as designed. The lack of a septage disposal facility on San Juan Island increases the cost for pumping a septic tank, thus discouraging many people from routinely servicing their systems as often as required. Improperly functioning septic systems can result in high levels of some **viruses and bacteria**, as indicated by coliform bacteria, in surface or ground water. This can harm human health. Consequently, legal standards exist to protect drinking water, shellfish areas, and swimming areas.

Even when functioning as designed, the ability of septic systems to effectively treat almost anything other than bacteria and excessive nutrients (nitrate and phosphorus) is limited or unknown (Staples et al. 2004, Klaschka 2008, Caliman & Gavrilescu 2009). Knowledge is particularly limited concerning the effectiveness of SJC septic systems for treating common household substances such as shampoo, odorants (whether labeled as "natural" or not), and pharmaceuticals. Despite not being widely viewed by the public as serious pollutants, these inescapable substances can damage aquatic life and contaminate aquifers (see discussion below, "Surfactants").

Other Contaminants Associated With Residences or Commercial Developments

Vehicles and machinery at residences, especially when parked outdoors, are a source of hydrocarbon (oil, grease, gasoline) and metal pollutants. Domestic animals, including pets, are a source of nutrients and bacterial contamination, adding to natural sources of such contamination such as deer and waterfowl. Many homeowners use herbicides to control weeds in gardens and lawns, and some use insecticides to control bothersome animals (e.g., spiders, mosquitoes, ants, termites, slugs) in homes and gardens. Also, fertilizers rich in phosphorus are sometimes applied to commercial and residential lawns and gardens, and can trigger blooms of algae that rob surface waters of dissolved oxygen essential to aquatic life. Precipitation running off zinc strips, zinc-based powders or detergents applied to building roofs for moss control can contaminate waterways and wetlands.

At least during the construction phase, the potential exists for increased erosion of soil around homes. This often continues if there is concentrated use of yards by people or animals. The movement of sediment and other substances associated with residences into downslope water bodies is accelerated by the increased runoff of stormwater that occurs from (a) roofs and paved surfaces around homes, (b) features that concentrate runoff, such as ditches and foundation/curtain drains placed to dry wet spots around homes, residential yards, athletic fields, golf courses, and driveways, and (c) clearing of vegetation (see section 4.2.2.3 Impacts of Removing Streamside Vegetation).

Roads

Most construction and widening of hard-surface roads in SJC occurred decades ago and such activities are currently very limited in the county. However, driveways to private homes are constructed all the time without a significant review of their environmental impacts, which can be substantial. Traffic along SJC roads, although light compared with mainland counties, introduces some amount of hydrocarbons and metal pollutants. Herbicides are not generally used along public roads, but are used by property owners along private roads and driveways.

The greatest impact of roads on surface water quality comes from their associated ditches. These can raise water temperatures, concentrate runoff, and cause water to move downslope so rapidly that vegetation and soil biological communities have less opportunity to process the waterborne pollutants before they reach waters considered most important for aquatic life. This impact is exacerbated when landowners illegally connect their private ditches and drainage tile to public ditches along roads.

Pesticides and Hydrocarbons

Research on the important risks posed to salmonids by pesticides was recently reviewed by Macneale et al. (2010). Although pesticide use in SJC is probably less than in many mainland areas with more extensive and intensive agriculture, pesticides are still used on crops and around homes. Pyrethroids (e.g., Bifenthrin, Cyfluthrin, Cyhalothrin, Esfenvalerate, Deltamethrin) are one of the most-often used groups. The most extensive data on pesticides in non-tidal waters of SJC are the data collected by Barsh et al. (2008) in collaboration with scientists at the University of Washington Friday Harbor Laboratories. They sampled 32 lakes, streams, and ditches throughout the county to determine concentrations of widely-used pyrethroid pesticides which people use to control carpenter ants and fleas (among other uses). They reported the following:

> Pyrethroid pesticides in excess of 1.0 part per billion (ppb) were found in at least one water specimen or one sediment specimen from 22 of 32 sampling sites. More than 10 ppb pyrethroid pesticides were found in water from three sites and sediments from two sites, with some results as high as 18 ppb. Only one site had no detectable pyrethroid pesticides in either water or sediments at the 0.1 ppb limit of detection.. It can safely be said that pyrethroid pesticide levels of 1-2 ppb are widespread in San Juan County waters. ... Six pyrethroid pesticides in local use are each toxic to rainbow trout at less than 2 ppb; thirteen pyrethroid pesticides in local use are each toxic to rainbow trout at 18 ppb or less.

Although remote, a possibility exists that a small portion of the measured pyrethroids may have been carried to the islands in rain clouds that previously had passed over more developed areas outside the county. For most pollutants, fish and other aquatic life are harmed at much lower concentrations than are humans. Some commonly-used pesticides such as pyrethroids are not effectively treated by most wastewater treatment systems. Pesticides often contain undeclared wetting agents such as alkyl phenyl ethoxylates (APEOs) which are believed to disrupt endocrine systems and may pose greater risks to aquatic ecosystems than the declared active ingredients (Barsh et al. 2010).

Another highly toxic hydrocarbon of potential concern is a coal-tar based substance used to seal parking lots and driveways. Extent of use in the county is unknown. Many cities and counties have recently enacted laws requiring use of an asphalt emulsion-based alternative.

Another study sampled just 6 nearshore locations on San Juan Island, and focused on soils. Concentrations of non-pyrethroid pesticides, herbicides, and some other potentially toxic substances were analyzed (Earth Solutions 2010a-b). At all locations, the sample points were less than 100 ft from both a single-family residence located uphill and the shoreline located downhill. At two of these locations, samples were also collected from undeveloped land near the residences. A common herbicide (MCPP) was detected at half the locations. Although levels of this herbicide were not found by that study at levels believed to be acutely toxic to some animals, the levels that are safe for all local aquatic life are unknown. No other manmade chemicals (phthalates, several insecticides) that were analyzed were detected. Many factors, including several unrelated to the presence or absence of residences, could explain the lack of detection of some of these substances in the samples at the time of sampling.

Pesticides are a potential threat to SJC amphibians as well as salmonids, butterflies, and other non-target species. Although adequately-sized wetland buffers can lessen somewhat the threats to pond-breeding amphibians from aerial spraying (Thompson et al. 2004), many species are highly sensitive to even low concentrations of herbicides (Solomon et al. 2008) or their wetting agents (see next paragraph). Lower amphibian hatching rates have been documented in several agricultural areas in the Pacific Northwest where pesticides and fertilizers are used (e.g., de S et al. 2002, Bishop et al. 2010), even where water quality guidelines for these have been met (Westman et al. 2010).

<u>Surfactants, Antibacterial Soaps, Pharmaceuticals</u>

Surfactants (from shampoo, laundry and dishwasher detergents), pharmaceuticals (including many with hormonal compounds), and antibacterial soaps (e.g., triclosan) can be expected to occur chronically in the effluent from many households. These are potentially disruptive to aquatic life, and in some cases are not removed completely by septic systems (e.g., Swartz et al. 2006, Standley et al. 2008, Wilcox et al. 2009, Conn et al. 2010, Dougherty et al. 2010, Sanford & Weinberg 2010, Sanford et al. 2010). The most extensive data on this group from SJC pertains to surfactants. Samples were analyzed for nonylphenol surfactants in samples collected by Barsh et al. (2008 and 2010). In 2008 they sampled 32 lakes, streams, and ditches throughout the county and reported the following:

> Anionic surfactants of 1.0 part per million (ppm) or greater were found in at least one water specimen from 8 of 32 sampling sites. The highest concentration observed was 1.6 ppm. Anionic surfactants were detected at all 32 sampling sites at our 0.2-ppm limit of detection. Indeed, only a single specimen from one site had no detectable surfactants. Variation was low between sampling sites and very low within sites as well. This family of surfactants appears to be nearly ubiquitous in San Juan County freshwater systems at a level of roughly 0.5 parts per million (500 parts per billion). This is currently the EPA's national secondary drinking water standard for surfactants—the maximum recommended for water consumed by humans.

The incompleteness of septic systems for processing surfactants, or the persistence of surfactants applied with herbicides, is hinted at by the discovery of surfactants in every one of 32 lakes, ponds, and streams sampled in July-August 2008 in SJC (three replicate sets of samples were collected from each site). In addition, in the False Bay watershed in 2010 they found nonyl phenol (an ingredient of many surfactants) at levels which they said the technical literature shows being high enough to result in loss of fertility in salmonid eggs. The USEPA is considering an aquatic life toxicity standard of 5.9 micrograms per liter for nonylphenol ethoxylates (Staples et al. 2004). The incompleteness of septic systems for processing surfactants, estrogenic pharmaceuticals, and other household substances that may be ecologically hazardous is also suggested by many peer-reviewed studies from other regions, as cited above.

<u>Phosphorus, Nitrate, and Ammonia</u>

Phosphorus and nitrate are essential for plant growth. However, in high concentrations these nutrients are widely known to be significant "nonpoint source" pollutants that can cause shifts in species composition and habitat structure that are detrimental to rare plants, aquatic food chains, and valued species (Carpenter et al. 1998, Anderson et al. 2002). High concentrations of nitrate in well water also are a human health hazard, and some levels of ammonia impair aquatic life. No numeric standards for nutrients in surface waters have been legally adopted at the federal, state, or SJC level. However, the USEPA (2000) recommended 2.62 mg/L as a maximum level for nitrate in fresh surface waters of the Puget Lowlands, and 1.8 mg/L for total phosphorus. A survey of freshwater locations in SJC in 2000 (Wiseman et al. 2003) found levels of nitrate and phosphorus averaged less than those EPA levels at all but one of 24 locations sampled on a semi-monthly basis. Ammonia toxicity depends on species but generally is around 0.2 to 2.0 ppm. The true extent of water quality impairments or lack thereof will remain uncertain until a sustained countywide monitoring program (including sampling during the largest runoff events) is implemented.

For groundwater intended for domestic use, the EPA's maximum allowable nitrate level is 10 mg/L. As of 2007 no SJC wells were known to be regularly exceeding this level. However, dozens of domestic wells in SJC have nitrate concentrations above 1 mg/L, indicating the initial stages of aquifer pollution due to human activities (San Juan County Health and Community Services 2007).

Inputs of phosphorus and nitrate to SJC wetlands, lakes, streams, and nearshore waters were possibly at least as great during early periods of the county's development as they are now. During those times wildfire, mining, and the drainage of wetlands (especially peatlands and forested wetlands) were more prevalent and would have increased nutrient and sediment export, as organic soils were oxidized and eroded soils were freely washed into lakes, streams, and estuaries. Much of the ditching and clearing occurred in the early 1900's. Although the paucity of streams in the county means that salmon runs were never as dominant an event as elsewhere, when salmon occurred more widely than now, they probably introduced nutrients of marine origin to headwaters of the county's few perennial streams. The large concentrations of waterfowl that occurred prior to the extensive regional wetland losses likely had a similar effect.

High levels of dissolved inorganic nitrogen have been mentioned as a possible cause of severe growths of algae in marine areas of relatively restricted circulation, such as near the southern end of Hood Canal (Redman 1998, Paulson et al. 2006). However, some analyses have suggested that nitrogen loading may not pose an immediate threat to biological communities in most of Puget Sound, and "the least sensitive sub-regions are the Strait of Juan de Fuca and the tidally-mixed passages linking it to Puget Sound and the Strait of Georgia" (Mackas & Harrison 1997).

When the excessive algal growths occur on marine rocks and sediments, aquatic invertebrates important to the food chain can be smothered. Excessive algal growths also can temporarily deprive the water of oxygen needed to sustain marine fish. When excessive algal growths are triggered by abnormally high levels of nutrients in the tidal or marine water column, they block light needed by eelgrass (Williams & Ruckelshaus 1993), a submersed plant very important to fish and wildlife. Discharge of unusually warm and/or contaminated water occurs in several of the county's nearshore areas that have limited circulation, such as Westcott Bay. That area has experienced a complete and unexplained die-off of its eelgrass within the last 10 years. Also, East Sound is listed by the WDOE as an impaired water body due to low dissolved oxygen, and discharge of sediment and excess nutrients could be partially creating that oxygen deficit. On the other hand, when nitrate makes salt marsh plants more productive and the dead material of those plants is washed into estuaries by tides, the material can help sustain important food chains.

In fresh water, excessive nitrate concentrations or the presence of correlated land uses have been associated with changes in species composition of plant communities in wetlands (Adamus et al. 2001) and in some other habitats. Increased invasion by weeds such as reed canary grass has especially been noted in wetlands with low organic content in their sediments (Perry et al. 2004) and with widely fluctuating water levels (Magee & Kentula 2005). Nitrate concentrations as low as 1 mg/L can change the structure of freshwater algae communities of streams (Pan et al. 2004) and contribute to blooms of toxic algae in lakes and wetlands. Streams receiving heavy nutrient loads from septic tank leakage have aquatic invertebrate communities that are significantly altered, especially where storm drains are commonplace (Walsh & Kunapo 2009). Nitrate loading has been shown to increase exponentially in response to increases in impervious surface in watersheds, even at low levels (5-10%) of imperviousness (Cunningham et al. 2009).

New research is helping define thresholds for defining "excessive" nitrate concentrations or loading rates for amphibians as well. Two components of many fertilizers -- ammonium nitrate (NH_3NO_3) and ammonium sulfate (NH_3SO_4) – are known to kill tadpoles at concentrations lower than typical application levels, which are lower than USEPA water quality criteria[3]. A study of farm ponds determined that to maintain species richness of amphibians, the nitrate concentration needed to be less

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[3] From Hayes et al. (2008): "The 7-day median lethal concentration (LC50) for *R. aurora* [red-legged frog] larvae was 4.0 mg/L NH_3NO_3, whereas the 15-day LC50 was 1.2 mg/L. In studies using *R. aurora* embryos, the 16-day LC50 for NH_3NO_3 was 71.9 mg/L; but the 16-day LC50 for sodium nitrate ($NaNO_3$) was 636.3 mg/L, which pointed to ammonium rather than nitrate ions producing the toxic effect. Moreover, significant decreases in the length and weight of *R. aurora* embryos were observed at NH_3NO_3 concentrations $\geq$ 13.2 mg/L, and at concentrations of $NaNO_3$ > 29.1 mg/L (Schuytema and Nebeker 1999). In similar work, concentrations of ammonium sulfate (NH_3SO_4) $\geq$ 134 mg/L impaired *R. aurora* larval growth."

than 2.5 mg/L (Knutson et al. 2004).

Metals

Copper, lead, zinc, mercury, and cadmium are part of a group of metals commonly known as "heavy metals." Especially when soluble or attached to suspended sediment or organic matter in concentrations that are much higher than natural background levels, they can be toxic to many forms of aquatic life. Potential sources in SJC are both human-related (abandoned gravel pits, road cuts, vehicle tires and emissions, zinc compounds used for moss control, discarded batteries) and natural geologic formations. Sampling and analysis of surface and well water for heavy metals has not been comprehensive in SJC, but limited data suggest that despite the current absence of major industrial facilities, heavy metals do sometimes occur at levels potentially harmful to aquatic life.

A recent study at 6 nearshore locations on San Juan Island (Earth Solutions 2010a-b) sampled copper, lead, zinc, and mercury in soils next to the shoreline. At all locations, the sample points were less than 100 ft from both a single-family residence located uphill and the shoreline located downhill. At two of these locations, metals were also sampled on undeveloped land near the residences. Levels of copper in the soil ranged from 4 to 30 mg/Kg (ppm), zinc from 4 to 96 mg/Kg, and lead from 3 to 12 mg/Kg. Many factors, including several factors unrelated to the presence or absence of residences, could explain the lack of excessive levels of these metals in the San Juan samples, and spatial differences in their concentrations, at the time of collection. None of these samples exceeded government standards on the particular day of sampling. However, an unrelated study found that a short-term (30 minute) exposure to only 20 ppm copper dissolved in water can reduce the ability of coho to smell a natural odorant by 82%, thus potentially impairing their homing ability; increasing the water hardness or alkalinity only slightly diminished the inhibitory effects of copper (McIntyre et al. 2008).

Sediment

Fine sediments suspended in water are a concern because they block the sun from reaching underwater plants, thus reducing aquatic productivity. Excessive suspended sediment can interfere with the respiration and reproduction of larval amphibians (Knutson et al. 2004) and important fish. Sediment also serves as a carrier for heavy metals, phosphorus, and some toxic household chemicals, which routinely bind to surfaces of suspended clay particles (Hoffman et al. 2009, Kronvang et al. 2009). When deposited, sediments can smother bottom-dwelling aquatic life, as well as eventually fill in small isolated wetlands, or at least reduce the duration of time they are saturated, thus reducing their suitability as habitat for some dependent species. Suspended sediments concentrations are expressed as turbidity or total suspended solids. Extensive year-round sampling in neighboring Island County determined that background levels in streams of relatively unaltered watersheds there are about 15 NTU (a unit of measurement typically applied to turbidity). Sampling of several streams throughout SJC by the County in 1997-1998 found several exceedences of the turbidity standard (San Juan County Dept. of Health and Community Services 2000). A survey freshwater locations in SJC in 2000 (Wiseman et al. 2003) found average turbidity levels to be within the standard at all but 4 of 24 locations sampled on a semi-monthly basis. Also, the San Juan Islands Conservation District (2008) between 2005 and 2007 found the turbidity standard being exceeded (during at least part of the year) at 6 of about 23 sites. Although there is a State standard for turbidity (which only grossly represents the level of suspended sediments), there are no standards useful to defining "excessive" sediment deposition rates in streams, wetlands, or estuaries. Turbidity results largely from soil erosion, and susceptibility to erosion is the dominant hazard or limiting factor in components of soils that comprise 34% of the land area of SJC (calculated from NRCS 2009). However, most such soils have slopes in excess of 30 percent and thus are unlikely to be developed or cultivated. Logging or road building on such slopes may nonetheless increase sediment in runoff. Suspended sediment also originates from eroding stream banks. Although bank erosion is a normal geologic process, it is greatly accelerated when vegetation in or near the channel is cleared and the extent of impervious surfaces in adjoining uplands is increased by development (Segura & Booth 2010).

<u>Bacteria, Viruses, and Fungi</u>

Microbial communities are diverse and essential to well-functioning ecosystems, but they also contain some organisms that are pathogenic to humans, other animals, and plants. Pathogens found in surface waters are overwhelmingly ones associated with human waste, but can also originate from waterfowl, dogs, and some other mammals. Septic systems are designed to reduce populations of harmful bacteria (indicated mainly by the presence of coliform bacteria, *Escherichia coli*) before they reach surface or groundwater and contaminate shellfish. However, a potential exists for some bacterial releases when systems in geologically sensitive areas exceed their designed lifespan. In Australia, concentrations of *E. coli* in streams were best predicted by the number of septic systems per square mile, weighted by septic system distance to streams measured along drainageways that led to the streams. At that location, subsurface stormwater drains were not found to be an important conduit for bacteria in septic leakage (Walsh & Kunapo 2009).

State standards exist for the bacterial group most often associated with animal waste, the coliforms. Examples of streams and lakes where very high levels of fecal coliform bacteria have been reported on at least one date in the last 10 years, in some cases exceeding state standards, are Horseshoe Lake (Blakely Island), an unnamed stream flowing southeast from Hummel Lake, Cascade Creek at Olga, an unnamed stream next to Cascade Creek, and streams or drainageways flowing into marine waters at East Sound, West Sound (Crow Valley), Doe Bay, Buck Bay, False Bay, Friday Harbor, Westcott Bay, Garrison Bay, and at numerous Lopez Island locations. Where failing septic systems are a likely contributor, the County has been working with homeowners to correct these issues. Most of the septic systems associated with newer construction of homes in the County are of a relatively advanced design that incorporates both aerobic and anaerobic processing of wastes.

4.2.2.2 Impacts of Channel Alterations

Although mostly small and flowing only seasonally, many SJC streams have been excavated and re-aligned (channelized), in some cases disconnecting productive wetlands from streams. Sometimes this was done to increase the productivity of crops growing in wetlands or to make wet soils suitable for home construction or roads. This inevitably results in overall simplification of the stream networks, meaning that rainfall now travels more quickly from uplands where it lands to places where water intercepts the ocean. Research elsewhere indicates that this can result in less infiltration, less recharge of aquifers, less processing of pollutants before they reach the ocean, stream flow that is warmer and more murky, and significant degradation of aquatic life except, perhaps, in places where channels and pools have been deepened sufficiently to improve fish access and perhaps the summer survival of fish.

The cross-sectional shape of some channels also changes when vegetation near the channel is cleared, especially when replaced by impervious surfaces. The larger volumes of runoff that result can cause channels to become more incised, depending on the slope and soil erodibility. Areas farther downstream where the eroded sediments are deposited can become shallower and wider, potentially restricting fish access and impairing aquatic life in many other ways.

The county's roads and private driveways have cut off historic fish passage to significant portions of many intermittent streams (for examples, see Barsh 2010). At some locations no culverts were installed perhaps because seasonal flows were judged too small and brief to matter. At other locations culverts were installed but are inadequately positioned or improperly sized to allow passage of fish, wood, and leaves. Although small numbers of coastal cutthroat trout in some SJC streams seem able to survive despite being landlocked and confined to scattered relict pools during late summer (Barsh 2010), this may be a precarious adaptation for local populations of the species in the long term (Gresswell et al. 2006).

4.2.2.3 Impacts of Removing Streamside Vegetation

Effects of Removal of Streamside Vegetation on Aquatic Life

The importance of streamside vegetation, especially trees, for sustaining the health of aquatic systems has been documented hundreds of times over the past 50 years, especially in the Pacific Northwest (e.g., Gregory et al. 1991, Naiman et al. 2000, Richardson et al. 2005, Wipfli et al. 2007). The scientific basis for protecting streamside vegetation as "buffers[4]" is also discussed extensively in Chapter 2 (Wetlands) of this document. A key finding is that *the primary water quality reason for protecting vegetated buffers in SJC is not to increase infiltration or filtering of overland runoff (buffers are often ineffective for that), but rather to prevent potential sources of pollution and runoff (i.e., development) from being placed on top of hydrologic source areas, which are the areas most responsible for rapidly transporting any pollution to sensitive water bodies downslope or downstream* (Creed et al.2008a,b; Qiu 2009a,b).

As one hydrologist (Walter et al. 2009) puts it:
"Riparian buffers are commonly promoted to protect stream water quality. A common conceptual assumption is that buffers "intercept" and treat upland runoff. As a shift in paradigm, it is proposed instead that riparian buffers should be recognized as the parts of the landscape that most frequently ***generate*** *storm runoff. Thus, water quality can be protected from contaminated storm runoff by disassociating riparian buffers from potentially polluting activities."*

Few if any studies have been done on the effects of buffers along *intermittent* streams on the abundance and diversity of aquatic life in those types of streams. The effects of buffers and/or tree canopy closure on aquatic life in *perennial* streams are varied, with some studies showing little effect on native fish (Roy et al. 2005, Fischer et al. 2009) and others a positive effect especially when buffer width was at least 100 ft (Frimpong et al. 2005, Horwitz et al. 2008). A 30-ft wide buffer along perennial streams in British Columbia was found to be insufficient to protect stream invertebrate communities from clear-cut logging, although the terrestrial insects the buffer provided were noted as a potentially important food source for fish using the streams (Hoover et al. 2007).

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[4] **Buffers** are generally-terrestrial areas surrounding a wetland or bordering a stream or shoreline, whose purpose is to reduce impacts to the functions of that protected water body, such as may occur from adjacent land uses. Like **setbacks**, buffers are measured a specified distance between a development and the water body being protected. Unlike setbacks, buffers usually are considered off-limits to some activities and land uses which themselves may impact the functions of the water body.

Another study of BC perennial streams found uncut riparian buffers of at least 30 ft were needed to limit changes from clear-cut logging to aquatic life in headwater forested watersheds; those changes included increase abundance of aquatic invertebrates and algae (Kiffney et al. 2003). In Maryland, agricultural streams with extensive buffers had greater diversity of aquatic invertebrates than urban streams. Perennial urban streams, even when impervious surfaces were extensive in their watersheds, had high diversity of invertebrates in places where a riparian forest canopy had been preserved (Moore & Palmer 2005). And the conversion of streamside cropland to natural vegetation resulted in more diverse stream aquatic communities within one year of the riparian planting (Teels et al. 2006).

Variation among the results found by some studies of buffer effects on aquatic life is perhaps due to the fact that *intensity of land use* and forest fragmentation in a stream's watershed often has a greater influence than buffer width (e.g., Shandas & Alberti 2009, Stephenson & Morin 2009). The effects of buffer width or proportion of forest in the watershed can also be overshadowed by differences in stream substrate type and flow duration (Roy et al. 2005). In Georgia, where the proportion of the riparian zone occupied by forest was great, only the perennial streams with coarse bed sediment and low bed mobility (vs. sites with high amounts of fine sediment) had greater richness and abundance of sensitive fish species (Roy et al. 2006). Comparing data from multiple regions, Utz et al. (2009) reported that aquatic invertebrates sensitive to impervious cover were generally lost when impervious cover was in the range of 3% (most sensitive taxa) to 23%. Agricultural land cover seemed less impacting than impervious cover. Most organisms were capable of tolerating high levels of agricultural land cover, but a few disappeared when agricultural land cover exceeded 21% of the watershed area. Once urbanization in a watershed reached 60%, all taxa remaining responded either neutrally or positively with respect to continued urbanization. Most were harmed at much lower levels. The degraded physical condition of urban perennial streams of the Puget Lowlands was best explained statistically by the extent of high-intensity land use and grassy urban land in the contributing area, and percent grassy urban land within about one-quarter mile of the stream. Stream physical condition was also much worse near road crossings, but conditions improved after a stream flowed through a forested buffer or a wetland (McBride & Booth 2005). A study in Australia found that sensitive aquatic invertebrate taxa rarely occurred in streams whose contributing areas had greater than 4% total imperviousness. However, within sites of similar imperviousness, those with more riparian forest cover were more diverse in terms of some insect groups. Canopy cover along the streams did not explain invertebrate community composition strongly (Walsh et al. 2007).

Changes in aquatic life caused by vegetation clearing near streams and wetlands are usually the result of changes in a series of interrelated factors that are affected by canopy removal, including stream temperature, dissolved oxygen, suspended and deposited sediment, channel morphology, flow duration, type and extent of replacement vegetation, and the abundance and instream retention times of woody material, terrestrial insects, and leaves (McBride & Booth 2005, Poff et al. 2006, Alberti et al. 2007, Roberts et al. 2008, Segura & Booth 2010).

As is widely known, one function of streamside vegetation is to help maintain regimes of **water temperature and dissolved oxygen** favorable to local fish and other aquatic life. Water temperature in smaller streams and wetlands is usually influenced the most by shade from the vegetation closest to these waters, and from the capacity of plant roots to open up soil pores that allow for greater subsurface interflow. Overall vegetation patterns in a watershed frequently have an equal or greater influence on stream temperature and aquatic productivity than vegetation just within buffer areas adjoining a stream (Brosofske et al. 1997, Sridhar et al. 2004, Stephenson & Morin 2008). This may also be true of air temperatures: maximum within one 100-ft wooded buffer was only slightly cooler than in a 16-ft wide wooded buffer (Meleason & Quinn 2004).

Streams whose contributing areas have a greater extent of roads (road density) have higher temperatures. A study of 104 streams in British Columbia found there is a 6-in-10 chance that the summer maximum weekly average water temperature will increase by 2.3 °F if road density in the contributing area exceeds 27 ft of road per acre and by 5.8 °F if road density exceeds 53 ft of road per acre (Nelitz et al. 2007). GIS analysis of County data indicates that road densities on most of the SJC islands exceeds these thresholds (Table 4-2).

Table 4-2. Densities of roads (excluding driveways) by island.

Island	Island Acres	Road Ft	Ft/Acre
Center	168	16430	98
Crane	226	14640	65
Obstruction	220	12108	55
Decatur	2237	112693	50
Orcas	36991	1385984	37
Lopez	18995	698871	37
San Juan	35503	1287438	36
Shaw	4889	141376	29
Stuart	1823	47170	26
Henry	999	22958	23
Blakely	4302	52821	12
Waldron	2905	32764	11

Besides shade and other thermal effects from vegetation, factors controlling temperature in streams of the Pacific Northwest include groundwater discharge (springs), stream orientation (buffers along north-south streams in British Columbia are more effective, Gomi et al. 2006), channel depth, presence of instream ponds (Rayne et al. 2008), and other factors reviewed by Moore et al. (2005).

The importance of water temperature is recognized by legal standards that have been adopted for streams. Cool waters (less than 68°F, ideally less than 60°F) are particularly important to salmonid fish because at higher temperatures less of the dissolved oxygen necessary for their survival (a minimum of 5 ppm is needed by most local fish) is able to remain in the water. It should be noted, however, that local populations of some fish in SJC may have adapted to somewhat higher temperatures (Barsh 2010). For example, coastal cutthroat (*Oncorhynchus clarki clarki*) have been observed in San Juan County streams at temperatures that were as high as 66.2 °F for at least short periods and even higher temperatures in deep ponds (Barsh 2010). Being highly mobile, fish can of course avoid channel segments with excessive temperatures or pollutants, unless trapped in pools by rapidly dropping water levels. However, when fish avoid areas due to pollution or physical barriers, this reduces the extent of useable habitat and thus the number of fish that can exist in an area.

Also, researchers in some parts of the Pacific Northwest have discovered that populations of a few species of native frogs, pond-breeding salamanders, and aquatic invertebrates sometimes *in*crease following partial removal of shading vegetation. That may be related to a subsequent increase in water temperatures and algae, provided that sediment inputs to streams do not increase greatly at the same time (Murphy et al. 1981, Hawkins et al. 1983).

A study by Pollock et al. (2010) of 40 small forested watersheds in the Olympic Peninsula found that mean daily maximum temperatures averaged 58.1°F and 53.8°F in logged and unlogged watersheds, respectively, even 40 years after logging. Diurnal fluctuations also were greater in the harvested watersheds, averaging 3.0 °F compared to 1.6 °F in the unharvested. Average daily maximum temperature depended on the amount that had been cut in both the watershed as a whole and in just the parts of the watershed near the streams. The amount of recently clear-cut riparian forest (<20 year) within ~2000 ft upstream ranged from 0% to 100% and was not correlated to increased stream temperatures. The probability of a stream exceeding the temperature standard increased with increasing amount of the watershed harvested. All unharvested sites and five of six sites that had 25-50% harvest met the temperature standard. In contrast, only nine of eighteen sites with 50-75% harvest and two of nine sites with >75% harvest met the standard. Many streams with extensive canopy closure still had higher temperatures and greater diurnal fluctuations than the unharvested basins, indicating that that the impact of past forest harvest activities on stream temperatures cannot be entirely mitigated through the reestablishment of riparian buffers. A study in Oregon found that thinning a forest to a density of 80 trees/acre did not affect soil temperature in streamside areas nor the water temperature of the stream (Olson & Chan 2005).

Riparian vegetation is also important for its ability to provide energy (mainly in the form of carbon) to aquatic food chains, and to add physical structure (downed wood) valued as habitat by many stream and lake species. Carbon is added in the form of leaves, logs, and large numbers of terrestrial insects that fall into streams. In the Pacific Northwest, the clearing of forests for home construction and roads has promoted a shift from coniferous or mixed vegetation to deciduous vegetation; this contributes 54% more nitrate and 40% more phosphorus to streams and alters the seasonal timing of the inputs and light availability (Roberts & Bilby 2009). Consequences for aquatic life in streams and perhaps estuaries are probably significant, but cannot be assumed to be positive or negative from a perspective of human values. A similar vegetation shift occurred as a result of clear-cutting near streams in British Columbia (Kiffney & Richardson 2010).

In some streams and at some times of the year, large quantities of insects fall from terrestrial vegetation into streams and the ocean, providing substantial food for fish. A study in Oregon found quantities were greater when streamside vegetation was deciduous shrubs and trees rather than conifers (Progar & Moldenke 2009). A study in Georgia found that, paradoxically, more terrestrial insects fell into open-canopy streams than forested streams. However, the insects were generally smaller and less often consumed by the fish, whereas insects falling into densely forested streams were larger and more often used (Roy et al. 2005). In the Pacific Northwest, some uncertainty remains regarding the relative importance of different land cover types and tree species as contributors of insects consumed by salmonids at different seasons. The dominant type of vegetation, both near a stream and in a watershed generally, undoubtedly has the potential to strongly influence aquatic productivity (Ball et al. 2010).

Although leaves from riparian vegetation ("litter fall") increase the abundance of aquatic invertebrates, they also take up oxygen from the water as they decompose (due to microbial respiration). When they accumulate in isolated pools, as in intermittent streams that slowly dry up each spring, this could be detrimental to any fish remaining in those pools.

Although **large wood** (fallen trees) can sometimes block fish access to parts of streams, the importance of large wood to aquatic life has been widely documented in perennial streams (literature reviewed by Murphy 1995, May 2003, Wenger 2000, Knutson and Naef 1997) and in lakes (Roth et al. 2007). A study in Montana found that channels having wider wooded buffers had more instream wood (McIlroy et al. 2008). During storms in-channel wood shelters fish from severe flow velocities, and at other times wood shelters fish from predators. Wood also provides shade and additional attachment surfaces for aquatic invertebrates that fish feed upon. By detaining leaves that fall into channels, wood lengthens the time that leaf decay occurs before leaves are washed downstream into the ocean. In doing so, this enriches the leaves and the invertebrates that feed on them, thus potentially supporting more fish, both in the stream and in nearshore waters. Adding large wood to a stream appeared in at least one instance to increase the stream's capacity to remove excessive nitrate (Roberts et al. 2007). Large wood that partially blocks flow can force more stream water into the underlying sediments (hyporheic flow), thus potentially cooling the water temperature and enhancing the processing of soluble pollutants. During the most severe storms, debris flows in streams nearest the marine shore can provide wood to coastal bays, with consequent benefits to marine forage fish and invertebrates. Treefall directly into marine waters from adjoining cliffs can serve the same purpose as large wood entering marine waters via streams , and because of the county's long shoreline relative to its total stream lengths, shoreline treefall is probably a larger source of marine wood.

Information from studies in the Pacific Northwest (FEMAT 1993) suggests that most large wood in streams is provided by trees that are within a horizontal distance of 0.5 (50% effectiveness) and 0.8 (90% effectiveness) tree-height of water, and that most leaf litter originates from trees that are within 0.2 (50% effectiveness) and 0.4 (90% effectiveness) of the water. In the soils and climate present in the San Juan Islands, most trees grow to about 85 feet tall. Thus, most large wood in SJC streams is likely to originate within 43-68 feet of water, and most leaf litter within 17-34 feet.

As contrasted with its role in perennial streams and rivers, the importance of large wood in narrow intermittent streams has not been firmly established. However, it would appear that most of the same principles should apply. A lack of wood in intermittent streams could force fish to use deeper pools for shelter. This might increase the risk of fish being stranded by rapidly receding water levels. Also, deeper pools often have less dissolved oxygen, thus potentially increasing the risks associated with greater physiological stress. Large wood falling into steep intermittent channels could also help minimize downcutting and head-cutting of those channels, which can be detrimental to aquatic habitat.

<u>Effects of Removal of Riparian Vegetation on Wildlife</u>

Few or no wildlife species in SJC reside in or depend directly on streams or their adjoining vegetation exclusively, perhaps because so few of the county's streams flow perennially and because stream networks historically present have been disrupted. Some of the county's wildlife species may occur disproportionately near fresh water (e.g., wetlands, lakes), but being located along perennial or intermittent streams per se may not be critical to the vegetation structures or food sources that comprise habitat for local species. No scientific evidence suggests that any SJC songbird or amphibian species prefers vegetated areas close to the marine shoreline over similarly vegetated areas located further inland, and the importance of a contiguously wooded corridor connecting the marine shoreline with habitats closer to the center of islands has not been demonstrated. It seems at least equally likely that many species would favor the warmer, more sheltered interior environments over the harsher conditions often found along shorelines.

The affinities of some wildlife species with streamside or shoreline vegetation may have less to do with the fact of the vegetation being along a stream or shoreline as with the plant species and structure of the vegetation that occurs disproportionately there (Shirley 2004), the microclimate which the vegetation creates, or to the fact that there often is a greater concentration of downed wood and snags valued by wildlife in the areas closer to shorelines, streams, and other topographic depressions (Martin et al. 2007). In British Columbia, activity levels of bats were more than 40 times greater in riparian than in upland areas, due to greater abundance of emerging aquatic insects, and were significantly greater where stand complexity and extent of forest edges was greater; bat activity levels were not correlated with forest stand age (Grindal et al. Brigham 1999, Grindal et al. 1999).

Although some studies (almost entirely from the eastern United States) have found more wildlife *species and individuals* in wider strips of vegetation, such as in buffers of increasing width along streams, this is an obvious outcome. Any time any sort of vegetation is added to the landscape, most wildlife species will respond positively because vegetation adds vertical complexity to the landscape in ways that buildings, roads, lawns, and croplands do not. Even if wide buffers were placed along every stream and shoreline and around every wetland in a county or large island, this will still not be wide enough to meet the habitat needs of all the county's indigenous wildlife species. Ecologically, more is always better, but *the key issue really is: How much is "enough?"* There are few if any SJC species for which this question can be answered confidently with the existing data. And as noted earlier, it isn't only the width of the buffer that matters – it's also the quality of the habitat within it and the intensity of land use behind it.

Mammals in SJC that probably use stream and shoreline riparian areas and wetlands disproportionately include muskrat, beaver, river otter, mink, raccoon, and all bats (Appendix 4-B). They all use upland habitats as well, and their buffer width requirements, if any, are not reliably known. A study in British Columbia compared abundance of small mammals in a 100-ft wooded buffer there with those in a clearcut and an unlogged forest (Cockle & Richardson 2003). No dramatic differences were noted. Two species (shrew-mole, montane shrew) were less numerous in the 100-ft buffer, but only slightly so. At increasing distances from streams, creeping voles increased and deer mice (during 1 of 2 years) decreased. In southwestern Washington, a 200-ft wetland buffer appeared adequate to protect small mammals in the wetland from effects of logging nearby forests (MacCracken 2005). Similarly, near an Oregon clearcutting operation, only one of 17 small mammal species declined in riparian buffers that were 10-50 ft wide (Wilk et al. 2010). Some published literature syntheses have made the mistake of assuming that the distance a species has been recorded from a stream or wetland is the same as the size of buffer it would require.

Among SJC birds, those that are likely to occur disproportionately near streams, based on knowledge of their habitat preferences in Washington (WDFW 2009) or adjoining states and provinces (e.g., Kinley & Newhouse 1997, Shirley 2006) include Willow Flycatcher, Olive-sided Flycatcher, Swainson's Thrush, Varied Thrush, Warbling Vireo, Yellow Warbler, Wilson's Warbler, and perhaps Western Screech-Owl, Pacific-slope Flycatcher, Pacific (Winter) Wren, and Black-throated Gray Warbler. In Ohio, 20 of 27 migrant bird species were *more* abundant (by 58 - 75%) in upland forest than in riparian forest. Migrant bird abundance was statistically unrelated to either percent urbanized land or percent forest cover within 0.6 mile (Rodewald & Mathews 2005). Also in Ohio, migrant songbirds had the strongest positive correlation with natural land cover near streams when it was measured within ~820 ft of streams, rather than in areas closer or farther. Some migrant songbirds were much less likely to occur where there were many buildings within that distance of streams (Pennington 2008).

4.2.2.4 Impacts of Human Presence Along Streams

The frequent and/or persistent presence of humans and domestic animals (particularly dogs and house cats) can discourage some wildlife species from using streamside areas (or any habitat area) where those species otherwise would be present. Noise, night-time outdoor lighting, large picture windows (a collision hazard for birds), trash dumping, and a host of other things associated with humans contribute to avoidance of residential areas by some riparian wildlife species. See section 4.3.2.2 Impacts of Human Presence for additional description.

4.2.2.5 Development Intensity

Because of the complexity in assessing the potential for each of the above-mentioned impacts in each development permit application, planners often just create a limited number of categories intended to reflect the likely cumulative intensity of pollution, vegetation alteration, hydrologic disruption, and other disturbance associated with particular land use types. For example, the WDOE (Granger et al. 2005, in Table 8C-3) rates various proposed expansion or creation of particular land uses as High, Moderate, or Low Intensity as follows:

> HIGH: Residential (if more than 1 unit/acre); industrial; commercial; high-intensity recreation (e.g., golf course, athletic field), or conversion to high-intensity agriculture (dairies, nurseries, greenhouses, growing and harvesting crops requiring annual tilling and raising and maintaining animals, hobby farms, etc.).
> MODERATE: Residential (if 1 unit per multiple acres); logging roads, driveways, paved trails; right-of-way or utility corridor shared by several utilities; or conversion to moderate-intensity agriculture (e.g., orchards, hay fields).
> LOW: Forestry (tree-cutting only), unpaved trails, utility corridor without a maintenance road and little or no vegetation management.

An alternative approach is to base the intensity categories on the proportion of vegetation cleared, impervious surface created, or other measurable features.

4.2.3 Data Gaps and Expanding the Knowledge Base

1. Significant uncertainty remains regarding the degree to which conclusions from studies of perennial streams can be extended to accurately describe many of the ecological relationships and processes in intermittent streams. It is unclear, for example, whether the abundance of many wildlife species is greater along SJC's intermittent streams than in uplands, or whether the supply of large wood in SJC's intermittent channels significantly limits fish populations.

2. Although most of SJC's streams are intermittent, the County lacks a comprehensively ground-truthed spatial data layer (map) that shows their locations accurately, particularly as regards their headwater points of origin. Creating such a map is as essential for water quality planning as for analysis of salmonid Habitat Conservation Areas. Observable geomorphic characteristics can be used to delimit headwater points

of origin in many cases. Also, the size of a contributing area that results in channel formation or flow initiation needs to be computed for SJC streams, in the context of specific local geologic, topographic, land cover, road density, and climate factors that cause variation in this relationship.

3. Recent water quality studies of limited scope have identified potentially harmful levels of pollutants of human origin in SJC streams and nearshore areas. To adequately protect aquatic Habitat Conservation Areas, a monitoring program that is geographically and chemically comprehensive is needed to portray the true scope of this issue, identify pollutant sources, and initiate remedial actions. The Stormwater Utility and Marine Resources Committee is currently developing a monitoring program which could, if adequately funded and staffed over the long term, provide such data.

4. Although Wild Fish Conservancy and other groups have discovered much about fish use of some SJC intermittent streams, funding should be provided to determine fish use of the remaining unsurveyed streams that have some potential to support fish, and to identify all natural or artificial barriers to fish passage.

5. More information is needed regarding minimum flows necessary in SJC streams during each month of the year to allow fish passage and support other aquatic life.

6. More information is needed regarding effects of non-native fish in SJC lakes and streams on native fish and amphibian populations. In the interim, effects should be assumed to be adverse based on studies elsewhere, and intentional stocking of ponds and lakes with bass, bluegill, and other non-native species should be strongly discouraged.

7. Despite the above data gaps and information needs, the County's efforts to protect aquatic Habitat Conservation Areas should not be put on hold until more information is available. State laws, the public trust, and popular concern for protecting natural resources from long-lasting harm dictate that both voluntary and regulatory efforts proceed with urgency using the best available science, whatever its current limitations.

4.2.4 Synopsis and Science-based Options

Synopsis

1. Buffers are not always the best way to protect the water quality of streams and other water bodies. Stopping stormwater and other pollution at its known or likely sources,

especially before it reaches ditches and drainageways that connect to streams and wetlands, is often a better strategy.

2. The effectiveness of buffers for protecting water quality is attributable less to their vegetation's active role in filtering and taking up pollutants, than to the simple fact that well-configured buffers can passively exclude development – with its concomitant removal of vegetation, increase in impervious surfaces, erosion and compaction of soils, installation of drains and ditches, and introduction of new pollutants -- from areas where development impacts, due to on-site hydrologic factors, are most likely to be magnified (see Chapter 2, section 2.4.5). Research also shows that the effectiveness of riparian buffers for maintaining water quality is strongly influenced by the type of underlying soils and geologic formations. However, these are difficult to assess. Buffer width is nearly the only characteristic relevant to predicting water quality that can be measured objectively and at reasonable cost, and so has commonly become the basis for regulations.

3. The necessary width or distance to remove or retain pollutants depends partly on the *intensity and extent of a proposed development activity or land use*. The most intensive activities or uses require higher percent-removal rates in order to maintain quality of receiving waters. There are limits -- both technical and financial -- as to what improved engineering for stormwater treatment can accomplish in SJC. Nonetheless, as detailed in Chapter 7, more could be done to improve the management and treatment of stormwater throughout the county in ways that will minimize changes to the water regimes of wetlands and streams and reduce the load of pollutants that reach wetlands. For stormwater treatment systems that are designed to increase the infiltration of runoff after it is treated, an appropriate setback will still be needed to allow that infiltration to occur.

4. The buffer width or distance also depends on whether the soluble pollutants commonly transported to streams and lakes are transported mainly via *subsurface seepage* (e.g., high water table), *sheet flow* (diffuse surface runoff), or channelized *surface runoff* (ditches, gullies, subsurface pipes). The latter require larger buffers. A determination of which transport route prevails at a particular location cannot legitimately be based only on county soil maps, topography, and one-time field observations; it requires an expensive geohydrological investigation at each location. Results would vary seasonally and sometimes even hourly as water tables rise after a storm and sheet flow channelizes for indeterminant periods. In lieu of requiring such investigations for each permit application, the County could assume that water quality buffers for streams and lakes be wider wherever slopes between the channel or lake and the proposed development activity are steep, or (b) the lake lacks a persistent surface

water outlet and is thus more likely to accumulate pollutants to the detriment of its aquatic life. Together, these are termed *transport and sensitivity* factors. Depending on the terrain, soils, and local surficial geological formations, infiltration of stormwater can sometimes be increased by implementing particular LID (Low Impact Development, see Chapter 7) measures, thus potentially converting surface flow to less hazardous subsurface seepage. When that is feasible, consideration could be given to reducing a buffer width requirement provided riparian habitat functions are also adequately maintained and the LID measures do not require maintenance over the long term.

5. Under ideal conditions, buffers of only a few feet width can remove most coarse sediment that is carried towards a stream or lake by diffuse sheet flow. However, for the removal or retention of finer sediments as well as some *soluble* substances that can harm aquatic life, buffers of between 10 and 810 feet are generally necessary.

6. Depending on the terrain and local surficial geological formations, infiltration of stormwater can sometimes be increased by implementing particular LID (Low Impact Development, see Chapter 7) measures, thus potentially converting surface flow to less hazardous subsurface seepage. However, there are no data quantifying the amount of buffer reduction that could be allowed if LID or other mitigative measures were implemented to varying degrees.

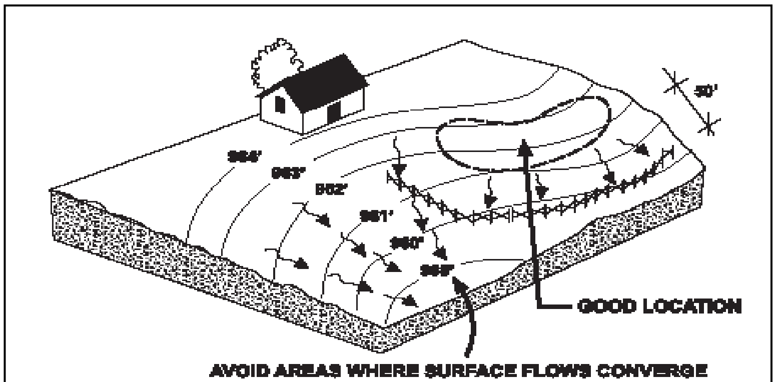
8. Large loads of many soluble substances such as nitrate potentially threaten aquatic life in lakes, perennial streams, wetlands, and semi-confined marine waters. However, the impact of these substances on mobile aquatic organisms that temporarily inhabit *intermittent streams* is largely unknown. In such habitats, exposure is more likely to be brief than chronic, and may occur chiefly at times when flowing water dilutes some substances. Compared with the situation in perennial streams and lakes, in intermittent streams large growths of oxygen-depriving algae may be of less concern, and therefore the nutrients that trigger their growth may be of less concern, because surface water is mainly present during seasons when light, rather than soluble nutrients, limits the growth of such algae. Oxygen deficits that occur in pools that persist seasonally in some intermittent streams may be due more to the decay of accumulated leaves and wood than to growths of algae triggered by excessive concentrations of soluble nutrients.

<u>Options</u>

Based on the Best Available Science, the County could do the following to protect the freshwater HCA's and their functions[5]:

1. For **fish habitat** protection, adopt the stream typing maps that have been prepared and ground-truthed by the Wild Fish Conservancy, as they are completed. For County-regulated development activities within streams shown on this map, landowners would need to request a permit from the County.

2. For assisting in the protection of **surface water quality**, adopt as well the countywide map titled "Possible Drainageways" (that was developed as part of this project using LiDAR imagery). This map has not been ground-truthed and the County does not intend to regulate activities in drainageways. Rather, this map is intended to alert landowners to parts of their property that often are most responsible for transporting possible pollutants, and to alert permit applicants and the County to areas where implementation of Low Impact Development (LID) practices would be most important. Buffers around lakes, streams, and wetlands could also be widened (perhaps with a "buffer width averaging" process) where mapped drainageways intersect those water bodies, once the existence and location of those drainageways on a parcel has been field-verified. Some of the areas shown on this map do not meet legal definitions for "streams" but are important nonetheless to the transport of pollutants into protected water bodies, as well as serving as corridors for amphibian movements.



Source: Purdue University, 1990.

3. Support the completion of the WDNR stream typing system countywide, as well as its integration with the drainageways map. Also support surveys of fish and fish

[5] Note that because section 4.2.4 is a synopsis, literature supporting many of the statements in this section is generally not cited here, but rather in preceding parts of this HCA chapter.

habitat in all of SJC's intermittent streams that might be accessed by fish. Regularly monitor those streams where spawning salmonids have been reported, to verify anecdotal reports and determine the persistence of salmonid populations as a basis for remedial action, especially if declining use is noted.

4. Continue to support the On-site Sewage System Operation and Maintenance Program with annual inspections of septic systems near sensitive marine waters, and if possible expand to also include annual inspections of systems closest to streams, lakes, and wetlands and those on soils least suitable for effective waste treatment. If necessary, consider requiring costlier septic systems with more advanced treatment capabilities for new home construction in the most sensitive areas, as well as implementation of Low Impact Development practices for maintaining stormwater quality.

5. Use buffers along streams as one tool to help keep pollutants out of these HCA's as well as marine waters. Rather than requiring the same width for all buffers, the County could require the application of simple, standardized decision rules to identify the scientifically appropriate buffer widths applicable to each stream, and apply these rules on a permit-by-permit basis. The rules would account for (a) the intensity of the proposed activity or land use, as well as the stream's (b) sensitivity as determined by adjoining slope and other factors, (c) the relative importance of the stream for salmonids, other aquatic life, and ecosystem processes. The widths of buffers to protect water quality of streams could be determined site-specifically using a standardized procedure.

6. The County could choose to apply the same buffer width criteria to lakes as to wetlands (as described in section 2.7).

7. An alternative approach to buffers might involve *adaptive management*, wherein larger buffers would be required only where monitoring indicated ground or surface water quality conditons are not in compliance with standards. There are several problems with such an approach. First, by the time a violation of standards is discovered, aquatic life may already have been harmed, perhaps irreversibly, and a new development that caused the problem cannot realistically be removed to make way for a buffer that is being widened in response. In particular, time lags of years are common between when a development occurs and when resulting pollution plumes reach groundwater and are discovered (Meals et al. 2010). Second, unless monitoring occurred in every stream and wetland and analyzed every potential pollutant at every season and storm event, there would be no assurance that aquatic life was not being harmed. Third, for the reasons detailed in section 4.2.2.1, even if no violations of water

quality standards were found, this would not necessarily mean aquatic life was unharmed by development. Finally, protecting water quality is not the only reason buffers are necessary; they are also essential for maintaining habitat of many fish and wildlife species. Annual monitoring of the populations of all those species, as would be necessary under an adaptive management approach, would be an extremely costly endeavor, and it might be impossible to attribute population declines to development in a specific area, as opposed to pollution carried from afar, or climate change, predators, or other factors.

4.3 Review of Information: Terrestrial FWHCA Requiring Protection

4.3.1 Terrestrial Classifications

4.3.1.1 State Natural Area Preserves, Natural Resource Conservation Areas, and Wildlife Areas

Counties and communities must consider the manner in which activities they regulate might adversely impact the State Natural Area Preserves and Natural Resource Conservation Areas managed by the Washington State Department of Natural Resources, and the Wildlife Areas managed by the Washington State Department of Fish and Wildlife. These areas represent an investment of public funds to conserve habitat within specific areas that are often of outstanding importance to populations of animals and plants. Natural Area Preserves are intended to protect the best remaining examples of many ecological communities including rare plant and animal habitat. Natural Resource Conservation Areas are intended to represent unique or high quality undisturbed ecosystems and habitats for endangered, threatened and sensitive plants and animals, and scenic landscapes.

Biological resources within these areas are assumed to be generally more secure than on most private lands.

The following such areas are in San Juan County:

1. Point Doughty Natural Area Preserve: Located on the coast of Orcas Island, this 57-acre forested preserve protects a natural forest community dominated by Douglas-fir

and ocean spray (a shrub), representing the "rain shadow" vegetation which occurs in the San Juan Islands.

2. Cattle Point Natural Resource Conservation Area: Located along the southeastern shore of San Juan Island, this 112-acre area includes freshwater wetlands, grasslands, gravelly beaches, dunes, mature conifer forest, and steep bluffs along waterfront on the Strait of Juan de Fuca and extending across Mount Finlayson to Griffin Bay.

There are no State Wildlife Areas in San Juan County.

Extensive additional areas of habitat are protected from severe impacts by being in public or conservation ownership, e.g., lands owned and managed by the National Park Service (San Juan National Historic Site), US Fish and Wildlife Service (San Juan Islands National Wildlife Refuge), Bureau of Land Management (see USDI BLM 2010), State Parks (Moran State Park and 14 others) and County Parks (e.g., Eastsound County Park). In addition, San Juan County is the only county in the state that has passed a real estate excise tax for purchasing and setting aside significant amounts of land for permanent protection from intensive development. As documented by island in Appendix 4F-1.10, the County's parks and Land Bank programs and the San Juan Preservation Trust have together protected 9% of SJC's area primarily for conservation, and an additional 10% of the county's area is owned by State, Federal, and private conservation groups.

4.3.1.2 Areas Important to Threatened, Endangered, or Sensitive Species

Both Federal and State agencies, through a public listing process, have designated particular species as Threatened, Endangered, or Sensitive. Under the GMA, cities and counties must adopt measures to protect habitat for populations of these species. Table 4-5 and Appendix 4-A indicate animal species that are currently listed as Threatened, Endangered, or Sensitive *and* which occur regularly in San Juan County.

Table 4-5. Species currently listed by Federal or State agencies as Endangered, Threatened or Sensitive and which occur regularly in San Juan County.

Group and Species:	**Status***	**General Habitat (breeding)**	**General Habitat (non-breeding)**
FISH:			
Chinook Salmon (Puget Sound)	FT	(not in SJC)	Marine
Chum Salmon (Summer)	FT	Streams	Marine
Steelhead	FT	(not in SJC)	Marine

Group and Species:	Status*	General Habitat (breeding)	General Habitat (non-breeding)
Rockfish (Boccacio)	FE	Marine	Marine
Rockfish (Canary and Yelloweye)	FT	Marine	Marine
MAMMALS:			
Killer Whale (Southern Resident Orca)	FE, WE	Marine	Marine
Humpback Whale	FE, WE	(not in SJC)	Marine
Steller Sea Lion	FT, WT	(not in SJC)	Marine
Sea Otter	WE	(not in SJC)	Marine
Gray Whale	WS	(not in SJC)	
BIRDS:			
Marbled Murrelet	FT, WT	Mature Forest	Marine
Bald Eagle	WS	Large trees	all
Peregrine Falcon	WS	Cliffs	all
Common Loon	WS	(not in SJC)	Marine & large lakes
Brown Pelican	WS	(not in SJC)	Marine
INSECTS:			
Taylor's Checkerspot Butterfly	WE	Grassy Shorelines	Grassy Shorelines

* F= Federal listing, W= State listing; listed as E= Endangered, T= Threatened, S= sensitive. See also Appendix 4-A and 4-B.

Note that Common Loon (another species considered Sensitive, but only when breeding) has not nested in San Juan County since around 1948 (Lewis & Sharpe 1987; Cassidy & Grue 2006) and currently breeds at only one location in western Washington. Forage fish are a principal food. Significant numbers are present in SJC primarily during the fall, winter, and spring in marine waters. The species deserves the same habitat protections as dozens of other waterbird species, many of which are unlisted but are equally or more sensitive, e.g., Western Grebe, Brant, Greater Scaup.

Similarly, Brown Pelican is listed as Endangered at the State level. Small numbers regularly visit marine waters surrounding the islands during warmer seasons. However, the species does not breed here and is not known to be present in significant concentrations. Forage fish are a principal food.

4.3.1.2.1 Marbled Murrelet

Life History and Preferred Habitat: This seabird with federal Threatened status has the unusual habit (for seabirds) of nesting high in the canopy of mature evergreen forests (Burger 1995). Because of this, nesting is nearly impossible to confirm, generally requiring at least 20 visits by experienced biologists during at least 2 consecutive years. Hamer and Nelson (1995) described characteristics of 36 murrelet nest stands in the Pacific Northwest. Nest stands in the Pacific Northwest averaged 510 acres. The smallest was 7 acres and the largest was 2725 acres. Because it is difficult to locate murrelet nests, a 1.5-mile radius circle mapped from the point where murrelets were observed flying within the forest canopy or circling above the forest canopy (occupied behavior) is used to delineate occupied murrelet habitat in Washington (WAC 222-16-080 (j)). All suitable murrelet habitat located within a contiguous stand from the point of observation within the 1.5-mile radius circle is considered to be occupied habitat. Because murrelets require only a single tree with suitable nest platforms surrounded by other trees to provide some cover for nesting, suitable habitat that occurs in patches smaller than 7 acres in size could be occupied by murrelets.

Adults fly between the nest and sheltered marine waters to feed on small forage fish and tiny swimming marine invertebrates. Those are most abundant where marine waters have been enriched by nutrients or where ocean currents concentrate these foods.

Status, Threats, and Protection in San Juan County: No nests have been confirmed in the county, but nest survey efforts have been minimal. Nesting here is very likely, as suggested by presence of mature forest (though of limited extent) and observations of many adults and young along shorelines during the breeding season. Murrelets nesting on Vancouver Island make regular round trips of 120 miles to feed in the San Juans. Possibly suitable nesting habitat, as determined by the USDA Forest Service, is shown in Chapter 8.

Especially during winter, the highest densities in Washington are found in the San Juan Islands and adjoining Strait of Juan de Fuca. Areas of concentration are the south shore of Lopez Island and Obstruction and Peavine Passes between Orcas and Blakely Islands in the San Juan Islands (Seattle Audubon Society: http://www.birdweb.org).

One potential threat that might be reduced through regulation is the fragmentation of older forests by scattered homebuilding, roads, or other clearing. The creation of even small clearings in larger blocks of unfragmented forest, as a result of home construction or timber harvest, would be expected to facilitate the invasion of murrelet nest predators such as ravens and crows. Increases in those species can also be triggered by increased availability of food debris that accompanies human settlement. Nelson and Hamer (1995b) found that successful murrelet nests were significantly further from edge than unsuccessful nests, and cover directly around the nest was significantly greater at successful nests. However, Zharikov et al. (2007) commented that habitat fragmentation *per se* need not have a negative effect on this species beyond that as a result of habitat loss, unless associated with increased abundance of such predators, which is not inevitable. The adverse effects of large clearings might be reduced somewhat by maintaining "soft" edges, i.e., a gradual spatial transition from open field to young forest to mature forest (Malt & Lank 2009).

Another potential concern is the permitting of new docks (and thus boats) within about 160 ft of key foraging areas for this and other local seabird species (Chatwin 2010). Boat traffic that is concentrated by docks might, to a small degree, adversely affect feeding activities of this and other seabird species (Bellefleur et al. 2009), though the cumulative effect of that on breeding success and population stability is unknown. There already is heavy boat traffic (both ferries and private recreational boats) near potential feeding areas at certain times of year, and the incremental effect of any additional increase is unknown.

Regulations that prevent harm to the marine habitats (e.g., eelgrass) and local populations of forage fish and other marine organisms that depend on them will benefit murrelets, eagles, and many other species.

4.3.1.2.2 Bald Eagle

Life History and Preferred Habitat: Eagles forage over areas that encompass a wide variety of open habitats, covering up to about 5 square miles on a daily basis. They are particularly attracted to marine and lake shorelines where dead or live fish or waterfowl are present or where colonies of nesting seabirds are nearby. Eagles also feed on rabbits, other small mammals, and carrion in open country. They nest in tall (>85 ft) trees, whether isolated or in forests. They typically use the same nest sites from year to year, but sometimes change as the supply of the most desirable nest trees changes. Nests are most often within about 0.25 mile of marine or lake shorelines. Some eagles are resident while others do not breed locally.

Status, Threats, and Protection in San Juan County: Until recently this species was listed as Threatened, but was delisted federally while its Washington status was changed to Sensitive. It also receives special protection under WAC 232-12-292 and RCW 77.12.655. Despite the concern for this iconic species at the national and state levels, eagles are quite common throughout SJC and the County hosts one of the largest nesting concentrations of this common species in the lower 48 states, numbering at least 125 pairs, or about one-quarter of the nesting population in Washington. Locations of many nest sites are known but change periodically, thus causing maps of locations to quickly become outdated.

Many individual eagles grow accustomed to being near people as they forage along settled shorelines and farmlands. Nonetheless they usually are highly sensitive to human activities around nest sites, especially while incubating their eggs during late winter and early spring. For this reason the WDFW recommends avoiding disturbances at that time from loud machinery within ~800 feet of known nest sites. Other activities that might be disruptive within about 400 feet of communal roosts (regularly-used clusters of trees where eagles sleep) also should be avoided, especially where visually screening vegetation is sparse or absent (WDFW 2004). A study of one eagle nest in SJC found that noise produced by pile driving seemingly had little effect on eagle behavior beyond 1300 ft (Bottorff et al. 1987).

To maintain productivity of eagle populations, prey must be abundant and uncontaminated by pollutants (see section 4.2.2.1 Impacts of Stormwater and Water Diversions on Water Quality and Quantity). Stormwater pollution, shade removal, expansion of ditches, and other actions likely to adversely affect fish and waterfowl or their availability to eagles will ultimately affect productivity of eagle populations by affecting the quality and quantity of food items. Land management practices that reduce the long-term supply of tall trees and facilitate more foot traffic near nesting and roosting areas may also be harmful in the long run. At the same time, the creation of ponds attractive to waterfowl, and the stocking of these with fish, might expand some types of feeding opportunities.

In accordance with WAC 232-12-292 and RCW 77.12.655, whenever activities are proposed that alter habitat near a nest or communal roost, landowners or their consultants must prepare a WDFW-approved site management plan, or submit an existing generic one for approval. Requirements apply to (a) all subdivisions; (b) projects within 800 feet of a nest; and (c) to sites that are within 250 ft. of the shoreline and are within a half mile of a nest. Custom plans are required for subdivisions, for lots within 400 feet of a nest, and for projects that cannot meet the requirements of a generic plan.

4.3.1.2.3 Peregrine Falcon

Life History and Preferred Habitat: Like the preceding species, Peregrine Falcons feed over a wide variety of open habitats, covering several square miles on a daily basis, and are particularly attracted to marine and lake shorelines where waterfowl concentrate or nesting seabird colonies are present. Nest sites are most often located on ledges on large (>45 ft) cliffs within sight of lakes or the marine shoreline, and are used consistently from year to year.

Status, Threats, and Protection in San Juan County: At a state and national scale, this species has rebounded from a sharp decline in the mid-1900's which prompted its initial listing as Threatened. It was recently delisted federally and its Washington status was then changed to Sensitive. As nesting birds Peregrines returned to the San Juans in 1980/ At least 20 pair are now known to regularly nest in the county, probably the highest nesting concentration in Washington if not the entire Pacific Northwest (see http://www.frg.org/SJI_project.htm). In addition, during the fall and winter individuals from other regions commonly forage along the county shorelines. As is true for Bald Eagle, stormwater and other pollution sources potentially threaten its fertility and available foods, but no recent toxicological data specific to this raptor are available from SJC, and the high productivity of the local population suggests no major problems currently. Avoidance of foot traffic and construction activities near active nests during the springtime may increase nest success further.

4.3.1.2.4 Taylor's Checkerspot Butterfly

Life History and Preferred Habitat: This Endangered butterfly is a subspecies of Edith's checkerspot, a medium-sized butterfly. Preferred habitat is various types of unmowed grasslands and rocky outcrops (even some forested ones), especially those with a dominance of native grasses and located near shorelines. It is a relatively sedentary species which remains year-round and rarely disperses more than 2 miles. Host plants include harsh paintbrush (*Castilleja hispida*), and possibly golden paintbrush (*Castilleja laevisecta*), which has been found in only 3 locations in the county. Some populations in other parts of its range appear to be dependent on the non-native English plantain *(Plantago lanceolata)*, a weedy introduced species. Local populations of this butterfly are prone to large year to year fluctuations.

Status and Threats in San Juan County:
Known from only one location on private land; its current status there is unknown. The species could potentially occur in grasslands on San Juan Island (e.g., American Camp) and possibly Lopez Island, but has not been reliably documented. Use of specific locations can vary from year to year. Key host plants for this species could be threatened by some exotic plants (e.g., Scotch broom, blackberry), altered fire regimes (allowing grasslands to be invaded by rose, blackberry, Douglas-fir, and other woody species), and overgrazing by a proliferation of deer and rabbits. Adults and larvae are vulnerable to pesticides and changes in habitat size and connectivity (e.g., by planting trees in particular abandoned fields, replacing grasslands with developments). Direct threats to the butterfly include trampling, fire, inappropriately timed grazing and mowing, and in some cases tidal inundation.

4.3.1.3 Locally Significant Habitat Conservation Areas

As noted at the beginning of this chapter, counties and cities may designate, through a public process, habitats and species they consider to be "locally significant" and thus worthy of a level of protection that is somewhat greater than accorded other private lands. Many counties in Washington have done so. Until now San Juan County has not, but some local citizens have recently made a strong case for recognizing three important habitats, while not nominating any particular species. Those three have also been noted as **Priority Habitats** by Cassidy & Grue (2006) and are described below. It may not be necessary to subject all private lands containing these habitats to an extraordinary level of regulation. Perhaps only those containing some of the highest quality representatives of their type, as evaluated by professional field ecologists and considering multiple ecological factors, are in need of greater protection or management.

1. West Side Prairie. These are uncultivated areas, including some meadows and fallow fields, that are mostly treeless and ideally have a significant presence of native forbs (e.g., *Camas* spp.) and grasses (e.g., *Danthonia californica, Festuca rubra*). Most seasonally wet prairies also qualify as wetlands. The WDFW recognizes West Side Prairie as a Priority Habitat and has mapped some such areas in SJC, e.g., parts of Mount Constitution, the southern slopes of the Turtleback Range on Orcas Island, the west side of San Juan Island, Iceberg Point on Lopez Island, Yellow Island, and a few other locations. Information on their prevalence and locations in SJC is not comprehensive. In SJC they support many plant species that are rare or that grow in few other land cover types. Their plant communities generally are described by Dunwiddie et al. (2006). In most places their native plants have been replaced by non-natives, so the highest level of protection should be given to those prairies that retain the highest cover of native plants, especially native wildflowers and other forbs. Areas as small as 1000 square feet should be protected. Mowing, brief light grazing, or burns may help maintain the native forbs when such activities are conducted sporadically. Machinery and off-road vehicles can damage this habitat.

2. Oak Woodlands and Savannas. These are grasslands containing numerous Garry oak (Oregon white oak) trees, especially those with >50% cover of oak and at least 1 acre in extent. This habitat often grades into West Side Prairie and/or Herbaceous Balds and Bluffs. In SJC this habitat supports several plant species that are rare or that grow in few other land cover types, as well as rare butterflies such as the Duskywing (*Erynnis propertius*). Mast from the oaks provides a key food for gray squirrels, many birds, and other wildlife. The WDFW recognizes "Oregon white oak" as a Priority Habitat and has mapped some such areas at, for example, English Camp, Point Disney, Turtleback Mountain, Cady Mountain, West Sound, and patches in the east, south and west edges of the San Juan Valley and west side of San Juan Island. A naturalist who explored the valley in 1859 found Garry oaks in the False Bay watershed extending for a square mile between the ridge and the wetland soils that comprised the southern two-thirds of the valley (Barsh 2010). See Larsen & Morgan 1998, Murphy & Barsh 2006 for management information. Consideration should be given to broadening the definition to include not only oak, but young stands of **other broadleaf shrubs and trees** (e.g., maple, alder, willow). Some of the Pacific Northwest's most eminent ornithologists (Betts et al. 2010) have noted that the bird species that are strongly associated with that habitat type are showing more declines in the Pacific Northwest than are birds typically associated with mature and old growth forests, for example.

3. Herbaceous Balds and Bluffs. These are native plant areas with few or no trees, with sparse herbaceous vegetation growing on steep exposed slopes, not usually bordering the shoreline. In SJC this habitat supports many plant species that are rare or that grow in few other land cover types. Most sites encompass fewer than 12 acres. They are a preferred habitat of the Taylor's Checkerspot butterfly, a species officially listed as Threatened. In SJC they also have been the subject of several botanical studies, including those of Rapp (1981), Salstrom (1989), Rust (1992) and Peterson & Hammer (2001). Their plant communities are generally described by Chappell (2006) and factors related to their conservation in the Gulf Islands are described by Sadler & Bradfield (2010). The WDFW also recognizes cliffs, caves, and talus as Priority Habitats; they often co-occur with herbaceous balds and bluffs.

Distributions of these habitats in San Juan County have been mapped approximately, but the maps have not been ground-truthed and no comprehensive survey of these habitats on private lands has been conducted.

All three of these habitats are relatively rare at this latitude, and their area regionally has diminished dramatically in the past century. Avoiding or minimizing impacts to these habitats now will lessen the likelihood of their component species being legally listed as Threatened or Endangered in the future. In some places these habitats could be threatened by future construction of homes and roads, as well as by natural vegetational succession (which may have historically and beneficially reduced the extent of tree canopy, but tree canopy is no longer removed as often by fires), by invasion of exotic plants (e.g., Scotch broom), and by conversion of abandoned fields to lawns or gardens. Potentially, the quality of these habitats could be impacted by off-road vehicle use, road construction, powerlines, and trampling of vegetation by people and domestic animals.

Other SJC habitats that WDFW has stated are Priority Habitats in SJC are Cliffs, Caves, Talus, Old Growth and Mature Forest, and Snags and Logs. An estimated 12 caves are present in the county (T. Domico, pers. comm.). In addition, Freshwater Wetlands, Riparian (Streamside) Habitat, and Instream Habitat are listed as Priority Habitats, but are discussed in other chapters or sections. Locations that meet definitions of Old Growth and Mature Forest have not been mapped in SJC. Such areas would most likely exist within existing public preserves. Snags and Logs are omnipresent throughout the county and no particular areas are known to deserve elevated attention. Cliffs, caves, and talus often occur together and in association with Herbaceous Balds and Bluffs. Cliffs in SJC were mapped by this study based on LiDAR topographic imagery. In the interior parts of the islands, several species of bats and reptiles depend highly on cliffs and/or caves, as do some rare plants. Due to the sensitivity of many of these species to human disturbance, trails should not be routed near cave entrances or cliffs. Protection of cliffs near the marine shoreline falls partly under the Shoreline Management Act.

4.3.1.4 Other Species

The WDFW maintains a list of "Priority Species and Habitats." That list includes all the legally-designated Threatened and Endangered species described in section 4.3.1.2 (Areas Important to Threatened, Endangered, or Sensitive Species). It also includes species with no extraordinary legal protection but which are considered to deserve some level of elevated conservation or management due to their population status, sensitivity to habitat alteration, and/or recreational, commercial, or tribal importance in Washington State. And it also includes Priority Habitats with unique or significant value to a diverse assemblage of species. A priority habitat may consist of a unique vegetation type, dominant plant species, a successional stage, or a specific habitat feature.

Although comprising only about 17% of Washington's entire list of vertebrates (and 42% of those in SJC), the 113 WDFW-designated **Priority Species** that occur in SJC contribute disproportionately to regional biodiversity. The list for SJC (Appendix 4-A) contains 44% of the county's birds, 46% of the mammals, 14% of the amphibians, and 17% of the reptiles in SJC. The list contains a disproportionately high number of waterfowl, shorebird, and seabird species, only a single amphibian, and no songbirds. WDFW has published management recommendations for some of these species (e.g., Larsen et al. 2004). Avoiding or minimizing impacts to these species and their habitats now will lessen the likelihood that these and other species associated with similar habitats will need to be legally listed as Threatened or Endangered in the future, with increased restrictions on what landowners may do.

<u>Wildlife</u>

WDFW’s Priority Species found in SJC are indicated in Appendix 4-A, and their habitats are noted in Appendix 4-B.

Also, the WDFW (2009) has rated the relative sensitivity to development of all wildlife species in Washington. Confirmed or probable breeding species in SJC which WDFW has classified as being the most sensitive to development are:

> Chipping Sparrow, Golden Eagle, Hermit Thrush, Long-eared Owl, Merlin, Olive-sided Flycatcher, Pileated Woodpecker, Short-eared Owl, Sooty (Blue) Grouse, Townsend's Warbler, Turkey Vulture, Vaux's Swift, and Western Toad.

Separately, two wildlife biologists at the University of Washington (Cassidy & Grue 2006) analyzed wildlife information statewide for the purpose of recommending additional species in each county that might not meet WDFW criteria for Priority Species status, but which local governments and landowners might wish to take additional steps to protect due to their sensitivity to development and important contribution to regional biodiversity. They recommended that heightened local conservation attention be given to the needs of the following SJC species not currently listed by WDFW as Priority Species:

> <u>Birds</u>: Cooper’s Hawk, Golden Eagle, Sandhill Crane, Barn Owl, Western Screech-owl, Short-eared Owl, Northern Saw-whet Owl, Common Nighthawk, Vaux’s Swift, Rufous Hummingbird, Red-breasted Sapsucker, Hairy Woodpecker, Olive-sided Flycatcher, Willow Flycatcher, Purple Martin, Tree Swallow, Brown Creeper, Swainson’s Thrush, Varied Thrush, Yellow Warbler, Chipping Sparrow, Vesper Sparrow, Western Meadowlark, Red Crossbill
> <u>Amphibians</u>: Long-toed Salamander
> <u>Mammals</u>: River Otter, Silver-haired Bat

A review of all the above lists, as well as information in Lewis & Atkinson (1987), Jensen (2010) and other local sources, indicates that breeding locations of several species from these lists warrant heightened local attention due to one or more of the following:

> (a) small local breeding population or infrequent recent sightings during breeding periods suggest they are likely to be in near-term (5-50 years) danger of disappearing as breeders from one or more of the islands in SJC, if they are not already gone;
> (b) apparently declining breeding population on the mainland or on at least one of the main islands in the region, combined with a relatively small population throughout their continental or Puget Sound range;
> (c) potentially slow recolonization rates due to strong aversion to crossing marine waters;
> (d) particular aversion to breeding near residential and other developed areas, or
> (e) rapid changes now occurring or anticipated to soon occur in much of their preferred local habitats.

These species are:

Sharp-tailed Snake (a, b, c)
Western Fence Lizard (a, c)
Northwestern Salamander (a)
Black Oystercatcher (b)
Wilson's Snipe (b)
Short-eared Owl (a, b, d)
Sooty (Blue) Grouse (a, b, c, d)
Common Nighthawk (b, e)
Western Bluebird (a, b, e)
Chipping Sparrow (b)
Vesper Sparrow (a, b, e)
Fox Sparrow (a)
Golden-crowned Sparrow (a)

Additionally, there have been reports of the following species in SJC during the breeding season, but breeding has not been confirmed in recent years, either because many potential breeding sites were on inaccessible private lands, or because the species has disappeared locally:

Western Toad (a, b, c), Western Pond Turtle (a, b, c, d, e), Rubber Boa (a, c), Northern Goshawk (a, b), Golden Eagle (a, b, d), Merlin (a), American Dipper (a, b, e), Long-eared Owl (a, c), Northern Pygmy-owl (a, c), Northern Harrier (a, b), Red-breasted Sapsucker (a), Hammond's Flycatcher (a), Horned Lark (a, b, e), Western Meadowlark (a, b, e).

If, in the future, any of these are confirmed to breed successfully and repeatedly in SJC, they and their habitat should be protected or managed as necessary to maintain species presence. Information on gross habitat preferences and general locations of all the above is given in Appendix 4-B. Also, trends in marine birds that don't breed locally but spend much of the winter in SJC should be evaluated, as studies elsewhere in the region have pointed to major declines in Western Grebe, Brant, and Greater Scaup (Anderson et al. 2009).

Consideration of species of local significance – not just habitats of local significance and species that are important at a state or national scale – is suggested by the decision Clark County Natural Resource Council et al. v. Clark County et al. (WWGMHB #96-2-0017 FDO 12-6-96) which stated, "The failure of the County to also include **species of local** importance results in noncompliance with the [Growth Management] Act." For some of these species, protecting specific locations where they are or were found is no guarantee that populations will be conserved or recover, because individuals may shift the local breeding locations from year to year. However, locations that receive consistent use over many years deserve attention. Also, Washington law (365-190-080(5) WAC) states that jurisdictions must work cooperatively to ensure that isolated subpopulations of a species are not created. Many such subpopulations exist in nature, especially in island environments where they are particularly vulnerable to adverse effects of further fragmentation.

The status and distribution of potentially thousands of ground beetles, freshwater mollusks, snails, and other invertebrate species has been little-studied in SJC. For example, little is known about status, trends, habitat needs, and vulnerabilities of the specific insects responsible for pollinating gardens, crops, and native vegetation in SJC. Some of these insects may not adapt to the replacement of native vegetation with non-native plant species, and are highly sensitive to fragmentation of some types of land cover (Aguilar et al. 2006). Some information on SJC butterflies and moths is documented in Hinchliff (1996) and in some local sources. Those with status as WDFW (2008) Priority Species include Island Marble, Great Arctic, Valley Silverspot, and Sand Verbena Moth. Additionally, very little is known about the status, distribution, and specific habitat needs of most of the small mammals and bats that would be expected to occur in SJC.

<u>Plants</u>

In addition to plant species recognized as Threatened or Endangered (Appendix 4-C), high-quality examples of several plant communities (Appendix 4-D) appear to be so limited in SJC that they may deserve consideration at least locally for heightened protection or management. This also is true of most of the dozens of species of native forbs and grasses that are described as "rare" in SJC by Atkinson & Sharpe (1993), as well as native species that have been documented only once in the county according to the online *Floristic Atlas of the San Juans* and from Dr. David Giblin's recent surveys of the smaller islands. Local botanists should be consulted. As well, several species of mosses, lichens, and fungi should be considered, although their distribution countywide has not been well documented. Mosses and lichens, where they were studied in neighboring coastal British Columbia (Coxson & Stevenson 2007, Sadler & Bradfield 2010), were found to be both functionally important and highly sensitive (Berglund et al. 2009). They are sensitive, for example, to the carving out of clearings amid blocks of forest, e.g., by single-family home construction, driveways, timber harvests. Their sensitivity is in response to changes to microclimate (temperature, moisture) and host vegetation initiated by forest thinning or clearing. See also the synopsis of literature in section 4.3.2.1 (Impacts of Upland Vegetation Removal, Alteration, and Habitat Fragmentation).

4.3.1.5 Biodiversity Areas and Corridors

When classifying and designating FWHCAs, jurisdictions are required by WAC 365-190-130 to consider "Creating a system of fish and wildlife habitat with connections between larger habitat blocks and open spaces, integrating with open space corridor planning where appropriate." In addition, the WDFW (2008) recognizes "Biodiversity Areas and Corridors" as a Priority Habitat and suggests jurisdictions consider using systematic approaches for identifying and protecting them. Additional guidance (CTED, WDOE) recommends that counties and cities not limit their protection of habitat to specific habitat types, but also identify and protect the connections between patches of important habitat ("connectivity"). Connectivity is important to maintaining the diversity of native plants and animals because reconnecting habitat patches amplifies biodiversity conservation both within and beyond areas already set aside as natural preserves (e.g., Damschen et al. 2006).

Corridors and large blocks of suitable habitat are important not only to some of the species already discussed in section 4.3.1.2 (Areas Important to Threatened, Endangered, or Sensitive Species), but also as a safety net for maintaining the thousands of species whose local status, distribution, and specific needs were judged by WDFW to be too poorly understood to justify their listing as Endangered, Threatened, or Sensitive and to receive the additional protections incumbent therein. Many of those species are unlikely to survive if the only areas protected from development are those in public ownership or which local jurisdictions designate as Locally Significant (e.g., prairies, oak woodlands, herbaceous balds) for other reasons. Many of these poorly-known or common species, which together comprise "biodiversity," cannot survive without species-focused efforts at a countywide or islandwide scale to identify areas in which they are likely to feed, reproduce, and travel. The problem in identifying which such areas are most important to wildlife in general is that *there is no such thing as "generally good" habitat characteristics*. Landscapes that are too fragmented for one species are ideal for another. Habitat patches that are too small or narrow for one species are optimal for others. "Corridors" and "landscape connectivity" that facilitate movements of some species often facilitates movements of their predators or competitors as well (e.g., Rogers 1997, Novotny 2003, Hilty & Merenlender 2004, Sinclair et al. 2005). And planning for the specialized and sometimes-conflicting needs of each of the 264-plus wildlife species that occur regularly in the county – not to mention the needs of thousands of invertebrates and plants – quickly becomes an overwhelming task.

In response, one strategy is to protect areas that science suggests will support *the most* species. Such areas are often those along the edges where multiple habitat types converge (i.e., not large blocks of homogeneous vegetation), vegetation structure is often more complex, and downed wood and snags are more abundant and will continue to be so (e.g., Harper & MacDonald 2001). However, not all species can be considered equal. Many "edge" species are adaptable generalists that will survive under a wide variety of conditions. Simply maintaining a large variety of species in one's yard, property, or other localized area (termed "alpha diversity") does not ensure that a full suite of species will be maintained at an island or county scale (termed "gamma diversity"). In some cases, it may be better to maintain conditions supporting fewer species on one particular parcel, if those few species that are maintained contribute more to overall island or county biodiversity by virtue of their occurring at few other locations.

Similarly, simply maintaining patches of each priority habitat type – while being a relatively promising way of protecting some of the most imperiled species – will not protect all or even most of the rare or sensitive species. As can be seen in Appendix 4-B in SJC, the habitat type hosting the most wildlife species is "Herbaceous Wetlands, Ponds, and Lakes" followed by "Wooded Wetlands & Streams," "Residential," and "Oak Woods & Balds" while the habitats hosting the fewest are "Open Marine Waters" and "Rocky Shore." If one focuses just on WDFW Priority Species, the richest habitat is again "Herbaceous Wetlands, Ponds, and Lakes" but is followed by "Sheltered Marine Waters" and "Beaches & Tidal Flats." However, many species do not prefer any of these habitat types. Also note that a ranking of these habitat types based on plants, invertebrates, fish, or other taxa might differ from a ranking based only on wildlife richness. Moreover, these habitat types are seldom homogeneous, and within each there are areas of greater and lesser quality that have significantly greater or fewer numbers of species, due to habitat features present only at a finer or broader scale. This internal heterogeneity was quantified by our LiDAR analysis.

Another strategy is to focus on maintaining areas important to the species which are least able to breed successfully around buildings and roads and the edges they create. To some degree, this can be achieved by assigning highest levels of protection to lands farthest from these features, and perhaps connecting those lands with blocks of natural vegetation not bisected by roads or driveways. Many (but not all) of the species that are rare and contribute the most to gamma diversity are ones that are most productive in secluded areas.

A third strategy, also compatible with the other two, is to assign highest priority to habitats of species which disperse the slowest over marine waters. Those are relatively sedentary species least likely to recolonize if anything should happen that eliminates their populations on one or more islands, and which (unlike most plants) do not become reestablished easily after being reintroduced to an area.

A fourth strategy would involve actually conducting a countywide or islandwide all-species biological inventory, building upon species data already collected by Kwiaht and others, and from those data identifying areas having the most species, or the most species that are rare, sensitive, sedentary, or whatever. However, many private landowners would not allow access for species surveys, unfortunately making this option infeasible in any comprehensive sense. Concentration areas and other key habitats of some species also change frequently over time.

At least two systematic attempts have been made to incorporate some of the above ideas into countywide analyses of biodiversity areas and corridors, addressing more that just those lands already in public reserves or conservation easements or receiving some degree of protection as wetlands, oak woodlands, or other locally significant habitats. One attempt, called a "Local Habitat Assessment," was made by Jacobson (2008) on behalf of the WDFW. The other was conducted as part of analyses needed to support this chapter.

Without considering the vertical habitat structure or needs of individual species, the WDFW approach assumed that the most important habitat areas were simply those with the lowest intensities of land use (70% of the weighting) and with low road densities (30% of the weighting). This resulted in a draft "landscape biodiversity map" which rated each 98 ft by 98 ft cell across the entire county. One of its many limitations is that land use intensity scores were based on a small number of broad land use categories that had been determined from interpretation of aerial images from the 1990's, and have since been shown by our LiDAR analysis to be vast oversimplifications. Several other limitations are described by the author (Jacobson 2008).

The other attempt, conducted as part of developing this FWHCA chapter, did not result in a new map of important biodiversity areas and their corridors. Rather, it has provided spatial data layers (maps) that could quickly be assembled in various ways for that purpose, along with other map themes. Habitat structure in each 30 ft by 30 ft cell in SJC is described in terms of average and maximum vegetation height, as well as height variation. Also, from our LiDAR analysis, statistics on the contiguity of the landscape with regard to tree or shrub canopy across each island have been compiled for this project. Thus, these spatial data layers describe the vertical vegetation structure and horizontal habitat connectivity in every vegetation height class within each cell.

This can be interpreted to identify areas likely to support the most species, or to support particular species whose vegetation height and patch size preferences are known. This information was the result of a state-of-the art computer analysis of the most current (2008) LiDAR aerial imagery, a new high-resolution systematic approach for quantifying habitat structure that is rapidly gaining in popularity among wildlife biologists (e.g., Genc et al. 2004, Seavy et al. 2009, Goetz et al. 2010).

4.3.2 Potential Impacts to Upland Habitats and Species

4.3.2.1 Impacts of Upland Vegetation Removal, Alteration, and Habitat Fragmentation

Overview

Vegetation is essential for meeting the food, shelter, and other habitat needs of most upland and wetland animals that occur in SJC. Vegetation is removed permanently whenever buildings, roads, or driveways are built, and this diminishes wildlife habitat permanently or for long periods.

Habitat suitability for a given species is determined largely by the type of plants that together comprise "vegetation" (e.g., species of grass, forb, shrub, tree; evergreen vs. deciduous, native vs. non-native), their structure (e.g., height, age class) and their arrangement relative to other plants of the same or different type and structure. These largely determine which particular wildlife species will be present and persist at various spatial scales. Context is important: the spatial scales important to a given species can be local (less than a few acres), "landscape" (many acres or square miles), or regional (larger areas). And the arrangement of vegetation, especially at a landscape scale, is often defined in terms of:

- Matrix: the prevailing vegetation type or land cover.
- Patch: a mostly nonlinear area that is less prevalent than, and different from, the matrix.
- Corridor: a special type of patch that links other patches in the matrix. Typically, a corridor is somewhat linear or elongated in shape, such as a stream corridor.
- Mosaic: a collection of patches, none of which is prevalent enough to connect with others of its type throughout the landscape.

"Habitat" for a species can exist within any or all of the above. When, through either natural processes or human actions, a species' preferred habitat becomes less prevalent within a landscape (i.e., switching from a matrix to a patch, corridor, or mosaic), this is termed habitat **fragmentation**, and is described in terms of the sizes of the remaining habitat patches, the distances between them, and the character of the new land cover matrix. Protection of wooded corridors facilitates movements of many forest species across openlands that separate large blocks of forest. To sustain most forest-dwelling species, driveways and other linear clearings should cause no gap in the forest canopy wider than about 100 feet (Belisle & Desrochers 2002, Tremblay & St. Clair 2010). Ideally, no clearing should result in a forest being fragmented into an isolate smaller than about 100 acres or narrower than 150 feet, and definitely not smaller than 2 acres or narrower than 100 feet (Donnelly & Marzluff 2004).

Habitat fragmentation and its effects must always be defined in terms of particular species and regions, because what comprises fragmentation for one species often comprises improved habitat for another, because different species have different needs. Although the removal of small areas of tree canopy and substitution with roads, buildings, and lawns fragments the habitat for tree-nesting songbirds and will cause them to disappear locally at some point, at the same time it creates habitat for songbirds that characteristically nest only around open areas. Creating or maintaining wooded corridors can potentially fragment the landscape for species such as Northern Harrier and Western Meadowlark that depend on large well-connected patches of open grassland distant from tall trees. Thus, decisions about where to maintain wooded corridors must consider all indigenous species, not just forest-dependent ones.

Within most landscapes, creation of moderate amounts of “edge” between tall and short patches of vegetation supports the largest number of species of both plants (McKinney 2008) and animals. Although this diversity of species confined within a relatively small area is appealing to many people, it does not necessarily promote the conservation of many species that can’t tolerate the fragmentation of their habitat that results from creating edges. In developing landscapes, species that require large nearly uninterrupted (or well-connected) patches of vegetation of a particular type – whether that be forest, grassland, or something else – are often the species that are rarest and threatened with extirpation (total disappearance from an entire county or region). If the policy goal is to maintain nearly all species indigenous to a landscape or region, then needs of those habitat area-sensitive species must come first, and emphasis placed on conserving large blocks of well-connected habitat having the types of internal features they need.

Many species also respond to particular features occurring at a finer scale within vegetation patches and the landscape generally. For example, large numbers of wildlife species require (or at least benefit from) downed wood and standing deadwood (snags). Downed wood is often the result of natural windthrow, which also creates small patches of semi-open canopy within blocks of forest and in so doing can support a larger number of wildlife species, despite the temporary loss of nest trees (Zmihorski

2010). Unfortunately, the needs of wildlife for an abundance and diversity of standing and downed wood run counter to human desires to keep yards manicured and "clean," both for aesthetic perceptions and to reduce hazards to people and property from fires and treefall. Other fine-scale elements that provide habitat for relatively large numbers of species within relatively small areas include but aren't limited to cliffs, caves, animal burrows and dens, nectar plants, tall perching trees, seeps and springs, mast (acorns), unusual soil types, dry sandy plains, mountaintops, and cool moist shady areas.

<u>Vegetation Dynamics and Habitat</u>
Regulations to protect wildlife habitat should recognize that even without the direct actions of humans, landscapes are not static. Fires, windstorms, drought, and other natural phenomena periodically re-set the natural succession of vegetation, especially along shorelines and on steep slopes where storm damage occurs most easily and recovery, if it occurs at all, is slowest. There are many species whose persistence depends on particular types of vegetation disturbance (not necessarily the types of disturbance associated with houses and roads), so protection of large unfragmented blocks of habitat must be balanced against the needs of those species as well. Indeed, many of the rarer species in SJC are ones associated with "disturbance-dependent" habitats, such as prairies, cliffs, and balds (see 4.3.1.3 Locally Significant Habitat Conservation Areas). Changes in the type, structure, arrangement, and extent of vegetation will occur periodically with or without direct intervention by people. No statistics have been compiled in SJC regarding long term trends in forest or openland patch sizes and proximities, road density, corridor connectivity, and other indicators of habitat fragmentation, but doing so would not be difficult and could provide a stronger basis for making decisions about building permits in various places throughout the county.

By creating disturbances that may or may not adequately mimic natural ones, human actions can accelerate habitat changes. For example, beavers have been intentionally eliminated from most parts of the county, and historically they were a key factor in sustaining wetlands and perhaps summertime stream flows. Logging practices and fires wrought massive destruction of old-growth forests and probably resulted in severe sedimentation of streams and bays in parts of the county in the 1800s and early 1900s. Vegetation and cleaner waters have mostly returned, but superficial appearances may fail to reveal the likely disappearance from the county of dozens of species .

Resilience appears high in formerly farmed lands that have been abandoned, as they are naturally replaced by shrubland and forest. Partly as a result, a small number of species has increased. Especially noticeable are increases in populations of species like deer, rabbits, and raccoons that adapt readily to human presence and are most productive in semi-open landscapes (Chamberlain et al. 2007). Since the elimination of large predators (other than humans) from the county during early settlement, populations of deer and European rabbits have prospered and have reduced the biomass and often the diversity of native forbs -- and consequently the butterflies, other insects, and birds that depend on them (Bassett-Touchell 2008, Martin et al. 2010). However, evidence from elsewhere suggests that rabbit warrens might provide beneficial microhabitats to some other wildlife (Gálvez Bravo & Belliure 2009). Damages to native ecosystems from abnormally high deer density have been documented in the San Juans (Martin et al. 2010) and on an island in British Columbia (Allombert et al. 2005). Such damage to shrubs and ground cover occurs in places where fragmentation of forests by scattered residential development or agriculture has created deer densities of more than about 1 per 25 acres (Thiemann et al. 2009, Martin et al. 2010). Overbrowsing of native shrubs often facilitates invasion by non-native shrubs such as Himalayan blackberry. Many of the non-native plants are less palatable to most wildlife. Reduced ground cover also means there may be less vegetation capable of taking up and processing polluted runoff, and greater potential for erosion and rapid runoff.

With increasing numbers of people and vehicles, an increasing number of non-native plants and animals also have incidentally "hitchhiked" or been intentionally introduced into one of more of the islands, to the point where non-native plants now comprise about one-third of the county's plant species. Removal of the forest canopy, creation of habitat edges around homes, and increasing vehicle and foot traffic have probably facilitated this increase (Parendes & Jones 2000), especially within 50 ft of the created edges (Watkins et al. 2003). Some of the new plants are aggressive invaders that eliminate manyfold more native species (Perkins & Willson 2005, Magee et al. 2008). Non-native plants are typically the first to respond to the disturbed conditions caused by home and road construction, and those disturbances are often ones that simultaneously constrain other important ecosystem functions. Non-natives also tend to have broad environmental tolerances, so areas dominated by them frequently are more resistant to further change (Werner et al. 2002, Wigand 2003, Stohlgren et al. 2002), which has both benefits and costs in terms of wildlife habitat. Non-native plants may also affect wildlife habitat, pollination, and other ecosystem functions (see section 4.3.2.1). For example, research from Oregon suggests that one of the most common invasive species in SJC – Himalayan blackberry – uses far more water than the closely related salmonberry (Caplan & Yeakley 2010).

A study in Alberta found that non-native plants within forests there were most abundant between 15 and 50 ft from the edge, and some of those species were found up to 130 ft from the edge. Although larger patches of forest generally supported more non-natives species than smaller fragments, the smallest fragments had the greatest number of non-native species per square meter (Gignac & Dale 2007). Wooded buffers with dense vegetation tend to restrict wind-driven dispersal of seeds of non-native plants into the area protected by a buffer (Cadenzas & Pickett 2001). However, wider riparian buffers in North Carolina were no less prone to invasion by non-native plants than narrow buffers (Vidra & Shear 2008), perhaps emphasizing the importance of considering individual species traits rather than relying on general paradigms.

As the area of a patch of natural habitat increases within a landscape, so does the diversity of plant species. A leveling off of the plant species-area accumulation curve in Alberta forests appeared at a forest patch size of about 27 acres (Gignac & Dale 2007), while on Prince Edward Island in eastern Canada, the small mammal species accumulation curve appeared to level off at a forest patch size of about 22 acres (Silva et al. 2005). Blocks of forest smaller than about 9 acres may be less capable of supporting the expected array of mosses in British Columbia (Baldwin & Bradfield 2007), although a study in Washington found that forest patches as small as 2.5 acres, if not narrow, may be large enough to have a microclimate supportive of most plants and animals (Heithecker & Halperin 2007). In Wisconsin forests that were studied over a 55-year period, larger patches of forest and those with more surrounding forest cover lost fewer plant species and were more likely to be colonized by new native species than smaller forests in more fragmented landscapes. Nearby urbanization further reduced the diversity of plants in the forest understory, and plant community composition was better explained by the amount of surrounding forest than by environmental factors within the studied forests (Rogers et al. 2009). In Ontario, forested wetlands with the most plant species were those with the largest areas and the largest proportion of upland forest within ~ 800 ft of the wetlands (Houlahan et al. 2006).

In agricultural landscapes, maintaining hedgerows of natural vegetation helps sustain populations of many species. In Quebec, wider hedgerows and those with more intact forest nearby had greater abundance and diversity of native forest-dwelling plant species (Roy & de Blois 2008). On Prince Edward Island, the abundance of most small mammals was greater in hedgerows longer than about 750 ft, but was unrelated to a hedgerow's length when the hedgerow was shorter. Most small mammals needed hedgerows with diverse shrubs, ground cover with vines and much leaf litter, and few non-vegetated gaps (Silva & Prince 2008).

<u>Snags, Blowdowns, and Downed Wood as Habitat</u>

As noted above, there often is a greater concentration of downed wood and snags in areas closer to streams and other topographic depressions. This may be true especially if wooded buffers are narrower than ~ 50 ft and thus more prone to wind damage (Lopez et al. 2006, Martin et al. 2007, Anderson & Meleason 2009). Along a lakeshore, the amounts of downed wood were greater from the lake edge up to at least 130 ft into the lakeside forest (Harper & MacDonald 2001). A study in Oregon found that the amount of downed wood in riparian buffers was unaffected by thinning operations in the adjoining upland forest unless the buffer was narrower than about 50 ft (Anderson & Meleason 2009). The amount of downed wood also depends on orientation of the cleared edge relative to wind, edge contrast (size differential of vegetation), the size of nearby clearings, tree species and age distribution, and local topography (Laurance & Curran 2008). Most instream wood originates in the parts of the riparian areas that are within 100 ft of a stream (McDade et al. 1990, Van Sickle & Gregory 1990, Robison & Beschta 1990, Meleason et al. 2003).

Where minimizing the loss of timber due to blowdown is a concern, a wooded buffer of 75 ft width may be adequate according to a literature review by Pollock and Kennard (1998). In California, researchers found that 100-ft buffers were inadequate to protect trees from windthrow (Reid & Hilton 1998). Tree fall rates were abnormally high for a distance of at least 656 ft from clearcut edges. Within riparian buffers that adjoined clear-cuts in Washington, tree fall rates were 26 times higher than normal for 3 years after logging, and may have caused the eventual replacement of coniferous trees with deciduous hardwoods. Trees tended to fall towards channels regardless of the channel orientation relative to the wind (Liquori 2006). It has not been proven that the deciduous vegetation that typically grows back after riparian trees are blown down (and persists for several years or decades) is less effective for purifying runoff. Such vegetation may, however, provide less shade and load the stream with more organic matter and nutrients if conifers were the vegetation being replaced (Roberts & Bilby 2009).

<u>Microclimate and Habitat</u>

Microclimate is a term that includes the humidity, soil moisture, and temperature within zones of between a few square feet and several acres in size. Microclimate is particularly important to the survival of amphibians, insects, and plant species. Microclimate within closed-canopy forests is the result of vegetation buffering of wind and direct sunlight. Microclimate can be altered by clearings created for home construction or roads, as well as by timber thinning, natural phenomena (blowdowns, landslides, streams), and overgrazing of shrub and understory vegetation by deer and domestic animals. Much of the forested land in SJC is near the ocean, and the associated humidifying effect might help counter the drying effect of a diminished ground cover and of clearings created in forested areas – at least as compared with similar clearings in forests in non-coastal areas. This has not been tested. Overgrazing is rampant in localized areas within SJC, and sometimes is greatest near streams. Requiring wider buffers for protecting the microclimate of streams and wetlands could be less effective unless excessive browsing of understory vegetation is first controlled. Streams and wetlands could be fenced where risk of overbrowsing by livestock is greatest.

Microclimate is influenced not only by the density, height, type, and configuration of vegetation (Wuyts et al. 2008), but also by elevation, wind exposure, aspect (solar exposure), proximity to surface waters (particularly marine waters), and distance from impervious surfaces. In some instances the topography (e.g., steep-sided ravine protected from wind and sun) may have far greater influence on microclimate than vegetation density, structure, and type. The influence of adjoining fields or clear-cuts on microclimate within a forest normally extends about 160 ft into the forest, but in extreme cases can extend as far as 500 ft (Dignan & Bren 2003, Ries et al. 2004, Moore et al. 2005, Hennenberg et al. 2008). Where forests are thinned rather than clear cut, buffers as narrow as 55 ft may be enough to offset changes in riparian microclimate that would otherwise have occurred from the thinning (Olson & Chan 2005). A modeling simulation suggested that air temperature in a forest might sometimes be affected up to 230 ft from an edge; a warming of only 7^{o} F could change relative humidity exponentially from 94% to about 77% (Dong et al. 1998) with consequent effects on mosses, lichens, amphibians, and other organisms which require vaporized water during certain phases of their development.

In the Pacific Northwest, early studies in western Washington found the light regime on the forest floor was affected ~100-200 ft from the edge, while humidity and air circulation were affected as far as ~800 ft into the forest (Chen et al. 1990, 1995). A second study of riparian areas in western Washington suggested a wooded buffer of about 150 ft might be necessary to approximate the natural microclimate gradients around streams (Brosofske et al. 1997).

A third study, in Oregon, examined buffers with widths of about 20, 55, 200, and 400 ft, and found buffers averaging as narrow as 55 ft could offset changes in microclimate that otherwise would occur as a result of thinning upland forests. Thinning to a density of 80 trees/acre within the buffer did not affect soil temperature in streamside areas or the water temperature of the stream (Olson & Chan 2005).

A fourth study from the region reported that most changes in light and temperature occurred within ~60 ft of an edge, and soil temperature reached normal levels ~100 ft from edges (Heithecker & Halperin 2007). The distance from edge within which the microclimate of a forested buffer was altered depended on forest structure and aspect, especially those conditions within ~50 ft of the edge of dense stands on steep terrain. When 15% of the forest canopy was retained, it did little to protect the remaining forest from microclimatic changes , with mean and maximum air temperatures being significantly warmer than at higher retention levels (Aubrey et al. 2009). When canopy retention reached 40%, mean air temperature was significantly cooler than when the canopy was totally removed, but maximum air temperature did not differ. Mean and maximum soil temperatures differed only between 0 and 100% retention, and different levels of canopy retention had no detectable effect on minimum air and soil temperatures and late-summer soil moisture. Light conditions within the forest did not differ significantly between 40 and 100% canopy retention (Heithecker & Halperin 2006). For most biological responses, the total amount of canopy was more important than how it was distributed horizontally (clumped or dispersed) (Aubrey et al. 2009).

Although the science showing the importance of riparian areas to streams is strong, the converse – the influence of intermittent streams on the adjoining uplands – is less certain. Because most of SJC's streams flow only during winter and early spring, their waters probably influence the humidity and other aspects of the microclimate primarily within a limited area of the narrow adjoining zones of vegetation. Removal of vegetation in some cases will temporarily bring the water table closer to the surface as water loss from transpiration diminishes, thus creating a more moist microclimate despite the absence of a vegetation canopy. But when new rapidly-growing vegetation takes hold a few years later, soil moisture losses and drier conditions may be higher than originally and will prevail for several years. And of course, if removed vegetation is supplanted by houses, roads, and other impervious surfaces, streamside humidity and temperature may never return to the original conditions necessary to support many frogs, salamanders, insects, plants, and birds.

Creating clearings and more edges also is potentially bad for water conservation, as vegetation water losses from evapotranspiration in some cases are increased; only in smooth-edged blocks of forest larger than about 250 acres are the typically greater water losses from the forest edge likely to be compensated for by water conserved by the interior forest (Herbst et al. 2007).

In Oregon, selective thinning of forests that adjoined riparian buffers did not affect the herbaceous or shrub cover in the buffers when they were wider than ~50 ft (Anderson & Meleason 2009). Thinning can increase the distance seeds disperse into the forest and the number that disperse successfully (Cadenasso et al. 2001). Lichens and mosses have been affected by edge-induced microclimate changes extending at least 50 ft into forested areas (Hylander et al. 2002, Boudreault et al. 2008) and as far as ~150 ft from the forest edge (Baldwin & Bradfield 2005). The orientation of the edge that is created can influence its impact on lichens (Johansson 2008). The negative effects on some lichens of removing the forest canopy also can be reduced by making the forest edge a spatially "soft" transition that shifts gradually from dense forest to shrubs to short open vegetation (Stevenson & Coxson 2008).

Upland Habitat for Amphibians and Reptiles

Frogs, toads, salamanders, and turtles may be the most demanding of all SJC upland wildlife in terms of the type and area of habitat they need. While it might seem that frogs could spend their entire life in a pond and along its shores as they mature from tadpoles to adults, in reality they and several other amphibians cannot and do not. As they mature, they instinctively disperse long distances from their natal ponds and wetlands, attempting to cross roads and fields that put them at high risk of predation and road-kill, and seeking accessible sheltered areas (burrows, logs, boulders) with a favorable microclimate and abundant invertebrates. In some cases, their times traversing uplands are short, intended only as direct movements to less crowded aquatic breeding sites. In other cases, many months are spent away from ponds and wetlands, and therein lies a major hindrance to preserving their populations: while wetlands and other aquatic habitats are to some degree protected from development, the poorly-defined types of upland areas that some amphibians require for lengthy periods seldom are.

Requirements of some amphibians and reptiles for large areas of terrestrial habitat have been noted both generally (e.g., Jehle & Arntzen 2000, Lemckert 2004, Regosin et al. 2005, Cushman 2006, Rittenhouse & Semlitsch 2007, Harper et al. 2008, Ficetola et al. 2009) and to a perhaps lesser extent, for species in the Pacific Northwest (Fellers & Kleeman 2007, Hayes et al. 2008). Unexpectedly, some analyses suggest that particular frog and salamander species may make less use areas directly adjoining a wetland or stream than of areas more than 300 ft away (Rittenhouse & Semlitsch 2007). Western Toad, Red-legged Frog, Rough-skinned Newt, and Northwestern Salamander are SJC species that, at least on the mainland, are known to disperse long distances overland from their natal wetlands, and/or to spend significant time in uplands during part of the life cycle. In Idaho, toads spent almost 60% of their time in terrestrial areas farther than 33 ft from the pond where they were born, which dried up late in the season. On a daily basis individuals traveled 127 ft, and seasonally they typically moved at least 0.36 (females) to 0.69 miles (males) from the pond, generally favoring shrublands and open forest (Bartelt et al. 2004). In Montana, toad movements follow stream corridors (Adams et al. 2005) and clearcuts may not be a major barrier (Deguise & Richardson 2009). Habitat characteristics measured within 300 ft of natal sites explained much of the variation in toad abundance in part of Alberta (Browne et al. 2009). When a forest patch was more than 150 ft from a wetland, only 15% of the toads moved successfully between the wetland and forest (Rothermel & Semlitsch 2002).

Northern Red-legged Frogs that were radiotracked were found to use areas as far as 1.7 miles from their natal sites, and when released frogs moved primarily toward the nearest riparian area (Fellers et al. 2007). Migration movements to and from breeding sites invariably extend over 1000 ft, and frequently over 3300 ft (Hayes et al. 2008). When radiotracked frogs on Vancouver Island were released inside clusters of trees amidst otherwise unsuitable habitat (clearcuts), the proportion of frogs abandoning the tree cluster was greater the smaller the cluster. Frogs were less likely to leave tree patches intersected by a running stream or where neighborhood stream density was high. Scattered tree patches of 2.0 to 3.7 acres, preferably in stream locations, were the minimum needed to allow successful overland passage of this frog species (Chan-McLeod & Moy 2007).

Radiotracked newts in France migrated with strong directionality up to 480 ft from their breeding sites, but most stayed within ~65 ft of the wetland edge. Burrows of small mammals were among their favored refuges while moving across uplands (Jehle et al. 2000). In Oregon, the occurrence of newts among 85 wetlands was greater where forest cover within 3281 ft was greatest (Pearl et al. 2005). However, the other species studied (red-legged frog, Pacific treefrog, long-toed salamander, northwestern salamander) were uncorrelated with surrounding forest cover, or were correlated to a lesser degree. Structural characteristics of individual wetlands were believed to be more important than landscape characteristics in predicting presence of those species (Pearl et al. 2005). Among Puget Sound wetlands (Ramos & Lawler 2010), those occupied by northwestern salamander and red-legged frog were near permanent water that was also occupied by bullfrogs, and tended not to be near deciduous or mixed forest. Wetlands with red-legged frog also had a greater proportion of shallow areas and had less high-density urban development, at least historically. Wetlands with bullfrogs were deeper and had more of the surrounding land cleared for development. Long-toed salamander occurred less often where the distance to the nearest forest patch was greater. Wetlands with Pacific treefrog had a greater proportion of emergent vegetation, had less medium-density surrounding development, and did not have fish. Another study found Pacific treefrog populations were best predicted by habitat characteristics within ~1800 ft of wetlands (Price et al. 2004). In the northeastern U.S., wetlands surrounded by less than 40% forest cover within a half-mile tend to have fewer amphibian species (Herrmann et al. 2005). In Ontario, the correlation of amphibians with surrounding land cover was greatest when land cover was measured in a radius of about 656 ft from a wetland (Houlahan et al. 2003).

Wetland buffers of 538 ft (Semlitsch 1998) or even more than 1000 ft (Semlitsch & Bodie 2003) have been recommended for amphibians. However, these are mostly for species found in the southeastern United States, not in the Pacific Northwest. And a study that recommended buffers of 150 ft along Oregon Coast Range streams was based mainly on stream salamanders that do not occur in SJC (Vesely & McCombs 2002). Also, Lemckert (2004) noted: "With distance values varying greatly, movement for an average species was difficult to predict. Individual movement within studies also varied widely, resulting in wide scatter of study populations...The wide scatter of data indicated that protective measures [e.g., typical wetland buffers] are uncertain to protect all or even most of a target population." On the other hand, based on computer modeling, Bauer et al. (2010) commented: "In landscapes dominated only by low-density residential housing, if there is a high density of ponds and wetlands, then buffers around these may be all that is necessary to maintain populations of amphibians, and preserving large patches of undeveloped non-buffer habitat is less cost-effective as an amphibian conservation measure. This is especially true if more than 80% of the suitable amphibian habitat is occupied by the target species."

Amphibian requirements for large upland areas may be less if the uplands have "stepping stones" or corridors of suitable habitat, as well as few roads and driveways. In Oregon, thinned forest stands with adjoining headwater stream buffers were not a significant barrier to amphibian movements, especially where adequate amounts of rocky or fine substrate were present to maintain microclimate conditions (Kluber et al. 2008). In Washington, a 100-ft buffer was found to be sufficient, at least in the short term, to maintain the relative abundance and richness of terrestrial amphibians at levels close to pre-logging conditions (Hawkes 2007). In Maine, amphibians (none which occur in SJC) were more abundant in 35-50 ft forested riparian buffers than in adjacent clear cuts two years following harvest, indicating at least some benefit to retaining buffers of this size (Perkins et al. 2006). In Pennsylvania, the abundance of 12 species of salamanders (including 4 wetland species) dropped where tree basal areas were below about 40 sq.ft./ acre (or approximately 50% to 60% canopy cover)(Ross et al. 2000). Based mainly on a synthesis of studies from eastern and central U.S., Semlitsch et al. (2009) recommended that no more than 40-50% of the canopy within a forest be cleared, especially in ravines, north-facing slopes, and uplands within a radius of about 300 ft from wetlands where amphibian abundance is likely to be greatest. Additional data on thresholds of amphibian tolerance of natural and artificial forest gaps is provided by Strojny & Hunter (2010).

Most clearcuts, grazed grasslands, croplands, and lawns are avoided whenever possible by dispersing amphibians, and when forced to move through such areas, fewer amphibians may survive (Rittenhouse & Semlitsch 2006, Patrick et al. 2006, Todd et al. 2009). To an unknown extent, the harshness of these areas to amphibian movements can be mitigated where they are intersected by drainage ditches (Mazerolle 2005), detention ponds or natural ponds (Knutson et al. 2004, Birx-Raybuck & Price 2010), streams, ravines, seeps, woody debris piles, tree or dense shrub stands of at least a few acres, or abundant logs, leaf litter, or boulders (Rittenhouse et al. 2008). These features can act as stepping stones or corridors for dispersing amphibians. Heavily grazed lands and ponds or ditches used frequently by horses and cattle are much less suitable (Knutson et al. 2004, Chandler et al. 2009).

Roads and/or traffic are a significant barrier to dispersing amphibians (Mader 1984, Fahrig et al. 1995, and see review by Fahrig & Rytwinski 2009). Although some amphibian populations are limited mainly by microclimate and indirectly by a lack of forest cover, for others (or for the same ones in other regions) the main limitation is roads and traffic. In Ontario (Eigenbrod 2008a) and Virginia (Marsh 2007), the presence of roads and traffic were the more significant limitation for amphibians, and "accessible habitat" -- defined as the habitat available to pond-dwelling amphibians without individuals needing to cross a major road -- was a better predictor of amphibian species richness than simply the amount of habitat within some distance of breeding ponds (Eigenbrod 2008b). Narrow roads gated to exclude traffic were crossed more often than roads with traffic by terrestrial salamanders in Virginia (Marsh 2007). Very high traffic volumes harmed amphibian populations even for species that were less prone to getting run over (Eigenbrod & Hecnar 2009). Most amphibians freeze at the approach of vehicles (Mazzerole et al. 2005).

Remarkably, even some narrow logging roads that had long been abandoned continued to impair movements and densities of salamanders in North Carolina; the road effect appeared to extend about 115 ft into the adjoining woods on both sides of the road (Semlitsch et al. 2007). If this research is applicable to SJC species, this finding may have implications for the effects of driveways on amphibians. For example, if a wetland buffer would intercept an existing driveway or road before the buffer's required width is met, land on the other side of the driveway or road should perhaps not count towards meeting the width requirement, and instead a comparable buffer width increase might be advisable on the opposite side of the wetland, i.e., buffer averaging, as suggested by Zanini & Klingemann (2008).

Upland Habitat for Birds and Mammals

The occurrence of most upland bird and mammal species is influenced both by the type and structure of vegetation and by its extent (total area and average patch size), connectivity, and configuration. Theoretical and limited empirical data suggest that 30% or more forest cover across a large area is the threshold value above which landscapes might provide sufficient habitat and connectivity for many forest species, allowing those species' populations to survive even in small remaining patches (Andren 1994). Minimum patch sizes required for breeding by those forest songbirds (e.g., Brown Creeper) which may be the most sensitive to forest fragmentation in the Pacific Northwest may be about 25 acres (Donnelly & Marzluff 2004, Poulin et al. 2008). However, a study in British Columbia found patch size had little to do with the abundance or diversity of birds in patches of old growth forest (Schieck et al. 1995). Parasitism of songbird nests by cowbirds studied in Montana was no less in large than in small patches (Fletcher & Hutto 2008).

A Montana study found the rates of predation on breeding songbirds were actually higher in forested landscapes than in landscapes that were dominated and fragmented by agriculture, which is contrary to what has been shown in other regions (e.g., Hobson & Bayne 2000) and by some computer models (e.g., Vergara & Hahn 2009). Patch size and distance to habitat edge did not influence predation rates, and predation of nests by crows and ravens increased only at very high levels of forest fragmentation (Tewksberry et al. 1998). Other studies have found that nests of forest-interior species located closer to forest edges are not necessarily less successful than nests placed in the forest interior (Argent et al. 2007), and in one case nestlings grew faster along edges than in forest interiors (Kaiser & Lindell 2007). The type of edge may matter: nest failure due to predation was greater around clearcut edges than logging road edges in Pennsylvania (Yahner & Mahan 1997).

Some mammals and perhaps birds follow edges during their daily travels. Because streams (at least perennial ones), lakes, and shorelines often form edges of contrasting vegetation heights and types with the surrounding landscape, they may to some degree concentrate and focus wildlife movements (e.g., Machtans et al. 1996, Shirley 2006). However, in an Alberta study, small mammals were found to be no more common (except at the immediate shoreline) near edges created by lakeside forests than in forests farther than ~160 ft from lakes (MacDonald et al. 2006). A review of 33 studies on the effects of forest edges and area on site occupancy patterns for 26 long-distance migrant forest songbirds in eastern North America showed that there was sufficient evidence only to show that 1 of 12 studied species avoided small patches and edges (Parker et al. 2005).

Forest gaps caused by placement of roads, driveways, or homes – as well as by natural features such as rockslides and wide tidal channels -- can impact movements of mammals and birds (Trombulak & Frissell 2000, Ortega & Capen 2002). This is especially true when the gaps are wider than about 100 feet (Rich et al. 1994, Rail et al. 1997, St. Clair et al. 1998, Belisle & Desrochers 2002, Laurance et al. 2004, Tremblay & St. Clair 2010), and definitely when wider than 200 ft (Creegan & Osborne 2005, Bosschieter & Goedhart 2005, Awade & Metzger 2008, Lees & Peres 2009). Species that prefer low vegetation may be particularly reluctant to cross forest clearings. The presence of small clusters of trees scattered within very wide forest gaps may be sufficient to enhance willingness of some forest bird species to cross those gaps (Robertson & Radford 2009). However, roads add additional risks (Forman et al. 2002, Clevenger et al. 2003, Massey et al. 2008, Minor & Urban 2010, Tremblay & St. Clair 2010, and see reviews by Fahrig & Rytwinski 2009, Benitez-Lopez et al. 2010). These include of direct collision (road-kill) and traffic noise that potentially interferes with reproductive success. In Quebec, traffic volume seemed to have a greater impact on birds than traffic noise (Tremblay & St. Clair 2009), but chronic noise has been shown to impair reproductive behaviors in songbirds (Wood & Yezerinac 2006, Slabbekoorn & Ripmeester 2008, Barber et al. 2010) and restrict habitat use by bats (Schaub et al. 2008).

A study in northern Alberta found no evidence that 330-ft wide wooded corridors that were preserved between forested patches improved the likelihood of most breeding bird species occurring in the connected patches after surrounding timber was cut (Schmiegelow et al. 1997, Hannon & Schmiegelow 2002). After clearing of the adjoining upland forest, forest-interior species were less often found in a forested buffer around a lake despite the buffer being 656 ft wide. Thus, effects of large-scale forest clearing are not fully compensated for simply by using of buffers and corridors. Nonetheless, the use and maintenance of high-quality buffers can lessen the impacts to wildlife when clearing or thinning of forests is less extensive or intensive.

Data relevant to choosing **buffer widths for species occurring in SJC** are limited. Birds associated with wider buffers in the Portland metropolitan area were Pacific (Winter) Wren, Brown Creeper, and Pacific-slope Flycatcher (Hennings & Edge 2003). A study in the Oregon Coast Range that compared buffers of 0 to 246 ft width found that the same three species, plus Chestnut-Backed Chickadee, were more likely to be present in wider riparian buffers, and even the widest buffers (131-230 ft) failed to support Hammond's Flycatcher, Varied Thrush, and Golden-crowned Kinglet (Hagar 1999). Pacific-slope Flycatcher was mostly absent from streamside buffers narrower than 145 ft in logged watersheds of British Columbia (Shirley & Smith 2005), and in clearcut areas in Southeast Alaska, the species peaked in riparian buffers of 820 ft (Kissling et al. 2008). That study also reported that Brown Creeper and Hairy Woodpecker might have been sensitive to buffer width, and it found few other nesting songbirds whose presence was correlated with buffer width, but it did not examine buffers narrower than ~330 ft.

In the Seattle metro area, Pacific (Winter) Wren occurred mostly in areas with less than 20% surrounding urban cover and forest patch size of more than 3 acres (Donnelly 2004, Donnelly & Marzluff 2006). That wren, as well as Golden-crowned Kinglet, Townsend's Warbler, and Varied Thrush, were found more often in wider buffers in a study in British Columbia that compared buffer widths of 46, 121, and 230 ft (Kinley & Newhouse 1997). In Quebec, Golden-crowned Kinglet, and Swainson's Thrush were seldom found in buffers narrower than 65 ft (Darveau et al. 1995). Surveys in the forested landscape of the Cedar River watershed east of Seattle also found Golden-crowned Kinglet and Brown Creeper, as well as Black-throated Gray Warbler, more often in wider buffers or uncut forest. Riparian buffer widths of ~150 ft were needed for these species in order to attain equivalence with numbers found in unlogged areas, and occurrence of most other species was associated with buffers of 100 ft but not 50 ft (Pearson & Manuwal 2001). In British Columbia, even buffers of 472 ft failed to support several species at densities equivalent to those in extensive uncut forests: Brown Creeper, Pileated Woodpecker, Golden-crowned Kinglet, Varied Thrush, and Red-breasted Sapsucker; however, at least 2 species -- Warbling Vireo and Swainson's Thrush – were more common in buffers than in uncut forest (Shirley & Smith 2005). Based on bird data from the Oregon Cascades, stream buffers of 200 ft were deemed adequate to support corridor and refuge functions for birds in clearcut areas (Lehmkuhl et al. 2007). In Alberta, the narrowest riparian buffers in which several species nested were as follows (Hannon 2002):

> 66 ft = Yellow Warbler, Song Sparrow, Black-capped Chickadee, Western Wood-Pewee, Yellow-rumped Warbler, Dark-Eyed Junco;
> 328 ft = Swainson's Thrush, Common Yellowthroat, Hairy Woodpecker, Brown Creeper;
> 656 ft = Western Tanager, Purple Finch.

Buffers in the range of 328-656 ft were not surveyed so precise recommendations for widths in that range cannot be made from this study.

In other regions, particular bird species or a majority of species have been shown to occur more often in riparian buffers with widths of 100 ft (Hanowski et al. 2006 – MN) or widths in the range of 100-150 ft (King et al. 2009 – MA; Mason et al. 2007 – NC, Minor & Urban 2010 – NC; Conover et al. 2009 - MS), compared with narrower buffers or with uncut upland forested areas of the same extent. Overall, however, most studies have not shown that forest interior bird species prefer natural forest more than buffers, and wider buffers do not result in greater similarity between reference forest and buffer sites (Marczak et al. 2010).

Some studies have reported more *individual birds per unit area* in wider buffers (Kinley & Newhouse 1997 in BC). In fact, most studies of birds and insects have found higher densities of birds in buffers than in areas of comparable size in the middle of extensive forests (Marczak et al. 2010). This could be because *most buffer studies have been of buffers next to vast clearcuts*, not small patch-cuts associated with single-family home construction in a large matrix of forest. Several studies (e.g., Betts et al. 2006) have noted how recent clearcutting can crowd individual birds (presumably those that formerly nested in the now-clearcut forest) into remaining patches of forest, e.g., buffers, for at least a year or two post-harvest.

Among buffers of different widths, wider buffers are more likely than narrow buffers to have higher bird and insect densities simply because they are more likely to contain a variety of vegetation types and size classes, which generally leads to higher avian abundance (Marczak et al. 2010). However, these findings do not apply to amphibians; the majority of those studies show lower densities of adult amphibians in buffers than in comparable areas of interior forest, perhaps highlighting the importance of microclimate to amphibians (Marczak et al. 2010).

The **density of vegetation** (e.g., basal area or percent canopy closure) in a buffer, corridor, or patch -- or in the landscape generally -- also influences habitat value for some species, perhaps as much or more than buffer width, corridor width, or patch size. A study in Minnesota found that when trees within riparian buffers were thinned to a basal area average of 17–25 sq.ft/acre, the number and variety of sensitive forest interior bird species declined in those buffers (Hanowski et al. 2005). In the Seattle metro area, the variety of breeding birds declined as forest canopy closure increased over the range of 45% to 100% (Donnelly & Marzluff 2006). That study found greater retention of native breeding birds where forests retained a tree density of at least 25 trees per acre.

Of particular concern in the Pacific Northwest are declining numbers of birds that are strongly associated with broadleaf deciduous shrubs and trees (chiefly maple, alder, oak). There are more such bird species than there are species associated with mature and old growth forest and currently in decline (Betts et al. 2010). Depending on the species and scale of measurement (distance of 500 ft or 1640-6560 ft around nest site), between 1.35% and 24.5% cover of broadleaf trees should be maintained to sustain particular songbirds with declining populations in this region (Betts et al. 2010). Wider riparian buffers in British Columbia supported a greater density of deciduous trees (Shirley 2004). Deciduous leaves often have higher nutrient levels (Roberts & Bilby 2009) and can support greater abundance and functional diversity of stream invertebrates (Piccolo & Wipfli 2002, Allan et al. 2003).

Changes in forest cover can cause changes to populations of some wildlife species that are long-lasting (Pavlacky & Anderson 2007). For example, both timber-harvested lands and lands burned by a natural fire had few forest-interior breeding bird species until 76–125 years after their respective disturbances (Schieck & Song 2006).

The cover of **non-native plants,** especially highly invasive ones, may also influence buffer use by some wildlife species positively or negatively, and would be expected to be greater in narrower buffers. Some studies have inferred a reduction in productivity or diversity of wildlife populations where non-native plants have invaded, but no studies in the Pacific Northwest have yet proven this. The assumption is well-founded, being based on the fact that the most common invasive plants typically simplify the physical structure and reduce the diversity of the plant community by outcompeting more diverse assemblages of native plant species. To varying degrees, native fish and wildlife species have come to depend on native plants (or their leaf litter) being available for food and/or cover at specific times of year. Thus, any significant simplification of vegetation structure, or shifts in the seasonal timing of food availability (due to different maturation, flowering, or fruiting times of non-native plants, or different times of leaf-fall, leaf decay, and nutrient release) is likely to adversely impact many fish and wildlife species (Burghardt et al. 2009, Rodewald et al. 2010). However, the likely effects of non-native plants on wildlife are probably very species-specific and region-specific, with some invasive plants benefiting particular native species of wildlife and others being detrimental or neutral (e.g., Kennedy et al. 2009). There is near-universal agreement among biologists that lawns and overgrazed grasslands are the poorest of the vegetated habitats for wildlife overall.

In some cases, bird and mammal use of riparian buffers and other small patches of vegetation is influenced less by buffer width than by the proportional extent and intensity of development (or natural areas) in the surrounding landscape, e.g., within a radius of 0.5 – 2 miles (Bolger et al. 1997, Melles et al. 2003, Rodewald & Bakermanns 2006, Oneal & Rotenberry 2009). Other studies have found the opposite, i.e., birds correlated more with riparian vegetation characteristics measured at a local scale (0.5 to 22 acres) than with land cover characteristics over a broad geographic area , e.g., Luther et al. 2008 and Nur et al. 2008, Seavy et al. 2009, Fletcher & Hutto 2008).

<u>Upland Habitat for Invertebrates</u>

In Oregon, a riparian buffer width of ~100 ft was needed to create an invertebrate community comprised of nearly the same species as nearby mature forests (Rykken et al. 2007). Ground beetles are particularly sensitive to roads, alteration of vegetation, and changes in microclimate. In Australia, a riparian buffer ~130 ft wide did not fully protect native ground beetle assemblages from impacts of upslope logging (Baker et al. 2009). In Scottish grasslands, wider buffers along streams actually had fewer species of ground beetles, but the species they supported were found in few other areas and so contributed heavily to regional biodiversity (Cole et al. 2008). In New Zealand, the abundances of many forest beetle species were affected as far as ~850 ft from forest edges, compared to the forest interior, but distance from forest edge was less important in predicting occurrence than size of the forest patch (Ewers et al. 2007, Ewers & Didham 2008). Based on studies of spider diversity in Quebec forests, Larrivee et al.

(2008) recommended riparian buffers there be at least 330 ft in order to maintain the same species composition of spiders as found in forest interiors.

Butterflies and other pollinators are also known to be highly sensitive to fragmentation of their habitat, and research on this theme was reviewed by Dover & Settele (2009). Amid Iowa farmlands, butterflies were most diverse and abundant in riparian buffers that were wider and had more forbs (Reeder et al. 2005). Studies of an endangered butterfly in Oregon prairies found that habitat patches for that species should be within ~1600 ft of each other and should be larger than ~5 acres (Schultz & Crone 2005). Models of butterfly dispersal suggested that butterflies are more successful where uncut grassy margins are left around agricultural fields (Dellatre et al. 2010). The optimal configuration was predicted to be six ~70-ft wide grassy margins for meadows ~800 ft apart, and four ~82-ft wide margins for meadows ~1000 ft apart. Another model simulation, of pollination services, indicated that optimal conditions occurred when the *size* of remnant habitat patches was equal to half the mean foraging and dispersal distance of pollinators and the *spacing* between remnant patches was equal to the mean foraging and dispersal distance. However, maximization of pollination services was predicted to be generally incompatible with conservation of wild pollinator-dependent plants (Keitt 2009).

Butterflies and other insects are also highly sensitive to plant species. In some studies, native butterflies have used non-native plants extensively (Matteson & Langellotto 2010) whereas other studies have documented lower butterfly or insect diversity in association with non-native than native plants (Burghardt et al. 2009, 2010, Tallamy & Shropshire 2009).

4.3.2.2 Impacts of Human Presence

The simple presence of humans and especially their pets can dissuade many wildlife species from using productive habitat areas around single-family homes, wetlands, and shorelines. Monitoring the behaviors of citizens and their domestic animals is impractical, so restrictions on locations of buildings are typically necessary to protect wildlife indirectly from human disturbance.

For most upland species, biologists from WDFW (2009) have identified building densities (dwelling units per acre), ranging from none to more than 7 per acre, which they believe might be tolerated by particular wildlife species. Those densities are summarized in Figure 4-2, and details are given by species in Appendix 4-B. A study in rural Massachusetts found lower abundances of sensitive forest-dwelling birds where housing densities were 1 per acre as contrasted with 8 per acre (Kluza et al. 2000).

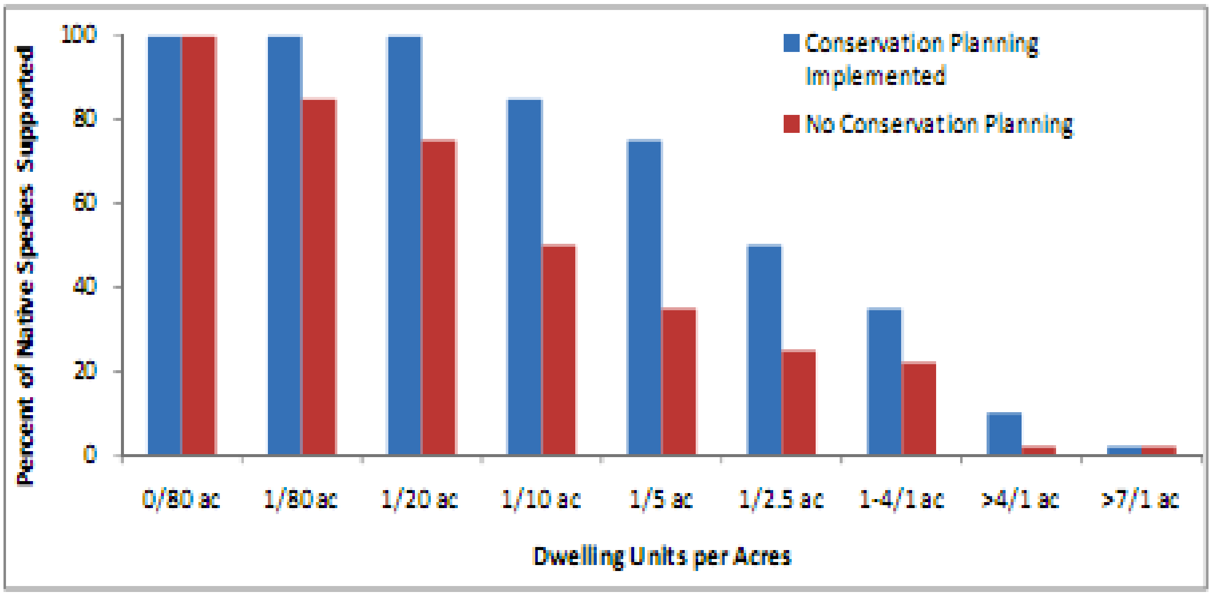


Figure 4-2. Impacts of different housing densities on richness of upland wildlife species in western Washington (from WDFW 2009).
"Conservation planning" refers to the measures described in the WDFW (2009) habitat manual, such as retaining dead wood and placing homes as far as possible from important habitat areas within a property.

In addition to disturbing wildlife, the dogs and cats that almost inevitably accompany human settlements prey directly on individuals of many species and can reduce local bird populations, not just kill individual birds (Kays & DeWan 2004, Baker et al. 2008, Barber et al. 2010, van Heezik et al. 2010, Dauphiné & Cooper 2010). Many songbirds arriving on the islands after exhausting overwater flights probably land first in shoreline vegetation where many homes and pets happen to be located. Songbirds there are more vulnerable to predation (Sperry et al. 2008). Where vegetation has been thinned or mowed by homeowners or by overbrowsing by deer and rabbits, songbirds become even more vulnerable to predators.

Almost as inevitably, human settlements are accompanied by an increase in refuse, whether it be illegally dumped trash, recklessly contained household garbage, or well-intended compost piles. These serve as a food for at least three species – raccoons, crows, and ravens – that prey extensively on native songbirds, frogs, and other wildlife (Chace & Walsh 2006). Crow populations have been shown to increase as a result of urbanization in areas up to at least 0.5 mile from the new urban areas (Oneal & Rotenberry 2009). Buildings provide useable habitat, but only for a few species, e.g., rats, bats, barn swallows, starlings (Marzluff & Ewing 2001). Collisions with picture windows are also a new hazard for many birds. Where homeowners put up bird nest boxes and feeders and maintain them annually over many years, this can help support populations of some species, especially in places where natural foods and nest sites (e.g., snags of suitable dimensions) are scarce. However, only a tiny proportion of all wildlife species are potentially benefited by such management actions (McKinney 2008). Declines in insects and some other natural foods preferred by many migratory songbird species are perhaps as likely to occur with development, especially if properties are landscaped with exotic plants, and insectivores are often the first to decline with increasing urbanization (Chamberlain et al. 2009).

Increased noise and light also accompany settlements and disturb some wildlife species, especially along roads, ATV trails, and in harbors. Artificial outdoor lighting alters the behaviours of some animals, and is particularly dangerous to birds along shorelines. During dark foggy nights, seabirds can be drawn to high-intensity shoreline lights, like a moth to a flame, and some are killed when they collide with hard objects. Also, research has demonstrated that many songbirds and frogs alter their vocalizations along roads and other environments with moderate but chronically present noise. This can reduce reproductive success if the noise is prolonged during critical breeding times. Even temporarily loud noises, such as from heavy equipment, blasting, and pile driving may disturb species for up to a quarter mile beyond the source of the noise, even causing nest abandonment (Watson and Rodrick 2002; Kennedy 2003).

Distances at which birds will or won't be disturbed by humans, pets, or noise vary depending on species, habitat, time of year, flock size, amount of visual screening by vegetation, and other factors (Dahlgren and Korschgen 1992). A buffer of 100 to 300 ft may be required to reduce disturbance of most waterbirds, and a few species sometimes take flight when humans or pets approach from as far as 800 ft away. Based on visits to a number of wetlands with various buffer widths, Cooke (1992) commented that buffers narrower than 50 feet seemed insufficient for the purpose of minimizing physical impacts to the vegetation within those mostly urban wetlands, e.g., by trampling, vandalism, non-permitted clearing. For the purpose of minimizing noise that could disturb some wildlife species, Shisler et al. (1987) found that "low-intensity" land uses could be effectively screened with vegetated buffers of 50-100 ft and "high-intensity" land uses required buffers of 100-150 feet. Neither study measured wildlife response to various buffer widths, and such information is crucial to making correct inference and extrapolation.

When humans on foot or their domestic animals approach individuals of some wildlife species, those species sometimes abandon their young or at least flee (termed "flushing") or interrupt their activities. When these disturbances occur regularly over periods of time, it reduces the food intake and weight of animals, eventually making their populations less competitive or putting individuals at greater risk of predation or disease. The energy balance may be especially delicate for bird species that characteristically have annual migrations spanning multiple continents, such as many of the warbler and flycatcher species. Large waterbirds (herons, swans) and perching hawks and eagles tend to be the most wary. However, as long as they are not shot at or chased by pets, over time many individuals of these species habituate to the presence of humans. Open habitats frequented the most by herons, waterfowl, and perching raptors probably deserve the widest visual/ noise separation from human activities. Based on extensive data collected on bird responses to boats in nearby marine waters off Vancouver Island, Chatwin (2010) recommended boats keep a distance of ~160 to 230 ft from foraging seabirds. In contrast, where the only objective is to visually screen birds inhabiting forested habitats from humans, a densely forested buffer of only about 25 ft width may be adequate as a visual screen. Much wider buffers could be necessary to reduce wildlife impacts where chronic noise is a potential concern. Where sensitive habitat areas are fenced or surrounded completely by a very dense thicket of vegetation (e.g., rose, blackberry, meadowsweet), such features might reduce disturbance by excluding humans and some predators of the wildlife species using those areas.

4.3.3 Data Gaps and the Need to Expand the Knowledge Base

1. Perhaps the greatest informational data gap that hinders planning for biodiversity in SJC is the lack of data on the patch sizes of suitable habitat, and dimensions of movement corridors, that are needed to sustain each indigenous species of terrestrial plant and animal.

2. Simultaneously, it is important to know which species the county harbors and where they are located. While this is relatively well-known for the more common species of birds, next to nothing is known of the locations favored by hundreds of species of breeding reptiles, amphibians, mammals, and uncommon birds, not to mention the potentially thousands of species of invertebrates and plants.

3. In addition, information is needed on the widths of noise buffers and general disturbance buffers that are needed to provide adequate seclusion to waterbirds and other sensitive wildlife.

Many other data gaps exist that pertain to upland habitat, but these are perhaps the ones that most limit attempts to base land use decisions on sound science. Despite the above data gaps and information needs, the County’s efforts to protect habitats and biodiversity should not be put on hold until more information is available. State laws, the public trust, and popular concern for protecting natural resources from long-lasting harm dictate that both voluntary and regulatory efforts proceed with urgency using the best available science, whatever its current limitations.

4.3.4 Synopsis and Science-based Options for Protecting Terrestrial FWHCA's

1. Planning for biodiversity should be based on needs of individual species, not focus *only* on conserving areas containing priority habitat types, or on some perceived notion of "generally good habitat structure" as is the case with many of the currently used methods for rapidly assessing habitat quality. Habitat planning and assessment methods must recognize that research findings on a particular species or species group in one region can not always be applied validly to different species in different landscapes and regions. As Zuckerberg & Porter (2010) note:

> "incorporating ecological thresholds in environmental planning should be species-specific and focus on populations on the verge of rapid ecological change."

And Schmiegelow et al. (2002) explain:

> "the magnitude of the fragmentation effects we documented is small compared with those observed elsewhere. Birds breeding in the boreal forest, where frequent small- and large-scale natural disturbances have occurred historically, may be more resilient to human-induced habitat changes, such as those caused by limited forest harvesting. "

And Tewksbury (1998) comments:

> "the effects of fragmentation are dependent on the habitat structure, the landscape context, the predator community, and the impact of parasitism. All of these factors may differ substantially in western ecosystems when compared to previously studied forests, making generalizations about the effect of fragmentation difficult."

Based on their extensive data from Vancouver Island, Schieck et al. (1995) concluded:

> "Most species of birds that occur in the Pacific Northwest may be less susceptible to adverse effects of forest fragmentation."

And finally, in a synthesis on this topic, Kremsater & Bunnell (1999) observed:

> "In the east and midwest many studies document increased predation and parasitism near edges; in the Pacific Northwest researchers have found little effect of patch area or negative edge effects"

These warnings to focus on species and be conservative in the application of popular landscape conservation paradigms, especially when dealing with regions and species different from the regions and species upon which those paradigms were based, are echoed by Pavlacky & Anderson 2007, Shanahan & Possingham 2009, McWethy et al. 2009, and many others. Even the applicability to SJC of the few habitat fragmentation studies conducted in the Pacific Northwest may be limited because virtually all such studies have been conducted on *mainland* environments, most often around clearcuts or in heavily urbanized landscapes.

2. On islands, the minimum patch areas and widths of natural land cover that would be required for sensitive species to persist might need to be larger. That is because of the severe inhospitably to many species of part of the matrix habitat (marine waters), as compared to mainland matrix habitats which typically are interspersed with some marginally suitable habitat patches (Cassidy & Grue 2006). On islands, recolonization of vegetation patches which have lost individuals of various species, due to humans or natural processes, is likely to occur slowly if at all because of the severe barrier posed by marine waters (Russell et al. 2006, Trevino et al. 2007). The availability of temporary "refuges" from humans or predators is far more constrained on islands. Many other factors that make SJC significantly different from the rest of western Washington are outlined in Chapter 2 (Wetlands).

Based on the Best Available Science, the County in amending current regulations could do the following[6]:

3. Adopt immediately as Locally Significant Habitats those habitats described in section 4.3.1.3. Also solicit information on species listed in section 4.2.1.4. If sufficient information exists (or can be easily generated by field surveys), take steps to protect their preferred habitats and locations.

4. Consider and possibly adopt or expand incentives to landowners to voluntarily and permanently set aside natural lands and open space for species and habitat protection. Highest priority could be given to habitat on islands that currently have the lowest proportion of lands permanently set aside for conservation, as well as to habitat elsewhere that is known to support Priority Habitats, Priority Species, and other species identified as rare or sensitive in section 4.3.1.4 of this chapter. Higher priority could also be given to patches of these habitats that are larger and/or are in the best condition, and are most likely to be self-sustaining over the long term.

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[6] Note that because section 4.3.4 is a synopsis, literature supporting many of the statements in this section is generally not cited here, but rather in preceding parts of this HCA chapter.

5. Provide information to private landowners describing voluntary measures, consistent with the BAS presented here in sections 4.3.1.5 and 4.3.2.1, which they can take to recognize and avoid impacting sensitive species and habitats on their lands, as well as to enhance habitat for sensitive species in a self-sustaining manner.

6. Encourage and help fund the centralized compilation, databasing, and synthesis of much species and habitat distributional information already collected by SJC citizens and various private groups, but not yet in the public domain. Without disclosing exact locations of the most sensitive species, continue to use these data to help refine priorities for the San Juan County Land Bank and other open space and conservation efforts.

7. Facilitate and help fund a countywide biological inventory that builds upon Appendix 4B and #6 above, and catalogs where all uncommon species breed or otherwise occur in SJC.

8. Consider restricting the placement or widening of driveways, roads, and linear clearings in situations where doing so would “lop off” part of a contiguous forest currently larger than 100 acres and create a non-continguous “forest island” smaller than 100 acres, especially if the driveway or road is wider than 100 ft. When new structures are built, encourage their placement such that any existing forest “islands” are not narrowed.

9. Support waste management programs and enforce littering regulations to ensure that all garbage remains as inaccessible as possible to raccoons, crows, and other songbird nest predators.

10. To minimize illegal harassment of sensitive shorebirds, enact and/or ensure strict enforcement of leash laws in known shorebird concentration areas (e.g., Westcott Bay, False Bay) along marine and lake shorelines.

11. Wherever landscaping of County property is needed or desired, use native plants and minimize the creation of new lawns. Continue supporting programs for noxious weed control throughout the county. Use herbicides only when no practical alternatives exist.

12. For Threatened, Endangered, and Sensitive species, the County could support -- through regulations, policies, and/or public education -- the actions shown in Table 4-6.

Table 4-6. Proposed protective actions for listed Threatened, Endangered, and Sensitive species.

See section 4.3.1.2 for background information on these species.

Species or Group	**Proposed Protections**
Bald Eagle	Require landowners to have a site management plan prepared in collaboration with WDFW, or by a professional wildlife biologist and approved by the WDFW, whenever regulated activities that alter habitat are proposed near a nest or communal roost. This requirement could apply to proposed projects within 800 feet of a nest and to projects that are within 250 ft of the shoreline and are within 0.5 mile of a nest. This is in accordance with WAC 232-12-292 and RCW 77.12.655. The plan could specify, in part, that the landowner maintain 50% of all trees in representative size classes and all trees ≥24 in. dbh within 250 ft of the shoreline for ½ mile on either side of a nest. Monitor compliance with the approved plan. Adopt and enforce buffer regulations for streams, lakes, wetlands, and the marine shoreline that help protect these surface waters from contamination. Identify pollution sources, partly through a countywide monitoring program, and remediate them. Adopt and enforce regulations and policies that protect habitat of salmonids and other fish.
Peregrine Falcon	Restrict or discourage public access to areas within 250 ft of nest cliffs during active nesting periods (generally spring and early summer). Require landowners to have a site management plan prepared in collaboration with WDFW, or by a professional wildlife biologist and approved by the WDFW, whenever regulated activities that alter habitat are proposed near nesting cliffs. Adopt and enforce buffer regulations for streams, lakes, wetlands, and the marine shoreline that help protect these surface waters from contamination.

Species or Group	Proposed Protections
	Identify pollution sources, partly through a countywide monitoring program, and remediate them.
Marbled Murrelet	Adopt and enforce regulations and policies that support populations of forage fish and swimming marine invertebrates. Protect the oldest coniferous forests having the greatest extent, especially any which currently have trees at least 32" in diameter and cover more than 7 acres. Support efforts of murrelet biologists to determine current nesting status of the species in SJC and identify more accurately locations of potential nesting habitat. If a nest is found, require landowners to have a site management plan prepared in collaboration with WDFW, or by a professional wildlife biologist and approved by the WDFW, whenever regulated activities that alter habitat near the nest are proposed. Adopt and enforce buffer regulations for streams, lakes, wetlands, and the marine shoreline that help protect these surface waters from contamination. Identify pollution sources, partly through a countywide monitoring program, and remediate them. Adopt and enforce regulations intended to keep recreational motorized boats and new docks at least 200 ft from seasonal concentration areas in marine waters.

Fish Salmon Chinook Chum Coho Pink Sockeye Cutthroat Steelhead	Adopt and enforce buffer regulations for streams and the marine shoreline that help protect these surface waters from contamination while supporting vegetation which supplies terrestrial insects to feeding fish. Identify pollution sources, partly through a countywide monitoring program, and remediate them. Adopt and enforce regulations and policies that protect forage fish spawning areas, eelgrass and kelp beds, and the dynamic complexity of nearshore habitat. Disallow construction of ponds that empty to streams and marine waters. Require properly sized culverts for all driveways and roads that cross fish-accessible streams. (For marine waters, see also Chapter 3)
Taylor's Checker-spot butterfly	In privately owned grasslands with potential for this species, actively seek landowner permission for annual surveys by a qualified entomologist. Even in grasslands not known to currently host this species, discourage use of herbicides, insecticides, intensive grazing, and vegetation clearing. This is especially applicable in areas where one of its host plants -- plantain (*Plantago* spp.) -- is common. Require landowners to have a site management plan prepared in collaboration with WDFW, or by a professional entomologist and approved by the WDFW, whenever regulated activities that alter habitat are proposed near a known site.

4.4 Literature Cited

Note: Peer reviewed references and documents that local, state or federal natural resource agencies have determined represents the best available science consistent with the criteria set out in WAC 365-195-900 through 365-195-925 are shown in bold.

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Appendices

4-A. Occurrence of SJC Wildlife Species by Island

4-B. Occurrence of SJC Wildlife Species by Habitat Type

4-C. Plant species considered to be rare in SJC by the Washington Natural Heritage Program (September 2010)

4-D. Plant communities for which high-quality examples are considered rare in SJC by the Washington Natural Heritage Program (September 2010)

4-E. Quality of SJC surface waters (from WDOE's WQA database)

4-F. Environment Summary Tables from GIS Compilation of Existing Data
    4F-1. Environment by Island

Appendix 4-A. Occurrence of SJC Wildlife Species by Island

Sources: Jensen (2010), WDFW (2009), Cassidy & Grue (2006), Lewis & Sharpe (1987), R. Barsh (pers. comm.), R. Myhr (pers. comm.), Adamus (personal observations)

Legend:
Native to WA: Y= yes, N- no
Times Present: R= resident; N= nesting season only; MW= migration/ wintering only; ? = nesting unconfirmed
Distribution by Island: C= confirmed by reliable report, P= probable based on known habitat preferences, ? = unknown but possible based on habitat
Listing Status:

Fed (Federal): E= Endangered, T= Threatened, SC= Species of Concern

State: M= species of potential concern whose status should be determined or monitored, C= Candidate (species that will be reviewed by WDFW for possible listing as Endangered, Threatened, or Sensitive according to the process and criteria defined in WAC-232-12-297), E= Endangered, T= Threatened

State PS (Priority Species): 1= state-listed species, 2= protect vulnerable aggregations, 3= species of recreational or commercial importance

Building Densities Tolerated (du/ac = dwelling units per acre): Based on scientific literature analysis by WDFW biologists (WDFW 2009). Blanks indicate lack of information, not insensitivity to impact. "Conservation Planning" refers to the measures described in the WDFW (2009) habitat manual.

				Distribution by Island				Listing Status			Building Densities Tolerated	
Common Name	Scientific Name	Native to WA	Times Present	SJ	Orcas	Lopez	Shaw	Fed	State	State PS	Without Conservation Planning	With Conservation Planning
Northwestern Salamander	Ambystoma gracile	Y	R	P	C	C	?				1du/10	1du/ac to 4du/ac
Long-toed Salamander	Ambystoma macrodactylum	Y	R	?	C	P	C				1du/5	>4du/ac to 7du/ac
Rough-skinned Newt	Taricha granulosa	Y	R	C	C	C	C				1du/10	1du/ac to 4du/ac
Western Toad	Bufo boreas	Y	R	?	P	?	P	SC	C	1	1du/40 to 1du/80	1du/5
Pacific Treefrog	Hyla regilla	Y	R	C	C	C	C				1du/5	>7du/ac
Northern Red-legged Frog	Rana aurora	Y	R	P	C	C	C				1du/20	1du/5
Bullfrog	Rana catesbeiana	N	R	C	C	C	C					
Western Painted Turtle	Chrysemys picta	Y	R	C	P	C	?					
Northern Alligator Lizard	Elgaria coerulea	Y	R	C	C	P	?				1du/5	>4du/ac to 7du/ac
Western Fence Lizard	Sceloporus occidentalis	Y	Y	C								
Rubber Boa	Charina bottae	Y	R	C	C	?	?				1du/10	1du/ac to 4du/ac
Sharptail Snake	Contia tenuis	Y	R	C	C	?	?				1du/10	1du/ac to 4du/ac
W. Terrestrial Garter Snake	Thamnophis elegans	Y	R	P	P	C	?				1du/10	1du/ac to 4du/ac
Northwestern Garter Snake	Thamnophis ordinoides	Y	R	P	P	C	?				1du/5	>7du/ac
Common Garter Snake	Thamnophis sirtalis	Y	R	P	P	C	?				1du/10	1du/ac to 4du/ac
Red-throated Loon	Gavia stellata	Y	MW	C	C	C	?			2		

				Distribution by Island				Listing Status			Building Densities Tolerated	
Common Name	Scientific Name	Native to WA	Times Present	SJ	Orcas	Lopez	Shaw	Fed	State	State PS	Without Conservation Planning	With Conservation Planning
Common Loon	Gavia immer	Y	MW	C	C	C	C		S	1,2		
Yellow-billed Loon	Gavia adamsii	Y	MW	P	P	C	?			2		
Pacific Loon	Gavia pacifica	Y	MW	C	C	C	C			2		
Pied-billed Grebe	Podilymbus podiceps	Y	R	C	C	C	C			2		
Horned Grebe	Podiceps auritus	Y	MW	C	C	C	C		M	2		
Red-necked Grebe	Podiceps grisegena	Y	MW	C	C	C	C		M	2		
Eared Grebe	Podiceps nigricollis	Y	MW	C	P	P	?			2		
Western Grebe	Aechmophorus occidentalis	Y	MW	C	C	C	C		C	1,2		
Brown Pelican	Pelecanus occidentalis	Y	M	C	C	C		E	E	1,2		
Double-crested Cormorant	Phalacrocorax auritus	Y	R	C	C	C	C			2		
Brandt's Cormorant	Phalacrocorax penicillatus	Y	MW	C	C	C	C		C	1,2		
Pelagic Cormorant	Phalacrocorax pelagicus	Y	R	C	C	C	C			2		
American Bittern	Botaurus lentiginosus	Y	R?	C	P	P	P					
Great Blue Heron	Ardea herodias	Y	MW	C	C	C	C		M	2		
Green Heron	Butorides virescens	Y	N?	C	P	P						
Tundra Swan	Cygnus columbianus	Y	MW	C		P				2,3		
Trumpeter Swan	Cygnus buccinator	Y	MW	C	C	C	P			2,3		
Greater White-fronted Goose	Anser albifrons	Y	MW	C	C	P				2,3		
Brant	Branta bernicla	Y	MW	C	P	C	P			2,3		
Canada Goose	Branta canadensis	Y	R	C	C	C	C			2,3		
Cackling Goose	Branta hutchinsii	Y	MW	C	P	P				2,3		
Wood Duck	Aix sponsa	Y	R	C	C	P	P			2,3		
Green-winged Teal	Anas crecca	Y	R	C	C	C	C			2,3		
Mallard	Anas platyrhynchos	Y	R	C	C	C	C			2,3		
Northern Pintail	Anas acuta	Y	R?	C	C	C	P			2,3		
Blue-winged Teal	Anas discors	Y	R	C	C	P	P			2,3		
Cinnamon Teal	Anas cyanoptera	Y	R	C	C	P	P			2,3		
Northern Shoveler	Anas clypeata	Y	R?	C	C	C	P			2,3		
Gadwall	Anas strepera	Y	R	C	C	C	P			2,3		
Eurasian Wigeon	Anas penelope	Y	MW	C	C	C	P			2,3		
American Wigeon	Anas americana	Y	MW	C	C	C	C			2,3		
Canvasback	Aythya valisineria	Y	MW	C	C	P	P			2,3		
Redhead	Aythya americana	Y	MW	C	P	P	P			2,3		
Ring-necked Duck	Aythya collaris	Y	R	C	C	P	P			2,3		

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Greater Scaup	Aythya marila	Y	MW	C	C	C	C			2,3		
Lesser Scaup	Aythya affinis	Y	R?	C	P	P	P			2,3		
Harlequin Duck	Histrionicus histrionicus	Y	MW	C	C	C	C			2,3		
Long-tailed Duck	Clangula hyemalis	Y	MW	C	C	C	C			2,3		
Black Scoter	Melanitta nigra	Y	MW	C	C	P	P			2,3		
Surf Scoter	Melanitta perspicillata	Y	MW	C	C	C	C			2,3		
White-winged Scoter	Melanitta fusca	Y	MW	C	C	C	C			2,3		
Common Goldeneye	Bucephala clangula	Y	MW	C	C	C	C			2,3		
Barrow's Goldeneye	Bucephala islandica	Y	MW	C	C	C	C			2,3		
Bufflehead	Bucephala albeola	Y	MW	C	C	C	C			2,3		
Hooded Merganser	Lophodytes cucullatus	Y	R	C	C	C	C			3		
Common Merganser	Mergus merganser	Y	R	C	C	C	C			2,3		
Red-breasted Merganser	Mergus serrator	Y	MW	C	C	C	C			2,3		
Ruddy Duck	Oxyura jamaicensis	Y	R?	C	P	C	P			2,3		
Turkey Vulture	Cathartes aura	Y	R	C	C	C	C		M		0du/ac	1du/10
Osprey	Pandion haliaetus	Y	R	C	C	C	P		M		1du/20	1du/ac to 4du/ac
Bald Eagle	Haliaeetus leucocephalus	Y	R	C	C	C	C	SC	S	1	1du/20	1du/2.5
Northern Harrier	Circus cyaneus	Y	R?	C	C	C	C				1du/10	1du/ac to 4du/ac
Sharp-shinned Hawk	Accipiter striatus	Y	R	C	C	C	C				1du/10	1du/ac to 4du/ac
Cooper's Hawk	Accipiter cooperii	Y	R	C	C	C	P				1du/5	>4du/ac to 7du/ac
Northern Goshawk	Accipiter gentilis	Y	R?	C	C	C	C	SC	C	1	1du/5	>4du/ac to 7du/ac
Red-tailed Hawk	Buteo jamaicensis	Y	R	C	C	C	C				1du/20	1du/2.5
Rough-legged Hawk	Buteo lagopus	Y	MW	C	P	P	P					
Golden Eagle	Aquila chrysaetos	Y	R	C	C	C	P		C	1	0du/ac	1du/10
American Kestrel	Falco sparverius	Y	R	C	C	P	P				1du/5	>4du/ac to 7du/ac
Merlin	Falco columbarius	Y	R?	C	C	C	P		C	1	0du/ac	1du/10
Peregrine Falcon	Falco peregrinus	Y	R	C	C	C	P	SC	S	1	1du/10	1du/ac to 4du/ac
Gyrfalcon	Falco rusticolus	Y	MW	C	P	P	P		M			
Ring-necked Pheasant	Phasianus colchicus	N	R	C	C	C	P			3		
Blue Grouse	Dendragapus obscurus	Y	R		C					3	0du/ac	1du/10
Wild Turkey	Meleagris gallopavo	N	R	C						3		
California Quail	Callipepla californica	N	R	C	C	C	C					
Virginia Rail	Rallus limicola	Y	R	C	C	C	C					
Sora	Porzana carolina	Y	R	C	C	P	C					

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American Coot	Fulica americana	Y	R	C	C	C	P			2,3		
Sandhill Crane	Grus canadensis	Y	MW	C	P	P			E	1		
Black-bellied Plover	Pluvialis squatarola	Y	MW	C	C	C	P			2		
American Golden-Plover	Pluvialis dominica	Y	M	C		P				2		
Pacific Golden-Plover	Pluvialis fulva	Y	M	C		P				2		
Semipalmated Plover	Charadrius semipalmatus	Y	MW	C	P	C	P			2		
Killdeer	Charadrius vociferus	Y	R	C	C	C	C			2		
Black Oystercatcher	Haematopus bachmani	Y	R	C	C	C	C		M	2		
Greater Yellowlegs	Tringa melanoleuca	Y	MW	C	C	C	C			2		
Lesser Yellowlegs	Tringa flavipes	Y	M	C	P	C	P			2		
Solitary Sandpiper	Tringa solitaria	Y	M	C	P	P	P			2		
Wandering Tattler	Heteroscelus incanus	Y	M	C	P	P	P			2		
Spotted Sandpiper	Actitis macularia	Y	R?	C	C	C	C			2		
Whimbrel	Numenius phaeopus	Y	MW	C	P	P	P			2		
Ruddy Turnstone	Arenaria interpres	Y	MW	C	P	P	P			2		
Black Turnstone	Arenaria melanocephala	Y	MW	C	C	C	C			2		
Surfbird	Aphriza virgata	Y	MW	C	P	C	P			2		
Sanderling	Calidris alba	Y	MW	C	C	C	C			2		
Semipalmated Sandpiper	Calidris pusilla	Y	M	C	P	P	P			2		
Western Sandpiper	Calidris mauri	Y	MW	C	C	C	C			2		
Least Sandpiper	Calidris minutilla	Y	M	C	P	C	P			2		
Baird's Sandpiper	Calidris bairdii	Y	M	C	P	C	P			2		
Pectoral Sandpiper	Calidris melanotos	Y	M	C	P	P	C			2		
Dunlin	Calidris alpina	Y	MW	C	C	C	C			2		
Short-billed Dowitcher	Limnodromus griseus	Y	M	C	P	P	P			2		
Long-billed Dowitcher	Limnodromus scolopaceus	Y	M	C	P	C	P			2		
Wilson's Snipe	Gallinago delicata	Y	R	C	C	C	C			2		
Red-necked Phalarope	Phalaropus lobatus	Y	M	C	C	C	C			2		
Parasitic Jaeger	Stercorarius parasiticus	Y	M	C	C	C	C					
Franklin's Gull	Larus pipixcan	Y	M	P	P	P	P					
Bonaparte's Gull	Larus philadelphia	Y	MW	C	C	C	C					
Heermann's Gull	Larus heermanni	Y	MW	C	C	C	C					
Mew Gull	Larus canus	Y	MW	C	C	C	C					
Ring-billed Gull	Larus delawarensis	Y	MW	C	P	P	?					

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California Gull	Larus californicus	Y	MW	C	C	C	C					
Herring Gull	Larus argentatus	Y	MW	C	C	C	C					
Thayer's Gull	Larus thayeri	Y	MW	C	C	C	C					
Western Gull	Larus occidentalis	Y	MW	C	P	P	P					
Glaucous-winged Gull	Larus glaucescens	Y	R	C	C	C	C					
Glaucous Gull	Larus hyperboreus	Y	MW	P	P	P	P					
Caspian Tern	Hydroprogne caspia	Y	MW	C	C	C	C		M	2		
Common Tern	Sterna hirundo	Y	MW	C	C	C	C			2		
Common Murre	Uria aalge	Y	NB	C	C	C	C		C	1,2		
Pigeon Guillemot	Cepphus columba	Y	R	C	C	C	C			2		
Marbled Murrelet	Brachyramphus marmoratus	Y	R	C	C	C	C	T	T	1,2		
Ancient Murrelet	Synthliboramphus antiquus	Y	MW	C	C	C	?			2		
Cassin's Auklet	Ptychoramphus aleuticus	Y	R	C	P	C	P	SC	C	1,2		
Rhinoceros Auklet	Cerorhinca monocerata	Y	NB	C	C	C	C			2		
Tufted Puffin	Fratercula cirrhata	Y	R	C	P	C	P	SC	C	1,2,3		
Rock Dove	Columba livia	N	R	C	C	C	C					
Band-tailed Pigeon	Columba fasciata	Y	R	C	C	C	C			3	1du/5	>4du/ac to 7du/ac
Eurasian Collared-dove	Streptopelia decaocto	N	R	C	C	C	C					
Mourning Dove	Zenaida macroura	Y	R	C	C	C	C				1du/10	1du/ac to 4du/ac
Barn Owl	Tyto alba	Y	R	C	C	C					1du/5	>4du/ac to 7du/ac
Western Screech-owl	Otus kennicotti	Y	R	C	C	C	?				1du/10	1du/ac to 4du/ac
Great Horned Owl	Bubo virginianus	Y	R	C	C	C	P				1du/10	1du/ac to 4du/ac
Snowy Owl	Nyctea scandiaca	Y	MW	C	P	P			M			
Northern Pygmy-owl	Glaucidium gnoma	Y	R?	C	C	P	?				1du/20	1du/2.5
Barred Owl	Strix varia	Y	R?	?	P	C	?				1du/5	>4du/ac to 7du/ac
Long-eared Owl	Asio otus	Y	R	C	C	C	C				0du/ac	1du/10
Short-eared Owl	Asio flammeus	Y	R?	C	P	C					0du/ac	1du/10
Northern Saw-whet Owl	Aegolius acadicus	Y	R	C	P	C					1du/20	1du/2.5
Common Nighthawk	Chordeiles minor	Y	N	C	C	C					1du/10	1du/ac to 4du/ac
Black Swift	Cypseloides niger	Y	NB	C	C	C		SC	M			
Vaux's Swift	Chaetura vauxi	Y	N?	C	C	C	?		C	1	1du/40 to 1du/80	1du/5
Anna's Hummingbird	Calypte anna	Y	R	C	C	C	C				>7du/ac	
Rufous Hummingbird	Selasphorus rufus	Y	N	C	C	C	C				1du/5	>4du/ac to 7du/ac
Belted Kingfisher	Ceryle alcyon	Y	R	C	C	C	C				1du/5	>4du/ac to 7du/ac

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Red-breasted Sapsucker	Sphyrapicus ruber	Y	MW?	C	C	C	?					
Downy Woodpecker	Picoides pubescens	Y	R	C	C	C	C				1du/10	1du/ac to 4du/ac
Hairy Woodpecker	Picoides villosus	Y	R	C	C	C	C				1du/10	1du/ac to 4du/ac
Northern Flicker	Colaptes auratus	Y	R	C	C	C	C				1du/10	1du/ac to 4du/ac
Pileated Woodpecker	Dryocopus pileatus	Y	R	C	C	C	C		C	1	1du/40 to 1du/80	1du/5
Olive-sided Flycatcher	Contopus borealis	Y	N	C	C	C	C				1du/40 to 1du/80	1du/5
Western Wood-pewee	Contopus sordidulus	Y	N	C	C	P	P				1du/20	1du/2.5
Willow Flycatcher	Empidonax traillii	Y	N	C	C	P	?				1du/10	1du/ac to 4du/ac
Hammond's Flycatcher	Empidonax hammondii	Y	N?		P						1du/20	1du/2.5
Pacific-slope Flycatcher	Empidonax difficilis	Y	N	C	C	C	C				1du/20	1du/2.5
Say's Phoebe	Sayornis saya	Y	M	C	C	C					1du/5	>4du/ac to 7du/ac
Western Kingbird	Tyrannus verticalis	Y	M	C	P	P					1du/40 to 1du/80	1du/5
Horned Lark	Eremophila alpestris	Y	M	C	P	P						
Purple Martin	Progne subis	Y	N	C	C	C			C	1	1du/10	1du/ac to 4du/ac
Tree Swallow	Tachycineta bicolor	Y	N	C	C	C	C				1du/20	1du/2.5
Violet-green Swallow	Tachycineta thalassina	Y	N	C	C	C	C				1du/20	1du/2.5
N. Rough-winged Swallow	Stelgidopteryx serripennis	Y	N	C	C	C	C					
Cliff Swallow	Hirundo pyrrhonota	Y	N	C	C	C					1du/10	1du/ac to 4du/ac
Barn Swallow	Hirundo rustica	Y	N	C	C	C	C				1du/5	>4du/ac to 7du/ac
Steller's Jay	Cyanocitta stelleri	Y	R		C						1du/5	>4du/ac to 7du/ac
American Crow	Corvus brachyrhynchos	Y	R	C	C	C	C				1du/5	>4du/ac to 7du/ac
Common Raven	Corvus corax	Y	R	C	C	C	C				1du/10	1du/ac to 4du/ac
Chestnut-backed Chickadee	Poecile rufescens	Y	R	C	C	C	C				1du/5	>4du/ac to 7du/ac
Bushtit	Psaltriparus minimus	Y	R	C	C	C	?				1du/10	1du/ac to 4du/ac
Red-breasted Nuthatch	Sitta canadensis	Y	R	C	C	C	C				1du/10	1du/ac to 4du/ac
Brown Creeper	Certhia americana	Y	R	C	C	C	C				1du/20	1du/2.5
Bewick's Wren	Thryomanes bewickii	Y	R	C	C	C	C				1du/5	>4du/ac to 7du/ac
House Wren	Troglodytes aedon	Y	N	C	C	C	C				1du/5	>4du/ac to 7du/ac
Pacific (Winter) Wren	Troglodytes troglodytes	Y	R	C	C	C	C				1du/20	1du/2.5
Marsh Wren	Cistothorus palustris	Y	R	C	C	C	C				1du/10	1du/ac to 4du/ac
American Dipper	Cinclus mexicanus	Y	R?		C							
Golden-crowned Kinglet	Regulus satrapa	Y	R	C	C	C	C				1du/10	1du/ac to 4du/ac
Ruby-crowned Kinglet	Regulus calendula	Y	MW	C	C	C	C					
Western Bluebird	Sialia mexicana	Y	R	C	C	C						

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Mountain Bluebird	Sialia currucoides	Y	M	C								
Townsend's Solitaire	Myadestes townsendi	Y	MW	C	C	C	C					
Swainson's Thrush	Catharus ustulatus	Y	N	C	C	C	C				1du/10	1du/ac to 4du/ac
Hermit Thrush	Catharus guttatus	Y	MW	C	C	C	C					
American Robin	Turdus migratorius	Y	R	C	C	C	C				>7du/ac	
Varied Thrush	Ixoreus naevius	Y	R	C	C	C	C				1du/20	1du/2.5
American Pipit	Anthus rubescens	Y	MW	C	C	C	P					
Cedar Waxwing	Bombycilla cedrorum	Y	R	C	C	C	P				1du/10	1du/ac to 4du/ac
Northern Shrike	Lanius excubitor	Y	MW	C	P	C	?					
European Starling	Sturnus vulgaris	N	R	C	C	C	C					
Hutton's Vireo	Vireo huttoni	Y	R	C	C	C	C				1du/20	1du/2.5
Warbling Vireo	Vireo gilvus	Y	N	C	C	C	C				1du/10	1du/ac to 4du/ac
Cassin's Vireo	Vireo cassinii	Y	N	C	C	C	C				1du/20	1du/2.5
Orange-crowned Warbler	Vermivora celata	Y	N	C	C	C	C				1du/20	1du/2.5
Yellow Warbler	Dendroica petechia	Y	N	C	C	C	C				1du/10	1du/ac to 4du/ac
Yellow-rumped Warbler	Dendroica coronata	Y	R	C	C	C	C				1du/20	1du/2.5
Black-throated Gray Warbler	Dendroica nigrescens	Y	N	C	C	C	C				1du/5	>4du/ac to 7du/ac
Townsend's Warbler	Dendroica townsendi	Y	R	C	C	C	C				1du/40 to 1du/80	1du/5
MacGillivray's Warbler	Oporornis tolmiei	Y	N	C	C	P	?				1du/20	1du/2.5
Common Yellowthroat	Geothlypis trichas	Y	N	C	C	C	C				1du/20	1du/2.5
Wilson's Warbler	Wilsonia pusilla	Y	N	C	C	C	C				1du/10	1du/ac to 4du/ac
Western Tanager	Piranga ludoviciana	Y	N	C	C	C	C				1du/20	1du/2.5
Black-headed Grosbeak	Pheucticus melanocephalus	Y	N	C	C	C	C				1du/10	1du/ac to 4du/ac
Spotted Towhee	Pipilo maculatus	Y	R	C	C	C	C				1du/10	1du/ac to 4du/ac
Chipping Sparrow	Spizella passerina	Y	N	C	C	P	?				0du/ac	1du/10
Vesper Sparrow	Pooecetes gramineus	Y	N	C	P	P					1du/20	1du/2.5
Savannah Sparrow	Passerculus sandwichensis	Y	N	C	C	C	C				1du/10	1du/ac to 4du/ac
Fox Sparrow	Passerella iliaca	Y	R?	C	C	C	C				1du/20	1du/2.5
Song Sparrow	Melospiza melodia	Y	R	C	C	C	C				1du/5	>4du/ac to 7du/ac
Lincoln's Sparrow	Melospiza lincolnii	Y	MW	C	P	P						
White-throated Sparrow	Zonotrichia albicollis	Y	MW	C	P	P						
Golden-crowned Sparrow	Zonotrichia atricapilla	Y	MW	C	C	C	C					
White-crowned Sparrow	Zonotrichia leucophrys	Y	R	C	C	C	C				1du/ac to 4du/ac	>7du/ac
Dark-eyed Junco	Junco hyemalis	Y	R	C	C	C	C				1du/ac to 4du/ac	

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Red-winged Blackbird	Agelaius phoeniceus	Y	R	C	C	C	C				1du/5	>4du/ac to 7du/ac
Western Meadowlark	Sturnella neglecta	Y	NB	C	P	P					1du/20	1du/2.5
Brewer's Blackbird	Euphagus cyanocephalus	Y	R	C	C	C	?				1du/10	1du/ac to 4du/ac
Brown-headed Cowbird	Molothrus ater	Y	N	C	C	C	C				1du/5	>4du/ac to 7du/ac
Purple Finch	Carpodacus purpureus	Y	R	C	C	C	C				1du/10	1du/ac to 4du/ac
House Finch	Carpodacus mexicanus	Y	R	C	C	C	C				>7du/ac	
Red Crossbill	Loxia curvirostra	Y	R	C	C	C	C				1du/20	1du/2.5
Pine Siskin	Carduelis pinus	Y	R	C	C	C	C				1du/5	>4du/ac to 7du/ac
American Goldfinch	Carduelis tristis	Y	R	C	C	C	C				1du/5	>4du/ac to 7du/ac
Evening Grosbeak	Coccothraustes vespertinus	Y	R	C	C	P	C				1du/5	>4du/ac to 7du/ac
House Sparrow	Passer domesticus	N	R	C	C	C	C					
Vagrant Shrew	Sorex vagrans	Y		C	P	C	C				1du/ac to 4du/ac	>4du/ac to 7du/ac
Little Brown Myotis (Bat)	Myotis lucifugus	Y		C	P	P	?			2		
Yuma Myotis	Myotis yumanensis	Y		P	P	P	?			2		
Keen's Myotis	Myotis keenii	Y		P	P	P	?		C	1,2		
Long-eared Myotis	Myotis evotis	Y		P	P	P	?	SC	M	2		
Long-legged Myotis	Myotis volans	Y		C	P	P	?	SC	M	2		
Californian Myotis	Myotis californicus	Y		C	P	P	?			2		
Silver-haired Bat	Lasionycteris noctivagans	Y		P	P	P	?					
Big Brown Bat	Eptesicus fuscus	Y		P	P	P	?			2		
Hoary Bat	Lasiurus cinereus	Y		P	P	P	?		M			
Townsend's Big-eared Bat	Corynorhinus (Plecotus) townsendii	Y		P	P	C	?	SC	C	1,2		
European Rabbit	Oryctolagus cuniculus	N	R	C	P	C	?					
Townsend's Chipmunk	Neotamias townsendii	Y	R	C	?	C					1du/ac to 4du/ac	>4du/ac to 7du/ac
Eastern Gray Squirrel	Sciurus carolinensis	Y	R			C						
Eastern Fox Squirrel	Sciurus niger	Y	R	P	C	P						
Douglas' (Red) Squirrel	Tamiasciurus douglasii	Y	R	?	C	?					1du/ac to 4du/ac	>4du/ac to 7du/ac
Northern Flying Squirrel	Glaucomys sabrinus	Y	R	C	P	?	?					
American Beaver	Castor canadensis	Y	R		C						1du/10	1du/ac to 4du/ac
Deer (White-footed) Mouse	Peromyscus maniculatus	Y	R	C	C	C	C				1du/ac to 4du/ac	>7du/ac
Townsend's Vole	Microtus townsendii	Y	R	C	C	C	?		M			
Muskrat	Ondatra zibethicus	Y	R	C	C	C	?				1du/ac to 4du/ac	>7du/ac
Black Rat	Rattus rattus	N	R	C	P	P	?					
Norway Rat	Rattus norvegicus	N	R	C	P	P	?					

Common Name	Scientific Name	Native to WA	Times Present	Distribution by Island: SJ	Orcas	Lopez	Shaw	Listing Status: Fed	State	State PS	Building Densities Tolerated: Without Conservation Planning	With Conservation Planning
House Mouse	Mus musculus	N	R	P	P	P	?					
Killer Whale (Orca)	Orcinus orca	Y		P	P	P	P	E	E	1,2		
Harbor Porpoise	Phocoena phocoena	Y		P	P	P	P		C	1,2		
Dall's Porpoise	Phocoenoides dalli	Y		P	P	P	P		M	2		
Gray Whale	Eschrichtius robustus	Y		P	P	P	P		S	1,2		
Red Fox	Vulpes vulpes	Y	R	C								
Steller's Sea Lion	Eumetopias jubatus	Y		P	P	P	P	T	T	1,2		
Raccoon	Procyon lotor	Y	R	P	P	C	C				>4du/ac to 7du/ac	
Mink	Mustela vison	Y	R	P	P	C	P			3	1du/10	1du/ac to 4du/ac
Northern River Otter	Lontra canadensis	Y	R	C	P	C	P				1du/20	1du/2.5
Harbor Seal	Phoca vitulina	Y	R	P	P	P	P		M	2		
Black-tailed Deer	Odocoileus columbianus	Y	R	C	C	C	C			3	1du/40 to 1du/80	1du/5

Appendix 4-B. Occurrence of SJC wildlife species by habitat type

Sources: WDFW (2009), Cassidy & Grue (2006), Lewis & Sharpe (1987), and author's experience.
Legend: State PS (Priority Species): 1= state-listed species, 2= protect vulnerable aggregations, 3= species of recreational or commercial importance

Common Name	State PS	Herbaceous Wetlands, Ponds, Lakes	Wooded Wetlands, Streams	Aspen Woods	Conifer & Mixed Forest	Oak Woods & Balds	Dry Grassland, Cropland	Beaches & Tidal Flats	Rocky Shore	Sheltered Marine Waters	Open Marine Waters	Resi-dential
Northwestern Salamander		X	X									
Long-toed Salamander		X		X	X	X	X					X
Rough-skinned Newt		X	X		X	X						X
Western Toad	1	X	X	X		X	X					
Pacific Treefrog		X	X	X	X	X	X		X			X
Northern Red-legged Frog		X	X	X	X	X						X
Bullfrog		X	X				X					
Red-throated Loon	2									X	X	
Common Loon	1,2	X								X	X	
Yellow-billed Loon	2									X	X	
Pacific Loon	2									X	X	
Pied-billed Grebe	2	X	X							X	X	
Horned Grebe	2	X								X	X	
Red-necked Grebe	2									X	X	
Eared Grebe	2	X								X	X	
Western Grebe	1,2	X								X	X	
Brown Pelican	1,2									X	X	
Double-crested Cormorant	2	X	X						X	X	X	
Brandt's Cormorant	1,2									X	X	
Pelagic Cormorant	2								X	X	X	
American Bittern		X										
Great Blue Heron	2	X	X				X	X	X	X		
Green Heron		X	X									
Tundra Swan	2,3	X						X				
Trumpeter Swan	2,3	X	X				X	X				
Greater White-fronted Goose	2,3						X	X		X		
Brant	2,3							X	X	X		
Canada Goose	2,3	X					X	X		X		X
Cackling Goose	2,3						X	X		X		
Wood Duck	2,3	X	X									

Common Name	State PS	Herbaceous Wetlands, Ponds, Lakes	Wooded Wetlands, Streams	Aspen Woods	Conifer & Mixed Forest	Oak Woods & Balds	Dry Grassland, Cropland	Beaches & Tidal Flats	Rocky Shore	Sheltered Marine Waters	Open Marine Waters	Resi-dential
Green-winged Teal	2,3	X					X	X		X		
Mallard	2,3	X	X				X	X		X	X	X
Northern Pintail	2,3	X						X		X	X	
Blue-winged Teal	2,3	X					X	X		X		
Cinnamon Teal	2,3	X					X	X		X		
Northern Shoveler	2,3	X					X	X		X		
Gadwall	2,3	X					X	X		X		
Eurasian Wigeon	2,3	X						X		X		
American Wigeon	2,3	X	X				X	X		X	X	
Canvasback	2,3	X								X		
Redhead	2,3	X								X	X	
Ring-necked Duck	2,3	X								X		
Greater Scaup	2,3	X								X	X	
Lesser Scaup	2,3	X								X		
Harlequin Duck	2,3								X	X	X	
Long-tailed Duck	2,3									X	X	
Black Scoter	2,3									X	X	
Surf Scoter	2,3									X	X	
White-winged Scoter	2,3									X	X	
Common Goldeneye	2,3	X	X							X		
Barrow's Goldeneye	2,3	X								X		
Bufflehead	2,3	X	X		X					X		
Hooded Merganser	3	X	X							X		
Common Merganser	2,3	X	X							X		
Red-breasted Merganser	2,3									X	X	
Ruddy Duck	2,3	X								X		
Turkey Vulture		X	X	X	X	X	X	X	X	X		X
Osprey		X	X							X		
Bald Eagle	1	X	X	X	X	X	X	X	X	X	X	X
Northern Harrier		X					X	X				
Sharp-shinned Hawk		X	X	X	X	X	X	X	X			X
Cooper's Hawk		X	X	X	X	X	X			X		X
Northern Goshawk	1		X	X	X							
Red-tailed Hawk		X	X	X	X	X	X	X	X			X
Rough-legged Hawk		X					X	X				

Common Name	State PS	Herbaceous Wetlands, Ponds, Lakes	Wooded Wetlands, Streams	Aspen Woods	Conifer & Mixed Forest	Oak Woods & Balds	Dry Grassland, Cropland	Beaches & Tidal Flats	Rocky Shore	Sheltered Marine Waters	Open Marine Waters	Resi-dential
Golden Eagle	1	X		X	X		X	X				
American Kestrel		X	X	X		X	X					
Merlin	1	X	X	X	X		X	X	X	X		X
Peregrine Falcon	1	X	X		X		X	X	X	X	X	X
Gyrfalcon							X	X	X	X		
Ring-necked Pheasant	3	X		X		X	X					X
Blue Grouse	3		X	X	X	X						
Wild Turkey	3		X	X	X	X						
California Quail		X		X		X	X					X
Virginia Rail		X										
Sora		X										
American Coot	2,3	X						X				
Sandhill Crane	1	X					X	X				
Black-bellied Plover	2							X				
American Golden-Plover	2	X					X	X				
Pacific Golden-Plover	2	X					X	X				
Semipalmated Plover	2							X				
Killdeer	2	X					X	X				X
Black Oystercatcher	2								X			
Greater Yellowlegs	2	X						X	X			
Lesser Yellowlegs	2	X						X				
Solitary Sandpiper	2	X										
Wandering Tattler	2											
Spotted Sandpiper	2	X						X	X			
Whimbrel	2							X				
Ruddy Turnstone	2							X	X			
Black Turnstone	2							X	X			
Surfbird	2							X	X			
Sanderling	2							X				
Semipalmated Sandpiper	2							X				
Western Sandpiper	2	X						X				
Least Sandpiper	2	X						X				
Baird's Sandpiper	2	X						X				
Pectoral Sandpiper	2	X						X				
Dunlin	2	X					X	X				

Common Name	State PS	Herbaceous Wetlands, Ponds, Lakes	Wooded Wetlands, Streams	Aspen Woods	Conifer & Mixed Forest	Oak Woods & Balds	Dry Grassland, Cropland	Beaches & Tidal Flats	Rocky Shore	Sheltered Marine Waters	Open Marine Waters	Resi-dential
Short-billed Dowitcher	2							X				
Long-billed Dowitcher	2	X										
Wilson's Snipe	2	X	X									
Red-necked Phalarope	2									X	X	
Parasitic Jaeger										X	X	
Franklin's Gull								X		X		
Bonaparte's Gull								X	X	X	X	
Heermann's Gull								X	X	X	X	
Mew Gull		X					X	X	X	X		
Ring-billed Gull		X						X	X	X	X	X
California Gull		X						X	X	X	X	
Herring Gull		X						X	X	X	X	
Thayer's Gull		X						X	X	X	X	
Western Gull		X						X	X	X	X	X
Glaucous-winged Gull		X						X	X	X	X	X
Glaucous Gull								X	X	X	X	
Caspian Tern	2	X						X	X	X	X	
Common Tern	2								X	X	X	
Common Murre	1,2										X	
Pigeon Guillemot	2								X	X	X	
Marbled Murrelet	1,2									X	X	
Ancient Murrelet	2										X	
Cassin's Auklet	1,2											
Rhinoceros Auklet	2									X	X	
Tufted Puffin	1,2,3									X	X	
Rock Dove							X					X
Band-tailed Pigeon	3		X		X	X						X
Eurasian Collared-dove							X					X
Mourning Dove	3	X	X	X		X	X					X
Barn Owl		X					X	X	X	X		X
Western Screech-owl		X	X	X		X						X
Great Horned Owl		X	X	X	X	X	X					X
Snowy Owl		X					X	X				
Northern Pygmy-owl			X		X							
Barred Owl		X	X		X	X						

Common Name	State PS	Herbaceous Wetlands, Ponds, Lakes	Wooded Wetlands, Streams	Aspen Woods	Conifer & Mixed Forest	Oak Woods & Balds	Dry Grassland, Cropland	Beaches & Tidal Flats	Rocky Shore	Sheltered Marine Waters	Open Marine Waters	Resi-dential
Long-eared Owl		X	X	X	X	X	X					
Short-eared Owl		X					X	X				
Northern Saw-whet Owl			X	X	X	X						X
Common Nighthawk		X	X	X		X	X					
Black Swift		X						X	X			
Vaux's Swift	1	X	X	X	X	X	X	X	X			X
Anna's Hummingbird						X	X					X
Rufous Hummingbird		X	X	X	X	X						X
Belted Kingfisher		X	X					X	X	X		
Red-breasted Sapsucker			X	X	X	X						X
Downy Woodpecker			X	X		X						X
Hairy Woodpecker			X	X	X	X						
Northern Flicker			X	X	X	X	X					X
Pileated Woodpecker	1		X	X	X	X						
Olive-sided Flycatcher			X		X							
Western Wood-pewee			X	X	X	X	X					X
Willow Flycatcher			X			X						
Hammond's Flycatcher			X		X	X						
Pacific-slope Flycatcher			X	X	X	X						
Say's Phoebe							X					X
Western Kingbird							X					X
Horned Lark												
Purple Martin	1	X						X		X		
Tree Swallow		X	X	X		X	X	X	X	X		X
Violet-green Swallow		X		X		X	X	X	X	X		X
N. Rough-winged Swallow		X					X	X	X	X		X
Cliff Swallow		X					X	X	X	X		X
Barn Swallow		X					X	X	X	X		X
Steller's Jay			X		X							X
American Crow		X	X	X	X	X	X	X	X			X
Common Raven		X	X	X	X	X	X	X	X			X
Chestnut-backed Chickadee			X		X							X
Bushtit			X	X		X						X
Red-breasted Nuthatch			X	X	X	X						X
Brown Creeper			X	X	X	X						X

Common Name	State PS	Herbaceous Wetlands, Ponds, Lakes	Wooded Wetlands, Streams	Aspen Woods	Conifer & Mixed Forest	Oak Woods & Balds	Dry Grassland, Cropland	Beaches & Tidal Flats	Rocky Shore	Sheltered Marine Waters	Open Marine Waters	Resi-dential
Bewick's Wren		X	X			X			X			X
House Wren					X	X						
Pacific (Winter) Wren			X	X	X							
Marsh Wren		X										
American Dipper			X						X			
Golden-crowned Kinglet			X	X	X	X						
Ruby-crowned Kinglet		X	X	X	X	X						X
Western Bluebird				X		X	X					
Mountain Bluebird				X	X	X	X					
Townsend's Solitaire			X	X	X	X						
Swainson's Thrush			X	X	X	X						
Hermit Thrush			X	X	X	X						
American Robin		X	X	X	X	X	X	X	X			X
Varied Thrush					X	X						X
American Pipit		X					X	X				
Cedar Waxwing		X	X	X	X	X						X
Northern Shrike		X					X					
European Starling		X	X	X	X	X	X	X	X			X
Hutton's Vireo			X	X	X	X						X
Warbling Vireo			X	X		X						X
Cassin's Vireo				X		X						
Orange-crowned Warbler			X	X		X						X
Yellow Warbler			X	X								
Yellow-rumped Warbler		X	X	X	X	X						X
Black-throated Gray Warbler			X			X						
Townsend's Warbler			X	X	X	X						X
MacGillivray's Warbler			X	X	X	X						
Common Yellowthroat		X	X			X	X					
Wilson's Warbler			X		X	X						
Western Tanager			X	X	X	X						
Black-headed Grosbeak			X	X		X						X
Spotted Towhee			X	X		X						X
Chipping Sparrow				X		X	X					X
Vesper Sparrow							X					
Savannah Sparrow		X					X					X

Common Name	State PS	Herbaceous Wetlands, Ponds, Lakes	Wooded Wetlands, Streams	Aspen Woods	Conifer & Mixed Forest	Oak Woods & Balds	Dry Grassland, Cropland	Beaches & Tidal Flats	Rocky Shore	Sheltered Marine Waters	Open Marine Waters	Resi-dential
Fox Sparrow			X	X	X							X
Song Sparrow		X	X	X	X	X	X	X	X			X
Lincoln's Sparrow		X					X					
White-throated Sparrow												X
Golden-crowned Sparrow		X	X	X		X						X
White-crowned Sparrow		X				X	X					X
Dark-eyed Junco			X	X	X	X						X
Red-winged Blackbird		X					X	X	X			X
Western Meadowlark		X					X					
Brewer's Blackbird		X	X	X		X	X					X
Brown-headed Cowbird		X	X	X	X	X	X					X
Purple Finch			X	X	X	X						X
House Finch							X					X
Red Crossbill			X		X							
Pine Siskin			X	X	X	X						X
American Goldfinch		X	X	X		X	X					X
Evening Grosbeak			X		X							X
House Sparrow												X
Vagrant Shrew		X	X	X	X	X	X	X	X			X
Little Brown Myotis (Bat)		X	X	X	X	X	X	X		X		X
Yuma Myotis		X	X	X	X	X	X	X		X		X
Keen's Myotis		X	X	X	X	X	X	X		X		X
Long-eared Myotis		X	X	X	X	X	X	X		X		X
Long-legged Myotis		X	X	X	X	X	X	X		X		X
Californian Myotis		X	X	X	X	X	X	X		X		X
Silver-haired Bat		X	X	X	X	X	X	X		X		X
Big Brown Bat		X	X	X	X	X	X	X	X	X		X
Hoary Bat	1,2	X	X	X	X	X	X	X		X		X
Townsend's Big-eared Bat	1,2	X	X	X	X	X	X	X		X		X
European Rabbit	2						X					X
Townsend's Chipmunk	1,2		X		X	X						
Eastern Gray Squirrel						X						X
Eastern Fox Squirrel	1,2					X						X
Douglas' (Red) Squirrel					X							
Northern Flying Squirrel	3		X	X	X	X						

Common Name	State PS	Herbaceous Wetlands, Ponds, Lakes	Wooded Wetlands, Streams	Aspen Woods	Conifer & Mixed Forest	Oak Woods & Balds	Dry Grassland, Cropland	Beaches & Tidal Flats	Rocky Shore	Sheltered Marine Waters	Open Marine Waters	Resi-dential
American Beaver		X	X	X								X
Deer (White-footed) Mouse	2	X	X	X	X	X	X	X	X			X
Townsend's Vole	3	X	X			X	X	X	X			
Muskrat		X	X									
Black Rat												X
Norway Rat												X
House Mouse												X
Killer Whale (Orca)											X	
Harbor Porpoise											X	
Dall's Porpoise	2										X	
Gray Whale	1,2										X	
Red Fox		X	X	X		X	X					X
Steller's Sea Lion	1,2									X	X	
Raccoon		X	X	X	X	X	X	X	X			X
Mink	3	X	X	X	X	X	X	X	X			X
Northern River Otter		X	X	X	X	X		X	X		X	
Harbor Seal	2								X	X	X	
Black-tailed Deer	3	X	X	X	X	X	X	X	X			X
Western Painted Turtle		X	X									
Northern Alligator Lizard				X		X		X	X			X
Rubber Boa			X	X	X	X	X					
Sharptail Snake	1			X		X	X					X
W. Terrestrial Garter Snake		X	X	X		X	X	X	X	X		X
Northwestern Garter Snake		X	X	X		X	X	X	X			X
Common Garter Snake		X	X	X	X	X	X	X				X

Appendix 4-C. Plant species considered to be rare in SJC by the Washington Natural Heritage Program (September 2010)

Note: These are mainly species which are rare statewide*, nationally, or globally. Dozens of species not listed here are believed to be rare just in SJC as reported in Atkinson & Sharpe (1985), and could disappear entirely from the county's flora, thus losing an important regional subpopulation.
State Status: E= Endangered, T= Threatened, S= Sensitive, X= no longer present?
Federal Status: LT= Threatened, SC= Species of Concern

Scientific Name	Common Name	State Status	Federal Status	Habitat
Carex pauciflora	few-flowered sedge	S		Wetlands (acidic bogs) at Mt. Constitution
Castilleja levisecta	golden paintbrush	E	LT	Native grasslands
Crassula connata	erect pygmy-weed	T		shorelines
Eurybia merita	Arctic aster	S		near summit of Mt. Constitution
Isoetes nuttallii	Nuttall's quillwort	S		Wetlands (seasonally dry)
Lepidium oxycarpum	sharpfruited peppergrass	T		Wetlands (seasonally dry)
Liparis loeselii	twayblade	E		Wetlands (acidic bogs)
Lobelia dortmanna	water lobelia	T		Wetland, pond, and lake margins
Meconella oregana	white meconella	T	SC	Native grasslands, moist meadows
Microseris bigelovii	coast microseris	X		open moist dunes and damp shaded bluffs
Ophioglossum pusillum	Adder's-tongue	T		Wetlands (acidic bogs)
Orthocarpus bracteosus	rosy owl-clover	E		Native grasslands
Oxytropis campestris var. gracilis	slender crazyweed	S		Native grasslands, open woodlands
Potamogeton obtusifolius	blunt-leaved pondweed	S		Wetlands, ponds, lakes
Ranunculus californicus	California buttercup	T		Native grasslands and bluffs
Sericocarpus rigidus	white-top aster	S	SC	Native grasslands
Symphyotrichum boreale	rush aster	T		Wetlands (acidic bogs)
Utricularia minor	lesser bladderwort	R1		Wetlands, ponds, lakes

* In addition, *Centaurium (Zeltnera) muehlenbergii* is currently under consideration for State listing as Threatened.

Appendix 4-D. Plant communities for which high-quality examples are considered rare in SJC by the Washington Natural Heritage Program (September 2010)

Note: Communities in bold are particularly uncommon or threatened in SJC (R. Barsh, pers. comm.) and are not entirely within protected preserves. A significant omission from this list is quaking aspen (*Populus tremuloides*) which also is uncommon and threatened.
Context: FW= freshwater wetland, SW= saltwater wetland, G= native grassland, U= other upland

Common Name of Plant Community	Dominant Form	Context	Scientific Name
Red Alder / Salmonberry	shrub	FW	Alnus rubra / Rubus spectabilis
Sitka Sedge	herbaceous	FW	Carex aquatilis var. dives
Cusick's Sedge - (Sitka Sedge) / Sphagnum moss	herbaceous	FW	Carex cusickii - (Carex aquatilis var. dives) / Sphagnum spp.
Bighead Sedge	herbaceous	FW	Carex macrocephala
Slough Sedge	herbaceous	FW	Carex obnupta
Coastal Spit with Native Vegetation		G	
California Oatgrass Valley Grassland	herbaceous	G	Danthonia californica
Saltgrass - (Pickleweed)	herbaceous	SW	Distichlis spicata - (Salicornia virginica)
Roemer's Fescue - Field Chickweed - Prairie Junegrass	herbaceous	G	Festuca roemeri - Cerastium arvense - Koeleria macrantha
Red Fescue - Great Camas - Oregon Gumweed	herbaceous	FW	Festuca rubra - (Camassia leichtlinii, Grindelia stricta var. stricta)
Red Fescue - Silver Burweed	herbaceous	G	Festuca rubra - Ambrosia chamissonis
Lagoon: Hyperhaline and Euhaline	herbaceous	SW	
Common Marestail	herbaceous	FW	Hippuris vulgaris
Bog Labrador-tea - Bog-laurel / Sphagnum moss	shrub	FW	Ledum groenlandicum - Kalmia microphylla / Sphagnum spp.
Low Elevation Freshwater Wetland	herbaceous	FW	
Low Elevation Sphagnum Bog	herbaceous	FW	
Lagoon, Mesohaline and Oligohaline	herbaceous	SW	
North Pacific Herbaceous Bald and Bluff	herbaceous	G	
Yellow Pond-lily	herbaceous	FW	Nuphar lutea ssp. polysepala
Lodgepole Pine - Douglas-fir	forest	U	Pinus contorta - Pseudotsuga menziesii cover type
Lodgepole Pine Forest	forest	U	Pinus contorta cover type
Shore Pine - Douglas-fir / Salal	forest	U	Pinus contorta var. contorta / Gaultheria shallon
Shore Pine / Bog Labrador-tea / Sphagnum moss	shrub	FW	Pinus contorta var. contorta / Ledum groenlandicum / Sphagnum spp.

Common Name of Plant Community	Dominant Form	Context	Scientific Name
Douglas-fir - (Grand Fir, Western Red-cedar) / Dwarf Oregon-grape - Salal	forest	U	Pseudotsuga menziesii - (Abies grandis, Thuja plicata) / Mahonia nervosa - Gaultheria shallon
Douglas-fir - Grand Fir	forest	U	Pseudotsuga menziesii - Abies grandis cover type
Douglas-fir - Pacific Madrone / Salal	forest	U	Pseudotsuga menziesii - Arbutus menziesii / Gaultheria shallon
Douglas-fir - Pacific Madrone / American Purple Vetch	forest	U	Pseudotsuga menziesii - Arbutus menziesii / Vicia americana
Douglas-fir - Oregon White Oak / Common Snowberry	forest	U	Pseudotsuga menziesii - Quercus garryana / Symphoricarpos albus
Douglas-fir - Western Hemlock / Salal / Swordfern	forest	U	Pseudotsuga menziesii - Tsuga heterophylla / Gaultheria shallon / Polystichum munitum
Douglas-fir - Western Hemlock / Salal	forest	U	Pseudotsuga menziesii - Tsuga heterophylla / Gaultheria shallon
Douglas-fir - Western Hemlock / Oceanspray / Swordfern	forest	U	Pseudotsuga menziesii - Tsuga heterophylla / Holodiscus discolor / Polysticum munitum
Douglas-fir - Western Hemlock / Dwarf Oregongrape	forest	U	Pseudotsuga menziesii - Tsuga heterophylla / Mahonia nervosa
Douglas-fir / Salal - Oceanspray	forest	U	Pseudotsuga menziesii / Gaultheria shallon - Holodiscus discolor
Douglas-fir / Baldhip Rose - Oceanspray	forest	U	Pseudotsuga menziesii / Rosa gymnocarpa - Holodiscus discolor
Douglas-fir / Common Snowberry - Oceanspray	forest	U	Pseudotsuga menziesii / Symphoricarpos albus - Holodiscus discolor
Oregon White Oak / Long-stolon Sedge - Common Camas	forest	G	Quercus garryana / Carex inops - Camassia quamash
Pickleweed	herbaceous	SW	Salicornia virginica (depressa, maritima)
Low salt marsh, sandy, high salinity	herbaceous	SW	
Hard-stem Bulrush	herbaceous	FW	Schoenoplectus acutus
Douglas' Spirea / Sphagnum moss	shrub	FW	Spiraea douglasii / Sphagnum spp.
Western Redcedar - Grand Fir / Swordfern	forest	FW	Thuja plicata - Abies grandis / Polystichum munitum
Broad-leaf Cattail	herbaceous	FW	Typha (latifolia, angustifolia)

Appendix 4-E. Surface water quality from from WDOE's WQA database

Some additional data from the County and other sources is not included in this summary. Data were not based on temporally or geographically systematic sampling. Query the online WDOE database for details on locations, dates, and methods.

Parameter	# of samples	Average	Minimum	Maximum
Ammonia (mg/L)	36	3.05	0.05	5.43
Arsenic (µg/L)	4	0.17	0.10	0.26
Arsenic III (µg/L)	4	0.06	0.03	0.09
Cacodylic acid (µg/L)	4	0.05	0.05	0.05
Chlorophyll (µg/L)	5	8.52	0.92	32.40
Conductivity (µmhos/cm)	53	139.47	46.00	245.00
Dissolved Oxygen (mg/L)	323	8.78	0.20	19.30
Fecal Coliform (# of colonies/ 100 ml)	209	85.34	0.00	2000.00
Hardness as CaCO3 (mg/L)	3	45.00	36.00	58.00
Monomethylarsonic acid (MMA) (µg/L)	4	0.03	0.01	0.05
Nitrate (mg/L)	36	0.35	0.01	0.81
Ortho-phosphate (mg/L)	61	5.03	0.00	30.00
pH	323	7.83	6.20	10.10
Phosphorus (µg/L)	2	10.00	10.00	10.00
Total Inorganic Arsenic (µg/L)	4	0.06	0.04	0.08
Total Persulfate Nitrogen (mg/L)	8	0.48	0.03	1.20
Total Phosphorus (µg/L)	8	49.84	1.30	219.00
Turbidity (NTU)	217	6.23	0.00	38.90
Water transparency, Secchi disc (feet)	4	16.50	3.00	30.00

Appendix 4-F. Environment Summary Tables from GIS Compilation of Existing Spatial Data

Compiling the Best Available Science involves compiling information not only from published literature, but also from the best available spatial data (digital maps) that are available for a county or city and relevant to understanding the particular type of critical area being addressed. Accordingly, we used GIS to quantify (in tables) several environmental themes from existing maps. This is useful for understanding the gross structure in SJC of habitat and land use, and potential impacts to species. Available environmental data have been tabulated below by major island. At project completion tables will also be available compiling data by watershed and protected vs. non-protected lands. As with all such efforts, the reliability of the compiled information is no better than the quality of the original data. Much of that has significant constraints, many of which (when known) are noted in metadata files provided to the CD&P.

4F-1. Environment by Island

Appendix 4F-1.1 Land acres and shoreline length by island

Island	Acres	Shoreline Length (ft)
Shaw	4889	136276
Lopez	18995	334607
Decatur	2237	65704
Center	168	10576
Blakely	4302	64427
James	117	12332
Waldron	2905	58998
Jones	187	15802
Orcas	36991	407963
Crane	226	14214
Patos	208	19911
Little Sucia	15	4752
Sucia	552	62261
Matia	152	17980
Obstruction	220	15290
Stuart	1823	78597
Henry	999	57380
San Juan	35503	393849
Spieden	505	32467
Johns	222	22078
TOTAL	111214	1825465

Appendix 4F-1.2. Elevation by island

	Maximum	Average
Shaw	384	122
Lopez	534	137
Decatur	550	167
Center	172	77
Blakely	1040	435
James	272	103
Jones	197	66
Orcas	2409	488
Crane	155	68
Obstruction	255	113
Henry	311	84
San Juan	1075	195

Appendix 4F-1.3. Area (acres) in various slope categories by island

Islands not shown lacked LiDAR data used in this analysis.

PERCENT SLOPE	Shaw	Lopez	Decatur	Center	Blakely	James	Jones	Orcas	Crane	Obstruction	Henry	San Juan
0 percent	44	216	24	2	23	5	3	119	2	11	16	101
0-1 %	55	408	23	1	34	0	1	393	2	0	15	727
1-2 %	134	1042	58	3	63	0	2	765	5	1	33	1691
2-3 %	195	1402	82	5	71	1	3	962	7	2	42	2159
3-4 %	239	1523	96	6	70	1	4	1060	9	3	48	2317
4-5 %	263	1484	103	7	67	1	5	1102	10	4	52	2287
5-7 %	550	2603	209	16	131	3	12	2211	22	10	107	4149
7-10 %	779	2961	290	25	207	6	20	3173	32	20	146	5037
10-15 %	978	3068	375	34	389	12	31	4664	44	39	184	5807
15-20 %	582	1625	249	22	418	11	24	3862	29	37	113	3570
20-30 %	538	1368	291	23	779	18	30	5816	29	43	107	3659
>30 %	541	1322	440	23	2056	59	53	12914	35	48	135	4048

Appendix 4F-1.4. Number of buildings by island

Raw data provided by San Juan County, August 2010. No guarantee is made of its comprehensiveness or accuracy in all cases.

	Blakely	Center	Crane	Decatur	Lopez	Obstruction	Orcas	San Juan	Shaw	Stuart	Waldron	Total
Commercial	24	4			101	2	249	78	6			464
Residential	142	133	57	2	2060	41	3497	3749	238	2	1	9922
Town								1255				1255
Other	89	60	5	1	799	17	2088	2218	156	2		5435
Total	255	197	62	6	2960	60	5834	7302	401	4	1	17082

Appendix 4F-1.5. Length (miles) of road by island

Raw data provided by San Juan County, August 2010. No guarantee is made of its comprehensiveness or accuracy in all cases.

	Blakely	Center	Crane	Decatur	Henry	Lopez	Obstruction	Orcas	San Juan	Shaw	Stuart	Waldron	Total
Private roads	10.00	3.11	2.77	13.78	4.35	63.62	2.29	175.36	133.94	12.55	5.74	1.67	429.18
Public roads	0.00	0.00	0.00	7.57	0.00	68.75	0.00	87.13	109.89	14.23	3.20	4.54	295.30

Appendix 4F-1.6. Length (ft) of driveway by island

	Blakely	Center	Crane	Decatur	Lopez	Obstruction	Orcas	San Juan	Shaw	Stuart	Waldron	Total
Total	119916	21326	15227	981	772649	10609	1318354	1456265	130102	347	410	3846185

Appendix 4F-1.7. Estimated length (ft) of perennial and possible intermittent streams by island

Based on automated interpretation of LiDAR topographic imagery. Not field-verified.

	Blakely	Center	Crane	Decatur	Henry	James	Jones	Lopez	Obstruction	Orcas	San Juan	Shaw	Total
Perennial or Higher Confidence Intermittent	138404	2116	4036	50909	9633		2156	494449	1771	1262696	1106616	121511	3194298
Low Confidence Intermittent	102277	361	3399	58315	17092	1474	1372	520875	285	1097802	1041787	105039	2950079
Total	240682	2478	7435	109224	26725	1474	3528	1015324	2057	2360498	2148403	226550	6144377

Appendix 4F-1.8. Acreage of mapped ponds and lakes by size category and island

Raw data provided by San Juan County, August 2010. Many small ponds are known to be missing from these data.

	All ponds and lakes			Ponds 5-20 acres			Lakes (>20 acres)		
	Count	Sum of Acres	Average Acres	Count	Sum of Acres	Average Acres	Count	Sum of Acres	Average Acres
Blakely	3	144	48				2	70	140
Crane	1	0	0						
Decatur	6	6	1						
Henry	4	2	0						
Lopez	117	81	1				1	34	
Orcas	305	663	2	9	11	96	4	105	34
San Juan	503	668	1	13	10	133	6	46	421
Shaw	44	32	1	2	7	13			278
Stuart	4	1	0						
Waldron	20	19	1	1	12	12			
Grand Total	1007	1616	2						

Appendix 4F-1.9. Lithology of major islands (acres, by type of rock or deposit)

Raw data provided by San Juan County, August 2010.

Type of Rock or Deposit	Blakely	Decatur	Henry	Lopez	Orcas	San Juan	Shaw	Spieden	Stuart	Sucia	Waldron
advance continental glacial outwash, Fraser-age				116.9			50.27				
alluvium						71.46					17.65
artificial fill, including modified land						5.48					
basalt flows		51.25		783.28							
beach deposits	23.6	60.84	42.96	135.42	65.68	35.71	28.88		83.9		88.62
chert-rich marine sedimentary rocks					4549.39		316.52				
continental glacial drift, Fraser-age	292.06		130.68	1692.69	5322.09	8132.24	309.24		9.61	100.63	1889
continental glacial outwash, Fraser-age				725.24							
continental glacial outwash, marine, Fraser-age					1343.84	477.41					
continental glacial till, Fraser-age	64.03	818.08	46.55	6517.98	1289.09	4102.33	530.96				
continental sedimentary deposits or rocks										399.91	
dune sand				7.55		21.02					
glacial and non-glacial deposits, undivided		5.51									
glaciomarine drift, Fraser-age		188.73		4542.58		3096.91	91.46				
intrusive rocks, undivided	3681.18	60.12	7.09		8335.58	137.83					
marine metasedimentary rocks			12.22	31.76	784.89	13725.46					
marine sedimentary rocks	55.18	1026.3		1356.57	9670.34	729.07	3408.12			34.39	
mass-wasting deposits, mostly landslides		6.92									
metasedimentary and metavolcanic rocks, undivided			1.1		476.44						
metasedimentary rocks, chert-bearing			742.83		20.13	2921.16	129.79				
metasedimentary rocks, cherty						763.22					
metavolcanic rocks				2750.91		505.91					
nearshore sedimentary rocks					164.18	75.34		496.61	1700.86		877.29
peat deposits				164.28		23.98					
schist, low grade						159.81					
tectonic zone	30.7			29.13	190.62						
tonalite				14.43		8.56					
volcanic and sedimentary rocks					4080.35						
volcanic rocks					131.7						
water	134.48	2.16		41.4	476.17	373.74					
Total	4281.23	2219.91	983.43	18910.12	36900.49	35366.64	4865.24	496.61	1794.37	534.93	2872.56

Appendix 4F-1.10. Public and other lands protected for conservation

Raw data provided by San Juan County, August 2010.

	Blakely	Crane	Decatur	Henry	Johns	Lopez	Orcas	San Juan	Shaw	Stuart	Sucia	Waldron	others	Total
Land Bank - Fully Built Out Conservation Easements				20.59		100.46	248.85	310.49				218.86	0	899.25
Land Bank Preserve						171.35	2184.53	762.46					0	3118.34
San Juan County Parks						44.64	1	19.23	17.63				0	82.5
San Juan Preservation Trust - Fully Protected Conservation Easement	60.35	16.74	11.76	32.14		809.41	1468.35	899.29	474	77.97		55.92	0	3905.93
San Juan Preservation Trust Preserve			112.74	41.18		140.14	281.66	474.32	256.86	115.4		437.72	0	1860.02
WDNR							76.39						0	76.39
WDFW	0	0	0	0	0	5.07	145.1	0	0	0	0	0	0	150.17
Washington Parks & Rec	0	0	0	0	5.75	58.26	672.46	40.11	0	0	0	0	0	776.58
State Lands DIvision	195.46					259.27	4811.51	437.54		85.13	551.95		136.58	6477.44
The Nature Conservancy												476.78	0	476.78
US Coast Guard						23.97							0	23.97
US-BLM						368.79							0	368.79
US government (other)				62.14		64.17		1706.36		74.12			546.8	2453.59
Univ. Washington								365.1					0	365.1
Protected Acres	255.81	16.74	124.5	156.05	5.75	2045.53	9889.85	5014.9	748.49	352.62	551.95	1189.28	683.38	21034.85
Island Acres	4302.13	225.68	2236.53	999.11	221.81	18995.22	36990.63	35503.29	4888.69	1822.68	551.96	2904.99	846.62	110489.34
% protected	6%	7%	6%	16%	3%	11%	27%	14%	15%	19%	100%	41%	81%	19%

Appendix 4F-1.11. Landscape disturbance scores assigned by Jacobson (2008) based mainly on maps of 1990's land use and current road density

See section 4.3.1.5 for description of Jacobson's Local Habitat Assessment for SJC. Units shown in this table are number of pixels (equal-sized land units) having that disturbance score. Disturbance scores were calculated based only on road density and assumed intensity of land use.

Potential Disturbance	Blakely	Center	Crane	Decatur	Henry	Johns	Jones	Lopez	Obstruction	Orcas	Patos	San Juan	Shaw	Spieden	Stuart	Sucia	Waldron
1 MOST								2		21		226					
2								76		210		462	1				
3	19			145				795		1505		1858	72		20		13
4	61	35	20	107	10			737	1	1610		1008	186		61		83
5	59	8	9	3	15	1		1706	3	663		1915	81	37	5		80
6	48			9	25	5	0	2766		923		4777	29		4	1	2
7	3		5	181	3	2		661		1562		1959	128	13	53		11
8	83	1	4	850	25	8		5245		10376	0	8414	1439	257	351	2	423
9	1945	121	184	837	590			5820	203	13965		11701	2117		979		1043
10	1911			62	306	197	183	952	2	5437	200	2526	747	188	308	537	1229
1 1 LEAST	139		0	4	1			61		549		499	13				
	4267	165	222	2198	975	212	183	18822	209	36821	200	35345	4812	495	1782	539	2885