Chapter 4. Biological Environment

This chapter addresses the biological resources and habitats found on the Refuge and the Unit. However, it is not an exhaustive review of all species and habitats. The chapter begins with a discussion of biological integrity (historic conditions and ecosystem function), as required under the Refuge Administration Act. The bulk of the chapter focuses on the presentation of pertinent background information for habitats used by each of the priority Resources of Concern (ROCs) and other benefitting species identified in the CCP (see Tables 4-1a and b).

ROCs are plant and animal species and their habitats that have been identified by a refuge through its refuge purpose or other conservation plan to receive special or enhanced management attention; these become the conservation targets for the CCP’s goals, objectives, and strategies. A priority ROC requires an even higher level of attention and management. Focal resources are species or species groups sharing the same or similar conservation needs as the priority ROC and selected by a refuge as representatives for the overall condition of the priority ROC. Species of concern (SOCs) are plant and animal species that are declining or appear to be in need of conservation. Their status is determined by the Service’s fish and wildlife office in a particular state, but the category is informal and confers no legal status under the ESA.

The background information includes descriptions, conditions, and trends of habitats and identifies threats (stresses and sources of stress) to the habitats or associated ROCs. This information was used to develop goals and objectives for the CCP.

4.1 Biological Integrity, Diversity, and Environmental Health

The National Wildlife Refuge System Improvement Act of 1997 directs the U.S. Fish and Wildlife Service to ensure that the biological integrity, diversity, and environmental health of the National Wildlife Refuge System (Refuge System) are maintained for the benefit of present and future generations of Americans. To meet this mandate, the Service developed a Biological Integrity, Diversity, and Environmental Health (BIDEH) Policy to provide implementation guidance (see policy 601 FW 3).

Elements of BIDEH are represented by native fish, wildlife, plants, and their habitats as well as those ecological processes that support them. The Refuge System policy on BIDEH provides guidance for consideration and protection of the broad spectrum of fish, wildlife, and habitat resources that represent BIDEH on refuges and in associated ecosystems. This policy provides refuges with a process for evaluating the best management direction to prevent the additional degradation of environmental conditions and to restore lost or severely degraded environmental components. It also provides guidelines for dealing with external threats to the BIDEH of a refuge and its ecosystems. The Refuge and the Unit developed BIDEH tables to examine the habitats supporting key fish and wildlife species (see Appendix E for the BIDEH tables).
4.1.1 Historical Land Use and Conditions

Grays Harbor National Wildlife Refuge

The Refuge manages approximately 1,500 acres within the 60,160-acre Grays Harbor estuary. Grays Harbor estuary is located between the mouth of the Chehalis River and the Pacific Ocean. The Refuge encompasses Bowerman Basin and is bounded to the north by uplands and rip-rap along State Highway 109, the south by Bowerman Airport, and the east by industrial lands. The primary habitat type is an estuarine ecosystem composed of open water, intertidal mudflats, salt and brackish marsh, and surrounding forest habitats (Map 2).

The biological integrity and health of the entire estuary has been significantly influenced by human activities. Prior to 1941 and the construction of Bowerman Airfield, the area was a contiguous part of the larger estuary. In the wide-open intertidal mudflats and open water was Moon Island; Mini-moon Island did not exist, nor did Paulson Road or Airport Way. Salt marshes surrounded the edge of the mudflats.

In order to construct Bowerman Airfield in 1941 and 1942, a long bulkhead connecting to Moon Island was filled with rocks, soil, and dredge spoils. Fill continued to be placed on the mudflats east of the bulkhead converting it to higher elevation land. The constructed bulkhead and fill created a peninsula and transformed open water and intertidal mudflats into a protected basin. An industrial area was subsequently developed (CH2M HILL 1979) to the east and southeast. Unconfined dredge spoil disposal continued near Paulson Road until 1972 (Cooper 1989). A berm was constructed extending from State Highway 109 near Bi-Pass Road toward Paulson Road and Airport Way to confine dredge deposits placed between 1973 and 1976 on what were then City of Hoquiam lands (Cooper 1989, NOAA 1987). The dredge fill and resulting airport peninsula confined water entry and exit to the western end of the basin (Kunze and Cornelius 1985, Cooper 1989). Long-term impacts from these significant changes in the landscape require further information and research.

Historically, dioxin and fecal coliform bacteria are contaminants identified as problematic in the greater estuary. Eight pulp mills violated water quality standards by discharging dioxin-contaminated effluent and sludge (USEPA 1992). The Refuge is located in a site where contamination may have occurred from dredge spoils, industrial waste, ship discharges, urban waste, agricultural residue, and general runoff (Chapter 3.8).

Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge

The Black River is a 25-mile long tributary of the Chehalis River, which drains a 144-square-mile basin. It flows from Black Lake at an elevation of 144 feet to the confluence with the Chehalis River at an elevation of 125 feet (Smith and Wegner 2001). The river has a very low gradient (averaging 9 inches/mile) within an oversized channel (Easterly and Salstrom 2008).

The Unit manages over 1,300 acres within the 3,900-acre approved boundary encompassing the upper third of the river, extending from the southern edge of Black Lake to approximately river mile 17.5 just south of 123rd Avenue. Habitats include approximately 7.5 miles of river channel, 6 to 16 miles of tributary channels; bog; shrub swamp; riparian forest; emergent marsh; seasonally flooded, nonnative grasslands; dry, nonnative grasslands; and mixed forest (see Map 5). The surrounding
landscape is primarily rural and includes large areas of commercial forest and agriculture, areas of low- to high-density development, and some small industrial development.

The lands within the approved Unit boundary appear relatively less impacted by human activities compared to other low-elevation river systems in the Puget Trough region. However, human activities since European settlement have substantially affected many of the habitats within and adjacent to the current boundary.

Some historically forested habitats were modified for agricultural purposes. For example, within the current Unit boundary, some uplands historically dominated by Douglas-fir and western hemlock forest were modified for agricultural purposes and converted to pastures, hayfields, and crop fields. Several of these areas were former dairy farms at the time of Unit acquisition (Easterly and Salstrom 2008).

The Black River originates from Black Lake, but its historic regime has been altered. In 1922, an approximately 3.4-mile ditch was constructed to connect the north end of Black Lake to what is now Capital Lake, at the southern end of Puget Sound. This additional drainage, which has continued to deepen through subsequent excavations, has lowered the lake level by 2 feet and altered the flow such that the lake seldom drains south into Black River. This loss of water has reduced the flow in the river, especially from October through March, which in turn increases water temperature, decreases DO levels, and concentrates toxins (Smith and Wenger 2001).

In the 1960s a gas pipeline was excavated across the Black River and its riparian zone about 1.5 miles downstream from the lake. Excavated spoils were sidecast. The line of spoils has supported altered vegetation, which in turn encouraged beaver dam building activity and debris accumulation. The berm may have created a blockage for fish access upstream from this point, as well as contributed to the reversal of flow in the wetlands of the upper Black River (Smith and Wenger 2001). Documentation of river dredging was not found, but anecdotal information described deepening of the river both above and below Littlerock to allow ferrying of people and products in the early 1900s (Westby, L. 2011, pers. comm.). Currently the river appears to be over 10 feet deep in areas with very steep, undercut sides that are unstable.

Two public roads cross the northern third of the Black River and associated wetlands within the approved boundary: 110th Avenue SW and 123rd Avenue SW. In both cases, the roads constrict the river’s flow. This alters both water flow and connectivity within the wetlands. The roads may influence water quality by increasing sediment and pollutant delivery and can be points of introduction for nonnative species. The physical changes imposed on various parts of the river can be observed, but the effects on the biological integrity and environmental health may not be easily observed or understood without further research and monitoring.

Surface and groundwater availability have also been altered in the Black River system. Various parts of the floodplain have been ditched, drained, cleared, and/or filled in the past primarily in connection with agricultural use. Blooms Ditch drains into the river on the Unit from the east. The implications of such ditches to the habitat are that they reduce surface flooding during the rainy season and effectively reduce seepage into the aquifer. Overall, they may alter the quantity and timing of surface flow into the river, its tributaries, and riparian systems.
Some forestry practices to the west and some agriculture practices to the east of the river may have increased sediment and nutrient loads. These activities have impacted native habitats and may have introduced populations of invasive, nonnative species.

Land use near the Unit has been changing, with increased residential and commercial development. These changes likely will result in greater amounts of well drilling and groundwater removal from the system.

### 4.2 Selection of Priority Resources of Concern

In preparing this plan, the planning team reviewed other local, regional, and national plans that pertain to wildlife and habitats within the Chehalis River Basin and southwest Washington. The team also sought input from Washington State conservation agencies, NGOs, and the public (see Appendix J). As a result of this information-gathering and review process, certain species and habitats were identified and listed in Biological Resources of Concern and BIDEH tables (see Appendix E). Wildlife and habitat goals and objectives in Chapter 2 were designed directly around the habitat requirements of species designated as priority ROCs (see Tables 4-1a and b).

ROC
tes described as conservation targets in conservation planning methodologies used by other agencies and NGOs. In developing objectives, the team followed the process outlined in the Service’s Identifying Refuge Resources of Concern and Management Priorities: A Handbook (USFWS 2010a). As defined in the Service’s Policy on Habitat Management Plans (620 FW 1), ROCs are:

> “all plant and/or animal species, species groups, or communities specifically identified in refuge purpose(s), System mission, or international, national, regional, state, or ecosystem conservation plans or acts. For example, waterfowl and shorebirds are a resource of concern on a refuge whose purpose is to protect ‘migrating waterfowl and shorebirds.’ Federal or State threatened and endangered species on that same refuge are also a resource of concern under terms of the respective endangered species acts” (620 FW 1.4G).

> “Habitats or plant communities are resources of concern when they are specifically identified in refuge purposes, when they support species or species groups identified in refuge purposes, when they support NWRS resources of concern, and/or when they are important in the maintenance or restoration of biological integrity, diversity, and environmental health” (620 FW 1).

Therefore, ROCs for a refuge may be a species or species group, or the habitat or plant community that supports a priority species or species group.

In further refining the extensive ROC tables and using the BIDEH table to create the priority ROCs with focal resources (see Tables 4-1a and b), the planning team analyzed the ecological attributes of the habitats to meet the life history requirements of ROCs. Those attributes are therefore critical to sustaining the long-term viability of the priority ROCs and other benefitting species. These provide measurable indicators that strongly correlate with the ability of a habitat to support a given species. Tables listing the habitat types found on the Refuge incorporate “desired” conditions based on scientific literature review and team members’ professional judgment. These desired conditions for specific ecological attributes were then used to help develop habitat objectives, as presented in
Chapter 2. However, other factors, such as feasibility and the Refuge’s ability to reasonably influence or measure certain indicators, played a role in determining the ultimate parameters chosen for each habitat objective. Thus, ecological attributes should be viewed as a step in the planning process. The ultimate design of habitat objectives was subject to further discussion and consideration.

Additionally, the planning team refined the species or species groups included in the ROC tables by selecting not only species mentioned in establishing documents for the Refuge and the Unit, but also species that captured the ecological attributes of habitats required by larger suites of species (see “Other Benefitting Species,” Tables 4-1a and b and in Appendix E). Priority ROCs may be species, species groups, or features that the Refuge and the Unit will actively manage to conserve and restore during the life of the CCP. Negative features of the landscape, such as invasive plants, may demand a large part of the Refuge’s and the Unit’s management efforts, but are not designated as ROCs.

Limiting factors were considered in developing objectives. A limiting factor is a threat to, or an impairment or degradation of, the natural processes responsible for creating and maintaining plant and animal communities. In developing objectives and strategies, the team gave priority to mitigating or abating limiting factors that presented high risk to ROCs. In many cases, limiting factors occur on a regional or landscape scale and are beyond the control of individual refuges. Therefore, objectives and strategies may seek to mimic, rather than restore, natural processes. In some cases the structure of plant communities utilized by ROCs can be created, rather than restoring the original native species composition. For example, management of nonnative vegetation by mowing and/or grazing may be necessary to maintain a desirable vegetation structure, when restoring native grassland communities may be impractical. Through the consideration of BIDEH, the Refuge and the Unit will provide for or maintain all appropriate native habitats and species. Refuge and Unit management priorities may change over time, and because the CCP is designed to be a living, flexible document, changes will be made if needed.

The main criteria for selecting priority ROCs included the following requirements:

- The resource must be reflective of the Refuge’s or the Unit’s establishing purposes and the Refuge System mission;
- The resource must include the main natural habitat types found at the Refuge and the Unit;
- The resource must be recommended as a conservation priority in the Refuge Wildlife and Habitat Management Review; and
- The resource is federally or State-listed as threatened or endangered, is a candidate for listing, or is a species of concern.

Other criteria considered in the selection of the ROCs included the following:

- Species groups and/or Refuge or Unit features of special management concern;
- Species contributing to the BIDEH of the ecosystem;
- Species where it is feasible to estimate population size (needed for future monitoring and adaptive management).
### Table 4-1a. Priority Resources of Concern with Focal Resources and Other Benefitting Species—Grays Harbor Refuge

<table>
<thead>
<tr>
<th>Priority Resources of Concern</th>
<th>Focal Resources</th>
<th>Other Benefitting Species</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tidal Open Water</strong></td>
<td>Bufflehead</td>
<td><strong>Concentrations of diving</strong> waterfowl such as scap species, red-breasted and common merganser, goldeneye species, scoter species; some dabbling ducks such as northern pintail, mallard, gadwall, green-winged teal, northern shoveler; geese such as Canada, cackling, white-fronted, brant; waterbirds such as loon species, cormorant species, grebe species, brown pelican, gull species; bald eagle, osprey; many fish species such as juvenile and adult flat fish, forage fish, salmonids, green sturgeon, bull trout, eulachon; mammals such as harbor seal, marine invertebrates, zooplankton, phytoplankton, algae**</td>
</tr>
<tr>
<td><strong>Native eelgrass</strong></td>
<td></td>
<td><strong>Fish species, especially those laying eggs on eelgrass, juvenile salmonids; benthic and other marine invertebrates including Dungeness crab, soft-shell clams; brant</strong></td>
</tr>
<tr>
<td><strong>Western sandpiper</strong></td>
<td></td>
<td><strong>Slightly probing shorebirds such as dunlin, least and semipalmated sandpiper; raptors such as peregrine falcon, merlin, bald eagle; benthic and water column invertebrates</strong></td>
</tr>
<tr>
<td><strong>Short-billed dowitcher</strong></td>
<td></td>
<td><strong>Moderately deep-probing shorebirds such as red knot, whimbrel, marbled godwit, long-billed curlew, yellowlegs species, long-billed dowitcher; raptors such as peregrine falcon, merlin, bald eagle; benthic and water column invertebrates</strong></td>
</tr>
<tr>
<td><strong>Semipalmated plover</strong></td>
<td></td>
<td><strong>Visually foraging shorebirds such as black-bellied plover, golden plover species; raptors such as peregrine falcon, merlin, bald eagle; benthic and water column invertebrates</strong></td>
</tr>
<tr>
<td><strong>Benthic invertebrates</strong></td>
<td></td>
<td><strong>Shorebirds; waterbirds; mink; otter; fish</strong></td>
</tr>
<tr>
<td><strong>Caspian tern</strong></td>
<td></td>
<td><strong>Gull species including glaucous-winged, western, mew, ring-billed; raptors such as peregrine falcon, merlin, bald eagle, osprey; fish species; benthic and water column invertebrates</strong></td>
</tr>
<tr>
<td><strong>American wigeon</strong></td>
<td></td>
<td><strong>Concentrations of dabbling waterfowl such as</strong></td>
</tr>
</tbody>
</table>
## Priority Resources of Concern | Focal Resources | Other Benefitting Species
--- | --- | ---
Salt and Brackish Marsh (156 acres) | Marsh wren | northern pintail, mallard, gadwall, green-winged teal, northern shoveler; geese such as Canada, cackling, white-fronted; waterbirds such as double-crested cormorant, gulls; harbor seal; juvenile and possibly adult fish including salmon species; benthic and water column invertebrates
Fish | Juvenile fish such as flat fish, forage fish, salmonids, eulachon, bull trout, green sturgeon; terrestrial insects; benthic and water column invertebrates
Sweetgrass (3-square bulrush) | Native salt marsh vegetation; juvenile fish; benthic and water column invertebrates; possibly Newcomb’s littorine snail
Representatives of High, Mid & and Low Salt Marsh plant species. | All plant species of the salt marsh; benthic and water column invertebrates; juvenile fish; passerines; shorebirds; waterfowl; waterbirds
Forest (95 acres) | Yellow Warbler/Yellow-rumped Warbler | Downy woodpecker, rufous hummingbird, willow flycatcher, Pacific-slope flycatcher, black-capped chickadee, tree-, barn-, and violet-green swallows, Bewick’s wren, Wilson’s and orange-crowned warblers, common yellowthroat, American robin, cedar waxwing, song and fox sparrows, American goldfinch;
### Priority Resources of Concern with Focal Species and Other Benefitting Species—Black River Unit

<table>
<thead>
<tr>
<th>Priority Resources of Concern</th>
<th>Focal Resources</th>
<th>Other Benefitting Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Channel and Tributary Channels with mud bottom (7.5 miles of river and 3 to 13 miles of tributaries)</td>
<td>Olympic mudminnow</td>
<td>Cooper’s and sharp-shinned hawk; long- and short-tailed weasel; black-tailed deer; garter snake species; Pacific chorus frog; amphibians; invertebrates; insects</td>
</tr>
<tr>
<td>Tributary Channel with cobble bottom (&lt;3 miles)</td>
<td>Coho salmon</td>
<td>Oregon spotted frog, red-legged frog, rough-skinned newt, northwest and long-toed salamanders; pied-billed grebe; belted kingfisher, green heron; three-spined stickleback, prickly sculpin; benthic and aquatic invertebrates, including freshwater mussels; insects such as Pacific clubtail dragonfly; freshwater sponge species; bat species; mink, muskrat, otter, beaver; possibly water howellia</td>
</tr>
<tr>
<td>Native crayfish</td>
<td></td>
<td>Bat species; great blue and green herons; mink, muskrat</td>
</tr>
<tr>
<td>Bog (56 acres)</td>
<td>Bog plants such as Labrador tea/sphagnum moss</td>
<td>Western bog laurel, bog cranberry, sundew, bog orchids, cotton grass, possibly water howellia</td>
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<tr>
<td></td>
<td></td>
<td>Bog specialists including invertebrates such as Beller’s ground beetle, Hatch’s click beetle, Queen Charlotte’s copper butterfly</td>
</tr>
<tr>
<td>Shrub Swamp (512 acres)</td>
<td>Willow/Pacific slope flycatcher</td>
<td>Downy woodpecker, marsh wren, flycatcher species, warblers such as McGillivray’s-, Wilson’s-, orange-crowned-, yellow-rumped, and common yellowthroat; song sparrow; belted kingfisher; pollinator insects</td>
</tr>
<tr>
<td></td>
<td>Olympic mudminnow</td>
<td>Pacific chorus frog, rough-skinned newt, northwest and long-toed salamander</td>
</tr>
<tr>
<td></td>
<td>Muskrat</td>
<td>Bat species; mink, otter, beaver, raccoon; benthic and aquatic invertebrates; possibly water howellia</td>
</tr>
</tbody>
</table>

(All habitat types are GIS acres)
<table>
<thead>
<tr>
<th>Priority Resource of Concern</th>
<th>Focal Resources</th>
<th>Other Benefitting Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Riparian Forest (265 acres)</td>
<td>Yellow warbler</td>
<td>McGillivray’s-, Wilson’s-, orange-crowned, black-throated gray, and yellow-rumped warblers; warbling vireo, American robin, spotted towhee, purple finch, song and fox sparrows, black-headed grosbeak, Bewick’s and winter wrens, cedar waxwing, red-breasted sapsucker; wood duck, hooded merganser; sharp-shinned and Cooper’s hawks; rufous hummingbird; belted kingfisher; pollinator insects</td>
</tr>
<tr>
<td>Swainson’s thrush/Downy woodpecker</td>
<td>Bat species; mice, shrew, vole, mole, flying squirrel, mink, raccoon, long and short-tailed weasel, opossum; red fox, coyote, bobcat, black bear, cougar</td>
<td></td>
</tr>
<tr>
<td>Pacific chorus frog</td>
<td>Rough-skinned newt, western red-backed salamander, northwest and long-toed salamanders; garter snake species; aquatic invertebrates; possibly water howellia</td>
<td></td>
</tr>
<tr>
<td>Emergent Marsh (34 acres)</td>
<td>Oregon spotted frog/Northwestern salamander</td>
<td>Benthic and aquatic invertebrates; pollinator insects; possibly water howellia; possibly Olympic mudminnow; bat species; mink, muskrat; Pacific chorus frog, red-legged frog, rough-skinned newt, northwest, and long-toed salamanders; garter snake, other snake species</td>
</tr>
<tr>
<td>Marsh wren</td>
<td>American bittern, Virginia rail, sora, Wilson’s snipe, great blue and green heron; pied-billed grebe; northern harrier; swallows, red-winged blackbird; dabbling waterfowl such as mallard, American wigeon, northern shoveler, northern pintail, American green-winged, blue-winged, cinnamon teal, coot, geese</td>
<td></td>
</tr>
<tr>
<td>Red-legged frog</td>
<td>Rough-skinned newt, northwest and long-toed salamanders; benthic and aquatic invertebrates; bats; mink, muskrat</td>
<td></td>
</tr>
<tr>
<td>Seasonally Flooded Nonnative Grasslands (82 acres)</td>
<td>Mallard</td>
<td>Dabbling waterfowl such as American wigeon, northern shoveler, northern pintail, American green-winged, blue-winged, and cinnamon teal, coot, Canada and cackling geese; purple martin, tree-violet-green, and rough-winged swallow; northern harrier; red-winged blackbird; sora, Virginia rail, American bittern</td>
</tr>
<tr>
<td>Priority Resource of Concern</td>
<td>Focal Resources</td>
<td>Other Benefitting Species</td>
</tr>
<tr>
<td>-----------------------------</td>
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</tr>
<tr>
<td>Killdeer</td>
<td>Killdeer in moist, short-grass areas</td>
<td>Wilson’s snipe, greater yellowlegs; migrating shorebirds; northern harrier; cackling and Canada geese; mice, shrew, vole, mole; bat species; garter snake species; freshwater and terrestrial invertebrates</td>
</tr>
<tr>
<td>Savannah sparrow</td>
<td>Western meadowlark, lazuli bunting, western bluebird; killdeer; common nighthawk, red-tailed hawk, American kestrel; Canada and cackling goose; western screech owl, barn owl, possibly short-eared owl, possibly northern shrike</td>
<td></td>
</tr>
<tr>
<td>American kestrel</td>
<td>Bat species; mice, vole, mole; weasel, spotted skunk; snake species, northern alligator lizard; pollinator insects; Roosevelt elk, black-tailed deer; coyote</td>
<td></td>
</tr>
<tr>
<td>Early–mid successional forest without understory</td>
<td>Black-capped chickadee</td>
<td>Yellow-rumped and orange-crowned warbler, white-crowned and song sparrow, rufous-sided towhee, dark-eyed junco, Steller’s jay, crow species; butterfly and moth species; garter snake species, northern alligator lizard; western red-backed salamander; mice, shrew, vole; bat species; weasel, opossum, raccoon, spotted skunk; coyote, bobcat, black bear, cougar; Roosevelt elk, black-tailed deer</td>
</tr>
<tr>
<td>Mid–mature successional forest with understory:</td>
<td>Chestnut-backed chickadee/Pileated woodpecker/Douglas squirrel/Varied thrush</td>
<td>Band-tailed pigeon; bald eagle, Cooper’s and sharp-shinned hawk, western screech-, northern saw-whet-, and great horned owl; Vaux’s swift, winter wren, Pacific-slope flycatcher, brown creeper, Townsend’s warbler, hermit thrush, Steller’s jay; snake species; Townsend’s chipmunk, Douglas squirrel, flying squirrel; spotted skunk; bat species; weasels; mice, shrew, voles; opossum; coyote, bobcat, black bear, cougar; Roosevelt elk, black-tailed deer; Northern possibly spotted owl</td>
</tr>
</tbody>
</table>

(All habitat types are GIS acres)
4.3 Habitat Types

Grays Harbor National Wildlife Refuge

4.3.1 Tidal Open Water

Overview

Approximately 723 acres of tidal open water habitat is located in the western portion of the Refuge. This habitat is inundated continually with marine waters, regardless of tide level. Salinity ranges from 10 to 25 ppt depending upon the time of year. In winter during intense rain events, salinity levels can drop because of large freshwater inputs from rivers and tributaries as well as from direct precipitation. In summer during periods of little rain, salinity rises due to decreased watershed drainage and increased evaporation. Phytoplankton, zooplankton, algae, and invertebrates thrive within this habitat.

Native eelgrass beds may exist where physical substrate characteristics are appropriate. However, rooted aquatic plants can be scarce in the main channels because of water depth, difficulty in photosynthesizing in turbid conditions, and strong, erosive currents.

Submerged tidal channels deliver oceanic nutrients and plankton to the tidal flats during high tides. The channels provide a route for fish to access the intertidal mudflats and cover from large predators during low tides (Coastal Resources Alliance 2007). Large woody debris (LWD), such as entire trees, branches, or root wads carried by tides and rivers, is distributed in the open water and may become waterlogged and sink to the bottom; such woody debris captures sediments and provides underwater cover for fish and invertebrates.

Ideally, water quality should be high, relatively free of contamination, pollution, and turbidity. Nonnative or invasive animals and plants should be at a minimum.

Regional Distribution, Conditions, and Trends of Tidal Open Water

Along the Pacific coastline, Grays Harbor is a 94-square-mile coastal estuary of hemispheric significance to migrating shorebirds and regional importance to a variety of fish and wildlife species (see Special Designation Lands 1.8). The tidal open water of the Refuge provides 723 acres for thousands of migrating birds needing food and rest. Tidal open water habitat accounts for nearly 50 percent of the overall Refuge area.

Water quality, invasive species, and climate change have and could compromise the ecological integrity of this habitat and its inhabitants. The primary threats to this habitat come from nearby pollution sources; heavy industries may contribute air and noise pollution, but water pollution is the largest threat. Ocean-going shipping vessels and barge traffic pass next to the Refuge and present a potential for grounding or possible fuel spills. Upstream, heavy industries, such as a pulp mill and storage facilities for oil and gas, may release pollutants or cause an accident that could impair the open water habitat. Ship hulls provide growing surfaces for plants and invertebrates from other areas of the world, and ballast water may include nonnative plankton, algae, and invertebrates. Establishment of nonnative plants and animals in Refuge open water habitat is likely and would
negatively impact native habitat, fish, and wildlife species. Sea level rise will increase this habitat coverage on the Refuge.

**Key Species Supported**

The open water of the Refuge provides habitat for juvenile and adult fish, wintering and migratory birds, a variety of invertebrate animals, and aquatic plants. Although specific species occurrence data is lacking for Refuge waters, these estuarine areas likely serve as foraging areas for adult salmon, eulachon, lamprey, sea-run cutthroat trout, and steelhead migrating upriver to spawn, and for juveniles moving downstream to the ocean. Sturgeon, forage fish, and ground-feeding fish may forage in the deeper channels and holes.

Oceanic nutrients, phyto- and zooplankton, and algae found in this habitat provide prey for fish. Specific occurrence information is lacking for Refuge waters, but likely clams, oysters, mussels, aquatic worms, amphipods, and other small organisms live along the bottom of the estuary and serve as a valuable food source for many species. Federally listed eulachon, green sturgeon, and bull trout (NFSC 2008, USDC 2009, Jeanes and Morello 2006, Chan, J. 2013, pers. comm.) juveniles may use this habitat. Many fish species that spend their adult life in the ocean spend time as juveniles in the estuary. The size of fish populations or stability of listed species using this habitat is unknown.

Open water provides necessary resting and foraging habitat for hundreds of waterfowl such as bufflehead, greater and lesser scaup, ring-necked ducks, and merganser species; waterbirds such as gull species, pelagic and double-crested cormorants and grebe species; prey for raptors such as osprey, and bald eagle during migration, breeding, and wintering periods. State-listed species are also dependent on this habitat.

**4.3.2 Intertidal Mudflat**

**Overview**

Intertidal mudflats are those areas of exposed mud, sand, and silt affected by rising and falling tides. This habitat is completely inundated at mean higher high water tidal levels and completely evacuated at lower tides, exposing approximately 64 percent (497 acres) of the Refuge. A large area of the intertidal mudflat habitat is free of rooted vegetation and supports algae growth. Twice daily, tidally driven marine waters flood the Refuge up to 12.5 feet deep and transport nutrients and a variety of animal life: zooplankton, phytoplankton, algae, and fish. Patches of native eelgrass, growing in slough channels at lower elevations, may be exposed briefly during extreme low tides. LWD is distributed across intertidal mudflats with tidal changes.

Intertidal mudflats within the Refuge boundary are at slightly higher elevation than those in the rest of Grays Harbor and are one of the last areas to be covered by rising tides. Because of this, the Refuge habitat provides exposure of benthic and epibenthic invertebrate populations for shorebirds to prey upon for 1 to 2 hours longer than at other areas of the harbor. This area also functions as an important roosting and loafing site for migrating and wintering shorebirds.
Regional Distribution, Conditions, and Trends of Intertidal Mudflat

In the Pacific Northwest large portions of estuarine habitat have been lost to diking, channeling, dredging, and filling. Washington is estimated to have lost between 45 and 62 percent of its pre-settlement estuarine habitat (Aitkin 1998).

Tidal marine waters carry zooplankton, phytoplankton, algae, seeds, and fish throughout the estuary and sustain epibenthic and benthic invertebrate populations. Organisms inhabiting intertidal flats must cope with the stress of currents, varied wave action, tides, and air exposure. Intertidal life is affected by light level, temperature change, amounts of oxygen and salinity, air exposure, wind, sediments, and turbidity (McConnaughey and McConnaughey 1985). Intertidal organisms may be negatively affected by invasive plant and animal species.

The Refuge intertidal mudflat is trending toward higher elevations. However, the sedimentation rate is not well understood. As soil elevations have increased, patches of pioneer plants have established on slightly higher elevation mudflats, the roots then stabilize the mud and trap more sediment, allowing more and larger plants to colonize. The loss of important tidal mudflats and the negative ramifications of shorebird foraging habitat needs to be closely examined and weighed against potential sea level rise predictions to make management decisions (see Chapters 2 and 3).

Another relatively new change to tidal mudflats on the Pacific coast is the establishment and spread of Japanese eelgrass, a nonnative, tidally dependent seagrass. It grows in greater Grays Harbor, including the Refuge, and is covering the intertidal mudflats where it can survive extended periods of air exposure (GHEMPTF 1987). Nonnative eelgrass could potentially cover large portions of the Refuge intertidal mudflats and likely negatively affect shorebird foraging habitat. Additional threats to the Refuge mudflats come from potential nearby pollution sources that could contaminate air, water, and sediments (see 4.3.1 Tidal Open Water). Climate change may bring warmer temperatures, which may create large algal mats on the mudflats and toxic algal blooms in the water. Climate change-induced sea level rise could convert mudflat to tidal open water or sub-tidal habitat which would reduce foraging habitat for shorebirds.

Key Species Supported

As many as 24 species of migratory shorebirds have been known to use the greater Grays Harbor intertidal mudflats as an important stopover site to forage and rest on extended migrations to and from South America and Alaska (USFWS 1990). The most frequently observed shorebird species at the Refuge include western and least sandpiper, dunlin, semipalmated and black-bellied plover, short- and long-billed dowitcher, and red knot (Appendix K). Approximately five to six thousand shorebirds (mostly dunlin) also use this habitat during winter season.

Shorebirds depend upon stopover sites such as the Refuge where large amounts of prey are readily available and where they can quickly build up fat reserves to provide energy along their northward migration to breeding grounds in Alaska. Generally, intertidal flats support an abundance of invertebrates including amphipods, polychaete and oligochaete worms, insect larvae, and nematodes (McConnaughey and McConnaughey 1985, Wolfe, Moore, and Cameron 1974). Specifically, invertebrate populations at the Refuge are composed of polychaete and oligochaete marine worms, bivalves, crustaceans, and insects (Buchanan et al. 1985, Warnock et al. 2004). A winter study at the Refuge on dunlin prey items showed 94 percent of dunlin stomach contents were tiny crustaceans.
such as cumaceans and amphipods (Brennan et al. 1990). Algal biofilm growing on intertidal mudflats has recently been found to be an important food source for shorebirds (Kuwae et al 2008).

Raptors such as peregrine falcon and merlin prey upon dense flocks of birds. Because higher elevation intertidal mudflats remain exposed for long periods, many thousands of shorebirds move into the Refuge and the dense flocks provide a greater probability of these raptors successfully capturing shorebird prey.

During higher tides, forage fish, ground fish, and most likely other fish species such as sculpin, stickleback, shiner perch, juvenile or sub-adult salmonids, juvenile eulachon, or juvenile green sturgeon forage on invertebrates, zooplankton, phytoplankton, and algae in the marsh habitats. Because fish use salt marsh habitats (Seliskar and Gallagher 1983), it is assumed the same species must travel through and forage in flooded intertidal mudflat habitat as well.

4.3.3 Tidal Salt and Brackish Marsh

Overview

The Refuge encompasses 156 acres of tidal salt and brackish marsh habitat that support a diverse array of species including birds, fish, and invertebrates. This habitat provides a major source of nutrients and detritus supporting both aquatic and terrestrial food webs.

Salt marshes on the Refuge are generally found within the tidal range of 9 to 11 feet NGVD where the ground is high enough to support emergent herbaceous plants but too low, wet, and saline to support shrubs or trees. Water salinity ranges from 10 to 25 ppt and varies seasonally. Less-saline (≤10 ppt) brackish marshes exist where freshwater drains from hillsides into the estuary. Vegetation density varies based on the duration and frequency of tidal inundation.

The productivity of the marshes is critical to the health of the estuary. Salt marshes provide a major source of nutrients for estuarine and terrestrial wildlife and help keep the estuary functional. Plants filter pollutants from the water. Marsh plants provide food in the form of seeds, roots, tubers, and leaves for ducks and geese, and uneaten plant matter eventually breaks down and is transported by tidal action into the greater estuary. Larger organisms, including filter feeders like clams and oysters, feed upon the decaying remains of plants and smaller invertebrates consume the detritus.

Regional Distribution, Conditions, and Trends of Tidal Salt and Brackish Marsh

Salt and brackish marshes are an important component of a functional estuary. In the Pacific Northwest, a large portion of estuarine habitat has been lost to diking, channeling, dredging, and filling. The state of Washington is estimated to have lost between 45 and 62 percent of its pre-settlement estuarine habitat (Aitkin 1998). Within Grays Harbor, approximately 3,840 acres of salt marsh habitat was lost to dredge material disposal (StreamNet).

Laws, rules, and regulations have been put into effect to protect wetlands, including estuarine marshes. Recent regional restoration efforts are helping to recover some of these lost habitats. Some have been successful in restoring a portion of this important habitat. At Billy Frank Jr. Nisqually National Wildlife Refuge, over 700 acres of estuary have begun to reestablish after removal of agricultural dikes. Similar restoration efforts are happening in northern Puget Sound, Willapa Bay on the Willapa National Wildlife Refuge, and along the Oregon coast.
Over time, successional changes will involve the transition of salt marsh to shrub-scrub habitat as sediment aggradation occurs. Conversely, sea level rise may cause salt and brackish marshes to flood enough to convert into mudflats and eventually convert into open water habitats. This conversion would not be beneficial to the wildlife species evolved to thrive in marsh habitat, including shorebird species. The native sweetgrass plant community is highly susceptible to mudflat elevation changes and climate change-driven sea level rise and is anticipated to have limited resilience. New sweetgrass development will be limited on the Refuge north side because of the proximity to State Highway 109.

**Key Species Supported**

Invertebrates such as true bugs and flies, mites and ticks, round and flat worms, benthic species, and mollusks need intertidal mudflats and salt marsh to have healthy populations. A diverse array of bird species including American wigeon, northern pintail, green-winged teal, gadwall, northern shoveler, mallards, and geese (cackling, Canada, and greater white-fronted) eat salt marsh plants and invertebrates. Waterbirds such as great blue herons, Virginia rails, soras and American bitterns; shorebirds such as least sandpipers, western sandpipers, and dunlin; and passerines such as common yellowthroats, marsh wrens, and song sparrows all eat invertebrates found within the salt marsh. Raptors and other predators such as northern harriers forage for small rodents in this vegetation. Refuge plants adapted to some of the most difficult conditions nearest the transition to intertidal mudflats include sand-spurry, pickleweed, seashore salt grass, jaumea, sea arrowgrass, and seaside plantain. Plants needing lower salinity or less-frequent inundation grow at slightly higher elevation and include tufted hairgrass, Pacific silverweed, saltmarsh bulrush, and Lyngby’s sedge. High saltmarsh plants include kneeling angelica, cow parsnip, sea watch, yarrow, owl-clover, and Douglas aster. Common plants on the Refuge that can live in brackish conditions include cattail and common rush. Sweetgrass (see Appendix E for other names) sedge seems to be associated with lower salinity levels and more dynamic conditions.

Fish are known to use salt and brackish marshes during high tides (Seliskar and Gallagher 1983). In Grays Harbor estuary and the Refuge it is likely that forage fish, ground fish, sculpin, stickleback, shiner perch, juvenile salmonids, juvenile eulachon, juvenile green sturgeon, and juvenile bull trout forage on invertebrates, zooplankton, phytoplankton, and algae that are present in the marshes. Both the larger- and smaller-sized fish find an abundance of food and rely on the variety of plants for cover and protection from strong currents and predators. In addition, these areas provide resting cover and roosting sites for bird and other animal species.

**4.3.4 Forest**

**Overview**

The Refuge protects approximately 95 acres of forest habitat. With the development of Bowerman Airstrip in the 1940s, the deposit of dredge spoils created higher-elevation lands, which supported the establishment of shrubs and trees in what was mudflat. The forest vegetation on Moon Island, the edges of the airstrip peninsula (including portions of Sandpiper Trail), and uplands near Paulson Road originated from bare ground (salty dredge spoils).

This newly developed forest surrounds the existing mudflats and may provide cover for falcons, which are important shorebird predators, and may negatively affect shorebirds’ ability to view avian predators.
Regional Distribution, Conditions, and Trends of Forest Habitat

Regionally, the forests in Grays Harbor County have been cut and replanted, are managed for timber production, and are of great importance in the sustainable timber industry to the regional economy. The small Refuge forest is in an early successional deciduous stage, but could eventually mature into longer-lived species such as big leaf maple and perhaps Sitka spruce.

Knotweed has invaded the forests and salt marshes in Grays Harbor County. Along Highway 109, on the north side of the Refuge, it has become well established. Coordination with the county is needed to control this invasive species.

If sedimentation accumulation and higher elevations develop in the adjacent saltmarsh, the forest trees and shrubs may expand out to cover more acreage. Conversely, in time, sea level rise and salt water inundation may occur, causing the trees and shrubs to decline and salt marsh to develop. Over a long period of sea level rise, extended tidal coverage may eventually cause a mudflat to develop.

Key Species Supported

Tree species in the forest habitat include red alder, native willows (Hooker’s, Sitka, Pacific, and Scouler’s), cascara, Pacific crabapple, Oregon ash, and other small, relatively short-lived trees. The forest’s mid-story shrub composition includes osoberry, salmonberry, thimbleberry, red elderberry, twinberry, and other native shrubs. A thick understory of waterleaf, coltsfoot, water parsley, skunk cabbage, sword fern, sedges, rushes, grasses, and horsetails completely covers the substrate in some areas and open, exposed soils exist in others.

The forest also provides important habitat for landbirds such as Pacific-slope and willow flycatchers; yellow, orange-crowned, and yellow-rumped warblers; American goldfinch; black-capped chickadee; rufous hummingbird; and other birds and wildlife. This habitat provides passerines and other landbirds with dense cover and foraging opportunities for insects, nectar, and seeds. The forests may be important for early migrating landbirds. Other wildlife also benefiting from this habitat are black-tailed deer, weasels, snakes, and rodents.

Falcons have been observed using the forest as cover to surprise their shorebird prey.

Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge

4.3.5 Channel Habitat

Overview

Within the Unit acquisition boundary, approximately 7.5 miles of free-flowing river channel habitat serves as a vital migration pathway and provides limited spawning grounds and rearing habitat for salmonids, resident fish, and amphibians. The river channel flows within the confines of the riverbanks and includes nearby edges of the sloped bank. The Black River channel is relatively narrow, ranging from 10 to 25 feet wide, with water depths ranging from 2 to 10 feet deep. Annual high water events spread water out over the floodplain in winter and spring. Currently, the river channel is indiscernible starting at Black Lake and remains indistinguishable due to the shrub swamp habitat above the pipeline berm. South of the pipeline berm, the river flow is visible, but due to the
dense stands of reed canarygrass, the channel can be difficult to identify. At approximately river mile 2 south of Dempsey Creek, the channel becomes easily visible.

**Regional Distribution, Conditions, and Trends of Channel Habitat**

Historically, water from Black Lake flowed down the Black River into the Chehalis River. However, today the start of the flow path is no longer evident. In 1922, the Black Lake ditch was dug to drain the wetlands north of Black Lake and stabilize water levels to allow shoreline development (Smith and Wenger 2001). The lake level is thought to have dropped almost 2 feet through ditch drainage and repeated dredging to maintain the ditch channel. In the 1960s a gas pipeline was dug by Williams Pipeline Company across the north end of the river approximately 1.5 miles south of Black Lake.

Conventional belief is that pipeline construction left spoils in the stream which, along with beaver dam debris accumulation, resulted in vegetation growth (Washington State Conservation Commission in Foster Wheeler 2003). An additional pipeline was placed in the same location using horizontal directional drilling techniques below the riverbed. In 2002, Foster Wheeler Environmental Corp. conducted a study to understand issues of water flow directionality in the Black River. Due to a complex set of issues including topographic effects of the lake, the Black Lake ditch drainage, the pipeline berm, and potential groundwater upwelling in between the lake and pipeline berm, the river flow has been significantly altered (See Chapter 3.3).


Threats to the river and channel include a significantly altered hydrologic regime. A reduction in water flow related to the Black Lake ditch (Foster Wheeler 2003) has most likely reduced water velocity. Other threats include demand for more water from increasing residential and commercial development, including the adjacent gravel mine, and increasing threats of water pollution and contamination.

Anecdotal information indicates the river channel was dredged in some areas. It appears some channel areas within the boundaries were straightened or deepened. Some indications of dredging include removal of natural stream meandering by straightening steep, undercut, and unstable channel edges and in some areas a >10 foot deep channel with a thick silt or muck substrate. The deep U-shaped channel is not usually associated with a slow-moving river and is in contrast to the more natural river channel south of downtown Littlerock, where the channel is cobble-bottom and much shallower. The deep, channeled, tannin-stained, dark water limits light penetration, and in combination with unconsolidated Semiahoo muck, bottom-rooted plant growth in the river bottom can be limited in some areas. Also important to understanding the ecological conditions of the river channel is a comment by a Black River resident who recalled a time when the “Black River ran thick with silt because of logging in the Black Hills … and that went on for years and years” (TESC 2001). Historical impacts of high-nutrient water runoff from agriculture fields, silt runoff from logging, and perhaps dredging projects are likely still affecting river conditions.
Nonnative fish and bullfrogs pose significant threats to native amphibians, small native fish, and natural wetland function. They also compete against native animals for prey resources (See Chapter 4.6.2).

Nonnative and invasive plant species (see Chapter 4.6 and Appendix L) also contribute significant threats to the river channel system by choking water flow, reducing native plant growth, and reducing food resources for wildlife. Reed canarygrass has infested the channel and channel edges to the point of compromising river function. Reed canarygrass establishment has eliminated most exposed mud patches along the river, impeded sunlight penetration, and restricted animal access through the understory. Reed canarygrass also roots on emergent plants within the channel and can grow over the surface of the channel and into the bank. Small, native, understory wetland plants growing along the river and in shrub swamp edge are unable to compete against this thick, tall grass.

Submersed exotic aquatic plants such as hydrilla, elodea, and parrotfeather are expected to colonize the Unit channel habitats at some point, as these invasive plants can be found in the watershed. These submersed exotic and invasive plants choke water flow, impede sunlight penetration, change the natural conditions of the river and tributary channels, limit animal (e.g., amphibian and fish) movement, and out-compete native submersed plants.

**Key Species Supported**

Key species include the State-endangered and federally threatened Oregon spotted frog, which lives its entire life in the wetland habitats. Oregon spotted frogs depend on the permanent, slow-moving, and almost still channel water during summer months when water levels drop in nearby marshes.

Additionally, specific and unique characteristics of the channel are critical to the endemic Olympic mudminnow, which lives its complete life cycle in densely vegetated, relatively low-oxygenated, tannin-stained water and mud bottom. This fish has evolved to survive warm water conditions and survive in habitats where many native cold-water fish cannot.

Coho salmon, Chinook salmon, cutthroat trout, and perhaps steelhead utilize channel habitat as a migration pathway to upstream tributary spawning grounds. The river provides a rich rearing habitat for juvenile salmonids, resident small fish, and amphibians. Freshwater sponges and freshwater mussels are found in the channel, but species distribution in the river is not well understood.

A variety of birds and mammals utilize tributary channel habitat for water, food, and travel corridors. Birds such as wood ducks, hooded mergansers, pied-billed grebes, and kingfishers are commonly found throughout these aquatic habitats. Beavers are a key species because they directly alter stream hydrology in the river channel habitat. Their dam building activities create and maintain wetlands that provide extensive benefits to fish and virtually all wetland-associated species and organisms (Grannes 2008). Other aquatic-oriented mammals such as river otter, muskrat, and mink are abundant.

The low elevation gradient and slow-moving river provide a rich environment for a thick growth of submersed, aquatic, native plant species such as pondweed, native western milfoil, and American waterweed; floating plants such as mosquito fern and duckweed; and emergent plants such as water starwort, spatterdock, smartweeds, and water pennywort. These species are important to this habitat and provide shelter and food for a variety of aquatic and terrestrial animals. Woody debris near the surface of the channel supports plants such as small-flowered touch-me-nots and monkey flower. The
vegetation and woody debris provide substrates for algae growth, an important food source to invertebrates and immature amphibians, as well as dense cover and foraging opportunities for amphibians, invertebrates, and fishes.

4.3.6 Tributary Channel Habitat

Overview

There are approximately 16 miles of tributary channel that provide habitat for a variety of aquatic and terrestrial plants and animals located within the Unit acquisition boundary. These waterways historically have been impacted by various habitat alterations since the time of Euro-American settlement in the area. Lands adjacent to the Unit were cleared of forests and managed for various purposes such as agriculture (farming activities, livestock grazing), forest products (lumber), and urbanization (roads, houses). All of these activities have resulted in increased impacts to tributary habitats, including water temperatures, erosion, chemicals, trash, reduced groundwater recharge, and water diversions for agricultural and industrial purposes, all of which affect the quality and quantity of water in the watershed and at the Unit.

Tributaries within the Unit acquisition boundary include Waddell, Dempsey, Stony, Darlin, Blooms Ditch, and several smaller, unnamed creeks, all of which vary considerably in size, length, depth, and character. Waddell Creek water runs clear, cool, has shallow areas with riffles, deep holes, a cobble bottom, woody debris, and in some summers it dries up or goes underground. Dempsey Creek has a soft peat bottom, steep sides, appears abnormally deep and channelized in former agricultural lands. Blooms Ditch is also deep and channelized but has a sandy substrate.

Regional Distribution, Conditions, and Trends of Tributary Channel Habitat

Prior to entering the Unit boundary, these creeks and streams meander through a variety of forest, agricultural, and residential areas presenting a variety of issues and conservation challenges for maintaining a healthy watershed.

An altered hydrologic regime outside the Unit boundary may have affected the health and individual tributary conditions. Perched culverts may prevent salmonid movement into appropriate spawning grounds. Within the Unit boundary, nonnative plant species such as reed canarygrass and yellow flag iris can dominate the channel edges, sides, and beds, impeding stream velocity, temperatures, and plant and animal diversity. Adjacent agricultural lands and development may provide sources for contaminants, including herbicides, fertilizer, fecal coliform from livestock and septic systems, and increases in sediments.

Nonnative plant and animal species (e.g., bullfrogs, nonnative warm-water fish, New Zealand mud snail, hydrilla, Eurasian watermilfoil, parrotfeather, fanwort) may also be problematic to the health of the tributaries. However, data are not yet available to determine which nonnative animals are living in the tributaries within the Unit.

Bridges over tributaries can be supported by wooden structures that are periodically treated with insect and animal retardant. Creosote contamination may impact aquatic invertebrates, Oregon spotted frog, and salmonids. The Delphi Road Bridge over Dempsey Creek was recently treated with creosote (~2012).
Key Species Supported

Some tributaries such as Waddell Creek have cobble-channel habitat with cool, rapid-flowing water which provides different habitat than the river or muddy bottom tributaries. Invertebrates, freshwater mussels, juvenile salmon (coho), crayfish, and perhaps freshwater sponges can be found in the cobble tributaries—all of which may be different species than those found in the Black River.

Dempsey Creek likely provides habitat for a variety of plants and animals similar to those found in the Black River because the creek has similar characteristics. The creek appears to have been dredged to increase agricultural field drainage; the substrate is muck and most of it is not shaded by trees or shrubs. Oregon spotted frogs have been known to use this creek to move through various habitats.

A variety of birds and mammals utilize tributary channel habitats for water, food, and as a travel corridor. Many of the same plant species found in the river are also found in the creeks (see Section 4.3.5 Channel Habitat).

4.3.7 Bog

Overview

The Unit protects approximately 56 acres of bog habitat that extends from the northern edge of the Unit boundary at Black Lake to the confluence of Dempsey Creek (see Map 5). Other occurrences of bog habitat may be found within the Unit boundary (Easterly and Salstrom 2008).

A bog is a slightly domed, low-nutrient, low-pH system which grows on sphagnum peat and is dependent on low-nutrient rainfall for moisture. The organic, wetland soils retain rainwater and provide a natural water filtration system. Various bog types have been found within the Unit, which include forested bog, shrub bog that contains a dry shrub bog, an intermediate between wet and dry bog, and areas of wet bog (Kunze, L. 2001, pers. comm.).

Regional Distribution, Conditions, and Trends of Bog Habitat

Bogs occur within Puget Sound lowlands, around lakes, slow-moving rivers, and valleys. Only a fraction of western Washington bogs remain undisturbed (Bigley and Hull 2000). Bogs are Category I wetlands because they are sensitive to disturbance and impossible to re-create through compensatory mitigation (Hurby 2004).

“Nutrient-poor wetlands, such as bogs, have higher species richness, many more rare species, and a greater range of plant communities than nutrient-rich wetlands” (reviewed in Adamus and Brandt 1990). They are, therefore, more important than would be accounted for using a simple assessment of wetland functions (Moore et al. 1989). In addition to being sensitive to disturbance, bogs are not easy to re-create. Restoration may be impossible because of changes to the biotic and abiotic properties that preclude the reestablishment of bogs (Schouwenaars 1995, Schrautzer et al. 1996). Furthermore, bogs form extremely slowly, with organic soils forming at a rate of about 1 inch per 40 years in western Washington (Rigg 1958 from Hruby 2004, Bigley and Hull 2000).

Bogs can be damaged by subtle nutrient and mineral inputs which change the chemical equilibrium of the bog system. For example, exposing bare soil near a bog can be particularly damaging as
resulting soil-laden runoff alters the chemical character of the bog and can kill living sphagnum. Burning slash, trash, or a wildfire near a bog can also be detrimental due to the release of high-nutrient ash (Bigley and Hull 2000). Typical logging and clearing practices in or around the Unit bogs most likely have had negative effects.

Subtle hydrologic changes cause problems for bog habitats. Diverting water into or around a bog will sever the habitats’ isolation, dependence on rainwater for nutrients, and may expose it to damaging chemicals. Removing water from bogs by dropping surface water levels with ditches or drains will lower the water table and will speed the decomposition of the peat, sometimes leaving trees standing on their roots. Loss and lowering of ground water levels may reduce spring flows around bogs. The WDNR Natural Heritage Wetland Program and Thurston County Critical Areas Ordinance regulation states that changes to water, drainage, or nutrient flow cannot occur within a minimum of 250 feet of a bog. Onsite sewage disposal systems or drain fields may not be within 300 feet of a bog (Thurston County 2012).

In addition, nonnative plants will change plant community function and dynamics. Specific invasive species that may cause problems include reed canarygrass, knotweed species, purple loosestrife, yellow flag iris, holly, and potentially New Zealand mudsnail.

**Key Species Supported**

Those plants dependent upon bog habitats and found in the Unit bogs include western Labrador tea, sphagnum species, sundew, cottongrass, bog cranberry, bog laurel, bog orchid, thinleaf (also called gray alder), bog birch, shore pine, and Sitka spruce trees.

A number of plant and animal species associated with bog habitats may be found with future research and study of this difficult-to-access area. The potential for three State-candidate and SOCs in this habitat include Beller’s ground beetle, Hatch’s click beetle, and Queen Charlotte’s copper butterfly. The State-candidate long-horned leaf beetle (bog idol) and the silver-bordered bog fritillary butterfly are also associated with Washington lowland bogs, but may or may not be found in this particular location (WDFW 1995). Additionally, Bradshaw’s lomatium, western or red-root yampah, water howellia, western toad, western pond turtle, and uncommon salamanders could be found in the bog complex with future monitoring. WDNR biologists recorded a patch of bristly (longhair) sedges that are listed in Washington’s Natural Heritage Program as a sensitive species (WNHP 2008). In the bog areas, signs of black bear and beaver were evident as were wildlife trails.

**4.3.8 Shrub Swamp**

**Overview**

The Unit protects 512 acres of shrub swamp habitat. This habitat occurs extensively in the lowland floodplains along the river channel, secondary channels, and in broad low-lying zones where soils are poorly drained, fine-textured organic muck, and the substrate would be semi- or permanently saturated. This habitat type is most extensive in the northern portions of the Unit and in narrow strips along the river southward to 123rd Avenue. This habitat grows interspersed with emergent marshes and riparian forest. It is wetter than forested swamps and slightly drier than marshes. It has been described as an impenetrable thicket of unstable ground and shrubs (Easterly and Salstrom 2008).
Regional Distribution, Conditions, and Trends of Shrub Swamp

This habitat ranges from Prince William Sound, Alaska, to the southern coast of Oregon (Crawford and Rocchio 2011). Historically this habitat was more prevalent, for example, small patches still exist in the Ohop and Green River valley (Barham, J. 2013, pers. comm.). Because this habitat is now an uncommon lowland wetland system, limited understanding of its requirements for healthy function and process exists. Future study could ensure a healthy ecosystem (Easterly and Salstrom 2008).

Evidence of past conditions shows a portion of this habitat type may have been a forested wetland populated with large Sitka spruce and other conifers. Large stumps indicate early logging has likely removed a forested overstory component of the wetland. Former logging may have contributed to converting a conifer-forested wetland to shrub swamp that is now dominated with Oregon ash, Pacific crabapple, willow, Douglas spirea, and slough sedge.

The Black Lake drainage ditch prevents strong flood events from occurring and has most likely caused changes in the shrub swamp plant community composition and disturbance regime, although the changes are not yet fully understood. The loss of river water amounts and flow reduction from water diversion, water withdrawal, and hydrologic changes could cause losses of seasonally occurring high water conditions and has most likely affected the shrub swamp plant community.

Over time, if water sources continue to be reduced, this habitat may transition into a drier forest, and invasive reed canarygrass will most likely increase in open patches or in areas of herbaceous groundcover. Portions of this habitat that extend farther from the river may have been converted to agriculture because of lower water levels. Additionally, because of hydrological changes over time, the shrub swamp may be shifting and moving into bog areas (Kunze, L.M. 2011, pers. comm.). An understanding of the hydrology will be needed throughout the life of this CCP to benefit all species living in the shrub swamp habitat. An examination of plant community interaction between bog and shrub swamp habitats is needed.

Nonnative, invasive plant species, especially reed canarygrass, present a serious threat to the shrub swamp. Reed canarygrass has become densely established in open areas of the shrub swamp, especially along the river channel edge, and has changed the composition of the vegetative community. Its establishment has eliminated exposed mud patches along the river, impeded sunlight penetration, and impeded animal access through the understory. Small, native understory wetland plants growing along the river and in shrub swamp edges are unable to compete against this thick, tall grass. Purple loosestrife and yellow flag iris have become well established in many locations in the shrub swamp.

Submersed aquatic plants such as hydrilla, elodea, and parrotfeather could also be threats when infested surface waters from the river or tributary channels spread under the shrubs. Because the soils in these shrub swamps remain wet and protected from sun throughout the year, many submersed plants could survive. Additional perennial or woody invasive plant threats to the shrub swamp include knotweed species and other new species from elsewhere in the watershed that may be inadvertently introduced.

Nonnative fish presence alters natural habitats and conditions for native animals sharing the same locations. Most nonnative, warm-water fish such as bass, crappie, and northern pikeminnow are predatory on native fish, amphibians, and invertebrates. Their presence changes and likely reduces native fish, amphibian, and invertebrate populations. In addition, nonnative fish reduce prey resource availability for native fish and amphibians. These fish may be especially deleterious to endemic
Olympic mudminnow and the State-listed as endangered and federally listed as threatened Oregon spotted frog and the prey resources they need to survive.

**Key Species Supported**

The shrub swamp consists of deciduous shrubs comprising a mosaic of willows, Oregon ash, red osier dogwood, Pacific crabapple, ninebark, twinberry, and Douglas spirea that range from 5 to 30 feet tall and support complex growth of lichen and mosses. The herbaceous plant understory typically includes skunk cabbage, veronica, marsh speedwell, burweed, smartweed, sedges, touch-me-not, gallium, Cooley's hedge nettle, horsetail species, and Pacific water parsley.

North of the pipeline, plant species composition also includes gray alder and patches of bog-related species. South of the pipeline, Easterly and Salstrom (2008) noted thinleaf alder to be a major component on this habitat along the river.

This habitat provides important cover and food resources for migrating passerines and landbirds such as Pacific-slope and willow flycatcher, yellow warbler, orange-crowned warbler, American goldfinch, and black-capped chickadee. During spring migration, high numbers of flycatchers have been observed using this habitat.

Extended periods of high water that inundate the shrub swamp habitats provide excellent habitat and foraging conditions for aquatic animals including small fish (e.g., juvenile salmon and mudminnows), salamanders, and frogs, including the Oregon spotted frog and Pacific chorus frog (also called tree frog).

Potential ROCs that may utilize this habitat include Chinook and coho salmon, steelhead trout, and cutthroat trout. Bristly sedge, a Washington State rare plant species, has been recorded where the shrub swamp and river channel edge intersect. Another Washington State rare species, the Pacific clubtail dragonfly, has been recorded in the same habitat as bristly sedge. The endemic Olympic mudminnow and the threatened Oregon spotted frog are likely to use this habitat as refugia during high-water conditions in winter and early spring and to avoid higher flow rates in the river channel.

**4.3.9 Riparian Forest**

**Overview**

The Unit supports approximately 265 acres of riparian forest habitat. Riparian forest habitats occur at slightly higher elevation than adjacent shrub swamp habitats and support plants that need slightly drier soil conditions. The Unit’s riparian forests consist of native deciduous trees of mixed age and species, dominated by big leaf maple, western cottonwood, red alder, and Pacific willow. Lichen and moss growth can be found on the trees. Larger trees provide LWD to the river channel and floodplain (Rocchio 2011a).

Some areas show an early to mid-successional stage of maturity with tree canopy, thick midstory cover, and good ground cover. Very early successional stages are sparsely vegetated and dominated by shrubs, small saplings, and herbaceous vegetation, and in this case often-dense reed canarygrass growth as well.
A key function of riparian habitat is to provide a safe corridor for animals to move between areas, including isolated natural areas. The importance of riparian areas as travel corridors and routes for dispersion is amplified in developed or fragmented landscapes (Knutson and Naef 1997). Even in early seral stages, this habitat can provide excellent nesting, cover, and foraging conditions for passerines and other landbirds, amphibians, and mammals, in part because of its proximity to the river and its tributaries. Over time, as young riparian habitats mature, the diversity and complexity of the habitat can support greater wildlife numbers and increased diversity (Knutson and Naef 1997).

**Regional Distribution, Conditions, and Trends of Riparian Forest**

At least 50 percent, and as much as 90 percent, of the riparian habitat in Washington has been lost or extensively modified since the 1800s (Knutson and Naef 1997). What remains of the diminished riparian areas are often small, disjunct patches in generally poor condition due to human impacts (Johnson and O’Neil 2001). Due to the density and diversity of species using riparian habitat, intact riparian areas are important to the conservation of Washington’s vertebrate species.

Threats to this habitat include a slow recovery of large-sized trees that were logged out earlier, loss of developing snags, water diversion or water removal from tributaries and the river, fragmentation, and a history of excessive nutrients from agriculture or development. Once again, invasive species are a very large threat. Reed canarygrass is the main impediment to natural regeneration and can dominate logged areas, while other invasive plants can also impact the habitats. An understanding of climate change and possible management options regarding potential impacts to this habitat type need to be addressed.

**Key Species Supported**

Broadleaf tree species found in the riparian community are big leaf maple, black cottonwood, red alder, Sitka and Pacific willow, red osier dogwood, ninebark, Pacific crabapple, black hawthorn, and Oregon ash. Conifers tend to increase with succession in the absence of major disturbance and can include Sitka spruce, grand fir, and western red cedar. Native shrubs such as twinberry, red osier dogwood, snowberry, salmonberry, thimbleberry, salmon, red and evergreen huckleberry, rose species, stinging nettle, osoberry, and devil’s club comprise the midstory, and a rich understory of skunk cabbage, inside-out flower, twinflower, wild ginger, trillium, vanilla leaf, false lily of the valley, and lilies provide flowers for pollinators and vegetation for wildlife foraging. Diverse lichen and moss communities grow on trees and shrubs in this habitat.

Approximately 85 percent of Washington’s terrestrial vertebrate species use riparian habitat for essential life activities (Knutson and Naef 1997). Of the 118 species of migrant landbirds occurring in Washington, 67 species (57 percent) use riparian habitat (Andelman and Stock 1994, Knutson and Naef 1997). The density of wildlife in riparian areas is comparatively high (Knutson and Naef 1997). Bird species that use riparian habitats include both resident and migrant species such as rufous hummingbird, red-breasted sapsucker, northern flicker, pileated woodpecker, Swainson’s thrushes, and warblers. In older riparian forests, accipiters (such as Cooper’s and sharp-shinned hawks) and owls can reside.

Riparian habitats are also very important for amphibians such as Pacific chorus frog, rough-skinned newt, and others species. Mammals including several species of *Myotis* bats, rodents, and carnivores such as long-tailed weasel and mink use the habitat throughout most of their lives, while larger
mammals such as black bear, bobcat, and cougar use riparian habitats as travel corridors within their home territories.

Riparian habitat is additionally important to supporting healthy native fish populations by improving channel characteristics including LWD, temperature, water quality, water chemistry, cover, and nutrients. Riparian habitat importance to the watershed includes providing leaves, twigs, and branches that provide basic food and nutrients to support instream habitats and animals. Riparian vegetation, litter layers, and soils filter incoming sediments and pollutants assisting in the maintenance of high water quality (Knutson and Naef 1997).

Potential ROCs include migrating passerines and nesting birds on watch lists or SOC lists such as Vaux’s swift, purple martin, pileated woodpecker, and merlin, as well as Keen’s myotis and Townsend’s big-eared bat.

4.3.10 Emergent Marsh

Overview

Emergent marsh is generally found in western Washington valley bottoms, lowlands, along slow-moving rivers, in oxbows, saturated soil depressions, and where there is abundant rainfall (Rocchio 2011b). The Unit supports more than 34 acres of emergent marsh habitat. On the Unit, the emergent marsh usually forms a mosaic with other wetlands such as shrub swamp, riparian forest, and the edge of the river channel. A lowland depression located around 123rd and 110th Avenues also supports emergent marsh.

Herbaceous wetland plants in shallow, seasonally to semi-permanently or permanently flooded areas dominate freshwater emergent marshes. The habitat is characterized by undrained hydric soils (muck or mineral) where nutrient-laden water is at or above the surface for most of the growing season. Surface water depths range from <2 to 25 inches deep with deeper-water conditions closer to the river. Surface water depth increases with fall, winter, and early spring rains.

In good quality habitat, there would be a moderate amount of soil exposure (no vegetation), some decaying LWD brought in by high-water events, and 30–70 percent cover of emergent hydrophytic vegetation and native seed-bearing plants.

The river and tributaries are consistent and permanent freshwater sources for these wetlands, which are essential to the function of this vegetative system and provide direct access to and from deeper water sites for amphibians and fish.

Regional Distribution, Conditions, and Trends of Emergent Marsh

It is estimated that 33–50 percent of Washington's wetlands have been lost since colonization, with some metropolitan areas in Puget Sound losing over 90 percent of their wetlands (WDOE 1992). Emergent marsh is found throughout western Washington and is still found near the Unit. Beaver, a species which can create and maintain these types of wetlands, was almost eliminated earlier in the century and these wetlands have decreased along with the diminished influence of beavers on the landscape. Even with regulatory protection, the amount of herbaceous and emergent marshes continues to be altered, farmed, and converted to other uses in Washington (Johnson and O’Neil 2001).
Reed canarygrass has aggressively invaded this habitat. Small, native sedges and low-growing herbaceous perennial plants are not able to compete against such an aggressive invader. This loss of habitat diversity negatively affects native wildlife species’ ability to use these compromised areas. Additional threats include the potential loss of connectivity to the river or tributaries due to roads and barrier construction; off-Refuge water diversion, water withdrawals and hydrologic regime alteration; passage barriers; water quality issues (temperature and sedimentation); conversion of former emergent marsh to seasonally flooded, nonnative grasslands; and natural succession to shrub swamp.

Bullfrogs are large, successful, nonnative predators of native frogs, salamanders, small fish, ducklings, and invertebrates (Hallock and McAllister 2009). Oregon spotted frogs did not evolve with bullfrogs and have no defense mechanisms (Leonard et al. 1993). Nonnative fish also negatively affect the native fish and amphibian populations and compete with wildlife for wetland invertebrates (Maxwell et al. 2010, Howell 2010). A worldwide chytrid fungus that is thought to contribute to the overall decline in amphibians, especially frogs (Weldon et al. 2004, Pearl et al. 2009), has been found in Unit emergent marsh waters where Oregon spotted frogs live part of their lives. The fungus, found on all tested Oregon spotted frogs, could be negatively affecting all species of amphibians in the Unit (Pearl et al. 2009).

Key Species Supported

Slough sedge and cattail can dominate in permanent, deeper-water areas. In shallow areas a diverse array of small sedges, bulrushes, rushes, spike rushes, bur-reed, beggar ticks, monkey flower, small-flowered forget-me-nots, skunk cabbage, creeping buttercup, possibly bristly sedge, and other low-growing, moisture-loving plants are found.

This habitat is exceptionally important for good-quality juvenile Oregon spotted frog-rearing conditions. It provides relatively warm surface water, shallow to moderately deep (2 to 24+ inches) in late spring and summer. Low to moderate vegetation density and algal growth on vegetative stems and leaves provide foraging opportunities. Herbaceous or shrubby vegetative cover provides direct swimming access to deeper water. This plant community provides adult Oregon spotted frog habitat in late spring and summer that includes still, standing, or slow moving surface water; connection to deeper and cooler water conditions; moderately complex vegetative cover; and invertebrates and small fish prey. This habitat is vital to the State-endangered and federally threatened Oregon spotted frog.

The presence of the federally listed water howellia plant is possible, but is unknown. Bristly sedge, a State-sensitive and rare plant, was recorded in a thin, long patch of emergent marsh between the river channel edge and shrub swamp. Another rare species, the Pacific clubtail dragonfly, has been recorded in this habitat. Additional key species include the Olympic mudminnow, Chinook and coho salmon, steelhead trout, and possibly western toad and western pond turtle.

Secretive marshbirds such as American bittern, sora, Virginia rail, green heron, great blue heron, pied-billed grebe, and American coot depend upon this habitat for their life histories. During higher water conditions, migrating and wintering waterfowl also use this habitat type. Elk and black-tailed deer browse on emergent plants, while otter, mink, beaver, and muskrat forage and den in this habitat. Northern harriers hunt over the habitat and use it to nest. Large numbers of amphibians, such as northwest and long-toed salamanders, rough-skinned newts, red-legged frogs, and Pacific chorus frogs, lay their eggs and the juveniles mature into adults in the marsh.
4.3.11 Seasonally Flooded, Nonnative Grasslands Overview

The Unit supports over 82 acres of seasonally flooded, nonnative grasslands. These lowlands are relatively flat, generally are seasonally flooded in winter and early spring, and can be covered with water nearly 36 inches deep. Portions of this habitat closest to the river tend to be inundated with water during most months except September and early October. The saturated, poorly drained Semiahoo muck soils generally remain wet even during extended late-summer dry conditions. Most sites are located along river and tributary edges, in swales, oxbows, and land depressions that connect to other wetlands and deeper waters.

Historically, these areas may have previously been emergent marsh, wet prairie, open areas within shrub swamp or riparian forest, or part of a forested wetland. However, after Euro-American settlement, these areas have been converted to grasses that are adapted to the saturated soils and surface water coverage found in lowland river valleys. The most likely plant found in these nonnative grasslands is reed canarygrass.

Regional Distribution, Conditions, and Trends of Seasonally Flooded, Nonnative Grasslands

Planting of reed canarygrass in the Pacific Northwest began in the late 1800s and has been widely used in northern states and Canada. No other forage plant is as well-adapted to wet, marshy areas as reed canarygrass. This aggressive, cool-season, mat-forming, nonnative grass moves out of pasturelands and into stream bottoms, wetlands, and canal banks and persists where it is not desirable. It now dominates where wetland herbaceous plants or open moist soil would have been found on the Unit and in other areas throughout the watershed. It grows so vigorously that it seriously inhibits or completely eliminates all other plant growth (Reinhardt and Galatowitsch 2004) and it is a major threat to wetland ecosystems (Kilbride and Paveglio 1999). It is estimated that over 98 percent of what was emergent marsh, wet prairie, or wetland forest has been converted to seasonally flooded, nonnative grassland (reed canarygrass).

Unlike native wetland vegetation, dense stands of reed canarygrass have little value for wildlife (Tu 2004). In summer and early fall, reed canarygrass stems grow over 8 feet tall and are dense enough to impede both large and small animal movement.

Key Species Supported

This monoculture of nonnative grass does not provide the diversity of a native marsh-plant complex, which is necessary for a healthy plant community and associated wildlife. However, some wildlife use this habitat, including waterfowl (dabbling ducks, Canada and cackling geese) during late fall, winter, and spring when it is flooded. Some secretive marshbirds, such as American bittern, sora, and Wilson’s snipe, may use shallow water edges. Elk and black-tailed deer graze on new grass shoots in late spring and summer. Leaf-mats are sometimes used as basking, resting, or feeding platforms by small aquatic mammals such as muskrats and waterfowl.

These grasslands obstruct movement of mature amphibians and fish. Negotiating through the dense grass (even when flooded) may cause both amphibians and fish to expend high energy levels that ultimately may reduce their ability to survive and reproduce. Stems and leaves provide an abundance of surfaces for algal growth in late spring and early summer and may provide food for juvenile amphibian growth and some insects.
4.3.12 Dry, Nonnative Grasslands

Overview

There are 163 acres of dry, nonnative grasslands on the Unit. Dry, nonnative grasslands on the Unit border include mixed forests; seasonally flooded, nonnative grasslands; riparian habitats; and marshes. These areas are now composed of a mixture of nonnative pasture grasses, herbaceous plants, and shrubs. This habitat occurs in a mosaic throughout the Unit acquisition boundary and in a large field approximately 100 acres near the 123rd Ave and Endicott Road area. Vegetation in this habitat is a mixture of nonnative pasture grasses (such as velvet grass, orchard grass, perennial rye, timothy), native perennial grasses (such as Roemer’s and red fescue), and some native and nonnative forbs (such as alfalfa). The mixture of vegetation heights ranges between 6 and 30 inches high. The edges of the grasslands may contain a shrubby component that transitions into mixed forests or riparian habitats.

Regional Distribution, Conditions, and Trends of Dry, Nonnative Grasslands

Generally, nonnative grasslands in western Washington are former prairie, oak woodlands, and forest habitats that were converted for agricultural purposes, such as horse or cattle pastures. Livestock grazing is necessary to keep the grasslands open and not overcome with other species.

Extensive work by TNC, Center for Natural Lands Management, South Puget Sound Prairie Landscape Working Group, and the Service (Western Washington Fish and Wildlife Office) has defined where native prairie habitats are located in the Puget Trough based on soil types. Prairie habitat is considered among the most imperiled habitats in western Washington, and many species associated with it are State candidates or SOCs. The Unit’s dry, nonnative grasslands are not considered true prairie because they are not native to western Washington. However, because of the large losses of western Washington native prairie habitat, retaining Unit nonnative grassland habitat may be helpful in supporting some species that rely on open uplands.

Threats include invasion from nonnative pest plants that thrive in open areas without competition, such as wild chervil, Scotch broom, common burdock, common teasel, Canada and bull thistle, Himalayan blackberry, and poison hemlock. Forest encroachment or conversion into shrub lands will take place in the absence of management by prescribed fire, mowing, grazing, or haying. Conversion into forestlands will reduce the habitat mosaic in the Unit and reduce open habitat availability for reliant wildlife species.

Key Species Supported

Although no listed species are known to rely on this habitat type, a number of grassland species that evolved to use open areas of relatively short grass and forbs may use dry, nonnative grasslands.

This habitat type provides ground-nesting and foraging areas for birds such as savannah sparrow, western meadowlark, purple martin, mourning dove, and killdeer, as well as denning sites for small mammals such as mouse, mole, and vole. It provides hunting sites for raptors such as American kestrel, red-tailed hawk, great horned and barn owls, and northern shrike. In winter, dry, nonnative grassland provides thermal cover for short-eared owl, small mammals, and other wildlife. These areas also provide winter forage and loafing sites for ungulates such as black-tailed deer and elk.
addition, they provide migration or dispersal corridors for small and large mammals as well as amphibians. This habitat may contain an occasional deciduous tree such as big leaf maple or Garry oak. These trees can grow into large cavity-producing specimens that enhance the habitat for American kestrel, owl, bat, Vaux’s swift, and insects. A tapered edge of flowering shrubs provides nectar and attracts pollinating insects and provides a transition area for animals utilizing both grassland and woodlands.

### 4.3.13 Mixed Forest

**Overview**

Mixed conifer and deciduous forest habitat is generally the most extensive forest system in the lowlands west of the Cascades and forms the matrix within which other plant communities occur as patches. Many of the local area forests managed for conifer production lack species diversity and forest function that benefits wildlife (Carey 2006). The Unit supports 394 acres of upland mixed forest habitat of varying ages. These forests have well-drained soils that are moist much of the year and dry for approximately 3–4 months.

Most forests on the Unit are young mixed forest stands reestablishing after logging prior to Unit acquisition. In naturally regenerating young forests, commonly represented species include grand fir, western red cedar, big leaf maple, and red alder. Reestablishing forests usually lack western white pine because there are few natural seed sources for this species. As stands mature, Douglas-fir, grand fir, western hemlock, western red cedar, and big leaf maple dominate the canopy as early successional and short-lived red alder dies off. Eventually big leaf maple needs more light than the conifers allow and it too become less common. Individual trees or groups of trees with >12” diameter and 20’ long become snags that provide nesting cavities, and fallen trees become nurse logs. Over time, this habitat can mature into old-growth forest.

Most of the Unit forests are products of restoration efforts. Carey (2003) notes “…many managed forests are impoverished in species. Intentional management can reduce the need for wide riparian buffers, produce landscapes dominated by late-seral stages that are hospitable to wildlife associated with old-growth forests, provide a sustained yield of forest products, and contribute to economic, social, and environmental sustainability.”

**Regional Distribution, Conditions, and Trends of Mixed Forest**

The State of Washington manages 1.4 million acres of forested lands in western Washington (DNR 1997). Long-term sustainable forest practices are a management priority in the State. Both public and private forestlands throughout the region are actively managed for a variety of purposes, including timber sales, recreation, and habitat conservation. Locally, Douglas-fir is the timber preferred by land owners and is currently the dominant species adjacent to the Unit.

Threats to this habitat include forest management narrowly focused on timber production, limited species diversity, poor function for wildlife species, habitat fragmentation due to development pressure, and some timber harvesting practices (Carey 2003, 2006, Heiken 2007). Other threats to the mixed forest ecosystem include invasive species infestations such as reed canarygrass in wetter areas; holly, spurge laurel, English laurel, English ivy, yellow archangel, and periwinkle in shaded areas and Scotch broom and blackberry in drier, more open locations.
Key Species Supported

Mid-story plants in older forests include vine maple, red-osier dogwood, evergreen and red huckleberry, salmonberry, thimbleberry, salal, osoberry, and perhaps native rhododendron. Additionally, rose species, stinging nettle, and devil’s club can be found. The understory is populated with sword fern, salal, dull Oregon grape, trailing blackberry, twinflower, inside-out flower, wild ginger, trillium, false lily of the valley, Pacific bleeding heart, and lilies. In the more mesic sites, lady fern and sword fern can be more dominant.

Wildlife associated with older, structurally complex and more diverse forests are rufous hummingbird, red-breasted sapsucker, northern flicker, pileated woodpecker, Steller’s jay, Vaux’s swift, purple martin, tree swallow, chestnut-backed chickadee, golden-crowned kinglet, winter wren, Swainson’s and varied thrushes, Pacific slope flycatcher, Wilson’s, Townsend’s, and MacGillivray’s warblers, Keen’s myotis, Townsend’s big-eared bat, elk, and black-tailed deer. Black bear and cougar use forests when enough habitat acreage exists and habitat corridors link to other large scale appropriate habitats.

4.4 Major Species Groups

4.4.1 Fish

Grays Harbor National Wildlife Refuge

Estuaries are a critical link between freshwater and marine habitats, providing a transition zone between fresh- and saltwater for anadromous species. They also are vital nursery areas for juvenile and sub-adult fish prior to migrating to the ocean. The diverse habitats represented in Grays Harbor, along with abundant food resources, support a wide variety of species and life stages. Some species make use of the estuary for all stages of their life cycle, while others use it primarily for one or two stages.

Much of the greater Grays Harbor estuary has been degraded by a combination of logging, channeling, gravel mining, water diversion, road building, dredging, aquaculture, small-scale coal mining, mill effluent, sewage release, and pesticide use for aquaculture and cranberry farming (Smith et al. 1976, Hiss et al. 1982, Wood and Stark 2002, Smith and Wenger 2001 (cited by Sandell et al. 2011)). However, despite the long-term degradation, it provides habitat for 54 fish species (Sandell et al. 2011).

No fish surveys have been conducted within the Grays Harbor Refuge boundary. However, some large-scale fish studies conducted in the greater Grays Harbor estuary have included a sampling site on the south side of Moon Island, which is located just on the other side of the peninsula to Grays Harbor Refuge (Simenstad and Eggers 1981, Simenstad 1981, Sandell et al. 2011). This site is relatively close to Refuge lands, but may include deeper water than is found in the intertidal mudflat habitats; however, it still may be representative of the open water portions of the Refuge.

Based on these studies, 28 species of fish use the shallow open water and intertidal area around Moon Island between March and October (Simenstad and Eggers 1981, Simenstad 1981). Juvenile chum salmon, coho salmon, Chinook salmon, and steelhead use the open water and intertidal flats. Juvenile chum enter the estuary in January, leave in May, and are most abundant in March and April.
Juvenile coho salmon arrive in April, leave in June, and are most abundant in May. Juvenile Chinook salmon arrive in April, leave in October or later, and are most abundant in June. Juvenile steelhead are generally present in the estuary between May and July. Juvenile Chinook salmon and chum salmon and juvenile English sole use shallow intertidal areas almost exclusively. Three individual bull trout were found in the southeastern portion of the estuary in 2011.

Different species of juvenile salmonids have differing food preferences (Simenstad et al. 1981). Two primary food categories are epibenthic organisms (harpacticoid copepods, and cumaceans) and neritic zooplankton (larval fish, crangonid shrimp larvae, calanoid copepods, and cyclopoid copepods). Primary prey for Chinook salmon are epibenthic cumaceans, drift insects, and fish larvae. Coho salmon mostly feed on neritic organisms, primarily crab species. Steelhead mostly feed on neritic crab larvae and juvenile smelt.

Grays Harbor estuary is an important rearing area for juvenile English sole (Simenstad and Eggers 1981). English sole spawn offshore from Grays Harbor and juveniles migrate into the estuary to rear. The density and abundance of epibenthic invertebrates, and specifically crustaceans, in shallow open water and intertidal areas is critical to rearing of English sole. Simenstad and Eggers (1981) found that first year juvenile fish are abundant near the Refuge throughout most of the study period and that they primarily feed on crustaceans. Two additional species of flounder may also occur at the Refuge.

Seven species of forage fish (or baitfish) are found near the Refuge (Simenstad and Eggers 1981). Of these, juvenile Pacific herring and all life stages of northern anchovies are abundant. Adult and juvenile surf smelt and all life stages of longfin smelt are common. Pacific herring juveniles are found near Moon Island from May through October and are most abundant July through September. Northern anchovies have three population peaks: May, July, and September. Juvenile longfin smelt numbers peak in March, June, July, August, and September. Juvenile and egg forms of Pacific sand lance were present mostly in April, and infrequently in May, July, August, and September. In addition, Sandell et al. (2011) found American shad and Pacific sardine present, but in small numbers. All forage fish were associated with sand flats and eelgrass, showing a strong preference for eelgrass far beyond the relative contribution of eelgrass to the overall estuary habitat complexity. All forage fish feed almost exclusively on zooplankton and are prey for larger predatory fish (Sandell et al. 2011).

Adult, juvenile, and larval stages of 12 additional species of fish use shallow open water and intertidal habitats. Adult and juvenile peamouth, three-spined stickleback, bay pipefish, shiner perch, saddleback gunnel, and staghorn sculpin were found, as well as all life stages of snake prickleback. Juvenile Pacific tomcod, eelpouts, walleye surfperch, and greenling are present (Simenstad 1981). The abundance of food resources is critical to these smaller fish, which in turn provide a food base for larger fish and many fish-eating waterbirds.

Few large pikeminnow or staghorn sculpin were captured, suggesting that size classes of these predators big enough to consume salmon smolts are not overly abundant (Sandell et al. 2011).

**Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge**

The Black River Unit encompasses a complex mosaic of wetlands and connecting uplands, extensive plant communities, and varied species of wildlife. The Creveling et al. study in 1980 is likely the most comprehensive natural history investigation of the upper Black River to date. It covers more area than the Unit acquisition boundary, so it encompasses most habitats found in the Unit and is an
excellent baseline source of information. The Unit species lists include those animals and plants that have been observed or are strongly thought to exist within Unit.

Twenty-nine species of fish are known to occur in the Black River, 20 of which are native. Native anadromous fish found in the river and likely within the Unit boundary are Pacific lamprey, coho and Chinook salmon, cutthroat trout, and steelhead. Native resident fish are cold-water species and include western brook lamprey, mountain whitefish, peamouth, speckled dace, redside shiner, large scale sucker, three-spined stickleback, Olympic mudminnow, and five species of sculpins. Nonnative fish are widespread in the river and, unlike the native fish, many are warm-water species: American shad, brown bullhead, pumpkinseed, bluegill, rock bass, large and smallmouth bass, black crappie, yellow perch, and northern pikeminnow (Kunze, L. 2011, pers. comm., Creveling et al. 1980, Caldwell et al. 2004).

Spring Chinook salmon, fall Chinook salmon, fall chum salmon, coho salmon, winter steelhead, and cutthroat trout, all of the Chehalis River Evolutionarily Significant Unit, occur in the Black River but mostly downstream of the Unit (Caldwell et al. 2004). No salmon of this Evolutionarily Significant Unit are listed with State or Federal agencies. Salmon and steelhead spawning habitat in the Black River drainage is primarily in tributaries because the majority of the mainstem has a mud or fine sediment bottom due to the extremely low gradients (Smith and Wegner 2001). Spring Chinook salmon spawn in the lower 9 miles of the river mainstem and likely do not spawn in the Unit. Fall Chinook salmon spawn up to river mile 9 and also between river miles 16 and 17.3, which is also downstream of the Unit. However, they also spawn in the first mile of Waddell Creek within the Unit (Smith and Wegner 2001).

Chum salmon were once abundant but their numbers have greatly diminished since the 1970s, and now they spawn only within the first 10 river miles (Phinney and Bucknell 1975 [cited in Smith and Wegner 2001]). Coho salmon spawning is widely distributed in Black River tributaries, with the most productive spawning habitat located in Waddell, Mima, and Allen Creeks (Caldwell et al. 2004). There is excellent rearing habitat for juvenile coho salmon in the upper reaches of the river, but high temperatures and low DO may limit use. Nonetheless, there is some rearing of juvenile coho salmon in the low gradient reaches within the Unit. Winter steelhead spawn in the lower 7 miles of the river below the Unit and in Blooms Ditch, Dempsey, Salmon, Beaver, Waddell, and Mima Creeks (Caldwell et al. 2004, Smith and Wenger 2001), some of which drain into the river within the boundary. Juvenile steelhead rear for 2 years and likely use the Unit, but may be limited by summer low-flow conditions (Caldwell et al. 2004). Cutthroat trout use the Black River from October through April with anadromous fish spawning January through mid-March and resident cutthroat trout spawning February through mid-March. Although the status is unknown, the stock is believed to be relatively abundant and widely distributed in the system (Caldwell et al. 2004).

Historically Chinook, coho, chum, and steelhead salmonids all migrated up the Chehalis River, through the Black River and into its tributaries, and into Black Lake, where they spawned in Black Lake’s tributaries. More recently, man-made alterations to lake water levels and the installation of a pipeline have impeded fish passage, contributing to the elimination of salmonid movement between Black River and Black Lake (Hawkins 2000, Smith and Wegner 2001, Caldwell et al. 2004). Salmon populations are likely much smaller than they were historically. The reduction of salmon abundance in the Black Lake and Black River watershed is of special concern because salmon are a keystone species, meaning that a wide array of organisms benefit from or depend on the trophic inputs salmon provide to the food web (Cederholm et al. 2000 in TNC 2005).
Low flows, high water temperatures, low DO levels, increased sediment loads, and concentrated toxins reduce survival of all salmonid life cycle stages. Pre-spawning mortality can be caused by low flows or reduced water quality. In 1989 there was a fish-kill in the river, south of Unit lands, which resulted in the death of adult Chinook salmon due to low DO, high nutrient levels, and warm water temperatures (Berg et al. 1995, Pickett 1994). Survival of eggs is dependent upon clean, stable gravel substrates. Low flows and high water temperatures can force early out-migration of juvenile fish, reducing their survival (see Chapter 3).

The small Olympic mudminnow (*Novumbra hubbsi*) is State-listed as a sensitive species and is a priority species under WDFW Priority Habitat and Species Program (PHS), but has no Federal status. Only three other species of *Novumbra* are found in North America and one in Eastern Europe, but the endemic Olympic mudminnow is found only in Washington State. The current distribution of the Olympic mudminnow includes the southern and western lowlands of the Olympic Peninsula, the Chehalis and lower Deschutes River drainages, and south Puget Sound, west of the Nisqually River (Mongillo and Hallock 1999). It occurs in quiet waters with several centimeters of soft mud substrate, little to no water flow, and abundant aquatic vegetation. If any of these characteristics are missing, no mudminnows are found (Mongillo and Hallock 1999). Meldrim noted that marshy streams with brownish water and overhanging banks are also important to the mudminnow (Meldrim 2012).

Adults are about 2 inches long and feed on live, moving prey, mostly ostracods, isopods, oligochaetes, mysids, mollusks, and dipterans. Spawning occurs over an extended period from late November to the following June (Mongillo and Hallock 1999). Females deposit eggs on vegetation and they hatch in approximately 10 days. Olympic mudminnows appear to be quite sensitive to competition or predation from exotic and native fish species (Mongillo and Hallock 1999). Because of this, the Olympic mudminnow's restricted range, and the continuing loss of wetlands, WDFW biologists believe the Olympic mudminnow is vulnerable and likely to become threatened or endangered in a significant portion of their range without cooperative management (Simon and Peoples 2006). Threats include habitat destruction, competition, and predation, particularly by exotic spiny-rayed fish (NatureServe 2012a).

Nonnative and invasive fish populations in the Black River include American shad, brown bullhead, pumpkinseed, bluegill, rock bass, largemouth and smallmouth bass, rainbow trout, black crappie, and yellow perch (Creveling et al. 1980). See Appendix L for the fish species list and Chapter 4, Section 4.7, for more information on these fish and their impacts on the habitat and native species.

Between August 6 and 7, 1989, a fish-kill occurred in the Black River and another on August 10 and 11 in the Chehalis River (Yake et al. 1989). Evidence suggests that a toxic substance entered the Black River at about river mile 9.2 on August 6 and moved downstream entering the Chehalis River. Estimates of the number of fish killed between river mile 9.2 and the mouth of the Black River include 100,000 coho salmon fingerlings, 17,000 cutthroat trout, and 118,000 forage fish (sculpins, dace, shiners, suckers, and lamprey). Over 300 adult Chinook salmon were killed in the Chehalis River. This fish-kill occurred below the Unit.
4.4.2 Waterfowl

Grays Harbor National Wildlife Refuge

The greater Grays Harbor estuary provides important migratory and overwintering habitat for waterfowl. It is listed as a key wetland requiring protection in both the Concept Plan for Waterfowl Wintering Habitat Preservation and Important Fish and Wildlife Habitats of Washington (USFWS 1979). As many as 45,000 birds have been recorded in the entire estuary during aerial surveys, with the highest counts during October and November. Grays Harbor is a large, protected estuary with a variety of habitats that provide foraging and cover sites, including eelgrass beds, shallow water areas, and marshes which produce sedge and grass seeds. Dabbling ducks are more prevalent than diving ducks in this shallow estuary. Surveys of the entire estuary showed American wigeon make up nearly 60 percent of the waterfowl, mallards 16 percent, green-winged teal 10 percent, and northern pintail 3 percent (USFWS 1990).

The most common species using the Refuge in the fall through spring are American wigeon, northern pintail, northern shoveler, green-winged teal, gadwall, surf scoter, common goldeneye, bufflehead, red-breasted merganser, and cackling and white-fronted geese. Mallards are common year round, as are Canada geese. Black brant were once rarely seen at the Refuge but are now occasionally observed on the open water or flooded intertidal mudflat in spring. It is unknown whether brant use reflects the increased presence of Japanese eelgrass (Baldwin and Lovvorn 1994), an invasive nonnative plant that is growing on the intertidal mudflats.

In the past, some waterfowl listed as occurring at the Refuge were actually using the Hoquiam sewage ponds to the east. Those species include canvasback, greater scaup, lesser scaup, and hooded merganser.

Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge

Mallards, American wigeon, green-winged teal, northern shoveler, northern pintail, hooded merganser, wood duck, bufflehead, ring-necked duck, and American coot use habitats within the Unit. Dabbling ducks are usually found in the open areas of emergent marsh, whereas diving ducks are usually found associated with the river’s deeper-channel waters. Typical seasonal rains create mild to moderate surface flooding conditions, which in turn support habitat for both dabbling and diving ducks and geese. Canada and cackling geese also use emergent marsh; seasonally flooded, nonnative grasslands; and dry, nonnative grasslands in late fall, winter, and early spring.

Waterfowl surveys were conducted by Unit staff twice a week in 2002, from mid-February to the end of March, in the open wetlands just north of 123rd Avenue. At that time approximately 115 ducks and geese a day were observed, and species included mallard, northern shovelers, green-winged teal, and American wigeon.

4.4.3 Water Birds

Grays Harbor National Wildlife Refuge

Great blue herons are common year round at the Refuge feeding in the intertidal areas. Double-crested cormorants are also common and forage in open water and flooded intertidal mudflats.
Horned grebes are common fall through spring in open water areas. Western grebes were once common in winter and spring but are now rarely observed. Common loons are seen and sometimes heard in the open water habitat.

Caspian terns historically bred on islands in Grays Harbor estuary, but the last known nesting was in 1989 (Seto et al. 2003). Caspian terns commonly forage in shallow waters at the Refuge in spring through fall. Glaucous-winged, western, hybrid cross, California, mew, and ring-billed gulls are common fall through spring.

Some water birds listed as occurring at the Refuge were actually observed using the nearby water treatment facility. These include brown pelicans and pied-billed grebes.

**Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge**

The Black River wetlands are excellent locations for migratory and resident waterbirds, especially secretive marshbirds such as green heron, American bittern, Virginia rail, and sora. These birds nest and forage in the dense cover that can be found in the emergent marsh, shrub swamp, and along the edge of the river channel. Great blue herons use the same habitats but also forage in more open areas such as the seasonally flooded, nonnative grassland. Pied-billed grebes use the deeper waters of the river channel to forage and nest in the cover where the shrub swamp and emergent marsh converge.

**4.4.4 Shorebirds**

**Grays Harbor National Wildlife Refuge**

Greater Grays Harbor estuary is one of the largest staging areas for spring migratory shorebirds on the Pacific coast of North America and hosts one of the largest concentrations of shorebirds on the Pacific coast, south of Alaska. In 1996 it was designated as a Western Hemisphere Shorebird Reserve Network Site of Hemispheric Significance (Manomet Center for Conservation Sciences 2013) and an Important Bird Area within the Washington Coast Estuaries IBA (Bayard 2013). In the spring of 1981 over 1,000,000 shorebirds were observed using the entire harbor to forage and rest as they made their way from South and Central America to breeding grounds in and around Alaska’s arctic and subarctic areas (Herman and Bulger 1981).

Grays Harbor Refuge occupies only 2 percent of the intertidal mudflat habitat of Grays Harbor estuary and yet hosts approximately 50 percent of the spring-migrating shorebirds (Herman and Bulger 1981). Of the 33 species of shorebirds that migrate annually along the west coast between the arctic and South or Central America, 24 have been observed at the Refuge. Currently the most abundant shorebirds using the Refuge are western sandpiper, dunlin, and semipalmated plover. Shorebirds that commonly use the Refuge in smaller numbers include black-bellied plover, greater yellowlegs, least sandpiper, short- and long-billed dowitchers, and red knot.

Grays Harbor Refuge brings together three characteristics critical to shorebirds. The first is a high concentration of invertebrates, which fuel the birds’ migration. The second is the higher-elevation intertidal mudflats that result in Refuge mudflats being the first in Grays Harbor to be exposed and the last to be inundated as the tide ebbs and flows, allowing birds to feed an additional 1 to 2 hours each tidal cycle. Third, the Refuge is protected from wave action, providing a sheltered environment for shorebirds and waterfowl (USFWS 1990). During low tides, shorebirds fan out over the intertidal mudflats following the receding water. As the returning tide advances, birds move shoreward and
may roost on the exposed intertidal mudflats, salt marsh, or on LWD until the tide begins to recede again (Herman and Bulger 1981). Birds often leave the Refuge to roost on Mini Moon Island just west of the Refuge.

The spring Refuge shorebird population is dominated early in the migration period by western sandpiper and dunlin, but semipalmated and black-bellied plovers, dowitchers, yellowlegs, and least sandpipers are also observed. Slightly later in the migration period, species diversity increases with red knots and occasionally whimbrels, marbled godwits, and ruddy turnstones observed foraging or resting at the Refuge.

The shorebirds migrate southward after breeding season ends or as dwindling food resources and cold weather forces them to move. The birds stop more frequently to forage on the southbound journey than they do in the spring. Some birds continue their flight into Central and South America, while some stop in Washington. These birds make a round-trip of 7,460 to 15,500 miles (Herman and Bulger 1981 [cited in USFWS 1990]).

Grays Harbor Refuge is important to shorebirds throughout the winter. Service records show that up to 20,000 shorebirds, mostly dunlin, use the Refuge through the fall and winter months (Herman and Bulger 1981 [cited in USFWS 1990]). Annual Audubon Christmas Bird Counts for the entire Grays Harbor estuary and coastline routinely record large numbers of dunlin (USFWS 1990).

Red knots are an SOC on both the east and west coasts of the United States. Individuals of the west coast subspecies (*Calidris canutus roselaari*) have declined in Grays Harbor estuary. It appears they are no longer using the Refuge in large numbers as they were in the past. Recent efforts to understand the natural history of *C. c. roselaari* have been helpful to understanding where these birds may be found within the greater Grays Harbor estuary (Buchanan 2006, 2008; Buchanan et al. 2011). It is possible that food resources and prey availability have declined at the Refuge, perhaps as a result of increased sedimentation levels (Buchanan, J. 2012, pers. comm.).

*Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge*

Shorebirds such as greater yellowlegs, dunlin, Wilson’s snipe, spotted sandpiper, and killdeer forage in the open, shallow wetlands. Yellowlegs winter there, dunlin may winter or stop during migration, Wilson’s snipe most likely nest there, and killdeer move up to the drier, nonnative grasslands to nest.

**4.4.5 Raptors**

*Grays Harbor National Wildlife Refuge*

Ten species of raptors are known to use the Refuge and five are common. Peregrine falcons and merlins are frequent sights during spring and fall migration and through the winter, feeding on the dense populations of shorebirds. Northern harriers and red-tailed hawks are common year round and feed mostly on small mammals in the salt marsh. Bald eagles commonly use the Refuge during the winter and spring, feeding mostly on fish and waterfowl, although they sometimes attempt to capture the highly maneuverable shorebirds. Ospreys, present spring through fall, feed exclusively on fish.

An often-seen raptor is the sharp-shinned hawk; less commonly seen is the Cooper’s hawk. Both hawks feed on small landbirds in forested habitat. Rough-legged hawks show up infrequently in
winter and prey on birds, small mammals, and carrion. American kestrels are observed even less frequently and feed mostly on insects, passerines, and small vertebrates.

Grays Harbor estuary is an important over-wintering area for peregrine falcons. During the winter of 1981–1982, six peregrines were radio-tracked in Grays Harbor and the most widely used areas were the Refuge, Point New to the northwest, and around the northeastern portion of North Bay to the mouth of the Humptulips River. Up to three peregrines have been seen at the Refuge at one time, their occurrence directly related to the large numbers of shorebirds in the area. Over 65 percent of wintering peregrine prey is shorebirds, mostly dunlin, (Dobler and Spencer 1989, Hayes and Buchanan 2002).

Merlins make use of Grays Harbor Refuge, notably during the winter (Buchanan et al. 1988) and spring shorebird migration. As many as 16 merlins were recorded in the greater Grays Harbor estuary during the 1977 Audubon Christmas Bird Count. Merlin use of the Refuge is tied to high densities of migrating and overwinter shorebirds.

Most of the raptors discussed above nest near the Refuge. Bald eagles nest along the entire coast of Washington, and adults and juveniles are seen year round at the Refuge. They teach their young foraging techniques on estuary waters. Numbers increase in fall and winter, and their occurrence is most closely tied to salmon spawning runs, waterfowl, and shorebird migrations. Ospreys have nested just outside the Refuge boundary in large banks of lights located along an abandoned open field. After a 2007 storm felled these lights, the Port of Grays Harbor erected an osprey platform near the Hoquiam water treatment pool. To date, ospreys have not used this as a nesting platform, although it is used by other raptors as a perch site. Peregrine falcons are known to nest within the estuary and on cliffs along the outer coast of Washington and make use of Grays Harbor year round. Merlins are thought to nest somewhere nearby. Red-tailed hawks commonly nest in the surrounding landscape.

Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge

Some raptors reside on the Unit year round, some use it as a stopover site during migration, and some winter in the area. Greater species diversity and larger numbers are observed in the fall and winter months. Owls that are common and nest in the area include barn and great horned owl. Owls that may use or nest in the area, but are not verified, are western screech, northern pygmy, and northern saw-whet. The short-eared owl may use the open old fields as hunting grounds during the nonbreeding season. Hawks expected to use the Unit include northern harrier, red-tailed hawk, Cooper’s and sharp-shinned hawk. American kestrels forage over the open grassland areas and are expected to be nesting nearby. Turkey vultures and bald eagles soar over open meadows and floodplains. Ospreys may also forage in the Unit.

4.4.6 Landbirds and Passerines

Grays Harbor National Wildlife Refuge

Over 54 species of landbirds have been observed at Grays Harbor Refuge, most making use of the forest and the tall shrubs and grasses along the margins of the Refuge (Sundstrom 2008). Most commonly occurring species appear to be breeding or year-round residents. A few species are either migratory, using the Refuge during the spring and/or fall, or overwintering.
A 2-year study along the State Highway 109 right-of-way (ROW) (in forest and salt marsh habitats) along the north side of the Refuge recorded a small group of species present during each season that included song sparrow, bald eagle, gull species, common raven, red-tailed hawk, and marsh wren (Sundstrom 2008). Song sparrow, American robin, black-capped chickadee, marsh wren, and American crow were the most frequently detected species and comprised 51 percent of all bird detections during the study. Thirty-three species were commonly detected in both study years, with fall being the season when most were detected (Sundstrom 2008).

In the southern end of the Refuge, 12 species of landbirds are common year-round: downy woodpecker, northern flicker, American crow, black-capped chickadee, Bewick’s wren, marsh wren, American robin, European starling, spotted towhee, song sparrow, house finch, and American goldfinch. Twenty-two species of landbirds are common during at least one season of the year, mostly spring through fall or summer. Seasonally common birds include rufous hummingbird, Pacific-slope flycatcher, willow flycatcher, violet-green swallow, tree swallow, cliff swallow, barn swallow, orange-crowned warbler, yellow warbler, yellow-rumped warbler, American goldfinch, Wilson’s warbler, savannah sparrow, and brown-headed cowbird.

**Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge**

Over 74 species of migrant or resident landbirds and passerines have been recorded within the Black River Unit boundary, including 8 species of raptors, including owls, hawks, falcons, and eagles. Long-distance migrants travel between breeding grounds in temperate North America and wintering grounds in Central and South America. Resident species both breed and winter in the local area.

Within the Unit, mixed forests, riparian forests, and shrub swamps provide differing growth forms, layers of vegetation structure, plant diversity, and food resources which support many species of landbirds. A mosaic of habitats and the transition zones between them provide bird species greater use of the areas. Many passerines rely on the cover, food availability, foraging space, undisturbed areas for nesting, branches to support nests, and access to water that the thickets and wetlands provide.

Year-round resident woodpeckers using mixed and riparian forests include northern flicker; downy, hairy, and pileated woodpeckers; and red-breasted sapsucker. Rufous hummingbird is the only known hummingbird species on the Unit, but Anna’s hummingbirds are expanding their range throughout western Washington and may now occur on the Unit. Belted kingfishers forage for fish in the river, band-tailed pigeons and cedar waxwings forage on fruit-bearing plants in the forests, and mourning doves use the open areas of dry, nonnative grasslands. Nesting violet-green swallow, tree swallow, barn swallow, cliff swallow, and northern rough-winged swallow consume insects over the floodplain. Some habitats should be appropriate for Vaux’s swift.

Many passerines rely on the Unit during migration to and from distant breeding grounds. Large numbers of warblers, vireos, flycatchers, thrushes, and swallows stop to refuel in the mixed forest, riparian forest, and shrub swamp habitats. Habitat in the riparian and shrub swamp is used by yellow warbler, yellow-rumped warbler, common yellowthroat, red-eyed vireo, Cassin’s vireo, warbling vireo, black-headed grosbeak, evening grosbeak, western tanager, bushtit, black-capped chickadee, chestnut-backed chickadee, Bewick’s wren, Pacific wren, and sparrow species.
The drier mixed forests support American robin, spotted towhee, Swainson’s thrush, varied thrush, hermit thrush, American goldfinch, Steller’s jay, American crow, raven, red-breasted nuthatch, Pacific wren, Bewick’s wren, Wilson’s warbler, Townsend’s warbler, black-throated gray warbler, brown creeper, chestnut-backed chickadee, ruffed grouse, blue grouse, and band-tailed pigeon. The emergent marsh supports the marsh wren, common yellowthroat, and red-winged blackbird. Dry, nonnative grasslands could provide habitat for western meadowlark, American kestrel, California quail, sparrow species, killdeer, American robin, purple martin, Vaux’s swift, and swallow species.

4.4.7 Mammals

Grays Harbor National Wildlife Refuge

No mammal surveys have been conducted at the Refuge, which has limited upland habitat and is isolated from adjacent lands. Black-tailed deer and breeding short-tailed weasel are observed annually. River otter are occasionally seen on the intertidal mudflats as well as the occasional harbor seal pup. It is likely that vole, shrew, raccoon, mink, and coyote use the Refuge, but surveys are lacking. Nonnative species including opossum, eastern gray squirrel, and eastern cottontail likely occur on the Refuge. A report of elk was once provided by a visitor but not verified, and a single, unverified observation of a dead black bear cub was made.

Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge

The most comprehensive inventory of mammal species for the Black River drainage was done by Creveling et al. in 1980 for the Washington Department of Game. They identified a total of 54 species of mammals from habitats found the Black River watershed: 4 species in aquatic habitats, 13 species in wetland habitats, 15 species in the riparian zone, 15 species in shrub habitats, and 36 in the forests. Today nutria, eastern gray squirrel, opossum, and eastern cottontail should be added to the list as nonnative mammals. Creveling et al. also found Norway rat and house mouse, but those are expected in more developed areas instead of natural areas.

Native species found exclusively within the aquatic and wetland habitats include water and vagrant shrew, shrew mole, Townsend’s and water vole, beaver, muskrat, mink, long-tailed weasel, and river otter. Those species found exclusively within upland habitats include masked and Trowbridge’s shrews, mountain beaver, Townsend’s chipmunk, Douglas’ squirrel, northern flying squirrel, deer mouse, bushy-tailed woodrat, Gapper’s red-backed vole, creeping vole, porcupine, coyote, red fox, ermine, striped skunk, Roosevelt elk, and black-tailed deer. Species which use both the upland and riparian habitats include Pacific water shrew, Townsend’s mole, long-tailed vole, Pacific jumping mouse, snowshoe hare, black bear, western spotted skunk, mountain lion, and bobcat. At least eight species of bats have been identified using the area: Yuma, Keen’s, long-eared, California myotis, Townsend’s big-eared, silver-haired, big brown, and hoary bats (Creveling et al. 1980). Many of these species use abandoned structures for roosting and maternity sites.

Beavers are an important source of disturbance in the Black River lowland floodplain ecosystem. Most beavers were removed from rivers and streams in the Pacific Northwest in the late 1800s as a result of the fur trade. Beaver populations were also reduced by eradication efforts to prevent flooding in lands planned for agricultural use and development and to reduce insect populations. Until recently, fisheries biologists encouraged natural-land managers to break up beaver dams because according to early studies, they thought the dams hindered passage for anadromous
salmonids and decreased fish habitat (Reid 1952 [cited in Pollock et al. 2008], Sanchez 2008). In areas where human development grew, beaver populations never rebounded to former levels. Areas impounded by beaver dams have been associated with biomass or diversity increases in a wide range of taxa, including birds, mammals, plants, and insects (Pollock et al. 2008). Beaver-impounded wetlands provide important off-channel rearing habitat for juvenile salmon during seasonal high water periods, and submerged vegetation and woody debris associated with beaver ponds provide excellent cover for rearing salmon. Beaver activity holds water through the dry season, providing needed habitat and water resources to a large number of species, animal populations, and plant communities. Beaver ponds also create a nutrient sink, which increases productivity of aquatic invertebrates, both in the ponds and in tributaries downstream of the ponds. Beaver dams provide storage areas of fine sediment and stabilize flows during high water events as water is stored in ponds and released slowly over the beaver dams (Cederholm et al. 2000, Smith and Wegner 2001).

In the entire Black River system, the only undeveloped or unaltered floodplain remaining is the wetlands along the upper reaches of the river. The low-gradient floodplain provides ideal conditions for beaver colonization and an abundance of off-channel habitats that are preferred by juvenile salmon species. In the river, the beaver dams across the river channel do not create characteristic open ponds. Instead, water spreads widely over the flat floodplain landscape. They help create the shrub swamp and emergent marshes which provide important ecological benefits to a variety of wildlife species. By constructing dams and impounding streams, beavers considerably alter stream hydrology in a way that provides extensive benefits to fish as well as other organisms, resulting in a high species diversity supported by these systems (Rossell et al. 2005). It is most likely that cutthroat trout and coho salmon make extensive use of these areas for overwintering and feeding.

### 4.4.8 Reptiles and Amphibians

#### Grays Harbor National Wildlife Refuge

Surveys for reptiles and amphibians are incomplete. Pacific chorus frog is expected to occur in the forest habitats, and there may be other species of amphibians and snakes in residence.

#### Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge

A total of 13 species of amphibians have been found within the Black River basin (Creveling et al. 1980). Most were found in the wetland zones, but many were also found in forested locations, including riparian habitats. Not all species found by Creveling et al. may occur within the Unit, but the expected species include northwestern, long-toed, and ensatina salamanders and rough-skinned newt. Native frogs or toads using the Unit include the Pacific chorus frog, red-legged frog, and Oregon spotted frog, and possibly western toad. Nonnative bullfrogs occur in localized areas. Detailed information on the Oregon spotted frog can be found in Section 4.5. Rare Species.

Ten species of reptiles were found within the entire watershed that might occur within the approved Unit boundary; eight of these were found in forested habitats, six in riparian, and three in both the aquatic and wetland areas. Two species of turtles occur in the wetland and aquatic habitats: painted turtle (native to eastern Washington) and the nonnative red-eared slider. At one time, Pacific (western) pond turtles, a State endangered species, were found but they are now thought to be extirpated. Two species of lizards are possible in the upland habitats: northern alligator and western fence lizard. Six species of snakes may occur within the Unit, including two species occurring
exclusively in the uplands: gopher and northwestern garter snake. Species that could occur in both uplands and wetlands include rubber boa and common and western terrestrial garter snakes.

4.4.9 Invertebrates

Grays Harbor National Wildlife Refuge

Invertebrates within the water column and in the substrates of Grays Harbor estuary are a vital part of the food web supporting the wealth of higher species that make use of the landscape. Invertebrates are a critical part of the food web at the Refuge, notably providing food for migrating and overwintering shorebirds, ducks, water birds, juvenile salmonids, and non-salmonid fish. Their densities, biomass, and species diversity support large concentrations of animals (such as migrating shorebirds), which in turn attract larger, vertebrate predators such as peregrine falcon, merlin, and bald eagle.

Benthic invertebrates (those below the sediment surface) are critical to shorebird use of the Refuge. Species composition and densities of benthic invertebrates vary depending on tidal level and substrate (Wolfe, Moore, and Cameron 1974, Wolfe and Moore 1973, Wolfe 1973, Warnock et al. 2004). Both abundance and biomass of invertebrates are considerations in food availability for predator species. Substrates at the mid-tide level have greatest biomass of insects, polychaetes, and amphipods but only half as many individual insects as either polychaetes or amphipods (Warnock et al. 2004). One individual polychaete animal accounted for two-thirds of the total mass of polychaetes in that 2004 study. Substrates at the low-tide level have very high biomass and numbers of individual polychaete worms, and moderately high biomass and numbers of individual bi-valves (Warnock et al. 2004).

Epibenthic invertebrates (those on the sediment surface) are important food resources for fish and some bird species, such as those that peck at the exposed surface. Forty-eight taxa of epibenthic invertebrates are found at the Refuge and are predominantly harpacticoid and calanoid copepods (Simenstad and Eggers 1981, Simenstad 1981). As many as 84,500 organisms per cubic meter were measured, which is near the highest density found at other locations along the Pacific coast. Species abundances shift with the tides. Historically the basin was a nursery area for Dungeness crab (Wolfe 1973).

Invertebrates in the water column, neritic zooplankton, are critical food for fish and some bird species. Over 100 taxa of zooplankton are found at the Refuge, of which at least 95 are invertebrates (Simenstad and Eggers 1981, Simenstad 1981). Seasonal species abundances shift dramatically, with the greatest abundance (about 1,900 organisms per cubic meter) the end of April and the beginning of May and the lowest abundance in July (about 51 organisms per cubic meter). A second peak in abundance occurs in September. By far, copepods and barnacles make up the greatest biomass.

Little is known about invertebrate food preferences of different avian predators using the Refuge. Two species of crustaceans and one species of amphipod make up about 94 percent of the stomach contents of overwintering dunlin at the Refuge (Brennan et al. 1990), which could indicate preferential feeding or could reflect species abundance at the time of feeding.

Anthropogenic impacts to sediment levels and tidal levels within the Refuge are of concern in that they most likely affect the density and species composition of invertebrates (Wolfe, Moore, and
Cameron 1974), which are critical to fish and migratory birds. Additionally, invasive plant species spreading over the intertidal mudflats may affect invertebrate species.

**Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge**

Studies of freshwater benthic invertebrates are incomplete, but water quality studies in the lower portions of the river (samples collected at 110th Avenue) noted that the invertebrate population generally is not diverse, is dominated by pollution-tolerant species, and has low numbers of pollution-sensitive species. Midge larvae, which are pollution-tolerant, are the most abundant, while mayflies, stoneflies and caddisflies, which are pollution-intolerant, were uncommon. The populations recorded from six sites along the river included mayflies, stoneflies, caddisflies, dragonflies, scuds (amphipods), water beetles, true flies (including midges), true bugs, moths, and alderflies. The Berg et al. study (1995) also found freshwater clams, snails, aquatic sow bugs, crayfish, and leeches.

More recent observations include broken freshwater mussel shells found on top of bent-over reed canarygrass in a flooded area next to the river. They were identified as Oregon floaters by Service biologist Donna Allard. Additional shells were found in Waddell Creek and were also identified as Oregon floaters. Crayfish have been observed in Waddell Creek, but the species has not yet been identified. However, a native signal crayfish was identified in emergent marsh near 123rd Avenue by Unit staff. Freshwater sponges (species unknown) are also thought to be living in the river within the Unit boundaries, and Mumford (2013, pers. comm.) has noted freshwater sponges are abundant between river miles 4 through 15. Nonnative bryozoan colonies have been found in the river just south of Littlerock and may also be within the Unit boundary.

Rare invertebrates that may occur at the Unit include Beller’s ground beetle, Hatch’s click beetle, and the Pacific clubtail (Kunze, L. 2011, pers. comm.).

### 4.5 Threatened, Endangered, and Sensitive Species

One goal of the Refuge System is “To conserve, restore where appropriate, and enhance all species of fish, wildlife, and plants that are endangered or threatened with becoming endangered.” In the policy clarifying the mission of the Refuge System, it is stated, “We protect and manage candidate and proposed species to enhance their status and help preclude the need for listing.” In accordance with this policy, the CCP planning team considered species with Federal or State status, and other special status species, in the planning process.

#### 4.5.1 Grays Harbor National Wildlife Refuge

**Fish**

Three species of fish listed as threatened under the ESA potentially occur at Grays Harbor Refuge: green sturgeon, eulachon, and bull trout; however, no surveys have been conducted to date within the Refuge boundary. The juvenile stage of green sturgeon might make use of the open water habitat. Eulachon eggs and larvae might be found briefly in either the open water or intertidal mudflat habitats. Adult and juvenile bull trout might make use of the open water habitat.

The **Southern Distinct Population Segment of North American Green Sturgeon** is a NOAA federally listed threatened species. Habitat use outside of natal areas includes coastal estuaries and
coastal marine waters from southern California to Alaska. Grays Harbor coast and estuary are specifically designated as critical habitat. Most of the fish expected to occur in Grays Harbor would likely be immature fish that use the Harbor during summer to feed and to optimize growth (Lindley et al. 2008, Moser and Lindley 2007 [cited in Federal Register volume 74, page 52300]). Little is known about green sturgeon spawning, but it is not thought to spawn in the Chehalis River. The greatest threats include overfishing, modification of spawning habitats, entrapment in water project diversions, and pollution (Adams et al. 2002, WSDOT 2010).

Eulachons, also known as candlefish or Pacific smelt, are a NOAA federally listed threatened species and a State-candidate species. Eulachon were commonly found in Grays Harbor estuary into the 1990s. Adults pass through Grays Harbor between late December and early March on their way to spawning grounds in the many rivers and tributaries draining into the Harbor. On the Refuge, eulachon would most likely be found only as eggs or larvae because they are soon washed out to the Pacific Ocean. The numbers of eulachon in Grays Harbor declined after the early 1990s to the point where they were only occasionally observed in 2001. Threats to eulachons are many, including possible predation of eggs and larvae. It is theorized that climate change may pose a significant threat through increased ocean warming and changes to their copepod prey base during the transition from larvae to juveniles (NFSC 2008).

Bull trout are a Service federally listed threatened species and State-candidate species. Most bull trout populations spend their entire lives in cold, clean, fresh water, but those in the Coastal-Puget Sound population migrate between fresh water and the marine environment (USFWS 2004). Chehalis River/Grays Harbor is a designated Critical Habitat Subunit of the Olympic Peninsula Critical Habitat Unit of the Coastal Recovery Unit for Bull Trout. This unit is considered essential for maintaining distribution of the anadromous life history form of bull trout which is rare across the species’ geographic range (USFWS 2010b). Grays Harbor estuary provides a key connection between the Pacific Ocean and freshwater habitats within the Chehalis River basin and Humptulips River drainage. Bull trout are not thought to spawn in the Chehalis River, rather are suspected to spawn in tributaries with headwaters north of the river (USFWS 2010b). Bull trout were found in the mouth of the Chehalis River in Grays Harbor estuary between 2001 and 2004, and historic data showed them netted near Moon Island once in 1973, three times in 1974, and three times in 1977 (Jeanes and Morello 2006).

The Refuge may provide important habitats such as native eelgrass beds, salt marshes, and intertidal mudflats at high tide. Contrary to the generally expected requirement of cold water temperatures and the need for complex habitat, bull trout were found to repeatedly use relatively shallow, near-shore waters in bays and estuaries in the lower Skagit River delta between March and August. In one study the majority of radio-tagged fish occupied depths < 4 meters and were found to use eelgrass, green algae, saltmarsh, and intertidal mudflats areas more than expected (Hayes et al. 2011). Shallow water habitats not only provide bull trout with opportunities for foraging, but may reduce predation by large predators such as seals.

Threats to bull trout include habitat degradation and fragmentation, blockage of migratory corridors, poor water quality, past fisheries management, and the introduction of nonnative species such as brown, lake, and brook trout. Effects from climate change threaten bull trout throughout their range in the coterminous United States. With a warming climate, cool-enough spawning and rearing areas are expected to shrink during warm seasons, in some cases dramatically, causing them to become even more isolated from one another. Climate change will likely interact with other stressors, such as habitat loss and fragmentation, invasions of nonnative fish, diseases, and other threats, to render
some current spawning, rearing, and migratory habitats marginal or wholly unsuitable (USFWS 2010b, USFWS 2010c).

**Birds**

**Bald eagles** are no longer federally listed as threatened in Washington, but continue to be protected by the Federal Bald and Golden Eagle Act and are considered a State-sensitive species. Both adult and immature eagles forage on flocks of waterfowl and shorebirds on the Refuge. Eagles most likely forage for fish in open water habitat, during high tide conditions on the intertidal mudflat, and in the surrounding greater estuary. They do not nest on the Refuge.

**Brown pelicans** are no longer federally listed as threatened in Washington; however, they are considered State-endangered. On the Pacific coast, brown pelicans nest in California and fly north along coastlines in Oregon and Washington to forage on fish-rich waters, most commonly between June and October. They can be observed in greater Grays Harbor estuary, including Refuge open waters. They have also been observed using the water treatment lagoon near Paulson Road.

**Common loons** are a State-sensitive species. They forage on fish in open water habitat, during high tides on intertidal mudflats, and in the surrounding greater estuary, including the shipping channel near the Refuge. Nesting habitat is not available on the Refuge.

**Peregrine falcons** are no longer federally listed in Washington, but are considered a State-sensitive species. This species preys on birds and can be observed chasing flocks of waterfowl and shorebirds during winter and spring seasons. They do not nest on the Refuge.

**Western Grebes** are an SOC. These birds may use the open water habitats of the Refuge to prey upon fish and to loaf. They do not nest on the Refuge.

**Invertebrates**

**Newcomb's Littorine Snail** is a State-candidate species. This snail lives on the stems of *Salicornia*, and possibly other estuarine marsh plants. It also lives on the substrate beneath vegetation, where it remains moist and protected from the sun and wind. It feeds on micro- and macroscopic algae and the vascular plants on and under which it lives (MacDonald 1969, Hinde 1954 [cited in Larsen et. al 1995]).

4.5.2 **Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge**

**Fish**

**Pacific lampreys** are an SOC (NatureServe 2012b). They occur from Alaska south through California, are widespread, but have declining numbers. They are anadromous parasitic fish that spawn in June and July in Washington. Juveniles live in freshwater for 4–6 years, then metamorphose into adults and migrate to the Pacific Ocean. Pacific lampreys use shallow backwater areas or eddies along edges of streams with mud, silt, and sand bottoms. They spawn in riffles with rock, sand, or gravel substrates in clear streams. Juveniles are filter feeders. Adults are parasitic on fish, particularly salmon, staying attached for 20–40 months. Primary threats are channelized streams, pollution, barriers to migration, and reduced food resources (salmon). Pacific lampreys have been found in tributaries draining into Black River (WDFW 2013).
Olympic mudminnows are a State-sensitive and endemic species. They require slow-moving rivers, ponds, or wetlands with muddy substrates and dense submerged vegetation such as in Black River. Mudminnows prey on an assortment of small invertebrates and depend on healthy wetland habitat for their survival. This species does not fare well when sharing habitat with nonnative species of fish. It is uncertain if this is a result of competition or predation, but some combination is likely. Because of this, and the Olympic mudminnows’ restricted range and the continuing loss of wetlands, they are thought to be vulnerable and likely to become threatened or endangered in a significant portion of their range without cooperative management (Mongillo and Hallock 1999).

Plants

Water howellia is a federally threatened species and a State-threatened species. It is regionally endemic, currently known from California, Montana, Idaho, and Washington and was historically known from Oregon (USFWS 1996a). In Washington, it occurs within the Columbia Basin and Puget Trough physiographic provinces. It occurs in wetlands, mostly in small, vernal ponds, although some of the ponds may retain water throughout the year. Soils are rich in organic matter and frequently contain partially decomposed leaves, stems, and wood. Water howellia is known to exist in the Black River watershed, although its presence is unknown within the Black River Unit.

The most significant threats and management concerns are changes in wetland hydrology, an increase in weedy species (e.g., reed canarygrass), the threat of invasion by noxious weeds (e.g., purple loosestrife), livestock overgrazing, and timber harvest activities on adjacent uplands (USFWS 1996a).

Bristly sedge is listed as State-sensitive and WDNR recorded its presence in what is now the Black River Unit (Kunze L. 2011, pers. comm.). Its status on the Unit is currently unknown.

Birds

There are no federally listed (threatened or endangered) birds using the Black River Unit.

Pileated woodpeckers are a State-candidate species. These woodpeckers prefer mature deciduous, coniferous, or mixed forests where larger trees provide appropriate habitat for nest cavities which are excavated new each year. They forage on insects and eats fruit and nuts (Seattle Audubon Society 2002).

Purple martins are a State-candidate species. Purple martins are loosely colonial and prefer natural cavities near water to nest. They often use holes excavated by woodpeckers in mature mixed deciduous and conifer forests where larger trees provide appropriate habitat for cavities. Purple martins build a cup nest within the cavity. They forage for aerial insects over open lands near water such as emergent marsh, open wetlands, or open fields (Seattle Audubon Society 2002).

Vaux’s swifts are a State-candidate species. Vaux’s swifts are loosely colonial and forage in open sky over woodlands, lakes, and rivers, where flying insects are abundant. Nesting habitats include either coniferous or deciduous forests that provide large, hollow trees or snags with vertical entrances for nesting and roosting. The nest is a shallow half-cup attached to the inside of a tree with sticky saliva (Seattle Audubon Society 2002).
Mammals

Townsend’s big-eared bats are an SOC and a State-candidate species that are known to use habitats in the Black River watershed and may occur within the Black River Unit boundary. Townsend’s big-eared bats can be found in British Columbia, throughout the western United States, and in Mexico. They commonly occur in mesic coniferous and deciduous forested regions. Townsend’s big-eared bats feed on flying insects, primarily moths, near trees and shrubs in the mid- to upper canopy. They typically use caves, mines, and buildings for both maternity colonies and hibernating. Nursery colonies tend to be small, up to 200 individuals. They hibernate singly or in small groups. These bats mate in late fall through winter, and a single young is born in mid-July. Primary threats are loss of habitat and disturbance of maternity roosts and hibernacula (NatureServe 2013, WDFW 2013).

Amphibians

Oregon spotted frogs are a federally threatened and State-endangered species. They have occurred from southwestern British Columbia to northeastern California but have been extirpated from California. Much-reduced populations are in British Columbia. Remaining extant populations are in isolated areas of eastern and western Washington and western Oregon. As of 2001, Oregon spotted frogs are known from eight sites in Washington State (USFWS 2011). Oregon spotted frogs are highly aquatic, staying in or in close proximity to open water. They prefer streams, lakes, ponds, and marshes that provide open, permanent, quiet waters with relatively warm temperatures and short vegetative cover throughout the year. Adults are opportunistic feeders on a wide range of insects, mollusks, crustaceans, and arachnids. Larvae and tadpoles depend upon vegetative detritus and algae.

Optimal Oregon spotted frog breeding, egg-laying, and rearing conditions occur between January and June and contain open, short vegetation locations in sun-warmed, shallow water which are hydrologically connected to permanent waters. Herbaceous plants used by Oregon spotted frogs are low-growing and sparse; some preferred areas show exposed mineral soils, and an occasional shrub provides a source of cover from predators. Shallow water allows surface water temperatures to rise and speeds egg development. Stable, shallow water levels are critical to keep egg masses hydrated during development into the larvae stage. As spring progresses to summer, surface water must remain connected to nearby deeper, permanent waters to allow tadpole migration. If surface water evaporates and water levels drop before tadpole migration occurs, the young frogs become isolated, desiccate, and cannot survive (USFWS 2011).

Major threats to Oregon spotted frogs include breeding and egg-laying habitat loss and limitations to natural life cycles. Densely growing reed canarygrass may cause frogs to expend large amounts of energy to move through it daily and seasonally. It potentially prevents frogs from reaching optimal breeding and egg-laying sites. Nonnative bullfrogs and nonnative fish in Unit wetlands and channels may prey upon both Oregon spotted frog adults and tadpoles (USFWS 2011, Cucherousset and Olden 2011, Howell 2010). Oregon spotted frogs tested in the Black River drainage showed exposure to chytrid fungus (Batrachochytrium dendrobatidis), which is responsible for the decline of many amphibian species worldwide. Dermal infections by chytrid fungus are thought to cause amphibian mortality by interfering with skin functions (Pearl et al. 2009, Speare and Berger 2004, in USFWS 2011).

The Service, WDFW, WDNR, and private landowner biologists in Thurston County coordinate with surveying, monitoring, and research on this species throughout the drainage, including the Unit.
Annual egg surveys help gauge frog populations and habitat quality. WDFW and Service data suggest the Black River drainage population is declining.

**Invertebrates**

Five invertebrate species of specific interest may occur on the Black River Unit. Future inventory of Unit habitats for these species should be conducted.

**Beller’s ground beetles** are a State-candidate species. They occur in sphagnum bogs in open areas with native cranberry, sundew, and low-growing graminoids (Xerces Society 2011). Adults breed in the spring. They eat seeds, vegetation, and small insects. Little is known about the larvae. Threats include habitat loss, changes in hydrology, trampling, and pollution. This species is distributed from the Queen Charlotte Islands through coastal British Columbia, Washington, and Oregon, but only about 25 populations are currently known (Maynard 2009). Two populations are found in Thurston County, including one within the Black River drainage.

**Hatch’s click beetles** are a State-candidate species. They occur in sphagnum bogs, possibly in drier areas associated with Labrador tea (Xerces Society 2011). Adults are capable of flight and have been found April through June. Little is known about the larvae but they may take several years to develop. Adults feed on honey dew, pollen, nectar, and floral structures. This species is endemic to the Puget Trough region and is known from King County. The primary threats to this species are loss of habitat and loss of connectivity between populations (Kunze, L. 2011, pers. comm.).

**Queen Charlotte’s copper butterflies** are a State-candidate species (NatureServe 2011). They were previously known as the Makah copper butterfly and occur in coastal bogs associated with native cranberry. Their range is from the Yukon Territory south through British Columbia and Washington.

**Bog idol leaf beetles** (formerly Long-horned leaf beetle) are a State-candidate species that is specifically associated with lowland sphagnum bog habitats and is at risk of extinction due to their limited distribution and isolated populations. The beetles’ larvae feed on submerged portions of aquatic plants, whereas adults feed on exposed portions of aquatic plants (White 1983 [cited in Larsen et. al 1995]). Threats are from urban runoff waters that may contain pesticides and other pollutants, and from exotic, nonnative fish that could potentially prey on beetle larvae (Larsen et al. 1995).

**Pacific clubtail dragonflies** are a State-candidate species. They occur from Washington south through California and east into Idaho. They are found in a variety of aquatic habitats including lakes and slow-moving rivers. Adults fly early June through mid-August. Adults feed on flying insects, whereas larvae feed on invertebrates and possibly small vertebrates. There are currently two known populations in Washington, one on the east side of Black Lake and the other in Skamania County. Larvae require fine-textured substrates for burrowing, and disturbance of appropriate substrates is a key threat. Additional threats include wind- or water-born insecticides, herbicides, and other contaminants (Kunze, L. 2011, pers. comm.).

### 4.6 Invasive and Nuisance Species

Invasive species are one of the most serious challenges that affect natural resources worldwide. Recent estimates of environmental and economic costs of invasive species in the United States alone
Invasive plants are plants that have been introduced to the region or U.S. from a different region or country. They may have been introduced intentionally (as an ornamental plant, for example) or accidentally (as a contaminant in crop seeds, for example). Many terms, such as nuisance, noxious, alien, invasive, pest, nonindigenous, are used in referring to nonnative plants and animals. While many nonnative plants are extremely beneficial to society, like rice or potatoes, invasive, noxious, and pest plants spread rapidly and cause or are likely to cause harm to economic, environmental, or human health.

President Clinton signed the Invasive Species Executive Order (EO 13112) in 1999 “to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause.” The EO further defines an invasive species as “an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health” (USFS 2015).

The Refuge encompasses a number of diverse habitat types, all of which are threatened by exotic or invasive plant species. An exotic species may be defined as any species occurring in a particular ecosystem or habitat that is not native to that ecosystem or habitat. An invasive species may be defined as an exotic species whose introduction is likely to cause economic or environmental harm or harm to human health (USFWS Executive Order 13112). The Washington State Noxious Weed Board maintains an official State list of noxious weeds and each county keeps a more locally prioritized list. Those lists provide guidance to Refuge staff, especially about plant species that are required to be controlled. Some species are more problematic than others on Refuge habitats and some nonnative species are not targeted for control.

The Refuge strives to maintain healthy plant communities to ensure that high quality habitat is available for native flora and fauna, and management of invasive plants is a major strategy. The management strategy utilized is Integrated Pest Management (IPM) (see Appendix G), an ecological approach that uses a number of mechanical, physical, biological, and chemical control methods, including herbicide application, mechanical mowing, haying, selective hand cutting and thatch removal, herbivore grazing, prescribed fire, water control methods, or barrier cloth placement that are minimally detrimental to rare or declining species populations. Preferred methods are those that have the least environmental impact while effectively controlling invasive species. Early detection of new invasions and rapid response is considered critical for cost-effective control and prevention of invasive species from rapidly spreading.

Nonnative animal species are present on the Refuge and threaten native animals, especially rare, sensitive, or listed species, as well as potentially impacting habitats. In 2001, over 42 species of introduced or nonnative species of wildlife (birds, mammals, amphibians, reptiles) were identified in Washington and Oregon, and more species have become established since then (Witmer and Lewis 2001). Many nonnative species have adverse ecological consequences through direct or indirect mechanisms (e.g., resource competition, displacement, predation, hybridization, disease transmission). Management and control efforts are often difficult and costly, and each situation must be assessed on a species- and site-specific basis (Witmer and Lewis 2001).

The establishment of any invasive species has the potential to cause significant ecological and economic damage to the host ecosystem. Invasive species are typically established without the predator they would experience in their native habitats, often allowing their populations to grow rapidly once introduced (Beck 1994).
Some nonnative species have been targeted for greater levels of control effort than others based on budget levels, staffing, perceived threat, and ability to enact effective reduction or control. The following descriptions are for some of the species known to affect the Refuge and the Unit and fish and wildlife populations.

4.6.1 Grays Harbor National Wildlife Refuge

Plants

*Spartina* (cordgrass species) occurs in the greater Grays Harbor estuary and in Grays Harbor Refuge. Rapid infestation rates likely occur on the West Coast because invertebrate herbivores (leaf-feeders and stem-borers) that naturally control *Spartina* within its native range on the Atlantic coast are not found on the West Coast. *Spartina* clones ultimately grow together to form dense, monotypic stands (meadows) in the mudflats that entrap sediments (~15 cm/yr) at and above mean higher high water. The intertidal mudflats displaced by *Spartina* are important habitat for migratory birds, juvenile fishes, native eelgrass, Dungeness crab, and clams. It also grows in the saltmarshes, rapidly outcompeting native saltmarsh plants and creating monocultures that become undesirable to fish and wildlife (WSAG 2011).

A cooperative agreement between the Service, WDFW, and Washington Department of Agriculture has been very successful in controlling *Spartina* in greater Grays Harbor estuary. This multi-agency partnership has provided funding and assistance in controlling this invasive plant. Surveys are conducted annually for this plant to determine presence, location, and to prioritize treatment (WSAG 2011).

*Common reed or Phragmites* is known from many areas of Grays Harbor estuary, but the infestation in the northern portion of the estuary, including the Refuge, has been the most damaging to native habitats.

This introduced grass grows extremely densely, 10–20 feet high, and outcompetes lower growing native herbaceous plants and shrubs. In the Pacific Northwest, it appears to spread mostly from rhizomatous growth instead of seed dispersal. It is tolerant of fluctuating salinity, is found throughout the temperate regions of the world, and is often found in disturbed areas where inundation is erratic. It flourishes in dredged material disposal sites, roadside ditches, and diked flats. *Phragmites* is known to spread as fast as 6–10 feet per year; thus control of this pest at an early stage is important to prevent widespread infestations.

*Phragmites* was first noted in 1941 as a small patch on the western tip of Moon Island (Alcorn 1941). A 1991 photo shows it was well established before the Refuge was created in 1990. More recent records show *Phragmites* had spread to sites along State Highway 109, and it had invaded high to mid-salt marsh habitat and upland transition zones adjacent to the airport and boardwalk. There was also a large, disjunct patch near the eastern end of the mudflats along the deep slough. A spray treatment in 1995, followed by manually cutting and treating each spring, took place until 2006, but the plant continued to spread rapidly through the marsh and into the mudflats. A concerted, long-term, cooperative effort with State partners since 2005 has been successful in reducing the *Phragmites* footprint on the marsh and allowing native plants to reestablish. Vigilant monitoring and re-treatment is necessary to ensure it does not again become dense enough to create habitat loss for fish and wildlife.
Japanese (or dwarf or Asian) eelgrass is found in estuaries along the Pacific coast in California, Oregon, Washington, and British Columbia. It is present in the greater Grays Harbor and in the Refuge, spreading across the intertidal mudflats. It appears to be able to grow and survive in mud, with extended periods of air exposure. Generally, Japanese eelgrass occurs higher in the intertidal zone than native eelgrass, *Zostera marina* (Ruesink et al. 2010), and occupies different niches in the intertidal zone (Shafer 2007, cited in Mach et al. 2010). Although the different intertidal ranges of Japanese eelgrass and native eelgrass limit direct competition, when these species do compete for space, in most instances both species are adversely affected.

Whether Japanese eelgrass is a threat to the Grays Harbor ecosystem is debatable. In a review of ecological effects of Japanese eelgrass, Mach et al. (2014) found that studies designed to quantitatively assess the nonnative eelgrass’s impacts are limited. However, the available studies suggest that Japanese eelgrass increases overall diversity in both vegetated and unvegetated habitats, while decreasing large infaunal species, such as Manila clam and ghost shrimp when compared to unvegetated habitats. While there were no significant differences to waterfowl and Chinook salmon when Japanese eelgrass replaced unvegetated habitats, waterfowl and fish species seemed to prefer native eelgrass over Japanese eelgrass.

Studies by Lamberson et al. (2011) and Frazier et al. (2014), based on the Yaquina estuary in Oregon, provide a preliminary evaluation of the impacts of Japanese eelgrass on bird use of intertidal habitats. Overall, these studies found that native eelgrass and possibly *Upogebia*/mudflat habitats supported significantly greater bird densities compared to low marsh, *Neotrypaea*/sandflat, and Japanese eelgrass. The Japanese eelgrass beds were used primarily by ducks (mostly mallards), coot, and geese foraging either at mid-tide levels (0.6–1.5 m) when the native eelgrass beds were flooded, or at high tide (1.8 m) when Japanese eelgrass was flooded but shallow. In late winter, the aboveground biomass of Japanese eelgrass died and plants were largely reduced to stubble, and shorebirds foraged both within this habitat and in the adjacent *Neotrypaea*/sandflat habitat without apparent regard to the presence of the stubble. There were no significant differences for any metric of bird use between Japanese eelgrass and *Neotrypaea*/sand habitat, which nonnative eelgrass has been supplanting. Thus, there was no evidence that birds will be negatively impacted by the presence of Japanese eelgrass in Yaquina estuary (Frazier et al. 2014). Baldwin and Lovvorn (1994) have shown that Japanese eelgrass is readily fed on and is an important food source for Brant and a variety of dabbling ducks.

Japanese eelgrass is known to cover over bivalves (such as oysters, clams, and mussels) and it may disrupt the bivalve natural system functions. It has been problematic for shellfish growers (WSNWCB 2011). This eelgrass may also trap sediment and become a factor in intertidal mudflats’ elevation rise. California and Oregon have been working to remove and prevent the spread of this plant for years. However, up until 2010, Washington had protected all eelgrass species, including both the native and nonnative species. Recent changes in the law allow commercial shellfish growers to legally control it on their lands (WSNWCB 2011). More work is needed to understand the ramifications of this nonnative species.

Knotweed is a collective name for the many introduced species of Japanese knotweed, Himalayan knotweed, giant knotweed, and the hybrid Bohemian knotweed that have invaded the Pacific Northwest. This perennial plant dies back each winter, but spring growth reaches 20–35 feet, overtaking all but tall trees. This aggressive plant grows in freshwater wetlands, riparian areas, high saltmarsh, and brackish water conditions. It rapidly spreads with each high water or flood event which carries it to new locations. This plant can root from any leaf or root node on the stem even...
when it is cut up into many small pieces. It appears to have been widely spread along road ways by ROW mowing (Prather et al. 2009). It is currently found and controlled in the high saltmarsh of Grays Harbor Refuge along the Sandpiper Trail boardwalk and on the western point of the peninsula. It is dense along State Highway 109 in the Grays Harbor Public Utility District (GHPUD) ROW and from there has spread into the Refuge. No control of the highway infestation has begun.

**Himalayan and evergreen blackberry species** are found along forest edges, in uplands, and along the transition zones with wetlands. This plant invades disturbed areas, open areas where low-growing native vegetation exists, and near where seed sources are located. Often this plant is not controlled unless intense restoration is planned. In many areas, this plant is first cut low to the ground, and regrowth is sprayed with herbicide and native plants are installed.

**Scotch broom** is generally located in upland sites, along ditches, roads, and trails, and has infested areas in the high salt marsh. In most cases, Scotch broom is either cut by hand, mowed, or removed with a weed wrench. Some indicators show that cutting it low to the ground when it is blooming can kill it. Scotch broom seeds can remain viable for more than 50 years in the soil.

**Canada thistle** and **bull thistle** are located in upland sites but can be found along wetland margins. Deflowering methods are temporary control measures to prevent the spread of seeds. Bull thistle can be manually controlled by cutting the vegetated top from the root at the soil line. Canada thistle grows through rhizomes and is not controlled with cutting. These invasive plants are controlled with herbicides in areas of soil disturbance, initial clearing for restoration, maintenance of past restoration sites, or maintenance of areas where buildings occur or were recently removed (TCNWCA 2013b).

**Fish**

Little is known about the presence of nonnative fish in Grays Harbor Refuge waters.

**Birds**

**Brown-headed cowbirds** forage in open areas and breed wherever small landbirds nest. Historically, they inhabited short-grass prairies of the mid-western U.S., but with development, agriculture, and forest fragmentation, they have expanded their range significantly. Females lay eggs in other birds' nests and leave the rearing to other species. They find nests to parasitize by looking for birds building nests, either by walking along the ground, perching quietly in shrubs or trees, or making noisy flights back and forth, possibly to flush potential hosts. Young cowbirds are at a competitive advantage as they mature faster than other young in the host nest. Over 220 species have been observed supporting brown-headed cowbird eggs in their nests, and at least 144 species have raised brown-headed cowbird young to the fledgling stage, often at the expense of their own young (Seattle Audubon Society 2002). At the Refuge cowbirds have been observed in the salt and brackish marsh and forest habitats.

**European starlings** have expanded their range westward ever since they were introduced to the east coast of America. At the Refuge they are found in the salt and brackish marsh and forest habitats and flocks can become large. They forage in open areas usually near development. They require nearby nesting cavities and are creative in using crevices in building structures such as plane hangars. Starlings can be aggressive and will persistently harass other species to take over limited numbers of nesting cavities such as natural hollows, old woodpecker holes, and birdhouses (Seattle Audubon Society 2002).
House sparrows were introduced to this country from Europe and are found in settled areas. These sparrows are opportunistic and eat whatever is available. While they are not highly territorial with their own species, they are aggressive toward other species and may drive native birds out of their nests. They typically breed in cavities or crevices in buildings, nest boxes, or other birds' nests, but if they are in an area with no available cavities, they will nest in trees or shrubs, often in small colonies (Seattle Audubon Society 2002).

Mammals

Little information is known regarding invasive or exotic mammals on Grays Harbor Refuge.

Reptiles and Amphibians

Little information is known regarding invasive or nonnative reptiles or amphibians on Grays Harbor Refuge.

Invertebrates

European green crabs were found by WDFW between 1999 and 2003 within the Refuge and on the south side of the airport peninsula (WDOE 2008). The green crab spread to the U.S. west coast around 1989 or 1990, most likely as larvae in ballast water from ships. It is speculated that during the El Niño winter of 1997–1998, ocean currents transported green crab larvae north to Washington State, where the first crabs were found in the summer of 1998. Field observations and laboratory experiments have shown that the European green crab both consumes and competes with a vast array of organisms, including clams, oysters, mussels, snails, and other crabs. The biodiversity of local ecosystems could be affected, with impacts on sensitive species of concern (Holmes 2001).

Most likely, more nonnative species exist in the marine waters and benthic communities, but data for the Refuge is lacking.

Potential New Threats from Nonnative and Invasive Species

Many nonnative and invasive species are present in Washington State and poised to become established on the Refuge. Early detection of new invasions and a rapid response is considered critical for cost-effective control and prevention of invasive species from spreading.

Virginia opossums were found only in Central America and the southeastern United States prior to European settlement. During the 1900s, their range expanded northward and westward and first arrived in Washington in the early 1900s as pets and novelties. Some of these animals, or their offspring, later escaped from captivity or were intentionally released. With few natural predators, the absence of hunting, and an abundance of food and shelter, opossums have adapted well to living close to people in urban and suburban environments. Except for higher elevations, opossums now occupy most human-occupied habitats in western Washington. These animals are most likely present in or near Grays Harbor Refuge.

Eastern cottontails were introduced to several areas in Washington as a game animal beginning in the 1930s. They often are associated with Himalayan blackberry thickets which provide them with a secure hideout to foray out at dawn and dusk or other shrubby cover areas. No rabbit is native to the west side of the Cascades. These animals are most likely present in or near Grays Harbor Refuge.
4.6.2 Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge

Plants

Reed canarygrass is the most threatening and major invasive plant problem on the Unit. It is a cool-season, sod-forming, wetland grass native to the northern temperate regions of Europe, Asia, and some parts of North America. Its use in the Pacific Northwest began in the late 1800s. Farming followed logging operations and reed canarygrass was often used to stabilize rough logging areas as it was extremely productive, easy to establish, and persisted very well. No other forage plant is as well adapted to wet, marshy areas as reed canarygrass. It can withstand flooding and can tolerate continuous inundation for as long as 60–70 days without permanent injury (possibly longer depending on temperature, current, and silt content of the water). It thrives along stream banks, wet meadows and pastures, wetlands, roadside ditches, river levees and dikes, drainages, and floodplains. Although wet areas in full sun are preferred, reed canarygrass is also very drought tolerant and able to withstand high degrees of variability in soil type, PH levels, fertility, temperature, and exposure (Tu 2004, Kilbride and Paveglio 1999).

Unfortunately, reed canarygrass has proven to be very aggressive in the Pacific Northwest. It moves out of pastureland and into stream bottoms, wetlands, and canal banks and persists where it is not desirable. Reed canarygrass can outcompete most native species, threatening natural wetlands by forming large, single-species stands. It has limited value to wildlife. Limited foraging occurs from deer and elk while it is young and tender, however, they do not continue to graze on it when it grows tall and coarse. It grows so densely that it inhibits movement of small mammals, waterfowl, amphibians, and reptiles. It causes increased siltation in slow-moving creeks and rivers. It produces large amounts of pollen and other grasses; pollen from reed canarygrass is easily airborne and is moderately allergenic to humans. Once established, reed canarygrass is very difficult to control because it spreads rapidly by rhizomes, seeds, and is so adaptive (Tu 1974, WDOE 2015a, TCNWCA 2013a).

This difficult pest has long dominated the Puget lowlands and is a serious threat to the Black River channel and tributary habitats and to the animals that depend upon this habitat. It is solidly established along the river edge growing out from the river banks and overtaking all open, sun-warmed, muddy bank sites that are so important for animals to bask in and rest. The river edge has become a dense, tall, grass monoculture instead of a diverse plant community of flowering plants. It has rooted on the abundant woody debris in the river. In the northern portion of the Unit between the pipeline and 110th Avenue, it has shown an ability to root on top of submerged native plants in the river channel and spread across to root on the banks. In the northern segments of the river, it has obscured the shallow river channel, choking water flow, impeding sunlight penetration, and preventing canoe access. It has significantly changed the wetland vegetative community of the Black River area.

Poison hemlock’s entire plant structure is toxic to humans and animals. It grows in both uplands and moist sites. Ongoing efforts to control this species have been successful and only a few small, resilient patches persist. For those sites where manual control is difficult, an appropriate herbicide has been used.

Purple loosestrife is identified throughout the U.S. as an invasive wetland marsh plant and has been found in many locations along the Refuge. The Thurston County Noxious Weed Agency has worked
diligently to control it for years, and recently the Billy Frank Jr. Nisqually Refuge Weed Warriors have taken up the challenge and continue the work to control it by hand digging. Although the control work has gone on for years, the seed bank allows plants to come up every year. Herbicide spot treatment is used judiciously on difficult-to-reach purple loosestrife plants. Bio-control beetles have been successful in helping to control large loosestrife populations in Oregon, but most likely would not be effective on the few plants that pop up each year on the Unit.

Yellow flag iris is a nonnative, ornamental flowering bulb that has escaped cultivation into wetland marshes, river channel edges, and wetland shrub-scrub. It forms dense clumps and thick mats of bulbs in freshwater wetlands and can tolerate brackish conditions. Its large seed pods float and spread viable seeds downstream to produce additional plants. Fragmented roots and bulbs rip off during high water events or can be torn out by animals and become new plants. Control of this species along the river will be difficult as the river banks are unstable muck that supports floating mats of reed canarygrass, shrub roots, and iris bulbs. Controlling the spread of this plant is dependent on annually removing seed pods before they are released into the river and treating with a wetland-approved herbicide using a cut-stump technique.

Wild chervil used to occur in a large infestation off 118th Avenue (originally about 15 acres) but is nearly gone as of 2012 and is closely monitored.

Tansy ragwort is occasionally found in dry, open areas or on margins of forest. A history of control has reduced the amount of ragwort to a very small level, and control efforts are ongoing annually.

Holly is generally found in uplands. It is a popular ornamental shrub or tree that has escaped and birds spread seeds by eating the fruit. Small plants can be pulled or dug with good results. In the past, larger specimens were cut (flowers and fruits are bagged and removed), but because of the cut stem’s ability to successfully develop roots and survive, they are now girdled and herbicide is painted onto the stripped area.

Himalayan and evergreen blackberry species are described in the Grays Harbor Refuge section (4.6.1). On the Unit, blackberry is also found in upland mixed forests, riparian forest edges, dry nonnative grasslands, and open areas.

Canada thistle and bull thistle are described in the Grays Harbor Refuge section (4.6.1).

White watercress is a “naturalized” submerged plant that is densely growing in the river channel, especially north of 110th Avenue. Its thick growth should be examined regarding its possible impact on the waterway. Some of the factors most likely related to the growth are increased nutrient levels, decreased pressure from healthy native populations, increased sedimentation or water temperatures, and decreased predation (Seery, M.J. 2012, pers. comm.). Unimpeded growth of nonnative, submerged plants chokes water flow, impedes sunlight penetration, changes the natural conditions of the river and stream channels, limits animal (e.g., amphibian and fish) movement, and outcompetes native submersed plants (WDOE 2015b).

Fish

Nonnative fish are widespread in the Black River and, unlike the native fish, they are warm-water species. They have been introduced most likely for sport fishing and include American shad, brown
bullhead, pumpkinseed, bluegill, rock bass, largemouth and smallmouth bass, black crappie, yellow perch, northern pikeminnow, and others (Creveling et al. 1980, Kunze, L. 1996b. pers comm.).

Nonnative fish presence alters natural habitats and conditions for native animals sharing the same locations. Most nonnative, warm-water fish (or spiny-ray) are predatory on native fish, amphibians, and invertebrates. Their presence changes (and most likely reduces) native fish, amphibian, and invertebrate populations. In addition, nonnative fish compete for and most likely reduce prey resource availability for native fish and amphibians. These fish may be especially deleterious to the populations of endemic Olympic mudminnow, the State-listed as endangered and federally listed as threatened threatened Oregon spotted frog (in every life phase), State candidate species Pacific clubtail dragonfly (egg, nymph, and naiad stages), and other sensitive species, and the prey resources they need to survive.

**Birds**

**Brown-headed cowbirds** are described in the Grays Harbor Refuge section (4.6.1).

**European starlings** are described in the Grays Harbor Refuge section (4.6.1).

**House sparrows** are described in the Grays Harbor Refuge section (4.6.1).

**Mammals**

**Eastern gray squirrels** were introduced in Washington in the early 1900s and have been repeatedly released in parks, campuses, estates, and residential areas and are adept at taking over cavities and bird houses. They are now the most common squirrels in urban and some rural areas, such as around the Unit.

The increasing number of introduced Eastern gray squirrels is often said to be responsible for the decrease in Douglas squirrels in certain areas. However, given that these squirrels have different food and shelter preferences, it is likely that increasing housing and other development and loss of coniferous forests is responsible for some of the decline in Douglas squirrel populations (Link 2004).

**Nutria** are semi-aquatic rodents native to southern parts of South America. In the 1930s, they were sold throughout North America to fur farmers and as a means of controlling unwanted aquatic vegetation. Various associations, magazine and newspaper articles, and demonstrations at county fairs promoted the sale of nutria in Washington. More than 600 nutria farms existed in Oregon and Washington from the 1930s to the 1950s. Flooding and storms damaged holding structures, allowing nutria to escape. Farmers also released their stock when nutria farming became uneconomical. By the 1940s, nutria were present on both sides of the Cascade Mountains in Washington (Link 2004).

Nutria generally occupy a small area throughout their lives. Daily travel distances for most nutria are less than 600 feet, although some individuals may travel much farther (Link 2004). Nutria are suspected to occur on the Unit based on observations of feeding platforms and clipped vegetation floating in the water. Nutria skulls found on the Unit in 2012 confirmed this animals’ presence.

**Virginia opossums** are described in the Grays Harbor Refuge section (4.6.1). These opossums are found on the Unit.
Eastern cottontails are described in the Grays Harbor Refuge section (4.6.1). This rabbit species is found on the Unit.

Reptiles and Amphibians

Red-eared sliders are native to the southern midwestern U.S. In Washington, this turtle occurs in the Puget lowlands (Brown et al. 1995, Dvornich et al. 2001). Red-eared sliders compete with indigenous species for food and basking sites (Frank and McCoy 1995, Williams 1999, Salzberg 2000). Red-eared sliders seem to be adaptable to many climates. This, combined with their omnivorous diet and ability to adapt to various habitats, gives them great potential for altering native habitats should reproducing populations become established. In Washington, they are a potential threat to Clemmys marmorata, the Pacific pond turtle (Williams 1999), a declining species endemic to the Pacific states (Brown et al. 1995).

Bullfrogs are native to the eastern and midwestern U.S. and southeastern Canada. They have been introduced to most of western North America and to Washington by the early 1930s to provide opportunities for frog hunting, food, and stock for frog farms. The bullfrog is the largest true frog in North America, measuring 8 inches in length, and lives nearly 10 years. Bullfrogs can leap up to 3 feet, cross pastures and grasslands, and may travel overland up to 1 mile. This mobility allows them to expand their range from the location where they were introduced. The large number of eggs (10,000 to 20,000) in each egg mass laid by the females allows bullfrogs to quickly establish themselves within a new territory. In the Pacific Northwest, tadpoles usually take 2 years to mature, thus they require year-round water (Corkran and Thoms 1996).

In Washington, bullfrogs thrive in the warm waters of natural and man-made ponds, marshes, sloughs, reservoirs, and sluggish irrigation ditches and streams. Disturbance and development around wetlands often create warmer conditions. Bullfrogs tolerate polluted and muddy waters better than most native frogs and may be found within cities in wetlands, reservoirs, and stormwater ponds (Corkran and Thoms 1996, Link 2004).

Large populations of this species are believed to have contributed both directly and indirectly to the drastic decline of native amphibians and reptiles. Bullfrogs are much larger than native frogs and have few predators in Washington. Adult bullfrogs usually are "sit and wait" predators that readily attack almost any live animal smaller than themselves—insects, frogs, tadpoles, fish, small snakes, turtle hatchlings, newts, salamanders, rodents, bats, hummingbirds, ducklings, and birds up to robin size (Link 2004, McKercher and Gregoire 2012). Large multi-year larvae (in Washington) can have a significant affect upon benthic algae, and thus perturb the aquatic community structure (McKercher and Gregoire 2012).

The effects of bullfrogs on Oregon spotted frog populations have been “disastrous” for the spotted frog according to Leonard et al. (1993). “It is widely believed that bullfrog predation is largely responsible for the disappearance of the spotted frog in the Puget Sound lowlands of western Washington and Willamette Valley of western Oregon.” The authors strongly suggest “land management agencies need to look seriously at limiting further introductions and methods of reducing or eliminating bullfrogs from more environmentally sensitive habitats” (Leonard et al. 1993).
Invertebrates

There are no known nonnative invertebrates within the Black River Unit.

Potential New Threats from Nonnative and Invasive Species

Several plant species from the Washington State and Thurston County noxious weed lists are likely to become threats to the Black River Unit. A few of them are described below.

Knotweed (Japanese, Bohemian, Himalayan, giant knotweed, or hybrids) is likely to be found infesting Unit habitats in the watershed. This aggressive, perennial plant dies back each winter; spring growth reaches 10–20 feet high and it overtakes all but tall trees. It seems to grow almost anywhere there is sunlight. It grows in moist conditions along wetlands, along the edges of riparian and mixed forests, and is aggressive in dry grasslands, old pastures, and open areas. Knotweed spreads with each high water or flood event, which carries pieces of the plant to new locations where they can root. This plant successfully roots from any leaf or root node on the stem, even when it is broken or cut into many pieces. High water, flood events, mowing, and careless cutting are known to enhance its ability to spread (King County 2013). It has been found within the Unit acquisition boundary (Thurston County 2013), but is not on currently on Service-owned parcels.

Hydrilla, Brazilian elodea, variable-leaf (Eurasian) milfoil, fanwort, parrotfeather, nonnative bladderwort, and other submerged aquatics are serious threats in Unit waterways, especially because some have been found in other parts of the watershed. Although it is not known if any of these species infest Unit waters, Eurasian milfoil occurs in Black Lake, which is linked to the headwaters of the Black River. Downstream from the Black River, in the Chehalis River, a large Brazilian elodea infestation that extended 6 miles was recently controlled by Thurston County.

4.7 Biotic Responses to Climate Change

Existing and strengthening evidence shows changing climatic conditions have affected, and will continue to affect, many biotic communities (Parmesan 2006, Rosenzweig et al. 2008, Geyer et al. 2011). Projections of continued and likely accelerating changes in temperature and precipitation are well supported, especially at global scales (see Section 3.2.4). However, at our current level of understanding, it is difficult to assess near-term biotic responses to changing climatic conditions at specific locations because of the inherent spatial and temporal complexity of ecological systems, coupled with short- and long-term weather pattern variability (Akçakaya et al. 2006, Parmesan et al. 2011). Compared to present-day conditions, most climate-related effects likely will not be detectable during the 15-year timeframe of this CCP, at least to document changes outside the wide, “normal” inter-annual range of expected physical conditions in the Pacific Northwest region. However, the seriousness of potential, long-term, climate-change-induced impacts to Refuge ecological resources warrants their assessment and inclusion in relevant planning efforts (USFWS 2010d), including this CCP.

4.7.1 Grays Harbor National Wildlife Refuge

Several climate-related factors may impact the Refuge’s estuary and upland habitats. In particular, species (especially shorebirds) that rely on low-elevation, intertidal habitats are vulnerable to the substantial habitat loss projected due to sea level rise in the Pacific Northwest (Glick et al. 2007).
The nearer-term factors of most importance to the Grays Harbor estuary include rising sea level and increased prevalence of invasive plants and animals. Over time, other climate-induced changes could substantially affect Refuge environments. Effects could include altered food availability resulting from physical changes in ocean and estuary waters; increasingly intense outbreaks of insects, diseases, and pathogens; and range shifts or phenological changes that disrupt plant and invertebrate community structure.

Following are brief discussions of those climate-related impacts most relevant to the habitats and ecological communities at Grays Harbor Refuge. Details concerning historic and projected climate change effects to the physical environment are provided in Chapter 3. Additional background regarding general responses of biotic communities to climate change is available in Littell et al. (2009), Tillmann and Siemann (2011), and National Fish, Wildlife and Plants Climate Adaptation Partnership (2012).

**Effects to Estuary Habitats**

**Sea Level Rise.** Potential impacts from sea level rise to the Refuge’s estuary habitats are critical to assess because a primary Refuge purpose is to provide habitat for shorebirds. At Grays Harbor, the large expanses of intertidal mudflats provide important foraging and roosting areas for migrating and over-wintering shorebirds. These intertidal habitats are extremely vulnerable to even small increases in relative sea level.

At the Refuge, the impacts of changing sea level will depend on the relative rates of sea level rise vs. sediment accretion. Unfortunately, current projections of future sea level change at Grays Harbor are largely uncertain. Changes in absolute sea level are difficult to measure because of the complexity and variability of regional ocean conditions in the northeastern Pacific Ocean, in addition to yet-unknown contributions from vertical land movements along the southwestern Washington coast.

Sediment accretion at the Refuge also is uncertain. There is recent evidence that tidal salt marsh is actually expanding (soil elevations are increasing) within the Refuge, possibly caused by altered tidal flows within Bowerman Basin and/or increased sediment loads associated with maintenance dredging of the nearby Grays Harbor shipping channel (see Chapter 3). This potential expansion of tidal marsh vegetation is a current management concern to the Refuge because it may be reducing the extent of intertidal mudflats available to shorebirds. However, this same elevation increase might mitigate potential future sea level rise.

**Invasive Species.** Controlling the extent of nonnative invasive plants, such as *Spartina* and *Phragmites*, is a major, ongoing Refuge management activity to maintain the quality and functioning of estuary habitats. The recent establishment of other invasive species, such as Japanese eelgrass, in Refuge subtidal and intertidal habitats is a potential management concern (Mach et al. 2010). Increased air and water temperatures, altered precipitation amounts and seasonality, and other factors associated with climate change will exacerbate the occurrence and prevalence of invasive plant and animal species (Hellman et al. 2008, Rahel and Olden 2008, Willis et al. 2010). Information on the current occurrence and/or prevalence of invasive animals (e.g., fish, crabs, mussels, snails) at the Refuge is lacking, but the threats associated with these potential invasive species are large, and changes in their future distribution and abundance as a result of climate change could have strong management implications.
Effects to Upland Habitats

Relative to estuary habitats, near-term climate-related impacts to Refuge upland (forest) habitat likely will be minimal. The Refuge’s forest species have low vulnerability to projected climate change (Aubry et al. 2011) because of the generally muted changes in temperature and precipitation projected for the Grays Harbor area (Mauger and Mantua 2011).

Changes in temperature and precipitation likely will cause some level of physiological stress that will affect forest health (Vose et al. 2012). The greatest threat is the increased risk for insect and pathogen outbreaks potentially resulting from new range expansions, as well as greater susceptibility to existing insects and pathogens (Ryan and Vose 2012). However, great uncertainty exists because of the complex interactions of insects, pathogens, hosts, and climate (Kliejunas 2011).

Similar to estuary habitats, climate change may exacerbate occurrence and prevalence of nonnative invasive plants that could alter species composition and expected forest community succession (Shafer et al. 2010). Also, any substantial sea level rise likely will cause greater saltwater intrusion into the groundwater that currently supports Refuge forest habitats (Brown and Newcomb 1963, Chang and Jones 2010).

Other Potential Long-term Climate Change Effects

Over time, many additional climate-related factors could impact Refuge biota, including:

- Ocean chemistry and sea surface temperature. Increased acidification has already affected oyster larvae survival in coastal Washington (Washington State Blue Ribbon Panel on Ocean Acidification 2012). Virtually all major biological functions of marine organisms—especially photosynthesis, respiration rate, growth rates, calcification rates, reproduction, and recruitment—are sensitive to increased ocean acidification (Doney et al. 2009). Projected increases in sea surface temperatures for the northeastern Pacific Ocean could impact biotic productivity (Overland and Wang 2007, Bograd et al. 2008) and also result in increased occurrence of harmful algal blooms (see Huppert et al. 2009).

- Intensity of ocean waves and storms. Projected increases in intensity and frequency of storms and wave heights along the Pacific Northwest coast may have lesser impacts to the more-protected inland portions of Grays Harbor. However, greater connection to ocean currents resulting from maintenance of a shipping channel (i.e., jetties and channel dredging) might exacerbate potential storm effects, potentially resulting in increased erosion of intertidal mudflats (Huppert et al. 2009).

- Range shifts and altered phenology of plants and animals. Warming temperatures and changing ocean currents likely will alter the seasonal productivity and availability of food resources, potentially causing a phenological decoupling for the animal species reliant on primary production (see Tillmann and Siemann 2011).

- These potential impacts to the marine environment and food web may negatively affect Refuge resources such as shorebirds and salmonids.
4.7.2 Black River Unit

Several climate-related factors may impact the Refuge’s aquatic and upland habitats. In particular, species (especially amphibians) that rely on wetland, riparian, and aquatic habitats are vulnerable to many climate-change-related effects in the Pacific Northwest (Lawler et al. 2008).

The nearer-term factors of most importance to Black River Refuge include increased prevalence of invasive plants and animals, as well as further-altered hydrology (e.g., stream flow, water temperature) within the Black River watershed. Over time, many other climate-induced changes could affect Refuge environments—these include more-intense outbreaks of insects, diseases, and pathogens; and range shifts and/or phenological changes that disrupt plant and invertebrate community structure.

Following are brief discussions of those climate-related impacts most relevant to the habitats and ecological communities at the Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge. Details concerning historic and projected climate change effects to the physical environment are provided in Chapter 3. Additional background regarding general responses of biotic communities to climate change is available in Littell et al. (2009), Tillmann and Siemann (2011), and National Fish, Wildlife and Plants Climate Adaptation Partnership (2012).

Effects to Aquatic Habitats

**Invasive Species.** Controlling the extent of nonnative and invasive plants, such as reed canarygrass, yellow flag iris, and purple loosestrife is a major, ongoing Refuge management activity to maintain the quality and functioning of aquatic habitats. Other invasive/introduced species, including aquatic plants (e.g., hydrilla, Brazilian elodea, Eurasian milfoil), algae, warm-water fish (e.g., northern pikeminnow, bullhead, bass, crappie), bullfrogs, and invertebrates (e.g., New Zealand mudsnails, red swamp crayfish), are or may be present within Unit habitats. Increased air and water temperatures, altered precipitation amounts and seasonality, and other factors associated with climate change likely will exacerbate the occurrence and prevalence of invasive plant and animal species (Hellman et al. 2008, Rahel and Olden 2008, HDR Alaska 2009, Willis et al. 2010). This may be particularly important regarding future management activities for Oregon spotted frogs. Invasive plants (especially reed canarygrass) and bullfrogs already are substantial threats to these frogs, and any additional impact from climate-enhanced invasive species populations would require greater management effort to maintain and enhance the Refuge’s Oregon spotted frog population.

**Hydrological Changes to the Black River Watershed**

The hydrology of the upper Black River watershed has already been impacted by anthropogenic alterations (see Chapter 3). These changes have affected water quality and quantity, and ultimately the Unit’s biological resources.

Climate change effects within the rain-dominated Black River watershed likely will be muted during the next few decades. However, projections for reduced summer (low) flows and increased air temperatures would undoubtedly impact water temperature and quality. Even these muted impacts likely would exacerbate algal blooms (Kundzewicz et al. 2007) and the prevalence of invasive plant and animal species (see above). Increased stream temperatures also could negatively affect salmonid use of the Black River as well as its tributaries (Mantua et al. 2010, Isaak et al. 2012). These same
climate impacts have been associated with increased infectious disease occurrence and resulting population declines in amphibians (Blaustein et al. 2012).

As described above for invasive species, any further degradation of hydrologic conditions would pose additional threats to priority Unit resources such as Oregon spotted frogs and Olympic mudminnows.

**Effects to Upland Habitats**

Relative to riverine habitats, near-term climate-related impacts to Unit upland habitats likely will be minimal. The Unit’s forest species have low vulnerability to projected climate change (Aubry et al. 2011) because of the generally muted changes in temperature and precipitation projected for the Black River watershed (Mauger and Mantua 2011). The Unit’s dry, nonnative grassland habitats are already greatly altered, and the plant species composition there likely is resilient to near-term projected changes in precipitation and air temperature (IPCC 2007:11).

Changes in temperature and precipitation likely will cause some level of physiological stress that will affect forest health (Vose et al. 2012). The greatest threat is the increased risk for insect and pathogen outbreaks, potentially resulting from both new range expansions as well as greater susceptibility to existing insects and pathogens (Ryan and Vose 2012). However, great uncertainty exists because of the complex interactions of insects, pathogens, hosts, and climate (Kliejunas 2011).

Similar to aquatic habitats, climate change may exacerbate occurrence and prevalence of nonnative invasive plants that could alter species composition and expected forest community succession (Shafer et al. 2010). Also, drier and warmer summer weather could increase occurrence of wildland fires (Climate Impacts Group 2004), which could affect forest composition and regeneration as well as grassland forage availability.

**Other Potential Long-term Climate Change Effects**

Over time, many additional climate-related factors could impact Unit biota. For the Black River watershed, the most important might be range shifts and altered phenology of plants and animals. Warming temperatures and altered precipitation patterns may alter many processes, including leaf unfolding, flowering, insect emergence, and the arrival of migratory birds (see Tillmann and Siemann 2011).
# 4.8 Wildlife and Habitat Research, Inventory, and Monitoring

## 4.8.1 Wildlife and Habitat Research and Monitoring Efforts

**Grays Harbor National Wildlife Refuge**

Many collaborative research and monitoring projects have been conducted at Grays Harbor Refuge since it was established. The Refuge routinely partners with other Service programs, other Federal and State agencies, NGOs, and universities.

### Table 4-2a. Grays Harbor Research, Inventory, and Monitoring Projects (past and current)

<table>
<thead>
<tr>
<th>Wildlife Surveys</th>
<th>Year/Season(s)</th>
<th>Active</th>
<th>Emphasis</th>
</tr>
</thead>
</table>
| Shorebirds Ground Survey  | 1988–present   | Yes    | Area: Refuge and sometimes Bottle Beach State Park  
Timing: Spring migration  
Data/Results Availability: Monitoring, Refuge records  
Emphasis: See Goal 4  
Survey maintained and conducted by staff and volunteers. Surveys to estimate numbers and species of shorebirds using Refuge habitats during northbound migration. |
|                           | Spring Migration |        |                                                                                                                                                                                                                                                                                                                                         |
| Christmas Bird Count      | Annually December | Yes    | Area: Official Audubon Grays Harbor Count Circle (includes the Refuge)  
Timing: December  
Data/Results Availability: Monitoring, Audubon records  
Emphasis: See Goals 3 and 4  
Nationwide monitoring program run by Audubon, volunteer surveyors, and Refuge staff. |
| Red Knot Research         | 2006–present    | Yes    | Area: Grays Harbor estuary, Refuge, and Willapa Bay  
Timing: Annual spring migration  
Data/Results Availability: Research, Publications on internet  
Emphasis: See Goals 3 and 4, Biologist Joe Buchanan working on red knots since 2006 has investigated knot migration, habitat use, foraging, and roosting sites. Abundance estimation by observing flagged red knots originating from Mexico is also ongoing. Observations of knots on the Refuge are passed on to researcher. |
<table>
<thead>
<tr>
<th>Wildlife Surveys</th>
<th>Year/Season(s)</th>
<th>Active</th>
<th>Emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shorebirds Aerial Survey</td>
<td>1999–2004 Peak Spring Migration</td>
<td>No</td>
<td>Area: Greater Grays Harbor estuary and Refuge. Timing: Staff estimates of peak spring migration. Data/Results Availability: Monitoring, Refuge records. Emphasis: See Goals 3 and 4. Flights provided a “snapshot” of the numbers of shorebirds using greater Grays Harbor estuary and shoreline during peak spring migration. Data were more valuable that localized Refuge surveys. Discontinued because of lack of funding.</td>
</tr>
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<table>
<thead>
<tr>
<th>Wildlife Surveys</th>
<th>Year/Season(s)</th>
<th>Active</th>
<th>Emphasis</th>
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</thead>
<tbody>
<tr>
<td>Waterfowl Aerial survey</td>
<td>1993–2003 Monthly in fall and winter</td>
<td>No</td>
<td>Area: Greater Grays Harbor estuary and Refuge</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Timing: Once a month November, December, January, February</td>
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<td></td>
<td></td>
<td></td>
<td>Data/Results Availability: Monitoring, Refuge records</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Emphasis: See Goal 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Monthly aerial surveys gained information on waterfowl and waterbird use of the entire Grays Harbor estuary, as well as the Refuge. Flight occurrence ranged from two to four surveys depending upon funding availability. The January flight was also the Service’s Mid-winter Waterfowl Survey. Discontinued all but the January flight because of funding loss and changing emphasis.</td>
</tr>
<tr>
<td>Waterfowl Ground survey</td>
<td>1993–2010 Monthly to bimonthly November to February</td>
<td>No</td>
<td>Area: Refuge</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Timing: Once a month November, December, January, February</td>
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<td></td>
<td></td>
<td>Data/Results Availability: Monitoring, Refuge records</td>
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<td></td>
<td>Emphasis: See Goals 4</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Monthly ground surveys of the Refuge were conducted to gain understanding of waterfowl habitat use of the Refuge during the winter season. Discontinued due to lack of staff and changing emphasis.</td>
</tr>
</tbody>
</table>

**Habitat and Invasive Species Monitoring**

<table>
<thead>
<tr>
<th>Phragmites Monitoring and Treatment</th>
<th>2005–present Annually</th>
<th>Yes</th>
<th>Area: Refuge</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Timing: Summer monitoring, fall treatment</td>
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<td></td>
<td></td>
<td></td>
<td>Data/Results Availability: Monitoring/Treatment, Refuge records</td>
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<td></td>
<td></td>
<td></td>
<td>Emphasis: See Goals 1, 2, 3, and 4</td>
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<tr>
<td></td>
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<td>WDFW and WSAG partnerships are important to this control effort.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Spartina Monitoring and Treatment</th>
<th>2005–present Survey ~ 1+ times during the growing season</th>
<th>Yes</th>
<th>Area: Greater Grays Harbor estuary and Refuge</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Timing: Three monitoring rounds of the estuary with treatment. Starts early spring and runs until fall.</td>
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<td></td>
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<td>Data/Results Availability: WSAG annual reports, online</td>
</tr>
</tbody>
</table>
### Wildlife Surveys

<table>
<thead>
<tr>
<th>Wildlife Surveys</th>
<th>Year/Season(s)</th>
<th>Active</th>
<th>Emphasis</th>
</tr>
</thead>
</table>
| Knotweed Monitoring and Treatment    | Annually since 2003 | South side: Yes. North side: No | Area: Refuge  
Timing: summer monitoring, fall treatment  
Data/Results Availability: Monitoring/Treatment, Refuge records  
Emphasis: See Goals 1, 2, 3, and 4  
The **South** side of the Refuge has been controlled as needed, treatment sites mapped and progress documented.  
The **North** side of the Refuge infestation comes off the GHPUD ROW. Need to coordinate with GHPUD to cooperatively control knotweed. |

### Research or Formal Studies

<table>
<thead>
<tr>
<th>Research or Formal Studies</th>
<th>Year/Season(s)</th>
<th>Active</th>
<th>Emphasis</th>
</tr>
</thead>
</table>
| Estuary and Climate Change          | 2013–2014        | Yes    | Area: Refuge  
Data/Results Availability: Research, USGS in progress  
Emphasis: See Goals 2, 3, and 4  
Establish baseline bathymetry, vegetation, tidal inundation conditions of the Refuge salt marshes. This data will be used to model sea level rise conditions and investigate how it impacts wildlife and the vegetation community. |
| Powerline Avian Study               | 2005–2008        | No     | Area: Refuge  
Timing: Year-round study, actual field work was 2 yrs.  
Data/Results Availability: Study, Refuge records  
Emphasis: See Goal 4  
Study to determine if waterfowl, shorebird, passerines, or raptors were negatively impacted by newly installed, tall powerlines along the north side of Refuge and along State Highway 109. A limited-time study. |
<p>| Shorebirds                          | Spring Migration | No     | Area: Pacific Coast Flyway from Central American to Alaska, including the greater |</p>
<table>
<thead>
<tr>
<th>Wildlife Surveys</th>
<th>Year/Season(s)</th>
<th>Active</th>
<th>Emphasis</th>
</tr>
</thead>
</table>
| Shorebirds                       | Varies         | No     | Grays Harbor estuary and Refuge  
Timing: Spring Migration  
Data/Results Availability: Research, Publications on internet  
Emphasis: See Goals 3 and 4  
Past research on long distance migration of western sandpipers, dowitchers, and dunlin by N. Warnock, J. Takekawa, and M. Bishop. |
| Multiple Research Projects over time | Varies         | No     | Grays Harbor estuary and Refuge  
Timing: Variable depending on project  
Data/Results Availability: Research, Publications on internet  
Emphasis: See Goals 3 and 4  
Past shorebird research on diet, foraging, and habitat use of the estuary by J. Buchanan, and S. Herman, J Bulger. |

Many important research projects have been conducted over time in both the greater Grays Harbor estuary and the Refuge. Specifically, S. B. Nightengale, C. Simenstad, D. Eggers, R. Thom, K. Radedeke, and many others. A wide range of projects on conditions that affect the greater estuary and what is now the Refuge. Reports and publications often include detailed information on natural history of fish, birds, invertebrates, and habitats.
Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge

Baseline inventory and ongoing monitoring is needed at many levels at the Black River Unit of Billy Frank Jr. Nisqually National Wildlife Refuge. Scientific research is needed to understand the changes and implications of mudflat sedimentation rates and the effects on shorebirds and food webs and to better understand predicted changes in sea level rise. (See Goals 1, 2, and 4 for detailed information).

Table 4-2b. Black River Unit Research, Inventory, and Monitoring Projects (past and current)

<table>
<thead>
<tr>
<th>Wildlife Surveys</th>
<th>Year/Season(s)</th>
<th>Active</th>
<th>Emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oregon spotted frog egg survey</td>
<td>2001–present</td>
<td>Yes</td>
<td>Area: Black River Unit Timing: Spring breeding season, annually Data/Results Availability: Monitoring, Unit records Emphasis: See Goals 1, 3, 4 Annual egg mass counts are conducted on Unit lands by Unit staff, volunteers, and partnering agencies to estimate Oregon spotted frog population size, habitat preference, and habitat quality.</td>
</tr>
<tr>
<td>Oregon spotted frog egg removal for new population establishment</td>
<td>2008–2012</td>
<td>No</td>
<td>Area: Black River Unit Timing: Early spring, annually Data/Results Availability: Species augmentation, Unit and WDFW records Emphasis: See Goal 4 Specific numbers of Oregon spotted frog eggs were removed for offsite rearing in support of WDFW project to introduce Oregon spotted frogs into a different watershed.</td>
</tr>
<tr>
<td>Waterfowl Survey</td>
<td>2002</td>
<td>No</td>
<td>Area: Black River Unit 123rd Area Timing: February and March Data/Results Availability: Baseline Survey, Unit records Emphasis: See Goal 1, 3, and 4 Unit staff conducted winter surveys early in land acquisition stage of the Unit.</td>
</tr>
<tr>
<td>Secretive marshbird survey</td>
<td>2003</td>
<td>No</td>
<td>Area: Black River Unit, River corridor from 123rd north 2.5 miles Timing: April, May, June Data/Results Availability: Baseline survey, Unit records Emphasis: See Goals 1, 3, 4 Survey conducted to better understand secretive marshbirds and habitat use along the river.</td>
</tr>
<tr>
<td>Bat roost survey</td>
<td>2003–2004</td>
<td>No</td>
<td>Area: Black River Unit 123rd Avenue Area</td>
</tr>
</tbody>
</table>
### Wildlife Surveys

<table>
<thead>
<tr>
<th>Year/Season(s)</th>
<th>Active</th>
<th>Emphasis</th>
</tr>
</thead>
</table>
| **Newly acquired parcel surveys** | 2001–2002 | No | Area: Black River Unit  
Timing: As parcels were acquired  
Data/Results Availability: Baseline observations, Unit records  
Emphasis: See Goal 4  
Unit staff recorded wildlife observations on newly acquired parcels for 1 year to better understand management needs. |
| **Seasonal wetland habitat management using herbivores** | 2008–2010 | No | Area: Black River Unit  
Timing: Year-round  
Data/Results Availability: Unit records  
Emphasis: See Goals 1, 3, 4  
Cattle were used as management tools to control rank, invasive reed canarygrass growth and enhance Oregon spotted frog egg-laying conditions. Private, NGO, and agency partners cooperated on this project. |
| **Plant species list development** | 1995 | No | Area: Black River Unit  
Timing: Opportunistic  
Data/Results Availability: Baseline survey, Unit records  
Emphasis: See Goals 1, 2, 3, and 4  
Unit volunteers created species list (with wetland affiliation) and herbarium records early in Unit development. The data has been used to understand habitats in the Unit. Additional species added as observed. |

### Research or Formal Studies

<table>
<thead>
<tr>
<th>Year/Season(s)</th>
<th>Active</th>
<th>Emphasis</th>
</tr>
</thead>
</table>
| **Oregon spotted frog** | 1990–present | No | Area: Black River Unit  
Timing: Variable dependent on research  
Data/Results Availability: Available on internet, Unit records  
Emphasis: See Goals 1, 3, and 4  
A number of research studies have been conducted by partners, including WDFW biologists related to the Oregon spotted frog’s natural history, habitat usage, |
## Wildlife Surveys

<table>
<thead>
<tr>
<th>Wildlife Surveys</th>
<th>Year/Season(s)</th>
<th>Active</th>
<th>Emphasis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Direction Hydrology Study</td>
<td>2003</td>
<td>No</td>
<td>Area: Black River Unit, the river, north of the pipeline location Timing: Winter and spring Data/Results Availability: Report available on internet, Unit records Emphasis: See Goals 1, 3, and 4 Hydrologists conducted a limited study to examine Black River water origin, flow, direction, speed, physical barriers and changes, water loss to the river, and changes to natural conditions surrounding the headwaters.</td>
</tr>
<tr>
<td>Malformed frog contaminant study</td>
<td>2002–2003</td>
<td>No</td>
<td>Area: Black River Unit Timing: Summer Data/Results Availability: Baseline observation, Unit and Service’s WFWO records Emphasis: See Goal 4 In response to a nationwide amphibian health concern, 2 years of surveys were conducted on red-legged frogs to determine the prevalence of physical deformation as a method to determine gross levels of potential wetland contaminants that looked abnormal. Surveys conducted in partnership with the Service’s WFWO.</td>
</tr>
<tr>
<td>History of habitat changes in Black River floodplain</td>
<td>2008</td>
<td>No</td>
<td>Area: Black River Unit - floodplain Timing: Spring and summer Data/Results Availability: Formal publication for WDNR, Unit copy Emphasis: Research to understand habitat changes occurring in the Black River floodplain since early European arrival and establishment. Includes portions of the Unit</td>
</tr>
<tr>
<td>Wild chervil control project</td>
<td>2003</td>
<td>No</td>
<td>Area: Black River Unit Timing: Summer and fall Data/Results Availability: Unit records Emphasis: See Goals 2, 3, and 4 The Unit worked with the Washington State Noxious Weed Board to determine</td>
</tr>
<tr>
<td>Wildlife Surveys</td>
<td>Year/Season(s)</td>
<td>Active</td>
<td>Emphasis</td>
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<tr>
<td></td>
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<td>effective methods to control nonnative and aggressive wild chervil.</td>
</tr>
</tbody>
</table>

**Monitoring**

<table>
<thead>
<tr>
<th>Habitat assessment</th>
<th></th>
<th>Yes</th>
<th>Area: Black River Unit Timing: As new land acquired Data/Results Availability: Unit records Emphasis: See Goals 1 and 2 To understand the habitats and management needs of newly acquired properties.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bog observation</td>
<td>2011</td>
<td>No</td>
<td>Area: Black River Unit Timing: Summer Data/Results Availability: Baseline observations, Unit records Emphasis: See Goals 1, 2, 3, and 4 Former WDNR wetland biologist and Unit biologist did a one-time visit of some bog sites in the northern-most portion of the Unit to begin the process of understanding the habitat and its wildlife components, as well as potential and current threats and management needs.</td>
</tr>
<tr>
<td>Targeted Invasive Species</td>
<td>Ongoing</td>
<td>Yes</td>
<td>Area: Black River Unit Timing: As needed Data/Results Availability: Unit records Emphasis: See Goals 1, 2, 3, and 4 Unit priority noxious weeds are monitored and treated to reduce land coverage and habitat impacts. The Unit works with Thurston County and Washington State Noxious Weed boards.</td>
</tr>
<tr>
<td>Seasonal wetland habitat management using limited numbers of cattle</td>
<td>2008–2010</td>
<td>Yes</td>
<td>Area: Black River Unit Timing: Year-round Data/Results Availability: Unit records Emphasis: See Goals 1, 3, and 4 Cattle are used as management tools to reduce the height of invasive reed canarygrass growth after a study showed habitat enhancement success and benefit for waterfowl, open wetland-related wildlife such as Oregon spotted frog, other amphibians, and Wilson’s snipe.</td>
</tr>
</tbody>
</table>
4.9 References


Seery, M.J. 2012. Discussion regarding the nonnative status of Rorippia nasturtium-aquaticum (white watercress). Thurston County Noxious Weed Agency. Olympia, WA.


TCNWCA. 2013b. Thurston County Noxious Weed Fact Sheets and Videos.


