Conservation Plan for Native Turtles in the Columbia Slough, Portland, Oregon

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I. Summary

Both the western pond turtle (*Actinemys marmorata*) and the western painted turtle (*Chrysemys picta bellii*) are considered priority conservation species in Oregon. The extensive aquatic resources support significant turtle populations in Portland. At the same time, the urban environment poses many challenges for short- and long-term conservation of these species. A strong alliance exists between natural resource professionals and the public to protect these fascinating reptiles. Recently completed conservation assessments recommended the development of a conservation strategy that incorporates both a community- and science-based approach for successful conservation of Oregon's native turtles. The conservation plan for Portland described in this document is the first step in the creation of a state-wide strategy. We have developed this conservation plan specifically for areas within Portland's Columbia Slough. The goal of this conservation plan is to create a blueprint for actions for conservation of native turtles in Portland, and specifically to inform management, education, research, and monitoring actions related to turtle conservation. Prior to implementation of our recommendations for any site, a site-specific evaluation with interagency involvement is needed to ensure compatibility of proposed actions with other ongoing management, plans, codes, and regulations for local, regional, and state jurisdictions.

One of the primary objectives of the Conservation Plan is to provide guidance for habitat management. In support of this effort, we conducted field work during spring and summer 2011 to (1) evaluate the distribution of native turtles by conducting a comprehensive survey of areas that could support turtles in the Columbia Slough watershed within Portland, (2) evaluate habitat conditions and factors associated with occupancy by turtles including prey abundance, and (3) initiate a pilot study on contaminant levels in turtles. We selected all sites, or portions of general areas, where western pond turtles or western painted turtles were previously observed and that were generally accessible. We also included sites that would provide a broad range of conditions upon which to evaluate habitat characteristics and broaden our understanding of the distribution of turtles within Portland. We included a total of 37 sites in our surveys of turtles and habitat conditions within the Columbia Slough watershed.

Turtles, both native and non-native, were distributed throughout the network of aquatic habitats within and near the Columbia Slough. Of the 37 Columbia Slough sites we surveyed, we detected turtles at 27 of the sites. We observed turtles in diverse habitats from small ditches to large lake systems. From the maximum number of turtles observed during the replicated surveys, we counted a total of 561 individual turtles. Because of the limited area we could visually survey and because the probability of detection of individual turtles is relatively low, we believe this represents a small proportion of the actual number of turtles in the planning area. We failed to find habitat characteristics that

were associated with site occupancy. This may have occurred because (1) factors other than what we estimated were most important, (2) we poorly estimated habitat characteristics, or (3) turtles were not highly selective within the study area when measured by occupancy rather than numeric abundance. Because several sites had very high densities and most sites had moderate to low densities, we do not believe that our lack of finding habitat correlates is due to a lack of variation in habitat quality as perceived by turtles and their demographic responses. We hypothesize that insufficient depth profiles of aquatic habitat and lack of brood habitat are the most limiting features to turtle abundance in Portland; we were not able to quantify either of these during our field work. We speculate that the two key limiting factors to turtle distribution and abundance in the Columbia Slough watershed is (1) rarity of deep pools, and (2) proximity of habitat for hatchlings (brood habitat) and nest habitat to aquatic foraging habitat.

We ranked key threats for each site. Threats, in the order of what we considered most important for Portland overall, include (1) release of pet turtles, (2) sedimentation and dredging, (3) traffic mortality, (4) recreation, (5) vegetation succession, (6) elevated predation, and (7) removal of native wild turtles. We provide a thorough discussion of each threat, the perceived mechanisms whereby threats may lead to declines in population, and how the importance of each threat varies among sites. Even lower ranking threats may have devastating consequences at a particular site.

Because of the patchy distribution of turtles within the Columbia Slough watershed and the opportunities for conservation at the scale of the landscape rather than site-by-site approaches, we identified five areas that we consider the most important for prioritizing conservation efforts from the eastern to western most portions of the Columbia Slough in Portland. Some TCAs include predominately public ownership, but other sites include a mix of both public and private ownership. The TCAs have no regulatory authority and have been delineated only for the purpose of identifying opportunities for conservation efforts by willing participants. Partnerships, and coordination, among agencies and other stakeholders are vital to turtle conservation in Portland. The Plan provides a suite of suggested projects for improving conditions for native turtles that would involve numerous partnerships.

II. Motivation for a Turtle Conservation Plan

Freshwater turtles are at risk worldwide, and the two species native to the Pacific Northwest are no exception. Both the western pond turtle (*Actinemys marmorata*) and the western painted turtle (*Chrysemys picta bellii*) are considered priority conservation species by the Oregon Department of Fish and Wildlife (ODFW 2006). In Washington, western pond turtles are state-listed as Endangered (Hays et al. 1999).

The Portland metropolitan area typifies the challenges and opportunities in conserving native turtles. The region has recently grown at unprecedented rates and continued development is expected. Conservation actions are needed while opportunities still exist. Only with careful management and planning to protect current populations and improve conditions where needed can viable populations of turtles coexist with increasing urban and suburban development. Substantial wetland habitat has been lost in the Portland area, but remnant and created habitat supports turtle populations.

Recently, a broad partnership sponsored conservation assessments for Oregon populations of western painted and western pond turtles. The conservation assessments (Gervais et al. 2009, Rosenberg et al. 2009) identified the development of a conservation strategy that incorporates both a community- and science-based approach as a critical need for successful conservation of Oregon's native turtles. The conservation plan for Portland described in this document is the first step in the creation of a state-wide strategy. Portland is an ideal choice for such an effort because local, regional, and state land management agencies are ready to provide turtle conservation measures and are seeking a management plan to guide and support their efforts.

The conservation plan builds on collaborative work led by the Lower Willamette Native Turtle Conservation Working Group, specifically their Draft Northwest Native Turtle Conservation Plan Outline, dated September 2008, recent management recommendations for Portland locations (NERI 2009) and the Portland metropolitan region (Kutschera 2010; and see Appendix 8). We also reviewed and incorporated concepts from other management documents for painted and pond turtles (Watkins 2004, Kohlmann and O'Neill 2009, Vesely 2009, Hezler 2012 [Appendix 8]). Sponsors of this Conservation Plan include the City of Portland, Metro, Oregon Department of Fish and Wildlife, Oregon Wildlife Heritage Foundation, Oregon Zoo, and Port of Portland.

This conservation plan was developed specifically for areas within Portland's Columbia Slough watershed (Figure 3). However, much of the plan is relevant for other areas, especially in the Portland metropolitan area. The goal of this Conservation Plan is to create a blueprint for actions for long-term conservation of native turtles in Portland, and specifically to guide and inform management, education, research, and monitoring actions that support native turtle conservation. We have attempted to identify our assumptions and rationale for each presumed threat and ultimately our recommendations.

Further, because of the very large number of sites, we were not able to evaluate the entire area of most sites. Prior to management actions, site-specific evaluation with interagency involvement is needed to ensure compatibility of proposed actions with other ongoing management, codes, and regulations.

III. Conservation and Regulatory Status

Western Pond Turtle

Because of the limited range of the western pond turtle and extensive habitat loss, there has been considerable concern for this species throughout its range. The western pond turtle is considered a Species of Concern by U.S. Fish and Wildlife Service (USFWS). Despite attempts to list the species under the Endangered Species Act, the USFWS found listing not to be warranted, which was partially due to a lack of data on declines and presumed threats (USFWS 1993). The Oregon Department of Fish and Wildlife (ODFW) included the western pond turtle as a Strategy Species in the Oregon Conservation Strategy (OCS) and as a "Sensitive-Critical" species on the State Sensitive Species list (ODFW 2006, 2008). The western pond turtle is protected under Oregon Administrative Rule 635-044-0130 (Protected Nongame Wildlife). Because of the very limited state distribution and threats to its viability, Washington listed the species as a State Endangered Species and began recovery efforts (Hays et al. 1999). In California, the western pond turtle is listed as a Species of Special Concern. A Conservation Strategy for the western pond turtle in California has been completed and is undergoing review by California Department of Fish and Game (H. Welsh, U.S. Forest Service, Redwood Sciences Laboratory; pers. commun., 2012).

The NatureServe/Natural Heritage Network ranks are Global Rank G3G4 (not immediately imperiled), State Ranks: California S3 (rare, uncommon or threatened), Oregon S2 (imperiled), Washington S1 (critically imperiled).

Western Painted Turtle

Unlike the western pond turtle, the western painted turtle has a very broad geographic distribution. Because of its broad distribution and abundance in many parts of its range (Ernst and Lovich 2009), the painted turtle has no special designation by the U.S. Fish and Wildlife Service. However, the range of the painted turtle in Oregon is quite limited. ODFW classified western painted turtles as a Strategy Species (ODFW 2006) and as a Sensitive-Critical species (ODFW 2008). In Washington, it is considered common and has no designated classification. In California it is considered a non-native species (Spinks et al. 2003). The NatureServe/Natural Heritage Network ranks are Global Rank: G5 (Demonstrably widespread); State Rank in Oregon: S2 (Imperiled); State Rank in Washington: S5 (Demonstrably widespread).

Non-Native Turtles
Both the red-eared slider (*Trachemys scripta elegans*) and common snapping turtle (*Chelydra serpentina*) are non-native species that are known to reproduce successfully in Oregon and have increasingly broad distributions across at least the western portion of Oregon (S. Barnes, ODFW, pers. commun., 2009). It is against state law (Oregon Revised Statute 498.052) in Oregon to release any species of turtles, and against state law (Oregon Administrative Rules 635-056-0000, http://www.dfw.state.or.us/OARs/56.pdf) to import, buy, sell, barter, trade, possess, or transport red-eared sliders and snapping turtles, and many other species of non-native turtle species.

IV. Natural History of Native Turtles in Portland

The ecology of both painted turtles and western pond turtles have been well studied. Numerous publications describe various aspects of their natural history. Painted turtles are one of the most-studied freshwater turtles in the world (Ernst and Lovich 2009). Although the literature is much less extensive for the western pond turtle, their basic biology is well understood, with a large number of papers published related to their reproductive ecology, habitat selection, and movement patterns, among other aspects of their ecology. Syntheses of existing work that relates to the ecology and conservation of western painted and western pond turtles in Oregon were recently completed. We refer readers to these works to provide a detailed synthesis of existing studies, both published and non-published, that relate to the ecology and conservation of western painted turtles (Gervais et al. 2009) and western pond turtles (Rosenberg et al. 2009) in Oregon. Both of these can be accessed at: http://oregonwildlife.org/products.htm

Below, we summarize the life histories and other factors that we believe are important for consideration in the Conservation Plan. Material is summarized from Gervais et al. (2009) and Rosenberg et al. (2009).

Summary of Western Painted Turtle and Western Pond Turtle Life History
Both western painted and western pond turtles have similar life histories and ecological requirements. The range of the western pond turtle includes northwestern Baja California, Mexico, north to Puget Sound of Washington and primarily west of the Sierra Nevada and Cascade Mountains. The painted turtle, including all subspecies, has the largest range of any North American freshwater turtle, and generally includes most of the eastern and central U.S., and southern Canada, and portions of the northwest U.S. and British Columbia.

In Oregon, both species inhabit sloughs, ponds, streams, rivers, and oxbow lakes, particularly those with numerous basking sites and submerged and emergent vegetation. Surprisingly, there is little work on selection of microhabitat conditions in their aquatic habitat. Basking is an important behavior that allows physiological requirements to be met. Aquatic vegetation is important for brood habitat, and for providing a food source for both turtles and their invertebrate prey. Differences in habitat selection between the two species have not been reported. Western painted and pond turtles often co-exist where their ranges overlap, such as in Portland. Water temperature is probably a key determinant of their micro- and macro-habitat selection, but little work has been conducted to elucidate patterns of thermal selection. This could be an important determinant of use of aquatic resources in Portland.

Adults are long-lived, with some individuals known to be over 40 years old. They begin breeding at 5-10 years old, and lay an average of 11 and 6 eggs/clutch for western painted turtles and pond turtles, respectively. They typically breed every year, but may skip some years depending upon environmental conditions. High nest and hatchling mortality occurs, but given a long life and relatively large number of eggs, this does not necessarily lead to declining populations.

Nests are constructed in a variety of soil and gravel types, ranging from sandy loam and clay soils to those with a large proportion of gravel, including gravel roads or roadside shoulders. Nests are typically constructed within 300 feet of their aquatic habitat in areas with relatively sparse vegetation such that the nest receives a high level of solar exposure, the latter being critical for incubation of the eggs.

Adult and juvenile pond turtles use both aquatic and upland habitats for overwintering. Upland overwintering sites are typically within 600 feet of water. Painted turtles more typically overwinter in in water depths of 5-6 feet, though selection of overwinter locations is not well understood.   Evidence in the Portland area suggests water depths of at least 5 feet may be important for painted turtles (Hayes et al. 2002).

Hatchling painted and pond turtles most frequently overwinter in their natal nests. The ecology of hatchlings is poorly understood, especially for western pond turtles (Rosenberg and Swift, In Press), and is one of the key areas for future research. Predation on nests and hatchlings is the least-studied aspect of the ecology of freshwater turtles, despite the importance to their conservation (Burke et al. 2000). There is little evidence behind claims that bullfrogs and bass are major predators that disrupt recruitment and are responsible for population declines. Because of the life-history strategy of both painted and pond turtles, understanding factors affecting survival of adults, particularly females, is crucial, yet few studies have been conducted on causative factors.

Life-History Cycle

A key concern for managing areas occupied by turtles is avoidance of direct harm during restoration, vegetation management, dredging activities, utility projects (pipes, outfalls), and trail and road construction. Here, we briefly review the life-history cycle for western pond and western painted turtles for consideration during management. Each situation will have unique conditions and constraints for avoidance measures, but an understanding of the seasonality of turtle activities is important in order to optimize management activities and avoid direct harm to turtles.

The active period in western Oregon is typically from March through October, but cold or drought (or other activities that result in low- or no-water conditions) may shorten the time turtles are active. During March to mid-May, juvenile and adult turtles spend most of their time in the aquatic environment. Hatchlings typically emerge in early spring, but may emerge as early as fall. From March to May, hatchlings may remain near their nest (as shown for western pond turtles; Rosenberg and Swift, In Press), though few studies have been conducted to give much guidance on how this varies among species and habitats. The most vulnerable period for population viability is most likely during the nesting phase, when adult females leave their aquatic habitat and search for suitable nest areas. This typically occurs from late May through July, though it extends earlier and later depending on the year and other conditions. Typically, nests remain occupied by eggs or hatchlings from laying through emergence the following spring. As fall begins, turtles begin to seek overwintering areas, though this is very sensitive to weather and aquatic conditions. The prevalence of aquatic vs terrestrial overwintering is not well known in Portland, but using other areas as a guide, painted turtles are most likely to buyr themselves in muck in aquatic habitat (Hayes et al. 2002) and pond turtles will use aquatic or terrestrial habitat, with the selection being very site specific. Warmer weather will initiate activity and movement from their overwintering site. Turtles are not true hibernators but "bruminators" and will leave their overwintering sites, dependent upon environmental conditions. In western Oregon, turtles typically leave their overwintering areas by March and begin the active season.

Potential Competition of Western Painted Turtles and Red-Eared Sliders

Both western painted turtles and red-eared sliders have broad native geographic ranges. Although the two subspecies co-occur in a small area of their respective ranges, red-eared sliders overlap the ranges of the other three subspecies of painted turtle to a much greater extent than they do the range of western painted turtles. We did not find reports of studies that compared the ecology and habitat use of western painted turtles and red-eared sliders in the same aquatic system. In addition, little information is available for either species in the Pacific Northwest, where the painted turtle occurs only in a limited area along the Columbia River south to primarily Salem. Our understanding of how these species coexist is based on inference from other geographic regions and often other subspecies, and must be regarded as tentative.

Red-eared sliders painted turtles (*C. picta*) were found in the same pond in southern Illinois, but sliders vastly outnumbered painted turtles. The authors reported that in Illinois, sliders dominated interspecies assemblages in the southern part of the state, but painted turtles dominated in the north (Dreslik et al. 2005). In contrast, a study in north-central Indiana found that painted turtles dominated local aquatic systems. The authors concluded that red-eared sliders were more likely to be affected by habitat fragmentation than midland painted turtles *(C. picta marginata*, Rizkalla and Swihart 2006). Resource partitioning in freshwater turtles appears to occur most often in microhabitat selection, particularly for basking sites, and food. Macrohabitat differences were minor (Luiselli 2008). Based on a synthesis of research, red-eared sliders tend to dominate in sites where both species occur (reviewed in Ernst and Lovich 2009).

Both species are highly omnivorous, apparently taking advantage of whatever plant material, carrion, or animal prey are available. Both species utilize similar foraging and nest habitat, including sites with slow-moving, soft bottom substrate, aquatic plants, abundant basking sites, and a variety of soil types near aquatic habitat with sparse or no vegetation to allow solar exposure to the nest. Habitat types listed for both species include ponds, sloughs, canals, swamps, and lakes. Of the two species, red-eared sliders appear to be slightly more adapted to warmer temperatures, feeding only after water temperatures warm to 18˚C (64˚F) whereas painted turtles resume feeding when water temperatures reach 15-18˚C (59-64˚F). Although there is some evidence that sliders outcompete native pond turtles for basking sites (Spinks et al. 2003), no information is available regarding whether sliders will dominate painted turtles if basking sites are limited. Both species have been regularly observed basking on the same log in Peninsula Canal (D. K. Rosenberg, pers. obs.) and elsewhere in the Portland metropolitan region (S. Barnes, ODFW, pers. commun, June 2012) . Similarly, they co-exist with western pond turtles at many sites in Oregon (Rombough 2007) and have been observed basking alongside each other in the upper Willamette Basin (S. Barnes, ODFW, pers. commun., June 2012).

In summary, little information exists to elucidate the risk sliders may pose to western painted turtles at the extreme edge of their range. Although competition for food or habitat resources such as basking or overwintering sites may affect interspecies interactions, indirect effects such as differential nest predation and reproductive success may also be important.

V. Physical and Biological Setting

The focus of this Conservation Plan is the network of aquatic resources, including drainageways maintained by the Multnomah County Drainage District, in the portion of the Columbia Slough watershed contained primarily within the City of Portland (Figure 3). The Columbia Slough runs a length of 18 miles, draining approximately 40,000 acres (City of Portland 1995). The origin of the Columbia Slough is Fairview Lake, located in the eastern Portland metropolitan area, south of the Columbia River and a mile west of the Sandy River delta.

From there, the slough continues west to the Willamette River, approximately 1 mile upstream from the confluence of the Columbia and Willamette Rivers. The Columbia Slough watershed contains many lakes and secondary waterways, including a complex system of drainageways, all of which ultimately empty into the Columbia Slough. Major aquatic resources within the watershed include Smith and Bybee Wetlands Natural Area, Vanport Wetlands, Whitaker Ponds, Whitaker Slough, Buffalo Slough, and the Big Four Corners Natural Area. In addition to the many remnants of lakes and wetlands in the watershed, many of the aquatic resources were originally created as part of mitigation or as water quality facilities. Secondary drainageways exist throughout many open space areas including several golf courses, Portland International Raceway, and neighborhood parks.

The Columbia Slough and its associated wetlands are remnants of the much greater network of wetlands that historically existed along the Columbia River between the Sandy and Willamette Rivers. Water flows are regulated by levees and pumps. Only in the Lower Columbia Slough do tidal influences still exist. The Columbia Slough serves as the main outlet for stormwater runoff in the Columbia Slough watershed which includes Portland International Airport. Properties adjacent to the Columbia Slough serve as one of the City's primary industrial zones, and include some of the most chemically contaminated areas within the Portland metropolitan region due to past industrial uses. Despite the dramatic alterations, the Columbia Slough comprises one of Portland's largest open space areas, and surely some of the most extensive and diverse aquatic resources.

Ownership and management vary widely within the Columbia Slough watershed. There are major industrial areas, particularly on the northern edge, residential areas, particularly in the southern portion, and publicly-owned open space areas, with Smith and Bybee Wetlands Natural Area and other nearby wetland areas contributing to one of the City's largest open space areas. Approximately 12% of the watershed consists of non-developed areas. Port of Portland, Metro, and the City of Portland have extensive ownership of open space areas in the watershed, and in particular, in the area near the Columbia Slough where most of the turtles of this watershed have been detected.

VI. Distribution and Abundance of Turtles in Portland

A recent description of the range and distribution of the two native species of turtles was provided in species assessments (Gervais et al. 2009, Rosenberg et al. 2009). In Oregon, the western pond turtle is most common south of Salem, whereas the western painted turtle is the predominant turtle species north of Salem, and is most abundant near the

Columbia River. Within Portland, painted turtles are most abundant in the Columbia Slough watershed. Western pond turtles are much less abundant and have been observed mostly within the Willamette watershed (Appendix 7). We observed pond turtles prior to our surveys in 2010 at Oak Bottoms Wildlife Refuge, and possibly at Smith and Bybee Wetlands Natural Area and Peninsula Canal during the surveys (see GIS survey layers submitted to each sponsoring organization and available from Oregon Wildlife Institute).

Historical Perspective

To better understand the distribution of turtles in Portland, we first provide state-wide perspectives. Several accounts were published prior to 1950 on the distribution of turtles in Oregon. Storer (1937), Graf et al. (1939), and Evenden (1948) came to the general conclusion that western pond turtles were rare north of Salem, whereas western painted turtles were most abundant along the Columbia River, its tributaries, and up the Willamette from its confluence with the Columbia to as far south as Salem. We are unaware of any reports of non-native turtles prior to 1950. These earlier observations suggest that the rarity of western pond turtles in the northern portion of their range, including Portland, is at least in part due to environmental and biological limitation near the edge of its range rather than a general reflection on declines of this species due to anthropogenic influences (see Section VI, *Population Trends*). This is further supported by the rarity of western pond turtles at Burlington Bottoms (ISRP, no date given). , near Sauvie Island, and Smith and Bybee Wetlands Natural Area, both of which are considered to have excellent turtle habitat. In summary, the current distribution patterns of native turtles in Oregon are generally consistent with the published historical observations: primarily western painted turtles along the Columbia and Willamette Rivers and their tributaries, north of Salem (Gervais et al. 2009), with western pond turtles predominately distributed along the Willamette and its tributaries in the central to southern Willamette Basin, and elsewhere in western Oregon and the Klamath Basin (Rosenberg et al. 2009).

Recent Patterns and Trends: State-wide and within Portland

Given the vast changes to the hydrology and land use of the Willamette (Taft and Haig 2003), and Columbia basins since dams were built and major development occurred, declines in abundance of native turtles must have been great. Here we summarize work that provides inferences on recent patterns of distribution since pre-1950 publications.

Western Painted Turtle

The current range of western painted turtles has expanded beyond their historical range in Oregon. This is largely due to the presumed introduction of pet turtles, which has resulted in self-sustaining populations in southern Oregon (Gervais et al. 2009). Dramatic changes to the hydrology of the Portland region and intensive urban development in areas that once likely supported turtles suggest that populations particularly in the eastern half of the Portland metropolitan area have dramatically declined from pre-settlement densities. However, we are not aware of any actual population estimates prior to the extensive landscape-level changes.

Western Pond Turtle

Despite enormous changes in hydrology and land use, survey efforts offer evidence that the recent distribution of western pond turtles is generally similar to the historical distribution. At smaller spatial scales, changes in patterns of abundance have presumably occurred with channelization of the Willamette River and development within the floodplain. These changes have certainly occurred within Portland, where intensive development along the Willamette River may preclude occurrence by turtles in many locales. However, we are not aware of data that would allow estimation of the decline in distribution or abundance.

Previous Surveys and Locality Records in Portland

Most of the work delineating the distribution of turtles in Oregon has been conducted in the Willamette Basin and included extensive surveys throughout the region (Table 1). The Holland (1993) and Adamus (2003) surveys were focused on western pond turtles. Based on where their surveys were conducted, they likely observed painted turtles, but no mention is made of observing this species. Reams (1999) conducted surveys for western pond turtles in several rivers in the Willamette Basin, including the Tualatin River. St. John (1987) reports on several locations where he found both painted and pond turtles. More site-specific surveys were carried out in various areas, and are described below.

Portland metropolitan area—Several surveys have been focused in the Portland metro region (Table 1). In 2008, ODFW and the Oregon Zoo initiated a citizen science effort that resulted in location records of turtles in the Portland region (Appendix 7). Recently, NERI (2009) conducted surveys in Portland in selected sites within the Columbia Slough and Johnson Creek watersheds. Several less extensive surveys have been focused in the Portland metropolitan area including the Columbia Slough and associated drainageways and nearby ponds (Gaddis 1984, Gaddis and Corkran 1985, Beilke and Christensen 2007, Beilke and Christensen 2008). St. John (1987) surveyed a few sites in the northern portion of Willamette Valley, including locations along the Columbia River. Additional opportunistic observations have been made of turtle locations by individuals and agency personnel, and recorded in either the Oregon Biodiversity Information Center (formerly ORNHIC) database, USFS database (NRIS), or BLM database (GeoBOB). We used the databases that formed the basis for the assessments of Gervais et al. (2009) and Rosenberg et al. (2009) in our review of location records, augmented by additional records in a database from the City of Portland (Appendix 7). Almost all of the distribution data were collected from selected sites based on a previous understanding of where turtles would most likely be found, and from opportunistic observations.

Annual or periodic surveys have been conducted in an effort to monitor trends in abundance of native and non-native turtles at a few sites in Portland. Counts for turtles have been conducted regularly since the early 1990s in a protected bottomland site managed by ODFW near Sauvie Island (S. Bielke, ODFW, pers. commun., 2009; ISRP). Similarly, Metro has monitored turtle populations using a standard survey protocol since 1999 (E. Stewart, Metro, pers. commun., March 2012). Staff from various municipalities in the Portland metropolitan area have conducted surveys prior to proposed development; some of these efforts identified painted turtles where they were previously unknown (Gervais et al. 2009). Unfortunately, we were not able to find written documents of the findings from these surveys, and we recommend the agencies that supported this work require annual monitoring reports. For our evaluation here, we relied on personal communication with individuals who conducted the surveys.

Port of Portland sites—Hayes and others (Hayes et al. 2002) conducted a detailed population and space-use study of painted turtles in and near the T-5 Powerline Mitigation site, owned and managed by the Port of Portland, from April 1999-April 2000. This site is located near Smith and Bybee Wetlands Natural Area. They used a combination of visual, mark-recapture, and radio-telemetry approaches for their study of demography and movements of painted turtles. Hayes and coworkers (Hayes et al. 2002: 96) estimated a population of approximately 100 adult painted turtles.

West Hayden Island—Rombough (2011) conducted surveys from December 2010 to August 2011 on West Heyden Island. He found one painted turtle at the outlet of a wetland to the Columbia River. Rombough concluded that the area provided poor habitat for turtles because of the lack of permanent aquatic habitats. Painted turtles were also observed in 2009 in Port of Portland's mitigation site, a created wetland (C. Butler, Port of Portland, pers. commun., 2011).

Smith and Bybee Wetlands Natural Area—All written accounts and expert opinions report that the greatest number of western painted turtles in the Portland metropolitan area occur in the Smith and Bybee Wetlands Natural Area. Metro has conducted visual surveys for painted turtles using a standardized protocol in most years from 1999 to 2010 (E. Stewart, Metro, pers. commun., 2012). Surveys have resulted in counts of from 108 – 303 turtles annually, with no apparent trend. Observers conducting mark-recapture efforts from 1999 to 2001 marked 332 juvenile and adult painted turtles. From these data, they estimated between 400 and 500 individuals (E. Stewart, Metro, pers. commun., 2012).

Population Trends

Population trends are virtually unknown. Understanding population trends is made difficult because of the challenges posed by sampling turtle populations and the nature of the survey work that has typically been conducted (Gervais et al. 2009, Rosenberg et al. 2009). Given the extreme reduction of wetland habitats in Portland, turtle populations must have been severely reduced since pre-European settlement. However, the current population trajectory, and any factors associated with it, is unknown. Monitoring work at Smith and Bybee suggested no apparent trends (see above, *Smith and Bybee Wetlands Natural Area*) as reported by E. Stewart (Metro, pers. commun., 2012. Similarly, monitoring conducted at Burlington Bottoms, near Sauvie Island (west of Smith and Bybee Wetlands Natural Area) suggests no apparent trend in numbers of western painted turtles (S. Bielke, ODFW, pers. commun., June 2012; ISRP report). Furthermore, there is recognition that monitoring efforts may not track population abundance as first intended because of the unknown and presumably changing detection probabilities among years (E. Stewart, Metro, pers. commun., 2012). This results in observing a different proportion of turtles at each survey which effectively makes the number counted a poor index of the actual population size. This is an important issue to recognize for future monitoring efforts (see Section X, *Monitoring*).

VII. Field Work Conducted in Support of Plan

The primary goal of the Conservation Plan is to provide guidance and justification for habitat management for long-term conservation of native turtles in the Columbia Slough watershed. In support of this effort, we evaluated the distribution of native turtles using previously collected survey data and sampled most areas that could support turtles, particularly in and near the Columbia Slough. At each site, we evaluated habitat conditions and potential conservation threats. This entailed limited sampling of mercury levels in turtles, biomass of invertebrate prey at several sites with either low or high abundance of turtles, and extensive collection of habitat characteristics. We quantitatively evaluated the relationship between habitat characteristics and the presence of turtles at each site.

Methods

Field Site Selection

We limited sites for field surveys to areas within the City of Portland, with only a few exceptions (Company and East Lakes) on areas of particular interest to funding agencies. Because of the vast aquatic areas that potentially provide suitable habitat for turtles within the city limits, and the presumed limited distribution based on previous work (see Section VI, *Distribution and Abundance of Turtles in Portland*), we chose to use a non-random selection procedure in identifying sites for field surveys for turtles and habitat conditions. Such an approach limits formal inference to only the sites we sampled.

Table 1. Summary of location data for western pond and painted turtles that included the Portland metro region. Modified from Rosenberg et al. 2009 and Gervais et al. 2009.

Region	Site	Author	Year of Report
State-wide	Included Portland metro.	Holland	1993
State-wide	Included Portland metro.	ODFW Citizen Science	2008 and continuing
Willamette Basin	Included Portland metro	Holland	1994
Willamette Basin	Calapooia, Row, and Tualatin Rivers	Reams	1999
Willamette Basin	Few sites within Portland; excluded Columbia Slough watershed	Adamus	2003
Portland metropolitan region	Columbia Slough watershed, Tualatin drainage; other Portland metro	Gaddis	1984
Portland metropolitan region	Sauvie Island, Col. Slough, and other areas	Gaddis and Corkran	1985
Willamette Basin	Few sites in Portland metro	St. John	1987
Portland	T-5 Powerline Mitigation site /Smith and Bybee area	Hayes et al.	2002
Portland metropolitan region	Metro region	Bielke and Christianson	2007
Portland metropolitan region	Metro region	Bielke and Christianson	2008
Portland	Columbia Slough and Johnson Creek watersheds	NERI	2009
Portland metropolitan region	Burlington Bottoms	S. Bielke, ODFW, pers. commun.; ISRP (non-dated).	ongoing
Portland metropolitan region	Smith and Bybee Natural Wetlands	E. Stewart, Metro, pers. commun.	Ongoing

However, given our limited resources, this approach provided a reasonable method to estimate patterns of distribution and habitat associations over a broad array of aquatic habitats. We selected all sites, or portions of general areas, where western pond turtles or western painted turtles were previously observed and that were generally accessible, and added sites along or near the Columbia Slough that we believed potentially provided suitable habitat. We also included sites that would provide a broad range of conditions upon which to evaluate habitat characteristics. We submitted an initial list of sites to members of the Lower Willamette Native Turtle Working Group and staff of the various land management agencies and organizations in Portland. Based on the reviews we received, we modified the site list. Ultimately, 41 sites were selected (Appendix 1; all sites included in GIS layer submitted to sponsoring agencies). These sites included a range of habitat conditions, from small ditches to large water bodies. Because of the large number of sites, the importance of the areas along the Columbia Slough, and the poor weather conditions that limited the number of survey days (see *Results*), we only included sites in or near the Columbia Slough in our replicated surveys. Thus, 37 sites were surveyed four times (Appendix 1), and four sites in southeast Portland (Johnson Creek watershed) were visited only once. We do not further discuss the four southeast Portland sites; survey results are included in the GIS data layer (available from Oregon Wildlife Institute).

Sites consisted of a single water body such as Morrow Pond, a portion of a large body of water such as the Columbia Slough crossings, or a set of nearly adjacent water bodies, such as exists at Broadmoor Golf Course. Within each site, we established one to six observation stations that provided the best visibility in the largest portion of the water bodies with reasonable accessibility. The size and location of the polygons in the GIS survey layers depict the approximate area that was surveyed (GIS data submitted t sponsoring organizations and available from Oregon Wildlife Institute).

Presence/Absence Surveys

Five observers performed the surveys from May 10 to June 24, 2011. Before any surveys were begun, one observer visited each site to determine where observation stations would be located. Stations were chosen so that a maximum amount of shoreline and number of basking sites could be seen from a distance of < 50' away. Observers performed "walking surveys" along ditches at which stationary observation points were not effective in determining occupancy by turtles. At these sites (Elrod Ditch, Children's Arboretum, and Leadbetter), an observer walked from two established points that could be walked in 30 minutes, with the observer searching for turtles in any aquatic habitat that allowed visibility.

All sites in the Columbia Slough watershed were surveyed four times by at least two different observers. Sites in the Johnson Creek watershed were surveyed only once.

Because of the relatively low detection probability for a single survey (see *Results*), only those sites surveyed four times are included in the analyses of occupancy and habitat associations. To maintain similar seasonal effects of detection, each of the four survey rounds was completed at all sites before the next survey round was begun. Logistical constraints imposed by traffic and other accessibility issues dictated the order in which sites were visited, which varied among surveys. We varied the time of day that a survey was conducted within the four replications at a particular site.

We conducted surveys for turtles between 09:00 and 16:00, when turtles were most likely to be basking, and therefore most detectable. We required that the air temperature be a minimum of 12 °C (55 °F) to conduct a survey. If the Beaufort scale indicated winds in excess of 12 mph (3 on the Beaufort scale), observations were discontinued.

Observers began watching for turtles while they approached the observation station. Once they arrived at the station, observers used binoculars and 20-60X spotting scopes to locate, count, and identify to species and size class each turtle observed during a 30-minute observation period. Size classes recorded were small juveniles, large juveniles, or adults. Observers also noted disturbances such as passing recreationists and responses by the turtles. After the half-hour observation period, observers recorded air and water temperatures. Air temperatures included sun and shade measurements if the weather was clear, and water temperatures were taken at approximately 1foot depth and 5 feet from shore. Water temperatures were not obtained when shorelines were inaccessible.

We trained observers to identify four species: western painted turtles, red-eared sliders, western pond turtles, and common snapping turtles. Of these, the western painted turtles and sliders were most likely to be indistinguishable during surveys. If the determination of either slider or painted turtle was not certain based on a good visual observation of marking patterns on the head, then they were identified as “PTRES” on the data form as opposed to “UNK”, which meant the observer was unable to distinguish any identifying characteristics to determine species.

We scored each survey as either “*detected*” or “*not detected*” based on whether any turtles of any species were seen at that site during the survey. We defined a site as “occupied” if any turtles were observed during the four surveys. Occupancy rate is the proportion of sites that are occupied at any given moment during the surveys. We then estimated occupancy rates and site-level detection probabilities (MacKenzie et al. 2006) using Program MARK (White and Burnham 1999). We modeled the probability of detecting turtles at any site as a function of turtle abundance (high versus low), allowing detection probability to remain fixed or vary independently or linearly with time. Because observers always observed turtles at sites with large populations, we fixed the probability of detection at the high-density sites at 1.0 in models that estimated detection probability separately for site density. We evaluated all occupancy models in Program Mark (Table 3).

Habitat Characteristics Associated with Turtles

Following completion of the turtle surveys, one person recorded habitat characteristics at each subsite between May 30 and June 17, 2011. A number of variables that are likely to be associated with turtle occupancy were estimated (Table 2). We explored these data for relationships between habitat characteristics and turtle occupancy at the spatial scale of the subsite.

Because of the relatively high detection probability achieved with four surveys (09; see *Results*) and the additional parameters required for the occupancy models versus the small number of sites, we chose logistic regression rather than occupancy modeling to evaluate habitat relationships. The sample size was relatively small (n=49 sub-sites) relative to the number of variables (Table 2), so we broke up the analyses into three parts: the first dealt with the characteristics of the land surrounding the water body, the second dealt with aquatic characteristics, and the third with human disturbance. Data categories were combined when needed to avoid quasi-separation in the data, which occurs if a variable was never or always associated with the response variable, which in this case is detection of turtles at any one of the four surveys. Some variables were dropped to avoid multicollinearity, which occurs when one variable completely or nearly completely predicts another variable in the data (Allison 1999). This is common in habitat relationships when a large suite of variables are included. Ultimately, we evaluated 19 models for habitat relationships (Table 5).

Trapping & Mercury Sampling

We trapped turtles to collect blood samples for mercury contamination in collaboration with U.S. Geological Survey (USGS). We conducted trapping at a subset of the sites where turtles were observed regularly and that provided a broad range of east-west locations along the Columbia Slough. We set traps at Morrow Pond, Peninsula Canal, Turtle Pond in the T-5 Powerline Mitigation site, Leadbetter Mitigation, and Force Lake which is part of the Heron Lakes Golf Course. We used a combination of box traps and hoop nets baited with perforated cans of sardines packed in oil. Traps were set between June 27 and June 30 and checked daily. Captured turtles were removed and placed in buckets or plastic bins prior to handling. We measured and weighed each turtle and drew 0.2-1.0 ml of blood from the occipital venous sinus (Martinez-Silvestre et al. 2002) or the caudal vein with a 25 gauge needle attached to a 1 mm syringe. The turtle's skin was swabbed with rubbing alcohol prior to sampling. We then marked the turtles with a dab of bright red nail polish on their carapace and released them at the water's edge near the trap location if they were painted turtles, and placed them in a plastic tote with 2.5 cm of water if they were red-eared sliders. We marked painted turtles to avoid re-sampling if they were recaptured. Sliders were transported to the Oregon Department of Fish and

Wildlife field office in Clackamas for humane euthanasia in accordance with ODFW policy. Sliders were delivered to the field office on the day of their capture to minimize the duration of stress to the animal.. We followed the protocols approved by Oregon State University's Institutional Animal Care and Use Committee and ODFW's Wildlife Scientific Take permit.

Blood samples were immediately placed in cryotubes and kept on dry ice prior to delivery to the USGS laboratory. They were then transferred to a freezer and kept at -20 °C prior to analysis. USGS analyzed blood samples using EPA method 7473 (U.S. EPA 2007) for total mercury using a Milestone DMA-80 Direct Mercury Analyzer (Milestone, Inc., Monroe, CT). An integrated sequence of drying (250 °C for 60 seconds), thermal decomposition (650 °C for 720 seconds), catalytic conversion, and then amalgamation, followed by atomic absorption spectroscopy was used for analysis. USGS calibrated the instrument over its entire operating range (0.05-1000 ng Hg) before running the samples with dilutions of a certified mercury standard solution (SPEX CertiPrep, Metuchen, New Jersey, USA).

Prey Sampling

We collected invertebrate samples at a subset of sites with low and high turtle densities to provide a preliminary evaluation of the relationship of invertebrate prey and turtle abundance. We collected ten samples at each of eight sites (Table 7). Samples were taken by the same observer using a 500 micron D-ring net deployed from a small kayak. We spaced the samples evenly around the perimeter in small water bodies such as Morrow Pond, or approximately every 25 m along a non-random selected section of shoreline in larger water bodies such as Ramsey Lakes. Samples were taken at depths of 2 – 5 feet. At each sampling point, the collector thrust the net into the bottom and jabbed 3 times, bringing the net up through the water column after the last jab. Any vegetation dangling from the net was broken off at the point it draped over the net rim. Net contents were rinsed free of mud by dipping repeatedly into the water. The collector then brought the net to the shore.

Table 2. Habitat characteristics measured at each subsite.

Characteristic	How measured or recorded
Type	Lake, slough, pond, river, marsh, or golf course pond
Bask 0-5, 6-10, 10-20, 20+	Basking sites within each distance class to shore
Bask type	Logs or wood, rocks, vegetation, other
Connect?	Aquatic connections to other waters- yes or no.
Type	Culvert, ditch, stream, or other
Size of connection	How many feet wide
Grate	Is there a grate in the culvert or ditch?
Turtle Access?	Grate large enough, culvert lip below water's surface
Nesting	Area of potential nest area: Scored 0 – 4
Nest Risk	0: no habitat; 1= within 100 feet of water's edge to 4=busy road
Aquatic Open	Percentage of water surface that is open
Aquatic Em	Percentage of surface that is emergent vegetation
Aquatic floating	Percentage of surface that is algal mat
Muck	% bottom substrate that is muck, visually assessed from shore
Sand	Percentage of bottom that is sand
BotVeg	Percent of bottom covered by rooted aquatic plants
Rocks	Percent of bottom covered by rocks or gravel
Other	Percent of bottom covered in tires, old metal, etc.
Tree%	Percent shoreline made up of trees
Shrub%	Percent shoreline made up of shrubs
Open%	Percent shoreline that is grass or dirt
Other%	Percent shoreline that is paved, etc.
R	Restricted access area activity: 0-no idea, R1-not busy, R2-moderate, R3-very busy although restricted, R4- not restricted
P	Public use: P1- light,P2- moderate (1-5 users/hour), P3- heavy (dog walkers, bicycles, joggers, etc, >5/hour), P0- no idea
W	Water use: W1-accessible but rarely used, W2- sometimes boated, W3- heavy use, W0- no idea

Net contents were emptied into a five-gallon bucket, and any vegetation shaken thoroughly to dislodge invertebrates. We then poured the bucket water through a 500 micron metal sieve, transferred the sieve contents to a sample bag and added sufficient 95% ethyl alcohol to cover the sample. Samples were stored at room temperature until processed.

Invertebrates present in the samples were identified in the laboratory to family, counted, and biomass estimated by dry weight. Not all samples were completed because of time constraints; in addition, some samples were sub-sampled because of the amount of material they contained. Only one site (Leadbetter) was entirely completed. For the remaining 7 sites, we randomly chose 5 of the 10 samples at each site for analysis. In most cases, these were sub-sampled using a plankton splitter. If the sample volume was small, the entire sample was examined. After examination, invertebrates were removed from their casings although snails and mussels were left in their shells. Samples were weighed and oven-dried at 50 °C for 24 hours then held in a desiccator until cool. Samples were then reweighed to determine dry mass.

Results

Presence/Absence Surveys

We completed four surveys at 37 sites to evaluate occupancy. Of these, five sites had high densities of turtles: Smith and Bybee (including “Pond 1”, “Turtle Turnout”, and “Tire Factory” [see GIS layer for exact locations surveyed]), Ramsey, Turtle Pond in the T-5 Powerline mitigation site, Peninsula Canal, and Leadbetter. Turtles were observed at these sites during every survey. Other sites varied from no turtles ever seen to turtles observed during all surveys. Turtles were never observed at 10 of the 37 sites. They were seen only once at 9 sites, twice at 7 sites, three times at 4 sites, and during all surveys at 7 sites (Appendix 1).

At sites where we detected turtles, numbers seen during a single 30-min observation period at a site ranged from 1 to 193 turtles. The consistently greatest numbers were recorded from observation stations at the Peninsula Canal. Painted turtles were observed at 16 sites, red-eared sliders at five sites, and both species were identified at 3 sites (Appendix 1). There were a number of instances where observers could not differentiate painted turtles from sliders; this occurred at nine sites. Unknown turtles were also recorded at 8 sites. Only painted turtles were positively identified at five sites with “PTRES” also recorded, and only sliders were identified at 1 site with “PTRES” also recorded. Three sites with “PTRES” contained both sliders and painted turtles. “Unk” turtles occurred at three sites where only painted turtles were otherwise identified, one site where only sliders were identified, one site where no other turtles were seen, and three sites where both painted turtles and sliders were identified (Appendix 1). Pond turtles were observed at two sites (Smith and Bybee Pond 1 and Peninsula Canal) and a common snapping turtle was observed at Peninsula Canal. Large juveniles were observed at most sites where large numbers of turtles were observed. Individuals we classified as juveniles based on size were observed at fourteen sites.

Based on the similar habitat use of painted turtles and red-eared sliders (Section IV, *Potential Competition of Western Painted Turtles and Red-Eared Sliders*), we believe it is likely that all the sites where we observed either species will also be occupied by the other species. All of the sites are reasonably well connected to the Columbia Slough so that there is little basis for assuming that the sliders we observed were pets released near the point of observation. Finally, we note that we observed a painted turtle at one additional site, the crossing at Columbia Slough at 185th (CS185, Appendix 1) during the habitat evaluations, and pond turtles at Oak Bottoms Wildlife Refuge (southeast Portland) prior to surveys.

Numbers of sites with any turtles detected declined slightly in the last two survey rounds, although turtles continued to be detected at sites for the first time during the final survey. Numbers of turtles observed at any site also tended to decrease as the surveys progressed (Appendix 1). This general trend may be associated with steadily increasing water temperatures, high water conditions later in the spring, and/or decreased visibility due to vegetation growth along the banks of the water bodies which made it increasingly difficult for observers to view turtles.

We modeled occupancy across all sites surveyed four times using the occupancy module in Program MARK. Because five sites are very large with dense turtle populations, we set the probability of detecting turtles at these sites to 1.0 rather than estimating detection at these sites. The five high-density sites were Leadbetter, Peninsula Canal, Ramsey, Smith and Bybee, and the T-5 Powerline Mitigation site. We also evaluated four models which did not differentiate detection probabilities between the low-density and high-density sites; in these models, we did not fix any parameters.

We evaluated how well the data fit the model, referred to as a goodness of fit test, by comparing simulated and observed deviances and evaluating over-dispersion (greater variance than expected) using the parameter c-hat (Cooch and White Chapters 5 and 9, Program MARK: a gentle introduction, 9th edition; http://www.phidot.org/software/mark/docs/book/). There appeared to be no issues with model fit based on these evaluations. This suggests that the model represented the data well enough that we can have some confidence in the estimates the model produces. However, tests to evaluate whether the model represents the data well enough to use the model to generate estimates often do not have much statistical power. In other words, if the sample size is small, there may be no basis to conclude the model doesn't fit, even in cases where it really doesn't. Other circumstances may also affect the ability of the statistical test to reject a poorly fitting model.

We evaluated models using Akaike's Information Criterion modified for small sample sizes (AICc, Burnham and Anderson 2002). There were three models with similar levels of support, indicated by delta AICc values of 2 or less (Table 3). These models differed only in how detection probabilities varied for the low-density sites. In order to fully incorporate all of the information provided by the entire model set, we used model averaging across the entire model set (Burnham and Anderson 2002). The model-averaged parameter estimates are given in Table 4.

Models that allowed detection probabilities to vary through time were based on the expectation that as water warmed, turtles would bask less often and detectability would decline with each survey. However, these models were not well supported, probably because there weren't enough data to adequately estimate these extra parameters as well as the absence of very strong time effects. How well a model is supported, when using AIC as a criteria, is based on the balance of how well the model fit the data and the number of parameters, with a penalty term for the number of parameters. In this sense, one is searching for the simplest model that explains the data well.

The model-averaged parameter estimates suggest that the probability an observer will actually see a turtle basking at a site that has turtles is approximately 0.4 during a single survey. In other words, even if turtles are present, they are likely to be detected at our sample of sites less than half the time if the site does not support large densities. Given these estimates, the average probability of detecting a turtle at a site over the four surveys is approximately 0.9 – i.e., we were fairly certain to detect a turtle if it occurs at the sites using the survey methods we employed. The overall probability of occupancy was 0.81, indicating that the large majority of sites surveyed were occupied by turtles of any species during the survey period. Because these sites were not randomly selected, however, it is important to restrict inference regarding occupancy and detection rates to only the selected sites and not all water bodies in Portland.

In order to meet the assumptions of the occupancy models, sites must remain either occupied or not for the duration of the surveys, and occupancy status must be independent among sites. Neither of these assumptions is likely to hold for turtles in the Portland metropolitan area, where water bodies are frequently close to one another and connected by ditches or drains. In addition, turtles move from site to site in response to environmental conditions, and when the surveyed portion of sites is small and not isolated, such as along the Columbia Slough, they are not likely to meet the assumption

Table 3: Turtle occupancy models. *Psi* represents occupancy and *p* is the detection probability. The dot (.) is used to indicate that the same value was used for both groups, whereas H and L indicate different values were estimated for high-density and low-density sites, respectively. Detection for H was fixed at 1.0 and not estimated as a separate parameter. The designation (t) is used when detection was modeled separately for each survey replication (four surveys numbered 1-4 for high-density sites and 5-7 for low-density sites). The designation (tlin) represents a linear function over time.

Model	No. Parameters	AICc	Delta AICc	Model Weight	Deviance
Psi(.)p(HL)	2	164.6747	0.0000	0.4541	14.3852
Psi(.)p(HLtlin)	2	165.1013	0.4266	0.3669	14.8119
Psi(.)p(HLt1-3,4)[1]	3	166.7140	2.0393	0.1638	14.0502
Psi(.)p(H.Lt)	5	171.4820	6.8073	0.0151	13.6100
Psi(.)p(HtLt)	9	184.2131	19.5384	0.0000	159.5466
Psi(.)p(.)	2	192.4154	27.7407	0.0000	188.0623
Psi(.)p(1-7,8)[2]	3	194.4858	29.8111	0.0000	41.8220
Psi(.)p(t)	5	199.3106	34.6359	0.0000	187.3751
Psi(.)p(tlin)	5	200.1917	35.5170	0.0000	188.2563

[1]Probability of detection was set at 1.0 for high-density sites. For low-density sites, the probability of detection was held constant for the first three occasions but allowed to differ on the fourth survey occasion.

[2]In this model, the detection probability was fixed across both high-density and low-density sites for all surveys in the high-density sites and for the first three surveys in the low-density sites. The probability of detection during the last survey for the low-density sites was allowed to vary from the others.

Table 4. Model-averaged parameter estimates for the occupancy models. Detection for the five high-density sites was fixed at 1.0. Detection at low-density sites was allowed to vary per survey interval (*p1-p4* corresponded to high-density sites in MARK, and *p5-p8* corresponded to the first through fourth survey of low-density sites).

Parameter	Mean	Standard Error*	Upper 96% CI	Lower 95% CI
Occupancy	0.8142	0.0917	0.5720	0.9349
Detection p5	0.4418	0.0626	0.3250	0.5654
Detection p6	0.4339	0.0632	0.3165	0.5592
Detection p7	0.4249	0.0683	0.2992	0.5610
Detection p8	0.4297	0.0859	0.2750	0.5996

*unconditional standard error

of closure. The departure from the assumptions is likely more severe for sites on the Columbia Slough, where only small areas could be observed at road bridges over the Slough. When an individual moves away from the site in its daily or seasonal movement patterns (equivalent to "temporary emigration"), detection probabilities are underestimated. However, the results provide our best estimate of detection and occupancy given the limitations of our field work.

Habitat Characteristics Associated with Turtles

We explored habitat relationships using logistic regression in SAS. The first three analyses examined the effect of land characteristics, aquatic factors, and human-disturbance factors on occupancy by turtles. Finally, we explored a fourth set of candidate models containing elements of the full models, including models that contained aquatic, land, and disturbance factors.

In the first round, we examined variables describing the characteristics of the habitat surrounding the water body (Table 2). Issues with quasi-separation (essentially, the condition when all responses are either "turtle detected" or "not detected" for a given explanatory variable [e.g., number of basking logs] and multicollinearity (when two or more explanatory variables are highly correlated) led to combining the "no nesting habitat present" (two cases, both associated with no site occupancy) with small amount of nest habitat, and "no risk" for nesting because no habitat was present was combined with low risk. The "no risk" category was recorded twice, again for two sites without turtles. There were no associations between the land characteristics we measured and site occupancy by turtles.

Aquatic habitat variables also included highly correlated variables and quasi-separation in the data. Originally, basking sites were counted in bands of distance categories from shore; however, because sites with many basking sites close to shore always had many basking sites a little farther out, we dropped the basking site category 6-10 m from shore. We modeled the effects of human disturbance on the presence of turtles at a site. To avoid quasi-separation of the data, we assumed if there was some public access, the public would use the site at least occasionally, and we combined the categories for no boat use with limited boat use. This and other pooling of data was required for analysis because of the limited sample sizes that was partially responsible for the quasi-separation of data, as explained in the preceding paragraph.

Finally, we examined a suite of 16 additional models from the habitat data (see Table 2), and compared all 19 of them using Akaike's information Criterion (Table 5).

Based on the results of all the models, none of the factors we measured had any predictive power for turtle presence or absence at a site. The one exception was the variable of tree cover around a site. Tree cover was marginally a preferred model when it appeared with other variables in models, although none of the models' slopes was statistically different from zero. When tree cover was modeled as the only variable in the model, that model was one of the best models of the set as defined by AICc score (see Burnham and Anderson 2002). The model that contained amount of nesting habitat near the water body and the amount of open water at the site gained similar support, but neither the model nor the parameter estimates had beta values different from zero. In addition, a competitive model was the null model, supporting the single-model analysis that none of the factors examined explained turtle presence (Table 5). The maximum rescaled R-squared value for the models of tree and nesting habitat plus open water were 0.111 and 0.122, respectively, which are considered low values and thus not explaining much of the variation. The null model by definition has an adjusted R-squared (explanatory power) value of zero. These results demonstrate the lack of association of turtle occupancy and habitat characteristics as measured in this study.

Tree cover did seem to vary between sites with and without turtles. Sites without turtles observed had a mean of 55% tree cover (95% CI 35-75%) whereas sites with turtles tended to have less tree cover around the perimeter (mean 34%, 95% CI 24-45%).

These results should be viewed as exploratory and preliminary. Sites used in this study were not chosen randomly, but were selected because it was felt that turtles were likely to be present and our resources limited evaluating a large number of additional sites. Furthermore, our measurements were relatively crude, visually estimated, and turtle occupancy was not based on a per area basis, whereas the interpretation of habitat association type analyses such as we conducted here are quantified in relative terms.

Mercury Levels

A total of 25 turtles were captured at the four sites we evaluated for mercury contamination. We trapped mostly (21 of 25) painted turtles (Table 6). We recaptured only one turtle during our study, a painted turtle at Turtle Pond. All painted turtles were released at water's edge near their point of capture. Two painted turtles were captured that had notches in their carapaces in a pattern clearly indicating previous capture and marking. We recorded the locations of the notches prior to release and submitted these to ODFW and the Lower Willamette Native Turtle Working Group. The 4 red-eared sliders were taken to the Clackamas office of Oregon Department of Fish and Wildlife as required by our permits. Blood was successfully drawn from 22 turtles, including all 4 sliders. We attempted to draw blood samples from the other 3 turtles, but after several unsuccessful tries, we released the animals without collecting samples. Painted turtles (n=21 individuals) ranged from 325 to 1125 grams (X = 683, SE = 51 g), with carapace length ranging from 13.6 to 20.4 cm (X = 16.9, SE = 0.4 cm) for the painted turtles. Red-eared sliders ranged from 855 to 1925 grams (X = 1207, SE = 246 g), with carapace length ranging from 18.3 cm to 23.4 cm (X = 20.1, SE = 1.2 cm). Data on captured turtles can be found in Appendix 2.

Both species' blood contained low levels of mercury. The geometric mean of total mercury in the blood of western painted turtles (n=18) was 11.25 µg/kg wet weight, with a range of 3.28-22.89 µg/kg wet weight. Red-eared sliders had a geometric mean of total mercury in the blood of 7.91 µg/kg wet weight, with a range of 6.11-17.5 µg/kg wet weight. The smaller range in values for sliders relative to painted turtles may reflect the very small sample size. Mercury concentrations for each turtle are given in Appendix 2.

The concentrations of total mercury found in the turtle blood from this study are similar to those found in *C. picta* from uncontaminated sites in Virginia, and are an order of magnitude lower than those found in turtles from a site known to be contaminated with mercury (Bergeron et al. 2007). Although we measured only total mercury in our study, the majority of mercury in the blood of several turtle species was found to exist in the methylated form (Bergeron et al. 2007), which is the most toxic. We therefore assume that a large fraction of the total mercury we detected is also in the methylated form.

Sliders and painted turtles appear to have similar exposure to total mercury when living in the same habitat although we understand little about each species' diet and response to intra- and inter-specific competition. Both species are omnivorous, taking a wide variety of plant and animal prey (Ernst and Lovich 2009). Generally, lower concentrations of total mercury indicate a diet more dominated by herbivory than consumption of invertebrates (Bergeron et al. 2007, Green et al. 2010). The low mercury concentrations are consistent with a diet made up primarily by vegetation. Analysis of stable istopes of turtles and their primary diet would allow a more formal test of this conclusion.

Table 5. Habitat models explored using logistic regression, and their ΔAICc scores. AICc is AIC corrected for small sample sizes. Any models within two units of the model with the lowest AICc value (where the ΔAICc score equals zero) are generally considered equally well supported by the data. For an explanation of model parameters, see Table 2.

Model	**AIC**	**K**	**AICc**	**Δ AICc**
% Shoreline with Trees (Tree)	64.282	2	64.543	0
Null (no factors included in model)	65.438	1	65.523	0.980
Nesting habitat + % open water	65.853	3	66.386	1.844
Tree + Open (% shore w/grass-bare)	66.18	3	66.713	2.171
Open	67.35	2	67.611	3.068
Shrub (% shoreline with shrubs)	67.87	2	68.131	3.588
Bask05 (No. basking structures 0-5m from shore	67.896	2	68.157	3.614
Public Access (P)	67.684	3	68.217	3.675
Connected to a ditch or culvert	68.161	2	68.422	3.879
Disturbance from water (W) by boaters	69.489	3	70.022	5.480
Connected+ Bask05 + % Floating Aquatic Veg. (AqFloat)	69.51	4	70.419	5.876
Disturbance by Land Recreation (R)	69.659	4	70.568	6.025
Open + P + % Aquatic emergent veg. (AqEm)	69.320	5	70.715	6.173
R + Tree + AqEm	69.186	6	71.186	6.643
All Land Factors[1]	71.153	10	76.943	12.400
Connected + P + Type of water body	75.845	8	79.445	14.902
Connected + Bask05 + Open	75.845	8	79.445	14.902
All Human Disturbance (R+P+W)	75.924	8	79.524	14.981
All Aquatic Factors[2]	77.335	10	83.125	18.582

[1]Nestrisk+Nesting+Tree+Shrub+Open+Landother

[2]Type+Bask05+ Bask1020+ BaskLog+ BaskRock+BaskVeg+BaskOther+ConnectType1+AqEm+AqFloat

Table 6. Summary of trapping data. Numbers are for separate individuals. Only one individual was recaptured.

Site	Painted Turtles	Red-eared Sliders
Peninsula Canal	7	4
Turtle Pond	12	0
Leadbetter	1	0
Morrow Pond	1	0
Force Lake	0	0

It appears that sliders could be used as surrogates for painted turtles for mercury contamination, and likely other contaminants that biomagnify in the food web and that bioaccumulate in tissues. This pilot study demonstrates that turtles can be reliably caught and their blood sampled in the field with relatively little disturbance to the animals. However, due to our entire sample of sliders from only 1 site and consisting of only 4 animals, we are unable to evaluate the level of correlation of mercury levels between sliders and painted turtles. Because of the importance of risk assessment of contaminants in aquatic habitats of the Columbia Slough, turtles occupying these waters may be provide an important source for evaluation of receptors of contamination (see Section VIII, Conservation Planning, *Contaminants*).

Prey Sampling

We collected 10 samples from all eight sites we visited. There was a large variance in the amount of material, including sediment and vegetation, in the initial sample. In the laboratory, we subsampled most of the initial samples because of the lengthy laboratory time that would have been required to sort and identify the prey from the entire sample.

We divided each sample's biomass by the proportion analyzed to standardize values for variable effort. Biomass samples were averaged by site for comparison. There were no consistent differences between sites with high densities of turtles (Leadbetter, Peninsula Canal, Ramsey, Smith and Bybee, and Turtle Pond) and those with low densities (Morrow Pond, Whitaker Pond, and Johnson Lake). This suggests that food resources as we measured them are not responsible for the large differences in turtle densities (Figure 1), although we recognize we had few sites and limited evaluation of prey densities.

The Leadbetter samples had the lowest invertebrate biomass. Leadbetter's water level was well above normal levels, and water depths of 0.75-1.25 m overlay ground that appeared to be dry land much of the year based on the vegetation and lack of muck. This may have been responsible for the low density and diversity of invertebrates in the Leadbetter samples.

We identified 40 taxa (Appendix 3), primarily invertebrate families, in the samples we included for estimation. Sites varied widely in their taxonomic profiles (Figure 2). There are no apparent relationships between taxonomic composition and biomass. The top five taxa in terms of numbers of individuals overall were: aquatic oligochaetes ("AqOligo" in Figure 2), 32.3%; Chironomidae, 15.3%; Daphniidae, 12.3%; Cyclopoida, 8.5%, and Physidae, 5.2%. All quantities have been adjusted to account for the proportion of each prey sample that was actually analyzed.

Table 7. The number and proportion of prey samples analyzed varied by site. For example, of the five samples taken from Peninsula Canal, all of the material from two samples and one-quarter of the material from each of three samples were analyzed.

Site	Total	No.	Prop.	No.	Prop.	No.	Prop.	No.	Prop.
Leadbetter	10 of 10	10	1.00						
Peninsula Canal	5 of 10	2	1.00			3	0.25		
Ramsey wetland	5 of 10	5	1.00						
Smith and Bybee	5 of 10	3	1.00	1	0.50	1	0.25		
Turtle Pond	5 of 10			3	0.50	2	0.25		
Morrow Pond	5 of 10					5	0.25		
Whitaker Pond	5 of 10					5	0.25		
Johnson Lake	5 of 10	1	1.00	1	0.50	2	0.25	1	0.13

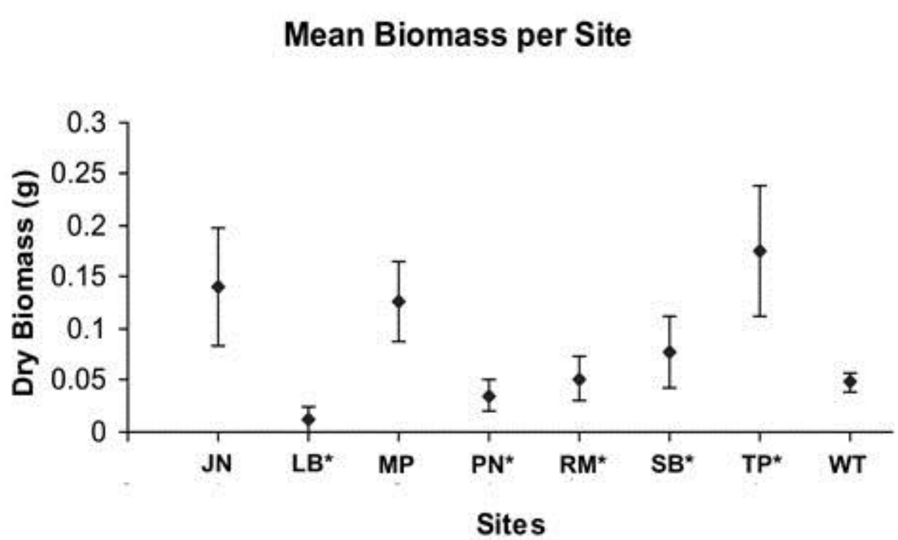
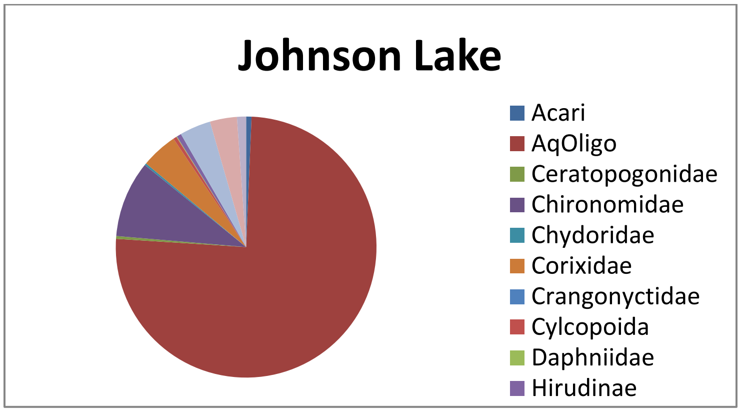
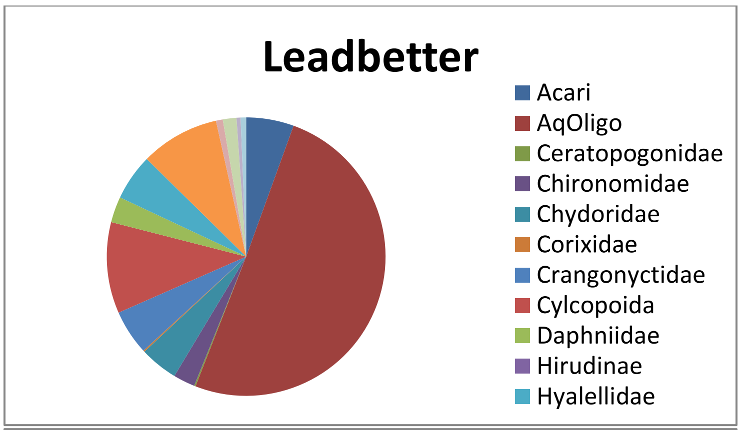
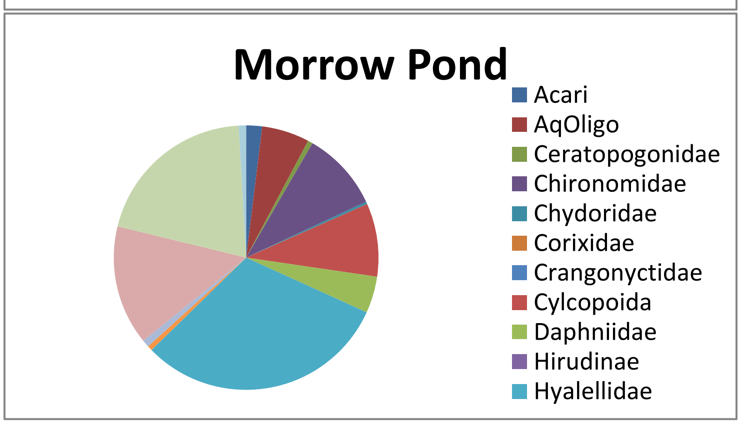


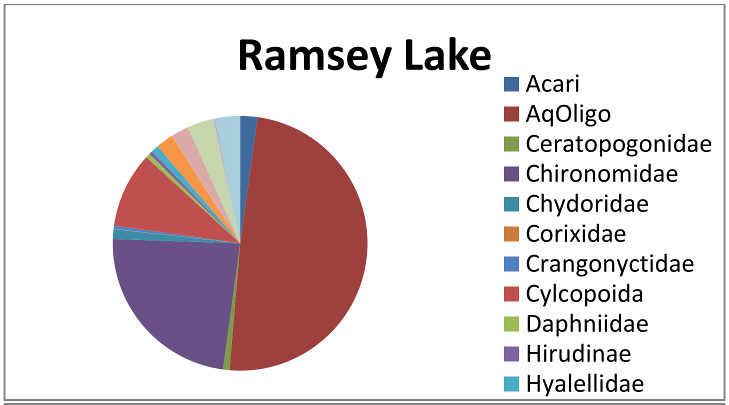
Figure 1. Comparison of mean dry biomass of prey collected at eight sites within the Portland Metro region. Error bars indicate standard deviations. Sites with asterisks (*) have large turtle populations. Sites are, left to right: Johnson Lake, Leadbetter, Morrow Pond, Peninsula Canal, Ramsey, Smith and Bybee, Turtle Pond, and Whitaker Pond.

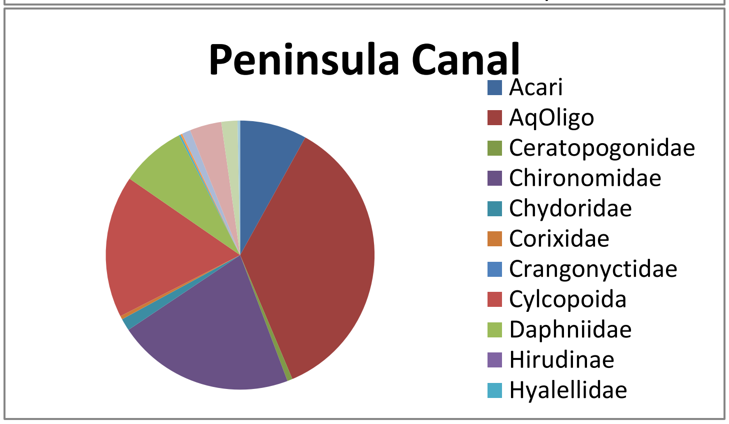
Figure 2. Most frequently observed taxa in samples from each site. Only 17 of 40 taxa are represented (see Appendix 3 for a complete taxa list). Sites with high densities of turtles were Leadbetter, Peninsula Canal, Ramsey Lake, Smith and Bybee Pond 1, and Turtle Pond at the T-5 Powerline Mitigation Site.

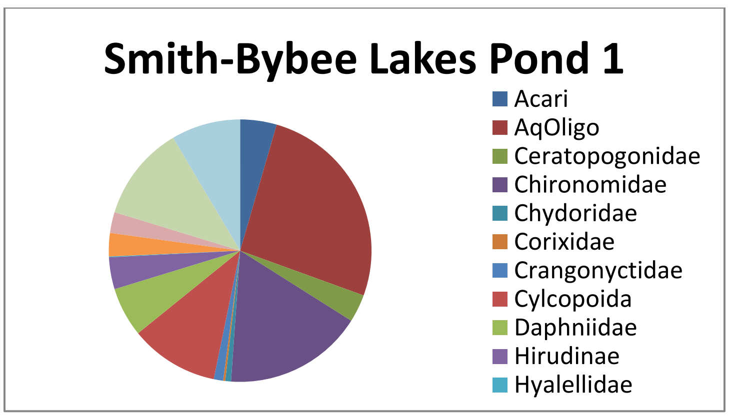


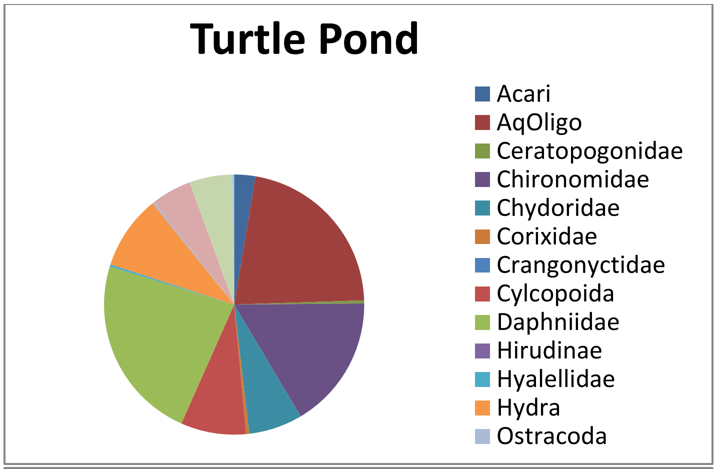


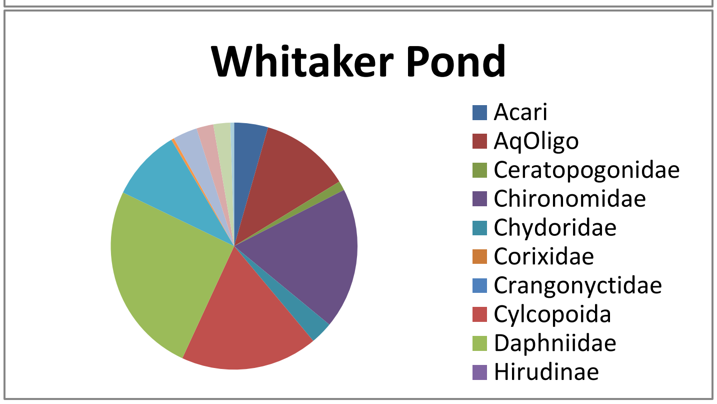



Ramsey Lake
Acari
AqOligo
Ceratopogonidae
Chironomidae
Chydoridae
Corixidae
Crangonyctidae
Cylcopoida
Daphniidae
Hirudinae
Hyalellidae


Peninsula Canal
Acari
AqOligo
Ceratopogonidae
Chironomidae
Chydoridae
Corixidae
Crangonyctidae
Cylcopoida
Daphniidae
Hirudinae
Hyalellidae


Smith-Bybee Lakes Pond 1
Acari
AqOligo
Ceratopogonidae
Chironomidae
Chydoridae
Corixidae
Crangonyctidae
Cylcopoida
Daphniidae
Hirudinae
Hyalellidae


Turtle Pond
Acari
AqOligo
Ceratopogonidae
Chironomidae
Chydoridae
Corixidae
Crangonyctidae
Cylcopoida
Daphniidae
Hirudinae
Hyalellidae
Hydra
Ostracoda


Whitaker Pond
Acari
AqOligo
Ceratopogonidae
Chironomidae
Chydoridae
Corixidae
Crangonyctidae
Cylcopoida
Daphniidae
Hirudinae

VIII. Conservation Planning

Goals and Objectives

A clear statement of population goals is essential to guide management. Although the goal of a viable population of native turtles well distributed in Portland's aquatic habitats is desired, identifying specific population targets is challenging. Population viability assessments have been recognized to be most helpful in evaluating the relative merits of different conservation strategies rather than as a prescription for population targets (Boyce 2001). We believe that even without a scientific basis for specific targets, articulating initial population targets is important if only to recognize their importance to guide management. Turtle Conservation Areas are intended to identify key landscapes for turtle conservation and assist in prioritizing habitat improvement. As an initial goal towards identifying population goals, we set a target population of 100 painted turtles in each TCA. We recognize that some TCAs already surpass this value, and several likely don't. The population objective of 100 painted turtles for each TCA is intended only as a starting point for discussion among public agencies and other organizations concerned with turtle conservation in Portland. We also recognize that age-class is an important consideration. However, because of the greater challenge in estimating actual proportions of different age-classes because of different detection probabilities, we do not include aspects of age-class as an initial conservation objective. Metrics for conservation goals other than turtle abundance should be considered given the challenge in monitoring abundance and its interpretation (see Section X, *Monitoring*).

Threats

Although the remarkable aquatic resources within Portland provide enormous potential for a large turtle population, their location within a major urban center also contributes to a broad array of threats. The conservation assessments conducted for western painted turtles (Gervais et al. 2009) and western pond turtles (Rosenberg et al. 2009) in Oregon highlight many of the threats that are relevant in Portland. We summarize the key threats identified in those reports, and expand upon threats we think are most important to consider for conservation of native turtles in the Portland metropolitan region, and specific to each Turtle Conservation Area. We then relate the threats to the hypothesized mechanisms whereby threats can lead to declines in population numbers and ultimately viability. Finally, we rank threats for each of the sites included in the turtle surveys, and discuss management approaches for alleviating threats. We relied on both published and unpublished literature, our own observations, personal communications with biologists and others working in the field, and data on intake of turtles into the Audubon Society of Portland's Wildlife Care Center, a state and federal licensed wildlife rehabilitation facility.

Loss of Habitat

Loss of habitat was identified as one of the key threats to native turtle conservation in ODFW's Conservation Strategy (ODFW 2006). There have been enormous changes to aquatic and adjacent terrestrial habitat since urbanization and flood control began in the Portland region. These changes have primarily affected aquatic species that relied on small channels and lentic habitats such as those occupied by both the painted and pond turtles. Although many aquatic areas are now protected from development, there are numerous sites that are still being developed in upland areas adjacent to wetlands that are important for turtle nesting and movement.

Other forms of loss of habitat, both in terms of area or quality, is equally important, and can occur through many of the pathways described for the other threats listed below. Both aquatic and nest habitat is lost or reduced in quality through changes in water quality, reduction of deeper pools through sedimentation, and changes in the quantity and composition of aquatic and terrestrial vegetation that can affect habitat quality especially for hatchlings and for nest success. In particular, loss of nest areas from invasive plants such as Himalayan blackberry (*Rubus armeniacus*, previously *R. discolor*) and reed canary grass (*Phalaris arundinace*a) that limit solar exposure in nesting areas is a major threat, though one that can be managed. Despite the good intentions of riparian restoration efforts and the benefits restoration provides, habitat will be degraded for native turtles if shrubs and trees are planted without leaving sufficient exposed areas for nesting and basking turtles. Furthermore, the loss of basking structures, either from removal or other causes, can result in degradation of habitat. These forms of habitat loss are at least as equally important to turtles as loss of habitats through development in the heavily urbanized and industrialized areas of Portland.

Sedimentation and Dredging

Although sedimentation and dredging are usually not commonly identified as a threat to turtles, we believe sedimentation in particular is potentially a major issue for turtles in the Columbia Slough watershed. Sedimentation may be the most limiting factor for increasing population size in Portland because sedimentation causes a loss of the deep-water pool habitat and may make development of brood habitat difficult. Deep pools are used for overwintering and may be a key limiting factor in some Portland areas (Hayes et al. 2002) if terrestrial habitat is not used for overwintering (see Section IV, *Natural History of Native Turtles in Portland*). Based on the limited research available (reviewed in Gervais et al. 2009, Rosenberg et al. 2009), deep pools are important during spring and summer as well, particularly as water levels drop in late summer. Most of the aquatic habitat occupied by turtles in this region is connected with the Columbia Slough which has very high sedimentation rates (D. Hendricks, MCDD, pers. commun., Nov. 2011).

Sedimentation occurs at such a high rate that the removal and manipulation of sediments is an important maintenance (and thus safety) issue for Multnomah County Drainage District (D. Hendricks, Multnomah County Drainage District, pers. commun., Nov. 2011). The related management activity to reduce sediments is dredging, which poses potential hazards that can be minimized by timing activities. In addition to dredging in channels managed by MCDD, the City of Portland (Bureau of Environmental Services) removes sediment from stormwater ponds that are occupied by turtles.

Many of the aquatic habitats in and near the Columbia Slough are less than 3 feet deep (D. Hendricks, pers. commun., Nov. 2011), which is shallower than the desired 5-6 foot depths for overwintering (Hayes et al. 2002).

Elevated Predator and Herbivore Numbers

One of the most-cited threats to native turtles throughout their range is the lack of juvenile recruitment due to elevated nest and hatchling predation. In Portland, introduced common carp (*Cyprinus carpio*) have raised concerns over potential competition for food resources and disturbance to sediments which increase turbidity.

Nest predation—Although high nest predation rates are a typical feature of the life-history of freshwater turtles (Ernst and Lovich 2009), elevated rates are often reported to be greatest in developed areas because of greater abundance of raccoons, skunks, and other medium-sized predators than would have been present historically (Rosenberg et al. 2009). Despite the concern and the number of management programs directed toward protecting nests, there has been little quantification of nest predation, and in particular, what level of predation is sustainable given the species' life-history strategy. This is important to understand to be able to allocate limited conservation funding wisely. Population models may be useful to evaluate at what point cause for concern is justified and under what circumstances nest protection may be a useful management tool. Although there have been some efforts to monitor nest success, we believe the most efficient way to gain reliable information of the effects of nest and hatchling predation and the effects of various management approaches is by a hypothesis-driven research approach using experimentation when possible *(*see Section X, *Research).*

Hatchling predation—Non-native aquatic and semi-aquatic species have been thought to contribute to population declines of native turtles in Oregon and elsewhere via heavy predation of hatchlings. In particular, there is a belief that bullfrogs (*Rana catesbeiana*) and both smallmouth and largemouth bass (*Micropterus dolomieu* and *M. salmoides, respectively*) are important predators of hatchling turtles and responsible for a lack of recruitment (see Rosenberg et al. 2009). This viewpoint has little supporting evidence, and was largely initiated through speculation in an early report of pond turtles in Oregon by Holland (1994). Despite a long list of citations of this work in numerous unpublished reports, the evidence for bullfrogs and bass impacting populations of turtles is lacking, and evidence to the contrary is much stronger. Experimental studies of painted turtles and largemouth bass indicate behavioral responses to predation by hatchlings results in low predation rates (Britson and Gutzke 1993). Although environmental conditions in which painted turtles, bull frogs, and largemouth bass coexist in the eastern portion of the turtle's range is different from that which occurs in Portland, the co-existence of bullfrogs, bass, and painted turtles in the sympatric portion of their native range provides further evidence against the hypothesis of population-level impacts. In Oregon, both painted and pond turtles are common in aquatic habitat that is shared by bullfrogs (Hayes et al. 2002, Gervais et al. 2009, Rosenberg et al. 2009), including populations that have a large number of younger age-classes (D. Rosenberg, pers. obs.). Based on the available evidence, the existence of bass and/or bullfrogs in aquatic habitat should not necessitate a different management approach nor be viewed as negative criteria in choosing restoration projects for native turtles in Portland.

Common carp impacts— Carp are perceived by many as a threat to native turtles in Portland because of their well-documented voracious appetite for and mechanical damage to aquatic plants that are needed to provide food and cover for native turtles, especially hatchlings. They are also considered a threat due to the disturbance of sediments as a result of foraging behavior which has been shown to increase turbidity and result in reduced growth of aquatic macrophytes (reviewed in Lougheed et al. 1998). Carp activity has been shown experimentally to increase sediment resuspension (Lougheed et al. 1998). Both Hays et al. (1999) and Hayes et al. (2002) argued that carp alter both aquatic vegetation and sediments in ways that would be detrimental to turtles. However, recent research demonstrating that turbidity levels did not affect foraging efficiency of painted turtles (Grosse et al. 2010) and that exclusion of carp by itself did not strongly affect macrophyte density (Lockheed et al. 1998) suggests that carp may not affect turtles as clearly as suggested by Hays et al. (1999) and Hayes et al. (2002). Carp are present at sites that have very large turtle populations in Portland, such as Smith and Bybee Wetlands Natural Area, Ramsey Lakes, and Peninsula Canal. Therefore, carp may not greatly impact native turtle populations. These diverse findings suggest that carp may negatively affect turtle abundance in some aquatic environments in Portland, but that they are not, by themselves, a major threat: context matters as the co-existence of carp and turtles in Portland demonstrate.

Carp probably occupy most, if not all, of the aquatic areas connected with the Columbia Slough at high water. A notable exception of where carp may not have invaded areas occupied by turtles in Portland are the ponds in the Big Four Corners Natural Area (D. Helzer, City of Portland, pers. commun., March 2012). Because eradicating or even controlling carp at the sites near or within the Columbia Slough system will be very difficult, management for co-existence will likely be more realistic and successful. Although sites without carp should be favored for restoration, all else being equal, considering sites with carp as unsuitable for turtle conservation is unwarranted given current understanding. However, if a restoration site currently lacks aquatic connectivity, deliberately adding connectivity may not be advisable. For example, the City of Portland decided to maintain the lack of aquatic connectivity between the ponds in the Big Four Corners Natural Area with the Columbia Slough during restoration efforts (D. Helzer, City of Portland, pers. comm., March 2012). If barriers to carp also result in restricting movements of turtles, then further consideration of options may be necessary.

Traffic & Roads—Roads affect turtle populations in the obvious way of direct mortality, indirectly by reducing connectivity among occupied habitats, and by creating a barrier to upland areas for nesting or hibernation. In Portland, the most likely effects are direct mortality, although we are not aware of any quantitative studies on the numbers killed or the resulting population effects within the region. In general, population viability is most sensitive to survival rates of adult animals for long-lived species. Except for the few extensive wetlands, almost all of the sites harboring turtles in Portland are near roads. For these reasons, road mortality is potentially a critical threat and one that affects both the local distribution of turtles and the population dynamics throughout the metropolitan region. This concern is well-supported in the literature. Road mortality is considered an important cause of decline in some species and populations (Fowle 1996, Griffin 2005, Steen et al. 2006, Andrews et al. 2008). Case studies also demonstrate that the mortality rate can be exceptionally high in some areas. In Florida, 343 turtles were killed on a half-mile stretch of highway separating two water bodies in just 10 weeks (Aresco 2005a). Females are likely more at risk due to greater terrestrial activity (Steen and Gibbs 2004, Aresco 2005b,Gibbs and Steen 2005, Steen et al. 2006). This would likely have greater effects on population viability because viability is particularly sensitive to mortality rates of females with non-monogamous mating systems, as is the case with turtles.

Although it is difficult to quantify the magnitude of mortality because of limited data, several lines of evidence suggest that at least in some areas, direct mortality may be great. During the most intensive study of movements of turtles in the Portland metropolitan area, Hayes et al. (2002:132) reported finding one adult female painted turtle killed by a car during the study of 14 adult females that were tracked via radio transmitters. The Audubon Society of Portland's log of intake of turtles at their wildlife care facility since 1990 provides further evidence of deaths of painted turtles. Of 50 intakes of turtles, largely in the Portland metropolitan area, Audubon reported 13 incidents of being hit by a vehicle. Although the average of just over 1 per year is by itself not a concern to the viability of the turtle population, we view these numbers as a very small proportion of the actual deaths due to traffic, partly because few incidents are ever reported and because turtles that died would not be brought to the care facility. There is no question that the incidence of traffic mortality is site specific and is greater in area with greater traffic near their aquatic and nest habitat. For the purposes of this Conservation Plan, we assume road mortality is an important threat for conservation of turtles in the Portland metropolitan region. We believe the potential for traffic mortality at a given site is an important criterion for prioritizing restoration work to benefit turtles.

Collection and Release

Collection—Collecting turtles as pets and harvesting them for meat have led to the decline of many freshwater turtles worldwide (Moll and Moll 2000, Ernst and Lovich 2009). The extent of recent collecting of turtles in the Portland metropolitan area as pets and for meat is unknown. Collection of turtles in Oregon, despite laws against all collecting or trade, does still occur (S. Barnes, ODFW, pers. commun., June 2012). Although there is no legal harvest in Oregon, a market exists for turtles as pets as demonstrated elsewhere by Gamble and Simons (2004).

Release— Release of both native and non-native pet turtles into Portland's waterways represents a potentially major threat to wild turtles. Although there is no direct evidence of the magnitude of the effects, we believe the potential for widespread negative effects is great given (1) the frequency of release (see below), (2) the unknown pathogens that may now or in the future be released from pet to native turtles, and (3) the unknown effects of how non-native turtles that become established interact with native turtles. Release of pet turtles has likely increased due to sales of turtles via the internet and lack of animal shipping regulations and enforcement (S. Barnes, ODFW, pers. commun., June 2012). The risks occur through increased competition for limited resources, the potential for disease transmission, and genetic swamping of local gene pools. Although only the red-eared slider and common snapping turtle are established as self-sustaining populations in the Portland metropolitan region, many other species have been introduced into Oregon waterways (Rosenberg et al. 2009). It is very difficult to predict which species will become invasive or spread diseases, and therefore, the release of pet turtles remains an important threat, particularly in urban centers, such as Portland. We do not believe that the current distribution of native turtles is strongly affected by non-native species, although their abundance is likely negatively affected to some degree.

Although it is common to assume introduction of pet (or translocated) turtles is a recent phenomenon, Storer (1930, 1937) suggested western pond turtles may have been introduced into some northern localities. Evenden (1948) further elaborated on the frequent tendency of releases, and even suggested that the few populations of western pond turtles observed in Washington resulted from translocated individuals, a view that is not now held (e.g., Hays et al. 1999).

Although not broadly distributed in Oregon, reports of common snapping turtles in Oregon have been increasing (Barnes 2009), probably due to both an increase in public education efforts and an expanding common snapping turtle population. Snapping turtles are established in various waterways within the Willamette Valley (Barnes 2009). In Portland, they have been observed in the Columbia River, Johnson Creek, and parts of the Columbia Slough side channels (S. Barnes, ODFW, June 2012), including Peninsula Canal (this study).

Red-eared sliders are extremely common in the Willamette Basin particularly near urban areas such as Portland, where they are particularly numerous (NERI 2009, Rosenberg et al. 2009, Appendix 1). Sliders often co-occur with western pond and painted turtles outside of the sliders' native range (Spinks et al. 2003, Rombough 2007, Bury 2008,

Appendix 1). Importantly, red-eared sliders and painted turtles co-occur in a portion of their native range. Understanding the mechanisms of co-occurrence for these two species that seem to have high overlap in their use of resources will be critical to finding management approaches to promote native painted turtles over red-eared sliders in the Portland metropolitan region.

An important and increasing threat is the loss of genetic integrity because of release of pet painted turtles from non-native stock. This issue is often given less attention than that of introduced species. Although native to the northern portion of Oregon, painted turtles have been introduced into Oregon from unknown source stock. The source stock likely included both Oregon and non-Oregon individuals. Painted turtles are now nesting as far south as the Rogue River in Oregon, where they have been reported since 1984 (Black and Black 1987). As Gervais et al. (2009) noted, the genetic integrity of naturally occurring western painted turtles is likely compromised by the introduction of previously captive turtles which may consist of other subspecies. This remains a threat in the Portland region.

Disease--A growing threat particularly in urban areas is disease transmission from turtles released by pet owners to wild populations (see *Disease,* below*)*. Many of the red-eared sliders received by ODFW, including both pet turtles and those captured in aquatic habitats, suffer from visible eye infections, shell rot, and lethargy (S. Barnes, ODFW, pers. commun., June 2012).

Relocation—Well-meaning members of the public may sometimes interfere with a turtle they find away from water. Although terrestrial movements are typically associated with nesting or overwintering, or movements between ponds, it is common for citizens to believe the turtles are "lost" and in need of help. ODFW biologists are often contacted by the public, most often during the nesting season, over concern for a turtle they find on land (S. Barnes, ODFW, pers. commun., 2009). In other cases, the turtle may be brought to the Portland Audubon's Wildlife Care Center. Based on 50 intake records of turtles at Portland Audubon since 1990, nine were reported as "human interference" and likely represent the well-intentioned but unnecessary and harmful displacement of the "lost" turtle. The ODFW Citizen Science database also includes reports of people moving turtles from land to water when encountered on trails, for example, at Smith and Bybee Wetlands Natural Area (ODFW, unpubl. data). Education efforts near turtle sites could alert the public to the terrestrial movements of turtles and likely reduce these well-intentioned relocations or removals.

Recreation Disturbance

Human disturbance to wildlife frequently occurs in urban settings, where natural areas are sought out by large numbers of recreationists. This is particularly true for aquatic habitats that attract a broad array of activities including dog walking, hiking, or bird watching along trails adjacent to water bodies, fishing, and kayaking. Disturbance by recreation is an important threat in the Portland metropolitan region, but one that can be managed. Recreation can negatively impact turtles (Garber and Burger 1995, Mitchell and Klemens 2000). Turtles are most sensitive to human disturbance when basking and nesting through disruptions of these essential life functions (Moll 1973, Mitchell and Klemens 2000). Disturbance during basking is more common, and when frequent, will cause important disruptions to the important physiological functions of basking. Disturbance during nesting is critical in specific areas. Any activity by people or pets within line-of-sight to turtles can cause disturbance. As has been demonstrated with many animals, and with turtles in particular (Leuteritz and Manson 1996), animals become tolerant in more frequently disturbed areas. It is obviously important to recognize threshold disturbance levels that will result in long-term effects including abandoning sites. Because of trails that are proposed in some key turtle areas (e.g., Peninsula Canal), early planning and avoidance of impacts is essential.

Fishing—Bait fishing (e.g., using worms or other natural material) is an important threat because of the sensitivity of population viability to changes in adult survival rates, the age class most likely vulnerable to bait fishing. Turtles have been captured and harmed when fishing with bait (Croghan 1983, Holland 1991, Hays et al. 1999, Hayes et al. 2002), including 2 of 50 intake records of turtles at the Portland Audubon Wildlife Care Center. Because fishing is regulated by the Oregon Administrative Rules, changes for specific waterways will require ODFW involvement and approval by the Oregon Fish and Wildlife Commission, ODFW's rule-making body.

Boating—Recreational boating, including motorized and non-motorized craft, will likely affect turtles if boats (or their wake) frequently interrupt basking. The frequency of this disturbance could potentially be managed through regulation, location of basking structures, and education. The threshold distance between a boat/recreationist and the basking turtle to avoid disturbance is not well established. The familiarity of individual turtles to the type of disturbance is likely an important factor. Evaluation of the threshold distance could be accomplished through experimental studies in local water bodies that harbor both turtles and boaters (see Section X, *Research*).

Hiking/Dog Walking--Trail use by humans and their dogs poses another recreational threat, both through passive disturbance and attempted predation by off-leash dogs. Trails often are placed adjacent to water bodies, and thus are potentially a threat to disturbance to basking and nesting turtles. Direct mortality has been observed between dogs and turtles. Audubon intake records since 1990 reported harm or death to 3 out of 50 turtles. Although this is a low number given the total number of years, these incidents surely represent only a small proportion of dog-turtle incidents.

Isolation and Fragmentation

Isolation and subsequent fragmentation of populations is a threat particularly relevant to turtles living in urban centers where connectivity could easily be diminished. Although both painted and pond turtles are able to move through watercourses and on land, their movements may be limited by roads and lack of passable culverts or ditches. The level of isolation is likely very site specific with some areas experiencing severe limitations and others none at all. We were not able to find research that provides management guidance regarding culverts or other methods to increase connectivity other than underpasses, such as what Port of Portland constructed in north Portland (Gervais et al. 2009: Case Study). An important consideration, however, is whether or not increased connectivity is of conservation value in areas where non-native turtles may expand into new areas via the increased connectivity (*sensu* Fausch et al. 2009). This is probably a moot point, however, because of the widespread distribution of non-native turtles in the Portland metropolitan area and the easy access by the public to numerous areas where turtles could be released.

Research/Survey Disturbance

Perhaps because biologists are so occupied with identifying external threats to biological diversity, we tend to ignore the impacts on wildlife from our own research and management activities. Although negative effects arising from survey, research, and management may be minimal in any particular situation, the effects may be important over time. We highlight this issue as a threat in the Portland metropolitan region because of the great interest in turtle populations, the limited number of sites with large populations, and the easy access to these sites by a large number of individuals engaged in research, survey, and management. Much of the work on turtles in Oregon, including the Portland metropolitan region, have not been documented through reports or publications so the potential long-term harassment to the turtles at these sites may not even be realized.

Illegal Shooting

In some areas, there have been reports of native turtles in Oregon being shot illegally (Elling 1966, Croghan 1983). How frequently this occurs is unknown, but given the information available it is not likely to be an important threat within Portland metropolitan region. Discharge of firearms is illegal within city limits of Portland.

Stream Restoration & Vegetation Succession

Planting of shrubs and trees, and the succession from forbs and grass to shrubs and trees in some areas represents a threat to turtle populations in Portland. Because of the recent emphasis on stream restoration to reduce water temperatures in response to state Department of Environmental Quality standards, tree planting has become the primary restoration tool adjacent to aquatic habitats, and is currently planned along many waterways. When tree cover is sufficiently extensive in aquatic and nest habitats, habitat quality for turtles may be diminished. Identifying the extent of solar exposure that is necessary at a given site, even as a first approximation, will be important for those doing restoration work to promote turtle conservation.

Contaminants

Turtles, both native and non-native species, live in many aquatic environments with high contaminant levels. Unfortunately, Portland provides an excellent example of this because of the concentration of turtles in some areas of the Columbia Slough that have historically been highly polluted, and many remain so today (City of Portland 2009). There have been few reports of contaminant effects in turtles (Sparling et al. 2010). For western pond turtles, the only study we are aware of was conducted on eggs in the Willamette Basin near Eugene, OR (Henny et al. 2003). A large number of contaminants were found in the eggs, including organochlorines, PCBs, and metals; however, the researchers did not detect a relationship between egg hatchability and contaminant levels.

Indirect effects are likely to occur from broad-scale insecticides used in aquatic habitats to reduce mosquito larvae and from herbicides used to control aquatic vegetation. Repeated applications may have effects on turtle populations. The indirect effects to turtles are through reduced invertebrate prey populations and reduced cover. Application of herbicides to reduce aquatic vegetation is usually conducted in Portland for drain management (D. Hendricks, MCDD, pers. commun., November 2011). Identifying areas to reduce herbicide use that are most important for turtle conservation and least disruptive to drain water management will be imperative in order to minimize this threat. However, it is possible that removal of extremely dense mats of vegetation could be beneficial to turtles in very eutrophic environments to increase oxygen availability; this remains an important and relevant research question for turtle conservation in Portland.

Another threat exists from the potential of contaminant spills on roadways adjacent to aquatic habitats. This has occurred in Oregon and California in several well known cases that killed native turtles (Rosenberg et al. 2009), and likely has occurred more often than these few reports suggest.

We are unaware of research on the effects of de-icing chemicals from Portland International Airport after their entry into the Columbia Slough, but this remains a potential threat. However, Port of Portland has made recent improvements to treating runoff containing de-icing chemicals prior to discharge into water bodies (http://www.portofportland.com/PDX_Deicing_Home.aspx).

Because of the large number of remedial investigation in the Columbia Slough area that include a risk assessment phase, western painted turtles may be an excellent candidate for evaluation as a receptor (E. Stewart, Metro, pers. commun., June 2012) and thus could part of risk assessments. How well turtles can serve as model organisms for contaminant risk assessment deserves further consideration.

Disease

Despite the concern over the introduction of disease to native turtle populations via release of pet turtles, there have been few studies on disease in freshwater turtles (Flanagan 2000). We are aware of only two reports on disease outbreaks in Oregon and Washington. Hays et al. (1999) reported an outbreak on what may have been a pathogen causing a syndrome similar to upper respiratory disease, and Todd (1999) reported on an unknown disease that potentially killed 24 turtles. The releases of pet turtles, trapping, handling, relocation, and moving of potentially contaminated material (such as traps) from one population to another are likely to increase the risk of disease transmission. This is another reason for minimizing handling of native turtles (see above, *Research/Survey Disturbance*). When turtles are handled, or their habitats are entered, established protocols should be followed to minimize disease transmission by sterilizing equipment, including field gear worn by workers.

Of 50 turtles brought into Portland Audubon since 1990, the reason for 3 intakes was listed as “Disease”, with one of these indicating pneumonia and the other 2 as unknown disease.

Climate Change

There is no question that climate change will affect the distribution of freshwater turtles, a group that is very sensitive to ambient temperatures and hydrological conditions. We believe the distribution of the range-limited western pond turtle is more likely to be affected than the much more wide-ranging painted turtle in response to climate change. However, because we do not understand the mechanisms that have affected these species’ range limits, it is impossible to make reliable predictions on the nature of the change, particularly at a local or regional scale. The direct and indirect effects of climate change on freshwater turtles are important to consider even though predictions of effects are in their infancy (Ernst and Lovich 2009:27). Consideration of predicted changes in precipitation patterns could be considered in planning by adding additional safety nets, such as by including deeper pools to mitigate against earlier drying of wetlands and other aquatic habitats.

Conceptual Models of Turtle Response to Threats

We identified seven direct threats that we believe have sufficient concern to address in the Conservation Plan. These are all threats that could be addressed by management actions at the spatial scale of Portland. Those threats include, traffic, sedimentation, release of pet turtles, removal of native wild turtles, elevated predation and herbivory, recreation, and vegetation succession.

We did not include habitat loss from development. Although development will often have negative effects, it is beyond the scope of this Plan to address this issue for each site. Effects of habitat loss will be very site specific and evaluating how it will affect wildlife will require specific details on the nature of the development.

In Appendix 4, we discuss each of these threats, stressors, and pathways, and then evaluate each of the threats in a management context for each site and designated Turtle Conservation Area.

Ranking of Threats

Here, we provide relative ranks of the threats that we generalized for the sites with turtles that we evaluated (Table 8), provide the basis for the ranking, and outline ways threats can be mitigated. We then provide an evaluation of threats for each of the sites included in our field work (Appendix 5) and Turtle Conservation Areas (see Section VIII, Turtle Conservation Areas). We recognize that the rankings are subjective, although they are informed through literature review, discussions with agency biologists and others, and our field visits. This ranking provides a context for further discussion and future revisions of this Conservation Plan as better understandings of threats develop. We ranked threats such that the higher the value, the greater the relative threat (Table 8).

Table 8. Relative ranking of perceived threats to turtle conservation, generalized over all Portland sites. Relative ranking of threats vary considerably by site. Lower values are considered the greater threat. Because of the lack of data on the impact of threats on turtles, these rankings should be considered tentative. *Table 8 is continued on next page.*

Threat	**Rank**	**Basis**
Release of Turtles	1	Because of the prevalence of releasing pet turtles, and the potential for disease transmission that could affect a large portion of the turtle population, disease ranks as an important threat to turtle conservation. Competition and increased predation of hatchings from release of non-native species is also an important threat.
Sedimentation & Dredging	2	Evidence suggests complex depth profiles with deep pools is key to occupancy and abundance. Given the large sediment loads in the Columbia Slough, and the shallow water of most of the waterways connected by the Slough, sedimentation deserves to be considered a large threat until shown otherwise. We believe dredging is a relatively small threat that can be minimized by attention to methods and timing at sensitive areas.
Traffic	3	Population viability for turtles is particularly sensitive to mortality of adult females. Females are particularly vulnerable in many of the sites turtles occupy in Portland. This threat is also one of the most difficult to reduce through management.
Recreation	4	We based this relatively low ranking because, by its nature, recreation has site-specific effects. We believe there are few sites where turtles occur in Portland and are heavily impacted by recreation. However, we do believe it is an important threat at some sites, and that effects can be reduced through management and education. The two sites with the highest number of turtles, Smith & Bybee wetlands and Peninsular Canal, have high recreational use or a planned trail, respectively, that could have strong negative effects on the turtle population. With further evaluation, this threat could be one of the greatest, although it can be moderated through regulations and management.
Vegetation Succession	5	Although for some sites this is not a threat because of regular management, in many areas natural succession will lead to dense shrubs and trees, reducing areas where turtles can successfully nest and potentially bask. Furthermore, restoration efforts that favor tree planting may limit potential nest areas. Succession that limits nest areas is apparent in many of the sites we observed with turtles.
Elevated Predation/Herbivory	6	We believe elevated predation to an extent that it negatively affects the population dynamics of turtles in Portland is likely a localized phenomenon, and not an important threat to the viability of Portland's turtle population. Predation on hatchlings by bullfrogs and bass is largely unsupported by the available evidence, and we do not consider the occurrence of these non-native species as a general threat. Similarly, there is little evidence that carp affects turtle abundance in most cases.

Removal of Native Turtles	7	Removal of native turtles does not seem to be a very large threat, primarily because it is likely to be site specific and affect the younger age classes. Population viability should be least sensitive to removal of younger age classes. This relative threat level should be updated if more information reveals removals are widespread. The removal of turtles as meat would entail larger age classes and would be an important threat if it occurs frequently. Evaluating the level and location of removal of adults is an important research need in Portland.

Minimizing Impacts of Threats

Most important to a conservation plan is not the identification of threats, but minimizing their effects through management actions and education to increase awareness. Here we describe general approaches to reducing threats.

Release of Turtles

Because the release of turtles largely results from citizens believing they are doing the "right thing" by finding a "natural" home for their pet turtle, we believe education and "adoption centers" are the only solutions. For example, a program such as a "Pet Amnesty Day" where non-native turtles can be relinquished to ODFW may be effective, as demonstrated in Florida (S. Barnes, ODFW, pers. commun., June 2012). Although releasing pet turtles is illegal under state regulations, the public is likely unaware of the law and has likely not been a sufficient deterrent. However, a continued effort by ODFW to ensure that pet stores, and to the extent possible, web-based retail and wholesale distributors adhere to the law is important to restrict the supply of turtles entering the pet trade in Oregon. Further educational efforts for would-be-buyers at pet stores, including on-line retailers, should be encouraged. Outreach efforts, both via signage and volunteer educators, at the sites most likely to attract releases of pet turtles are important. Research on the extent and nature of releases of pet turtles, and an evaluation of effectiveness of education efforts, should be a priority and is within the realm of possible research efforts that could be conducted through small grants in Portland (see Section X, *Research*). We believe this sort of research is likely to have greater conservation value than studies on the species ecology in Portland or the current emphasis on survey and monitoring work.

Sedimentation and Dredging

To address the threat of sedimentation, we first recommend evaluating water depths in selected sites (see Section IX, *Buffalo Slough East End*). If the water depth profile is not sufficiently complex, including areas with depths of at least 5 feet, we recommend an adaptive management effort to increase the depth profile and evaluate the effect on patterns of turtle use of these sites. Specifically, in water bodies that are managed by Multnomah County Drainage District (MCDD), it will be imperative to collaborate and seek approval from them prior to evaluating or designing changes bathymetry. MCDD has already been conducting "channel and benching" activities that can accomplish some of these goal. If this type of drain management can be done in partnership with agencies managing sites to include turtle conservation, the threat of habitat loss from sedimentation could be enormously reduced.

Because we were not able to evaluate water depths during our study, we relied on assessments of depths by various agencies. In most cases, we were not able to obtain data on water depths. Before actual work is done to modify depths and complexity, a thorough evaluation of depths at selected sites is needed. Furthermore, our ranking of sedimentation and the concerns of lack of depth complexity should be considered a hypothesis, and further work needs to be done to evaluate how well depth modification does improve aquatic conditions for native turtles. We recommend an adaptive management approach, beginning with the eastern end of Buffalo Slough adjacent to the Port of Portland mitigation site (see Section IX, *Buffalo Slough East End*).

We believe dredging is largely an important positive tool for increasing water depths. However, care must be taken to assure that removal of turtles (including direct harm) and placement of sediments elsewhere does not inadvertently include overwintering turtles. By dredging outside of the November to February overwinter season should minimize harm. This is particularly important in key areas for turtle conservation. Because of the need for clear guidance to MCDD whose primary responsibility is flood control, we suggest that Best Management Practices are developed for conducting dredging in a manner to minimize negative impacts to turtles.

Whitaker Ponds Natural Area is a good example of efforts to maintain sufficiently high water depths for turtle conservation. The Bureau of Environmental Services (City of Portland) worked with Portland Parks and Recreation and MCDD to set a new invert elevation that would retain 4 feet of perennial water (D. Helzer, City of Portland, pers. commun., June 2012). With this new elevation, flood management and efforts for turtle conservation were achieved; evaluating the response by turtles will be informative.

Traffic

The number of turtles that die from motor vehicles is difficult to quantify with existing data. Furthermore, traffic mortality is the most difficult threat to reduce via management or education. Our approach in this Conservation Plan is to promote conservation of turtles in areas less prone to traffic mortality (i.e., avoid attracting turtles to areas with potentially high traffic mortality) and to minimize the distance turtles move on land by encouraging nest and over-winter habitat to be managed near their primary aquatic habitat. There have been some extraordinary efforts to minimize traffic mortality by Port of Portland by their construction of an underpass (see Case Studies, Gervais et al. 2009) and barriers to encourage its use. Such approaches can reduce mortality, but their construction is expensive and not likely to be considered in most cases. Similarly, constructing barriers (Gervais et al. 2009, Case Study) or temporary fencing (Aresco 2005b) to restrict movement onto roadways is another method to reduce road mortality at sites near heavy traffic and near nest areas. A good example of this is the planned construction of barriers adjacent to Airport Way that is part of the Mason Flats Wetland

Enhancement project at the Big Four Corners Natural Area (D. Helzer, City of Portland, pers. commun., March 2012).

Recreation

Although modifying human behavior is always challenging, we believe there are many opportunities to reduce the impacts of recreation on turtle populations. This is particularly true given that the seasons and time of day when turtles are most vulnerable is well-known (see Section IV, Life History Cycle).

Fishing—At sites where fishing may impact turtle populations, we recommend the placement of educational displays on how to minimize harming turtles if captured and noting the use of lures instead of bait to avoid or minimize capture. For the most sensitive sites, we recommend the public agency overseeing the management of the water body to work with ODFW to change regulations to restrict bait fishing. In some cases, use of vegetation to discourage bank fishing at sensitive areas may be beneficial.

Boating—The impacts of boating are likely to be very site-specific and the impacts are primarily through disturbance to basking. Because disturbance to basking is the key pathway of harm (Appendix 4), turtles are most sensitive to boating disturbance during early spring activity (April through June). We recommend the following course of actions:

1) Conduct experimental research on distance thresholds with different frequencies of recreational boating. Use the results of this research to guide educational efforts to boaters.

2) Place additional basking structures in areas that are least sensitive to disturbance by boaters (and trail users, see below). Work with MCDD for placement of basking structures within waterways they manage.

3) At key sites, post educational displays to inform boaters of recommendations to avoid disturbing turtles.

4) Work with partner organizations that have regular contact with boaters at key sites (e.g., Columbia Slough Watershed Council) to further educational efforts and identify key areas for minimizing disturbance through placement of basking structures.

5) Encourage/require boating be re-directed to locations where fewer impacts occur.

Trail Use/Dog Walk—Similar to the other recreational impacts, the intensity of disturbance to turtles from use of trails will be very site specific. We envision four approaches to minimize disturbance at sites that are particularly sensitive: 1) avoid the impacts by locating trails away from important turtle habitat; 2) restrict use of or move trails, at appropriate times of the year, that are located in likely turtle nest areas; 3) placement of visual barriers, such as shrubs, where hikers or their dogs are likely to have line-of-sight contact with basking or nesting turtles; 4) placement of basking structures that minimize line-of-sight contact, and, and 5) require dogs to be on-leash in nesting areas if restricting the area as off-limits is not possible.

Displaying educational/Informational signage at sensitive sites specific to turtles and the reason for the restrictions should be considered.

Vegetation Succession

Retaining open areas is key for attracting nesting turtles and ultimately for nest success. Vegetation management is a critical part of maintaining a site's habitat suitability for turtles especially when the goal is to minimize terrestrial movements because of concerns over mortality arising from traffic, pets, and human interference. Succession from forbs and grass to shrubs and trees occurs naturally at all of the sites and thus requires regular maintenance because frequent disturbance regimes have been largely removed. There are numerous methods for maintaining an open vegetative structure by discouraging or removing woody plants, and most agencies involved in turtle conservation are already involved in such management. The timing of vegetation management in relation to the lengthy time turtles may be in the terrestrial environment (Section IV, *Life History Cycle*) is perhaps the greatest challenge. In potential nest areas, care must be used not to use heavy machinery at any time of the year; June and July should be considered the most vulnerable period because of the potential harm to adult females that are nesting during this period that is typically the primary months for laying eggs (Gervais et al. 2009, Rosenberg et al. 2009). In many areas, avoidance may not be practical and thus alternative Best Management Practices need to be developed that take into account the variability among sites in terms of practical and thoughtful approaches to vegetation management and turtle conservation. Hand spraying is the preferred method if herbicides are used. Deviations from this approach to accommodate the typical multiple goals and constraints at a given site must be carefully considered. Many of the sites are already managed for this open structure for reasons unrelated to turtle conservation. Monitoring these sites for nest area suitability may be important (see Section X, *Monitoring*).

The other threat related to vegetation succession is the intentional planting of trees and shrubs in riparian areas that may otherwise provide nesting areas for turtles. This threat can be avoided by 1) identifying which areas are to be maintained as nest areas, and 2) working with organizations involved in riparian restoration to develop site management plans that can meet the goals of both riparian restoration efforts and other wildlife management goals, such as maintaining nesting areas for turtles.

Elevated Predation
Perhaps second only to *Traffic* as a threat that is difficult to manage, reducing predation on nests and hatchlings has been conducted successfully only on a very small scale, and realistically can only continue at a few select sites. There have been some extraordinary efforts in the Portland metropolitan area to minimize nest predation by finding nests, either through visual observations or use of females that are tracked via radio transmitters (reviewed in Gervais et al. 2009). Nests are then protected via wire-mesh exclosures. Finding nests is very difficult, and finding a large proportion of nests is that much more challenging. We are unaware of any concerted efforts to increase survival of hatchlings by removing predators, other than the work in Washington, where bullfrog abundance has been managed (D. Shepherdson, Oregon Zoo, pers. commun., 2012). We are unaware of any research in Washington on whether or not those efforts resulted in increased recruitment to the breeding population, or even to the degree of improvement in hatchling survival; the former being the more important metric. Until further evidence supports alternative management strategies, we believe the best approach is to recognize sites that have fewer of these potential impacts as a higher-priority for restoration/recovery efforts when all else is equal. However, we do not give much greater ranking for such sites as turtle conservation areas.

For sites where nesting may (or could) occur in resident's backyards, as exists at the Fairview Headwaters area in Gresham (see Case Study, Gervais et al. 2009), developing a program where residents are involved in protecting nests may have particularly great benefits. The Gresham example may serve as an excellent model for some specific sites in Portland, such as Bridgeton Slough (see Section VIII, *Bridgeton Slough*).

Removal of Native Turtles
Because of the illegal nature of removal of turtles, we found very little quantitative assessment of removal for either collecting turtles for pets or meat. Before efforts are made to reduce this impact, we recommend that an assessment is made to evaluate if this is an important consideration, and if so, where and who are the most likely individuals responsible, so educational efforts can be made most effective.

Other Factors to Improve Conditions for Turtle Conservation
In addition to minimizing threats, several management approaches have the potential to improve conditions of turtles in Portland. This includes modifying water depths to increase complexity and create deeper pools, creation of brood habitat, and placement of basking structures. We hypothesize that insufficient depth profiles and lack of brood habitat are the most limiting features to turtle distribution and abundance in Portland. Similarly, the proximity of nest, brood, foraging, and basking habitat to one another is critical. We hypothesize that proximity of this suite of habitat conditions is also a major limiting factor to turtle distribution and abundance in Portland.

Ranking of Habitat Suitability

We ranked the suitability of each of the sites we evaluated in the Columbia Slough watershed. We defined suitability as the ability to support all life stages of turtles; the score is based on the proximity of forage/bask, brood, and nest habitat, and the connectivity to other sites to increase effective area. We did not include overwinter habitat because of our inability to predict suitability with the information available. Suitability scores are the minimum of each contributory factor, with adjustment for connectivity. Given our ranking approach, individual sites can be a major contributor to turtle conservation even if suitability scores are low. Scoring was based on our evaluation of habitat quality for each contributory factor regardless of actual current use. Scores are based on limited evaluations and will require further evaluation prior to management actions. Suitability scores for each site are provided in Appendix 6.

Turtle Conservation Areas

We identified areas that we considered critical for providing a viable population of western painted turtles within the Columbia Slough watershed. We did not identify areas for pond turtle conservation because of the rarity of this species in the Columbia Slough watershed, which is at least partly due to the more southerly range of this species (see Section VI, *Distribution and Abundance of Turtles in Portland*). Furthermore, the recommendations we make for painted turtle should also be favorable for pond turtles.

We defined five Turtle Conservation Areas (TCAs) based on locations that provided a relatively large area of aquatic and terrestrial resources that we believed could provide suitable habitat for populations of at least 100 individuals and that were sufficiently connected via aquatic habitat (the Columbia Slough) to avoid isolation. TCAs have no regulatory authority and are only used here to facilitate conservation planning among willing landowners, including public agencies. Most of the TCAs currently have relatively large populations of painted turtles. Furthermore, turtles have been observed in all of the TCAs. TCAs provide opportunities for prioritizing conservation work to increase turtle populations and their long-term viability. There are important areas outside of TCAs that do or could contribute to turtle conservation; these are discussed in the next section, *Other Contributory Sites*. Similarly, not all areas within the TCA will contribute to turtle conservation due to other management goals, including how private landowners wish to participate voluntarily.

Figure 3. *Location of Turtle Conservation Areas* within the Columbia Slough watershed (shown in blue). The watershed, other than the easternmost portion, is within the City of Portland.

Smith and Bybee Wetlands Natural Area Complex

Contributing Sites

Smith and Bybee Wetlands Natural Area, including:
- Columbia Slough (including North/South Columbia Slough Mitigation Site)
- Kelly Point
- T-5 Powerline Mitigation and Bonneville Ponds
- Ramsey Lakes
- St. Johns Landfill (North and Blind Sloughs)
- Leadbetter Mitigation and Leadbetter Stormwater ponds/Water Quality Facility
- Smith and Bybee Lakes

General Description

This is the largest TCA (approximately 3060 acres) with most areas contributing to turtle conservation. This is the only TCA that consists entirely of land owned by public agencies, including City of Portland, Metro, and Port of Portland. Smith and Bybee Wetlands Natural Area comprise the largest area. The areas within the TCA are managed in part for wildlife conservation by Metro and Port of Portland as part of the latter agency's mitigation program. Upland areas of this TCA provide nesting habitat which could potentially be increased through the creation of upland prairie (or any structure that allows solar exposure) at the St. John's Landfill, as proposed (see *Existing Management Documen*ts, below, for Smith and Bybee). Nesting areas were recently improved through the addition of silt-loam soil at Smith and Bybee (Stewart 2008), and the Port of Portland improved a nesting area at the Leadbetter site by removing jute from a sand slope and seeding with native species. The Port has also anchored basking logs at Ramsey Lakes, Leadbetter Mitigation, and Turtle Pond at the T-5 Powerline Mitigation site (C. Butler, Port of Portland, pers. commun., June 2012). Painted turtles have been observed moving throughout most of the TCA (Hayes et al. 2002; E. Stewart, Metro, pers. commun., 2012). Out of the five TCA's, contributory sites at Smith and Bybee Natural Wetlands Area Complex scored the highest for Habitat Suitability (Appendix 6).

Existing Management Documents
Port of Portland Vegetation Management Plan (2010)
Smith and Bybee Wetlands Comprehensive Natural Resource Plan
http://www.oregonmetro.gov/index.cfm/go/by.web/id=33853 (in progress)

Threats
Primary threats include recreation, release, traffic, sedimentation, and possibly collection as pets or meat. In general, threats were lowest at contributory sites (Appendix 5) in this TCA except for recreation which will remain an important threat that must be managed. Recreation in many forms is an important consideration at Smith and Bybee Wetlands Natural Area (e.g., Stewart 2008) and within other parts of the Columbia Slough where kayakers, fisherman, and bird watchers frequent. Other threats, more limited in extent, include contaminants in some City of Portland stormwater ponds within Smith and Bybee Wetlands Natural area.

Surveys
Turtle surveys have been conducted in this TCA for many years, primarily as part of Metro's monitoring program for Smith and Bybee Wetlands Natural Area. All written accounts and expert opinion report that the greatest number of western painted turtles in the Portland metropolitan area occur in the Smith and Bybee Wetlands Natural Area. The following material is taken from E. Stewart (Metro, pers. commun., 2012). Metro has conducted visual surveys for painted turtles using a standardized protocol in most years from 1999 to 2010. Surveys have resulted in counts up to 108 – 303 turtles annually, with no apparent trend. From 1999 to 2001, Metro marked 332 juvenile and adult painted turtles and estimated a population size of between 400 and 500 individuals. Several other surveys have been conducted. C. Butler (Port of Portland, pers. commun., 2012) has counted up to 70 turtles in the T-5 Powerline Mitigation ponds. In 2007, Bielke and Christenson (2007) conducted surveys at Smith and Bybee and observed native and non-native turtles; details of numbers or locations of their efforts were not reported. In 2009, based on a single survey in mid-July, NERI (2009) observed 7 painted turtles at St. Johns Maintenance Bay and 4 painted turtles in the Port Stormwater Wetlands. Both sites are approximately 500 feet south of Ramsey Ponds where we conducted our surveys. In addition, NERI (2009) surveyed areas from the mouth of the Columbia Slough to approximately Kelly Point Park during a late-June survey in 2009, but they did not detect any turtles. The most extensive research that also contributed to understanding population numbers was conducted by Hayes et al. (2002) for the T-5 Powerline Mitigation ponds. Their work suggested that a population of approximately 80

adult painted turtles existed during their field work in 1999 and 2000; they observed a minimum of 74 adult painted turtles.

Based on our maximum counts of individuals from the four replicated surveys at 5 of the sub-sites in this TCA, which represents only a small portion of the areas occupied, we counted 328 turtles, including individuals whose species was undetermined, but excluding those that were identified as red-eared sliders (Appendix 1). Given the small area covered, that detection probability per turtle is relatively low in some areas, and that small juveniles are usually not detected, we believe the population size is substantially larger than the 328 turtles we counted. Based on all available information, this TCA has the largest population of western painted turtles in Portland.

Recommended Improvements

- Education/outreach for recreational threats, release, and capture

- Ammend ODFW's fishing regulations to restrict bait fishing; i.e., only allow lures without any form of live or dead animal or plant material within Smith and Bybee Wetlands Natural Area.

- Continued protection from human disturbance.

Information Needs

- Evaluation of fishing and boating threats and means to minimize negative effects to turtles

Heron Lakes Complex

Contributing Sites
Columbia Slough
Columbia Wastewater Treatment Plant (channels, "triangle")
Heron Lakes Golf Course (sloughs, ponds)
Force Lake
Vanport Wetlands
Portland International Raceway (sloughs, wetlands)

General Description
This is the second largest TCA (approximately 1320 acres), but with only a small proportion of the area within the TCA likely contributing to turtle conservation. Because this TCA is adjacent to the Smith and Bybee TCA, it is effectively larger than its size of contributing areas suggests. Over 90% of the area is publicly owned, and the portion that is privately owned is undeveloped. The City of Portland owns the majority of the area, but the large Vanport Wetlands Mitigation Area is owned by the Port of Portland. Metro owns a small parcel of developed property. Vanport Wetlands is a mitigation site managed for wetland protection. Most of the other areas are primarily managed for recreation, including the Heron Lakes Golf Course and the Portland International Raceway. After review of potential contaminant issues that may affect turtles, the

Columbia Wastewater Treatment Plant, in the southwestern corner of the TCA, should be considered for opportunities for turtle conservation along channels outside of the treatment ponds. There are numerous sloughs throughout the TCA, which is bordered on the south by the Columbia Slough. North Portland Road and the Union Pacific Railroad provide a partial barrier to connectivity to the Smith and Bybee TCA. We assume the Columbia Slough provides the primary connectivity for turtles between the Heron Lakes and Smith and Bybee TCAs. The Heron Lakes Complex TCA scored relatively low for Habitat Suitability, but we believe there are many opportunities for turtle conservation.

Existing Management Documents

1. Portland International Raceway Master Plan (2003)
2. Port of Portland Vegetation Management Plan (2010)
3. Columbia Waste Water Treatment Plant Master Plan 2004
4. Port of Portland Vegetation Management Plan (2010)
5. Peninsula Drainage District #1 Natural Resources Management Plan, 1997

Threats

Highest ranking threats in this TCA include sedimentation, vegetation, recreation, and release. We do not believe traffic (including from the railway) is a primary threat, but this scoring remains tentative. Force Lake is an EPA Superfund site and it is currently unknown how remaining contamination may affect turtles.

Surveys

We know of only two other surveys that were conducted within this TCA. Most recently, NERI (2009) conducted counts throughout the Golf Course (presumably including Force Lake) during a single survey in July 2009. They counted a total of 3 painted turtles. Gaddis and Corkran (1985) surveyed for turtles at a few ponds in the Golf Course and failed to detect them during a 1-day survey in June 1985. We are not aware of any surveys outside of the Golf Course in this TCA, other than what we conducted. However, on May 31, 2012 (May 31), staff of Heron Lakes Golf Course found 9 western painted turtle hatchlings (OWI verified species identification by photographs submitted to us) recently emerged from a sand trap by the number 11 Green (J. Goodling, Heron Lakes Golf Course, pers. commun., June 2012).

Based on our maximum counts of individuals from the four replicated surveys at 7 sub-sites, which represents only a small portion of the areas occupied by turtles in this TCA, we counted 12 turtles, including individuals whose species was undetermined but excluding those that were identified as red-eared sliders (Appendix 1). We believe the population size is substantially larger than the 12 turtles we counted. Based on all available information, this TCA has one of the smaller population of turtles but the extensive area of aquatic and upland resources provide great potential for increasing population size.

Recommended Improvements

- Portland International Raceway: (1) After an evaluation of water depths, deepen ponds and sloughs to provide a more complex profile if needed; (2) Create turtle aquatic habitat in the south wetland by deepening channel; manage for nest habitat in selected uplands near sloughs (see Section IX, *Priority Projects for Implementation*).

- Heron Lakes Golf Course: (1) create nesting areas outside of areas managed for golf and adjacent to ponds and sloughs that are nearest the Columbia Slough; (2) manage vegetation at Force Lake to create nest habitat; (3) provide basking structures in selected ponds and in Force Lake; (4) for Force Lake, after evaluation of contamination and an evaluation of water depths, provide a more complex profile if needed; (5) provide signage on turtles and their conservation at golf courses. Revegetation at the southern end of Force Lake was recently initiated by the Columbia Slough Watershed Council and Friends of Force Lake, primarily working to remove Himalayan Blackberry and control other weeds (M. Boercker, Columbia Slough Watershed Council, pers. commun., June 2012). Areas were replanting with native plants. Improvements for turtles will necessitate allowing for solar exposure for basking in Force Lake and nesting in uplands near the lake.

- If evaluation of potential contaminant effects on turtles suggest greater gain than harm for turtles occupying the waste water treatment plant, consider these following recommendations for the Columbia Wastewater Treatment Plant: (1) provide connectivity to Columbia Slough for entry into side channels in manner consistent with CWTP regulations for containing drainage from treatment ponds; (2) manage vegetation in areas adjacent to side channels to create nest habitat.

Information Needs

- Qualitative evaluation of potential contaminants in treatment ponds adjacent to proposed areas at CWTP for turtle conservation;

- Evaluation of contamination at Force Lake, which is a superfund site;

- Evaluation of fences and other barriers along the border with N. Portland Drive in reducing road/railroad track mortality;

- Evaluation of water depth profiles at PIR sloughs and southern wetland; and Heron Lakes slough (nearest Columbia Slough, and bordering PIR);
- Evaluation of approaches to attract turtles to created nest areas in golf courses (see Section X, *Research*);
- Develop Best Management Practices for turtle conservation at golf courses to aid grounds maintenance staff.

Middle Columbia Slough Region

Contributing Sites
Columbia Slough, including portions adjacent to levee
Peninsula Canal
Elrod Ditch
Buffalo Slough
Broadmoor Golf Course and Subaru wetlands
Confluence of Whitaker and Columbia Sloughs

General Description
This TCA (approximately 670 acres), differs from the two TCAs along the Lower Columbia Slough by its predominately private ownership (approximately 70%). Potentially important properties are owned by Port of Portland (approx. 185 acres) and a smaller proportion adjacent to the Peninsula Canal is owned by City of Portland (20 acres). Because of the numerous sloughs throughout this TCA, a large proportion will potentially contribute to turtle conservation goals. The predominant aquatic sites consists of Peninsula Canal, which is currently a closed system that is functionally a shallow lake, Buffalo Slough, Columbia Slough, Elrod Ditch, and other smaller drainageways that are part of the network of sloughs and drains managed by MCDD. Importantly, this TCA also includes the confluence of the Whitaker and Columbia Sloughs, which we believe may have significant habitat quality and provides important connectivity into the

Whitaker TCA. The sloughs in the Middle Columbia Slough Region TCA are often adjacent to open space, including wetlands, golf courses, and other non-built areas that improve the suitability of habitat for turtles. This is unique to the sloughs in this TCA relative to others in the Middle and Upper Columbia Slough system. We assume that the Columbia Slough provides the primary connectivity for turtles into and out of this TCA, and that connectivity is not limiting the population. The contributory sites in this TCA scored high for Habitat Suitability (Appendix 6), and had some of the highest rankings for the Columbia Slough because of the proximity to habitat that could provide brood and nest habitat. We believe this TCA has some of the greatest opportunities to create significant turtle habitat and thereby increase population size.

Existing Management Documents

Port of Portland Vegetation Management Plan (Buffalo Slough Mitigation Site), 2010

Threats

Highest ranking threats in this TCA include sedimentation, vegetation, and recreation. Recreation is potentially a threat if boaters frequently access Buffalo Slough and a major threat if a trail is developed as proposed alongside Peninsula Canal (proposed Regional Trail, Metro 2008). A trail along Peninsula Canal could severely reduce the turtle population if avoidance measures to minimize disturbance and potentially elevated nest predation are not taken. We believe Peninsula Canal has the second highest numbers of painted turtles in Portland, and likely the highest density.

Surveys

We know of only two other surveys in this TCA, both of which only included the Peninsula Canal. Gaddis and Corkran (1985) surveyed for turtles at Peninsula Canal and counted 8 painted turtles during their 1-day survey of aquatic habitat in the Columbia Slough area in June 1985. Gaddis (1984) counted a maximum of 8 painted turtles from his repeated (details not provided in his report) surveys of the entire length of the Canal, conducted in late summer 1984. Gaddis (1984) also set traps for turtles, and captured one painted turtle during 19 “trap days”. Based on our maximum counts of individuals from the four replicated surveys, which represents only a very small portion of the areas occupied by turtles in this TCA, we counted 211 turtles, including individuals whose species identity was undetermined but excluding those that were identified as red-eared sliders (Appendix 1). However, most (193) were counted at Peninsula Canal from only 2 observation points. We believe the population size is substantially larger than the 211 turtles we counted because of the small area we covered during the surveys. Based on all available information, this TCA has the second largest population of turtles in Portland. Furthermore, the extensive area of aquatic and upland resources that do not currently harbor large populations provide great potential for increasing population size.

Recommended Improvements

Buffalo Slough: (1) Easternmost section, approximately 300 feet, create greater depth and profile complexity; add basking structures; nest site improvements on Port of Portland Buffalo Mitigation site; (2) based on observations of turtles using the site, consider improving depth profile and adding basking structures throughout Buffalo Slough in partnership with MCDD. We believe this project deserves consideration as a priority management effort (see Section IX, *Priority Projects for Implementation*).

Broadmoor Golf Course: Vegetation management to maintain an open vegetative structure for nesting areas along Buffalo Slough, Columbia Slough, and the tributary of Elrod Ditch. Nest areas should have potential brood habitat nearby, such as the terminal end of Buffalo Slough.

Peninsula Canal: Protect the site from human disturbance. This will be a critical need given the proposed trail that will traverse the levy.

Information Needs
Evaluation of "Subaru Wetlands", within Broadmoor Golf Course as turtle habitat and restoration needs;

- Elrod Ditch: Surveys for both painted turtles and opportunities for habitat improvement along Elrod ditch from Columbia Slough east through Airport property, and along secondary drainageways within Subaru wetlands and to east end of Broadmoor Golf Course, and from Columbia Slough north through Riverside Golf Course. We placed this information needs project as a priority (Section IX, *Priority Projects for Implementation*). This work could potentially be coordinated with MCDD's current plans for habitat enhancement along Elrod Ditch.

- Evaluation of water profile complexity at Buffalo slough; effectiveness monitoring of modification to depth profile (see Section X, *Research and Monitoring*).

- Evaluation of management needs at confluence of Whitaker and Columbia Sloughs, and opportunities for management of nest areas on adjacent Port of Portland property. We believe this project deserves consideration as a priority evaluation for possible management efforts (see Section IX, *Priority Projects for Implementation*).

Whitaker Slough Complex

Contributing Sites
Whitaker Slough
Whitaker Ponds Nature Park and adjacent non-developed areas
Colwood Golf Course
Holman Pond

General Description
This is the smallest of the five TCAs (approximately 160 acres). Connectivity to the other TCAs is primarily via Whitaker Slough and probably to a lesser extent via the Columbia Slough. The primary natural areas within this TCA is the Whitaker Ponds Nature Park (and undeveloped areas in private ownership along a portion of east Whitaker Pond) and adjacent areas with ownership primarily by City of Portland (approximately 22 acres) and Metro (approximately 12 acres). The other prominent open space is Colwood Golf Course, which is bisected by Whitaker and Columbia Sloughs. These sloughs and adjacent uplands provide the primary turtle habitat in Colwood Golf Course. The eastern portion of Whitaker Slough, including the portion within Colwood Golf Course, is particularly wide and has great potential as aquatic habitat for turtles. A narrow riparian area is adjacent to both Whitaker and Columbia Sloughs, but otherwise they are surrounded by industrial areas other than the Whitaker Ponds Nature Park area. Holman Pond is privately owned and vegetation is aggressively managed by the property owner (S. Barthel, City of Portland, pers. commun., May 2012). We believe this TCA has important opportunities for creating significant turtle habitat and thereby increase population size, primarily within Whitaker Slough and Ponds and including the portion of Whitaker Slough adjacent to Colwood Golf Course. There is a high potential to increase the native turtle population in this TCA to the stated goal of at least 100 native turtles in each TCA. The high habitat suitability scores reflect this perspective

Existing Management Documents
Whitaker Ponds Master Plan (Portland Parks and Recreation 2006)

Threats
Highest ranking threats in this TCA include sedimentation, traffic, and vegetation. Further, recreation and release remain as threats for Whitaker Ponds Nature Park. We listed traffic as a key threat because of the industrial areas that surround so much of Whitaker Slough.

Surveys
We know of only one other survey for turtles within this TCA. The survey included Whitaker Ponds and the portion of Whitaker Slough from Colwood Golf Course west to Whitaker Ponds (NERI 2009). During 1-2 surveys of the Ponds and the Slough in mid- to late June, NERI reported a total of 2 painted turtles in the East Pond and 1 painted turtle in Whitaker Slough near the ponds.

Based on our maximum counts of individuals from the four replicated surveys, which represents only a very small portion of the areas occupied by turtles in this TCA, we counted only 2 turtles, one of which was confirmed as a painted turtle and the other was unidentified (Appendix 1). In general, all of the surveys, including ours, covered only a small portion of this TCA. However, based on all available information, this TCA has one of the smallest populations of turtles, but the habitat conditions should allow improvements to aquatic conditions that may result in a much larger population despite that industrial development surrounds much of the TCA.

Recommended Improvements

- Whitaker Ponds: (1) Educational kiosks/information areas have high potential for reaching children and other members of the public. With further work on habitat quality of the west Whitaker Pond (see below), basking structures could be strategically placed to allow viewing of turtles from the educational display; (2) ensure that basking structures are strategically placed in areas that would receive less disturbance from visitors to the park; (3) ensure adequate solar exposure in potential brood areas where trees and shrubs have recently been placed alongside east Whitaker Pond; (4) after increase in population size of painted turtles, manage several sites for nesting areas;

- Whitaker Slough: (1) After thorough site evaluation, manage vegetation along areas of slough as nest areas; (2) we recommend the east end (west of Alderwood Rd for approx. 450 feet) of Whitaker Slough adjacent to the Colwood Golf Course as an important area for improving both aquatic and terrestrial habitat conditions. If evaluation of water depth profiles in this area show inadequate complexity and depth, create deeper channels as foraging and over-winter habitat and shallow areas along perimeters for brood habitat; (3) add basking structures in areas least likely disturbed by visitors to area; (4) Collaborate with Colwood Golf Course for identifying areas to manage as nest habitat near perimeter of this section of Whitaker Slough; (5) following demonstrated use by painted turtles of the east end of Whitaker Slough, consider similar work along other sections to the west, including water depth profiles, nest and brood areas, and basking structures.

- Colwood Golf Course: In collaboration with Colwood G.C., manage vegetation for nesting areas along Whitaker and Columbia Slough; in particular, area near Alderwood Rd. and adjacent to Whitaker Slough and side pools. We believe, however, that the most significant improvement for turtle habitat at Colwood Golf Course is through improvement of aquatic habitat as described above.

Information Needs

- Identify areas to be managed for nesting and brood habitat at Whitaker Ponds Natural Area and adjacent areas;

- Evaluation of vegetation encroachment, abundance of basking structures, and water profile complexity along entire length of Whitaker Slough to prioritize management. Work with MCDD to identify areas of Whitaker Slough that are most amenable to modifications of depth profiles and that can create a win-win situation for flood control and turtle conservation.

- The east end of Whitaker Slough near Alderwood Rd and adjacent to Colwood Golf Course is a priority area for additional information on depth profiles;

Big Four Corners Natural Area Complex

Contributing Sites
Columbia Slough
Mason Flats
Winmar Ponds
Bernard's Pond
Morrow Pond
Secondary drainageways/channels
Gresham's CS02b project area

General Description
Big Four Corners Complex is the easternmost of the five TCAs, totaling approximately 325 acres. This TCA is second only to the Smith and Bybee TCA in relation to the acres of protected habitat. It includes a small portion of the Columbia Slough within the City of Gresham. Connectivity to the other TCAs is via the Columbia Slough. This TCA is almost entirely composed of natural areas, predominately the Big Four Corners Natural Area owned and managed by the City of Portland, and smaller adjacent wetland areas, including City of Portland stormwater ponds and water quality facilities. Approximately 24.5 acres are privately owned or owned by a utility or water district. There are additional wetland areas adjacent to City of Portland property, and within the City of Gresham that are likely now contributory to turtle conservation and have excellent potential for improvement as turtle habitat (referred to by the City of Gresham as the CS02b site). The parcel is privately owned and has been proposed for restoration funding. A major contributory portion of the TCA consists of ponds within the Big Four Corners Natural Area, and two adjacent water quality/stormwater facilities (Bernard's Pond and Morrow Pond), which together have been known to be occupied by turtles for many years and provide one of the largest known populations of turtles within Portland. Additionally, the City of Portland is currently planning on modifying the wetlands for stormwater management and wetland enhancement, which will include work that is intended to improve conditions for turtles. Gresham's CS02B proposed project is intended to restore

complex wetlands adjacent to the Columbia Slough and is near the Big Four Corners Natural Area. Because of the ongoing wetland enhancement and turtle conservation efforts, the goal of this site, like Smith and Bybee TCA, is continued management to retain the high habitat suitability for turtles that is already present. All of the sites within this TCA that we ranked scored high for habitat suitability (Appendix 6). We did not include Mason Flats and Winmar Ponds in our evaluation but those sites clearly have some of the best habitat.

Existing Management Documents
City of Portland: Mason Flats Wetland Enhancement (City of Portland 2012)

Threats
Highest ranking threats in this TCA include traffic, sedimentation, and vegetation. We listed traffic as a key threat because of the industrial areas that are near many of the presumed nesting areas. The City of Portland is minimizing the threat of traffic by installing barriers adjacent to Airport Way in the Mason Flats Wetland Enhancement project.

Surveys
The only other survey that we are aware of that included sites within this TCA was conducted by NERI (2009) within the Winmar Ponds and Mason Flats area, including Morrow Pond. They counted 15 painted turtles (including adults and juveniles) during their two visits from late June to late July, and found 31 nest attempts at Morrow Pond. In our surveys, we only included Bernard's Pond, Morrow Pond, and the Columbia Slough Crossing at 185th St. The maximum number of painted turtles that we observed during any one survey was 7 individuals.

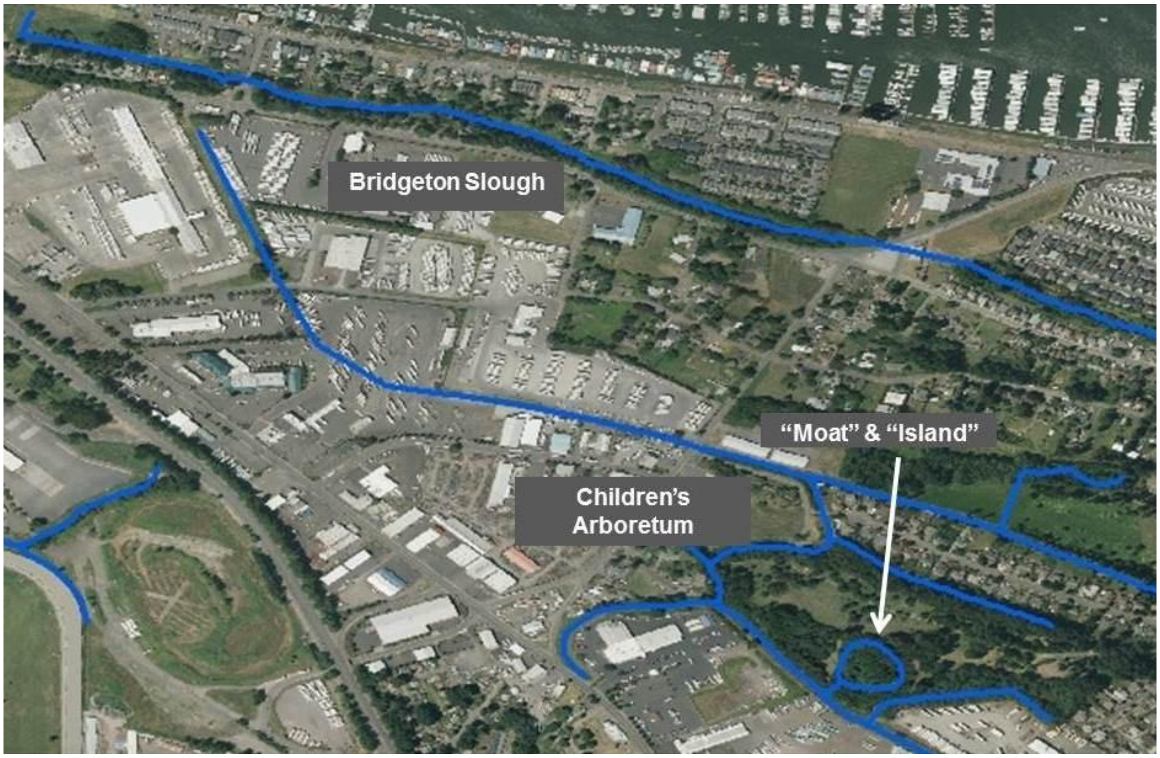
Recommended Improvements
The Bureau of Environmental Services, City of Portland, is initiating actions to improve the primary sites within this TCA for turtles, including (1) establishing a nest area on the northern portion of Winmar Ponds and Mason Flats, (2) installing barriers to limit turtles moving onto Airport Way, and (3) creation of shallow water areas with numerous partially submerged logs that are intended to serve as brood and juvenile habitat as well as for the principal purpose of stormwater management. We believe that the planned set of actions by BES will provide excellent improvements for turtle conservation and their success is worthy of careful monitoring (see Section X, *Monitoring*). Additionally, Morrow Pond would likely benefit from additional basking structures, which are largely lacking, as NERI (2009) found in 2009 and we observed in 2011. Vegetation management to increase the area of nesting habitat at Morrow Pond and Bernard's Pond would be desirable, as would efforts to attract turtles to non-road areas for nesting (see Section X, *Research and Monitorin*g). We did not evaluate CS02b for improvements.

Information Needs

- A careful evaluation of ways to improve turtle habitat at Gresham's proposed restoration of CS02b would be useful prior to restoration. Evaluation of water depth profiles would be informative to guide management;

- Turtle response to habitat improvement at Mason Flats (effectiveness monitoring; see Section X, *Monitoring*).

Other Contributory Sites



Bridgeton Slough

General Description

Bridgeton Slough is a secondary drainageway, a portion consisting of a small side channel that is the continuation of Faloma Ditch. It stretches from NE 6th Drive to just west of the current end of Bridgeton Rd., near Haight Ave. The westernmost section is currently undeveloped. Bridgeton Slough, as defined here, is approx. 0.8 miles in length. It is often referred to as East and West Bridgeton Slough. Faloma Slough flows from NE 13 to Marine Drive. After the slough emerges west of Marine Drive it becomes Bridgeton Slough. They are identified as 2 separate systems The riparian zone is narrow, bordered by residential areas on both sides with few exceptions, and is bordered by residences and Marine Drive on the south. The area is all in private ownership other than two small parcels owned by the City of Portland. The Bridgeton Neighborhood Association is active in this area and could potentially provide a means for discussion on conservation actions. The area is known to be occupied by turtles, and area residents reported observing turtles in some backyards (D. Bedell, turtle observer for OWI, pers. commun., 2011). We ranked this site as relatively poor habitat because of the presumed poor nesting conditions, including threats from domestic animals. We believe there are many opportunities for enhancing this slough for turtle conservation using Gresham's Fairview Headwaters turtle conservation project as a model to guide management in this residential area and engage citizens in conservation actions in their own community.

Existing Management Documents
None known

Threats
Highest ranking threat is traffic, but release and removal, sedimentation, vegetation and recreation are also important threats. Elevated predation on hatchlings and nesting females by dogs and cats is likely an important threat that potentially can be minimized through outreach activities including citizen participation in a turtle conservation program.

Surveys
The only other survey that we are aware of that included Bridgeton Slough was conducted by NERI (2009) during a single visit in late June; no turtles were observed. During our surveys, we detected a maximum of five painted turtles and one turtle that was either a red-eared slider or a painted turtle that was observed during a single survey.

Recommended Improvements
We provide the following recommendations based on our brief review of the current conditions from field and map work:

- Creation of a neighborhood effort to promote turtles, modeled after City of Gresham's Fairview Headwaters program;
- Manage selected areas as nest habitat;
- Education/outreach to promote wildlife conservation with specific messages about releasing and removing turtles.

Information Needs

- Identify potential nest areas that are neighborhood appropriate;
- Evaluate areas for adding and securing basking structures, if needed;
- Identify opportunities for habitat improvement, both aquatic and terrestrial on or adjacent to properties that are not intended to be developed;

1. In coordination with MCDD, evaluate depth profile and potential to use “channel and bank” methods to create more complex depth profiles in some portions of slough;

2. Evaluate conditions on the continuation of the secondary drainageway from NE 6^{th} Drive to Columbia Edgewater Country Club.

Children's Arboreteum

General Description

Children's Arboretum is a 28-acre "hybrid" Portland Parks and Recreation site intended to serve both as natural habitat and as a recreation park (Portland Parks and Recreation 2004; L. Barlow, Portland Parks and Recreation, pers. commun., 2012). The park is located in the East Columbia Neighborhood, approximately 1/3 mile south of Marine Drive, and bordered by NE 6th Drive on the northwest. The park consists of secondary drainageways that exist around most of the perimeter of the Park and a ditch within the interior of a park that forms a circle, called the "moat" in the management plan (Portland Parks and Recreation 2004). All of these drainageways are ultimately connected to the Columbia Slough via pumping. There is a relatively wide swath of vegetation along most edges of the drainageways, and the "moat" is surrounded by a relatively large patch of trees and other vegetation. The Columbia Children's Arboretum Management Plan (Portland Parks and Recreation 2004) proposes many improvements to the natural quality of the park, including water quality. We ranked this site as providing moderate habitat suitability because of concerns over nest and aquatic habitat, both of which we believe may be able to be improved with appropriate management. We believe there are many opportunities for enhancing the drainageways and adjacent uplands for turtle conservation and for excellent educational opportunities for viewing and learning about turtles in a park setting.

Recent work to remove Himalayan blackberry from the island (inside the "moat") was conducted in fall of 2011 and planting is planned for fall 2012 and winter 2013, demonstrating interest in restoration work at Children's Arboreteum (M. Boercker, Columbia Slough Watershed Council, pers. commun., June 2012). Revegetation and other management outside of the island will need to allow for solar exposure for basking in aquatic habitat and nest habitat nearby. Other drainageways at the perimeter of Children's Arboretum can provide aquatic habitat as well and there are ample opportunities for improving conditions for turtles there as well as the island area.

Existing Management Documents

Columbia Children's Arboretum Management Plan (Portland Parks and Recreation 2004)

Threats

Highest ranking threats at this site include sedimentation, vegetation, mowing, release, recreation, and removal if the turtle population increases.

Surveys

We are unaware of any surveys for turtles other than the replicated surveys we conducted. During our surveys we detected 1 red-eared slider.

Recommended Improvements
There are many opportunities for improvements, with the approach depending entirely on meeting the multiple goals of this site, including partnership with MCDD to create more complex depth profiles. We recommend the following improvements, all of which can be flexible in terms of location and extent:

- Create more complex depth profiles and monitor for turtle use, prior to conducting the recommendations provided below. This may entail allowing greater depths to exist in the moat area by modifying culvert heights rather than "channel and bank" approaches;

- Manage trees to provide solar exposure for basking and retain suitable open areas for nesting;

- Restrict recreation and dogs from locations managed as turtle nesting areas;

- Conduct education/outreach to promote wildlife conservation with specific message about releasing and removing turtles;

- Creation of a neighborhood effort to promote turtles, modeled after City of Gresham's Fairview Headwaters program;

- Consider "Citizen Science" approaches for monitoring turtle use of drainageways.

Information Needs
Because of the potential to improve this area for turtle conservation, we recommend a more detailed evaluation of the site to identify opportunities to:

1. Evaluate water depth profiles and identify areas that are suitable for providing deeper pools, including the "moat";

2. Monitor aquatic habitat for turtle occupancy following modification of depth profiles;

3. Evaluate solar exposure in aquatic habitat and remove vegetation as needed to provide some areas for basking;

4. Identify potential nest areas within 50 feet of waterways and that are appropriate for limiting recreation.

Johnson Lake

General Description
Johnson Lake, located directly west of I-205 and east of NE 92nd , is a natural lake with an interesting social and ecological history. Prior to the construction of I-205 in the late 1960s and early 1970s, Johnson Lake was larger than its present size, and a prime recreational center. The spring-fed lake was once very clear, prior to the Vanport Flood in 1948. Soon thereafter, the release of effluents from the neighboring Owens-Illinois glass factory led to the contamination and further degradation of Johnson Lake (http://www.portlandonline.com/parks/finder/index.cfm?&propertyid=207&action=ViewPark, accessed March 2012). Today, Johnson Lake is approximately 25 acres in extent, with approximately 35 acres of undeveloped land surrounding the lake. Ownership is a mix of public (approximately 12 acres) and private ownership. Johnson Lake is approx. 650 feet south of Columbia Slough. The lake drains into Whitaker Slough. Johnson Lake potentially remains a highly polluted lake, contaminated with PCBs and many other industrial contaminants (Oregon DEQ Press Release, April 6, 2009); it's current pollution levels following the 2012 cleanup is unknown to us. Owens Illinois completed a DEQ directed cleanup and capping of lake sediments in late winter 2012. This means that they have done the protective measures designed to encase contamination in the sediments. In 1996, the City of Portland purchased a portion of the property for environmental protection, and a consortium of agencies and neighborhood associations are working to revegetate the land and surrounding non-developed areas (see above referenced website). The remediation project that applied a cap to the lake bed is now completed (D. Helzer, City of Portland, pers. commun., June 2012). We ranked this site as moderately low for habitat suitability under current conditions. However, we believe this lake and surrounding property has potential as an important stronghold for a population of turtles in this upper section of the Middle Columbia Slough watershed. Further work to elucidate limiting factors to a large turtle population is needed.

Existing Management Documents
Johnson Lake Vegetation Survey, Portland Parks and Recreation 2007

Threats
Because of the complexity of this site, including recent remediation work, we offer our perspective on current threats as tentative and requiring a more detailed review. Highest ranking threats at this site may include sedimentation and vegetation. Possible future threats likely include recreation, such as fishing (boating is currently restricted), and release. Contaminants are a potential threat that we have not addressed but the remediation actions (see General Descriptions) may have resolved this issue.

Surveys
The only surveys for turtles other than the replicated surveys we conducted was a single survey in late June, conducted by NERI (2009); they did not detect any turtles. From a single observation point on the eastern edge of the lake, we detected one painted turtle and one other turtle that was identified as either a painted turtle or a red-eared slider. Given the limited visibility of the entire lake, and the incomplete detection probability within the viewing area, there are likely other turtles inhabiting this lake but the density is clearly low.

Recommended Improvements
We believe the main impediment to significant and viable turtle populations in this large lake is the poor aquatic conditions but further evaluations are necessary for this relatively large lake with a long-history of contamination. We recommend the following improvements, all of which can be flexible in terms of location and extent:

- Based on evaluations of water depths, we recommend creating a more complex depth profile, recognizing the ability to do this may be significantly curtailed because of the capping to retain contaminated contaminants.

- Modify distribution and abundance of aquatic vegetation if evaluations suggest this may be limiting foraging and brood habitat;

- Add basking structures in locations that are least affected by recreationists and in a manner that satisfy MCDD concerns;

- Restrict recreation and dogs from locations managed as turtle nesting areas;

- If use of lake by public warrants, increase education/outreach to promote wildlife conservation with specific messages about releasing and removing turtles, and how to minimize disturbance when fishing (if and when fishing becomes a frequent activity);

- Consider restrictions on fishing with bait in consultation with ODFW if and when fishing occurs regularly.

Information Needs

- Evaluate water depth profiles and if needed, identify areas that are suitable for providing more complex depth profiles to provide shallow-water brood habitat and deeper areas for foraging and over-wintering;

- Identify areas for developing brood habitat, in particular, shallow areas conducive to well-developed aquatic vegetation and where woody debris can be maintained;

- Identify potential nest areas that can be maintained without conflict with recreation.

Company and East Lakes

General Description
These two natural lakes are located approximately 1.25 miles north of Troutdale in Multnomah County, within an undeveloped area of approximately 180 acres that occur north of the flood control levee. Company Lake is approximately 1500 feet from the confluence of Sandy and Columbia Rivers, an area where painted turtles have been observed (S. Barnes, ODFW, pers. commun., June 2012). East Lake is approximately 700 feet directly east of Company Lake and 300 feet west of the Sandy River. Company Lake was heavily contaminated from former discharge from the manufacturing plant, and is part of the Reynolds Metals Company Superfund Site. Contaminants at the Superfund Site included cyanide, polycyclic aromatic hydrocarbons, heavy metals, PCBs (Reynolds Metals Company Superfund Site Information Sheet, Port of Portland). Cleanup was completed in 2004, and the water in the lakes meet DEQs criteria. Recreational use of the area is primarily as a walking path, which exists along the levy. Few individuals have been observed fishing in this lake (C. Butler, Port of Portland, pers. commun., 2012). The Port of Portland enhanced both sites in 2009 to provide wetland mitigation for impacts related to development of the new FedEx operation located south of the levee. East Lake is fenced, with the bottom portion of fence removed to allow turtles to freely come and go. Logs and root wads were added during mitigation, and located away from the trail to minimize disturbance to turtles (C. Butler, Port of Portland, pers. commun., June 2012). We ranked this site as moderately high for habitat suitability because we believed many of the physical traits of suitable habitat were present.

Existing Management Documents
Port of Portland Vegetation Management Plan, March 2010

Threats
Highest ranking threats at these two sites are vegetation, and possibly recreation, though we are unaware of the intensity of various recreational uses of these sites. Vegetation is currently managed by Port of Portland and does not pose a current threat because of on-going management. The threat of contamination affecting turtle demography remains plausible.

Surveys
We are unaware of reports on turtle survey work at these two sites other than work that has been conducted by the Port of Portland, which we report on here. NERI conducted a survey in September 2008 during which five western painted turtles were captured from Company Lake but none were captured during efforts at East Lake (C. Butler, Port of Portland, pers. commun., June 2012). During late summer and early fall 2011, Carrie Butler (Port of Portland, pers. commun., April 2012) observed three and four painted turtles at East and Company Lakes, respectively. During our surveys, we detected one red-eared slider at East Lake and five painted turtles at Company Lake. Given the limited visibility of the entire lake, and the incomplete detection probability within the viewing area, there are likely many more turtles that inhabit this lake but the densities are clearly low.

Recommended Improvements
Following more detailed evaluation than possible during our review, we recommend the following improvements, all of which can be flexible in terms of location and extent:

- Increase abundance of aquatic vegetation;
- Ensure that basking structures are available during low water levels;
- Identify several areas adjacent to Company Lake to manage specifically for nesting by maintaining open vegetative structure and minimizing disturbance from recreationists, similar to the Port of Portland's efforts at East Lake;
- Education/outreach to promote wildlife conservation with specific messages about releasing and removing turtles;

Information Needs

- Evaluate water depth profiles and identify areas that are suitable for providing more complex depth profiles, to provide brood habitat and deeper pools for foraging and over-wintering. Options may be limited because of the rules governing this Superfund Site;
- Identify potential nest areas where recreation impacts are minimal;

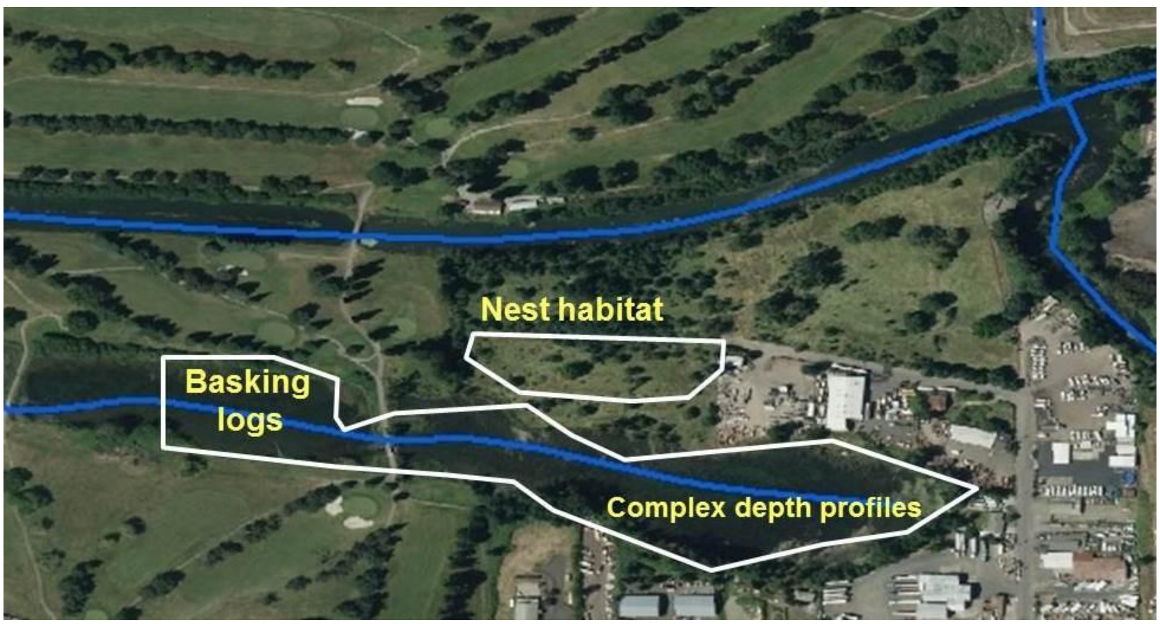
- Evaluate need for adding vegetation to minimize human and pet disturbance at Company Lake.

- Qualitatively evaluate current contaminant levels and potential effects on turtles;

IX. Priority Projects for Implementation

Although identification of specific projects will depend upon many factors relevant to an agency initiating or a group of stakeholders participating in a project to improve conditions for native turtles, we believe there are several actions that may have both large positive effects on abundance and influence future projects. We provide a brief overview of these suggested priority actions. Specific details should be determined in consultation with all stakeholders, and in particular will require MCDD participation because all of the recommended projects require modifications to the aquatic environment and often adjacent terrestrial areas that are managed by MCDD.

Buffalo Slough East End



The terminal end of Buffalo slough provides a potentially excellent area for creating an appropriate combination of nest, forage, overwinter, and brood habitat in an area that is bounded by stakeholders interested in partnerships with wildlife conservation. We believe this project not only provides an excellent opportunity for creating habitat that can support a large number of turtles but will provide an excellent case study on management approaches with the diverse stakeholders that will need to be part of most restoration efforts for turtles in the Columbia Slough watershed. In the management scenario that we envision, the portion of Buffalo Slough from the terminal end and for approximately 300 feet west would be managed as the key aquatic habitat. The southwestern corner of the Port of Portland Buffalo Mitigation Site would constitute the nest area. Initial first steps include (1) discussion among all partners on feasibility, constraints, and recommendations for specific management options; (2) sufficient bathymetry work to understand existing depth profiles in terms of adequate pools of at least five feet deep and shallow areas for brood habitat, where aquatic vegetation can achieve relatively high density and that would also allow placement of large woody debris that is acceptable to MCDD standards; (3) identification of other sites along Buffalo Slough within the 300 foot project area that could be managed as nest areas on Broadmoor Golf Course adjacent to Buffalo Slough; (4) identification of areas for additional basking structures that meets MCDD standards; and (5) evaluation of need for shrubs to screen sensitive areas from human disturbance. Finally, a detailed management plan would need to be developed with clear goals, responsibilities for partners, and a clear discussion of effectiveness monitoring. The City of Portland and the U.S. Army Corps of Engineers are replacing the restricted Buffalo Slough culvert at NE 33rd just downstream from the terminal end. This may help establish brood habitat and reduce sedimentation, but also may lower water levels at some times of year (D. Helzer, City of Portland, pers. commun., June 2012). Effectiveness monitoring of work conducted at Buffalo Slough could be conducted in a manner to help inform management at this site and elsewhere (see Section X, *Monitoring*).

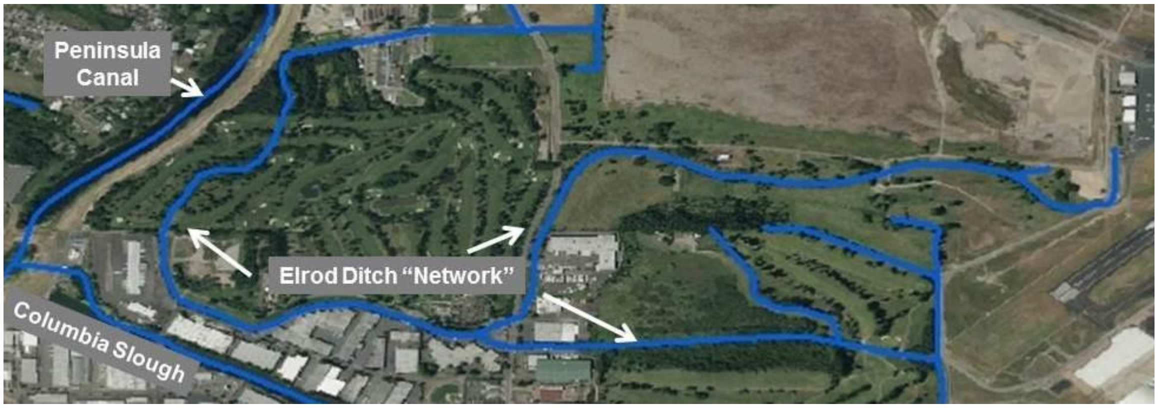
Confluence of Whitaker Slough and Columbia Slough

This area seemingly provides an excellent location for habitat improvements for brood habitat and nest areas. It may already serve one or both of these functions. The key step for this project is a formal review of site characteristics, current use by turtles, and opportunities for habitat improvement for turtles. We did not evaluate nor conduct surveys at this particular location. We note that this area is also part of the Port of Portland Buffalo Slough Mitigation site, and therefore the management of both this project and the Buffalo Slough East End project may be most efficiently conducted as a single project.

Portland International Raceway

Although there has seemingly been little consideration of this site for turtle conservation, we believe it has excellent properties for contributing substantially to the Heron Lakes TCA turtle population. There are three key areas that need further evaluation for habitat improvement before work is actually conducted. The South Wetlands may provide excellent brood and forage habitat for turtles, and is connected to the other sloughs on the PIR property. At the time of our surveys, the Middle Slough was occupied by turtles (we observed two turtles, unknown species; Appendix 1). From our brief evaluation of this slough, we believe it can provide excellent turtle habitat. Although we did not evaluate the Northern Slough, it likely has similar properties as the Middle Slough and deserves evaluation. Together, these aquatic habitats, and their connection to other contributory properties of the Heron Lakes TCA, suggest the PIR as an excellent opportunity to evaluate the efficacy of management approaches that could be conducted at many similar sites. A detailed evaluation of depth profiles, connectivity, and potential for partnership collaboration and future management responsibilities would be important prior to developing a detailed management plan. Key partners include MCDD, PIR (and generally Portland Parks and Recreation), Columbia Slough Watershed Council, and BES (City of Portland).

Elrod Ditch and Associated Drainageways



As described in Section VIII, *Middle Columbia Slough Region TCA*, there is good evidence that Elrod Ditch and many of the associated drainageways provide excellent turtle habitat and are currently occupied in many sections. There are also great opportunities for management to improve nest and potentially brood habitat. We recommend further evaluations of these areas for turtle occupancy and conservation.

X. Research and Monitoring

We recognize the limited funding available for research and monitoring within local and regional jurisdictions. Therefore, we identify a few projects that we believe are realistic for local-scale investigations and monitoring efforts in Portland and the metropolitan region.

Research

- Effectiveness of educational approaches;
- Evaluation of methods to control aquatic vegetation;
- Effects of removal of extremely dense mats of vegetation that occurs with maintenance of sloughs and other waterways;
- Evaluating the level (frequency and magnitude) and location of removal of adults and young as meat and pets;
- Evaluation of management approaches to attract turtles to created nest areas;
- Experimental study on recreation disturbance thresholds testing high and low use levels;
- Evaluation of culvert design as barrier to turtle movement.

Monitoring

There have been very few efforts at monitoring various metrics related to turtle conservation. Of those that we are aware of, all were based on the desire to track trends in abundance at a few key sites. Because of the lack of established threshold levels that would trigger management intervention and because of the recognition that survey efforts lacked precision and accuracy, these monitoring efforts do not seem to have been successful in meeting their intended goals. What was achieved is recognition at these sites that there are large turtle populations, with a better understanding of distribution and areas of specific activities, such as nesting. We do not recommend further non-targeted monitoring (e.g., Nichols and Williams 2006). Rather, we believe effectiveness monitoring will provide the type of feedback response needed to allow adaptive management to be successful. We note that careful consideration of the metric that will be monitored is crucial, and may not include counts of turtles.

Recently, Metro has designed a monitoring program that does identify several key indicators of western painted turtle populations, including target population sizes that trigger specific management actions (E. Stewart, Metro, pers. commun., June 2012). Metro's revised strategy also avoids the very expensive estimation of population size that would be required to achieve reliable estimation. We believe Metro's work in developing Key Ecological Indicators is an important step in designing a monitoring program for turtles in the Portland metropolitan area.

As an initial starting point, we recommend the following monitoring activities, some of which could include Citizen Science efforts:

- Compliance monitoring of vegetation management at proposed areas for improving nest habitat;
- Effectiveness monitoring of modification of depth profiles (Buffalo slough as test case);
- Effectiveness monitoring on turtle conservation actions at Mason Flats following Bureau of Environmental Services wetland enhancement project;
- Development of the Key Ecological Indicators (Metro strategy) for application throughout the TCA's identified in this Plan.

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XII. Appendices

Appendix 1. Columbia Slough watershed survey results. Results of surveys conducted in 2011 on 37 sites within or near the Columbia Slough watershed. RESL is red-eared slider, PATU is painted turtle, PTRES is either a slider or painted turtle, POND is western pond turtle, SNAP is common snapping turtle, and Unk was recorded for turtles that were not identified. Numbers are summarized over all observation locations within a site for that survey. CS indicates Colombia Slough crossing, WS indicates Whitaker Slough crossing, WQF indicates Water Quality Facility. Sites are shown from a generally west to east direction. GIS layers, sent to all sponsoring agencies and available from OWI, represent these results and their specific locations.

Region	Site	Survey 1	Survey 2	Survey 3	Survey 4
Lower Columbia Slough, Section 1[b]	T-5 Powerline Mitigation (Turtle and Long Ponds)	13 PATU 2 PTRES 1 Unk	11 PATU	21 PATU 4 PTRES	1 PATU
	Ramsey	78 PATU 1 RESL 3 PTRES 47 Unk	28 PATU 32 PTRES 1 RESL 3 Unk	21 PATU 29 PTRES 2 RESL	8 PATU 6 PTRES 2 RESL
	North-South Slough	0	0	0	1 PATU 1 Unk
	Leadbetter Mitigation	13 PATU 1 Unk	16 PATU 1 PTRES	3 PATU	2 PATU
	WQF Leadbetter	1 PATU	0	0	0
	Smith and Bybee complex	44 PATU 98 PTRES 3 RESL 1 POND 4 Unk	71 PATU 27 PTRES 10 RESL 6 Unk	35 PATU 39 PTRES 2 RESL	65 PATU 12 PTRES 10 RESL 3 Unk
Lower Columbia Slough, Section 2[c]	Columbia Wastewater Treatment Plant	0	0	0	0
	Heron Lakes Golf Course	8 PTRES 1 PATU	9 PTRES	5 PTRES 2 PATU	4 PTRES
	Force Lake	1 PTRES 1 Unk	0	0	1 PETRES 1 RESL
	PIR	1 Unk	2 Unk	0	0
	Vanport Wetlands	0	0	0	0

Region	Site	Survey 1	Survey 2	Survey 3	Survey 4
Lower Columbia Slough, Section 3[d]	Bridgeton Slough	0	0	1 PTRES	5 PATU 1 PTRES
	Children's Arboretum	0	0	0	1 RESL
	Peninsula Canal	187 PTRES 4 Unk	146 PTRES	127 PTRES 1 SNAP 65 Unk	1 PTRES 8 PATU 6 RESL 1 POND
Middle Columbia Slough [e]	Elrod Ditch West	8 PATU	2 PATU	0	1 PATU
	Elrod Ditch East	0	0	1 PATU	0
	CS 21	0	0	0	0
	Broadmoor Golf Course	0	7 PATU	8 PATU	3 PATU
	CS 47	0	0	0	0
	Whitaker Ponds	1 PATU	1 PTRES	0	1 PATU
	WS 63	0	0	0	0
	Colwood Golf Course	0	1 Unk	0	0
	Holman Pond	0	1 PATU	0	1 PATU
	Johnson Lake	2 PTRES	2 PTRES	1 PATU	2 PTRES
	Glen Widing	0	0	0	0
	Inverness/Prison Pond	0	0	0	0
Upper Columbia Slough [f]	CS Cross Levy	0	0	1 PATU	0
	CS 148	0	0	0	0
	WQF 148	0	0	1 RESL	1 RESL
	CS 158	1 RESL	1 RESL	0	0
	WQF 162	0	0	0	0
	CS 166	0	0	0	0
	WQF Bernard's Pond	0	0	1 PATU	0

Region	Site	Survey 1	Survey 2	Survey 3	Survey 4
	WQF Morrow Pond	3 PATU	0	6 PATU	2 PTRES
	CS 185[a]	0	1 RESL	0	0
East of Columbia Slough	Company Lake	5 PATU	3 PATU	0	0
	East Lake	1 RESL	0	0	0

[a] One painted turtle was observed at this site during habitat evaluations.

[b] Willamette River to N. Portland Dr.

[c] N. Portland Dr. to I-5

[d] I-5 to Cross Levy (Middle C. Slough)

[e] Cross Levy to 148th

[f] Cross Levy to Gresham

Appendix 2. Data from captured turtles. Sites included Peninsula Canal, Turtle Pond at T-5 Powerline mitigation site, Leadbetter, and Morrow Pond, June 28-30, 2011. PATU: Painted turtle; RESL: Red-eared slider; Capcode: C indicates first capture, R indicates recapture; sex: J is juvenile, F is female, M is male; breast was measured as the minimum span of the plastron between the front legs. Hg (mercury concentration in blood) is in micrograms/kilogram.

Site	Species	Sex	CapCode	Carapace length (cm)	Breast (cm)	Mass (g)	Hg
Pencan	PATU	J	C	16.2	7.75	475	5.63
Pencan	PATU	J	C	16.8	8.4	600	N
Turtle	PATU	J	C	14.2	7	450	21.55
Turtle	PATU	F	C	18.9	9.9	1050	15.24
Turtle	PATU	F	C	18.9	9.7	900	16.78
Turtle	PATU	F	C	17.3	9.3	850	22.88
Turtle	PATU	M	C	17.8	8.7	750	8.37
Turtle	PATU	J	C	16.4	8.2	650	12.12
Turtle	PATU	J	C	14	7.25	450	N
Turtle	PATU	J	C	13.6	7.1	400	N
Turtle	PATU	F	C	18.2	9.4	900	16.16
Ledbet	PATU	M	C	17	8.6	650	21.93
Morrow	PATU	F	C	19.3	9.45	935	18.32
Pencan	RES	F	C	19.9	9.3	855	6.11
Pencan	RES	F	C	18.3	8.8	925	6.55
Pencan	RES	F	C	18.8	9.05	1125	5.60
Pencan	PATU	F	C	19.3	9.7	925	11.02
Pencan	PATU	F	C	20.4	10.4	1125	10.17
Pencan	PATU	M	C	16.6	8.2	525	6.27
Turtle	PATU	F	R	.	.	.	.
Turtle	PATU	M	C	14.25	6.75	325	8.72
Turtle	PATU	F	C	17.5	8.9	825	17,12
Turtle	PATU	F	C	15.85	18.4	575	11.06
Pencan	PATU	M	C	15.9	7.8	503	4.70
Pencan	PATU	M	C	15.95	76.25	478	3.28
Pencan	RES	F	C	23.4	10.4	1925	17.50

Appendix 3. Aquatic invertebrate taxa observed in samples taken from eight sites. Sites included Johnson Lake, Leadbetter, Morrow Pond, Peninsula Canal, Ramsey Lake, Smith and Bybee Lakes Pond 1, Turtle Pond in the T-5 Powerline mitigation site, and Whittaker Pond.

Taxa	Common name	Phylum	Class	Order	Family	Genus
Acari	mite	Arthropoda	Arachnida	NA	NA	NA
Aquatic Oligochaete Pieces	oligochaete worm	Annelidae	Clitellata	NA	NA	NA
Asellidae	isopod	Arthropoda	Malacostraca	Isopoda	Asellidae	NA
Bryozoan Pieces	bryozoan	Ectoprocta	Phylactolaemata	Plumatellida	NA	NA
Caenidae Caenis	mayfly	Arthropoda	Insecta	Ephemeroptera	Caenidae	Caenis
Calanoida	microcrustacean	Arthropoda	Maxillopoda	Calanoida	NA	NA
Ceratopogonidae	fly/midge	Arthropoda	Insecta	Diptera	Ceratopogonidae	NA
Chironomidae	fly/midge	Arthropoda	Insecta	Diptera	Chironomidae	NA
Chydoridae	microcrustacean	Arthropoda	Branchiopoda	Diplostraca	Chydoridae	NA
Coenagrionidae	damselfly	Arthropoda	Insecta	Odonata	Coenagrionidae	NA
Collembola	springtail	Arthropoda	Entognatha	Collembola	NA	NA
Corixidae	water boatman/true bug	Arthropoda	Insecta	Hemiptera	Corixidae	NA
Crangonyctidae	amphipod	Arthropoda	Malacostraca	Amphipoda	Crangonyctidae	NA
Cyclopoida	microcrustacean	Arthropoda	Maxillopoda	Cyclopoida	NA	NA
Daphniidae	microcrustacean	Arthropoda	Branchiopoda	Diplostraca	Daphniidae	NA
Ephydridae	fly	Arthropoda	Insecta	Diptera	Ephydridae	NA
Fish	fish	Chordata	Actinopterygii	NA	NA	NA
Gerridae	water strider/true bug	Arthropoda	Insecta	Hemiptera	Gerridae	NA
Haliplidae	beetle	Arthropoda	Insecta	Coleoptera	Haliplidae	NA
Higher Diptera Larvae (Ephydridae?)	fly	Arthropoda	Insecta	Diptera	NA	NA
Hirudinea	leech	Annelidae	Clitellata	NA	NA	NA

Hyalellidae	amphipod	Arthropoda	Malacostraca	Amphipoda	Hyalellidae	NA
Hydra	hydra	Cnidaria	Hydrozoa	Anthoathecatae	Hydridae	Hydra

Appendix 3, continued…

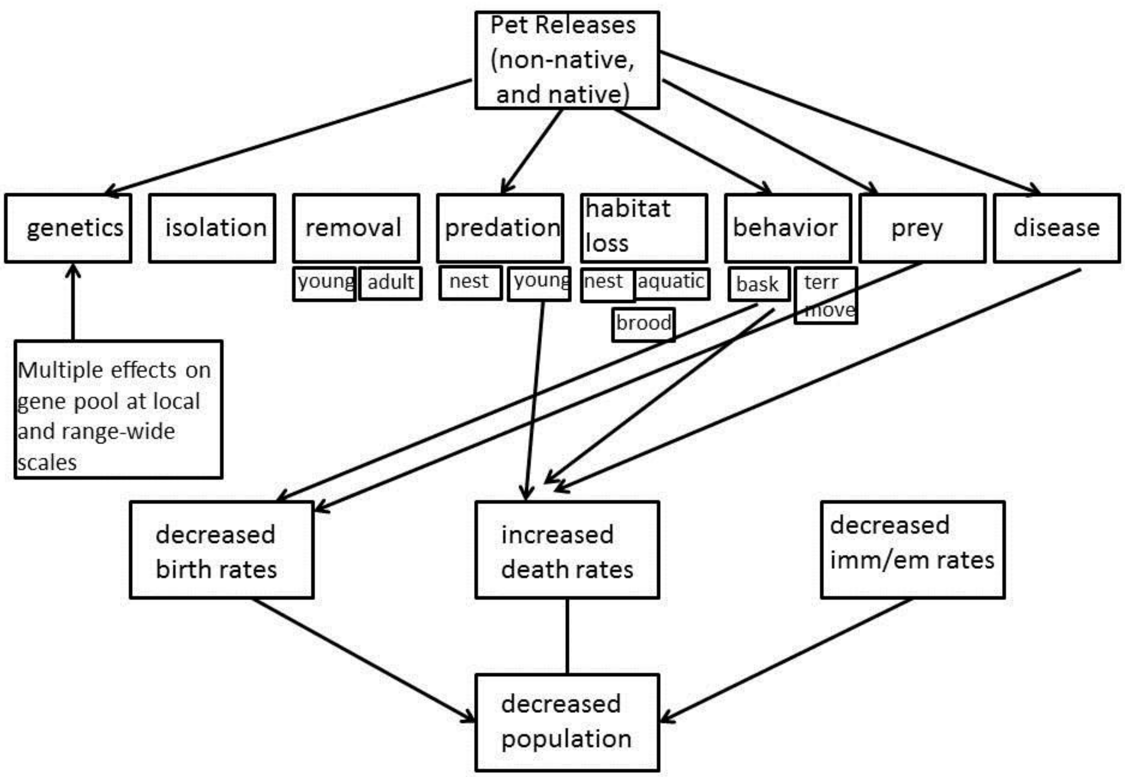
Taxa	**Common name**	**Phylum**	**Class**	**Order**	**Family**	**Genus**
Hydroptilidae	caddisfly	Arthropoda	Insecta	Trichoptera	Hydroptilidae	NA
Hydroptilidae Orthotrichia	caddisfly	Arthropoda	Insecta	Trichoptera	Hydroptilidae	Orthotrichia
Hydroptilidae Oxyethira	caddisfly	Arthropoda	Insecta	Trichoptera	Hydroptilidae	Oxyethira
Leptoceridae	caddisfly	Arthropoda	Insecta	Trichoptera	Leptoceridae	NA
Libellulidae	dragonfly	Arthropoda	Insecta	Odonata	Libellulidae	NA
Limnephilidae	caddisfly	Arthropoda	Insecta	Trichoptera	Limnephilidae	NA
Nematoda	roundworm	Nemata	NA	NA	NA	NA
Ostracoda	microcrustacean	Arthropoda	Ostracoda	NA	NA	NA
Physidae	snail	Mollusca	Gastropoda	Basommatophora	Physidae	NA
Planorbidae	snail	Mollusca	Gastropoda	Basommatophora	Planorbidae	NA
Snail fragments	snail	Mollusca	Gastropoda	Basommatophora	NA	NA
Sphaeriidae	clam	Mollusca	Bivalvia	Veneroida	Sphaeriidae	NA
Stratiomyidae	fly	Arthropoda	Insecta	Diptera	Stratiomyidae	NA
Tipulidae	fly/cranefly	Arthropoda	Insecta	Diptera	Tipulidae	NA
Turbellaria	flatworm	Platyhelminthes	Turbellaria	NA	NA	NA
Zygoptera (Probably Coenagrionidae)	damselfly	Arthropoda	Insecta	Odonata	NA	NA

Appendix 4. Conceptual models of population threats. To aid in our understanding of how each perceived threat may affect turtle populations in Portland, we developed conceptual models to link threats to stressors, and then to population processes, following the general framework described in the Desert Tortoise Recovery Plan (USFWS 2011). Each of the threats leads to one or more stressors. We identified eight generalized stressors that result from the threats: genetics, isolation, removal (loss from population either through mortality or illegally removed as pet, etc.), predation, habitat loss, behavior, prey, and disease. For removal, predation, habitat loss, and behavior, we divided the stressors into more specific pathways. For removal, we separated the pathways for young and adult; for predation, we partitioned nests and hatchlings as separate pathways; habitat loss as nest, aquatic, or brood habitat; and behavior as basking or terrestrial movements. These stressors, or their subcategories, then lead to one or more population-level effect: decreased birth rates, increased death rates, or decreased immigration and emigration rates. These population-level effects ultimately lead to decreased population sizes under the scenarios envisioned here.

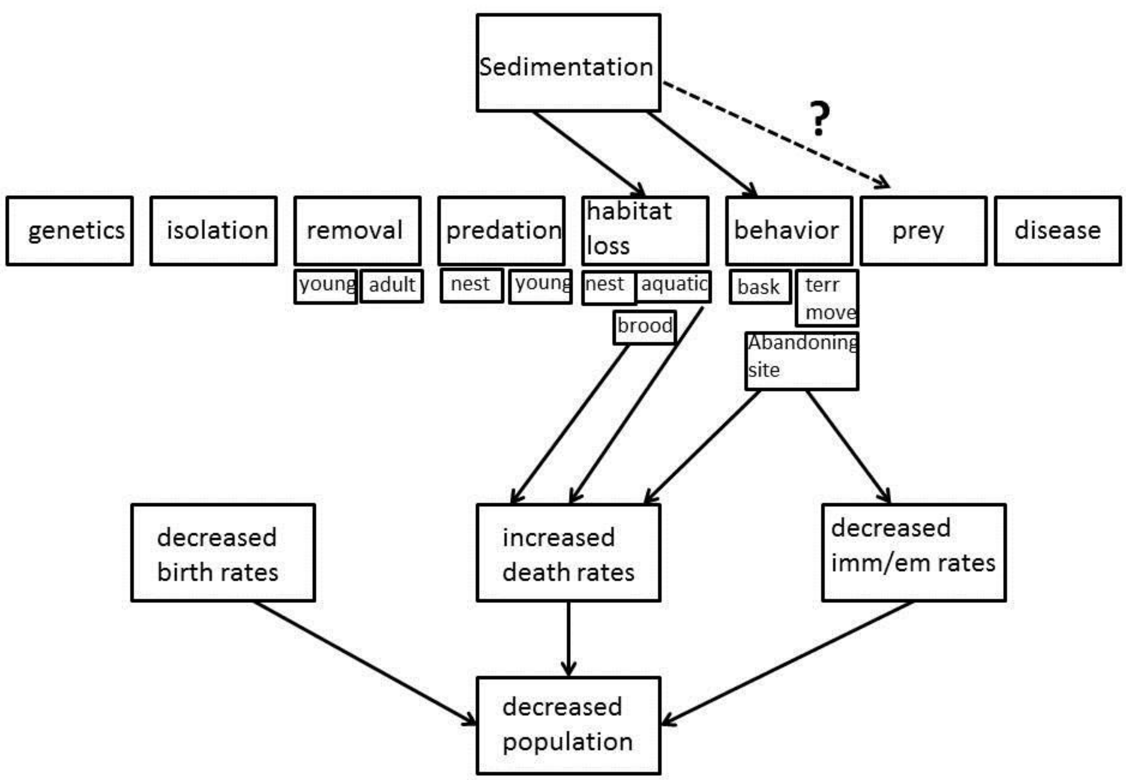
Each of the pathways of the seven key threats, in the order of ranking of greatest to lowest threat generalized to Portland, is discussed below.

Release of Turtles

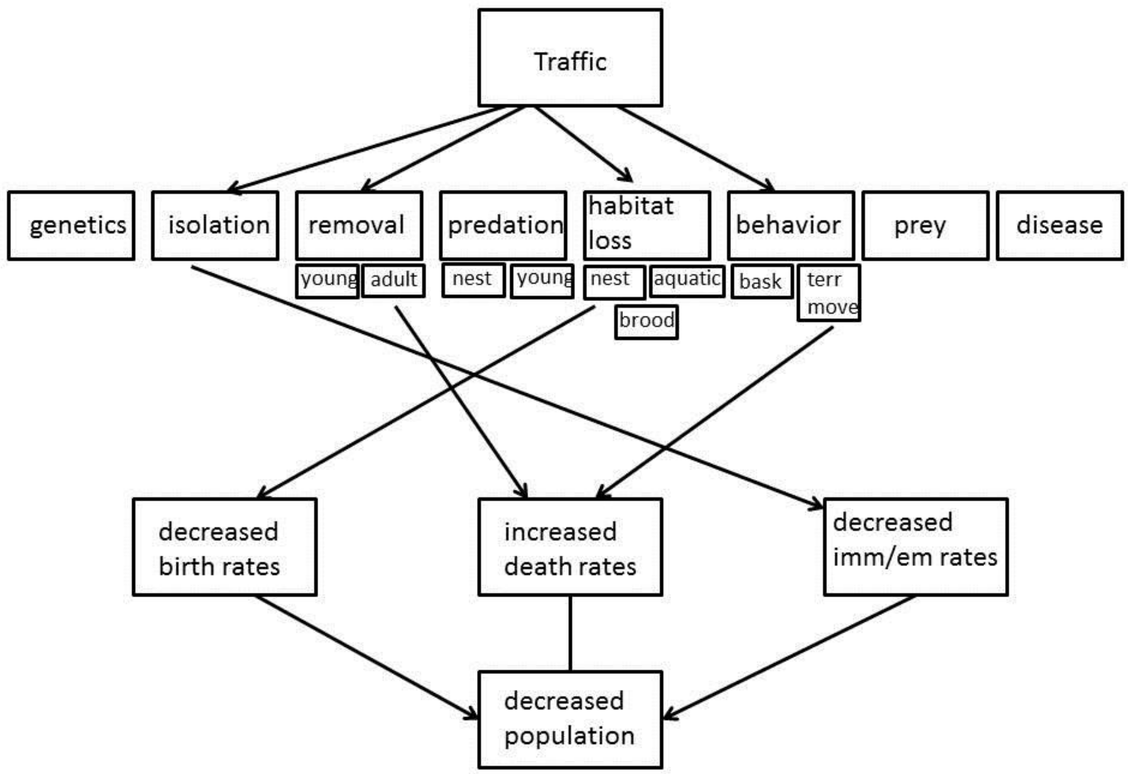
Release of turtles previously held in captivity may impact native turtles through genetic swamping, higher predation rates of hatchlings, altered behavior, reduced prey, and importantly, disease. The effects on population size depend on how turtles with the "hybrid" genes affect demographic rates; however, the population size of local gene pools would be reduced. Predation rates of hatchlings could be affected if the introduced species consumes hatchlings, which has been reported for common snapping turtles (Ernst and Lovich 2009). Introduced red-eared sliders have been hypothesized to increase native pond turtle nest predation because the sliders may nest slightly earlier, and nest predators are therefore alerted to the presence of nesting turtles by the time pond turtles begin nesting (C. Yee, ODFW, personal commun., 2009). Changes in behavior can occur through competition for basking areas. We would expect this to lead to decreased birth rates and increased death rates resulting from poorer physiological condition if basking rates are not sufficient.   Similarly, reduced prey levels could result from competition for food resources, which we believe would most likely result in lower birth rates. Perhaps most importantly, releases of captive-reared turtles have a large potential to introduce diseases to the native turtle population. This would likely lead to higher death rates. All of these factors, with the possible exception of the genetic stressors, would lead to lower population size.



Sedimentation and Dredging
In the Columbia Slough system, we believe that sedimentation could affect turtles via loss of aquatic habitat, specifically deeper pools but potentially also through loss of brood habitat if sedimentation restricts vegetation growth in shallow-water areas. Behavior may be affected leading to increased movement rates if individuals abandon the site. Prey populations may also be affected if vegetation does not re-establish. We hypothesize that loss of habitat from sedimentation results 1) in higher death rates via lower quality over-winter habitats and 2) lower immigration rates when poor conditions are encountered. All of these factors would lead to lower population numbers. Although not illustrated with the conceptual models, sedimentation results in the need for sediment removal ("dredging") in order to maintain beneficial use of the water body for stormwater management. Dredging could directly harm turtles via mortality or injury from heavy equipment. We envision harm would occur by removal of turtles in sediments particularly if dredging is conducted during the late fall to mid-winter. For example, when Laurelhurst Pond in Portland was dredged several years ago, turtles were found in dredged material where the turtles were buried, but still alive (S. Barnes, ODFW, pers. commun., June 2012).

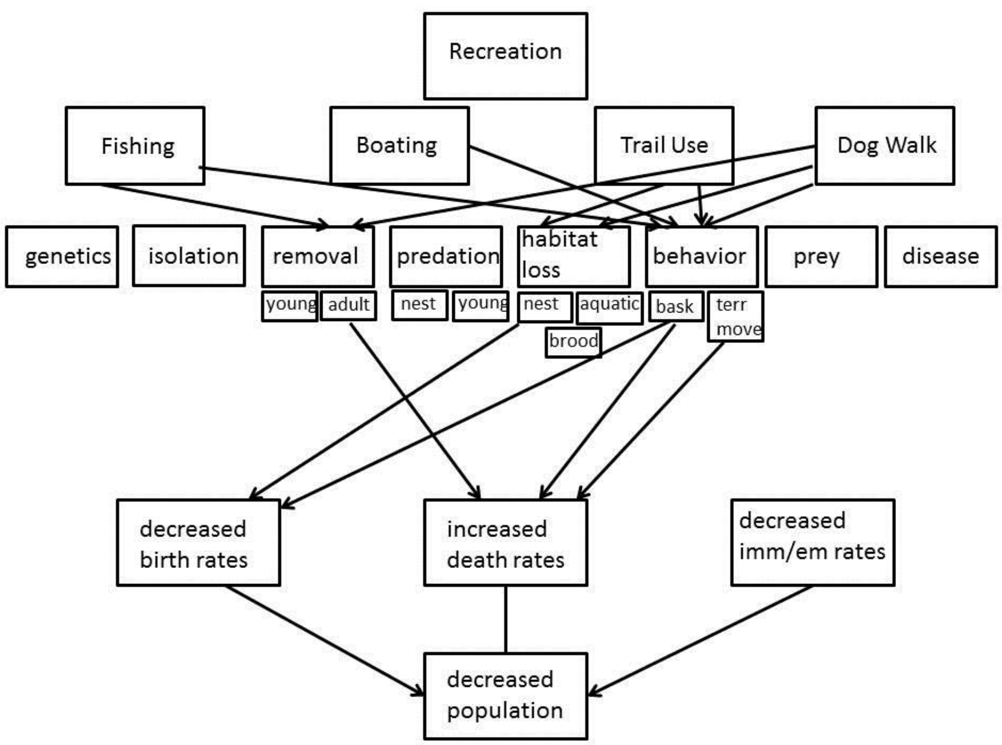


Traffic
Vehicular traffic likely affects turtles in Portland via four stressors: increased isolation form other populations, removal of adults (particularly sexually mature females), loss of nest habitat because of restricted movements, and changes in behavior which are manifested via increased terrestrial movements to search farther for nest habitat. Isolation results in decreased movements to and from other populations, removal occurs from increased adult death rates, increased terrestrial movements increases death rates, and loss of nest habitat results in decreased birth rates.



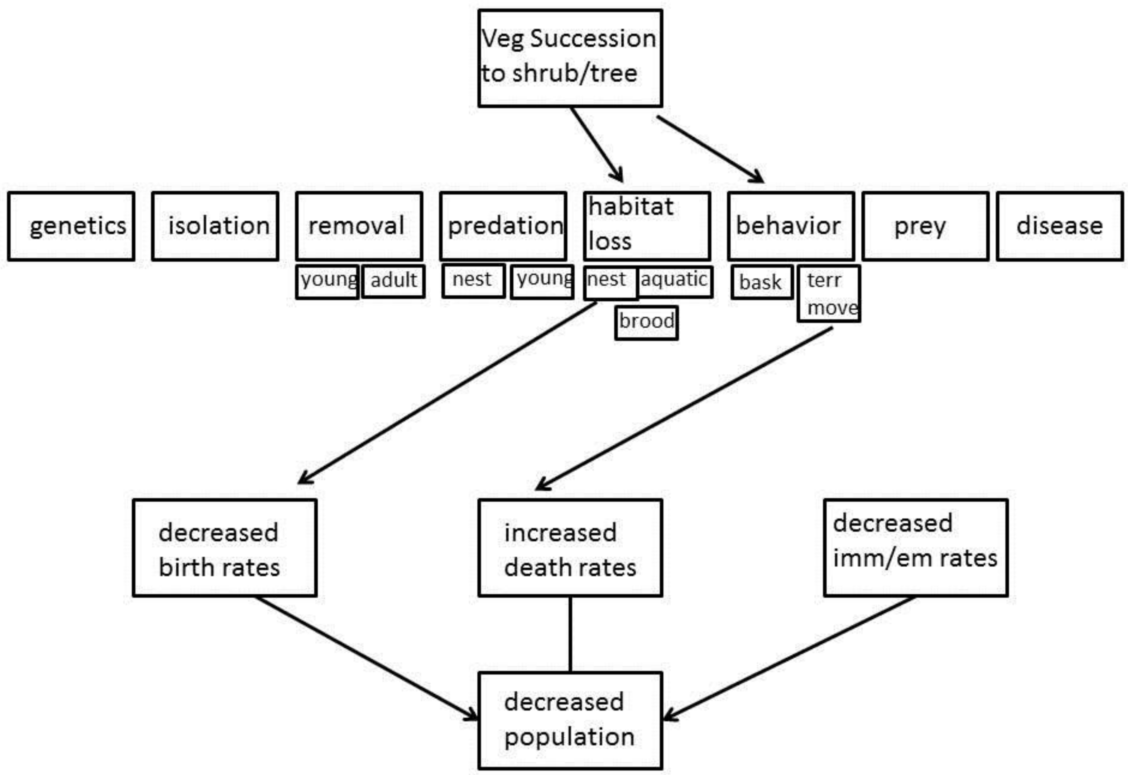
Recreation

Disturbance by recreation is an important consideration for turtle conservation in Portland because of the accessibility of many of the aquatic areas for the ever-increasing allure of outdoor recreation near home. We identified possible direct threats and pathways for four aspects of recreation that we thought were most relevant to turtle conservation: fishing, boating, trail use, and dog walking, with recognition that trail use and dog walking occur simultaneously. Fishing in Portland affects turtles via two direct stressors, removal following inadvertent capture resulting in harm but ultimately in increased death rates, and through behavioral changes by disturbance to basking, which can lead to both increased death rates and reduced birth rates. Boating affects turtles primarily through modified basking behavior. Similar to the above pathway, this can lead to both increased death rates and lower birth rates. Trail use near turtle habitat can lead to nest habitat loss by disturbing nesting turtles, resulting in reduced birth rates. Furthermore, trail use can affect behavior of turtles while basking if there is a line-of-sight between turtles and trail users. When accompanied by an unleashed dog, we postulate that the disturbance to nest areas that occurs with human use of trails is increased with the added potential direct stressor of removal via attempted predation on the turtle and/or its nest. Thus, dogs in turtle areas may result in both decreased birth rates and increased death rates. All of the hypothesized effects would be sensitive to the time of the year (see Section IV, *Life History Cycle*).



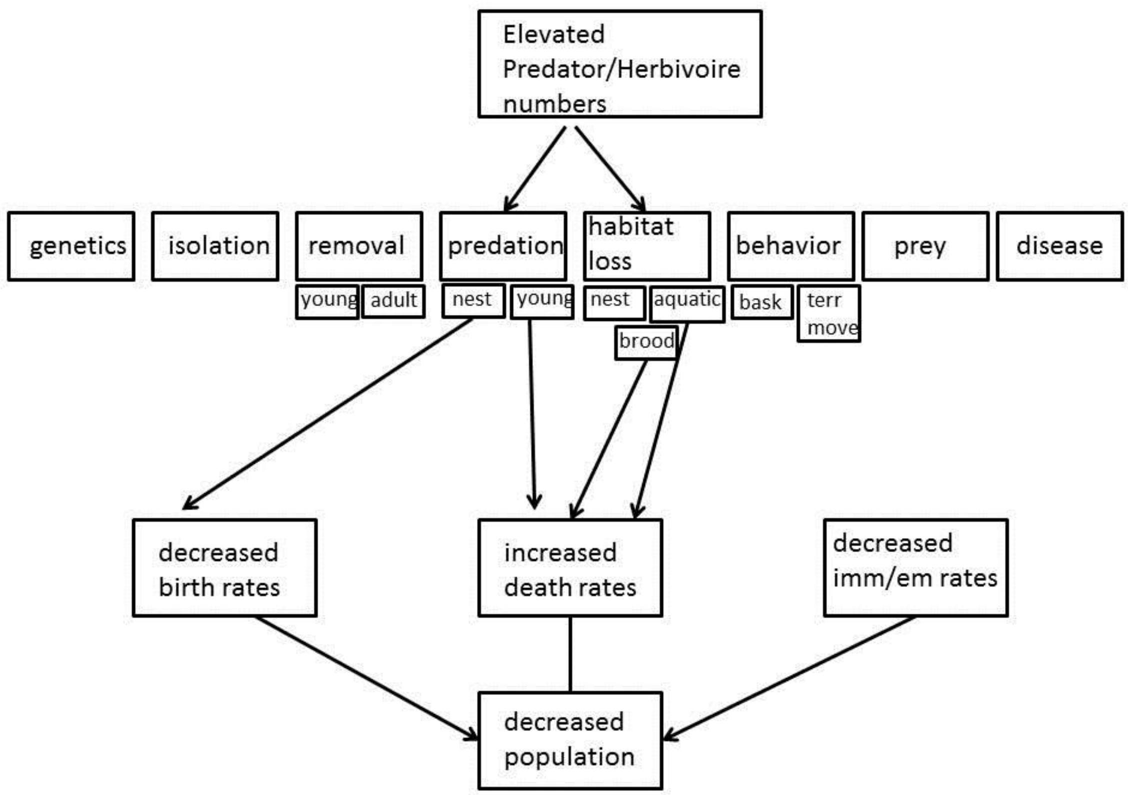
Vegetation Succession

One of the most common threats to turtle conservation in Portland is the loss of nest habitat following the shading of potential nest sites by trees and shrubs that encroach upon sparsely vegetated areas or that are planted for restoration of an area. This results in lower birth rates. Furthermore, behavior is modified by increased terrestrial movements in search of nest habitat. This results in increased death rates.



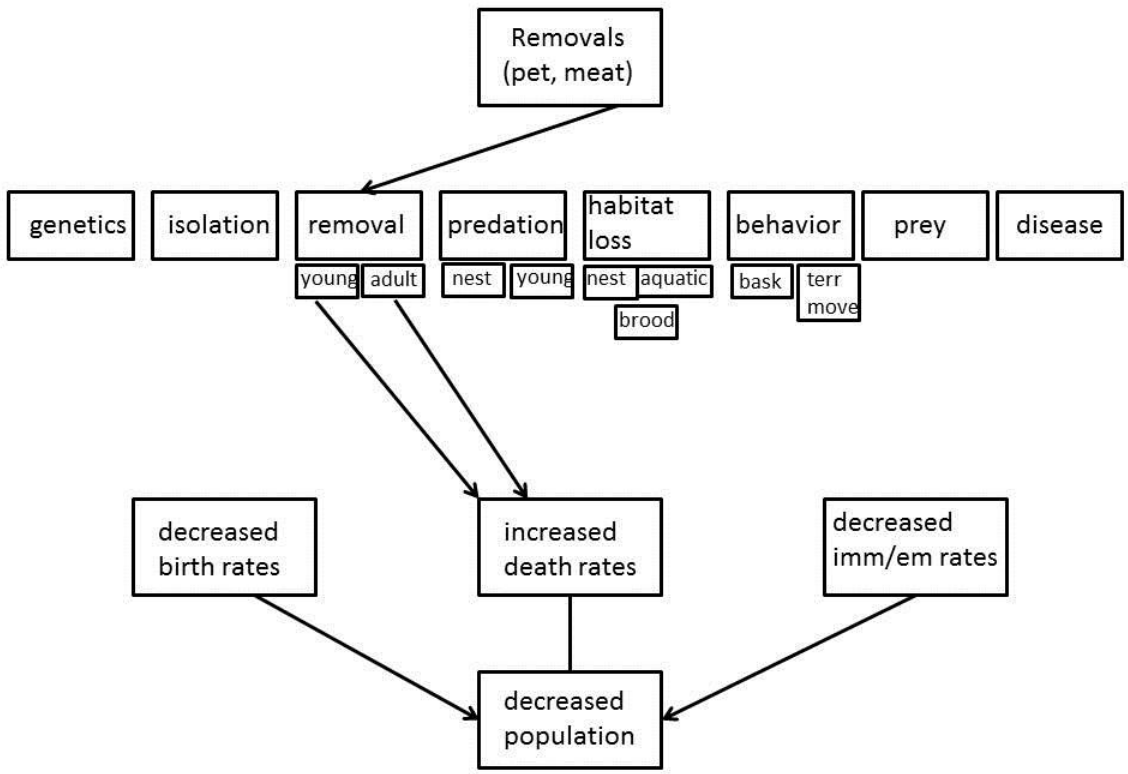
Elevated Predation/Herbivory

Elevated predation on nests and hatchlings by non-native species such as bullfrogs and bass, and from greater abundances of native predators has been the most cited concern regarding native turtles. In this threat category we included non-native carp. Carp may degrade habitat through herbivory and increased suspension of sediments. Whether or not there are realized effects to the population from the presumed elevated predation (Gervais et al. 2009, Rosenberg et al. 2009), the most likely stressors and demographic pathways would include predation of nests leading to decreased birth rates, predation of hatchlings (young) leading to higher death rates, and habitat loss from carp leading to higher death rates.



Removal of Native Turtles

Pathways for this threat are clear: removal results in increased mortality, when mortality is defined as the survival of an individual in the wild. Greater mortality rates from removal lead to decreases in population size assuming no compensatory population responses occur – i.e., lower mortality from other causes. Compensatory responses could occur when the younger age classes are removed because of their expected high mortality rates.



Appendix 5. Summary of site specific threats. We scored each site as a relative ranking of specific threats. Our scores represent our view of the entire site, based on visual or map inspection. Threat levels relate to current management. Veg (vegetation succession) relates to shading of potential nest areas. Other codes used are Tra (Traffic), Rel (Release), Sed (Sedmimentation), Trail use indicates any human disturbance along trails, paths, or roads that could cause disturbance, Rem (removal). Scores indicate low (1) to high (10) threat. A zero (0) indicates we do not believe the threat exists because the mechanism giving rise to the threat does not occur at the site under current or realistic future management; NA indicates we do not believe the site currently or as proposed in this Plan has value as nest sites. A question mark,"?" , indicates a very tentative understanding.

Region	Site	Tra	Rel	Sed	Veg	Fish	Boat	Trail	Rem
Lower Columbia Slough, Section 1 [a]	Columbia Slough	4	2	7-10	NA	?	5	5-10	1
	T-5 Powerline Mitigation	5	1	1	3	2 ?	0	1	1
	Ramsey Lakes	2	1	1	3	1 ?	0	1	1
	North-South Slough	3	1	7	NA	1	4?	1	1
	Leadbetter Mitigation	1	1	7	3	1	6 ?	1	1
	WQF Leadbetter	7	2	?	6	1	0	1	1
	Smith and Bybee complex	2	10	?	7	7 ?	7 ?	7 ?	7
Lower Columbia Slough, Section 2[b]	Columbia Slough	3	2	7-10	NA	?	5	5-10	1
	Columbia Wastewater Treatment Plant	1	1	?	10	0	0	7	3

Region	Site	Tra	Rel	Sed	Veg	Fish	Boat	Trail	Rem
	Heron Lakes Golf Course Ponds	1	2	5	8	1	0	7	1
	Force Lake	4	7	1	7	4 ?	0	4	3
	PIR	4	1	7	7	1	0	1	1
	Vanport Wetlands	3	1	?	3 ?	0	0	1	1
Lower Columbia Slough, Section 3[c]	Columbia Slough	7	2	7-10	NA	?	2 ?	5-10	1
	Bridgeton Slough	8	7	7	7	1	1	7	7
	Children's Arboretum	5	7	7	7	1	1	7	7
	Peninsula Canal	1	2	1	3	1	0	1-10[d]	7
Middle Columbia Slough	Columbia Slough	1-7	2	7-10	10 - NA	?	5	5-10	1
	Elrod Ditch West	4	2	7	4	1	0	4	2
	Elrod Ditch East	1	1	7	4	1	0	1	1
	Broadmoor Golf Course	1	1	7	7	1	5 ?	7	1
	Whitaker Slough (to Colwood GC)	1-7	2	8-10 ?	1-10	5-8 ?	1-3 ?	1	1
	Whitaker Pond - East	2	2	7 ?	7	1 ?	1	1	1
	Whitaker Pond -West	1	7	7?	7	7?	2	8	3 ?

Region	Site	Tra	Rel	Sed	Veg	Fish	Boat	Trail	Rem
	Colwood G. C.	1	1	7	7	1	1 ?	7	1
	Holman Pond	5	10	?	8	?	1	8	4
	Johnson Lake	4	5	7	7	?	?	1	1
	Glen Widing	10	7	?	8	?	1	4	1
	Inverness/Prison Pond	10	10	?	NA	?	1 ?	2	5
Upper Columbia Slough	Columbia Slough	1-7	2	7-10 ?	7-10, NA	?	5-9	5-10	1
	CS Cross Levy	1	2	7-10	8	?	1 ?	3	2
	WQF 148	5	1	?	7	1	0	3	2
	WQF 162	8	1	?	8	1	0	8	2
	WQF Bernard's Pond	8	1	?	7	1	0	3	2
	WQF Morrow Pond	2	1	?	7	1	0	1	2
	CS 185/CS02b [Gresham]	4	1	7	7	1	1	1	1
East of Columbia Slough	Company Lake	1	4	?	7	?	1	4	2
	East Lake	1	1	?	7	?	1	1	1

[a] Willamette River to N. Portland Dr.
[b] N. Portland Dr. to I-5
[c] I-5 to Cross Levy (Middle C. Slough)
[d] Highly vulnerable with proposed trail

Appendix 6. Habitat suitability scores for each site. We define suitability as the ability to support all life stages of turtles; the score is based on juxtaposition of forage/bask, brood, and nest habitat, and connectivity to other sites to increase effective area. Suitability scores are the min of each contributory factor, with adjustment for connectivity. Scoring is based on our perceived quality regardless of actual current use. The scores ignore threats. Scores indicate our ranking of their quality given the criteria evaluated. Scores are based on limited evaluations and will require further evaluation prior to management actions. Sites can be a major contributor to turtle conservation and still retain a low suitability score. Scores range from 1 (low) to 10 (high).

Region	**Site**	**Connectivity**	**Forage/Bask**	**Brood**	**Nest**	**Suitability**
Lower Col. Slough, Section 1 [a]	Columbia Slough	10	1 - 4	1	1	1
	T-5 Powerline Mitigation	10	10	10	10	10
	Ramsey Lakes	10	10	10	10	10
	North-South Slough	10	1	1	7	1
	Leadbetter Mitigation	10	8	10	10	10
	WQF Leadbetter	7	5	2	7	2
	Smith and Bybee complex	10	10	10	10	10
Lower Col. Slough, Section 2[b]	Columbia Slough	10	1-3	1	1	1
	Columbia Wastewater Treatment Plant	1	5	5	2	2
	Heron Lakes Golf Course Ponds	10	5	8	4	5
	Force Lake	5	4	4	5	4

Region	**Site**	**Connectivity**	**Forage/Bask**	**Brood**	**Nest**	**Suitability**
	PIR	7	7	6	6	6
	Vanport Wetlands	5 ?	4	5	10	4
Region	Site					
Lower Col. Slough, Section 3[c]	Columbia Slough	10	1	1	1	1
	Bridgeton Slough	7	6	8	3	3
	Children's Arboretum	7	5	8	5	5
	Peninsula Canal	7	10	10	10	10
Middle Col. Slough	Columbia Slough	10	1-8	1 - ?	1-5	1-5 ?
	Elrod Ditch West	8	8	8	6	6
	Elrod Ditch East	8	8	7	8	8
	Broadmoor Golf Course (Elrod trib, CS, Buffalo S.)	10	10	8	7	7
	Buffalo Slough	10	10	10	10	10
	Whittaker Slough from CS through Colwood GC	10	10	10	10	10
	Whitaker Pond – East	8	10	10	10	10
	Whitaker Pond -West	8	10	10	10	10
	Colwood Golf Course	10	10	10	10	10
	Holman Pond	7 ?	6	5	5	6
	Johnson Lake	6	4	4	6	4
	Glen Widing	1	8	8	5	1

Region	Site	Connectivity	Forage/Bask	Brood	Nest	Suitability
	Inverness/Prison Pond	10	8	6	1	1
Upper Col. Slough	Columbia Slough	10	1-8	1-4	1-4	1-4
	CS Cross Levy	10	7	4	10	4
	WQF 148	9	8	8	8	8
	WQF 162	9	8	8	8	8
	WQF Bernard's Pond	9	8	8	8	8
	WQF Morrow Pond	9	7	8	8	7
	CS 185/CS02b [Portland/Gresham]	10	10	10	?	10
East of Col. Slough	Company Lake	8	10	8	8	8
	East Lake	10	8	8	8	8

[a] Willamette River to N. Portland Dr.
[b] N. Portland Dr. to I-5
[c] I-5 to Cross Levy (Middle C. Slough)

Appendix 7. Summary of location records from previous GIS Databases. Records omitted for those that resulted from the surveys described in this Conservation Plan. Locations in ORNHIC database are not listed here because they were redundant with the other databases we searched. When databases were redundant on several records we only included one record of an observation. SB indicates Smith Bybee Wetlands Natural Area.

FID/OID	Observer	Date	Species and Number	Location	Database	Comments
0	Unk	March 2007	1 Pond	Crystal Springs	ODFW Cit. Sci.	
1	James Andrews	April 2007	Pond	East of Swan Lake, Greely and Sumner Streets	ODFW Cit. Sci.	Terrestrial, in backyard, overlooking bluff above Willamette R
4	Rachel Felice	May 2005 and 2006	5 Painted	Whitaker Slough and west W. Pond	ODFW Cit. Sci.	
19/131	Chris Cox / Lyane Kimnel	June 2007 / June 2008	2 Painted / 1 unk	Humane Soc Pond @ Columbia Blvd	ODFW Cit. Sci.	
26	Steve Leibrant	Aug 2007	1 unk	approx.. 1 mi. south of Wright Island; 8000 block of N. Chase Ave.	ODFW Cit. Sci.	Terrestrial, in backyard,
63	Laura Kudiska	July 2008	1 Pond	Oaks Bottom Refuge	ODFW Cit. Sci.	Terrestrial, grassy area. Yellow stripes noted, possible painted

FID/OID	Observer	Date	Species and Number	Location	Database	Comments
132/144	Unk/unk	July 2008/June 2008	4 unk/7 unk	Laurelhurst Park pond	ODFW Cit. Sci.	
141/142	Unk	June 2008	6 (sliders and unk)	SB	ODFW Cit. Sci.	
196	Unk	July 2008	unk	SB trail near landfill	ODFW Cit. Sci.	Turtle digging
210	Unk	Aug 2008	Unk	T-5 Powerline road	ODFW Cit. Sci.	Dead on road
216	Dave Kennedy	Aug 2008	Painted	Col Slough @ 82nd	ODFW Cit. Sci.	
226	Unk	October 2008	1 Painted	T-5 Powerline mitigation pond area	ODFW Cit. Sci.	Turtle walking trying to cross RR tracks
2	Mart Hughes	June 2009	2 unk	Bridgeton Slough	City of Portland	Point shown on GIS is East Bridgeton Slough
1	Dave Helzer	June 2009	3 unk	Port swale east of Lombard Bridge	City of Portland	Port of Portland "North/South Slough" mitigation area
8	Toby Query	June 2010	3 unk	Ramsey Stormwater facility	City of Portland	
5	Marc Hayes	1993	19, Unk	SB	Metro	

FID/OID	Observer	Date	Species and Number	Location	Database	Comments
6	Marc Hayes	1993	"many" , Unk	North Slough, SB/Landfill	Metro	
10	E. Barclay	1994/1995	32 Nests	SB wetlands	Metro	
23	Bruce McClelland	2001	No data	Peninsula Canal	Metro	
25	Jim Hartman	2001	1 Unk.	Crystal Springs area	Metro	
29	M. Hughes	1999	2 Unk.	Spring and Johnson Creek		
34	N. Proctor	2001	1 Painted	Reed College Canyon	Metro	
44	M. Miller	1999	3 Unk	Audubon Pond	Metro	Forest Park area
68	Dan Holland	1993	1 Pond	SB	Metro	
69	P. Kavanagh	1965	1 Painted	Near Hoyt Arboretum		Collected turtle?
74	Dan Holland	1993	128 Painted	SB	Metro	
76	Graf et al.	1939	Painted	Kelly Pt area	Metro	
78	Dan Holland	1991	1 Painted	Audubon Pond	Metro	Forest Park area

FID/OID	Observer	Date	Species and Number	Location	Database	Comments
85	D. Kromer	2000	>10 NLA*, Pond	SB	Metro	
86	D. Kromer	2000	>10 NLA*, Pond	Outside Forest Park area	Metro	
87	T. DeLorenzo	1990	No data	Mt Scott area	Metro	GIS pt in residential area
91	E. Barclay	1995	128 Painted	SB wetlands	Metro	
95	Port of Portland	1999	7-23 Painted	T-5 Powerline Mitigation ponds	Metro	
96	A. St John	Unk.	1 Unk.	NW Portland, Washington Park area	Metro	
107	E. Roth	1999	>10 NLA*, Painted	Outside Forest Park area	Metro	
109	E. Roth	1999	>10 NLA*, Painted	SB	Metro	
110	E. Roth	1999	>10 NLA*, Painted	SB	Metro	

*We do not know what the acronym "NLA" indicates.

Appendix 8. Habitat recommendations for western painted turtles provided by Bureau of Environmental Services, City of Portland.

Western Painted Turtle
Habitat Recommendations for Restoration Projects

UPDATED VERSION • June 20, 2012

Compiled by City of Portland Bureau of Environmental Services. Contact: Dave Helzer.

These specifications were complied to inform the Mason-Winmar Flats Wetland Enhancement Project (Columbia Slough). The intent of this document is to provide detailed design specifications for botanists, biologists, engineers, and construction inspectors working on the Mason-Winmar Project. Ideally, these specifications will also inform other painted turtle habitat projects in our area.

CONTENTS:
Timing of construction, wood placement, pond conditions, nesting habitat design & maintenance

BACKGROUND

The Western Painted Turtle (*Chrysemys picta bellii)* is native to Oregon and in significant decline; it is listed as Critical-Sensitive by the Oregon Department of Fish and Wildlife. These turtles occur in quiet, low gradient backwater sloughs and wetlands. A population persists in the Columbia Slough Watershed in Portland. More information on the life history and conservations status of the turtle is available in the Conservation Assessment referenced below; BES is also working a set of Turtle Guidelines for park managers and restoration project managers.

TIMING OF CONSTRUCTION

If turtles are present in the project area, the best time for major construction is mid-August to the end of September. Consult with local biologists to develop a turtle rescue plan during construction.

WOOD PLACEMENT

Placing wood in the project site provides two benefits for Western Painted Turtles. Adult turtles require logs for basking and juvenile turtles require logs/woody debris for cover and basking.

Basking Logs for Adults:
For every half acre surface of open water, place at least two logs in the center of the water body, close to the deepest part of the pond. Cable and anchor logs to maintain their position in the center of the ponds. Logs should be 8 to 20 inch diameter and a minimum of 6 feet long with bark and limbs attached. Root wads may or may not be attached.

In addition to the floating logs, supplemental logs can be placed on the east and west shores of the ponds. Position the logs so that a majority is at, or above, the water's surface for April-May water levels. Place additional logs at variety of angles and depths, with some perpendicular to the shore with the majority of the log extending out into the open water. Log spacing in these areas should be every 20-30 feet. Logs and limbs can also be piled to create complexity, cover from avian predators, and varied basking opportunities.

If logs cannot be anchored in the middle of the ponds, increase the number of logs along the shore. Additional logs can also be placed on the north banks if they do not interfere with potential nesting areas.

Root Wads for Juveniles:
Placing root wads in the east, north and west edges of each pond will greatly benefit juveniles. Place at least one large root wad in 6-24 inches of water, 2-10 feet from shore (April-May water levels; within the 2-10 foot range, further into the water – closer to 10 feet – is better). They will receive the highest use from juveniles if they are surrounded by thick vegetation. Smaller diameter logs and limbs are also appropriate in shallow areas for juvenile turtles.

POND CONDITIONS

Water Depth
A variety of water depths is important. Shallow areas that are 6 inches to 2 feet deep, sunny, and sheltered from wind are important for juveniles. Deeper areas are also needed; plan for minimum depth of 3-4 feet in annual low water conditions. It is desirable to allow some wetland areas to dry completely during the low water season, but permanent water at least 3-4 feet deep should be present on the site year round.

Aquatic Vegetation
The shallows should host emergent vegetation for cover. Macrophytes (i.e. native *Elodea*) also provide both a food resource and cover within ponds and should be promoted. The presence of lots of aquatic (e.g., submergent or floating) vegetation is important, *Elodea, Potamogeton,* and *Polygonum* are ideal. Cattails (*Typha*) and bulrushes (*Scirpus*) are less desirable for turtle habitat.

NESTING HABITAT

Turtles need nesting habitat in close proximity to wetlands. In Oregon, they may move as much as 100 m from the water, but typically nest as close to the water as conditions allow. Typical distance ranges from 0.5 to 50 m. Locate (or enhance) nesting habitat as close as possible to ponds/wetlands, but above annual high water. It is preferable to create several patches of nesting habitat rather than one contiguous patch. Ideally, each patch will be at least 625 square meters (25m x 25m). Smaller patches can be created (or enhanced) but they will colonized by plants and shaded out sooner than larger patches.

Slope & Aspect
Full solar exposure is critical for nesting areas; avoid areas that will be shaded during any portion of the day. Flat sites are ideal for nesting habitat, if there is any slope the site must have a southern aspect. Is the site is not flat, ideal slope is 10-15 degrees; avoid slopes above 30 degrees. 50 degrees is an absolute maximum for slope. Again, south facing is key.

Vegetation in Nesting Areas
Plant clumps of native grasses and forbs less than 2' in height that are not aggressive in colonizing a site. Maintain areas of open bare ground, 40 percent vegetated cover is a good target. Native shrubs can be planted at about 30 foot spacing but do not use species that are aggressive and will colonize the site. Use caution with shrub placement as it is important that shrubs do not shade out nesting areas. If you are working with a smaller nesting patch, avoid planting shrubs as they will shade a majority of the site.

Table 1. Metro Parks and Greenspaces has seeded the following grass and forb species (clumped mosaic pattern with bare ground interspersed) for nesting habitat at Smith & Bybee Wetlands.

Scientific name	**Common name**
Festuca occidentalis	Western fescue
Lotus purshianus	Spanish-clover
Gilia capitata	Bluefield gilia
Achillea millefolium	Yarrow
Prunella vulgaris	Self-heal
*Lupinus bicolor**	Two-color lupine

*avoid L. *rivularis* & L. *polyphyllus* as they have larger growth forms and can provide too much shade in the nesting area.

Table 2. Metro Vegetation Monitoring Results for Nesting Habitat at Smith & Bybee Lakes. Includes many un-intended species that colonized the site, an expected outcome.

Scientific name	**Common name**	**2005 percent cover**	**2006 percent cover**	**2007 percent cover**
Festuca occidentalis	Western fescue	9	6	32
Poa sp.	Annual grass	-	-	10
*Trifolium arvense**	Hare's-foot	T	15	9
Lotus purshianus	Spanish-clover	3	1	6
Gilia capitata	Bluefield gilia	T	-	2
Bromus sichensis	Sitka brome	-	-	2
Achillea millefolium	Yarrow	2	1	1
*Hypericum perforatum**	St. John's wort	-	-	1
Agrostis exarata	Spike bentgrass	1	16	T
*Plantago psyllium**	Sand plantain	T	T	T
Navarretia squarrosa	Skunkweed	T	-	T
Hieracieum sp.*	Hawkweed	-	-	T
Gnaphalium uliginosum	Marsh cudweed	T	-	-
Prunella vulgaris	Self-heal	T	5	-
Conyza canadensis	Horseweed	T	2	-
Lupinus bicolor	Two-color lupine	2	T	-
Deschampsia elongata	Slender hairgrass	5	-	-
Elymus glaucus	Blue wildrye	T	-	-
TOTAL		27	49	63

* Indicates non-native species.

The ideal species mix depends on soil conditions. A variety of native upland prairie species are suitable. Most importantly, avoid grasses that spread quickly, especially those that are rhizomatous (i.e., spread with runners as opposed to clumping forms).

<u>Soil Matrix</u>
To work with existing compacted soils, till/mix gravel into the soil to loosen it up and keep vegetation down. Sandy soils can be amended with native silt loam to improve the substrate. Vegetation can be suppressed in some sections by covering with fine gravel or clay.

When importing local fill, cover an area (at least 25m x 25m) to a depth of 30 cm (1 foot) to 60 cm (2 feet).

Guidelines for ideal fill for nesting habitat: 25% or less fine clay, 25-50% sand, and 25% aggregate. Use ¼ minus gravel (rounded if available); aggregate may be mixed with loose organics. For the aggregate gravel size, expert recommendations range from ¾ inch down to 1/8 inch.

The following construction specification was used for the Mason Flats Wetland Enhancement II BES Project # E10406:

> **01091.12 Turtle Habitat** - Turtle nesting aggregate which is a blend of 10% native silt/sand, 40% import coarse sand, and 50% import 5/8-inch crushed aggregate. Material shall meet the following requirements:
>
> (a) **Native Silt/Sand** - Excavated material from site, free of organic materials and debris shall be acceptable.
> (b) **Import Coarse Sand** - Shall be free from overburden, spoil and organic material, and will comply with Coarse Sand as defined by ASTM D2487.
> (c) **Import 5/8-inch Minus -** Shall be free from overburden, spoil and organic material.

If above ideal specifications cannot be met, any available fill can be used, providing it does not have a high percentage (more than 50%) of organic material or silt which compacts easily and retains moisture, or is mostly large aggregate (e.g. > 1 inch / 25mm diameter). Good drainage is a key element of nesting substrate.

NESTING HABITAT MAINTENANCE

Nesting sites will need long term maintenance to control vegetation succession. Fresh fill can also be added after a few years. The timing of nest site maintenance should avoid emerging hatchlings and adults seeking sites to lay eggs. The best time in Portland is often early May, but specific timing should be based on monitoring and/or by consulting with local turtle biologists on the timing of the local population. If there are no eggs over wintering in a site, maintenance can take place anytime November to March.

REFERNECES:

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