Conservation Assessment For The

Western Painted Turtle

In Oregon

(*Chrysemys picta bellii*)

Version 1.0
August 2009

Sponsored by:
U.S.D.I. Bureau of Land Management and Fish and Wildlife Service
U.S.D.A. Forest Service Region 6
Oregon Department of Fish and Wildlife
City of Portland
Metro

Jennifer Gervais and Daniel Rosenberg
Oregon Wildlife Institute

Susan Barnes
Oregon Department of Fish and Wildlife

Claire Puchy
City of Portland
Bureau of Environmental Services
Science, Fish and Wildlife Program

Elaine Stewart
Metro

Jennifer Gervais and Daniel Rosenberg are Ecologists with the Oregon Wildlife Institute, and faculty members in the Department of Fisheries and Wildlife, Oregon State University.
Susan Barnes is the Northwest Region Wildlife Diversity Biologist with the Oregon Department of Fish and Wildlife.
Claire Puchy is the Terrestrial Ecology Enhancement Strategy Program Coordinator, Bureau of Environmental Services, City of Portland
Elaine Stewart is a Senior Natural Resources Scientist with Metro

Table of Contents

Data Disclaimer

The location data used in this Assessment were gathered from numerous sources, none of whom are responsible for the accuracy of the data, nor was the accuracy of the data evaluated as part of this Assessment. The agencies that contributed data make no warranty of any kind, expressed or implied, including any warranty of merchantability, fitness for a particular purpose, or any other matter with respect to its geospatial data. The agencies and the authors of this Assessment are not responsible for possible errors, omissions, misuse, or misrepresentation of its geospatial data. If you have information that will assist in conserving this species or questions concerning this Conservation Assessment, please contact the Oregon Wildlife Institute: http://www.oregonwildlife.org

Executive Summary

Species: Western painted turtle (*Chrysemys picta bellii*)

Taxonomic Group: Reptile

Management Status:
U.S.D.I. Fish and Wildlife Service Species of Concern, U.S.D.A. Forest Service, Region 6 and U.S.D.I. Bureau of Land Management in Oregon-- Sensitive Species. Oregon Conservation Strategy - Strategy Species and Oregon Sensitive-Critical species. Washington—no special status. Natural Heritage Global Rank: G5 (Demonstrably widespread); State Rank in Oregon: S2 (imperiled); State Rank in Washington: S5 (Demonstrably widespread).

Range:
The painted turtle is the most widespread native turtle species in North America, occurring from the Atlantic to the Pacific coasts. Its range includes most of the eastern and central United States. The subspecies *C. picta bellii*, the western painted turtle, occupies the largest portion of the species range, from western Ontario to British Columbia and south into the central United States. In Oregon, native western painted turtles are narrowly distributed along the northern portion of the state. They are found in north-central and north-eastern Oregon, primarily in the Columbia River Basin, and in the northern portion of the Willamette Basin, primarily north of Salem. Painted and pond turtles co-occur in aquatic habitats in the northwest portion of Oregon, especially in the Willamette basin north of Salem.

Specific Habitat:
Aquatic and terrestrial habitats are required for western painted turtles. Their aquatic habitat is typically slow-moving and shallow water, including streams, canals, sloughs, small lakes, and ponds. They appear to select water bodies with surface or emergent vegetation and a muddy substrate. Terrestrial habitat is used primarily for nesting, but occasionally for over-wintering and overland movements among aquatic habitats. Nest habitat is composed of sparsely vegetated areas with southern exposure near aquatic habitat, usually within 50 m. A broad array of substrates is used for nesting, including recent fill. Over-wintering is often in shallow aquatic environments but also occurs in terrestrial habitats. Little is known of habitat use by hatchlings, but evidence suggests they tend to use shallower aquatic habitats. In Oregon, western painted and western pond turtles use similar habitat. The primary difference appears to be the painted turtle's greater dependence on aquatic habitat for over-wintering and selection of slower, more stagnant aquatic habitats.

Threats:
Threats to western painted turtles in Oregon are very similar to western pond turtles and are often landscape-specific. Factors most often cited as limiting western painted turtle populations include loss of wetland and upland habitat, and elevated nest and hatchling

predation. Elevated hatchling predation has been purported to be from introduced fish and bullfrogs, but evidence is lacking to support this hypothesis. Predation on nests is believed to be elevated in urban environments due to greater abundance of mid-sized predators that have adapted to human disturbance such as raccoons, skunks and coyotes, but there has been little quantification of these threats. Reduced nest site availability is a concern as well, particularly in urban environments. Because a large portion of the western painted turtle population in Oregon is in or near urban areas, threats are tied to factors associated with large human populations. This includes road mortality and limited connectivity between nesting, over-wintering, aquatic, and dispersal habitat, competition from introduced turtle species, human disturbance from increased recreational use of aquatic systems, and indirect effects of pesticide use. Indirect effects of research activities in some populations are a concern. Although wetland systems are often protected, the adjacent upland areas that are crucial for reproduction are frequently not protected. An important and increasing threat is the loss of genetic uniqueness because of release of pet painted turtles. Most of these threats are associated with the reduction in habitat and increased human access in the western portion of the painted turtle's range in Oregon.

Management Considerations:

Conservation actions to improve conditions for western painted turtles in Oregon include improving aquatic and terrestrial habitats especially in managed waterways such as the Columbia Slough, increasing connectivity among populations, and reducing loss of adults by decreasing road mortality and reducing illegal removal by the public. Improving or creating nest habitat, hatchling habitat, and basking structures in some aquatic habitats, and managing recreation near turtle-use areas are feasible management actions. Populations of introduced and invasive species, especially the red-eared slider and more recently the common snapper, need to be managed. Furthermore, eliminating the release of pet painted turtles is vital to maintain genetic integrity of the populations in Oregon. Education on introductions and translocations is critical to reduce or eliminate the frequency of these often well-intended activities by the public. Further, if the threat of the capture and removal of western painted turtles from their native habitats in the Portland metropolitan areas is as high as local natural resource professionals fear, instituting a volunteer citizen "watch" may be very useful. Because of long-term survey and research efforts that have been occurring at some vulnerable populations, we recommend the development of a larger-scale research and survey strategy, designed to avoid or minimize possible impacts on turtle populations from all of the survey and research activities. Further, if the threat of removal of painted turtles in the Portland metropolitan areas is as high as local natural resource professionals fear, instituting a volunteer citizen "watch" may be very useful. Because of long-term survey and research efforts at some vulnerable populations, we recommend the development of a strategy to avoid or minimize possible impacts on turtle populations.

Development of a conservation plan for painted turtles in the Portland metropolitan region would facilitate the coordination of effective conservation actions across numerous jurisdictions. Because western painted turtles occur largely on private lands and designated open spaces managed by public agencies, management will need to focus on non-federal lands, and engage private landowners and local municipalities.

Inventory, Monitoring, and Research Opportunities:
The overall distribution of the painted turtle is generally well known in Oregon, with significant populations primarily in the Columbia and Willamette Basins. Although not occurring frequently in the location databases, western painted turtles are believed to be most common in the Columbia River Basin. Its distribution on public lands is probably better known than on private lands. Based on location data and the range of the western painted turtle in Oregon, lands held by the federal government are unlikely to contribute appreciably to conservation of western painted turtles. Lands managed by the State, several counties, and local municipalities probably have the potential to play the largest role for public lands regarding western painted turtle conservation.

Survey efforts have resulted in development of survey protocols although most surveys conducted on western painted turtles have used multiple protocols, including *ad hoc* procedures. The protocols have undoubtedly improved the likelihood of detecting painted turtles but standardized methods alone are not sufficient for reliably estimating abundance, including occupancy and trends in abundance through time. Further evaluation of these methods and recognition of their uses and limitations would be desirable.

Research topics that are most likely to contribute to the conservation of western painted turtles in Oregon include (1) understanding the level and causes of nest and hatchling predation, (2) identifying methods to reduce predation on nests and hatchlings when appropriate, (3) evaluating habitat requirements of hatchlings, (4) evaluating methods to reduce road mortality, and (5) identifying methods to increase the suitability of waterways and adjacent terrestrial habitat within the range of the painted turtle in urban areas. Research on educational tools to highlight the importance of not releasing pet turtles to aquatic systems and to not remove native turtles is needed. Further, research should address the development of effective management actions to remove or control introduced turtles. Development of population models to evaluate various risks, including rates of survival of various age classes and landscape factors (such as road networks) would be a useful tool for both research and management, particularly towards developing a conservation strategy in the Portland metropolitan area.

Adaptive management would facilitate developing standards for turtle conservation. There are many opportunities for using adaptive management approaches to strengthen turtle conservation. This approach, if done thoughtfully, links research and management.

I. INTRODUCTION

Goal

The western painted turtle, *Chrysemys picta bellii*, is one of two endemic freshwater turtles in Oregon. The other is the western pond turtle, *Actinemys marmorata*. The painted turtle has the largest range of the North American freshwater turtles, and occurs from the Atlantic to the Pacific coast. In many parts of its range, painted turtles are common and one of the most abundant turtles. Native western painted turtles occur in only a small portion of Oregon. They are the most commonly occurring turtle in the most northern portion of the state (Fig. 1 and 2), especially in the Portland metropolitan area (Fig. 3). In Oregon the western painted turtle is a state priority species (ODFW 2006), and has been the subject of numerous conservation measures by the City of Portland, Metro, and Port of Portland. The Lower Willamette Valley Interagency Turtle Conservation Work Group was formed in 2006 to encourage conservation of western painted and western pond turtles. Despite this interest from the public and numerous public agencies, there has been no comprehensive synthesis of existing information. The first goal of this Conservation Assessment is to fill that gap.

The other goal of the Assessment is to synthesize and critique previous and current research, monitoring, and management efforts relevant to conservation of the western painted turtle in Oregon. The Assessment is intended to provide biologists engaged in research and/or management a concise understanding of the state of the knowledge on the western painted turtle's ecology, and to highlight gaps in our understanding that are most critical for managing the western painted turtle on both private and public land in Oregon. There are surprisingly few research papers that have been published on western painted turtles in the Pacific Northwest. Research, monitoring, and survey work that has been conducted on western painted turtles in Oregon is difficult to access. To fully succeed in obtaining the primary goal of synthesis, a secondary goal has been to locate, obtain, and compile the unpublished work conducted on western painted turtles in Oregon.

Scope

Because of the limited studies in Oregon, we draw upon the literature from throughout the species' range, emphasizing work on the western painted turtle subspecies as much as possible, particularly in environments most similar to those where the painted turtle is found in Oregon. We attempt to synthesize and critique the biological understanding most relevant for populations in Oregon, especially for those populations that are within or adjacent to the densely populated Portland metropolitan area. We compiled information from published literature on painted turtles range-wide, and unpublished reports, theses, and dissertations, and expert opinion regarding the Oregon populations. We compiled distribution data from location records from the Oregon Natural Heritage Information Center, U.S.D.A. Forest Service, U.S.D.I. Bureau of Land Management, City of Portland, Metro, Port of Portland, responses to ODFW's citizen science efforts, and replies to our requests for location information. We do not consider our efforts at compiling reports or location information complete as we are aware of surveys and research efforts whose reports and location records were not submitted to us, or records that require additional preparation prior to input into a database.

We do not consider our efforts at compiling reports or location information complete as we are aware of surveys and research efforts whose reports and location records have not yet been submitted to us.

Management Status

The western painted turtle's range in Oregon is only a small part of the painted turtle's transcontinental range. The area occupied within Oregon is relatively small and many areas where the species occurs in abundance are within or adjacent to urban areas. Oregon Department of Fish and Wildlife (ODFW) classifies western painted turtles as an Oregon Conservation Strategy Species (ODFW 2006) and as a Sensitive-Critical species (ODFW 2008). The City of Portland considers the western painted turtle to be a Special Status Species because it is on the State Sensitive Species and Oregon Conservation Strategy Species lists. In Washington, it is considered common and has no designated classification (http://www1.dnr.wa.gov/nhp/refdesk/herp/html/4chpi.html#statuscomments; accessed April 28 2009). In California, painted turtles are introduced (Spinks et al. 2003). The western painted turtle, unlike the western pond turtle, has no special designation by the U.S. Fish and Wildlife Service. Both the U.S.D.A. Forest Service and the U.S.D.I. Bureau of Land Management consider the species as Sensitive for their lands in Oregon. 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). Updated management status (USFWS, ODFW, NatureServe) can be found on the web at: Natural Heritage Information Center: http://oregonstate.edu/ornhic/data_download.html

II. CLASSIFICATION AND DESCRIPTION

Systematics

The systematics of the painted turtle have been controversial (Ernst and Lovich 2009). Currently, the species is separated into four sub-species (Ernst and Lovich 2009). However, recent genetic work (Starkey et al. 2003) suggests the painted turtle is best described as a two-species group composed of *C. dorsalis* (the subspecies *C. picta dorsalis*) in the southern Mississippi drainage, and the remaining subspecies combined into a single wide-ranging species, *C. picta*. The western painted turtle, *C. picta bellii,* would thus be recognized as simply "the painted turtle", *C. picta*. Although genetic analyses were the basis of Starkey and coworkers' (2003) suggested reclassification of the painted turtle complex, they point out that the red mid-dorsal stripe of the *dorsalis* form is easily recognizable, and undoubtedly led Agassiz (1857, cited in Starkey and others (2003) to place *C. dorsalis* as a separate species. The current classification of subspecies was proposed by Bishop and Schmidt (1931) based on morphological traits. Starkey and coworkers consider their conclusions tentative until confirmation from nuclear genes, although their work remains the most thorough recent evaluation of the painted turtle complex. It remains controversial however, particularly with the elevation of *C. picta dorsalis* to full species, because of the lack of reproductive isolation (Ernst and Lovich 2009). The current taxonomy maintains the four subspecies classification (Ernst and Lovich 2009). As Starkey and colleagues (2003) explain, the criteria used to identify categorically different forms such as sub-species depend on one's view of the species concept, and thus will likely remain controversial.

Species Description

The western painted turtle is the largest of the four previously recognized subspecies of *Chrysemys picta*. As its name implies, it is a colorful turtle. It has a notched upper jaw with red markings on its marginals. Its carapace length is up to 25 cm (Ernst and Lovich 2009). The carapace is marked by a netlike or reticulate pattern of dark colored lines and the plastron is marked with dark patterning that is most pronounced on the seams (Ernst and Lovich 2009). The pleural and vertebral seams alternate and the mid-dorsal stripe is largely or completely absent. Reticulate melanism on the carapace has been reported, although it is largely confined to males (Ernst and Lovich 2009).

Comparison with sympatric turtles—

The western pond turtle lacks the red and yellow markings, the dark markings on the plastron, and the notched upper jaw characteristic of the painted turtle. Their carapace length is also only 13.5-19.0 cm (Nussbaum et al. 1983, Ernst et al. 1994), but there is considerable overlap in size between painted and pond turtles within populations. The snapping turtle (*Chelydra serpentina*) is not native to Oregon, but has recently been found in localized populations that are reproductive. This species reaches nearly 50 cm in length and is noteworthy for the distinct serrations on the posterior end of the carapace. The plastron is proportionately small and appears cross-shaped (Ernst et al. 1994). The head is proportionately large and the tail is typically as long as the carapace, and marked with three longitudinal lines of tubercules. The skin is usually patternless although it may have contrasting flecks (Ernst et al. 1994). The red-eared slider (*Trachemys scripta*) is native to the southeast United States, but has now established breeding populations throughout much of Oregon, particularly in or near urban areas (Bury 2008). This turtle can reach 28 cm in carapace length, and is noteworthy for its prominent postorbital stripe that can be red, orange or yellow in color (Ernst et al. 1994). The skin is prominently striped with yellow on the neck and limbs, and the face is marked several prominent stripes of yellow to red in addition to the postorbital marking (Ernst et al. 1994). The posterior of the plastron has a slightly serrated edge. Mature males may show melanism great enough to obscure the typical bright markings, but this usually occurs only within a subset of mature males (Ernst et al. 1994). Of the three species, the slider is most likely to be mistaken for painted turtles.

Section Summary

The western painted turtle is the largest of the four recognized subspecies of *Chrysemys picta,* reaching a carapace length of 25 cm. The western painted turtle could be confused with the western pond turtle. These species overlap in their distribution and their aquatic habitat. The western pond turtle lacks the red and yellow markings, the dark markings on the plastron, and the notched upper jaw characteristic of the painted turtle. The western painted turtle is probably most easily confused with the introduced red-eared slider. The slider has a prominent postorbital stripe that can be red, orange or yellow in color. The skin is prominently striped with yellow on the neck and limbs, and the face is marked several prominent stripes of yellow to red in addition to the postorbital marking.   Mature males may show melanism great enough to obscure the typical bright markings. The slider is most likely to be mistaken for the painted turtle.

III. BIOLOGY AND ECOLOGY

There is an enormous literature on the painted turtle due to its transcontinental range in North America, its abundance in many parts of its range, and its unique physiology and adaptations. We provide a brief overview of the painted turtle's life history, emphasizing natural history most relevant for conservation in Oregon. We draw upon both the published literature which is based on studies primarily outside of the Pacific Northwest, as well as the unpublished reports based on studies within Oregon.

Habitat

Aquatic—

The painted turtle's aquatic habitat is composed of both slow-moving water and ponds. In Oregon, they are most commonly found in sloughs, ponds, streams, rivers, and oxbow lakes associated with the streams and rivers (Ernst and Lovich 2009). Painted turtles are often associated with mucky bottoms and sites with numerous basking sites and submerged and emergent vegetation (DonnerWright et al. 1999, Hayes et al. 2002). In streams and rivers, they are found in slow-moving pools. Because they nest on land, painted turtles rely on terrestrial habitat, which must be in close proximity to their aquatic habitat.

Differential habitat use by different age classes has been suggested; juvenile turtles, particularly those 3 years or younger, occupied shallower waters than larger, older individuals (Congdon et al. 1992). A preference for warmer water, lesser swimming ability in young animals, limited predator avoidance ability, and social factors may all play a role in habitat selection (Congdon et al. 1992). However, little is known regarding habitat use by hatchling and young juveniles due to the difficulty in detecting them (Congdon et al. 1992, Hayes et al. 2002). Understanding habitat selection by hatchling and juvenile painted turtles is a primary research need that will facilitate management, and in particular, developing appropriate conservation plans *(see Sections V, Conservation and VI, Inventory, Monitoring, and Research Opportunities).* High quality habitat for hatchlings may be a limiting factor in many of the urban waterways such as the Columbia Slough.

Although turtles are vulnerable to extremes of drought and flooding, they have some capacity to respond to these challenges. If painted turtles are caught in a drying pond, they may bury themselves in the muck, potentially in large numbers (Cagle 1942). In a 2001 drought, painted turtles in a North Portland wetland complex traveled over land to more permanent water that included constructed ponds and ponded areas behind beaver dams (E. Stewart, pers. obs.). Both emigration and burrowing into the mud have been recorded in response to drought in other turtle species (Gibbons et al. 1983). Drought can however be a major cause of mortality even for large individuals (Lindeman and Rabe 1990). Similarly, flooding may cause loss of nests and hatchlings, destruction of high-quality habitat, and increased predation on adults (Ernst 1974). Both severe drought and flooding are potential pressures faced by painted turtles in Oregon.

Hibernation is not physiologically necessary in western painted turtles. When they do hibernate over the winter, they may choose either aquatic or terrestrial environments depending on the region. Painted turtles may bury themselves underwater in muck, a muskrat den or bank burrow, or on land in floodplain woodlands, pastures, or under overhanging banks (Ernst and Lovich 2009). In Oregon, they appear to spend the winter primarily underwater, although the studies that investigated over-wintering are limited to a few in the Portland metropolitan area (Hayes et al 2002.; S. Beilke, pers. obs.; E. Stewart, pers. obs.). This is in contrast to the western pond turtle, which spends the winter both on land and in aquatic habitats (Rosenberg et al. 2009). Hayes et al. (2002) is the only study that we are aware of that described over-winter site selection in western painted turtles in Oregon. In that study, radio-tagged painted turtles over-wintered only in aquatic habitat, selecting the deepest ponds and within those ponds the deepest water (Hayes et al. 2002). Selection for the deepest ponds required movement from one pond to another, which occurred frequently (Hayes et al. 2002). Given the subspecies' plasticity in over-wintering behavior across its range, it is likely that western painted turtles in Oregon will use terrestrial over-wintering sites when aquatic conditions are not appropriate.

Basking—

Regulating temperature to maintain basic metabolic processes is a major challenge for reptiles in particular. Basking behavior is prominent in this species, and it appears that any emergent object may be utilized for this purpose. Western painted turtles have even been observed basking on the backs of common loons (*Gavia immer*) incubating eggs on their nests (Gelatt and Kelley 1995). There are many reported instances of large numbers of turtles sharing basking sites. Turtles may actively seek out basking sites already in use by other members of the species (Ream and Ream 1966). Basking is clearly an important behavior in this species, serving to warm the body temperature to optimal levels for feeding and metabolic processes (Ernst and Lovich 2009). Lack of basking sites almost certainly affects habitat suitability. Frequent disruption of basking from human disturbance can be a threat to conservation of this species (*see Section V, Conservation: Recreation Disturbance).*

Terrestrial—

The primary use of terrestrial habitats by western painted turtles is for nesting. Western painted turtles nest near aquatic habitat, usually within 50 m *(see Section III, Biology and and Ecology: Terrestrial Movements).* Flood plains, shrubby fields, roadsides, pastures, and open beaches have all been used as nesting habitat (Mahmoud 1968, Ernst and Lovich 2009). Direct exposure to sunlight appeared to be the common characteristic of nests throughout the western painted turtle's range (Mahmoud 1968, Ernst and Lovich 2009). A broad range of substrates used for nesting has also been reported for nests in Oregon. In several sites in Oregon, western painted turtles selected areas of recent fill composed primarily of gravel and sand in areas where most of the available area was primarily native soils (S. Beilke, ODFW, pers. commun., July 2009, L. Guderyahn, pers. comm., May 2009). This suggests that such materials may be selected by painted turtles for nest construction, perhaps because historically nest habitat may have developed from scouring during flooding events (Hayes et al. 2002).

The primary criteria for nesting habitat are close proximity to their aquatic habitat, sparse vegetation, and good solar exposure (see *Habitat, Terrestrial*). Sandy, loamy, or clay soils may all be utilized (Ernst and Lovich 2009). Nests consist of an access tunnel and chamber, resulting in a flask-shaped excavation. Nests are quite shallow, with recorded depths of as little as 7 cm (Mahmoud 1968, Ernst and Lovich 2009). The diameter of the entrance tunnel is 5-6 cm across, and 6-7 cm across at the very bottom of the nest (Ernst and Lovich 2009). Nests in Wisconsin were at an angle of 45° in sandy or loamy soil, loose gravel, or clay (Mahmoud 1968). Similar nest site selection and placement occurs in Oregon (Hayes et al. 2002).

Diet

Western painted turtles are omnivorous. Fish, crayfish, tadpoles, amphipods, and some orders of insects were found in turtle stomachs from southern Saskatchewan (MacCulloch and Secoy 1983a). Carrion and plant matter are also consumed (MacCulloch and Secoy 1983a, Ernst and Lovich 2009). Adult turtles in Michigan in one site appeared to be feeding almost entirely on aquatic vegetation based on stomach contents, whereas stomachs from another site frequently contained earthworms, fish, and snails (Gibbons 1967). However, adults collected from the Kalamazoo River were consuming animal matter almost exclusively. The highest growth rates were correlated with the diets with the greatest percentage of carnivory (Gibbons 1967). In Idaho and eastern Washington populations, *C. picta* stomachs contained almost exclusively invertebrate matter although sites varied considerably in prey item composition (Lindeman 1996). Young turtles may consume zooplankton, potentially in quantity (Maurer 1995). Generally, young animals are carnivorous and consume more plant matter as they mature, but the extent to which adult turtles appear to rely on plants in their diet is highly variable (Ernst and Lovich 2009). Feeding commences in the spring when water temperatures reach 15 °C (Sexton 1959).

Movements

The life history of western painted turtles requires several different types of seasonal movements. Within their aquatic habitat, daily movements to forage, thermoregulate, avoid predators, and find mates make up their aquatic home range. Reported seasonal movements in painted turtles from throughout their range include a tendency to move away from areas of permanent water into seasonally flooded regions in the spring, whereas they retreat back to more permanent waters as temporary waters dry (McAuliffe 1978, Hayes et al. 2002). Overland movements from aquatic to terrestrial systems occur seasonally to seek nest sites and sometimes over-wintering areas. Dispersal occurs largely through aquatic systems, but overland movements are important as well. However, as is true of most vertebrates, little is known about their dispersal behavior despite its conservation importance. Painted turtles will move overland through constructed undercrossings (C. Butler, Port of Portland, pers. commun., June 2009).

Aquatic movements—

Aquatic movements by painted turtles are highly variable and are context specific. In a river system of slow-moving current, painted turtles did not appear to show fidelity to a small home range, but moved variable distances both up and down the river over the course of the season. Maximum distances traveled were up to 6.5 km in a single day or 26 km over the course of the season (MacCulloch and Secoy 1983b). In this system, males were found to move greater distances than females, and juveniles were only detected within 2 km of the site where they were first found (MacCulloch and Secoy 1983b). At some wetlands in the Portland metropolitan area, there were many turtles that made short-distance movements of at least 1 km around the wetland complex (E. Stewart, pers. obs.).

Turtles in Michigan began to become active as the ice melted, and once water temperatures reach 8 °C they emigrated from the ponds in which they spent the winter. The animals began to return to the over-wintering pond as the outlying habitat began to dry out in summer (Sexton 1959). Small individuals remained in ponds whereas the larger individuals were the ones who emigrated, and females were more likely to move than males (Sexton 1959). Similar seasonal patterns were observed in a population of western painted turtles in Nebraska (McAuliffe 1978). Turtles in a slow-moving river were more likely to move, and moved greater distances, than did pond or lake turtles (MacCulloch and Secoy 1983b). Movements in the spring appeared related to mating, and overland routes appear to be used only when no aquatic route exists (Gibbons 1968b).

Terrestrial movements—

Over-winter

No information was found regarding the prevalence of use of any particular over-wintering habitat in any geographic area, although northern populations appear to over-winter entirely within aquatic habitats based on the lack of reports of any other behavior. It is not clear whether this pattern holds in western Oregon and Washington, where winter weather is much milder. In the Portland metropolitan area, radio-tagged western painted turtles over-wintered only in aquatic habitat (Hayes et al. 2002). Overall, painted turtles will over-winter in aquatic habitats if appropriate conditions are found. This is in contrast to the western pond turtle in Oregon, which over-winters frequently on land (Rosenberg et al. 2009)

Nest Sites

Western painted turtles choose nesting sites close to aquatic habitats. Existing data suggest that painted turtles may nest closer to their aquatic habitat than sympatric western pond turtles (Rosenberg et al. 2009). Although there is a bias towards researchers finding nests near aquatic habitat due to nest-searching strategies, radio telemetry confirms this general pattern throughout the species' range (Ernst and Lovich 2009) as well as in Oregon (Hayes et al. 2002).

Distance of nests from the turtles' aquatic habitat varies considerably among study areas and even individual turtles. In one study in Minnesota, 16 nests were found within 52 m (average of 39.1 ± 2.4 SE) from the water, with one nest found 250 m away. Two female turtles carrying eggs were found crossing a road over 500 m from water, apparently in search of a nesting site (Legler 1954). Another researcher reported locating nests 20-500 feet (6-152 m) from water (Mahmoud 1968). A study of nest success at the E. S. George Reserve in Michigan reported that nesting areas were within 100 m of water, and usually were less than 50 m (Tinkle et al. 1981). Distances of up to 160 m from water have been recorded at the Reserve (Congdon and Gatten 1989). A study in New Hampshire documented nests from 54 to 115 m from water; these sites required female turtles to cross up to 5 roads to reach them (Baldwin et al. 2004). Older females tended to travel farther from water than younger females, and first clutches tended to be farther from water than second clutches in another study in Illinois (Harms et al. 2005).

The few studies conducted in Oregon found similar results, with nests found within 100 m of the aquatic habitat of painted turtles, and usually much closer. In the Portland metropolitan area, Beilke (ODFW., pers. commun., July 2009) reported that she located 19 nests via telemetry and visual observations of nesting turtles. These 19 nests averaged 39.3 m from the water's edge and ranged from 0.6 – 58 m away. Similarly, the 6 nests Hayes et al. (2002) found from radio-tracking females in another Portland metropolitan area site were all within 10 m of their aquatic habitat. Hayes et al. (2002) suggested painted turtles nest as close to the water as suitable habitat allows in order to decrease dehydration of hatchlings and to increase survival rates during the hatchlings' return to aquatic habitat in the spring. The turtles often have no choice; one of the major populations in the Portland area is surrounded by industrial land where the built environment is located within 30 m of water.

Dispersal

There have been few studies that have shed light on dispersal of western painted turtles. Emigration of several kilometers' distance has been documented (McAuliffe 1978, MacCulloch and Secoy 1983b). Little other information was found on either adult or juvenile dispersal as opposed to seasonal movements.

Strength of inference and gaps in understanding—

Understanding movement patterns of animals is challenging at best, and this is particularly true of dispersal. Daily movement rates, estimates of home range shape and size, and differences in these parameters between genders and among age classes comprise most of our understanding of the movement patterns of vertebrates. What we understand less well is how movement patterns are affected by environmental conditions (Rosenberg et al. 1997), and most importantly, how management activities affect movement patterns and the demographic consequences of changes in space use (MacDonald and Johnson 2001). Even anecdotal natural history information on dispersal, especially of dispersal of juveniles and their eventual recruitment into breeding populations, is poorly known. Dispersal patterns in vertebrates are one of the least understood but most relevant parameters for successful conservation (MacDonald and Johnson 2001). Because of the limited understanding of painted turtle dispersal particularly with regard to factors that affect their overland movements and the importance of understanding and manipulating this process, experimental or quasi-experimental research and adaptive management is needed.

Breeding Biology

Our understanding of the variation in the painted turtle's breeding biology across very different climates is emerging from numerous natural history investigations from across the range of the species. In the section below, we summarize what has been documented regarding the western painted turtle's breeding biology, and in particular, what is relevant for populations in Oregon. Our understanding of how breeding biology of western painted turtles in the Pacific Northwest differs from other regions, however, is limited due to the few reports of intensive studies of western painted turtles in the region.

Physiological phenomena including sexual maturity are size-based rather than age-based within each gender (Ernst and Lovich 2009). At the point of sexual maturity, growth rates are reduced in both male and female painted turtles (MacCulloch and Secoy 1983a, Ernst and Lovich 2009). Males in western painted turtles reach maturity at smaller sizes and at younger ages than do females (Legler 1954, MacCulloch and Secoy 1983a, Ernst and Lovich 2009). This appears to be influenced by latitude, as Wisconsin turtles appeared to require 2 additional years to reach maturity than did turtles studied in New Mexico (Christiansen and Moll 1973). Females of western painted turtles have been considered mature at carapace lengths of 12.3 cm and males at 8.3 cm, based on nesting behavior or dissection in females and secondary sexual characteristics including elongated forefoot claws and increased pre-anal length in males (Legler 1954). Corresponding ages at first breeding have been estimated at 4 or 5 years in males and 7 years in females in Michigan (Wilbur 1975, Congdon et al. 1992). Female painted turtles in a Michigan population appeared to reach maturity at plastron lengths greater than 112 mm (Tinkle et al. 1981).

In Oregon, Hayes et al. (2002) reported age at sexual maturity for a population in the Portland metropolitan area. They found that the smallest gravid female (based on palpation) in their sample of 166 turtles for which they had age data was 156 mm plastron length, and they estimated her to be 9 years old based on counts of growth rings. Based on their morphometric data, they estimated that a female could reach this size by age 7, but most would be at least 8 years old. In another sub-population within the same area, Hayes et al. (2002) reported the smallest gravid female was 168 mm plastron length, and a minimum of 11 years old. Individual males displayed secondary sexual characteristics at plastron lengths equal to 84 mm or longer, suggesting males could be sexually mature by 3 years. Most male turtles were this size only by their 4th year.

Painted turtles emerge from their over-wintering sites when the thermal environment is conducive to active foraging. Juveniles appeared several weeks following the appearance of the first adults in a Michigan population (Gibbons 1968b). Large turtles in this population first appeared in early May and juveniles in late May (Gibbons 1968b). In the mild climate of western Oregon, emergence from over-wintering probably occurs in March and April, similar to western pond turtles. However, we were unable to locate emergence records for juvenile and adult western painted turtles in Oregon. Because over-wintering hibernation is facultative in Oregon, painted turtles do move throughout the year (Hayes et al. 2002). Painted turtles court and mate from March into June, and courting behavior is also seen in the fall (Gibbons 1968b). Sperm can be stored, and clutches are likely to be the product of multiple matings (Ernst and Lovich 2009). The reproductive cycle begins with courtship, of which little is known regarding timing and behavior.

The nesting season in Oregon is similar to western pond turtles with most nests constructed during June and July (Hayes et al. 2002). There is limited understanding of nest site fidelity, but evidence suggest that at least some individuals return to near (<12 m) their previous year's nest (Lindeman 1992). Females showed some nest site fidelity in Michigan, with smaller inter-annual distances between nests laid by the same female than among individual turtles in the population (Rowe et al. 2005). Related to nest site fidelity is the concept of nesting areas, where females return to each year. In most studies, it is unknown whether the same female nested in a particular area, but from annual nest surveys it is clear that some areas consistently have large number of nests. This has been demonstrated in Oregon populations(S. Beilke, ODFW, pers. commun., July 2009, L. Guderyahn, pers. commun.), similar to pond turtles (Rosenberg et al. 2009). Beilke (ODFW, pers. commun., July 2009) reported that during one observation day, three different turtles nested within approx. 2-3 m of one another in an established nesting area.

Females may excavate several nests before creating one suitable for egg deposition. Mature eggs may be retained for at least up to six weeks until a suitable nest is excavated, allowing the female sufficient time to locate suitable substrate (Lindeman 1989). Nesting has been observed in the afternoon between 1600 and 2300, and in the early morning between 0500 and 0900 hours. Urination onto the soil prior to or during the process of digging has been observed by many investigators (Mahmoud 1968). It has been assumed that turtles do this to soften the soil, although it has also been suggested that the urine may help maintain proper humidity within the nest (Legler 1954). Based on observations of females digging, the nests were dug to the depth the turtles could reach with their hind legs while the front legs remained braced outside the nest (Mahmoud 1968). If turtles encounter obstacles that interfere with digging, they will abandon the effort (Mahmoud 1968). Clutches of 8-11 eggs took 15-27 minutes to lay in total (Mahmoud 1968). Females then filled in the nests using only their hind limbs, and finished by dragging twigs and other debris over the freshly disturbed dirt before the turtle tamped down the soil over the nest (Mahmoud 1968). Females typically emerge from the water in late afternoon, complete nesting activities, and return to the water without remaining on land overnight; this appears to be a strategy to avoid predation of the females themselves (Congdon and Gatten 1989).

Young turtles hatch in the fall, but spend the winter in the nest in most parts of the species' range (Breitenbach et al. 1984). There are reports of hatchlings emerging in fall in Pennsylvania (Ernst 1971) and Oregon (C. Butler, Port of Portland, pers. commun., June 2009). Emergence of hatchlings in the spring in northern latitudes is associated with physiological adaptations in western painted turtles that do not appear to be prevalent in the other subspecies (Reese et al. 2004). Even at the northernmost extent of their range, the western painted turtle hatchlings remain on land for the winter (Koonz 1998). Hatchlings were first observed in June in a Michigan population (Gibbons 1968b). In Minnesota, hatchlings appeared in early April, three weeks after ice out, and when water and air temperatures were recorded as 9.0 and 11.5 °C (Legler 1954). In Oregon, hatchlings have been observed leaving the nest from April to as late as mid-May (L. Guderyahn, pers. commun., May 2009) and also in the fall (October) in the Portland metropolitan area (C. Butler, Port of Portland, pers. commun., June 2009). Fall emergence in Oregon may be related to inundation of nests, as has been observed with the western pond turtle (Rosenberg et al. 2009), or more generally to poor nest conditions as observed for other freshwater turtles (Nagle et al. 2004).

Demography

Reproductive output—

Data on age- and habitat-specific reproductive rates, particularly on a population scale, are very limited because of the difficulty in finding freshwater turtle nests and estimating their success rate. When available, estimates are typically for clutch size per female. Estimates of population-level nest-success rates are almost non-existent. Most estimates for the number of hatchlings per female are anecdotal. Below, we summarize work done on each of these parameters of reproductive output on painted turtle emphasizing what has been done in the Pacific Northwest, primarily Oregon.

Clutch Size

Clutch size is highly variable with painted turtles, but in general, western painted turtles lay large clutches with a mean of 11 eggs and ranging from 4-23 eggs (Ernst and Lovich 2009). Several clutches may be laid in each breeding season. There appears to be a pattern of fewer clutches with more eggs dominating in the northern part of their range, whereas farther south, turtles are more likely to produce more clutches (Ernst and Lovich 2009). Some females in northern populations may not breed each year (MacCulloch and Secoy 1983a), and this is likely true elsewhere, including Oregon. In one population in Michigan, only 25-50% of adult females appeared to be reproductive in any given year although individual females were known to have reproduced each year of a three-year period (Tinkle et al. 1981). In that population, most turtles (70%) only nested once per season, but some individuals (4%) produced two clutches and 30% of mature females did not reproduce at all (Tinkle et al. 1981).

The relationship between female body size and number of eggs laid is not consistent. There is some evidence that clutch size may increase with age (Tinkle et al. 1981) or size of the female (Ernst and Lovich 2009). Other studies failed to find relationships of size or age with clutch size (e.g., (Bowden et al. 2004). Second clutches tend to be smaller than first clutches (Bowden et al. 2004), which may have confounded attempts to describe clutch size and body size relationships. Female carapace length is correlated with the size of individual eggs, particularly egg width (Rowe 1994). However, some populations of painted turtles appear to follow a strategy of fewer, larger eggs while others in the same region lay more, smaller ones (Rowe 1994). Generally, larger females lay larger clutches with greater mass than smaller individuals (Ernst and Lovich 2009). Older females laid larger eggs than younger ones, even when the animals were the same size (Bowden et al. 2004). The younger turtles grew at faster rates than the older ones; in turtles, growth rates diminish sharply with the onset of reproduction (Bowden et al. 2004).

Clutch Frequency

Determining number of clutches produced each year by each female requires intensive study of marked females. There are few studies that have estimated clutch frequency. Those studies that have estimated clutch frequency have found that multiple clutches per breeding season are common in painted turtles. This may be an adaptation for high nest predation, the common-sense strategy of “not putting all of your eggs in the same basket”. Painted turtles in at least some regions appear to lay two clutches of eggs per year based on examination of follicles in females. In a Michigan population, this occurred in mid-May and again in late June or early July, for an annual total of 13 eggs split roughly evenly between the two clutches (Gibbons 1968b) Of 42 females examined, 60% of the females contained 6 or 7 eggs, only 2 turtles contained less than 5 eggs, and only 2 contained more than 8 (Gibbons 1968b). However, studies of other populations from Michigan suggested that only one clutch is laid per year (MacCulloch and Secoy 1983a, Rowe 1994). The number of large follicles found during dissection suggested that these nests were each produced by a single female (MacCulloch and Secoy 1983a). An estimated 61.5% of painted turtle females produced two clutches in Wisconsin in a single season, and multiple nests were recorded with increasing frequency in more southerly populations (Moll 1973). Two clutches per year were also produced by 6 of 36 females in Michigan (Snow 1980). Several females were reported to lay two clutches in a single season in an Idaho population (Lindeman 1996). Laying of several clutches per year probably occurs in Oregon but as far as we are aware, clutch frequency has not been estimated for any of the state’s populations of turtles.

Nest Success

Painted turtles seem to have a similarly low nest success (defined as producing at least 1 hatchling) as other freshwater turtles in North America. At least in some years, nest success can be very low with nearly complete nest failure across the population. Nest success has been estimated in several studies across the species’ range and in some sites for several to many years, providing information on the variability of nest success across space and time. Modifying nest success rates has been one of the primary management tools used on both western painted and western pond turtles in Oregon (Rosenberg et al. 2009), and thus understanding factors affecting these rates, and population consequences, is important to management *(see Section VI, Inventory, Monitoring, and Research Opportunities)*.

Similar to other freshwater turtles, nests appear to be most prone to discovery by predators within the first few days after laying, perhaps because of the odor of the urine released during the digging process (Legler 1954). However, another study found that although the risk was greatest the first day, a little over half of the predated nests were destroyed after the first 72 hours (Snow 1982). Nests closer to water appeared to suffer greater predation rates than those farther away from the shore (Legler 1954). Furthermore, predation pressure appeared to increase as the nesting season went on, which meant that early nests were more likely to reach a later stage than nests initiated late in the season. In this particular study, skunks were identified as the most common predator (23 nests of 39 predated), followed by raccoons and foxes (4 of 39 nests in both cases), and 5 of 39 nests were destroyed by chipmunks (Snow 1982). Understanding predator foraging behavior may yield greater insights into nest vulnerability, as it does not appear that cues necessarily weaken with time (Snow 1982). Although nest predation rates have been reported to be high in general, Tinkle and coworkers studying a population in Michigan calculated that nest survivorship on their site approached 80% (Tinkle et al. 1981) and a more recent study also in Michigan estimated nest survivorship at greater than 80% (Rowe et al. 2005). Interestingly, in the latter study predation did not appear to be related to distance to water or roads (Rowe et al. 2005). A study using snapping turtle eggs in artificial nests found that nests in traditionally used areas were at no greater risk than artificial nests placed away from where natural ones were found (Wilhoft et al. 1979). In Oregon, at least some sites in the Portland metropolitan area have high nest success (Hayes et al. 2002). In the Portland metropolitan area, in addition to skunks and raccoons, coyotes may be an important nest predator (C. Butler, Port of Portland, pers. commun., June 2009). Stray dogs and dogs off-leash may also contribute to nest disturbance and predation.

These studies provide a reasonable understanding of the variation and magnitude of nest success, and provide an understanding of factors that, at least proximally, cause nest failure. Part of the problem in evaluating estimates of nest success stems from the inclusion of nests that were found because they had been depredated already. Depredated nests are much easier to find than non-depredated nests, resulting in an overestimate of nest failure (Williams et al. 2001) The most reliable samples come from location of recently constructed nests and subsequent monitoring of their fate, similar to the methods developed in avian ecology (Williams et al. 2001).

The results of these studies, and estimates of nest success under different circumstances, may provide initial steps for developing population models *(see Population Modeling, below in this section)*. Population models, using field-based estimates, will be useful to evaluate what success rates are needed across space and time for long-term viability of Oregon’s turtle population, especially in particular areas such as in the Portland metropolitan area.

Survival and recruitment—

Hatchlings

We were unable to find any attempts to estimate hatchling survival, despite its clear importance in the population dynamics of turtles and the implications for aquatic and terrestrial habitat management. Researchers have long noted that hatchlings are extremely difficult to detect (Ernst and Lovich 2009). Development of methods to study the ecology of hatchlings is a research priority (*see Section VI Inventory,Monitoring, and Research Opportunities*). Hatchling survival within the nest appears to be relatively high, although occasional harsh winters were associated with loss of most nests

(Breitenbach et al. 1984). No information was found on hatchling over-winter survival in Oregon.

Juveniles and Adults

Although long-lived and generally thought to have a life history strategy of high survival rates and low predation rates, juvenile and mature turtles are not immune to predation. In an Idaho pond, the loss of habitat due to drought resulted in the recovery of roughly 30 carcasses, many of which bore tooth marks or missing limbs (Lindeman and Rabe 1990). Large turtles whose plastron lengths were between 167 and 183 mm also bore marks on their plastrons and carapaces suggesting predator attack (Lindeman and Rabe 1990). Increasingly, road mortality may be a major source of mortality of adult turtles in many populations *(see Section V Conservation: Road Mortality)*.

Additional estimates of adult survival based on mark-recapture data in a Michigan population were 0.21–0.51 for females and 0.64-0.83 for males (Frazer et al. 1991). In this population, the oldest known-age animals were 15 and 21 years for females and males, respectively and the oldest animals were 34 and 31 years for females and males, respectively (Frazer et al. 1991). Juveniles, defined as turtles less than 6 years old, had estimated survival rates of 0.21-0.51, with survival increasing with each year of age (Frazer et al. 1991). The authors speculated that the low survival rate estimates for females could be confounded by emigration during the breeding season.

Heppell (1998) derived survival rates of juvenile and adult painted turtles based on previously published work to examine basic population characteristics (Heppell 1998). Juveniles, or turtles aged 1-3 years, had estimated survival rates of 0.76 or 0.82; juveniles aged 1-2 years in another study had estimated survival rates of only 0.46. Subadults, defined as animals 3-7 years of age, had survival rates of 0.944. Adult turtles had estimated survival rates of 0.76 or 0.82 for populations in Michigan (Wilbur 1975, Tinkle et al. 1981) and 0.944 for populations in Virgina based on Heppell’s (1998) analysis.

Population structure—

We consider two functionally different types of population structure – geographic and demographic. The genetic similarity of groupings of individuals provides an understanding of connectivity among populations, and provides clues to the spatial arrangement of individuals and sub-populations. This is often what is considered “population structure”. Although there has been recent genetic work on the subspecies complex of painted turtles (Starkey and others 2003), we are not aware of any genetic work that allows inferences on population structure.

Demographic population structure refers to the age structure and sex ratio of a population, and can provide clues to population trajectories and potential causes of declines. When connectivity of populations is considered, both geographic and demographic processes influence the future of populations across space and time. Research on these topics with painted turtles would be very illuminating in terms of conservation planning and more generally with questions of connectivity in urban environments. From numerous studies that have captured, marked, and aged individuals, we have an initial understanding of the demographic population structure of several western painted turtle populations. This understanding includes both sex ratios at hatchling and at later stages, and age structure.

Gender of Hatchlings

The gender of painted turtles is determined by environmental conditions surrounding the eggs in the nest, and are thus sensitive to both environmental and climate influences. Nests of western painted turtles in Illinois produced hatchlings of one gender only 66% of the time, and over 80% of nests were mostly (80%) one gender. Males emerged from nests that were partially shaded more often than females did, although a cool, overcast summer did not result in a strong pattern (Janzen 1994). Females may choose nest sites to influence gender outcomes. Morjan (2003) speculated that females in a New Mexico population chose nests with less vegetative cover and closer to water, perhaps due to microsite conditions that influence hatching success. Ensuring that a variety of exposures are present when nesting areas are created will also be important, particularly in isolated, small populations. In addition, soil moisture is more important in determining hatching success and hatchling size than temperature (Cagle et al. 1993). This may have impacts on western painted turtles in western Oregon due to the hot, dry summer climate, and greater potential for soil dessication than in other parts of the turtles' range. Nesting near water, however, may maintain appropriate soil water content (Hayes et al. 2002).

Population Sex Ratio

Sex ratio in turtles is assumed to be 1:1 unless mortality factors are biased towards one gender. In a study of a painted turtle population in a Michigan marsh, Gibbons (1968a) captured over 1000 turtles. It appeared that adult sex ratios were essentially 1:1, and adults made up a little less than half the population. Sex ratios may be affected by differential mortality experienced by breeding females in areas with high densities of roads (Steen and Gibbs 2004, Gibbs and Steen 2005). In Oregon, the population of western painted turtles in some Portland area wetlands had a sex ration of 1.5:1 females to males based on capture data from 1999-2001 (E. Stewart, unpubl. data).

Age Structure

Sampling biases make it very difficult to estimate age structure of freshwater turtles, because the greater capture probabilities of the larger animals result in an overestimate of older age classes. Survey methods have been shown to vary widely in their inherent biases and in their results (Ream and Ream 1966). Baited nets appeared to disproportionately attract males, and the presence of a turtle in the trap appeared to attract other turtles over other similar traps set nearby (Ream and Ream 1966). Ramp steepness in the basking traps appeared to influence maximum size of turtles caught by traps designed to mimic basking sites, and there still was a male bias in trapping success. Use of a method that caught turtles that fell off natural basking sites was most successful in capturing females, although this trap type also was located near a nesting beach and not surprisingly, also caught the greatest proportion of gravid females. This study also demonstrated that all four trap methods compared had very poor success at capturing juveniles. However, hand grabs may bias results toward juveniles (Ream and Ream 1966). Undoubtedly the inherent biases introduced by sampling have influenced all aspects of demographic estimation, although relatively few field studies have addressed it. Therefore, reported ratios of juveniles and adults are difficult to interpret.

Population Modeling

Population models can be developed to provide insight into conservation planning. One value of population models is to give insight into the sensitivity of the population to mortality on different age classes (Heppell et al. 1996, Caswell 2001, Mills and Lindberg 2001) and allow projections of future populations given different assumptions of the biology of the species or management alternatives. The expectation is that species that are long-lived but have large number of young will have population growth rates that are most sensitive to changes in adult mortality (Heppell et al. 1996). However, for many of these species, it may be easier to increase survival rates for younger age classes through management. Interpretation of sensitivity analyses must also consider management options and the feasibility to affect various age classes (Mills and Lindberg 2001).

Several studies on painted turtles have collected demographic data which was then used to construct life tables. This was first done by Wilbur in the 1970s, who built on mark-recapture studies done 20 years earlier at the George Reserve of the University of Michigan (Wilbur 1975). Tinkle and coworkers focused on estimating reproductive parameters in the late 1970s, and offered some recalculations of the work originally presented by Wilbur (Tinkle et al. 1981). Juvenile survivorship was identified as a key parameter in distinguishing between the divergent outcomes of Wilbur's model versus their calculations. The authors pointed out that Wilbur assumed parameter values for some vital statistics, including early juvenile survival, nesting frequency, clutch size, age at first breeding, and nest mortality (Tinkle et al. 1981). Adult survival rates were estimated to range from 0.76 to 0.83 (Wilbur 1975).

These parameter estimates resulted in variable patterns of how changes in survival affected projected population growth rates (Caswell 2001) for painted turtles. Based on their general life history, populations of western painted turtles would be expected to be most influenced by changes in adult survivorship, with relatively little influence coming from altering fecundity (e.g., (Heppell 1998, Heppell et al. 2000, Caswell 2001). The exception to this pattern occurred with data from a population of painted turtles in Michigan (Tinkle et al. 1981, Heppell 1998). The Michigan population's parameter estimates led to a pattern of equal importance of adult and juvenile survival to population growth; however, this population was apparently growing rapidly (Heppell 1998). When population growth rate is high, juvenile survivorship may increase in its impact on population growth rate relative to a stable or declining population (Gervais et al. 2006). These results are mathematical expectations and do not take into account the ability to modify survival rates of different age classes. Consideration of predicted population sensitivity from population models and the ability to manipulate reproductive and survival rates are both critical to developing effective conservation strategies.

Section Summary

The painted turtle is one of the most-studied freshwater turtles in North America. In Oregon, they are most commonly found in sloughs, ponds, streams, rivers, and oxbow lakes, particularly those with numerous basking sites and submerged and emergent vegetation. The limited studies in Oregon that do exist suggest over-wintering occurs largely in shallow aquatic environments. Nests are constructed in sandy loam or clay soils, typically within 100 m of their aquatic habitat. Painted turtles may lay multiple clutches per year with an average of 11eggs per clutch, although there is great variability. Most hatchlings emerge the following spring. Nest and hatchling predation is the least-studied aspect of their ecology, despite the importance to their conservation. Many management decisions regarding western painted turtles in Oregon revolve around assumptions of nest and hatchling predation and resulting lack of recruitment. This is one of the most important aspects for future research. Factors affecting survival rates of juveniles and adults are also poorly known. Because of the life history strategy of painted turtles, factors affecting survival rates of adult females are important to understand.

IV. RANGE, DISTRIBUTION, ABUNDANCE, AND POPULATION TRENDS

Range and Distribution

The painted turtle is the most widespread native turtle species in North America. Its range spans the continent from the Atlantic to the Pacific coasts, and includes most of the eastern and central U.S., and southern Canada (Ernst and Lovich 2009). The range narrows in its western portion, remaining primarily on the northern edge of the western US and southern Canada. Although there is debate on the recognition of subspecies (e.g., Starkey et al. 2003, *see Section II:Systematics*), there are currently four subspecies described. The western painted turtle occupies the largest portion of the range, from western Ontario to British Columbia and south into the central and western U.S. In Oregon, native western painted turtles are distributed in north-central and north-eastern Oregon, and in the northern portion of the Willamette Basin primarily north of Salem (Nussbaum et al. 1983, St. John 2002), occurring primarily in the Columbia Plateau, Blue Mountains, and Willamette Valley Ecoregions (Fig. 1). Based on records in the ORNHIC database, painted turtles rarely occur above 1000 m elevation in Oregon. They are largely absent from faster moving lower-order streams, preferring bottomlands. Their current range differs from their historic range in Oregon primarily due to the presumed introduction of pet turtles, and their subsequent reproduction and dispersal in areas not occupied by native western painted turtles (Fig. 1). There is also evidence that local populations within the eastern edge of the Willamette Basin have declined considerably and are largely extirpated following development and subsequent isolation (*see Case Study*). The evidence is largely from the existence of a few isolated populations remaining in some of these areas and the pattern of development that makes occupancy by western painted turtles unlikely. The earliest records of painted turtles in Oregon suggest that painted turtles were seen only in abundance along the Columbia River, its tributaries, and up the Willamette from its mouth with the Columbia as far south as Salem, the same general area as the northern extent of abundant pond turtle populations (Storer 1937, Graf et al. 1939, Evenden 1948). Later accounts corrected earlier statements by Storer (1932) that restricted the distribution of native painted turtles to east of the Cascades.

Introduced painted turtles have been reported from many areas of Oregon starting as early as the 1920s (Storer 1932, 1937), and continuing today with numerous but unknown numbers of introductions. Releases of captive turtles that originated from areas outside of Oregon make detecting changes in the range of Oregon native populations difficult. There have been several location records in Oregon accompanied by photographs which demonstrate that painted turtles are now nesting as far south as the Rogue River in Oregon (Fig. 1). Records of painted turtles in southwestern Oregon data back to at least 1984 (Black and Black 1987). There is ample evidence that these individuals were either pet turtles that were released, or were the offspring of these introduced turtles. Genetic work will be required to further elucidate the extent of this problem. The genetic integrity of naturally occurring painted turtles is likely being compromised by the introduction of previously captive turtles from unknown genetic stock. This is an important conservation threat that has not received adequate attention (*see Section V: Conservation: Introductions and Collection*).

Surveys Conducted

Given the substantial changes to the hydrology of the Willamette River Basin, the once vast wetlands that are now in agriculture (Taft and Haig 2003) and industrial development along the Columbia, declines in abundance of turtles in the Willamette Basin and the Columbia Basin must have been great. There is no historic survey data that allows an assessment of the changes in either population distribution or abundance. Most survey efforts have been conducted to identify locations with western painted turtles and at a few sites, with the goal of monitoring changes in abundance.

The painted turtle's general distribution is reasonably well known in Oregon, but specific locations, especially on private lands, have not been well documented. There are only 53 records in the Oregon Natural Heritage Information Database (accessed February 2009), mostly from 1980-1995. Many location records exist that have not been incorporated into accessible databases. A useful first step would be to compile existing records from the various agencies. We initiated that effort for this Assessment (Fig. 1) but numerous other records exist, particularly for eastern Oregon. A few records exist in the FS NRIS and BLM GEOBOB databases (both accessed January 2009). Both databases contain two records each, and all are likely from introduced stock. ODFW has records of painted turtle locations, and some of these may have been submitted to ORNHIC, but numerous other records exist that could be incorporated into a compiled database. Metro staff and volunteers have compiled locations (123 records since 1984) of western painted turtles observed in the Portland metropolitan region.

Citizen science efforts were initiated in 2008 by ODFW and the Oregon Zoo. Participation was impressive, with over 300 records submitted on turtle locations, 31 of which were listed definitively as painted turtles. The Citizen Science survey efforts identified numerous sites with painted turtles in areas that were not previously recorded on the ORNHIC database. Using the public to help identify areas with painted turtles should be fruitful in better describing management opportunities for painted turtles, especially in urban areas.

Surveys to identify locations of painted turtles and related research efforts have been conducted in some areas, sometimes over several years. In the Portland metropolitan area several critical areas for western painted turtle conservation have been identified (names have been dropped to protect the turtle populations) (Hayes et al. 2002; E. Stewart, unpubl. data; Gaddis and Corkran 1985). A few occur generally in the Portland metropolitan area and some outlying areas (Gaddis and Corkran 1985, Beilke and Christensen 2007, Beilke and Christensen 2008). (Gaddis and Corkran 1985, Beilke and Christensen 2007, Beilke and Christensen 2008). The City of Portland has contracted with the Northwest Ecological Institute to conduct turtle surveys at a number of sites in the Columbia Slough and Johnson Creek watersheds in the summer of 2009. The only survey work we are aware of east of the Cascades was conducted near the Columbia River, in or near Irrigon, Oregon (Croghan 1983), despite that the majority of western painted turtles in Oregon are believed to occur in eastern Oregon ((St. John 2002). Most, if not all, of the survey work conducted has identified the same areas where painted turtles are consistently found, and determined the areas with the largest populations. Additional survey work should address information needs for developing conservation plans. A reasonable understanding of the painted turtles' distribution in the Portland metropolitan area now exists, probably sufficient for identifying key populations and areas that could be restored for auxiliary populations and to provide connectivity among populations. It is important to note that the surveys of limited areas (e.g., "site surveys") are probably too small in extent to rule out the use of a particular aquatic habitat. Further, detection rates may be very low for some areas due to the wariness of painted turtles and limited access to view them. For example, the Tualatin River may fall into this category (Reams 1999). However, as the Urban Isolation Case Study demonstrates (*see Section VII Case Studies*), there may be local areas that harbor western painted turtle populations that were assumed to be unlikely sites due to urbanization (see Fig. 6). In general, continued surveys are unlikely to provide useful estimates of population trends because of the difficulty in obtaining precise and unbiased estimates. In addition, there has been little effort to link occupancy or trends with management actions.

Importantly, many surveys have been conducted for which reports were either not produced or were otherwise unavailable for inspection during our review. An important first step for better understanding the current distribution of western painted turtles in Oregon, and in particular the Portland metropolitan area, is a thorough compilation of survey efforts, methods used, and a critical review of survey data on western painted turtles. Future survey efforts should require submission of data to a centralized source, such as the Oregon Natural Heritage Information Center. One of the reasons for the difficulty in accessing survey data is likely the concern over protecting turtles from illegal collection from the public. This deserves further discussion as it relates to dissemination of knowledge of the distribution of turtles in the Portland metropolitan area and ensuring their protection.

Conclusions on distribution and abundance of western painted turtles in Oregon, based on the location records (Figures 1-5), must be viewed with caution because the surveys were not conducted in any formal sampling framework across the species' range in Oregon. Some areas may have the appearance of greater abundance simply because there has been a more concentrated survey effort. However, given the limitations of these data, the existing data supports the consensus that western painted turtles are most abundant north of Salem and occur primarily in the Willamette Basin and along the Columbia River and its tributaries (Fig. 1). There is likely much broader distribution and abundance of western painted turtles in eastern Oregon than the location records represent. Most of the records document turtles on private lands, with very few sightings occurring on state or federal lands (Fig. 2). In contrast to the western pond turtle (Rosenberg et al. 2009), few western painted turtles have been reported on lands managed by the U.S.D.A. Forest Service or U.S.D.I. Bureau of Land Management (Fig. 2). The majority of records in Oregon are largely from the Portland metropolitan region (Fig. 3). Although many records document turtles on private lands, large concentrations do occur on or near public open space in the Portland metropolitan area (Fig. 4 and 5).

Western painted turtles occur in many urban areas within the City of Portland, with most records within the Columbia Slough watershed (Fig. 5). Painted turtles are also found in some, though few, isolated urban wetlands in the Portland metropolitan region (Fig. 6).

Several local and regional surveys of western painted turtles have been conducted. We report each of those here to provide a summary of work conducted on the distribution and abundance of painted turtles in Oregon.

Eastern Oregon and the Columbia Gorge—

In eastern Oregon, we know of only two areas where surveys for western painted turtles were conducted. At a site near the Columbia River, Croghan (1983) estimated abundance and population structure at a site previously studied by R. Rohweder in 1979 (cited in Croghan 1983). Croghan captured 99 painted turtles in a series of natural and human-made ponds and described age and size structure. He compared his captures to those obtained by Rohweder in 1979; Croghan concluded the population was declining due to low recruitment and a lower catch-per-effort. Based on his comparison of capture data and visual searches, he concluded visual surveys using transects did not yield meaningful data. In a survey in the John Day Reservoir in the Columbia River, counts were made of western painted turtles during a six week period in 1995 using visual and trapping surveys (Behrens et al. 1995). They captured 10 painted turtles during their trapping efforts; the number observed during visual surveys was not clear. Many other records exist of painted turtles in Oregon (ODFW, unpublished data), but these may not exist in a searchable database.

Western Oregon—

Willamette Basin

Several geographically broad surveys for western pond turtles have occurred within the Willamette Basin. Although most of the areas surveyed were outside the range of the western painted turtle, some of the areas surveyed could have been occupied by this species (Holland 1994, Reams 1999, Adamus 2003). Holland (1994) surveyed for western pond turtles throughout the Willamette Basin, including sites near the Columbia River. Although he must have detected western painted turtles, we are not aware of these data; his report is restricted to western pond turtles. Data from his surveys may be available but we are not aware of their location. A follow-up survey was conducted by Adamus (2003) in the Willamette Basin, with the goal of expanding the geographic area where western pond turtles were observed. His survey includes areas in which western painted turtles occur, but he makes no mention of their occurrence. Reams and colleagues (1999) conducted surveys for western pond turtles in several rivers in the Willamette Basin. The only area likely to harbor painted turtles in his survey was the Tualatin River. Unfortunately, Reams and colleagues did not detect either pond or painted turtles during their surveys. They refer to an earlier report (Reams and Williamson 1997) of a painted turtle sighting in the Tualatin River, but we have not been able to acquire the report for additional details. An informal survey was conducted by St. John (1987) in the Willamette Valley. He reported finding painted turtles in the lower Willamette Basin, but not in the upper Willamette. He reported their occurrence south to Corvallis.

Portland Metropolitan Area

There have been several studies conducted in a protected bottomland site managed by ODFW. Hayes et al. (2002) commented that work has been conducted on painted turtles at this site since the 1990s. Visual surveys, trapping, and studies of movement of radio-tagged females was conducted in 1996 and 1997 (S. Beilke, ODFW, pers. commun., July 2009). A total of 36 painted turtles were captured in 1996 and a total of at least 94 painted turtles were captured in 1997. There were additional painted turtles captured in 1997 that were also captured and marked in 1996, but the number of individuals that were recaptured is not clear. Hayes and coworkers (Hayes et al. 2002) used this site as a lower-disturbance comparison to their primary sites in a Port of Portland area.

Staff from various cities in the Portland metropolitan area have conducted site surveys prior to development, and some of these efforts identified painted turtles where they were previously unknown (see *Case Study*). A few of these records were submitted to ORNHIC.

Columbia Slough and associated canals and ponds

Several of the surveys in the Portland metropolitan area reported the regular occurrence of painted turtles in the Columbia Slough and associated drain canals and nearby ponds (Gaddis and Corkran 1985, Beilke and Christensen 2007, Beilke and Christensen 2008). During 2009, surveys will be conducted in the Columbia Slough and Johnson Creek watersheds to further identify areas with painted turtles. The primary objectives of these survey efforts were to verify occupancy of sites by native turtles. The locations from these surveys are not yet accessible and were not included in this report nor in the database that we compiled. As far as we are aware, the locations from these surveys were not in the ORNHIC database.

Port of Portland sites

Hayes and others (Hayes et al. 2002) conducted a detailed population and space-use study of painted turtles in a Port of Portland and Metro wetland complex from April 1999-April 2000. The report of their work is a very thorough review and treatment of their findings, which they translate into very clear management suggestions. They used a combination of visual, mark-recapture, and radio-telemetry approaches for their study of demography and movements of painted turtles. We cite their work throughout this report and hence do not summarize their findings here other than those related to estimates of abundance.

The site of Haye’s et al. study included about 2800 acres, and is the largest industrial area with undeveloped wetlands. Hayes and coworkers (Hayes et al. 2002: 96) estimated approximately 100 adult painted turtles and marked at least 73 juveniles.

Smith and Bybee Lakes

All written accounts and expert opinions report the greatest number of western painted turtles in the Portland metropolitan area occur in the Smith and Bybee Lakes and wetland complex. The following material is taken from E. Stewart (Metro, pers. commun., June 2009). Metro has conducted surveys for painted turtles using a standardized protocol since at least 2001 to at least 2005, using both visual and capture surveys. Surveys have resulted in counts of from 108 – 303 turtles annually, with no apparent trend. Mark-recapture methods have been used as part of the research work. From 1999-2001, a total of 332 painted turtles were marked. Nesting and over-winter sites have been located during the project. One of the questions being addressed is the degree to which visual surveys can serve as an index to population size.

Metro has been conducting one of the most through and long-term demography studies of painted turtle populations in Oregon and is one that is very relevant to conservation issues. However, there is a need to summarize the research, management efforts, and the primary findings.

Other Areas

Sauvie Island

There have been several informal surveys conducted on Sauvie Island and there will be a survey conducted in 2009 (S. Beilke, ODFW, pers. commun., July 2009). Previously, Gaddis and Corkran (1985) conducted visual observations at selected sites on the island and reported that painted turtles were abundant at some sites. They also captured and marked individuals in one area. The authors commented on an "aging population" based on few juveniles or hatchlings seen or trapped. We have not been able to obtain location information from any of the surveys conducted on Sauvie Island other than some rough maps in Gaddis and Corkran (1985).

Marion County

As part of a class project at Oregon State University, Elling (1966) conducted a study of a population of painted and pond turtles that co-occurred at an oxbow lake located 1.5 miles east of the Willamette River within Marion County. She captured 5 turtles of each species. She noted that the lake has abundant bullfrogs and bass.

Population Trends

Population trends are virtually unknown. A few sites in the Portland metropolitan area have had surveys at somewhat regular intervals but the data have not yet been summarized. Even with regular surveys, understanding population trends is made difficult because of the challenges with sampling turtle populations, discussed below. Because of the limited understanding of painted turtle abundance through time, it is difficult to make inferences on population trends. It may be possible to identify populations that have been extirpated, and if a good case can be made for the cause of the local extirpation, inferences on general population patterns may be possible. Further efforts to compile existing survey and location records would be useful, as would identifying specific locations that may be worth monitoring with a hypothesis-driven approach (Nichols and Williams 2006). Broad-scale monitoring to collect trend data is unlikely to yield inferences that can efficiently guide management (Nichols and Williams 2006), despite the frequent call to monitoring trends in this species. Targeted monitoring however would be a useful and necessary aspect of an adaptive management plan. Targeted monitoring evaluates specific changes called for in a management plan, such as minimizing recreational impacts to specific turtle populations. Given the extreme reduction of wetland habitats in the range of the painted turtle in Oregon, there is no question that painted turtle populations have been reduced since pre-European settlement. However, the current population trajectory is unknown. Given development patterns (see *Case Study*), it makes more sense to develop conservation plans now rather than requiring evidence of a declining population before actions are taken.

Section Summary

In Oregon, native western painted turtles occur along the northern portion of the state. Their current range differs from their historic range in Oregon primarily by the introduction of new populations founded by released pet painted turtles in previously unoccupied areas, and a decrease in its range in the eastern edge of the Willamette Basin from local extirpations following development and subsequent isolation . Releases of pet turtles that originated from areas outside of Oregon make detecting changes in the range of Oregon native stock difficult. Limited survey efforts have been reported for western painted turtles in Oregon. Additional survey work should address information needs for developing conservation plans. In general, continued surveys are unlikely to provide useful estimates of population trends because of the difficulty in obtaining precise and unbiased estimates. In addition, there has been little effort to link trends with management actions or options. Further efforts to compile existing survey and location records would be useful, and to identify specific locations that may be worth monitoring with a hypothesis-driven approach. Given the extreme reduction of wetland habitats in the range of the painted turtle in Oregon, there is no question that painted turtle populations have been reduced since pre-European settlement. However, the current population trajectory is unknown. Given development patterns (see *Case Studies*), it makes more sense to develop conservation plans now rather than requiring evidence of declining and threatened populations before actions are taken.

V. CONSERVATION

Threats and management approaches to the conservation of western painted turtles in Oregon are often landscape- and site-specific. The primary threats relevant to the limited range of the western painted turtle in Oregon result from the fact that a large proportion of its Oregon range exists in a largely urban environment. We discuss documented threats to population persistence, threats that have been identified in published and unpublished work, and threats that are likely to exist given our current understanding of painted turtles.

Threats

Reduced Nest Site Availability—

Limited nest site availability is a particular concern in urban and urbanizing environments. Loss of nesting areas from development, including conversion of suitable nesting habitat into parking lots, roads, and other infrastructure and buildings remains an important threat throughout its range. Loss of sparsely vegetated nesting habitat to invasion by invasive plants that form dense mats or shade such as Himalayan blackberry (*Rubus armeniacus*) is a continued threat. Additional loss of nesting habitat may occur through riparian restoration efforts (see *Other Threats*, below) if trees are planted along watercourses without leaving exposed areas for nesting turtles. Agricultural activities can also reduce availability of nest sites.

Elevated Nest and Hatchling Predation—

Factors cited as limiting western painted turtles include lack of juvenile recruitment due to nest and hatchling predation, the latter often purported to be from introduced fish and bullfrogs. However, evidence is lacking to support this. Because painted turtles naturally co-occur with these species in other parts of their range, population limitation from these predators seems unlikely in most environments. Further, behavioral observations of aggressive behavior of painted turtle hatchlings have led several investigators to consider hatchling predation by bullfrogs unlikely to be of conservation concern (Hayes et al. 2002). Predation on nests is believed to be elevated in developed areas because of greater abundance of coyotes, raccoons, and skunks, but there has been little quantification of these threats other than documentation that they are indeed some of the most common nest predators. From the work that has been done in Oregon, levels of nest depredation are site- and year-specific (Hayes et al. 2002). This is well documented throughout the painted turtle's range (Ernst and Lovich 2009). Nest predation has been a focus of the management of western painted turtles in Oregon. At some sites, nests have been protected from predators by installation of exclosures. Assessment of whether predation pressure on nests is much greater than it would have been historically might help evaluate the best allocation of resources among different management options.

Population models will be useful to put the levels of nest depredation into perspective and evaluate at what point cause for concern is justified and under what circumstances nest protection is 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 VII Inventory, Monitoring, and Research Opportunities).*

Road Mortality—

Roads affect turtle populations in two primary ways: they cause direct mortality to adults, especially females, and they reduce connectivity among populations and between nesting and aquatic habitats. Limited connectivity as a result of urban and agricultural development continues to be a concern, and some small populations in the Portland metropolitan area may no longer retain connectivity to other populations. Road mortality has been cited as a cause of decline of specific populations (Griffin 2005, Steen et al. 2006), and is considered to be a major mortality factor. One study reported 14 road mortalities of western painted turtles in a single day on a stretch of road 250 m long in Pennsylvania (Ernst 1974). This is potentially a major mortality risk in many of the populations in the Portland region, including on Sauvie Island (S. Beilke, ODFW, pers. commun., July 2009) and is expected to increase as a threat as the human population increases in the Willamette Valley.

It has been assumed that females would be more prone to such mortality due to nesting activities (Steen et al. 2006). An analysis of 165 estimates of sex ratios published for 36 species of turtles throughout the United States suggested an increasing skew toward males in aquatic species (Gibbs and Steen 2005). A similar skew was found in populations of painted turtles in New York when road densities around the wetlands were high (Steen and Gibbs 2004). Road mortality must be considered as a potential factor in conservation, particularly in areas where wetlands are surrounded by busy roads (Andrews et al. 2008), such as the Portland metropolitan area. Evidence to date suggests that roads are a major source of mortality for adult females in Oregon. For example, on Sauvie Island, several females were found either dead or sufficiently injured that they were brought to a local wildlife rehabilitation center (S. Beilke, ODFW, pers. commun., July 2009).

Introductions and Collection—

A growing threat particularly in urban areas is competition with and disease transmission from introduced turtle species. 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. Genetic work will be required to further evaluate the extent of the threat. Illegal collection of wild western painted turtles for pets or other purposes remains an important threat. Although there is no legal harvest in Oregon, a market exists for painted turtles both in the pet trade and from biological supply houses. In Minnesota, where collection was legal, a total of 319,554 turtles were removed from 1991-2001 according to commercial license returns (Gamble and Simons 2004), demonstrating the large market for painted turtles.

Common snapping turtle

The common snapping turtle is not native to Oregon and is considered an invasive species because of its ability to survive and reproduce in natural habitats in Oregon.

Snapping turtles were classified by Oregon Administrative Rules (OAR 635-056) as a Nonnative Prohibited wildlife species in 1996, which prohibits the import, possession, transport, buying, selling and bartering of live snapping turtles. How snapping turtles reached most localities remains unknown but pet releases seem most probable (Bury and Luckenbach 1976, Beebee and Griffiths 2000). The introduction of snapping turtles has been intentional in at least some cases, for example, in British Columbia, Canada (Gregory and Campbell 1984). Reports of common snapping turtles in Oregon have recently increased, probably in part due to an increase in public education efforts, including the development of a turtle sighting reporting system by ODFW and the Oregon Zoo. In Oregon, snapping turtles are known to occur in various waterways, primarily within the Willamette Valley. They have been collected in the following areas: Eugene / Springfield, Lebanon, Corvallis, Troutdale (Sandy River), North Fork Reservoir fish ladder on the Clackamas River, Beaverton / Hillsboro (Tualatin River and tributaries), Milwaukie (Willamette River / Kellogg Lake), Lake Oswego (Lake Oswego), and Portland (Columbia River, Johnson Creek). Snapping turtles have also been collected in coastal Oregon (Coos Bay) and sighted in a pond near Roseburg (Brown et al. 1995). ODFW and partners are actively conducting a snapping turtle trapping project at a specific pond within the City of Beaverton to learn more about snapping turtles in Oregon. Between 2004 and 2008, 55 snapping turtles have been captured and removed from the pond and multiple nests with eggs have been dug up and removed (S. Barnes, unpubl. data).

Red-eared sliders

Red-eared sliders are perhaps the most globally distributed freshwater turtle from introductions from the pet trade. This species is also classified as nonnative Prohibited Wildlife by Oregon state law (OAR 635-056) and considered an invasive species. In Oregon, they are much more common and more widely established than common snapping turtles. They co-exist with pond turtles and western painted turtles, although the effects of this species upon the others have not been reported as far as we are aware. Sightings of red-eared sliders have also increased, again most likely due to increased educational efforts. Many red-eared sliders are still seen illegally in the pet industry in Oregon (S. Barnes, pers. obs.). Outreach and education efforts to pet stores are underway throughout the state. Importation in of farm-raised hatchlings still occurs as highlighted by recent law enforcement confiscations. Many sliders also are purchased legally in Washington and are brought across state lines. Turtles obtained in California have also been brought into Oregon, and in at least one instance, is known to have escaped from their owners (C. Puchy, pers.obs.).

Recreation Disturbance—

Disturbance by recreationalists of areas occupied by turtles has been blamed for population declines of freshwater turtles, including the extirpation of some populations (Mitchell and Klemens 2000). The painted turtle is very sensitive to disturbance when basking and nesting, as observations in Oregon have demonstrated (Hayes et al. 2002). Interestingly, juveniles and hatchlings were tolerant of people, allowing approach within a few meters when the animals were basking on vegetative mats (Hayes et al. 2002).

Adult turtles, however, are generally very sensitive to disturbance, leaving basking logs on the approach of a person even 30 m away (Hayes et al. 2002). The sensitivity of painted turtles to human disturbance is well documented outside of Oregon as well. In Michigan, turtles were less tolerant of human activity at sites with greater disturbance, and retreated into the water at greater distances from the disturbance than they did in less disturbed sites (Leuteritz and Manson 1996). This may have important implications for thermoregulation and consequently digestion and other metabolic processes in sites with heavy disturbance. Any activity by people or pets within line-of-sight to turtles or their nesting habitat can cause disturbance.

A large portion of the western painted turtle population in Oregon is either in or near urban areas. This is likely to result in high recreational use of aquatic systems and adjacent upland areas, increasing the likelihood of disturbing the turtle's behavior, particularly time spent basking and home range use. Disturbance results from a plethora of human activities in or near aquatic habitats, including walking, hiking, and jogging along trails; motor boats, canoes, and kayaks; and bicycles either on or off trails. A primary management activity at some of the Portland metropolitan area sites with turtles is directing recreation away from turtle use areas (E. Stewart, pers. commun.).

Trails are an important issue because they are planned for many natural areas in urban centers, such as the Portland metropolitan region (S. Beilke, ODFW, pers. commun., July 2009). In Washington County, stream buffers widths of 25-50' are required and trails are often allowed within the buffers (S Beilke, ODFW, pers. commun., July 2009). In some areas, these trails will likely negatively impact western painted turtles by increased disturbance by recreationists and their pets. Cities within the Portland metropolitan region have varying codes related to development of trails in natural areas. Some proposed trails would go through or nearly adjacent to nesting areas. Some of the turtle populations in these areas are the only ones known to still exist in the area (S. Beilke, ODFW, pers. commun., July 2009).

Other Threats—

Stream Restoration

Within the past decade, there have been unprecedented efforts to restore riparian areas along many of Oregon's waterways, often to promote healthy streams for salmonids. Although these efforts have improved water quality and restored fish habitat, there needs to be recognition of the value of open habitats (without shrubs and trees) for turtle nesting habitat and sunny areas within the stream environment to allow for basking. Planting of shrubs and trees in some areas represents a threat to western painted turtles.

Contaminants

Broad-scale pesticide use to reduce mosquito larvae in wetland areas may reduce invertebrate prey. The largest wetlands are most likely to undergo pesticide use to reduce mosquito larvae and it is these wetlands that contain the largest remaining painted turtle populations in the Portland metropolitan region. In one wetland complex, larvicide was applied more than ten times to the wetlands' perimeter during a single spring-summer season (E. Stewart, pers. obs.). Effects of repeated applications on non-target dipteran populations and wetland food webs are poorly understood. In addition, herbicide use for aquatic invasive plants may alter the availability of cover and basking sites especially for very small turtles. Other sources of water pollution may also affect western painted turtles. No information was found detailing with any of these potential threats.

Fishing

Painted turtles are known to get caught by fisherman using bait, such as worms (Croghan 1983, Hayes et al. 2002) The extent of harm is unknown, but several females were found injured and in one case dead in a lake in the Portland metropolitan area (S. Beilke, ODFW, pers. commun., June 2009).

Agricultural Activities

Because of the broad habitat selection of painted turtles, and the proximity of much of the aquatic habitat of painted turtles to agricultural land in the Willamette Valley, western painted turtles are potentially at risk from agricultural activities. This is primarily during nesting. Painted turtles will construct nests in agricultural fields if the vegetation is sparse. Subsequent agricultural activities have resulted in nest destruction and mortality to adult females (ODFW memo dated June 27 1995; S. Beilke, ODFW, pers. commun., July 2009). The extent of this problem for western painted turtles is unknown.

Illegal shooting

In some areas, there have been instances of turtles being shot illegally (Elling 1966, Croghan 1983). The frequency of this should be assessed and discussions with ODFW District Biologists should be conducted to find a way to lessen the occurrence of this illegal activity if it is still considered a problem. Illegal shooting should be considered when installing basking structure so as to minimize potential harm from illegal shooting as well as other human disturbances.

Research/Survey Disturbance

Although we tend to concentrate on disturbances to the populations researchers do not cause, there is no question that research or survey work (such as nest searches) can be disruptive to populations. We raise this issue as a threat because it may be particularly relevant for the western painted turtle population in the Portland metropolitan region. We believe this is the case because of the following reasons: (1) there is a relatively large and important population in the Portland metropolitan region; (2) there is valid concern for turtles in the area and hence great interest in studying them; (3) the population is limited in size; (4) there are only a few areas with relatively large populations and these would typically be the areas researchers would select for their study areas, (5) these same areas are publicly owned and managed by agencies that desire to conduct research to better their management, and hence funding is most likely available at these sites, and (6) much of the research and survey efforts at these sites 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. Together, these conditions may lead to researcher effects at the most important and potentially vulnerable populations.

Climate Change

Climate change represents major perturbations in environmental conditions for many organisms. For freshwater turtles, water temperature is likely a factor limiting distributions and so we would expect large changes to the distribution of turtles in Oregon with changes in temperature of aquatic habitats. Climate change will also likely affect hydrological patterns. This may cause nest loss from winter flooding and loss of aquatic habitat if increased summer drought occurs. Climate change in the Willamette Valley has the potential to decrease and increase suitable habitat for western painted turtles. We do not address this risk further in this Assessment other than to note its likely importance for long-term conservation planning.

Conservation Status

The western painted turtle is considered vulnerable in Oregon because of its limited distribution, considerable modification to and loss of wetland habitats, threats from presumed elevated nest and hatchling predation, and potentially high rates of mortality to adults from motor vehicles. A suite of threats are relevant to the conservation of this species (see *Threats*, above), primarily in the Portland metropolitan region. The distribution and abundance of western painted turtles outside the Portland metropolitan region may be well known but has not been as well documented. The assessment of the vulnerability of this species in Oregon is partly dependant on understanding its viability outside of the metropolitan area, where threats are lowest. These issues, together with the large range of western painted turtles in North America and its purported broad distribution in adjacent Washington, justifies the subspecies ranking by NatureServe as G5 (globally widespread) and S2 (state imperiled).

Known Management Approaches

Despite the keen interest in conservation of western painted turtles, we are aware of few assessments on the success of management approaches. Construction of an undercrossing in the Portland metropolitan region and the community effort towards conservation of an isolated wetland serve as excellent success stories (see Section VII, *Case Studies*). In a wetland complex in the Portland metropolitan region, a nesting area for painted turtles that was improved through soil amendments and addition of native plants demonstrated successful nesting (Stewart 2008). The use of exclosures to protect nests from predation has been implemented on the western pond turtle in Oregon (Rosenberg et al. 2009), and may provide a short term tool to maintain or increase populations, while working on longer term solutions. The western painted turtle is an Oregon Conservation Strategy priority species. However, we are unaware of any conservation plans for this species in Oregon. The Native Turtle Working Group (see http://www.oregonturtles.com) has developed an outline of action items as an initial step towards a conservation plan for the western painted turtle in the Portland metropolitan region.

Management Considerations

There are several management and restoration activities that could improve conditions for Oregon's native turtles. Both the western pond and painted turtle, to our best understanding, face similar threats and would be expected to respond similarly to management actions. One of the primary differences is the narrow distribution of western painted turtles in Oregon, primarily on private lands and designated open space managed by local public agencies, compared to the western pond turtle's broad distribution in western Oregon and the occurrence of large populations on lands managed under federal, state, and local jurisdictions (Rosenberg et al. 2009).

Management responses include addressing habitat suitability, increasing recruitment into the breeding population, providing connectivity among populations while at the same time minimizing spread of invasive turtle species, and reducing loss of adults through mortality and illegal removal of turtles by the public. Because of the limited distribution of the western painted turtle in Oregon and the large proportion of the painted turtle's range in Oregon within urban or rapidly urbanizing areas, special attention to urban issues such as the impact of development is needed.

Reduced Nest Site Availability—

Improving or creating nest habitat, hatchling habitat, and basking structures in some aquatic habitats are feasible management actions. Long-term management is needed to retain and create nest areas by maintaining vegetation in an early successional state, and reducing invasion by species that will create shade, such as Himalayan blackberry. Given the broad array of substrates used for nesting and the painted turtle's selection for sparse to no vegetation, management efforts should be able to increase nest site availability. There have been some efforts to provide nest habitat in Oregon and the results are promising (Stewart 2008, *see Section VII Case Studies: Isolated Urban Wetland*). Development of a detailed management plan would be useful for identifying existing nest areas to avoid impacts from development, and to locate areas where nesting areas may be limited and would benefit from construction of potential nesting habitat.

Elevated Nest and Hatchling Predation—

Management actions to increase nest and hatchling predation may include using nest exclosures and reducing numbers of predators. However, we caution use of these measures prior to an assessment of the degree to which nest and hatchling predation is limiting populations (*see Section VI: Inventory, Monitoring, And Research Opportunities: Research Priorities*).

Road Mortality—

Reducing road mortality and its impacts to the population and maintaining connectivity among populations and between aquatic and terrestrial habitat is critical, but difficult. Under-crossings may be appropriate in some locations, but costs will limit when and where this is possible (*see Section VII: Case Studies*). Other management activities should be considered for reducing road mortality, including where nest habitat is improved or created.

Introductions and Collection—

Populations of introduced and invasive species, especially the red-eared slider and more recently the common snapping turtle, need to be managed. It will also be important to identify methods to stop new introductions. Furthermore, eliminating the introduction of painted turtles by the public is vital to maintain genetic integrity of the populations in Oregon. Educational materials produced in various languages that discuss introductions, translocations, and removal/collection of turtles are crucial to lessening the frequency of these often well-intended activities by the public. Further, if the threat of removal of western painted turtles in the Portland metropolitan areas is as high as local natural resource professionals fear, instituting a volunteer citizen “watch” may be very useful.

Recreation Disturbance—

In many areas, recreational impacts can be reduced by redirecting areas used for recreational use to other areas or through temporary closures. Determining critical distances between recreationists and western painted turtles in various environments and recreational activities would facilitate management of these disturbances. In turtle-sensitive areas, closure of fishing areas to bait fishing would reduce or eliminate injury or mortality.

Other Threats—

Best management practices and conservation plans would facilitate reducing threats from agricultural activities. Mapping exercises of painted turtle locations (actual or modeled) with land use activities would be useful to identify areas of concern in agricultural areas.

We recommend the development of a strategy to minimize direct and indirect effects of research activities from happening while at the same time learning important aspects of these populations for improved management. Such a strategy would need to limit research to that which is critical, avoid duplication of effort, and review methods to ensure effects are minimal. In addition, the research findings should be widely reported and easily accessible to natural resource professionals. This has rarely been the case for the work conducted previously.

Section Summary

The primary threats of the western painted turtle in Oregon are related to the fact that a major part of its range in Oregon occurs within the urban environment. Limited nest site availability is particularly a concern in urban and urbanizing environments. Low recruitment of juveniles as a result of nest and hatchling predation is a concern that needs to be evaluated. An important concern is elevated mortality of adults, particularly females, from road mortality. Releases of pet turtles to natural areas are a growing threat and may result in increased competition and disease transmission. Loss of genetic integrity because of release of pet painted turtles from non-native stock is an important but often-ignored issue. Recreational use adjacent to and within aquatic habitats will affect the turtle’s behavior and likely cause harm in some cases. Further, illegal shooting and accidental catch of turtles while fishing results in elevated mortality. The frequencies of these events are unknown and are likely to vary in importance among locations. Long–term conservation planning will also need to consider effects of climate change on the aquatic habitats of turtles. There are many management options to address the primary factors that are likely to affect the conservation of western painted turtles in Oregon.

VI. INVENTORY, MONITORING, AND RESEARCH OPPORTUNITIES

Data and Information Gaps

We consider the following to be the most important gaps in our understanding of western painted turtles in Oregon that is relevant for management. We believe by addressing these data and information gaps through thoughtful monitoring, research, and adaptive management, more effective conservation can be achieved.

- Distribution and abundance patterns in relation to land allocation and existing conservation areas
- Distribution in eastern Oregon, including the Columbia Gorge, is lacking in existing databases; evaluate need for additional location information.
- Distribution of native vs introduced painted turtles and potential for disease transmission
- Factors contributing to high-density turtle areas
- Habitat associations that allows development of a habitat suitability map
- Habitat selection regarding juxtaposition of aquatic habitat, terrestrial habitat, and rearing habitat
- Hatchling habitat relationships
- Barriers and facilitators of movement/connectivity of populations
- Sustainable levels of nest and hatchling predation
- Impacts of urban predators (e.g., raccoons, skunks) and introduced species (e.g., non-native turtles, fish and bullfrogs)

Inventory and Monitoring

There are numerous sources for location records but there remains a need to organize the records so they can be more easily combined into a searchable database, perhaps administered by ORNHIC. Before further efforts are made to compile location records, it will be useful to first carefully evaluate how these data would be used. These data are unlikely to be useful for monitoring changes in population size, regardless of any use of an established protocol, because most samples are opportunistic. However, they could prove valuable for evaluating changes in occupancy given various land alterations, and could be used in conjunction with more controlled studies evaluating various impacts to painted turtles, as well as improving our understanding of occupied sites.

Survey efforts have resulted in survey protocols that are sometimes but not regularly used. These protocols stemmed from other efforts to develop standardized methods for efficiently and reliably surveying western pond turtles in a broad array of habitats (Bury and others 2001). The protocols used (Beilke and Christensen 2007, Beilke and Christensen 2008) have undoubtedly improved the likelihood of detecting painted turtles but it is clear that standardized methods alone are not sufficient for reliably estimating occupancy or abundance, nor for estimating trends in abundance through time. Further evaluation of these methods and recognition of their uses and limitations would be desirable.

Formal methods for estimating occupancy (MacKenzie et al. 2006) and abundance (Williams et al. 2001) are well developed but often require more rigorous effort than has been typically used in surveys of the painted turtle in Oregon. Evaluation of the usefulness of these methods to address the objectives of many of the survey efforts would be worthwhile as would a reconsideration of the survey and monitoring needs for painted turtles in Oregon. We emphasize a targeted monitoring approach versus the more typical surveillance approach (Nichols and Williams 2006). Targeted monitoring approaches aim to address specific hypotheses from monitoring changes in some aspect of the population of interest, whereas surveillance monitoring is typically detecting changes in a population (e.g., abundance) through time, without regard to any causative factors. Results from surveillance monitoring do not necessarily identify when and how management should intervene.

Research Priorities

Research opportunities that are most likely to contribute to the conservation of western painted turtles in Oregon will emanate from a carefully constructed conceptual model of threats to the population combined with consideration of possible management tools and how the turtle population is likely to respond to management. Under this formal conceptualization of threats and solutions, the most appropriate conservation-based research can be identified.

Given our understanding of threats and previous research on painted turtles, we believe the following are critical research needs.

1. We emphasize research on nest and hatchling survival because of the purported lack of recruitment in both painted and western pond turtle populations in Oregon and Washington, and because these stages in the life-cycle have not received attention due to the difficulty in their study. Specifically, research to evaluate threats to nest and hatchling survival and to evaluate habitat requirements of hatchlings is needed. Before this research can be productive, methods to study hatchlings needs to be developed. An initial pilot study incorporating harmonic radar detection is underway (D. Rosenberg, June 2009, Oregon Wildlife Institute).

2. Given the urban concentration of painted turtles in Oregon, evaluating population consequences of road mortality and methods to reduce such mortality is vital. An initial step would be to evaluate population risk from road mortality of adults by constructing spatially-explicit population models that are parameterized in a meaningful way. Although we lack detailed turtle population data, we do know the road networks, land use, and the turtles' response to undercrossing availability (e.g., Port of Portland's undercrossing, C. Butler, Port of Portland, pers. commun., June 2009).

3. Adaptive management approaches are needed for improving aquatic and terrestrial habitat in the Portland metropolitan region including evaluating methods to increase connectivity of populations while still minimizing spread of invasive turtle species (Fausch 2009). Carefully guided management can be linked to monitoring to assess turtles' response to modified habitat. We recommend this approach rather than continued survey efforts without a hypothesis/management driven direction.

4. Research on educational tools to reduce introductions of turtles will be very helpful in determining what outreach efforts will be most effective in preventing the release of captive animals into the wild or the taking of wild animals into captivity. Consideration of cultural issues and best ways to address illegal take from ethnic groups for food or spiritual reasons will be important in making the educational effort effective. Connecting with these cultural groups and translating educational materials into various languages may be prudent.

5. Finally, development of population models to evaluate various risks, including rates of survival of various age classes and landscape factors (such as likely dispersal routes) would be useful tools for both research and management, particularly to facilitate developing a conservation plan in the Portland metropolitan area. In particular, this would be a useful tool to evaluate effects of habitat loss or reduction in quality from development within proposed urban and rural reserves.

Section Summary

Inventory and monitoring data for western painted turtles in Oregon and in particular in the Portland metropolitan region have been collected but are difficult to access. An important first step is to compile reports and location records so they can be more easily combined in a searchable database, perhaps administered by ORNHIC. Survey protocols that have attempted to standardize sampling methods will not be sufficient for reliably estimating occupancy or abundance, or for estimating trends in abundance through time. Further evaluation of these methods and recognition of their uses and limitations would be desirable. Formal methods for estimating occupancy and abundance in general are well developed. Evaluation of these methods to address the objectives in many of the survey efforts would be useful. Research priorities include:
(1) evaluate factors affecting nest and hatchling survival
(2) evaluate methods to improve aquatic conditions using an adaptive management approach
(3) evaluate educational tools to reduce introductions of turtles
(4) develop population models to evaluate various risks, including rates of survival of various age classes and landscape factors (such as road networks)

VII. Case Studies

Painted Turtle Conservation in an Isolated Urban Wetland: A Case Study

Laura Guderyahn
Watershed Management Division
City Staff, Portland Region

Background

In 2007, the Portland metropolitan region, the local city's environmental division began doing herpetological surveys as part of a larger multi-year effort to document the City's natural resources. Because Oregon's two native turtle species are experiencing population declines and there is a lack of documentation (either written or oral records) of any turtle sightings in the area, the City did not expect to find many turtles. Basking surveys began in May of 2007 and the City was pleasantly surprised to find that of the 10 sites surveyed, native turtles were found at two of them. A large, deep, in-line storm water pond contained at least 5 adult western painted turtles. The second site (Fig. 6), a low-gradient headwaters stream contained a large, successfully breeding population of western painted turtles. Over 100 turtles were ultimately captured at this site. It is this last population that the rest of this Case Study will focus on.

This population of turtles was found in a 43-acre groundwater fed wetland complex that, over the past 10 years, has experienced rapid urbanization, with apartment complexes, neighborhoods of single family homes, and four-lane roads being built that now almost completely surround it. The only land adjacent to the wetland that is not developed is an 85 acre forested butte that may serve as nesting habitat. In addition, up until 1988 the wetland had been drained, channelized and used for cattle grazing. It wasn't until 1988, when the City acquired the property as open space that an effort was made to restore it back to a wetland complex for improving water quality, reducing flood events, and improving wildlife habitat.

Development Planned

At the time that the turtles were found in this headwater wetland, two major City projects were being planned, both of which had the potential to negatively impact the wetland and the turtle population directly. The first was a 30" water pipe project that was designed to bring groundwater through the apartment complex along its eastern edge, directly west through the wetland itself and up to the top of the butte, where a water reservoir exists. A trail project was also planned which would pave a bike path through the eastern edge of the wetland along an old railway bed which was serving as some of the last nesting habitat available to the western painted turtles.

continued on next page

City Finds Solutions

As soon as the turtles were discovered and City staff realized that these two projects had the potential to negatively impact the population, Watershed Management began working closely with the Oregon Department of Fish and Wildlife (ODFW) to determine what impacts these projects would have and how those impacts could be minimized.

The Water Division had already created a wetland conservation plan to minimize impacts to the headwaters from their water pipe project. They had already decided to tunnel under the wetland with a borer to get their pipes across, rather than trenching through the wetland. There were also plans in place to ensure that the water pumped out of the bore hole was released into the wetland at a low velocity and to make sure that it was filtered to remove excess sediment that would have made the water in the wetland highly turbid.

Minimizing impacts from the Trail Project turned out to be much more complex. Using the railway bed as the trail alignment posed two major problems. First, the railway bed was narrower than the 14ft needed for the trail, so it would have to be widened, resulting in direct impacts to the wetland itself and potential wetland mitigation costs. The second was paving over the turtle nesting habitat. ODFW made it clear to the City's Parks Department that they would not support building the trail on the railway bed if it meant eliminating this habitat. The only alternative that would solve both of these issues was to move the trail alignment completely out of the wetland and up the eastern slope along the edge of the headwaters, directly below and parallel to the apartment complexes.

Even though the presence of the turtles meant spending additional time and resources mitigating impacts of their projects, both the Water Division and Parks Department saw consideration of this state-listed population in their project plans as part of responsible resource management and were willing to work with Watershed Management to make whatever changes were necessary to ensure no negative impacts were made on the turtles.

The neighbors living in the surrounding neighborhoods have also reacted positively to the presence of the western painted turtles. Besides nesting on the railway bed, they also nest at the base of the butte in at least one homeowner’s yard. This citizen and his family have taken great pride in helping the City do nesting surveys on their property. Every spring and summer, they watch the turtles build nests. The homeowners mark the nests and call Watershed Management staff, who go out to record the nest locations. The following spring the homeowners watch the nest sites for signs that the hatchlings are emerging and call Watershed Management staff so they can collect data on the young turtles. Additional residents call Watershed Management staff on a weekly basis to report the number of turtles they see basking in the wetland and still others serve as the "eyes and ears" of the wetland, calling the City to report any vandalism, unauthorized trapping or other illegal activity.

The City as a whole has taken great pride at having this population and is continuing to take steps to protect them. Watershed Management staff are also working with volunteer groups to create additional healthy nesting and basking habitat in and around the wetland. We are also working closely with ODFW to continue basking and nesting surveys in an effort to collect long term data on the population. Finally, we are doing trapping surveys each summer to catch, collect data on, and mark each turtle in order to better understand the size and health of the population.

The City’s ability and willingness to work to mitigate the impacts of the two large-scale projects in 2007 and our continued efforts at conserving this population is an example of how a City can strive to preserve its urban natural resources, be they turtles, a rare plant species, or a rare habitat, and yet still provide the recreation and services necessary for healthy urban living.

Wildlife Undercrossing Protects Western Painted Turtles: A Case Study

Carrie Butler
Mitigation Site Specialist
Port of Portland

Background

Plans for a road-over-rail project in the Rivergate Industrial District of North Portland prompted the Port of Portland (Port) to contract a study on movements of western painted turtles in 1999 (Hayes et al. 2002). Hayes et al. found that turtles frequently used the area where traffic would be diverted as an important habitat corridor that connects the Willamette River and the Columbia Slough. Hayes et al. proposed several options to reduce turtle fatalities including seasonal road closures, a wildlife overpass and an undercrossing

Partners & Funding

Port of Portland recognized the need for the undercrossing and began researching existing designs that could work for turtles and other small animals. The Port contracted engineers to design an undercrossing, based on the Port's research, that would be appropriate to allow turtles to move between the Port's wetland mitigation sites. The total cost to design and construct the undercrossing was approximately $160,000. In 2008 the Port won an award for Environmental Enhancement for this project from the American Association of Port Authorities.

Project Description

The project consisted of a 160-foot steel culvert with a 36-inch diameter, six light box grates, and two wildlife guide walls at both ends of the culvert. This "tunnel" spans below a paved road used by cars and semi-trucks, an operational railroad track and a private gravel road. Sand displaced during construction was used to amend the bottom of the culvert along the entire length to provide a flat surface. The guide walls were constructed using rebar and concrete; a 9-inch overhang prevents reptiles and small animals from climbing over the wall. The light box grates allow natural light into the tunnel to make it more appealing to animals. Ground that was disturbed during construction was seeded and planted with native species and a temporary irrigation system was installed on both sides of the crossing. Once established, the native shrub buffer may act as a partial barrier and divert wildlife towards the undercrossing.

Camera Operation, Monitoring & Maintenance

Wildlife use of the undercrossing is monitored with a motion sensor camera with an infra-red flash. A single motion sensor is mounted on the ceiling of the tunnel and positioned about three feet in front of the camera. A custom steel locking box attached to the ceiling of the tunnel contains the camera which is housed in a waterproof case provided by the manufacturer (Faunatech). The camera and sensors run on a rechargeable 12 volt battery which is exchanged every one to two weeks at which time the flash card is also exchanged. Maintenance of the undercrossing structure includes keeping the tunnel entrances clear of dense vegetation, clearing debris out of the tunnel, clearing vegetation along the guide walls and maintaining the native plants during establishment.

continued on next page

Wildlife Use

Since the camera was first installed in March of 2005, the Port has documented western painted turtles and at least 15 other animal species using the undercrossing. It is very difficult to identify individuals due to the photo quality. In 2007 western painted turtles were first photographed in May and again in June. During this time, the remote camera took 21 turtle photos, 8 identified as western painted and the remainder were not identified to species due to distance and photo quality. In 2008 turtles were again photographed in May; due to a date stamp failure it is unknown if successive turtle photos were taken in June or July (a total of 8 turtle photos, 4 identified as western painted).. No evidence of predation has been documented in the undercrossing. So far, in 2009, the camera has taken 14 photos of turtles between April 20th and May 5th.

Challenges & Recommendations

The Port encountered many challenges regarding the monitoring of the undercrossing including camera set-up. The initial sensors that triggered the motion sensor camera were floor mounted; this proved to be a poor choice when the tunnel flooded in January of 2006.. In August of 2006 a road-killed western painted turtle was discovered on the paved road that went over the undercrossing , over two years after the tunnel was complete and before any turtles were photographed using the tunnel. In response the Port installed silt fence extensions at both ends of the west guide wall in order to capture more of the turtles moving towards the undercrossing from the wetland habitat. Turtles were first photographed using the tunnel the following spring. It took approximately three years for turtles to find and use the undercrossing; fatalities could have been avoided had the tunnel been in place well in advance of the traffic diversion to allow wildlife to adjust to its presence. The construction of the wildlife undercrossing has clearly been successful in at least reducing if not eliminating mortality associated with movements onto a road that bisected wetland habitat.

VIII. DEFINITIONS

The criteria for NatureServe ranks listed under *Management Status* (Section II) are the following:

2 = Imperiled because of rarity or because other factors demonstrably make it very vulnerable to extinction (extirpation), typically with 6-20 occurrences.

5 = Demonstrably widespread, abundant, and secure.

IX. ACKNOWLEDGMENTS

Support for the conservation assessments for Oregon's native turtles was provided by the Interagency Special Status Sensitive Species Program (ISSSSP) of the U.S.D.A. Forest Service and U.S.D.I. Bureau of Land Management, the U.S.D. I. Fish and Wildlife Service, Oregon Department of Fish and Wildlife, City of Portland Bureau of Environmental Services' Science, Fish and Wildlife Program and Columbia Slough Watershed, and Metro. We thank Mark Brown (BLM) for his excellent help and insight in making this work possible, and Sue Beilke (ODFW), Carrie Butler (Port of Portland), Kim Garner (USFWS), Laura Guderyahn (City Staff), Rob Huff (ISSSSP), Lindsey Koepke (ORNHIC), and Kelli Van Norman (ISSSSP) for discussions and contributions to the Assessment and for sharing data and reports. We are indebted to all of the individuals and agencies that provided reports and location data, the Oregon Natural Heritage Information Center for sharing their state-wide database, and the Oregon Department of Fish and Wildlife for conducting and sharing the Citizen Science location information, Nate Pope for location determination and data entry of the Citizen Science database, Peg Boulay (ODFW) for assembling turtle reports and Kat Beal (USACE), Bruce Bury (USGS), Audrey Hatch (ODFW), Dave Helzer (City of Portland), Lauri Holts (City of Eugene), Roberta Swift (USACE), Dave Vesely (OWI), Chris Yee (ODFW), and participants at the 2009 Oregon Native Turtle Forum held at the Oregon Zoo (http://www.oregonturtles.com/native_turtle.html) for fruitful discussions on turtle topics. This Conservation Assessment is Contribution No. 204 of the Oregon Wildlife Institute.

X. REFERENCES

Adamus, P. 2003. Distribution of western pond turtle populations in the Willamette River Basin, Oregon. Interagency Western Pond Turtle Working Group, Portland, Oregon.

Andrews, K. M., J. W. Gibbons, and D. M. Jochimsen. 2008. Ecological effects of roads on aphibians and reptiles: a literature review. I*n* J. C. Mitchell, R. E. J. Brown, and B. Bartholomew, editors. Urban Herpetology. Society for the Study of Amphibians and Reptiles, Salt Lake City, UT.

Baldwin, E. A., M. N. Marchand, and J. A. Litvaitis. 2004. Terrestrial habitat use by nesting painted turtles in landscapes with different levels of fragmentation. Northeastern Naturalist **11**:41-48.

Behrens, N. L., E. H. Schwartz, and E. W. Styskel. 1995. Survey of amphibians and reptiles in selected areas of the John Day Reservoir - Columbia River. Completion Report submitted to ODFW.

Beilke, S., and A. Christensen. 2008. Surveys for Oregon's two imperiled turtle species, the western painted (*Chrysemys picta bellii*) and western pond (*Actinemys marmorata*) turtles. *in*. The Oregon Zoo, Portland, OR.

Beilke, S. G., and A. Christensen. 2007. Surveys for Oregon's two imperiled turtle species, the western painted (*Chrysemys picta bellii*) and western pond (*Actinemys marmorata*) turtles. Submitted to The Oregon Zoo, Portland, OR.

Black, J. H., and A. H. Black. 1987. Western painted turtles in Grant county, Oregon. . Great Basin Naturalist **47**:344.

Bowden, R. M., H. K. Harms, R. T. Paitz, and F. J. Janzen. 2004. Does optimal egg size vary with demographic stage due to a physiological constraint? Functional Ecology **18**:522-529.

Breitenbach, G. L., J. D. Congdon, and R. C. Van Loben Sels. 1984. Winter temperatures of Chrysemys picta nests in Michigan: effects on hatchling survival. Herpetologica **40**:76-81.

Brown, H. A., R. B. Bury, D. M. Darda, L. V. Diller , C. R. Peterson, and R. M. Storm. 1995. Reptiles of Washington and Oregon. Seattle Audubon Society, Seattle.

Bury, R. B. 2008. Do urban areas favor introduced turtles in western North America. . Pages 343-346 In J. C. Mitchell, R. E. J. Brown, and B. Bartholomew, editors. Urban Herpetology. Society for the Study of Amphibians and Reptiles, Salt Lake City, UT.

Bury, R. B., and a. others. 2001. Western pond turtle: survey protocol and monitoring plan. Final Draft. I*n* Interagency Western Pond Turtle Working Group.

Cagle, F. R. 1942. Turtle populations in southern Illinois. Copeia **1942**:155-162.

Cagle, K. D., G. C. Packard, K. Miller, and M. J. Packard. 1993. Effects of the microclimate in natural nests on development of embryonic painted turtles, *Chrysemys picta*. Functional Ecology **7**:653-660.

Caswell, H. 2001. Matrix Population Models., Second Edition edition. Sinauer Associates, Inc., Sunderland, MA.

Christiansen, J. L., and E. O. Moll. 1973. Latitudinal reproductive variation within a single subpecies of painted turtle, Chrysemys picta bellii. Herpetologica **29**:152-163.

Congdon, J. D., and R. E. Gatten, Jr. 1989. Movements and energetics of nesting *Chrysemys picta*. Herpetologica **45**:94-100.

Congdon, J. D., S. W. Gotte, and R. W. CmDiarmid. 1992. Ontogenetic changes in habitat use by juvenile turtles, *Chelydra serpentina* and *Chrysemys picta*. Canadian Field-Naturalist **106**:241-248.

Croghan, S. 1983. A field study to establish baseline data for monitoring population trends in western painted turtles *Chrysemys*. . *in*, Irrigon, Oregon.

DonnerWright, D. M., M. A. Bozek, J. R. Probst, and E. M. Anderson. 1999. Responses of turtle assemblage to environmental gradients in the St. Croix River in Minnesota and Wisconsin, USA. Canadian Journal of Zoology-Revue Canadienne De Zoologie **77**:989-1000.

Elling, K. C. 1966. A follow-up study of concurrent populations of Chrysemys picta and Clemmys marmorata. Unpubl. Class Report, Oregon State University, Corvallis, OR.

Ernst, C. H. 1971. Population dynamics and activity cycles of *Chrysemys picta* in southeastern Pennsylvania. Journal of Herpetology **5**:151-160.

Ernst, C. H. 1974. Effects of Hurricane Agnes on a painted turtle population. Journal of Herpetology **8**:237-240.

Ernst, C. H., R. W. Barbour, and J. E. Lovich. 1994. Turtles of the United States and Canada. Smithsonian Institution Press, Washington.

Ernst, C. H., and J. E. Lovich. 2009. Chrysemys picta (Schneider, 1783): Painted turtle. *In* Turtles of the United States and Canada. Johns Hopkins University Press, Baltimore, MD, USA.

Evenden, F., Jr. 1948. Distribution of turtles of western Oregon. Herpetologica **4**:201-204.

Fausch, K. D. et. al. 2009. Invasion versus isolation: trade-offs in managing native salmonids with barriers to upstream movement. Conservation Biology **23**:859-870.

Frazer, N. B., J. W. Gibbons, and J. L. Greene. 1991. Growth, survivorship and longevity of painted turtles Chrysemys picta in a southwestern Michigan marsh. American Midland Naturalist **125**:245-258.

Gaddis, P., and C. Corkran. 1985. Distribution and ecology of native turtles. Final Report to ODFW. . Northwest Ecological Research Institute.

Gamble, T., and A. M. Simons. 2004. Comparison of harvested and nonharvested painted turtle populations. Wildlife Society Bulletin **32**:1269-1277.

Gelatt, T. S., and J. D. Kelley. 1995. Western painted turtles, *Chrysemys picta bellii*, basking on a nesting common loon, *Gavia immer*. Canadian Field-Naturalist **109**:456-458.

Gervais, J. A., C. M. Hunter, and R. G. Anthony. 2006. Interactive effects of prey and p,p'DDE on burrowing owl population dynamics. Ecological Applications **16**:666-677.

Gibbons, J. W. 1967. Variation in growth rates in three populations of painted turtle, *Chrysemys picta*. Herpetologica **23**:296-303.

Gibbons, J. W. 1968b. Reproductive potential, activity, and cycles in the painted turtle, *Chrysemys picta*. Ecology **49**:399-409.

Gibbons, J. W., J. L. Greene, and J. D. Congdon. 1983. Drought-related responses of aquatic turtle populations. Journal of Herpetology **17**:242-246.

Gibbs, J. P., and D. A. Steen. 2005. Trends in sex ratios of turtles in the United States: implications of road mortality. Conservation Biology **19**:552-556.

Graf, W., S. G. Jewett, Jr., and K. L. Gordon. 1939. Records of amphibians and reptiles from Oregon. Copeia **1939**:101-104.

Gregory, P. T., and R. W. Campbell. 1984. The reptiles of British Columbia British Columbia Provincial Museum Handbook (Victoria) **44**:i-viii, 1-103.

Griffin, K. A. 2005. Why did the turtle cross the road? Consequences of habitat fragmentation on a painted turtle population (abstract only). Intermountain Journal of Sciences **11**:105-106.

Harms, H. K., R. T. Paitz, R. M. Bowden, and F. J. Janzen. 2005. Age and season impact resource allocation to eggs and nesting behavior in the painted turtle. Physiological and Biochemical Zoology **78**:996-1004.

Hayes, M. P., S. G. Beilke, S. M. Boczkiewicz, P. B. Hendrix, P. I. Ritson, and C. J. Rombough. 2002. The western painted turtle (*Chrysemys picta bellii*) at the Rivergate Industrial District: management options and opportunities.

Heppell, S. S. 1998. Application of life-history theory and population model analysis to turtle conservation. Copeia **1988**:367-375.

Heppell, S. S., H. Caswell, and L. B. Crowder. 2000. Life histories and elasticity patterns: perturbation analysis for species with minimal demographic data. Ecology **81**:654-665.

Heppell, S. S., D. T. Crouse, and L. B. Crowder. 1996. A model evaluation of headstarting as a management tool for long-lived turtles. Ecological Applications **6**:556-565.

Holland, D. C. 1994. The western pond turtle: habitat and history. U.S. Department of Energy, Portland, Oregon.

Janzen, F. T. 1994. Vegetational cover predicts the sex ratio of hatchling turtles in natural nests. Ecology **75**:1593-1599.

Koonz, W. H. 1998. Western painted turtle hatchlings overwintering in Manitoba nests. Blue Jay **56**:183-184.

Legler, J. M. 1954. Nesting habits of the western painted turtle, *Chrysemys picta bellii* (Gray). Herpetologica **10**:137-144.

Leuteritz, T. E., and C. J. Manson. 1996. Preliminary observations on the effects of human perturbation on basking behavior in the midland painted turtle (*Chrysemys picta marginata*). Bulletin of the Maryland Herpetological Society **32**:16-23.

Lindeman, P. V. 1989. *Chrysemys picta bellii* egg retention. Herpetological Review **20**:69.

Lindeman, P. V. 1992. Nest-site fidelity among painted turtles (*Chrysemys picta*) in northern Idaho. Northwestern Naturalist **73**:27-30.

Lindeman, P. V. 1996. Comparative life history of painted turtles (Chrysemys picta) in two habitats in the inland Pacific Northwest. Copeia **1996**:114-130.

Lindeman, P. V., and F. W. Rabe. 1990. Effect of drought on the western painted turtle, *Chrysemys picta bellii*, in a small wetland ecosystem. Journal of Freshwater Ecology **5**:359-364.

MacCulloch, R. D., and D. M. Secoy. 1983a. Demography, growth, and food of western painted turtles, *Chrysemys picta bellii* (Gray), from southern Saskatchewan. Canadian Journal of Zoology **61**:1499-1509.

MacCulloch, R. D., and D. M. Secoy. 1983b. Movement in a river population of *Chrysemys picta bellii* in southern Saskatchewan. Journal of Herpetology **17**:283-285.

MacDonald, D. W., and D. D. P. Johnson. 2001. Dispersal in theory and practice: consequences for conservation biology. Pages 358-372 *In* Dispersal. Oxford University Press, Oxford.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, and K. P. Pollock. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. . Academic Press, New York, NY.

Mahmoud, I. Y. 1968. Nesting behavior in the western painted turtle, *Chrysemys picta bellii*. Herpetologica **24**:158-162.

Maurer, E. F. 1995. *Chrysemys picta bellii* (western painted turtle) feeding behavior. Herpetological Review **26**:34.

McAuliffe, J. R. 1978. Seasonal migrational movements of a population of the western painted turtle, Chrysemys picta bellii (Reptilia, Testudines, Testudinidae). Journal of Herpetology **12**:143-149.

Mills, L. S., and M. S. Lindberg. 2001. Sensitivity analyses to evaluate the consequences of conservation actions. Pages 338-366 *in* S. R. Beissinger and D. R. McCullough, editors. Population viability analyses. University of Chicago Press, Chicago, IL.

Mitchell, J. C., and M. W. Klemens. 2000. Primary and secondary effects of habitat alteration. Pages 5-32 *in M. W. Klemens*, editor. *Turtle Conservation.* . Smithsonian Institution Press Washington, D.C.

Moll, E. O. 1973. Latitudinal and intersubspecific variation in reproduction of the painted turtle, Chrysemys picta. Herpetologica **29**:307-318.

Nagle, R. D., C. L. Lutz, and A. L. Pyle. 2004. Overwintering in the nest by hatchling map turtles (*Graptemys geographica*). Canadian Journal of Zoology **82**:1211-1218.

Nichols, J. D., and B. K. Williams. 2006. Monitoring for conservation. Trends in Ecology and Evolution **21**:668-673.

Nussbaum, R. A., E. D. Brodie, and R. M. Storm. 1983. Amphibians and Reptiles of the Pacific Northwest. University of Idaho Press, Moscow, ID, USA.

ODFW. 2006. Oregon Conservation Strategy. Oregon Department of Fish and Wildlife, Salem, OR.

ODFW. 2008. Oregon Department of Fish and Wildlife Sensitive Species. Oregon Department of Fish and Wildlife, Salem, Oregon.

Ream, C., and R. Ream. 1966. The influence of sampling methods on the estimation of population structure in painted turtles. American Midland Naturalist **75**:325-338.

Reams, J. 1999. Western pond turtle survey and monitoring in the Calapooia, Row, and Tualatin Rivers. Turnstone Environmental Consultants, Inc.

Reese, S. A., E. R. Stewart, C. E. Crocker, D. C. Jackson, and G. R. Ultsch. 2004. Geographic variation of the physiological response to overwintering in the painted turtle (*Chrysemys picta*). Physiological and Biochemical Zoology **77**:619-630.

Rosenberg, D. K., B. R. Noon, and E. C. Meslow. 1997. Biological corridors: form, function, and efficacy. Bioscience **47**:677-688.

Rosenberg, D. K., D. G. Vesely, and e. al. 2009. Conservation assessment for western pond turtles in Oregon. Contribution No. 203. Oregon Wildlife Institute.

Rowe, J. W. 1994. Egg size and shape variation within and among Nebraskan painted turtle (Chrysemys picta bellii) populations: relationships to clutch and maternal body size. Copeia **1994**:1034-1040.

Rowe, J. W., K. A. Coval, and M. R. Dugan. 2005. Nest placement, nest-site fidelity and nesting movements in midland painted turtles (*Chrysemys picta marginata*) on Beaver Island, Michigan. American Midland Naturalist **154**:383-397.

Sexton, O. J. 1959. Spatial and temporal movements of a population of the painted turtle, *Chrysemys picta marginata* (Agassiz). Ecological Monographs **29**:113-140.

Snow, J. E. 1980. Second clutch laying by painted turtles. Copeia **1980**:534-536.

Snow, J. E. 1982. Predation on painted turtle nests: survival as a function of nest age. Canadian Journal of Zoology **60**:3290-3292.

Spinks, P. Q., G. B. Pauly, J. J. Crayon, and H. B. Shaffer. 2003. Survival of the western pond turtle (*Emys marmorata*) in an urban California environment. Biological Conservation **113**:257-267.

St. John, A. 2002. Reptiles of the Northwest. Lone Pine, Renton, Washington.

Starkey, D. E., and a. others. 2003. Molecular systematics, phylogeography, and the effects of pleistocene glaciation in the painted turtle (C*hrysemys picta*) complex. . Evolution **57**:119-128.

Steen, D. A., M. J. Aresco, S. G. Beilke, B. W. Compton, E. P. Condon, C. K. J. Dodd, H. Forrester, J. W. Gibbons, J. L. Greene, G. Johnson, T. A. Langen, M. J. Oldham, D. N. Oxier, R. A. Samuture, F. W. Schueler, J. M. Sleeman, L. L. Smith, J. K. Tucker, and J. P. Gibbs. 2006. Relative vulnerability of female turtles to road mortality. Animal Conservation **9**:269-273.

Steen, D. A., and J. P. Gibbs. 2004. Effects of roads on the structure of freshwater turtle populations. Conservation Biology **18**:1143-1148.

Stewart, E. 2008. Improvement of Painted Turtle Nesting Habitat,Progress Report #3 Metro Parks and Greenspaces.

Storer, T. I. 1932. The western limit of range for Chrysemys picta bellii. . Copeia **1932**:9-11.

Storer, T. I. 1937. Further notes on the turtles of the north Pacific coast of North America. . Herpetological Notes **1**:66-67.

Taft, O. W., and S. M. Haig. 2003. Historical wetlands in Oregon's Willamette Valley-Implications for restoration of winter waterbird habitat. Wetlands **23**:51-64.

Tinkle, D. W., J. D. Congdon, and P. C. Rosen. 1981. Nesting frequency and success: implications for the demography of painted turtles. Ecology **62**:435-438.

Wilbur, H. M. 1975. The evolutionary and mathematical demography of the turtle *Chrysemys picta*. Ecology **56**:64-77.

Wilhoft, D. C., M. G. Del Baglivo, and M. D. Del Baglivo. 1979. Observations on mammalian predation of snapping turtle nests (*Reptilia, Testudines, Chelydridae*). Journal of Herpetology **13**:435-438.

Williams, B. K., J. D. Nichols, and M. J. Conroy. 2001. Analysis and management of animal populations. Academic Press, San Diego, CA.

XI. Figures

Figure 1. Distribution of painted turtle observations among ecoregions in Oregon. Location records were obtained from ORNHIC, U.S.D.A. Forest Service, U.S.D.I. Bureau of Land Management, ODFW Citizen Science efforts, Port of Portland, Metro, and other respondents to our request for location data. Few surveys have been conducted in eastern Oregon, contributing to the lower number of location records in the databases. Some of the records in addition to those indicated may also have been from introduced non-native stock of painted turtles. Shown in blue, from north to south, is the Columbia River, Willamette River and selected tributaries, the Sixes River, and the Rogue River.

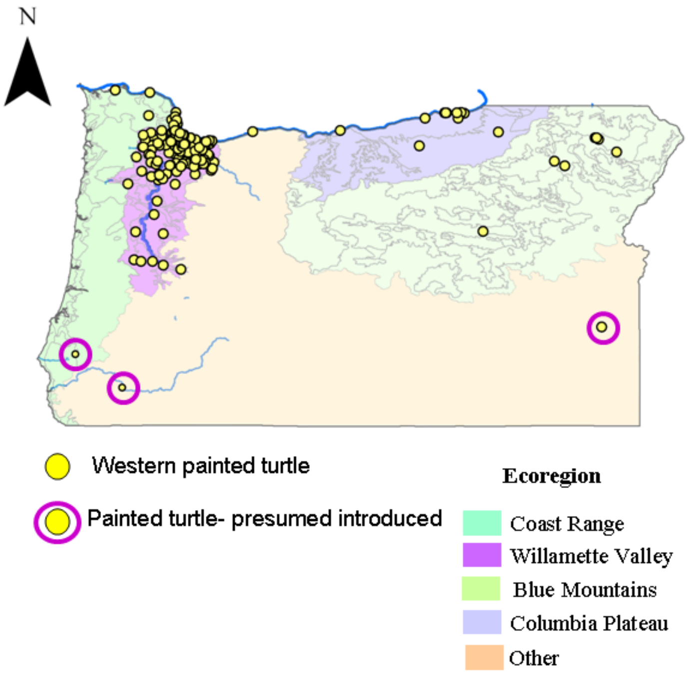

Figure 2. Distribution of painted turtle observations among public and private lands in Oregon. Location records were obtained from ORNHIC, U.S.D.A. Forest Service, U.S.D.I. Bureau of Land Management, ODFW Citizen Science efforts, Port of Portland, Metro, and other respondents to our request for location data. Few surveys have been conducted in eastern Oregon, contributing to the lower number of location records in the databases. Some of the records in addition to those indicated may also have been from introduced non-native stock of painted turtles. Selected watercourses are shown in blue.

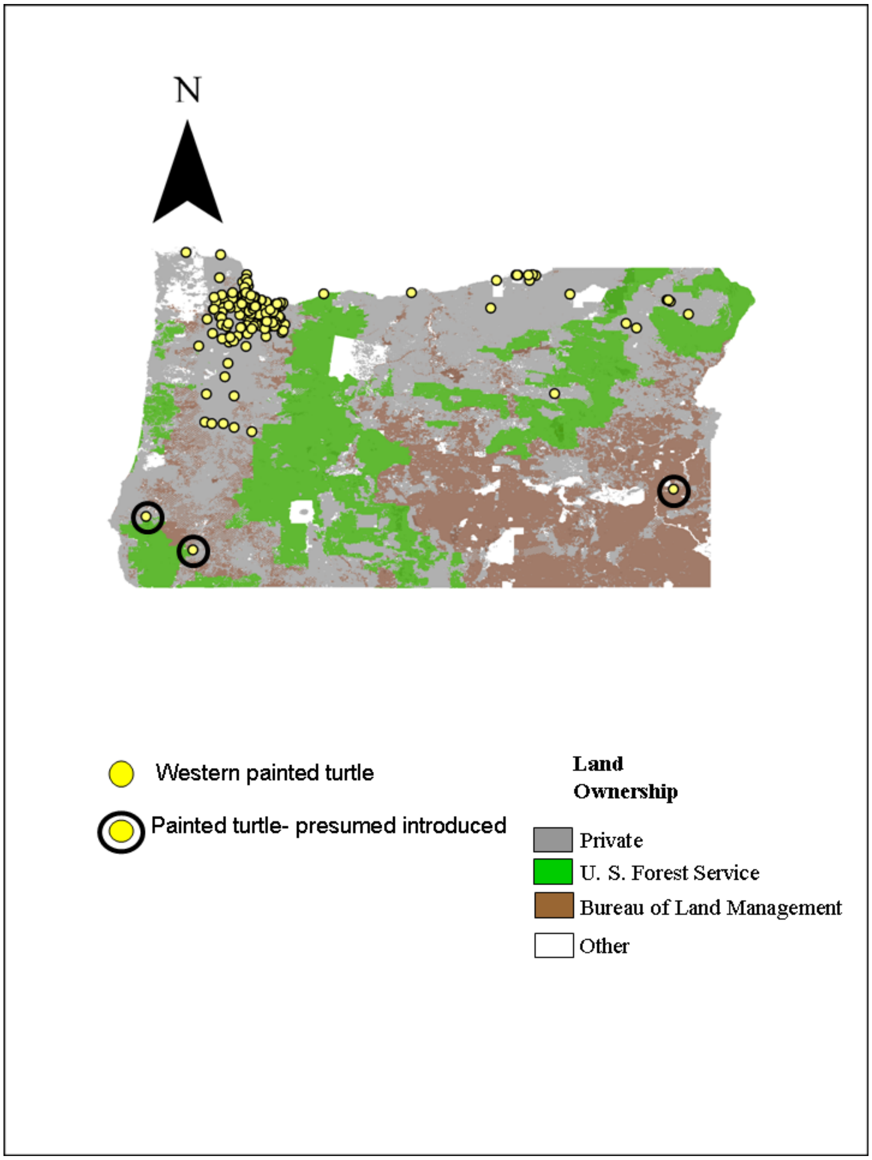

Figure 3. Distribution of western painted turtle observations in the primary cluster of records in Oregon. Metro boundaries are indicated in red, City of Portland is shaded, and the Columbia Slough Watershed is indicated in blue. Location records were obtained from ORNHIC, ODFW Citizen Science efforts, Port of Portland, and Metro. Some of the records may be from introduced non-native stock of painted turtles. Blue lines indicate selected tributaries of the Willamette River.

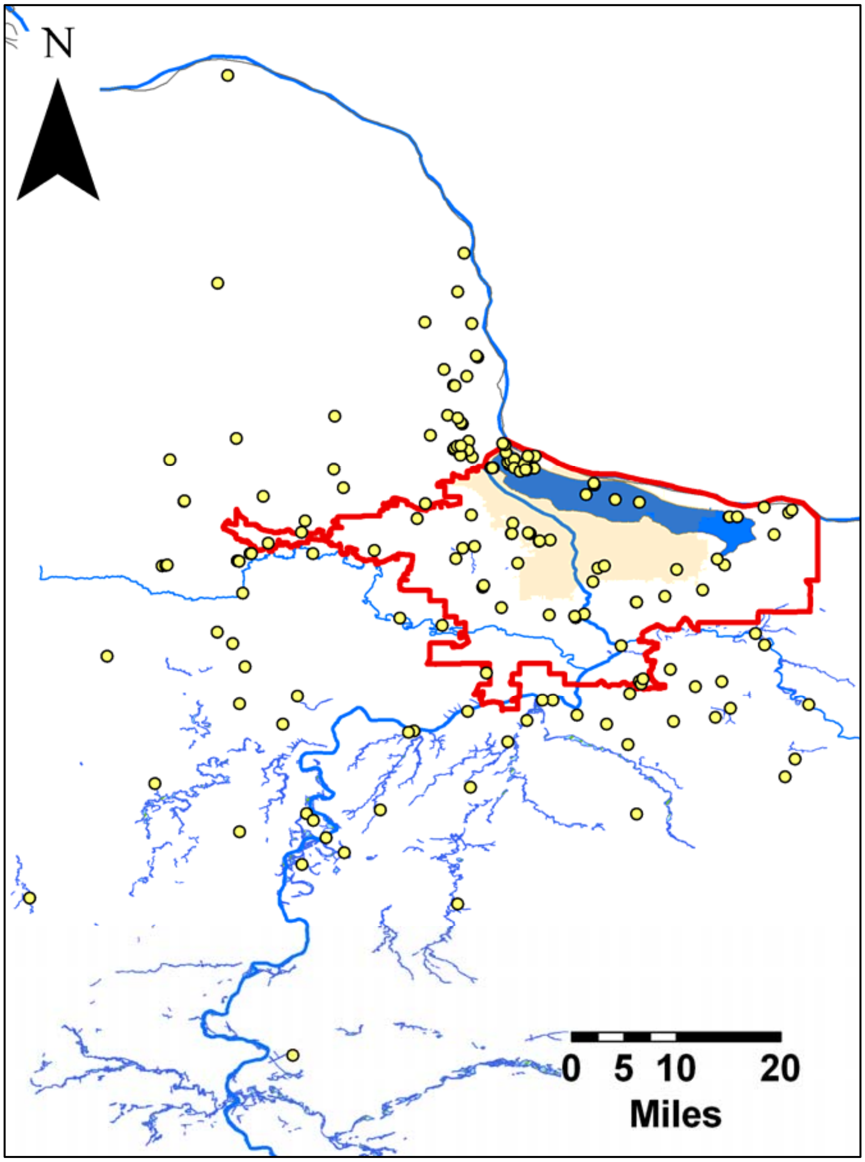

Figure 4. Distribution of western painted turtle observations within Metro by landowner type. Location records were obtained from ORNHIC, ODFW Citizen Science efforts, Port of Portland, and Metro. Some of the records may be from introduced non-native stock of painted turtles.

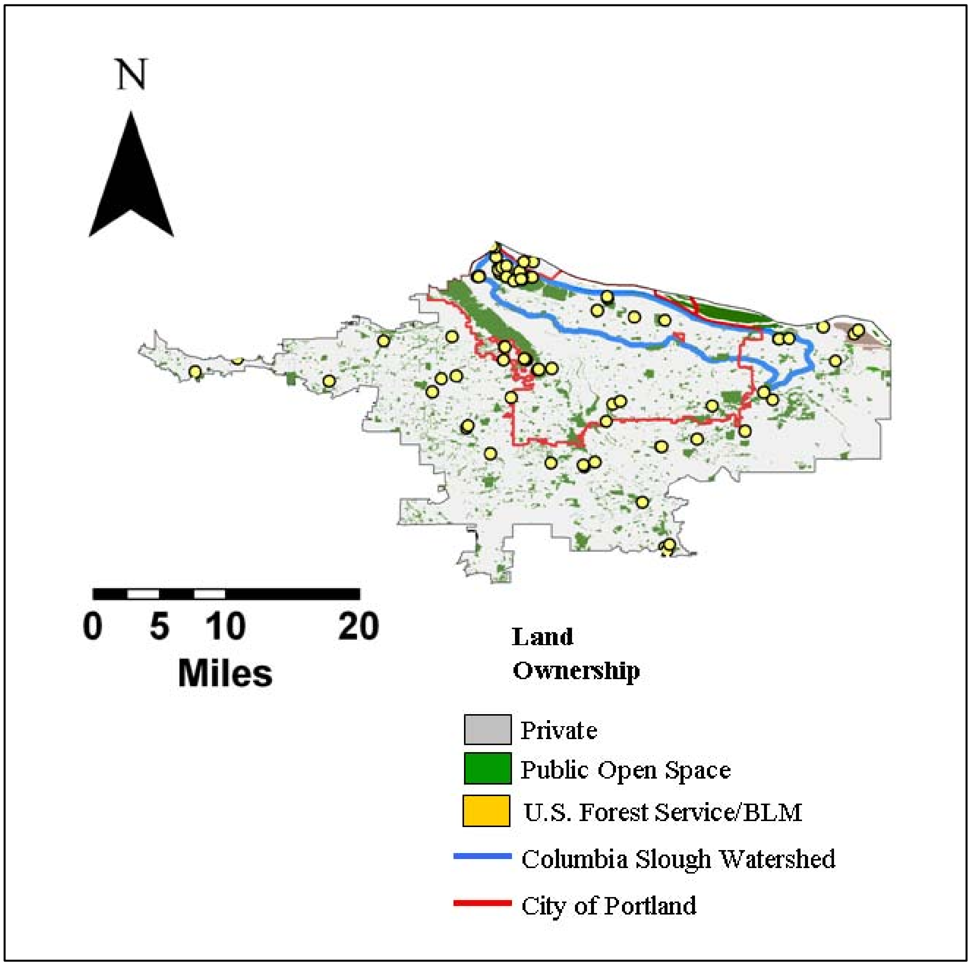

Figure 5. Distribution of western painted turtle observations within the City of Portland, showing predominant locations in or near public open space. Location records were obtained from ORNHIC, ODFW Citizen Science efforts, Port of Portland, and Metro. Some of the records may be from introduced non-native stock of painted turtles.

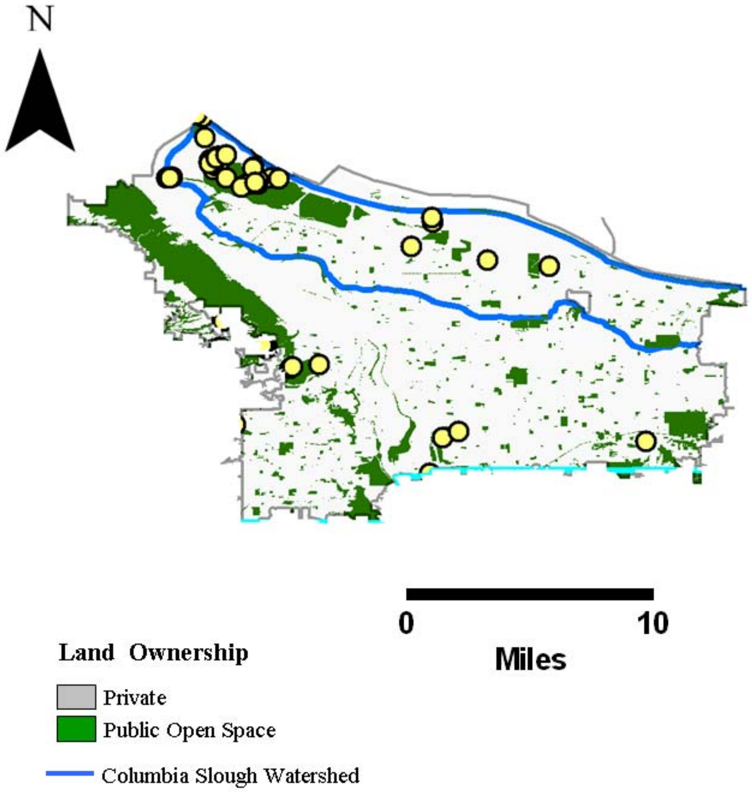

Figure 6. Example of a western painted turtle population in an urban wetland in the Portland metropolitan region. See Sec. VIII Case Studies.