Conservation Assessment of the Western Pond Turtle in Oregon
(Actinemys marmorata)

Version 1.0
November 2009

Sponsored by:
U.S.D.I. Bureau of Land Management and Fish and Wildlife Service
U.S.D.A. Forest Service Region 6
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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. This Conservation Assessment was prepared to compile published and unpublished information on the western pond turtle (*Actinemys marmorata*). If you have information that will assist in conserving this species or questions concerning this Conservation Assessment, please contact the interagency Conservation Planning Coordinator for Region 6 Forest Service, BLM OR/WA in Portland, Oregon, via the Interagency Special Status and Sensitive Species Program website at http://www.fs.fed.us/r6/sfpnw/issssp/contactus/

EXECUTIVE SUMMARY

Species: Western pond turtle (*Actinemys marmorata*)

Taxonomic Group: Reptile

Management Status: USDI Fish and Wildlife Service Species of Concern. USDA Forest Service, Region 6 (Oregon and Washington) and USDI OR/WA Bureau of Land Management, Sensitive Species. Oregon Department of Fish and Wildlife: Conservation Strategy - Strategy Species and Oregon Sensitive-Critical Species. Washington: Endangered Species; Conservation Strategy – Species of Greatest Conservation Need. California: Species of Special Concern; Wildlife Action Plan – included in Wildlife Species Matrix as priority species. Natural Heritage Global Rank: G3G4 (not immediately imperiled); State Rank: California S3 (rare, uncommon or threatened), Oregon S2 (imperiled), Washington S1 (critically imperiled).

Range: The western pond turtle's range extends from northwestern Baja California, Mexico, north to Puget Sound in Washington. It is restricted to areas west of the Sierra Nevada and Cascade Mountains with a few exceptions. In Oregon, the western pond turtle occupies regions primarily west of the Cascades with suitable habitat, at elevations below approximately 1800 m or 6,000 feet (Nussbaum et al. 1983, ORNHIC database 2008). The largest populations in Oregon are found in the Willamette, Umpqua, Rogue, and Klamath River drainages.

Specific Habitat: The western pond turtle requires both aquatic and terrestrial habitats. It uses permanent and seasonal aquatic habitats including rivers, sloughs, lakes, reservoirs, ponds, and irrigation canals. The species moves onto land for nesting, overwintering, dispersal, and basking. Overwinter sites typically include terrestrial refugia, burial in the substrate of aquatic habitats, or in undercut banks along streams. Nesting typically occurs within 200 m of aquatic habitat in areas with compact soil, sparse vegetation, and good solar exposure.

Threats:
Major factors cited as limiting western pond turtle populations include loss of aquatic habitats, elevated nest and hatchling predation, reduced availability of nest habitat, and road mortality. Predation of nests may be above historical levels in human-altered landscapes due to greater abundance of medium-sized predators. Predation of hatchlings by introduced bullfrogs (*Rana catesbeiana*), smallmouth bass (*Micropterus dolomieui*), and largemouth bass (*Micropterus salmoides*) is thought to be significant although evidence for this is lacking. Road mortality is an important threat particularly in urban and recreational areas. Release of pet turtles to natural areas is a growing threat and may result in increased competition and disease transmission. In addition, removal of western pond turtles by the public for pets may cause local declines. Connectivity between aquatic and upland habitats increasingly becomes a concern as urban and agricultural development continues to fragment landscapes. Agricultural and vegetation management activities can result in nest destruction and mortality to adult females. Recreational

activities within or adjacent to aquatic and nest habitats are an important concern in some parts of the species' range. Accidental catch of turtles while fishing also occurs. Illegal shooting of western pond turtles may occur in some areas. Research and survey work can affect western pond turtles by disrupting behavior, increasing the risk of disease transmission, and potentially influencing predator behavior. Therefore, we argue for more use of existing research before initiating site-specific studies.

Management Considerations

Western pond turtles occur on lands managed by public agencies at many jurisdictional levels including City, County, State, and Federal levels. Western pond turtles occur predominately on lands in private ownership in the Willamette Valley Ecoregion. Management approaches and actions will need to take into account the diversity of land allocation patterns. Because of the broad distribution of western pond turtles on private lands, management will need to focus on non-federal lands in some regions by engaging private landowners and watershed councils. Because both aquatic and upland habitats are required by western pond turtles, management by more than one public agency or landowner is likely to affect a given population or even an individual turtle. Despite these challenges, management actions that can contribute to the conservation of western pond turtles are numerous. Conservation actions to improve conditions for western pond turtles in Oregon include improving aquatic and terrestrial habitats, reducing road mortality, managing recreation near turtle-use areas, controlling non-native turtles, eliminating future releases of pet turtles, and in some areas may include reducing nest and hatchling predation.

Inventory, Monitoring, and Research Opportunities

There has been a substantial effort in many parts of the state to identify locations that harbor western pond turtles. Survey and monitoring efforts could be much more effective if a hypothesis-driven approach is used that links with management, and if sampling designs are used that allow inferences on land allocation and environmental correlates. Surveys should be specifically carried out to answer questions needed to refine management techniques, and these surveys should be designed so that land ownership patterns or other characteristics can be included in the analysis. Development of a comprehensive database of location records of western pond turtles will be an important first step in utilizing existing distribution information. The charismatic nature of western pond turtles and the concern over their conservation will facilitate public involvement, which could be used to monitor response of turtles to local management activities.

Priority research opportunities include (1) understanding the patterns and causes of nest and hatchling predation and their population-level impacts, (2) evaluating habitat requirements of hatchlings, (3) developing habitat suitability maps, (4) evaluating connectivity of populations using landscape genetics, (5) developing population models to evaluate management actions, and (6) developing effective education programs addressing turtle introductions and removal. Many of these research efforts could be conducted using an adaptive management approach which would facilitate developing standards for turtle conservation.

I. INTRODUCTION

Goal

The western pond turtle is one of two native freshwater turtles in Oregon. The concern over declining populations of this species throughout its range motivated a listing petition under the Endangered Species Act in 1992. The petition was denied primarily due to the species' broad distribution, occurrence in human-modified environments, and lack of evidence supporting allegations of specific threats such as a lack of juvenile recruitment (USFWS 1993a). However, concern remains over conserving this species because of specific life history traits that increase its vulnerability to the numerous threats that exist in many parts of its range. Several interagency working groups were formed to develop western pond turtle conservation measures and to standardize monitoring and survey protocols. Despite this interest in the species, there has been no comprehensive synthesis of existing information since the 1992 listing petition.

The goal of this Conservation Assessment is to synthesize and critique previous research, monitoring, and management efforts relevant to conservation of the western pond 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 pond turtle's ecology and management, and to highlight gaps in our understanding that are most critical for managing the western pond turtle on both private and public lands. There is only a single published paper and several unpublished theses on data collected from western pond turtles in Oregon despite a large number of research and monitoring projects. Furthermore, reports from these unpublished studies have been difficult to obtain. To fully succeed in obtaining the primary goal of synthesis, a secondary goal has been to locate and compile the unpublished work conducted on western pond turtles in Oregon.

The information presented here was compiled to help manage the species in accordance with Forest Service Region 6 Sensitive Species (SS) policy, Oregon/Washington Bureau of Land Management Special Status Species (SSS) policy, USFWS Species of Management Concern, and the City of Portland's Terrestrial Ecology Enhancement Strategy. The information presented here is intended to provide guidance for local governments because several city and county governments have expressed interest, if not enacted policy, to promote turtle conservation. For example, see Chapter 9, Land Use Section 9.9660(13) West Eugene Wetlands Policy, (page 548) of the City of Eugene Code. Additional information for Region 6 SS and Oregon BLM SSS is available on the Interagency Special Status Species website (http://www.fs.fed.us/r6/sfpnw/issssp/). This assessment will also support conservation efforts through implementation of the Oregon Department of Fish and Wildlife's Oregon Conservation Strategy (http://www.dfw.state.or.us/conservationstrategy/index.asp).

Scope

Although the Assessment draws from work done on western pond turtles throughout their range, we synthesize and critique the biological data most relevant for populations in Oregon. We compiled information from published literature range-wide, examined unpublished reports, theses and dissertations primarily from Oregon, and sought expert opinion. Distribution data were compiled from the Oregon Natural Heritage Information Center, USFS, BLM, Oregon Department of Fish and Wildlife, including data from their citizen science program, and replies to our requests for location information.

Management Status

The western pond turtle is considered a Species of Concern by USFWS; a petition for listing under the Endangered Species Act was found not to be warranted in 1993 (USFWS 1993a) because of the species' widespread distribution and lack of evidence for broad-scale threats (see *Section V, Conservation: Conservation Status*). The western pond turtle is classified in Oregon as a Strategy Species under the Oregon Conservation Strategy (OCS) and as a Sensitive-Critical species (ODFW 2006, 2008). The western pond turtle is protected by Oregon state law under Oregon Administrative Rule 635-044-0130 which classifies the species as Protected Nongame Wildlife. In Washington, the western pond turtle is classified as a State Endangered Species and a recovery plan was developed in 1999 (Hays et al. 1999). In California, the western pond turtle is listed as a Species of Special Concern, and a conservation strategy is currently being developed (H. Welsh, USFS Redwood Sciences Laboratory, pers. comm.). USDA Forest Service, Region 6 (Oregon and Washington) and USDI OR/WA Bureau of Land Management list the species as a Sensitive Species. The NatureServe/Natural Heritage Network ranks are Global Rank G3G4 (not immediately imperiled), State Ranks: California S3 (rare, uncommon or threatened), Oregon S2 (imperiled), Washington S1 (critically imperiled). The Oregon state rank of "imperiled" may no longer be valid because of the increase in records of occurrence since the time of state rank determination (See *Section IV, Range, Distribution, and Abundance*).

Updated management status (USFWS, ODFW, NatureServe) can be found at the Natural Heritage Information Center: http://oregonstate.edu/ornhic/data_download.html
Updated status from the USFS/BLM Interagency Special Status Sensitive Species Program can be found at: http://www.fs.fed.us/r6/sfpnw/issssp/agency-policy/

II. CLASSIFICATION AND DESCRIPTION

Systematics

The phylogenetic relationship of this turtle to other species within the family Emydidae (semi-aquatic pond and marsh turtles) is not well understood (see Spinks and Shaffer 2009). Recent work suggests they should be in a monotypic genus *Actinemys* (Iverson et al. 2008), rather than in *Clemmys*, as previously accepted (Iverson et al. 2001). Other authors believe the western pond turtle is best placed in the genus *Emys* (Bickham et al. 2007). Two subspecies of western pond turtles were previously recognized, with the northwestern pond turtle (*Emys* or *Actinemys marmorata marmorata*) occurring from northern California north to Washington, and the southwestern pond turtle (*Emys* or *Actinemys marmorata pallida*) occurring from San Francisco Bay south to Baja California (Seeliger 1945). Although recent research is in disagreement regarding the delineation of clades, there is general agreement that northern populations show sufficient genetic differentiation from southern populations to be considered a distinct clade, and that northern populations have very low levels of genetic variation, in contrast to southern populations (Gray 1995, Janzen et al. 1997, Spinks and Shaffer 2005, 2009). The most recently published genetic analysis identified four mitochondrial clades, which are defined generally as biological taxa that share features from a common ancestor. The "Northern Clade" extended from Washington to central California, coincident with the former delineation of the northwestern subspecies (Spinks and Shaffer 2005). The other three clades were within the formerly defined southern subspecies. Disagreement continues over the taxonomy of western pond turtles (Ernst and Lovich 2009). As methods for genetic analyses become increasingly sophisticated, our ability to discriminate among smaller and smaller geographic scales of population uniqueness will increase and may help resolve the disagreement over taxonomy within this species. Evidence to date, however, supports considering northern populations (including all of those in Oregon) as a distinct conservation unit, regardless of the taxonomic rank assigned to it by various investigators.

Species Description

Numerous accounts have detailed the morphology of the western pond turtle (e.g., Buskirk 2002, Bury and Germano 2008, Ernst and Lovich 2009). In brief, this semi-aquatic freshwater turtle has a broad, smooth carapace that usually reaches a maximum length of 20 cm. Carapace color tends to be drab olive and reticulated, whereas the plastron is generally a light yellow. Males usually have varying degrees of pale yellow on the neck and chin, but otherwise the skin is essentially gray to almost black and often mottled. The male has a concave plastron whereas the female's plastron is generally flat. The thickness of the tail is also markedly greater in males. Todd (1999:16) provides one of the most comprehensive field comparisons of male and female western pond turtles. Juveniles tend to have mottling on the throat and their limbs are striped with yellow rather than mottled. Buskirk (2002) provides excellent descriptions and photographs showing individual, gender, geographic, and age-related variation of the coloration and markings of western pond turtles.

Comparison with Sympatric Turtles

There are three other turtle species that are currently sympatric with the western pond turtle in Oregon, and numerous other species have been introduced into the range of the western pond turtle (Holland 1994, Bury 2008). Of the introduced species in Oregon, the most common are the red-eared slider (*Trachemys scripta*) and the common snapping turtle (*Chelydra serpentina*).

The other native turtle in Oregon, the western painted turtle (*Chrysemys picta bellii*), is sympatric in the northern portion of the western pond turtle's range, but the western painted turtle rarely occurs naturally south of Salem (Gervais et al. 2009). However, records of introduced painted turtles of unknown geographic origin have been noted farther south (Black and Black 1987, Gervais et al. 2009). Although the pond turtle is quite distinct in appearance from the painted turtle and red-eared slider, there is often confusion over species identification, particularly by the public. The key differences between the western painted and pond turtles are the red and yellow lines on the neck and limbs of the painted turtle and its notched upper jaw. The pond turtle differs from the red-eared slider in the slider's red facial stripe and the serrated appearance of the rear edge of the carapace. Red-eared sliders can be confused with the pond turtle in the case of melanistic (that is, showing an increased amount of dark coloration) individual sliders, which lack the red and yellow markings (Bury and Germano 2008). Melanism is more typical in larger, older turtles (Ernst et al. 1994). Non-melanistic red-eared sliders are more easily confused with painted turtles (see Gervais et al. 2009). A distinguishing feature between pond turtles and red-eared sliders is the shape of the posterior marginal scutes, or the outermost upper shell segments toward the rear of the animal. The marginal scutes are defined as numbers 8-12 starting at the nuchal scute at the center front. Sliders possess bifid or slightly forked or scalloped posterior marginal scutes whereas these scutes are straight-edged in western pond turtles. The bifid scutes give the slider's carapace edge a somewhat serrated appearance. Sliders reach much greater sizes than western pond turtles and their carapaces are shinier. All of these characteristics can be difficult to observe in the field. Not surprisingly, these two species are often confused by the public. Familiarity with western pond turtles, western painted turtles, and red-eared sliders is critical for survey work in Oregon. The common snapping turtle is sufficiently different in appearance that confusion between the snapping and pond turtle is unlikely.

The Oregon Conservation Strategy web site shows photos of the western pond and painted turtles, red-eared slider and common snapping turtle: http://www.dfw.state.or.us/conservationstrategy/turtles.asp

Section Summary

The relationship of western pond turtles to other freshwater turtles in the Emydidae (semi-aquatic pond and marsh turtles) is not clear, but recent work suggests they should be in a mono-specific genus *Actinemys* or in an expanded *Emys* genus. Two subspecies were previously recognized, with the northwestern pond turtle occurring in Oregon. The most recent genetic analyses supports considering northern populations (including all of those in Oregon) as a distinct conservation unit. Western pond turtles have a broad, smooth carapace, with a maximum length of 20 cm. The carapace is generally olive in color and reticulated, whereas the plastron is generally light yellow. The western pond turtle is sometimes confused with the western painted 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 pond turtle could also be confused with the introduced red-eared slider. Mature male sliders may show melanism great enough to obscure the typical bright markings, contributing to confusion with western pond turtles. However, carapace characteristics, most notably the bifid marginal scutes, can be used to differentiate between them. Confusion with the distinct-looking introduced snapping turtle seems unlikely.

III. BIOLOGY AND ECOLOGY

Life History

The life history of western pond turtles is typical of North American Emydidae, the semi-aquatic family of mostly freshwater turtles. As a group, these turtles have life history traits that make them vulnerable to increased mortality from expanding human populations and therefore require special consideration for management (Gibbs and Amato 2000). The western pond turtle forages in the aquatic environment, nests in nearby terrestrial areas, and overwinters either buried in mud in aquatic habitats or under soil and duff in terrestrial habitats. Variability in the time the pond turtle spends in the aquatic environment is in response to (1) drying conditions in ephemeral aquatic habitats, (2) response to cold-weather conditions, and (3) avoidance of strong currents in flowing water. Despite the name “pond turtle” the species inhabits a broad array of aquatic habitats. This, together with its use of a variety of terrestrial environments, has probably been at least partly responsible for the fact that its range includes such contrasting environments as arid regions of Baja California, the Mojave desert, and the temperate rain forests of western Oregon and Washington. We provide a brief overview of the western pond 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 Oregon as well as the unpublished reports and theses based on studies within Oregon.

Habitat

Aquatic—

Western pond turtles are found in both intermittent and permanent aquatic habitats. They are most common in stagnant or slow-moving waters. They inhabit a broad range of lentic (still-water) and lotic (moving-water) habitats including sloughs, streams, large rivers, human-made ponds including flooded gravel pits (Vesely 2005) and sewage treatment ponds, irrigation canals, small lakes, reservoirs, marshes, and oxbow lakes formed from larger rivers (Nussbaum et al. 1983, Buskirk 2002, Bury and Germano 2008, Ernst and Lovich 2009). In streams and rivers, western pond turtles most frequently occupy low-velocity waters and particularly deep pools (Evenden 1948, Nussbaum et al. 1983, Stern and Rosenberg 1992, Holland 1994, Reese and Welsh 1998a, 1998b; Ernst and Lovich 2009).

Although there has been limited research on the micro-habitat associations of western pond turtles in their aquatic environment, several patterns are evident. They are associated with aquatic habitats with muddy bottoms that include basking sites such as logs, mud banks, or cattail mats (Holland 1994, Todd 1999, Bury and Germano 2008). Open banks, logs, tree stumps, and other objects provide basking opportunities for western pond turtles, an important element for suitable habitat (Todd 1999, Bury and Germano 2008, Ernst and Lovich 2009). Underwater refugia, including cut banks and large woody debris, provide cover from aquatic predators such as river otters and mink (Reese and Welsh 1998b). In large lakes and reservoirs, western pond turtles seek protected coves with southern exposure and shallow water (Hardin 1993). In a small southern Oregon lake, western pond turtles avoided areas near shore (Todd 1999). A high density of emergent vegetation that contributes to a high density of invertebrate prey appears to be selected by turtles in many aquatic habitats such as in Todd's (1999) study site. However, research has not been conducted on the role of vegetation, prey, and western pond turtle density. Despite the importance of the aquatic environment to western pond turtles, there has been considerably less research on aquatic than on terrestrial habitat selection. This remains an important research area and presents opportunities for adaptive management (see *Section VI, Inventory, Monitoring, and Research Opportunities: Research*).

Aquatic habitat conditions selected by young juveniles and hatchlings have been described as slow-moving, shallow, and warmer bodies of water, often with extensive cover of emergent vegetation (Reese 1996), but the scarcity of observations of hatchlings require generalizations to be tentative. The few hatchlings that have been observed in the aquatic environment were in shallow and slow moving waters, typically with emergent vegetation (Buskirk 2002). Interestingly, hatchlings may use extremely small and ephemeral habitats. Holte (1998) marked and tracked hatchlings by using fluorescent dye, metal washers and magnetic locators, and light-weight radio transmitters. Holte reported that hatchlings during at least their first month move very short distances; the maximum daily movement was 5.8 m. During approximately 2-3 weeks of tracking data, hatchlings remained hidden under mud and vegetation. Holte (1998) described the habitat in which she found two hatchlings opportunistically. Both hatchlings were found in small ephemeral water bodies – one was basking on a small piece of vegetation in a puddle only 2.5 cm deep and the other was in a cow hoof-print that was embedded in a wetland.

The difficulty in detecting hatchlings and juveniles has made studying them problematic, and their ecology remains one of the most important topics for future research (see *Section VI, Inventory, Monitoring, and Research Opportunities: Research*). This is particularly true because most of the management efforts are based on increasing recruitment of young turtles to the breeding population via nest protection (Oregon; e.g., Fern Ridge Reservoir [Holte 1998]) or, in Washington, releasing captive-raised, head-started turtles [Hays et al. 1999, Clark 2001]).

In Oregon, western pond turtles typically enter a state of semi-dormancy during the winter, and opportunistically seem to select either aquatic or terrestrial environments. We discuss overwintering below, in the terrestrial habitat section.

Basking—

Like all other reptiles, western pond turtles must maintain a relatively constant body temperature for metabolic processes. Basking is a method of raising and maintaining body temperature and is a prominent behavior of the species (Ernst and Lovich 2009). It appears that any object protruding from the water that can be climbed upon is potentially suitable, provided that the animals are not disturbed. Turtles will share basking sites, and appear to seek out those already in use by other turtles (Ream and Ream 1966). Lack of basking sites may affect suitability of aquatic habitat. When basking, western pond turtles will quickly terminate basking if disturbed, and if frequent, disturbance is expected to reduce habitat suitability and may be a threat to the conservation of the species (*see Section V, Conservation: Threats, Recreation Disturbance*).

Terrestrial—

Overwinter

Collectively, the evidence suggests that western pond turtles are opportunistic in selecting their overwintering sites. Most individual western pond turtles in Oregon that have been studied via radio transmitters selected overwintering sites either at the bottom of the substrate of aquatic habitats, in undercut banks along streams, or in terrestrial refugia typically buried under 5-10 cm of leaf litter (Beal 1993, Holland 1994, Ryan 2001, Riley 2006 and others), consistent with findings elsewhere in their range (Rathbun et al. 1992, Reese and Welsh 1997, Rathbun et al. 2002, Bondi 2009, Vander Haegen et al. unpublished ms). Western pond turtles often emerge from their terrestrial refugia to bask and/or to move to other locations during the winter (Holland 1994, Rathbun et al. 2002, Bury and Germano 2008). Some individuals are active throughout the year (Holland 1994, Bury and Germano 2008).

Western pond turtles spend considerable time on land for overwintering, basking, dispersal, and nesting (*see Movements, below*). Western pond turtles in the Trinity River of northern California occupied upland terrestrial habitats for 7 or more months of the year, with the majority of the time spent at overwintering refugia (Reese and Welsh 1997). Juvenile and sub-adult turtles followed a similar pattern in southwest Washington, where Vander Haegen et al. (unpublished ms) reported that radio-tagged turtles were found on land for over 6 months of the year (mean = 215, range 138-311 days). The extent of overwintering varies considerably among habitats and individuals (Holland 1994, Reese and Welsh 1997, Rathbun et al. 2002).

Western pond turtles use terrestrial refugia primarily during late fall to early spring, but they have been observed to also use them during summer if their ephemeral aquatic habitat dries out (Holland 1994, Reese 1996, Rathbun et al. 2002, Bondi 2009). In the Trinity River, Reese and Welsh (1997) found that all 12 of the radio-equipped turtles left the river for overwintering sites between September and December. Turtles returned to the Trinity River beginning in February and continuing through June. Movement to terrestrial overwintering sites was initiated as early as late July through mid-December in the study in southern Washington (Vander Haegen et al. unpubl. ms), but most movement to upland sites occurred during September and October.

Terrestrial over-wintering sites include a much broader array of vegetation structure than nest sites. Shrubby, open, and forested environments have all been used by western pond turtles for overwintering, although access to some solar radiation appears to be important (Rathbun et al. 1992, Holland 1994, Rathbun et al. 2002). In northern California, 10 of the 12 radio-tagged turtles overwintered in forested upland habitat, buried in duff (Reese and Welsh 1997). The remaining 2 turtles overwintered in aquatic habitats: a pond and a lake. Vander Haegen and his colleagues (unpublished ms) investigated use and selection of terrestrial hibernacula over a three year period. Their study population included 37 radio-tagged juvenile and sub-adult (ages 1-4 years) that were released at a newly established site as "head-start" turtles – wild stock raised in captivity until approximately 1 year old (Vander Haegen et al., unpublished ms). Their study area consisted of several impounded and natural ponds and sloughs, all of which were hydrologically connected to a permanent creek. Almost all (34 of 37, 92%) of the turtles overwintered in upland habitat, in contrast to the previously described pattern (Holland 1994) that over-wintering on land occurred most frequently for turtles in lotic or moving water habitats. Work in Oregon demonstrates the variability and potentially facultative response to environmental conditions that lead to use of terrestrial or aquatic overwinter habitat (Beal 1993, Holland 1994, Riley 2006).

Vander Haegen et al. (unpublished ms.) also compared hibernacula to random sites to understand selection patterns. They found two types of burying behavior: turtles used *shallow* or *deep* hibernacula. Shallow use resulted in the plastron being 0 – 6 cm below the soil surface, and consisted essentially of simply burrowing under duff. Deep hibernacula resulted in the plastron being up to 13 cm below soil surface and consisted of earth excavation and coverage by soil. Turtles were associated with <10% slope, good solar exposure, open ground cover and duff, and seemed to avoid dense grass and dense forest cover.

Throughout their range, hatchling western pond turtles often overwinter in their natal nests (Holland 1994, Reese and Welsh 1997, Bury and Germano 2008), and that seems to be primarily the case in Oregon as well (Holte 1998, Riley 2006, L. Holts, unpublished data). Western pond turtle hatchlings overwintering at their nest site are typical of several other semi-aquatic turtles in North America (e.g., Nagle et al. 1004), which Gibbons and Nelson (1978) hypothesized was an evolutionary strategy to avoid unpredictable and adverse winter weather. At least for the western pond turtle, remaining in the nest from fall to spring coincides with the temporal pattern of overwintering for most of the adult populations as well, suggesting that hatchlings that emerged in the fall would be evolutionarily selected against. It is unclear what the likelihood of survival is for turtle hatchlings emerging in the fall immediately after hatching, relative to spring emergence after overwintering in the nest. Holte (1998) monitored daily nests protected by exclosures at the Fern Ridge Reservoir study area. She found that hatchlings emerged only in spring. Interestingly, in the same general area, emergence occurred during the fall from two nests that were in low-lying areas saturated by water (R. Swift, unpublished data). These results, together with most observations of emergence in the spring, suggest that fall emergence can occur in response to poor environmental conditions for overwintering (Nagle et al. 2004). In most years and sites, emergence likely occurs during the spring.

Nesting

The western pond turtle depends on terrestrial habitats for nesting. Nesting habitat is usually in areas of sparse vegetation consisting of grass and forbs, with compact soil composed of clay or silt fraction, or sandy loam, and sometimes gravel/cobble mixed with soil (Reese and Welsh 1997, Holte 1998, Rathbun et al. 1992, Holland 1994, Rathbun et al. 2002, Riley 2006, Lucas 2007). Nest habitat also is characterized by good solar exposure with little or no tree canopy cover that would shade the nesting site. Suitable nest habitat near aquatic environments may often be limited (Holland 1994), particularly in urban settings (Spinks et al. 2003).

Detailed evaluations of nest habitat have been conducted in the Willamette Valley (Holte 1998) and in southwest Washington (Lucas 2007). These studies quantified nest habitat in terms of soil composition, distance to aquatic habitat, density and height of ground vegetation, slope, aspect, and tree canopy cover. Holte (1998) included nests found from transect searches as well as via radio tracking of gravid females. Lucas (2007) found all nests by radio-tracking of females. Both investigators compared characteristics of nest locations with random locations within a specified area surrounding potential nest habitat. Consistent with previous findings, nests were located within approximately 200 m from water (see below, *Movements*). Nests were generally located in areas with gentle topography (0-40º slopes). In Lucas's (2007) southwest Washington site, all nests were on slopes ≤16 º despite availability of steeper areas, including those near water where turtles were most likely to nest. However, nests do occur on steep slopes, at least if near their aquatic habitat (D. Rosenberg, pers. obs.). Turtles selected south to southeast aspects, except in one of Lucas's study sites where all of the southerly exposed slopes had thick shrub cover, which was avoided by nesting females. Soil types varied considerably across study areas, and there was little or no apparent selection for soil types based on the characteristics measured including percent silt, percent clay, and compaction. At the Fern Ridge Reservoir study area, Holte found low but dense ground vegetation at nest sites; vegetation heights ranged from 0 to 20 cm with a mean of 4.8 cm. Given the wide range of densities of ground vegetation, and the generally low ground vegetation height throughout the study area, it seems that ground vegetation at the Fern Ridge site was not a strong selection factor. Similarly, in southwest Washington, turtles nested in areas with ground vegetation similar to what was generally available, with vegetation heights of 24-45 cm. Turtles completely avoided areas with particularly tall vegetation. At the Fern Ridge site, there was no forest canopy near the nest areas, whereas in the southwest Washington study areas, forest vegetation provided canopy cover in some areas. At this site, turtles selected more open canopies (average of 14%), especially on the southern and eastern slopes. Several of these factors relate to solar exposure, and taken together, turtles seemed to nest in those areas that allowed nests to receive solar radiation. Lucas' finding that soil temperature at nest sites was warmer than at random sites is consistent with this hypothesis. These detailed studies reinforce the general finding that nest sites are generally characterized by sparse ground cover, solar exposure, and close proximity to aquatic habitat.

Holte (1998) also compared nest success to periods of inundation. Of 39 nests monitored for inundation, 28 were inundated for a total of 70-157 days in the fall and winter after the eggs had hatched but prior to emergence (November – April). Holte found that successful nests tended to be inundated for a shorter period (mean = 76 days, n=9) compared to failed nests (mean = 128 days, n=30). These results support managing nesting habitat to reduce the risk of prolonged inundation during the fall and winter.

Overall, these studies identify a set of variables that turtles are likely to respond to and that management can modify. Adaptive management or other experimental approaches would provide confirmation on what characteristics matter most to nesting turtles.

Diet

Western pond turtles are omnivorous and opportunistic feeders. They forage exclusively in aquatic habitats (Ernst and Lovich 2009). Animal matter constitutes the majority of the diet, including larvae of aquatic insects, earthworms, mollusks, and crustaceans, and vertebrates such as tadpoles, frogs, and small fish. Plankton are common in many of the habitats where western pond turtles occur and this may be an important nutrient source (Bury 1986). The diet of adults and occasionally juveniles consisted of small quantities of plant matter, including algae and roots of aquatic plants (Bury 1986, Holland 1994, Ernst and Lovich 2009). Aquatic insects comprised the majority of the prey of juveniles in a stream habitat (Bury 1986). Pond turtles also scavenge (Nussbaum et al. 1983, Bury 1986, Holland 1994). Observations of western pond turtles scavenging waterfowl (L. Holts, pers. obs.) and several fish species (C. Yee, pers. obs.) further support the conclusion that western pond turtles have a very opportunistic diet, which is at least partly responsible for their ability to use of a broad array of aquatic habitats.

Movements

The life history of western pond turtles requires several different types of movement. Within their aquatic system, daily movements to forage, thermo-regulate, defend basking sites, avoid predators, and find mates make up their aquatic home range. Seasonal movements to seek nest sites, to find overwintering areas, and to leave ephemeral aquatic habitats when they dry up require movements on land. During the nesting season, movements may include initial exploratory forays (Rathbun et al. 1992, Holland 1994). In Oregon, movements to terrestrial overwintering sites usually entail relatively short distances of less than 150 m into upland sites where the turtles may remain for months, with only occasional forays during warm days. Finally, dispersal from one area of regular occupancy to another, or in the case of hatchlings, from their natal nest to their rearing area and then to an area of adult occupancy, may entail long-distance movements. Below, we synthesize studies on each of these types of movements.

Aquatic movements—

Studies of aquatic movements of western pond turtles in moving and still bodies of water demonstrate great variability in movement patterns. The vastly different estimates of daily and seasonal movement among study sites suggest that the western pond turtle is capable of moving many kilometers during the active season, and some individuals probably moved greater distances than the observers were able to detect. Daily movements of up to 3 km have frequently been reported (e.g., Ryan 1998). Estimates of daily and seasonal movements in aquatic habitats are related to the size of the body of water. In a small lake in southern Oregon, Todd (1999) reported short daily movements and small home ranges in discrete portions of the lake. In large reservoirs in Oregon, Hardin (1993), Thaut (1994), and Ryan (2001, 2002) found extensive movements throughout the active season. Most turtles generally remained within a single cove, but frequent movements outside of the cove resulted in movements of up to 1.5 km from capture to farthest location detected. Movements became greater as the water level receded in the reservoirs. In a large river system in northern California, Bury (1979) reported seasonal movements of up to 2.4 km. Holland (1994) estimated movements in many different aquatic systems. From studies of the daily movements of individuals, Holland (1994) concluded that aquatic movements were greater in larger bodies of water, reporting movements of up to 600 m/day in a reservoir. He found some evidence of long-distance (>1 km) movements but because the transmitter signal was lost in some of these cases, the distances moved probably were greater than those detected. He also found extensive use of small modified channels during movements. Although Holland (1994) monitored movements for a large number of turtles in Oregon (approximately 131 individuals, but the exact number is not clear), he made few general statements regarding movement patterns and apparently avoided estimating home ranges for these individuals. It is clear from his results that movements were highly variable, and dependent on the size of the aquatic system.

Using marked individuals for estimation of home range, Bury (1979) found annual home ranges included an average of 145 m of stream length for juveniles, 149 m for adult females, and 367 m for adult males in northern California. Bury (reviewed in Bury and Germano 2008) found a few turtles that moved relatively long distances, including an individual that moved 1.5 km in a two-week period. Bury (1979) reported average home range size over a period of one to several years of 1.0 ha (range: 0.2-2.4), 0.24 ha (0 – 0.8), 0.36 ha (0 – 1.1) ha for males, females, and juveniles, respectively, with a maximum distance between captures of individuals (representing home range length) of up to 2.4 km. In streams, western pond turtles can clearly move long distances, and probably rather quickly. Bury’s finding of 1.5 km movement in 2 weeks is probably not unusual. In an intermittent stream in central California, radio-transmitters were used to track movements of 4 pond turtles during late spring into the summer when the stream becomes a series of stagnant pools due to summer drought (Rathbun et al. 1992). Movements of the 4 turtles within the stream ranged from <500 m (2 turtles) to 1-2 km (2 turtles) during a 4-month period in late spring and summer.

Terrestrial movements—

Overwintering

Western pond turtles in Oregon overwinter in both aquatic and terrestrial environments. Of the hundreds of western pond turtles that have been monitored with radio tracking to locate overwintering sites, we are aware of only two records for distances ≥500 m from water. The greatest distance we are aware of was a terrestrial overwinter site 1.4 km from the turtle’s aquatic habitat, which consisted of a large reservoir in the upper Willamette Basin (Ryan 2001). Reese and Welsh (1997) reported that the greatest distance western pond turtles traveled from their aquatic habitat to terrestrial overwintering sites was approximately 500 m in the Trinity River system in northern California. Factors that affect long-distance movements are unknown. Presumably, turtles select sites near their aquatic habitat if suitable habitat is available, and indeed, most studies demonstrate this. Holland (1994) using radio-telemetry found that overwintering sites ranged from 15-260 m from their aquatic environment. Vander

Haegen et al. (unpublished ms), one of the most thorough studies of overwinter movement patterns, found all sites to be within 150 m of permanent water and the average distance was 45 m. Most of the other studies using telemetry reported similar results with almost all movements <250 m throughout the species' range (Rathbun et al. 1992, Beal 1993, Thaut 1994, Rathbun et al. 2002, Bondi 2009). The greatest distances that western pond turtles moved overland for overwintering may have been on steeper slopes surrounding reservoirs (e.g., Ryan 2001). Fidelity to overwinter sites has been documented, and includes returning to the same substrate for cover as the previous year (Bondi 2009).

Nesting

Western pond turtles choose nesting sites close to aquatic habitats. Although there is a bias towards researchers finding nests near aquatic habitat where turtles are observed regularly due to how nest searches are conducted, radio telemetry confirms this general pattern throughout the species' range (Rathbun et al. 1992, 2002; Holland 1994, Holte 1998, Lucas 2007). Most nests are nearly adjacent to or within 100 m of aquatic habitat. Of 402 nests known to Holland (1994:5-7; Holland's Fig. 9) in the Willamette River Basin in Oregon, distances from the edge of the water to the nest site ranged from 3 to 402 m with most nests located within 50 m of the water's edge. Rathbun et al. (1992, 2002) reported similar distances. Holte (1998) in the Willamette Valley reported a range of 1-212 m for 136 nests, with 75% of nests within 150 m of water. Lucas (2007) reported that 26 of 29 turtles nested within 13-87 m of permanent water, with the remaining 3 turtles found nesting 150-180 m from water for a population of western pond turtles in the Columbia River Gorge in Washington. Characteristics for nest habitat vary among study areas, but it is clear that nest sites are near the turtles' aquatic habitat, and almost all nests occur within 200 m.

Dispersal

There have been few studies that shed light on dispersal of western pond turtles. A few anecdotal accounts of adult and juvenile dispersal exist. Dispersal barriers that isolate individuals from larger populations are presumed threats to this species conservation. Holland (1994: 7-26) notes the paucity of dispersal data and the importance of juvenile dispersal: "Determination of the movements of juvenile western pond turtles will form a critical part of any overall management efforts for this species", with which we concur. The only research that we are aware of that provided estimates of dispersal were two studies (Bury 1979, Holland 1994) designed to estimate home range size and movements within home ranges. As such, long-distance movements would fall outside of the researchers' area of detection. Limitations to the zone of detection is known to cause potentially serious underestimation of dispersal in other taxa (Koenig et al. 2000) and applies to turtles as well, as noted for the western pond turtle by Holland (1994:7-28). Both Bury (1972, reported in Bury 1979) and Holland (1994) report movements of adults that were greater than 2.3 km, including both overland movement (Bury 1972, reported in Bury and Germano 2008) and via aquatic systems (7 km upstream, Holland 1994:7-28). Western pond turtles may move overland between drainages. Holland (1994) reported that a western pond turtle traveled 5 km overland between drainages. However, genetic analyses suggest that most movements occur within drainages (Spinks and Shaffer 2005).

Anecdotal accounts of dispersal of adults and young exist from the 1995 floods in California. Following flooding of several rivers where pond turtles were known to occur, individuals were observed at the mouth of the rivers (http://www.santaclarariverparkway.org/theriver/species/wpt). Although the immediate response by the public and management agencies when finding western pond turtles in coastal areas was to repatriate them into areas where their occurrence was known, this event demonstrates the ability of turtles to disperse long distances, even if mediated by infrequent but large natural disturbances such as floods.

Urban, agricultural, and water development affect dispersal of western pond turtles. Their ability to maneuver around at least some of these human-created obstacles has been demonstrated. For example, western pond turtles have been observed moving around a concrete dam to reach the reservoir from the stream below it (Thaut 1994). Given how little is known about their dispersal, conclusions regarding factors affecting isolation of populations remain speculative but important considerations for management.

Strength of Inference and Gaps in Understanding—

Understanding movement patterns of animals, especially dispersal, is particularly challenging. Most of our understanding of movement patterns of vertebrates is based on daily movement rates, estimates of home range shape and size, and differences in these parameters between genders and among age classes. What we understand less well is how movement patterns are affected by environmental conditions (for example, biological corridors, Rosenberg et al. 1997), and how management activities affect movement patterns and their demographic consequences (MacDonald and Johnson 2001). Generally, dispersal patterns in vertebrates are one of the least understood but most relevant parameters for conservation (MacDonald and Johnson 2001). Our understanding of western pond turtle movements is generally inadequate. We have a basic understanding of within-home range movements in different environments from the published and unpublished literature, but our ability to predict how management would affect movements is very limited. We have virtually no understanding of barriers and facilitators of movement, nor what proportion of the population disperses at different distance intervals – the so-called "dispersal function". Unfortunately, this is typical of most animal populations (Clobert et al. 2001). An understanding of dispersal is critical for discussing and evaluating long-term viability of western pond turtles in managed ecosystems, particularly those that we suspect will face major changes due to increased human population growth such as in the Willamette Valley. New approaches to understanding patterns of movement and connectivity beyond radio telemetry will be needed to broaden our understanding and shed light on impacts of management (*see Section VI, Inventory, Monitoring, and Research Opportunities: Research*).

Breeding Biology

Although there are many facets to the reproductive biology of western pond turtles that are not well understood, the variation in their breeding biology across their range is beginning to be elucidated through numerous natural history investigations. In the sections below, we summarize what has been documented regarding the western pond turtle's breeding biology, and in particular, what is relevant for populations in Oregon. The breeding biology of western pond turtles is reviewed in Holland (1994), Buskirk 2002, Bury and Germano (2008), and Ernst and Lovich (2009). Recent work by Germano and Rathbun (2008) and Scott et al. (2008) significantly expands the earlier work.

The reproductive strategy of western pond turtles is consistent with other long-lived animals that incorporate a bet-hedging strategy in which reproduction may be skipped in some years if necessary resources are lacking, to better ensure survival and future reproduction. Male western pond turtles are sexually mature by 5-9 years and females at 7-10 years (Bury and Germano 2008). Maturity may be more related to age than size for females but not males (Gibbons et al. 1981 for red-eared sliders), giving rise to large size variation at maturity for females (Scott et al. 2008). Western pond turtles have different growth rates in different habitats and regions of their range, and therefore the size at sexual maturity of females would be expected to vary. Scott et al. (2008) reported that the largest minimum size at maturity was 140 mm carapace length (CL) in central California, similar to Holland's (1994) determination of a minimum CL of 131 mm for sexually mature females in southern Oregon. Variability of size at sexual maturity is likely due to environmental conditions that affect growth, such as water temperature and food supply, as has been demonstrated for other freshwater turtle species (Gibbons et al. 1981). Western pond turtles, similar to other freshwater turtles, grow at a faster rate in warmer water (Ernst and Lovich 2009). Some variation is expected in the relationship between water temperature and growth rates due to the influences of other factors such as food availability.

The reproductive cycle begins with courtship, about which little is known regarding timing and behavior. Limited observations suggest copulation occurs in early spring (Buskirk et al. 2002). Western pond turtles often make several terrestrial forays prior to constructing a nest. Nests are shallow, 7-12 cm below the surface (Ernst and Lovich 2009). In Oregon, the majority of nesting occurs from May through mid-July (Holland 1994, Holte 1998, Riley 2006). Clutches contain 1-13 eggs, but average 6 (Ernst and Lovich 2009). Eggs are hard-shelled, and measure approximately 30-43 mm in length and are 19-27 mm wide (Lucas 2007, Ernst and Lovich 2009). Several clutches may be laid in a season, a characteristic that has been documented with many freshwater turtle species (Bury 1979, Ernst and Lovich 2009). Little is known, however, of the western pond turtle's lifetime reproductive success, including the frequency distribution of the number of clutches laid per year, and the number of years that females reproduce during their lifetime. The intensive study of Scott et al. (2008), however, provides a significant step towards understanding lifetime reproductive success. Although variation of the number of eggs per clutch and presumably frequency of clutches exists among study sites (reviewed in Bury and Germano 2008), it is unknown how this varies geographically. Scott et al. (2008) suggested that clutch frequency may be the reproductive parameter most affected by environmental conditions. They suggested that split clutches, whereby a female lays eggs in more than one nest during a single episode of nesting, may occur in western pond turtles. This behavior has been reported for other freshwater turtles (Ernst and Lovich 2009). Estimation of the occurrence of split and multiple clutches will be important in understanding the demography of western pond turtles, especially in constructing population models. See *Demography: Reproductive Output* below for additional details on clutch size and frequency**.**

From the time of incubation through emergence, western pond turtles may spend nearly a year in their natal nest. Incubation time in the wild ranges between 94-122 days and may be even longer (Bury and Germano 2008). Incubation time is related to temperature (Ernst et al. 1994). In a detailed field study in southwest Washington, Lucas (2007) reported a mean incubation time of 92.1 ± 3.0 (1 SD), with some eggs hatching after only 87-88 days. Gender may be temperature dependent (reviewed in Ernst and Lovich 2009). Hatchlings that emerged in spring averaged 29.3 mm CL (range 26.4-32.3 mm) and weighed 5.7 g (range 3.7 – 6.8) in a western Oregon study (Holte 1998), similar to the CL and mass that Lucas (2007) reported from southwest Washington (29.5 ± 1.5 [SD] mm; 5.4 ± 1.0 [SD] g). Although there have been few intensive studies on nestling emergence, the preponderance of evidence suggests that in Oregon most hatchlings overwinter in their nest (see section above on *Habitat: Terrestrial--Overwintering*). Emergence of hatchlings is also likely to be weather dependent, but because of the difficulty in identifying when emergence will occur, few observations have been reported.

Demography

Understanding the patterns of survival, reproduction, and population structure and their influence on population dynamics of long-lived animals such as the western pond turtle is critical for their effective conservation. Studies on the demography of vertebrates, especially long-lived species such as western pond turtles, are challenging because of the need for an intensive and long-term approach. Based on a few marked individuals recaptured decades after their initial capture, western pond turtles are thought to be very long-lived, with some individuals reaching over 40 years of age (Bury 1979). Western pond turtles have delayed sexual maturation. Some individuals require nearly a decade to reach breeding status, but have a potentially long lifespan for reproduction. These traits give rise to the expectation of a high proportion of juveniles and sub-adults in a stable population (Gibbs and Amato 2000).

Despite several long-term studies, estimates of the key vital rates of a population – survival and reproductive output- are rarely reported in published and unpublished studies of western pond turtles. Furthermore, the estimates that exist have rarely been linked to factors that are relevant to management, such as habitat and landscape parameters. Reese and Welsh (1998a) reported on the comparative demography of this species in a riverine system in northern California during a three-year period from a study that is ongoing (H. Welsh, USFS, pers. comm.) and likely to result in new insights on the species' demography. They reported survival estimates but did not estimate reproductive parameters. Scott and coauthors (2008) report on reproductive patterns of a central California population for a period of 7 years using radio-tagged individuals but did not report on survival rates. A long-term study that has used a mark-recapture approach has been conducted by S. Wray (ODFW, pers. comm.) in southern Oregon. Analyses of that study have not yet been reported, but should also provide insight into demographic patterns. The only study area that has contributed to estimates of both survival and reproductive effort that we are aware of is the study in southwest Washington that evaluated the success of the captive-rearing program ("head start") through studies that followed the early cohort of releases (Lucas 2007, Vander Haegen et al. 2009).

Reproductive Output—

Because of the difficulty in finding nests, attributing them to a particular female, and estimating nest success rate, there are limited data on age- and habitat-specific reproductive rates. More commonly, estimates are for clutch size on a per-female basis; these are biased towards the few individuals for whom nests were found. X-ray evaluation of gravid females provided estimates of per-female clutch size in a number of study areas including California (Scott et al. 2008) and Oregon (Hardin 1993). Estimates of population-level nest-success rates are almost nonexistent. Little is known about the number of clutches per female per year, but more than one clutch per season has been observed in several study areas (Goodman 1997, Lucas 2007, Bury and Germano 2008, Germano and Rathbun 2008, Scott et al. 2008). Multiple clutches per breeding season may be an adaptation for high nest mortality via predation or natural disturbance events, the common-sense strategy of "not putting all of your eggs in one basket". In some cases, a female may lay eggs in more than one nest during a single episode of nesting. Scott and coworkers (2008) suggested that split clutches may occur with western pond turtles more frequently than realized. The strategy of split clutches may be an important adaptation to increase fitness in environments where entire nests are often depredated. Only recently is it becoming clear that double clutching and that even split clutches may be typical for this species (Scott et al. 2008), which would affect estimates of reproductive output. Below, we summarize work done on several parameters of reproductive output.

Clutch Size

The number of eggs per nest has received the most attention from studies on the reproductive output of western pond turtles. Limited analyses of clutch sizes from throughout the turtle's range have reported a positive correlation between clutch size and female body size (Holland 1994), whereas within a study area, there have been mixed findings. Both Goodman (1997) in a southern California study area and Lovich and Meyer (2002) in a Mojave Desert study area found positive correlations between body size and clutch size, with larger clutches laid by larger females. Scott et al. (2008) failed to find a statistically significant correlation, although their findings were consistent with the hypothesis that larger females produced larger clutches. Although we are unaware of analyses of clutch size and age for western pond turtles, there is evidence of a positive relationship in some species of turtles (Tinkle et al. 1981).

There are only a few studies that included a large number of nests from which to draw inferences on the variation in clutch size. Holland (1994) examined 168 clutches throughout the species range; the number of eggs ranged from 1-13, with a mean of 6.1 eggs per clutch. The variation among clutches, other than the range in numbers, was not reported. In the most detailed analysis to date, Scott et al. (2008) palpated 152 females in a central California study area, and of these, 43 were gravid. Based on X-rays of gravid females, mean clutch size was 5.7 (SD=1.2) with a range from 3 to 8 eggs. In the Willamette Valley, Holte (1998) reported a mean clutch size of 7.0 eggs (n=52 successful nests, range 2-12 eggs), with half of the nests with 5-8 eggs. Lucas (2007) reported a mean clutch size of 6.3 eggs per successful nest in the Columbia River Gorge population in southwest Washington. Thus, throughout the species' range, data suggests that clutch size is most variable among individuals within a study area, with less variation geographically.

It is important to keep in mind the sampling method used for estimating clutch size. Methods used have included number of eggs in a particular nest and number of eggs detected from X-rays of gravid females. If split nests (one clutch laid in more than one nest) or double clutches (more than one clutch per breeding season) occur, then counts of eggs from a single nest may underestimate reproductive output for a female in a given year. The magnitude of this bias would depend on the frequency of split nests and double-clutching. This frequency is unknown, largely due to the difficulty in detecting radio-tagged western pond turtles at their nests without disrupting their nesting. Furthermore, the proportion of females that did not nest is rarely reported and difficult to estimate (see *Clutch Frequency*, below), but this is important to include in population models.

Clutch Frequency

The possibility that western pond turtles have multiple clutches was suspected early during natural history studies (Holland 1994), consistent with other freshwater turtles (Tinkle et al. 1981). Double clutches have been reported throughout the species' range including Oregon (Riley 2006), Washington (Lucas 2007), and California (Goodman 1997, Scott et al. 2008). Goodman in southern California (1997) was the first to estimate the frequency of double clutches for western pond turtles, and reported 3 of 7 females that laid eggs double-clutched, with 38-41 days between the two clutches of each female. Scott et al. (2008) reported double clutching occurred in a minimum of 50% of the females. They reported a range of 27-43 days between the first and second clutch in their central California study site. Double clutching may be more common than previously thought, and only detailed evaluation of individual females would be likely to detect this pattern.

In some years an individual may not nest (Holland 1994, Scott et al. 2008, Ernst and Lovich 2009). In central California, Scott et al. (2008) found that 15% of the adult females did not nest in a given year. Goodman (1997) reported that only 33-50% of adult females (using 110 mm CL as criterion for adult female) were gravid in a given year. The percent of adult females nesting reported by Goodman (1997) may have been biased because some turtles that nested may have been undetected, and the minimum size he used may have included immature females (Scott et al. 2008).

Scott et al. (2008) emphasized the importance of estimating clutch frequency, together with clutch size, as potentially critical parameters in demographic analyses. We note that this is also very important in developing useful population models, particularly where nest success is a component in the model.

Nest Success

Nest failure of over 80% is typical for many freshwater turtles, even over several successive years (Burke et al. 1998, but see Tinkle et al. 1981 for cases of high nest survival) and is a characteristic of their demography (Gibbs and Amato 2000). Patterns of nest success for western pond turtles are consistent with those for other freshwater turtles. Nest success for western pond turtles has been estimated in several studies across the species' range, and at some sites for many years. These studies provide us with 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 depredated, because they may not have been found otherwise. Depredated nests are much easier to find than non-depredated nests, resulting in an overestimate of nest failure. This problem is well recognized in the avian literature (Williams et al. 2001). The most reliable samples are those that are found soon after they are laid because there is evidence that depredation rates of freshwater turtle nests are highest within 48 hours of nesting (Legler 1954, Tinkle et al. 1981, Holland 1994, R. Swift, pers. obs.), although that pattern is not consistent across studies (Gervais et al. 2009). Observations of nest predation of western pond turtles in Oregon suggests that predation may occur in quick succession, once a search image is established (R. Swift, pers. obs.). Although a potentially greater abundance of predators may have increased nest failure rates in urban areas, nest predation may also be related to the concentration of nesting in what little available habitat is left. The hypothesis that nest predation rates increase with increasing nest density was tested by Burke et al. (1998) with several freshwater turtle species in southeastern U.S. They reported that predation rates were not related, as a single factor, to nest densities. However, the potential that very small areas with high densities of nests undergo high predation rates remains a concern because management can create this situation (D. Rosenberg, pers. obs.).

Holland (1994) was the first to report on nest success rates for a large number of western pond turtles. He reported a depredation rate of 91.6% for 106 nests found across the western pond turtle's range. Holland's report initiated the concern that nests had unusually high failure rates that would lead to declining populations. This motivated the management strategy of protecting nests with exclosures (e.g., Holte 1998). Locating nests and protecting them with metal exclosures has been a primary management tool at several sites, including Delta Ponds in Eugene, Oregon (L. Holts, pers. obs.) and Fern Ridge, Hills Creek, and Fall Creek Reservoirs (Holte 1998, R. Swift, pers. obs.). It is unclear, however, how Holland (1994) estimated depredation rates and interpreted their importance to population viability. Similar to Holland, Holte (1998) found nearly 100% nest failure within 24-48 hours following egg laying at the Fern Ridge Reservoir study area. Raccoons and striped skunks have been documented as nest predators at these sites (Holland 1994, R. Swift, pers. obs.). The role of small fossorial mammals has not been evaluated, but they likely predate nests as well. Nests that have been protected from predators with exclosures have high success rates. Of 32 nests found soon after laying in the Fern Ridge area within the Willamette Valley, only the 24 nests protected with exclosures were successful (Holland 1994: 5-8). Riley (2006) reported that 11 of 12 nests protected from predators in the upper Willamette Basin hatched successfully. Because of the extremely high nest failure rates that have been reported for western pond turtle nests in Oregon, and the difficulty of finding nests to protect, understanding the patterns and population implications of nest failure rates is a research priority (see Section *VI, Inventory, Monitoring, and Research Opportunities, Research*).

Survival and Recruitment—
Many species of animals are predators of western pond turtles. Indeed, the list of predators includes most animals that are sufficiently large to consume either a nestling or adult (Ernst and Lovich 2009). Most mustelids inhabiting areas near aquatic habitats, including river otters (Manning 1990), are predators of adults. Many other mammals including canids and black bears, and many bird species including great blue herons are predators (Holland 1994, Buskirk 2002, Bury and Germano 2008). Great blue herons may be an important predator of hatchlings in particular. Predation on larger juveniles and adult freshwater turtles tends to be low because of the protection afforded them by their shell (Gibbs and Amato 2000).

Hatchlings

Survival of freshwater turtle hatchlings is presumed to be very low, and is a characteristic trait of their demography (Gibbs and Amato 2000). We are unaware of any data-based estimates of survival of western pond turtle hatchlings after they leave the nest, despite the predominant view that high post-emergence mortality is a major conservation threat (Hays et al. 1999).

Despite the paucity of data on the magnitude of predation of hatchling and juvenile turtles, introduced smallmouth bass, largemouth bass and bullfrogs have been reported to cause population declines (Holland 1994, Buskirk 2002). The initial speculative comment in Holland (1994:2-12) has been cited numerous times, apparently unchallenged, resulting in management strategies to remove bullfrogs and bass. We note that the review by Bury and Germano (2008) points out that the effects of bullfrogs and largemouth bass on turtle populations are unknown and that these predators commonly co-occur with western pond turtles. Furthermore, bullfrogs and smallmouth and largemouth bass co-occur in their native range with other freshwater turtle species such as painted turtles (Gervais et al. 2009). In the only study that attempted to evaluate the frequency of bullfrog and largemouth bass predation on hatchling turtles that we are aware of, Corn and Hendricks (1998) failed to find hatchling painted turtles in the stomach contents of bullfrogs or largemouth bass in areas where hatchlings were detected. From their observations, the authors believed frequency of predation by bullfrogs and largemouth bass was low. Many, if not most, western pond turtles occupying ponds in Oregon co-occur with bullfrogs. However, the concern over hypothesized elevated rates of depredation on hatchlings provided the motivation in Washington for releasing captive-raised turtles that are sufficiently large to escape predation by bullfrogs and bass, a management tool referred to as “head-starting” (Hays et al. 1999, Clark 2001). Head-starting was used as a trial program in Oregon at some U.S. Army Corps of Engineers turtle management sites (R. Swift, pers. obs.). Resolving the issue of the effects of bullfrogs and bass on hatchling predation is a research priority (see *Section VI, Inventory, Monitoring, and Research Opportunities: Research*).

Based on visual observation of hatchlings at Fern Ridge, and the known minimum number of protected nests that were successful, Holland (1994:5-8) reported a minimum survival rate of 0.84%, which reinforced his view that near complete mortality existed at this site. Given the difficulty in detecting hatchlings (Holte 1998 and many others) the estimate of near zero survival is clearly negatively biased to an unknown extent, making such estimates rather meaningless. Hays et al. (1999) and Spinks et al. (2003) assumed there was extremely low or no survival of hatchlings based on the failure to detect hatchlings. We were unable to find any quantitative estimates of hatchling survival, despite its clear importance in the population dynamics of pond turtles and the implications for aquatic and terrestrial habitat management. Holte's (1998) data on hatchlings may be able to provide an initial estimate, albeit for a small number of individuals and for only a brief period of time after emergence. The extreme difficulty of detecting hatchlings has been noted since Storer's (1930) work. Development of methods to detect hatchlings is a research priority (see *Section VI, Inventory, Monitoring, and Research Opportunities: Research*).

Juveniles and Adults

Despite studies that have incorporated mark-recapture approaches that would allow estimation of survival rates, the only study we are aware of that has estimated survival of western pond turtles is in southwest Washington conducted by Vander Haegen and colleagues (2009). Over four years, they radio-tagged 68 turtles that were captive-reared and released as "head-started" turtles into a previously unoccupied site. From the initial sample of 68 turtles, 6 were found dead, and 5 of these died during use of upland areas in the winter. At least 4 of the 6 mortalities were due to predators. During the 4 years of the study, annual survival estimates ranged from 88-95%, with no detectable difference among years. Among age-classes, survival estimates ranged from 86-97%, with no detectable difference among age classes. The lack of variation among years and age classes was in part due to the very broad confidence intervals of the estimates, a result of small sample sizes.

Population Structure—

There are two functionally different types of population structure: geographic and demographic. The genetic similarity of groupings of individuals infers connectivity among populations, and provides clues to the spatial arrangement of individuals and sub-populations. This is often what is considered geographic population structure. Although there has been considerable genetic work on subspecies and clades (see *Section II, Classification and Description: Systematics*), there have been only a few evaluations on inferences on geographic population structure of western pond turtles (e.g., Spinks and Shaeffer 2005, 2009).

Demographic population structure refers to the age structure and sex ratio of a population, and provides clues to causes of declines. Geographic and demographic processes both are influential on the dynamics of populations across space and time. From numerous studies that have captured, marked, and aged individuals, we have an initial understanding of the demographic population structure of western pond turtles. Because detection probability was not incorporated into estimates of age structure, despite the widely acknowledged issue that younger age-classes are difficult to detect (e.g., Congdon et al. 1993), estimates are usually biased towards older and larger animals. Further, estimates of age and sex ratios are sensitive to the sampling method used (e.g., Ream and Ream 1966). Therefore, until efficient and reliable methods are used for estimating age- and sex-ratios, demographic studies will be difficult to interpret. Statistical methods using mark-recapture approaches exist (e.g., Williams et al. 2001), but these methods have not been incorporated into analyses of western pond turtle populations with the exception of Reese and Welsh (1998).

The two most reliable studies on age/size structure for western pond turtle populations were conducted in California. Germano and Bury (2001) reported that aquatic habitats with relatively large numbers of turtles had estimated adult to juvenile ratios that ranged from mostly adults to a relatively even mix of adults and juveniles. Germano and Bury (2001) concluded that recruitment was apparently sufficient in the Central Valley of California based on a broad survey of aquatic habitats that used a variety of methods. Their results contrasted with earlier concerns about recruitment which were largely based on the lack of visual observations of young turtles. Germano and Rathbun (2008) reported 84% of adult-sized (CL $\geq$ 120 mm) western pond turtles in their sample, but found that because of fast growth rates at their study site, almost 41% (73 of 133 aged turtles) were less than 5 years old, 12% (16 of 133) were 3 year olds, and 9 % (12 of 133) were 2 years old. This study represents the most thorough evaluation of population structure of western pond turtles of which we are aware.

Population Modeling

Population models give insight into the sensitivity of the population to mortality of 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. Modeling allows explorations of combinations of age-specific survival and reproductive rates that will be necessary to maintain population sizes.

The expectation is that species that are long-lived but have a large number of young will have population growth rates that are most sensitive to changes in adult mortality, all else being equal (Heppell et al. 1996). However, management activities may be able to affect one age class more effectively than another, thus creating a more complex decision-making process than the sensitivity analyses would suggest (Mills and Lindberg 2001). For example, it may be easier to increase survival rates for younger age classes through management such as increasing quality of nest habitat, than by reducing road mortality of adults. Thus, interpretation of sensitivity analyses must also consider management options and the feasibility to affect various age classes (Mills and Lindberg 2001). This is the underlying assumption for head-start programs, such as that used by Washington in their western pond turtle recovery efforts (Hays et al. 1999). The assumption that management can affect juvenile recruitment sufficient to result in population increase is supported at least in part by the initial high survival rates of head-started turtles (Clark 2001) and the increasing numbers of western pond turtles in sites where the population was supplemented or reintroduced by head-start turtles (e.g., Vander Haegen et al. 2009).

A number of studies on painted turtles collected sufficient demographic data such that life tables and population models could be constructed. To the extent that western pond turtle life history overlaps that of the painted turtle, general conclusions drawn from the painted turtle models may be applicable to western pond turtle ecology and management. Although in general the delayed reproductive maturity and long lifespan of both turtle species suggests that adult survival is most influential on population growth rate (Heppell 1998, Heppell et al. 2000, Caswell 2001), model outcomes are specific to the assumptions and parameters used (Gervais et al. 2009). 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

Western pond turtles have a life history similar to other semi-aquatic freshwater turtles. Adults are long-lived, and begin breeding at 5-9 years in males and 7-10 years in females. Nest site selection has been studied in a number of locations and is fairly well described. Nesting habitat is characterized by its proximity to water, relatively sparse vegetation, and a high level of solar exposure. Adult and juvenile pond turtles use both aquatic and upland habitats for overwintering, and upland overwintering sites are typically within 200 meters of water. Hatchling pond turtles most frequently overwinter in their natal nests. Pond turtles disperse over land and along waterways, but long-distance movement patterns are still poorly understood. Both double-clutching and splitting a single clutch between two or more nests occurs. However, estimates of any demographic parameters other than clutch size per nest are scarce, and estimates of hatchling survival are essentially nonexistent. Hatchling ecology is almost unknown and is one of the key areas for future research. This includes both habitat selection and the extent of predation by introduced species. Very few estimates of demographic parameters exist for western pond turtles, but will be helpful for developing models to evaluate management alternatives.

IV. RANGE, DISTRIBUTION, AND ABUNDANCE

Range and Distribution

The western pond turtle is the only turtle that is native to only western North America. The species' range includes northwestern Baja California, Mexico, north to Puget Sound of Washington and is restricted with few exceptions to areas west of the Sierra Nevada and Cascade Mountains. It inhabits relatively remote landscapes (e.g., Reese and Welsh 1998b), in addition to rural (Holland 1994, Adamus 2003) and urban (Spinks et al. 2003) environments throughout its range. Western pond turtles have been uncommon in Washington since at least the 1940s (Evenden 1948). There has been a recent increase in distribution and abundance within Washington with WDFW's recovery efforts (Campbell et al. 2006, Vander Haegen et al. 2009). In Oregon, the western pond turtle is most abundant in the drainages of the Willamette, Umpqua, Rogue and Klamath Rivers, but occurs in lowland aquatic habitats throughout western Oregon. Western pond turtles have been observed as high as 1830 m elevation in Oregon (Nussbaum et al. 1983, ORNHIC database 2008). In the Willamette River Basin, western pond turtles have sparse distribution and abundance in areas north of Salem (Adamus 2003), but this may not indicate a major decline because this is consistent with earlier observations (Graf et al. 1939, Evenden 1948). There are no known gaps in their distribution, nor any understanding of patterns of distribution other than that which is defined by their aquatic habitat and elevation limits. Predicting their occurrence based on environmental correlates is a research priority (see *Section VI, Inventory, Monitoring, and Research Opportunities, Research*).

Surveys Conducted

The stated goals of most of the surveys conducted to date have been to identify locations where western pond turtles occur and to provide "baseline" data on abundance from which later trends could be determined. Surveys have been conducted to document distribution throughout the range of the western pond turtle in Oregon. Holland (1991) conducted surveys throughout the range of western pond turtles in Oregon. However, most of the distribution work has been conducted in the Willamette Basin and included extensive surveys throughout the region (Holland 1993, 1994; Adamus 2003) and in smaller management units including reservoirs of the upper Willamette tributaries, tributaries of the Willamette, and on lands managed by land trusts, municipalities, and the State of Oregon (Table 1). Although it is recognized that the Klamath region has a large number of western pond turtles, we are aware of only a single survey (Holland 1993) that reported results throughout the region. An intensive and extensive survey of the Umpqua drainage on federal lands was conducted over 3 years (Horn 1998, 2000, 2001). Limited surveys have been conducted in coastal areas (Holland 1991, Stern and Rosenberg 1992), primarily in areas that were previously known to be occupied by western pond turtles. In 2008, ODFW and the Oregon Zoo initiated a citizen science effort. Participation was impressive, with over 160 western pond turtle locations reported. Additional opportunistic observations have been made of western pond turtle locations by individuals and agency personnel, and recorded in either the ORNHIC database, USFS database (NRIS), or BLM database (GeoBOB). We accessed records in these databases in January 2009. Almost all of the distribution data on the western pond turtle were collected from selected sites based on a previous understanding of where turtles would most likely be found, and from opportunistic observations. The only survey that we are aware of that used a probabilistic sampling design was conducted in the Umpqua drainage (Horn 1998, 2000, 2001).

Only limited inference on patterns of distribution and abundance of western pond turtles in Oregon is possible because the surveys, with the exception of those in the Umpqua Basin, were conducted without a formal sampling framework. This limits the ability to draw inferences on the occurrence and relative abundance of western pond turtles based on habitat conditions and land ownership, two factors of primary consideration in developing conservation strategies. Some areas may have the appearance of greater abundance simply because there was a more concentrated survey effort. However, given the limitations of these data, the existing data support the conclusion that western pond turtles are abundant south of Salem and occur in the Willamette Valley, Klamath Mountains, East Cascades, West Cascades, and the Coast Ranges ecoregions and Northwest Forest Plan Physiographic Provinces (Fig. 1a and b). This distribution pattern is consistent with species occurrence as indicated in the Oregon Conservation Strategy (ODFW 2006). Each ecoregion is dominated by different land allocations and land ownership patterns. Land ownership varies by ecoregions. The Willamette Valley is almost entirely under private ownership (Fig. 3, 96%), with increasing public ownership from Coast Ranges (Fig. 4, 40%), Klamath Mountains (Fig. 5, 53%), East Cascades (Fig. 6, 61%), and West Cascades (Fig. 7, 77%) ecoregions (ODFW 2006). USFS and BLM are the predominant public land managers in the area surrounding many of the records of western pond turtle locations (Fig. 2), although smaller parcels of State Lands, USFWS, USACE, and city and county municipalities are important throughout many parts of the species range in Oregon. The location records demonstrate that western pond turtles also occur in or near many urban areas in Oregon (Fig. 8).

Table 1. Summary of survey or location data for western pond turtles in Oregon. Citation details for the reports are in *Section IX, References*.

Ecoregion	Site	Author	Year
State-wide		Holland	1993
State-wide		ODFW Citizen Science	2008
Willamette	Region-wide	Holland	1994
Willamette	Region-wide	Adamus	2003
Willamette	Opportunistically	St. John	1987a
Willamette	Finley Refuge	Drut	1995
Willamette	Finley Refuge	Loegering	1998
Willamette	Finley Refuge	Brunkel	1998
Willamette	Coast and Middle Forks, Willamette	Moehl	1994
Willamette	Fern Ridge Res.	Leatham	1994
Willamette	Fern Ridge Res.	Beal	1993
Willamette	Calapooia, Row, and Tualatin Rivers	Reams	1999
Willamette	McKenzie River floodplain	Vesely	2003a
Willamette	McKenzie River	Vesely	2005
Willamette	Vanderpool (Benton County)	Vesely	2003b
Willamette	Newton Creek Watershed (Mary's River)	Vesely and Rosenberg	2007
Willamette	Sauvie Island	Gaddis and Corkran	1985
Willamette	Portland metropolitan region	Gaddis	1984
Willamette and West Cascades	Dorena,Cottage Grove, Hills Creek, Foster, and Green Peter Res.	Saxton	1993
West Cascades	Fall Creek Res.	Thaut	1994

Table 1. Continued…..

Ecoregion	**Site**	**Author**	**Year**
West Cascades	Elijah Bristow State Park	Riley	2006
West Cascades	Umpqua Basin	Horn	1998, 2000, 2001
Klamath Mtns	So. Umpqua Basin	Todd	1999
Coast Ranges	South coast	Stern and Rosenberg	1992

Willamette Basin—
Several geographically broad surveys for western pond turtles have occurred within the Willamette Basin. Holland (1994) surveyed for western pond turtles throughout the Basin. A follow-up survey was conducted by Adamus (2003), with the goal of expanding the areas surveyed. Both researchers selected sites most likely to result in locations of turtles. Reams (1999) conducted surveys for western pond turtles in several rivers in the Willamette Basin. These and other opportunistic observations resulted in 448 locality records as of 2003 reported in ORNHIC. Holland's (1993, 1994) and Adamus' (2003) survey efforts demonstrate that the general distribution of the western pond turtle in the Willamette Basin is similar to the presumed historic distribution. Additional surveys (Table 1) contributed a large number of locations which detailed occurrence more precisely, and further demonstrate the broad distribution. Many of the locations from these surveys have not been submitted to a database, and are thus not included in our mapping efforts. Although there are many location records on public lands (e.g., lands managed by U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, U.S. Forest Service, Oregon State Parks, and open space within many municipalities), most locations are on private land (Fig. 3), which is not surprising given that 96% of the Willamette Valley ecoregion is privately owned (ODFW 2006).

Umpqua River Basin—
We know of two extensive surveys for western pond turtles in this region. Holland (1993)used both visual and mark-recapture approaches. From his surveys throughout Oregon, he reported that the Umpqua Basin had the largest known population of western pond turtles in Oregon, occurring primarily on U.S. Forest Service lands (Holland 1993:16). The surveys reported by Horn (1998, 2000, 2001), were the most intensive survey efforts. The visual surveys, combined with mark-recapture at several sites, were conducted over three years using a probabilistic sampling framework that allows broader inferences than other surveys conducted on this species in Oregon. Additional temporal coverage of a subset of the sample points was conducted to evaluate observation methods (Horn 2001). Along the Umpqua River, sample points were randomly located every 20 km and repeated during each field season for three consecutive years (Horn 2001). In addition, Horn and colleagues surveyed a large number of accessible ponds (n>100) that were visible within 100 m from public land. Western pond turtles were detected at almost half of the sample points along the Umpqua over the 3 years of the river surveys and detected at over 60% of the pond sites (Horn 2000). The data from Horn's surveys are unique among studies of western pond turtles because of the formal sampling strategy and estimation of detection rates. Because of the large number of sample points and detections over several years, there are potentially additional analyses that could be conducted with these data to better understand habitat and environmental correlates of occupancy (see *Section VI, Inventory, Monitoring, and Research Opportunities: Research*).

Opportunistic observations of locations of western pond turtles were collected by USFS, BLM, and others and reported in the databases we accessed. In addition, observations in small lakes in the southern portion of the Umpqua Basin (Todd 1999) contribute to abundance and location data.

Rogue River Basin—

The only extensive survey that we are aware of was conducted by Holland (1993) during his statewide survey employing both visual and capture methods. Holland (1993) reported low densities of western pond turtles in the Rogue Basin, which he commented was unexpected given the densities reported in habitats similar to those that he surveyed. He did find some moderate-sized populations of 30 or more individuals. Because most of the species' habitat in the Rogue Basin is in public ownership, both the USFS and BLM potentially play a large role in conservation of this species in this region. As with the other sites Holland surveyed, the records from these surveys are apparently not in any of the databases we examined. There are however a number of opportunistic observations of western pond turtles in the Rogue Basin recorded in those databases.

Klamath Basin and East Cascades—

We are aware of three sources of surveys in the Klamath and East Cascades ecoregions. These include Holland's (1993) statewide survey that detailed observations in the Klamath Basin, the observations that St. John reported in his series of surveys (St. John 1987b), and surveys conducted by ODFW (unpublished data) on the Upper Klamath Lake. Holland (1993) conducted the most extensive surveys and detected western pond turtles in 30% of the 43 sites he surveyed. Only a few sites were responsible for most of his 113 observations of western pond turtles. St. John (1987b) considered the western pond turtle to be common throughout aquatic habitats in southwestern Klamath County. As noted for other basins, neither Holland's (1993) records, nor those of St. John's, were in the databases we accessed.

Coastal Areas—

There have been two reported surveys for western pond turtles in Oregon coastal areas (Holland 1993, Stern and Rosenberg 1992), and a third survey is being conducted during 2009 by the US Forest Service (Cindy Burns, USFS, pers. comm., July 2009). In 1991, Holland (1993) conducted visual surveys at 14 sites that were each surveyed once from the vicinity of Tillamook south to Brookings. Holland failed to detect western pond turtles in this extensive but not intensive effort, but speculated that small, disjunct populations existed in the coastal areas in Oregon. Stern and Rosenberg (1992) surveyed for western pond turtles primarily in sites where they were previously observed in the south coast within Coos, Curry, and Douglas counties. Additional sites which they believed were likely habitat for western pond turtles were included in their survey. Based on these surveys and anecdotal observations by others that are reported in the databases (Fig. 4), the western pond turtle at the time of the surveys was distributed throughout the south coast of Oregon in small and apparently disjunct populations. Because low detection rates can occur with this species, the populations may not be as isolated as Stern and Rosenberg's (1992) survey results suggest. Preliminary results from the survey being conducted by the U.S. Forest Service confirms occupied habitat, but no confirmed reproduction, farther north to Newport (C. Burns and R. Miller, USFS, pers. comm., July 2009).

Population Trends

Given the vast changes to the hydrology and land use of the Willamette River Basin (Taft and Haig 2003), declines in abundance of western pond turtles along the Willamette River and many of its tributaries may have been great. Holland (1994) argues that the population has declined precipitously, by 98%, although the estimate Holland provides is based on numerous assumptions that were unlikely to have been met by his *ad hoc* method. Despite what must surely be large-scale changes in patterns of abundance of western pond turtles, the survey efforts demonstrate that the general distribution is similar to the presumed historic distribution, with the likely exception of the Portland metropolitan area. Estimation of reliable population trends over large areas, which is often advocated, is very difficult to accomplish because of detectability issues. Further, such broad-scale monitoring is rarely able to guide management because reasons for the declines are unknown (Nichols and Williams 2006). To be effective, we recommend that future survey work address specific information needs for developing conservation plans and be conducted in a manner that would facilitate linking western pond turtle occupancy or abundance patterns with environmental factors.

Table 2. Description of data sources included in the western pond turtle distribution maps in Oregon. The data from these sources vary in the accuracy of the location of the observation. Observations may include turtles at their nest sites, roost sites, basking sites, and location during other activities. The location records from these data sources and shown on the figures (See *Section X*, *Figures*) should not be used to infer relative abundance, changes in trends, nor absence of western pond turtles.

Source	Region	Years
Oregon Natural Heritage Information Center	Statewide	1939-2007*
ODFW Citizen Science	Statewide	2007-2008
Assessment Request	Statewide	2008
ODFW Chub Survey	Willamette	1993-2007
USFS Region 6 (NRIS)	Statewude	1990-2008 **
FS Region 6 (NRIS)	Columbia Gorge	1978-1995
BLM	West Eugene Wetlands	2005-2007
BLM (GeoBOB)	Klamath and Umpqua	1992-2008

* predominately 1990-2003
** dates are missing for some records

Section Summary

Western pond turtles occupy regions in western Oregon with suitable habitat at elevations typically below 1800 m. Western pond turtles are most abundant in the drainages of the Willamette, Umpqua, Rogue and Klamath Rivers, but occur in lowland aquatic habitats throughout western Oregon, primarily in the Willamette Valley, Klamath Mountains, West Cascades, and Coast Ranges ecoregions. Numerous surveys have been conducted, and occurrence records have been augmented substantially by ODFW citizen science program and opportunistic sampling by biologists. Almost all of the surveys were conducted without using a formal sampling protocol for site selection, limiting their potential value in describing patterns of distribution in relation to environmental conditions and land ownership. There are opportunities for linking the occurrence records with environmental variables in order to better understand habitat relationships. Location records are consistent with land ownership patterns: in the Willamette Valley, a large number of western pond turtles occur on or near private land, whereas in the other ecoregions western pond turtles occur frequently on public lands, especially in the southwestern portion of Oregon and on USFS and BLM lands. Reliable estimation of population trends will be difficult to achieve over the range of the western pond turtle in Oregon, and is unlikely to be able to guide management. We recommend that additional survey work address specific information needs for developing conservation plans and use a hypothesis-driven approach to inventory and monitoring efforts.

V. CONSERVATION

The previous sections demonstrate that the western pond turtle has life-history traits that make the species potentially vulnerable throughout its range. In addition to its inherent vulnerability, there are many threats that cause concern for the future of this species in specific sites in Oregon. However, the western pond turtle occupies many disturbed environments, demonstrating its ability to occupy human dominated landscapes including urban areas. The species has also persisted in areas where it was once considered likely to be extirpated. This tenacity offers opportunities for conserving this species throughout its range. In this section, we highlight conservation opportunities, threats to populations, and management approaches and considerations to secure the species in Oregon. We provide general guidelines rather than specific recommendations, as the latter will need to be context specific. Future steps in native turtle conservation in Oregon could include the development of a statewide conservation plan that addresses these issues in a spatially explicit format, presented with both a regional and state-wide perspective, and with specific turtle management areas and actions identified.

Land-Use Allocation

Because of their broad distribution in western Oregon, western pond turtles occur on lands managed by a number of public agencies as well as by private landowners. Land allocation in the range of the western pond turtle in Oregon varies considerably among regions of the state. Distribution in the Willamette Basin is largely on private lands, but important populations occur on federal lands, primarily those managed by the US Army Corps of Engineers and US Forest Service. In the Willamette Basin, western pond turtles occur in many of the waterways managed by Oregon Parks and Recreation Department. They are also common in some open-space properties of County and City municipalities. Effective conservation in the Willamette Basin will require coordination with private landowners. In southern Oregon, western pond turtles occur frequently on lands managed by the US Forest Service and BLM, primarily in the Umpqua and Rogue River drainages. Despite known large populations in the Klamath Basin, there were relatively few records in the databases that we reviewed. Valid inferences on distribution patterns by region and land ownership are very limited because a formal sampling strategy was rarely used (see Section *IV Range, Distribution and Abundance: Surveys Conducted*).

Recognition of land-use allocation and land ownership are important in considering management approaches for western pond turtles. Because of the largely opportunistic sampling approach that defines most of the western pond turtle surveys, the proportion of western pond turtle sites that occur on private versus public ownership in Oregon is unknown. What is clear from the survey data is that there is a need and many opportunities for public agencies, watershed councils, and private landowners to develop and implement conservation actions for this species. Evaluation of the relative importance of threats and management approaches and considerations will need to consider the complex land ownership underlying the western pond turtle’s range in Oregon.

Threats

Loss of Habitat—

A substantial amount of aquatic and adjacent terrestrial habitat has been lost since major development and flood control has been implemented throughout many parts of the range of western pond turtles in Oregon. The loss of wetlands (Taft and Haig 2003) and especially small channels and oxbow lakes, has reduced the extent of aquatic habitat for western pond turtles considerably. Because of these large-scale changes to the western pond turtles' habitat, habitat loss is considered one of the greatest threats to the conservation of western pond turtles in Oregon. Loss of deep pools from streams due to sedimentation and loss of large structure such as woody debris may have reduced aquatic habitat following timber harvest (Todd 1999:44). Western pond turtles have shown remarkable adaptability to human-made aquatic systems, even occurring in water-treatment ponds and flooded gravel pits. This adaptability may partially mitigate the loss and degradation of the wetland ecosystems in the Willamette and Klamath Basins, although the extent to which adaptability can offset natural habitat loss is unknown. Most of the loss and degradation of aquatic habitats have occurred on private land as those areas were developed for agriculture and urban uses.

Reduced availability of suitable nest habitat adjacent to the turtle's aquatic habitat is a major threat in some areas. Loss of nest habitat likely resulted from flood control by reducing the extent and frequency of floods that provided ephemeral open areas near aquatic habitat. This is particularly true on private lands within the Willamette Basin which are mostly now in agriculture, which also directly contributed to loss of nest habitat. Another and more manageable threat is loss of nest habitat due to invasive plants that form dense mats or shade such as Himalayan blackberry (*Rubus armeniacus* or *R. discolor*) and reed canary grass (*Phalaris arundinacea*). 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.

Loss of terrestrial habitat is also due to land use zoning and planning regulations. Aquatic habitats have more protection under state and federal laws; upland habitats are more subject to development pressure and conversion to other uses. Sunny, well-drained soils upslope from rivers and creeks that are suitable nesting and overwinter areas for western pond turtles continue to be impacted by residential and agricultural development, particularly within the Willamette Basin.

There is concern over loss of aquatic rearing habitat for hatchlings, and this remains an unquantifiable threat until habitat relationships of hatchlings are better understood. For example, Hardin (1993:24) found few juvenile pond turtles or other evidence of recruitment at a reservoir in the West Cascades ecoregion, and believed that the lack of habitat for juvenile and hatchlings was responsible.

Elevated Nest and Hatchling Predation—

One of the most-cited reasons for declining western pond turtle populations throughout their range is the lack of juvenile recruitment due to elevated nest and hatchling predation. Introduced fish and bullfrogs are often considered major culprits although evidence is lacking to support this. Predation on nests is believed to be elevated in developed areas because of greater abundance of raccoons and skunks than would have been present historically, but there has been little quantification of these threats other than documentation that they are indeed some of the most common nest predators. Reducing nest predation has been a major focus of management activities for western pond turtles in Oregon. Several land-management agencies have protected nests from predators by installation of exclosures. Assessment of whether predation pressure on nests is affecting population viability might help when evaluating the best allocation of resources among different management options (see *Section VI, Inventory, Monitoring and Research Opportunities: Research*). Until our understanding of nest and hatchling predation is improved, elevated rates remain a potential threat to western pond turtles.

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 terrestrial and aquatic habitats. Road mortality has been cited as a cause of decline of populations of freshwater turtles (Fowle 1996, Gibbs and Shriver 2002, Griffen 2005, Steen et al. 2006), and is considered to be a major mortality factor, particularly for adult females due to their seasonal movements to nest (Gibbs and Steen 2005, Andrews et al. 2008).

For example, a study on western painted turtles in Montana determined a mortality rate of 28.5 turtles/km of road (Fowle 1996). Like most semi-aquatic turtles, females have greater overland movements than males because of the time and distance required to find suitable nest sites. Holland (1994) speculated that the annual loss due to automobiles may reach 3-5% of the population in the Willamette Valley. Although this estimate is not data-based, the potential for an important population consequence of road mortality is evident. The additive mortality that results from vehicles has been associated with turtle declines in North America, and may be affecting population viability in some areas (Gibbs and Shriver 2002).

Despite the importance of road mortality to the conservation of freshwater turtles (Andrews et al. 2008), we are unaware of assessments of road mortality on western pond turtles other than numerous reports of individual turtles found killed on or alongside of roads. Horn (2001) located a crushed turtle on a road in Douglas County during 1999. In Eugene, Oregon numerous reports of road mortality have been reported (Holland (1994:7-30), L. Holts, City of Eugene, unpubl. data). Several turtles have been struck and killed at a specific location on a dike road on Sauvie Island (S. Beilke, ODFW, pers. commun.). Presumably impacts of roads on mortality and connectivity are a greater issue where road networks are dense near large turtle populations. This may be true in many areas in the Willamette Basin (e.g., Galen 1994). Roads often bisect nesting habitat near streams, forcing turtles to cross the road to reach suitable nesting habitat. Because of high anticipated human population growth in the Willamette Valley, road mortality and reduced connectivity between aquatic and upland habitats and among populations is likely to increase as a threat to the persistence of western pond turtles in some areas.

Despite the lack of formal assessments, road mortality may be a primary threat to western pond turtles in Oregon, particularly in areas where wetlands are surrounded by roads.

Collection and Releases—

Collecting for the pet trade and human consumption has been an important factor in the decline of many turtle species worldwide (Moll and Moll 2000, Ernst and Lovich 2009). Harvesting of western pond turtles for human consumption may still occur, but if so, to a much lesser extent and in limited geographic areas, and is probably related to the cultural practices of some ethnic groups. Historically, collecting for human consumption likely affected the distribution and abundance of western pond turtles. Storer (1930) reports on large numbers of western pond turtle being sold in the San Francisco market for human consumption. Although Oregon's other native turtle species, the western painted turtle, has been collected commercially for the pet trade (Gervais et al. 2009), we are not aware of any evidence that this has occurred for the western pond turtle. However, collection of western pond turtles by individuals for pets does still occur (e.g., examples in newspaper articles: http://www.lagrandeobserver.com/Features/Outdoor/Recreation/Turtles-Humans-good-intentions-can-harm-the-cute-creatures). Western pond turtles have also been removed for management purposes. During the 1990s, hatchling and young turtles were removed from the wild for the "head start" program that existed in Oregon. In some cases, young turtles that were found through other management and research efforts were removed from the wild and placed into the head start program (e.g., Hardin 1993, Holte 1998). Because of the restricted effort, both geographically and numerically, removal of these turtles may not have had a measureable long-term effect on population dynamics.

The pet trade also threatens native freshwater turtles through the release of non-native pet turtles into natural areas. This practice could increase competition for limited resources and introduce diseases to native turtles. The threat posed by introduced turtle species is growing as the number of new releases into the wild is presumably increasing with access to western pond turtle habitat from urban growth and increased access to recreational areas. There are at least 15 species known to have been introduced into the range of the western pond turtle (Bury 2008). The red-eared slider and common snapper are the most common introduced turtle species in Oregon. They are known to successfully reproduce in Oregon's waterways and have become invasive in many aquatic habitats.

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 (Barnes 2009), probably due in part 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 (Barnes 2009). They have been collected in the following areas: Eugene / Springfield, Lebanon, and Corvallis (Willamette River); 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 trapping snapping turtles at a specific pond within the City of Beaverton to learn more about snapping turtles in Oregon. Between 2004 and 2009, 66 snapping turtles have been captured and removed from the pond and multiple nests with eggs have been dug up and removed (S. Barnes, unpublished data).

Red-eared sliders

Red-eared sliders are perhaps the most globally distributed freshwater turtle due to introductions from the pet trade. This species is also classified as Nonnative Prohibited Wildlife by Oregon state law (OAR 635-056) and is considered an invasive species. In Oregon, red-eared sliders are much more common and more widely established than common snapping turtles. Currently, sliders are distributed throughout the Willamette Basin particularly in or near urban areas. Although sliders have established breeding populations, cool water appears to limit breeding in some sites (C. Yee, pers. obs.). Pet stores and people began mass "dumping" of sliders following the prohibited classification (C. Yee, pers. obs.). Sliders often co-occur with western pond turtles (Spinks et al. 2003, Bury 2008) and are found in many sites in Oregon with western pond turtles (Rombough 2007). Where sliders co-occur with western pond turtles, they are often far more numerous than the native species (C. Yee, pers. obs.). Reports of sightings of red-eared sliders have increased, 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 of farm-raised hatchlings still occurs as highlighted by recent law enforcement confiscations (S. Barnes, pers. obs.). 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, are known to have escaped from their owners (C. Puchy, City of Portland, pers. comm.).

Recreation Disturbance—

Disturbance by human recreation may have been responsible for population declines of freshwater turtles in some areas (Garber and Burger 1995, Mitchell and Klemens 2000). Semi-aquatic turtles are very sensitive to disturbance when basking and nesting (Moll 1974, Mitchell and Klemens 2000). This may have important implications for thermoregulation and consequently digestion and other metabolic processes in sites with heavy disturbance.

Because of the broader distribution of western pond turtles than western painted turtles in areas away from human population centers, the potential for recreational impacts on western pond turtles is not as great as Gervais et al. (2009) described for western painted turtles in Oregon. However, there are a sufficient number of aquatic systems that are used for recreation such that these activities could negatively affect western pond turtles. The primary areas that would be affected would be near urban areas and in high-use aquatic recreation areas (Hardin 1993). For example, in Eugene, Oregon, trails used by many people for hiking, bicycling, and dog walking are adjacent to aquatic habitats occupied by western pond turtles (L. Holts, pers. obs). In Fern Ridge, Lookout, and Fall Creek reservoirs, recreationists use areas for swimming, boating, and fishing that are occupied by western pond turtles (e.g., Hardin 1993). Hardin (1993) expressed concerns over recreation effects including boating, fishing, and swimming in reservoirs with turtles, especially near areas with campgrounds, because these areas not only attracted large numbers of people, but were also coincident with the shallow and protected areas used by turtles. Holland (1993:15) emphasized the potential for impacts to western pond turtles from recreational use of the Umpqua River on US Forest Service Lands as recreation sites are developed.

Trails are an important issue because they are planned for many natural areas in urban centers, such as the Portland metropolitan region (S. Bielke, ODFW, pers. comm., July 2009). In some counties, trails are often allowed within areas designated as riparian buffers (S Bielke, ODFW, pers. comm., July 2009). In some areas, these trails will likely negatively impact native turtles. 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. Bielke, ODFW, pers. comm., July 2009).

Native turtles in Oregon are known to get caught by fisherman using bait (Croghan 1983, Hays et al. 1999, Horn 2000, S. Barnes, pers. obs.). Holland (1991) estimated that 3.6% of the turtles captured at a site in Oregon had evidence of fishing trauma.

Other Threats—

Isolation and Fragmentation

Isolation and subsequent fragmentation of populations is one of the most-cited threats to biodiversity worldwide, and is relevant to western pond turtle conservation. Little is known about the dispersal abilities of western pond turtles. However, their broad distribution in aquatic environments in western Oregon suggests that isolation may not be a primary concern in many parts of its range in Oregon. Anecdotal data on movements demonstrates western pond turtles can move over what were once considered barriers, including maneuvering around large dam systems (Thaut 1994). However, because of urbanization in many areas with western pond turtles, isolation and fragmentation of these more urban populations remains a threat.

An important consideration, however, is whether or not increased connectivity is of conservation value in areas where non-native turtles may potentially use that connectivity to expand into new habitat. Recently, Fausch et al. (2009) developed a conceptual model that evaluated the tradeoffs of connectivity and invasion risk. This is a relevant issue to consider in evaluating threats due to isolation of western pond turtles, especially near urban centers where non-native turtles may be released more frequently.

Research/Survey Disturbance

Effects on wildlife from research and management activities are often not considered when assessing threats to populations. Although research, survey, and management effects may be minimal in any given time or place, they may be important population-wide, especially over time. We raise this issue as a threat because it may be particularly relevant for some western pond turtle populations, particularly those that are on public lands for which management interest exists. For example, nest searches have been conducted in some areas in order to locate nests and protect them. The effect of repeated visits to locate nests on nest predation and effects on the turtles themselves is unknown but may be harmful. The assumption is that the benefit from protecting nests is greater than the influence of the disturbance. Studies involving radio telemetry provide another example to consider for effects of research disturbance. For example, a series of studies was conducted to identify movement patterns, nest areas, and over-winter sites at several large reservoirs in Oregon, and several of these studies reported death or other harm to turtles soon after trapping (e.g., Beal 1993, Hardin 1993, Leatham 1994).

Illegal Shooting

In some areas, there have been reports of native turtles in Oregon being shot illegally (Elling 1966, Croghan 1983). How frequently this occurs is unknown.

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 or to meet required water quality standards. Although these efforts have improved water quality and restored fish habitat, these efforts can destroy or prevent the development of open habitats that provide turtle nesting habitat as well as sunny areas within the stream environment to allow for foraging and basking. Greater recognition of the value of these habitat features will be helpful.

Contaminants

Western pond turtles live in many aquatic environments that are known to have high levels of contaminants, including major rivers through urban centers (e.g., Willamette River), and impoundments such as waste water treatment ponds and effluent ponds from lumber mill operations. It is expected that freshwater turtles would bioaccumulate aquatic contaminants because they consume animal matter including vertebrates, and they are long-lived. The only published study on western pond turtles and contaminant levels that we are aware of was conducted on a set of eggs from western pond turtle nests from Fern Ridge Reservoir, in the Willamette Basin near Eugene, OR (Henny et al. 2003). A large number of contaminants were found in the eggs, including organochlorines, PCBs, and metals. However, Henny and colleagues (2003) did not find a relationship between egg hatchability and contaminant levels. Hatchability is only one potential endpoint of concern; contaminants may interfere with proper sexual development, immune function, or survival of hatchlings. There is potential for contaminants to affect the population dynamics of western pond turtles, particularly in areas subject to high contaminant loads. Other samples were taken for contaminant evaluation from Finley National Wildlife Refuge, but analyses and results were not included in the single report we found (Brunkel 1998).

Broad-scale insecticide use to reduce mosquito larvae in wetland areas that contain western pond turtles may reduce invertebrate prey, although label restrictions on the pesticide products are designed to reduce that risk. In addition, herbicide use for aquatic invasive plants may alter the availability of cover and basking sites especially for very small turtles. No information was found detailing either of these potential threats. The greatest threat from herbicide used to treat invasive aquatic plants is likely associated with the immediate loss of vegetative cover suitable for hatchling, juvenile, and adult turtles. A potentially useful role for herbicide use is in maintaining sparse vegetation in nest areas.

Toxic spills on roadways adjacent to aquatic habitat present another risk of contaminants. The effects will likely be acute but localized. Todd (1999) reviewed contaminant spills throughout the western pond turtle's range and reported two spills that were known to have killed western pond turtles. In one case in California, diesel fuel contaminated a creek after a train derailment (Bury 1972, reported in Todd [1999]). In a similar case in southern Oregon, a train derailed and spilled over 6,000 gallons of diesel fuel (USFW 1993b).

Agricultural and Vegetation Management Activities

Western pond turtles can be negatively affected by agricultural activities. This is primarily during the nesting season because of the proximity of much of their aquatic habitat to agricultural land in the Willamette Valley and their selection for sparse vegetation in which to nest. Agricultural activities can result in nest destruction and mortality to adult female freshwater turtles (Gervais et al. 2009). Mowing of road right-of-ways and fields adjacent to waterways has resulted in mortality to adult turtles (L. Holts, pers. obs.). The extent of this problem for western pond turtles is unknown, but exercises in mapping their locations (actual or based on a habitat model) with land use activities would be useful to identify areas of concern. Management solutions might include mowing at times that do not coincide with nesting.

Disease

Little is understood about disease in freshwater turtles regarding pathogens, transmission, and resistance (Flanagan 2000). We are aware of only two reports of disease outbreaks in western pond turtles, one in southern Washington (Hayes et al. 1999) and the other in southern Oregon (Todd 1999). Hayes et al. (1999) reported an outbreak in 1990 of what was believed to be a pathogen (possibly a virus or mycoplasma) causing a syndrome similar to upper respiratory disease; approximately one-third of the population was killed. In southern Oregon Todd (1999) reported on an unknown disease that potentially killed 24 turtles. Introductions of pet turtles, release of captive-reared turtles, and translocations from one location to another may increase the risk of disease transmission. This is presumed to occur with other turtles (Flanagan 2000). Other activities that include trapping and handling turtles, and moving potentially contaminated material from one population to another, increase the risk of disease transmission. This is another reason for minimizing handling of native turtles (see above, *Research/Survey Disturbance*).

Climate Change

Climate change will cause major perturbations in environmental conditions for many organisms. For freshwater turtles, water temperature is likely a factor limiting distributions. Consequently, 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, which could also impact freshwater turtles considerably. Climate change in the Willamette Valley will change the distribution of suitable habitat for western pond turtles. We do not address this risk further in this assessment other than to note its importance for long-term conservation planning. The direct and indirect effects of climate change on freshwater turtles are important to consider, although predictions for effects are in their infancy (Ernst and Lovich 2009:27).

Conservation Status

The western pond turtle is considered a sensitive species and a species of conservation concern by most public agencies in Oregon primarily because of the considerable degradation and loss of wetland habitats within the state, and the presumed unsustainably high level of nest and hatchling depredation. A suite of threats are relevant to the conservation of this species (see *Threats*, above). The vulnerability of western pond turtles is largely due to the numerous threats that will increase as the human population of western Oregon increases. The assessment of the vulnerability of this species in Oregon is partly dependent on understanding the level of connectivity among existing populations, whether recruitment of juveniles into breeding adults is sufficient for population viability, and how future modifications to the landscape in western Oregon will affect populations. The turtles' broad distribution, including occupancy of human-modified environments and areas of high turtle density, provide many opportunities for effective management.

Because of the concern over the conservation of western pond turtles throughout their range, a petition to list the species under the Endangered Species Act was filed in 1992, although it was later denied by the U.S. Fish and Wildlife Service (USFWS 1993a). The U.S. Fish and Wildlife Service denied the petition in part due to the species' broad distribution and its apparent ability to survive and reproduce in many human-modified environments. The USFWS (1993a) also cited the lack of evidence supporting the listing petition's claims of broad-scale threats, primarily the lack of juvenile recruitment due to elevated nest and hatchling predation. Much of the rationale for denying the petition, including broad distribution, occurrence in human-modified habitats, and lack of supporting data for hypothesized threats, remains unchanged. However all of the evidence to date suggests that local declines are occurring in parts of its range in Oregon. The species remains vulnerable due to the many threats to a long-lived species that requires both aquatic and upland habitats, and that occupies areas that are quickly becoming urbanized with further large-scale development expected in the near future.

Known Management Approaches

Despite the keen interest in conservation of western pond turtles, reports on the success or failure of management approaches are limited. Effectiveness monitoring and reporting the result of management actions would add considerably to our ability to provide useful guidelines for management.

The work by Washington Department of Fish and Wildlife demonstrates that "head start" turtles, young turtles that were raised in captivity until a size deemed sufficient to minimize predation was reached, can increase recruitment in at least some situations (Vander Haegen et al. 2009). Other management approaches that have been used include creating nest habitat and protecting nests from predation by installing nest exclosures. Although we are unaware of any formal assessments of these management approaches, these actions indicate success in some cases (R. Swift, pers. obs., L. Holts, pers. obs.). With regard to protecting nests, there is no question that predation can be reduced by installing nest exclosures, but how this ultimately affects recruitment is not known, nor is it established that nest success is limiting populations. Abundant examples also exist of maintaining nest habitat by mechanical removal of woody species and thinning dense grass and forbs. Nesting areas have been maintained in this manner as shown by their continued use (R. Swift, pers. obs.). There are many opportunities for improving aquatic habitat; however, the only approach that we are aware has been used by managers has been the installation of basking structures. Although the effect of introduced turtle species on western pond turtles has not been quantified, there have been several management efforts to remove red-eared sliders and common snapping turtles from aquatic habitats in Oregon. Efforts to remove non-native turtles through hand-capture and trapping using baited and basking traps demonstrated that removal is possible, at least in small areas if further releases do not occur (Rombough 2007, Barnes 2009).

Non-juvenile translocation may be useful for expanding the population back into areas it has been extirpated from (Reinert 1991). Studies on the viability of this technique for western pond turtles are limited, but Holland (1994) translocated 28 non-juveniles in Douglas County during 1992. In 1999, Horn (2001) documented a population estimate of 25, and at least 5 of the turtles appeared to have been hatched at the site. This indicates that many of the non-juveniles remained at the site and reproduced. The use of translocation is controversial and should only be considered after careful evaluation of the situation and long-term need. Given the broad distribution of western pond turtles in Oregon, natural dispersal is likely to fulfill colonization of suitable unoccupied habitat if it is accessible.

Limited juvenile recruitment is often stated as the cause for declines for western pond turtles, and is the motivation for head-start programs and nest protection efforts (e.g., Holte 1998, Hayes et al. 1999). If juvenile recruitment is limiting the population and a cause of declines, then head-starting or translocation may be useful short-term tools (Hays et al. 1999; but see Moll and Moll 2000 and references cited therein for caution on this approach). This approach has been used in Washington (Hays et al. 1999), California (Spinks et al. 2003), and Oregon (e.g., Holte 1998); however, it is not currently permitted in Oregon (P. Boulay, ODFW, pers. comm.). There is concern over using captive-raised western pond turtles to aid recruitment in Oregon for several reasons. First, productivity information to ascertain whether the measure really is necessary to maintain a healthy population is lacking. Second, the practice ensures the survival of most or all of the individuals from selected nests, including those from nests that would have otherwise failed. This practice can artificially alter the selective forces that would otherwise ensure that, presumably, the most genetically fit individuals survive. Third, we know little to nothing about the genetic variability of western pond turtle populations and how it may be altered by moving individuals within the range. Finally, there remains the potential for the spread of pathogens from captive-reared individuals to wild populations.

Head-starting does remain a potential management tool should the need arise. The introduction of captive-raised or translocated juvenile turtles has been shown to increase the number of turtles (Spinks et al. 2003, Campbell et al. 2006), or initiate new populations (Vander Haegen et al. 2009). It is not known, however, if recruitment was limited in these cases because of hatchling depredation or lack of high-quality habitat, or other factors that limited recruitment. The long-term success for natural recruitment depends on reversing the conditions that led to the recruitment problem in the first place. Understanding the magnitude and the cause of lack of recruitment where it exists will be critical for long term conservation of the western pond turtle. An important focus for linking future research and management is the exploration of nest and hatchling depredation (see *Section VI, Inventory, Monitoring, and Research Opportunities: Research*).

Management Considerations

The ultimate goal for conservation of the western pond turtle is long-term persistence throughout its historic range. Because of the broad distribution and diversity of aquatic habitats that it occupies, this is a feasible goal. Specific distribution and population objectives have not been identified. Development of these objectives will be critical in establishing site-specific management considerations.

One of the first management considerations regarding conservation of western pond turtles in Oregon is the pattern of land ownership. Because of the western pond turtle's broad distribution in western Oregon, the species occurs on lands managed by many jurisdictional levels (City, County, State, and Federal), as well as large areas of private ownership. Another important consideration is that because both aquatic and upland habitats are required by western pond turtles, management by more than one public agency or landowner is likely to affect local populations, and even individual turtles. Thus, one of the most important general considerations is the coordination of management actions. A good example of the importance of such coordination is with turtles occupying reservoirs in the Willamette Basin that are managed by US Army Corps of Engineers and surrounded by upland areas managed by US Forest Service such as the Fall Creek, Lookout, and Hills Creek reservoirs (Hardin 1993, Ryan 1998, Ryan 2002).

Management actions that result in increasing habitat suitability, increasing recruitment into the breeding population, providing connectivity among populations, and reducing loss of adults through mortality and illegal removal of turtles by the public will contribute to conservation of western pond turtles. Below, we summarize general recommendations for management actions for each threat listed above for which research or management provides clear guidance. These recommendations are aided in part from Hays and colleagues (1999), Adamus (2003), the Oregon Native Turtle Forum 2009 held at the Oregon Zoo (http://www.oregonturtles.com/ and the Northwest Native Turtle Conservation Plan Outline (Native Turtle Working Group 2008). These recommendations are relevant to all land ownership categories, but are most easily applied to lands in public ownership.

Based on our synthesis of the species ecology and management efforts by public agencies, we provide general guidelines for management of western pond turtles in Oregon as a first step in developing both range-wide and site-specific management plans. To be most successful, actions intended to reduce threats to western pond turtles should be site specific and tailored to the management agency or private landowner.

Loss of Habitat—

From the large number of site-specific studies on nest site selection and over-winter habitat selection as well as observations of abundance in different aquatic habitats, we have a good understanding of habitat requirements for adults. Our understanding of habitat requirements for hatchlings and young juveniles is tentative.

- Maintain and increase deep pools in streams
- Provide shallow water habitats with abundant aquatic vegetation for hatchling rearing habitat
- On southern exposures, provide sparse vegetation structure adjacent to aquatic habitat for nesting within 200 m of aquatic habitat; remove all woody plants in designated nesting areas if appropriate
- Provide open fields or open woodlands within 200 m of stream and river habitats for over-wintering
- Consider juxtaposition of management actions in terrestrial and aquatic habitat in relation to roads and recreation uses to minimize negative effects

Elevated Nest and Hatchling Predation—

If elevated nest and/or hatchling predation are the reason for declines, several management actions should be considered:

- Locate and protect nests in key conservation areas using nest exclosures
- After determining primary species causing elevated predation and after evaluating the ability to modify their rate of predation of nests and/or hatchlings, initiate a predator control program if appropriate and feasible for the long-term
- Increase area of nest habitat to (1) potentially (i.e., if nest habitat is limiting) increase the total number of hatchlings by increasing number of females nesting, and (2) reduce nest density to potentially reduce predation rate

Road Mortality—

Consider wildlife under-crossings in turtle high-use areas that are bisected by busy roads particularly during spring and early summer (Gervais et al. 2009). These high-risk areas are likely to occur most frequently in urban and recreational areas. Other methods to reduce road mortality include: (1) avoid building roads in western pond turtle use areas, (2) discourage movement between aquatic and terrestrial habitats that are bisected by roads by reducing the quality of nest habitat in high risk areas and improving nest areas near aquatic habitats that are not bisected by roads, (3) use fencing to direct turtles away from existing roads, and (4) consider educational tools to alert drivers to the presence of turtles in the roadways.

Collection and Releases—

Until the affect of non-native species of turtles on western pond turtles is evaluated, introduced species of turtles should be removed from aquatic and terrestrial habitats, although this will be a difficult task because of their widespread distribution. Several methods have recently been tested to find the most efficient approach to remove common snapping turtles (Barnes 2009). It will also be important to identify methods to stop new introductions. Educational materials produced in various languages, as appropriate for the specific area, that discuss introductions of non-native turtles, translocations of native turtles, and removal/collection of native turtles are crucial to lessening the frequency of these illegal, though often well-intended, activities by the public.

Recreation Disturbance—

- Reduce human disturbance in areas where human traffic may impede or prohibit use of suitable habitats by turtles
- Identify turtle use areas that are at risk from fishing activities and take appropriate actions to reduce or eliminate harm. Actions may include restricting use of bait fishing.
- Consider managing recreational impacts by redirecting areas used for recreational use away from turtle use areas as appropriate.
- Development of regionally accepted buffer areas would be useful to minimize impacts from trail use. Any activity by people or pets within line-of-sight to turtles or their nesting habitat can cause disturbance. Determining critical distances in various environments would facilitate management of these disturbances
- Use vegetation to obstruct line-of-sight disturbances where feasible

Research/Survey Disturbance—

Research and survey disturbance can be minimized by incorporating results from previously conducted research rather than initiating site-specific studies for topics that have already been sufficiently addressed. This includes nest and overwinter habitat selection, within-home-range movement patterns (particularly to nest and over-winter sites), and distances moved within aquatic and terrestrial systems. There have been a large number of studies in western Oregon that have addressed these topics, almost all of which remain unpublished. These studies provide ample management guidelines and ability to predict site-specific outcomes for management without further research efforts. Results from these studies provide a great starting point for adaptive management. We suggest that rather than implementing studies whose inference will be limited to a single study site and time period, future research should take an approach that will allow generalization through time and across locations to maximize the benefit gained against the disturbance the research may cause. As much as possible, existing information should be used to guide management, rather than relying on additional studies on topics that have been well explored.

Agricultural and Vegetation Management Activities—

Mapping turtle use areas, either actual or based on a habitat model, with overlays of land use activities would be useful to identify areas of concern. Vegetation clearing (mowing, discing) can be timed to avoid nesting.

Illegal Shooting –

The frequency of illegal shooting 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 considered a problem in a given area. Illegal shooting should be considered when installing basking structure so as to minimize potential harm from illegal shooting as well as from other human disturbances.

Section Summary

One of the challenges and opportunities for conservation of the western pond turtle in Oregon is the diversity of land ownership in areas occupied by the species. Land allocation is region specific, a fact that conservation planning will need to recognize. Conservation will be most effective under interagency collaboration with private landowners. One of the prime conservation concerns is the loss and degradation of wetland and adjacent habitats. Low recruitment of juveniles as a result of nest and hatchling predation is a concern that needs to be evaluated. Elevated mortality of adults, particularly females, from road mortality is an increasing threat to population viability especially in urban areas. Releases of non-native pet turtles into aquatic and terrestrial habitats are a growing threat and may result in increased competition and disease transmission. Recreational use within both aquatic and terrestrial habitats will affect the turtles' behavior which may cause harm in some cases. Further, illegal shooting and accidental catch of turtles while fishing results in elevated mortality. Research and survey work can affect western pond turtles and we argue for more use of existing knowledge and careful evaluation on what information new site-specific research would bring to managers before initiating site-specific research. 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 pond turtles in Oregon. Effectiveness monitoring and reporting the result of management actions would add considerably to our ability to provide useful guidelines for management.

VI. INVENTORY, MONITORING, AND RESEARCH OPPORTUNITIES

Data and Information Gaps

A long list of data and information gaps is possible with any vertebrate species, and the western pond turtle is no exception. Here, we summarize what we consider to be the most important gaps in our understanding of western pond turtles in Oregon that are relevant for management. We believe by addressing these data and information gaps through thoughtful monitoring, research, and adaptive management, more effective conservation of western pond turtles can be achieved.

- Distribution and abundance patterns in relation to land allocation and existing conservation areas
- Distribution and habitat associations of high-density turtle areas
- Habitat associations that allow 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
- Trade-offs of improving nest habitat versus protecting nests
- Effects of bullfrogs and bass on hatchling survival
- Sustainable levels of nest and hatchling predation
- Location records in the Klamath Basin need to be added to databases; evaluate data gaps with local experts.

Limitations of Inventory and Monitoring Efforts

The western pond turtle, despite its visibility when basking, is actually a difficult species to survey and monitor in a reliable manner. The species is very shy and wary, as described by many naturalists and researchers. Storer (1930:431) said it clearly: "… [it] takes refuge below the surface at the first hint of danger". In many aquatic habitats, it is difficult for an observer to approach without causing the turtles to retreat from basking logs where they are readily observable, as those conducting surveys have pointed out (e.g., Moehl 1994, Reams 1999). Observations, both visual and from capture, demonstrate the sensitivity of turtles to environmental conditions (Todd 1999, Horn 2001). This makes assumptions about similar detection rates through space, time, and among observers unlikely, making comparisons of survey results problematic (e.g., Williams et al. 2001).

Because of the interest in evaluating population stability and identifying areas for conservation, there have been a large number of efforts to survey this species on private and public lands (Table 1). There are two primary methods of surveys, trapping and visual surveys. It has been postulated that visual surveys may not be valid in determining relative abundance, and that trapping surveys are more reliable. Horn (2001) concluded that the maximum number of turtles observed during any of six replications of visual surveys at three sites ranged from 40.3 % to 53.5% when compared to population estimates from captures. Much effort has gone into establishing standardized protocols to allow comparisons across space and time. There have been a series of protocols that have been developed in Oregon, and currently, the most commonly used approach is that of Barkhurst et al. (1997) which was updated by Bury et al. (2001). This protocol was evaluated for its reliability in estimating the occurrence and relative abundance of western pond turtles using visual surveys in the Umpqua drainage (Horn 1998, 2000, 2001). Horn (2001) found the protocols to be effective but recommended changes to the methodology to allow greater detection of pond turtles in certain habitats and to broaden the period of sampling during the year.

Although efforts are underway to prepare an improved protocol (B. Bury, USGS, pers. comm.), standardized protocols using count data from either trapping or visual surveys will be limited in their rigor due to factors that affect the detection of turtles in a broad array of habitats and conditions. This is true for many animal populations (e.g., Williams et al. 2001), but particularly those that have low detection probabilities that vary due to many factors, as is true with western pond turtles. For this reason, general methods have been developed for estimating detection probabilities rather than assuming a detection probability of 1.0 (i.e., certain detection if present). The estimates of detection probabilities are incorporated into estimates of occupancy or abundance (e. g, Williams et al. 2001). Efficient survey methods for estimating either occupancy or abundance of western pond turtles will need to incorporate this approach in future survey efforts if the goal is to provide reliable indicators of these parameters. These methods also would facilitate linking habitat data to survey results.

Additional survey and monitoring work will likely be most useful to conservation if focused on particular management actions, or hypotheses of effects of threats or management, rather than broad-scale monitoring to evaluate changes in population size (Nichols and Williams 2006). 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 western pond turtles. A probability-based method for selecting survey sites and incorporation of these methods into existing survey protocols would be an important first step in making inferences from the survey data.

Because of the concern over lack of juvenile recruitment based on detections primarily of adults during survey efforts, opportunities exist for developing methodology to detect younger turtles in a manner that allows inference on population age ratios.

Existing Data from Inventory and Monitoring

There are a large number of surveys that have been conducted for western pond turtles throughout western Oregon (Table 1). Distribution of western pond turtles in Oregon is sufficient to provide a good understanding of broad patterns. However, there are a large number of location records of western pond turtles from previous survey efforts that have not been incorporated into existing databases such as the ORNHIC database. Furthermore, many of the records that do exist in databases are incomplete and would benefit from a careful review of date of observation and accuracy of location. To make the best use of existing data, the missing and existing records could be compiled into a searchable database, perhaps administered by ORNHIC. However, the limitations of these data should be recognized. Most of the location data are unlikely to be useful for monitoring changes in population size because of the opportunistic sampling regardless of any use of an established protocol. Further, only sites where turtles were detected have been entered into the database, with the exception of Horn's (1998, 2000, 2001) surveys in the Umpqua basin. However, the database 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 pond turtles. The data would also be helpful in developing sampling strategies for future monitoring and research efforts.

Research

Research opportunities that are most likely to contribute to the conservation of western pond 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 western pond turtles in Oregon, we believe the following are critical research needs.

1. Elevated nest and hatchling predation. We emphasize research on nest and hatchling survival as the highest research priority because of the purported lack of recruitment and because these stages in the life-cycle have not received attention due to the difficulty in their study. Furthermore, there are existing management efforts to either reduce predation by installing nest exclosures and predator removal and increase hatchling survival by captive rearing, or the "head-start" programs such as has been conducted in Washington (Hays et al. 1999). Specifically, research to evaluate threats to nest and hatchling survival is needed. Research on the role of bullfrog and bass on nestling survival is needed because so much management is based on the belief that predation by these species are a primary cause of population declines of western pond turtles. Before research on hatchlings can be productive, methods to study hatchlings needs to be developed. An initial pilot study is underway (D. Rosenberg, June 2009, Oregon Wildlife Institute). To make appropriate inferences on the influence of nest and hatchling predation to population dynamics, development of population models to evaluate sensitivity to various changes in demographic rates would be useful.

2. Habitat relationships and development of habitat suitability maps. Nest and overwinter habitat relationship studies have been conducted throughout the species' range and provide sufficient understanding to aid management. The next step is to understand aquatic habitat selection, habitat relationships for hatchling and juveniles, and how the juxtaposition of aquatic habitat, terrestrial habitat, and rearing habitat affects distribution and abundance of western pond turtles. Studies are needed to quantify risks posed by road networks. Understanding factors that are contributing to high density turtle areas would be particularly useful. Ultimately, development of a model to map habitat suitability across the species' range would be a very useful management tool. Surveys conducted in the Umpqua Basin (Horn 1999, 2000, 2001) were the only ones that we are aware of that used a probabilistic sampling design and this study may provide data that can contribute to habitat modeling. At a minimum, developing a habitat model from these data would be a useful pilot study to a larger scale project.

3. Connectivity of populations. There has been a plethora of studies evaluating movement patterns within the home-range of western pond turtles in Oregon, but research on dispersal, and factors affecting population connectivity are entirely lacking. Research using telemetry methods to track individuals to assess dispersal or evaluate connectivity for western pond turtles has been ineffective. Using a hypothesis-driven approach to ask questions about connectivity using recent advances in landscape genetics (e.g., Schwartz, in press) may lead to a better understanding of movement patterns and factors that may be facilitating or impeding movement across populations.

4. Incorporating adaptive management as part of research and monitoring efforts. Adaptive management approaches are needed to improve aquatic and terrestrial habitat throughout the species range. Carefully guided management can be linked to effectiveness monitoring to assess turtles' response to modified habitat. We recommend this approach rather than continued survey efforts without a hypothesis/management-driven direction.

5. Develop population models to evaluate management actions. Understanding how western pond turtles are vulnerable to changing land use practices, increased human presence, and risks of invasion either by exotic turtles or pathogens will offer managers the ability to evaluate the potential for various management actions to bring about the desired outcome. General models can be used to understand basic threats, whereas site-specific models may be needed to evaluate specific threats such as road expansion or development adjacent to a waterway.

6. Developing effective education on turtle introductions and removal. 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 removal of wild animals. 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.

Section Summary

Inventory and monitoring data for western pond turtles in Oregon 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. Almost all of the inventory and monitoring efforts for western pond turtles have lacked a site-selection strategy that allows reliable comparisons. Inventory and monitoring efforts can be improved in the future through use of probabilistic sampling and explicit consideration of detection probability. Furthermore, to be most useful, survey and monitoring efforts should address hypotheses about response to management or causes of decline. Methods need to be developed to detect and study hatchlings. Existing data can provide some baseline information on range and abundance, particularly to provide context for studies of management action outcomes. Further evaluation of survey methods and recognition of their uses and limitations would be desirable. Research priorities include:

(1) evaluate factors affecting nest and hatchling survival
(2) develop habitat suitability models
(3) develop a greater understanding of landscape connectivity
(4) incorporate adaptive management as part of research and monitoring efforts
(5) develop population models that can be used to evaluate risks
(6) evaluate educational tools to reduce both removal of western pond turtles and introductions of non-native turtles.

VII. DEFINITIONS

The criteria for NatureServe ranks used in this Assessment 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.

3 = Rare, uncommon or threatened, but not immediately imperiled, typically with 21-100 occurrences.

4 = Not rare and apparently secure, but with cause for long-term concern, usually with more than 100 occurrences.

VIII. ACKNOWLEDGMENTS

We thank the Interagency Special Status Sensitive Species Program (ISSSSP) of the U.S. Forest Service and Bureau of Land Management, the U.S. Fish and Wildlife Service, Oregon Department of Fish and Wildlife, City of Portland (BES and Columbia Slough), and Metro for funding. We thank Mark Brown (BLM) for his excellent help in making this work possible. We are grateful for the input and direction provided by Rob Huff and Kelli Van Norman of ISSSSP, and for providing USFS and BLM data and survey protocols. We are indebted to all of the individuals and agencies that provided reports and location data on western pond turtles in Oregon. The Oregon Natural Heritage Information Center shared their state-wide database, and especially Lindsey Koepke (ORNHIC) who assisted us with the database. We also thank the Oregon Department of Fish and Wildlife for conducting and sharing the Citizens Science location information, Nate Pope for data entry and location determination for the Citizen Science database, and Peg Boulay (ODFW) for compiling and sharing reports on western pond turtles. Cheron Ferland (USFS) and Betsy Glenn (OSU) generously helped with GIS. Kat Beal (USACE), Sue Beilke (ODFW), Bruce Bury (USGS), Kim Garner (USFWS), Audrey Hatch (ODFW), Claire Puchy (City of Portland), Elaine Stewart (Metro), and participants at the 2009 Turtle Forum provided fruitful discussions on turtle topics. We thank Hannah Lucas for reviewing the section on nest-site habitat selection, Phillip Spinks for reviewing the taxonomy section, and Rob Huff (ISSSSP), Hope Anderson (BLM), Eric Greenquist (BLM), Glenn Lorton (BLM), Roy Price (BLM), and Theresa Stone (USFS) for constructive reviews of the entire document.

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X. FIGURES

Figure 1a. Distribution of western pond 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, Oregon Department of Fish and Wildlife, and other respondents to our request for location data. Each circle represents records of one or more western pond turtles. Distribution as depicted from these observations is a function of both occupancy by turtles and the survey effort. See Table 2 for summary of sources of location records.

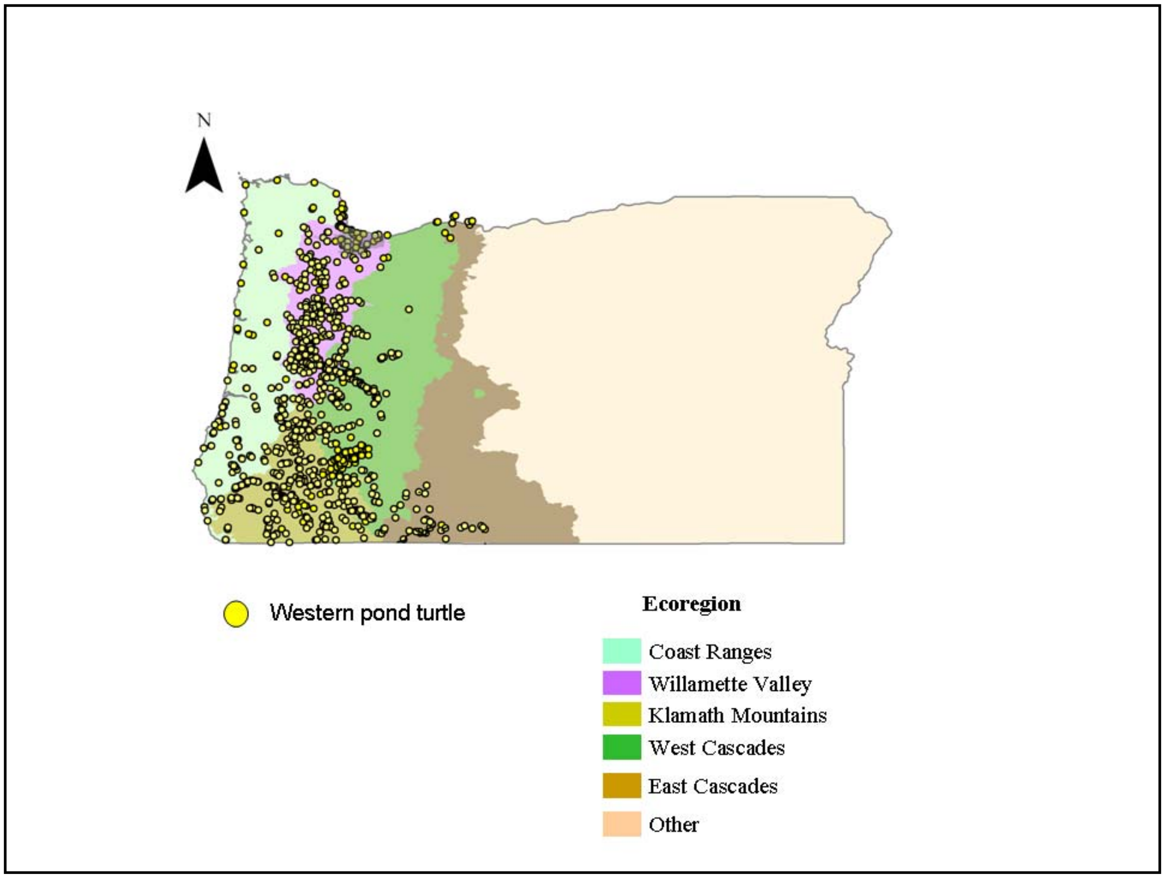

Figure 1b. Distribution of western pond turtle observations among Northwest Forest Plan Physiographic Provinces in Oregon. Location records were obtained from ORNHIC, U.S.D.A. Forest Service, U.S.D.I. Bureau of Land Management, Oregon Department of Fish and Wildlife, and other respondents to our request for location data. Each circle represents records of one or more western pond turtles. Distribution as depicted from these observations is a function of both occupancy by turtles and the survey effort. The eastern portion of the East Cascades Ecoregion was added to the Northwest Forest Plan East Cascades Physiographic Province to include the entire range of the western pond turtle in Oregon. See Table 2 for summary of sources of location records.

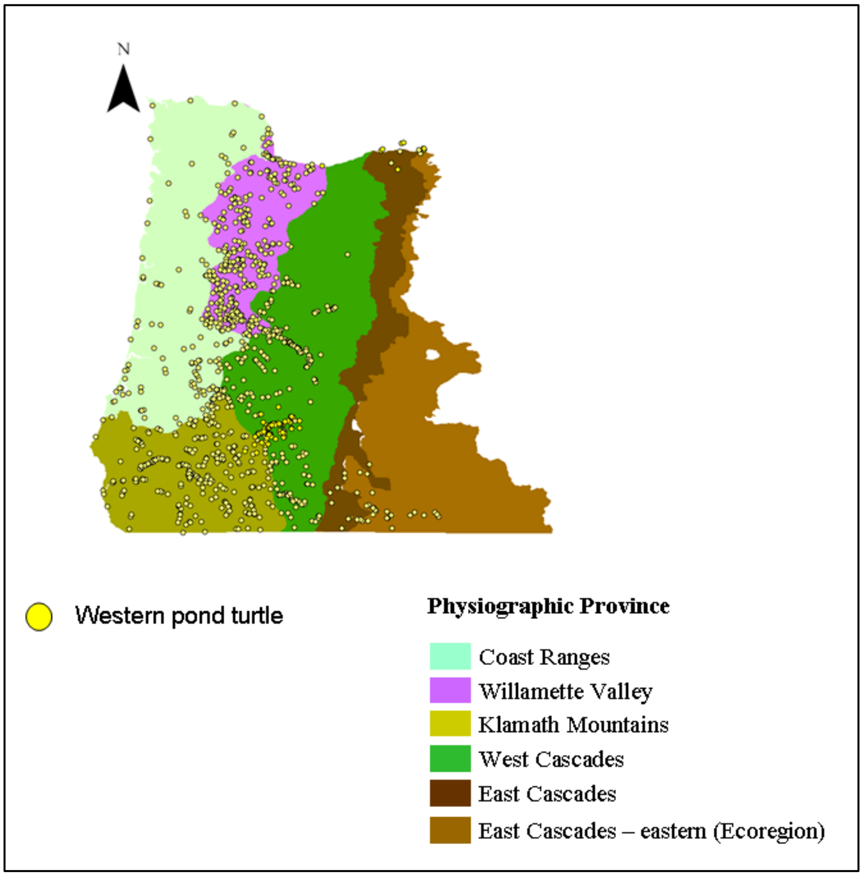

Figure 2. Distribution of western pond turtle observations within public and private lands in Oregon. Location records were obtained from ORNHIC, U.S.D.A. Forest Service, U.S.D.I. Bureau of Land Management, Oregon Department of Fish and Wildlife, and other respondents to our request for location data. Each circle represents records of one or more western pond turtles. Distribution as depicted from these observations is a function of both occupancy by turtles and the survey effort. See Table 2 for summary of sources of location records.

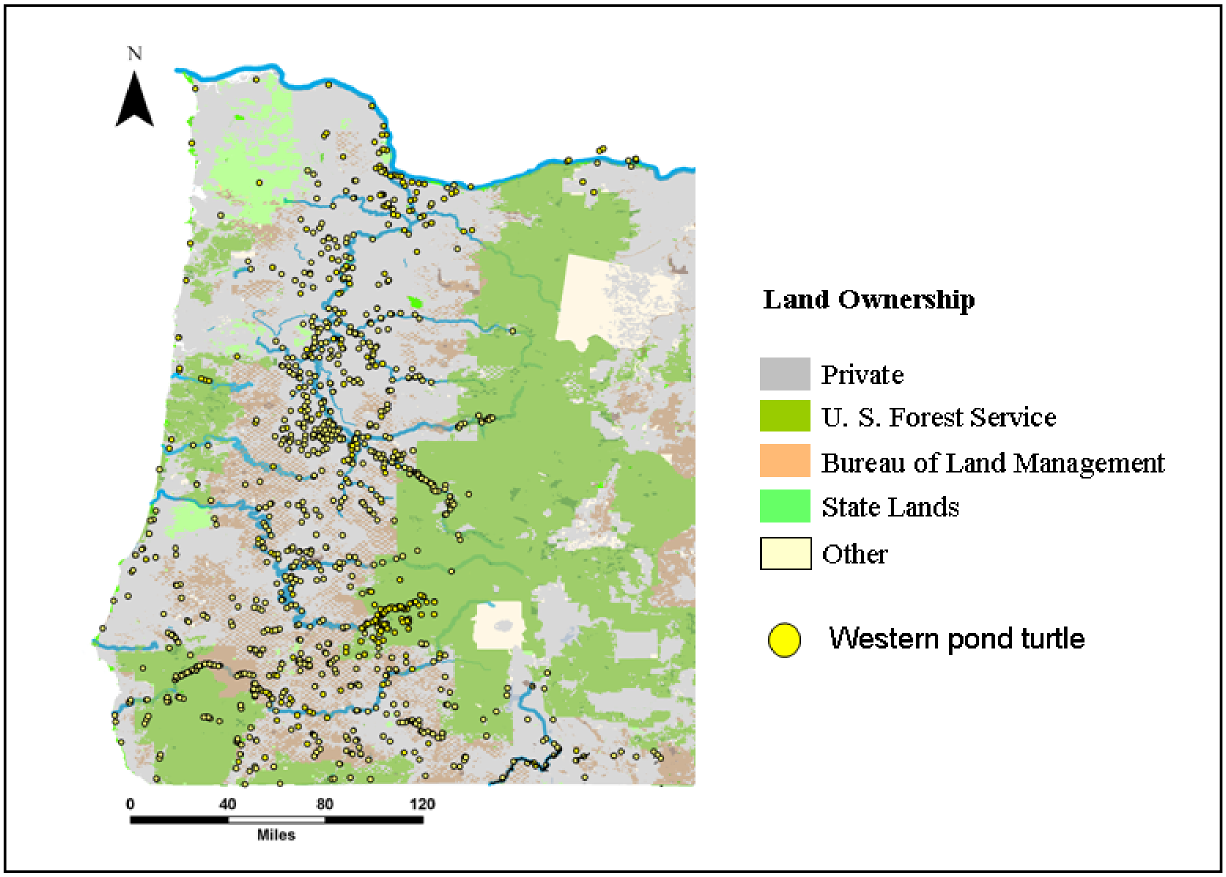

Figure 3. Willamette Valley Ecoregion: distribution of western pond turtle observations within public and private lands. Location records were obtained from ORNHIC, U.S.D.A. Forest Service, U.S.D.I. Bureau of Land Management, Oregon Department of Fish and Wildlife, and other respondents to our request for location data. Each circle represents records of one or more western pond turtles. Distribution as depicted from these observations is a function of both occupancy by turtles and the survey effort. See Table 2 for summary of sources of location records.

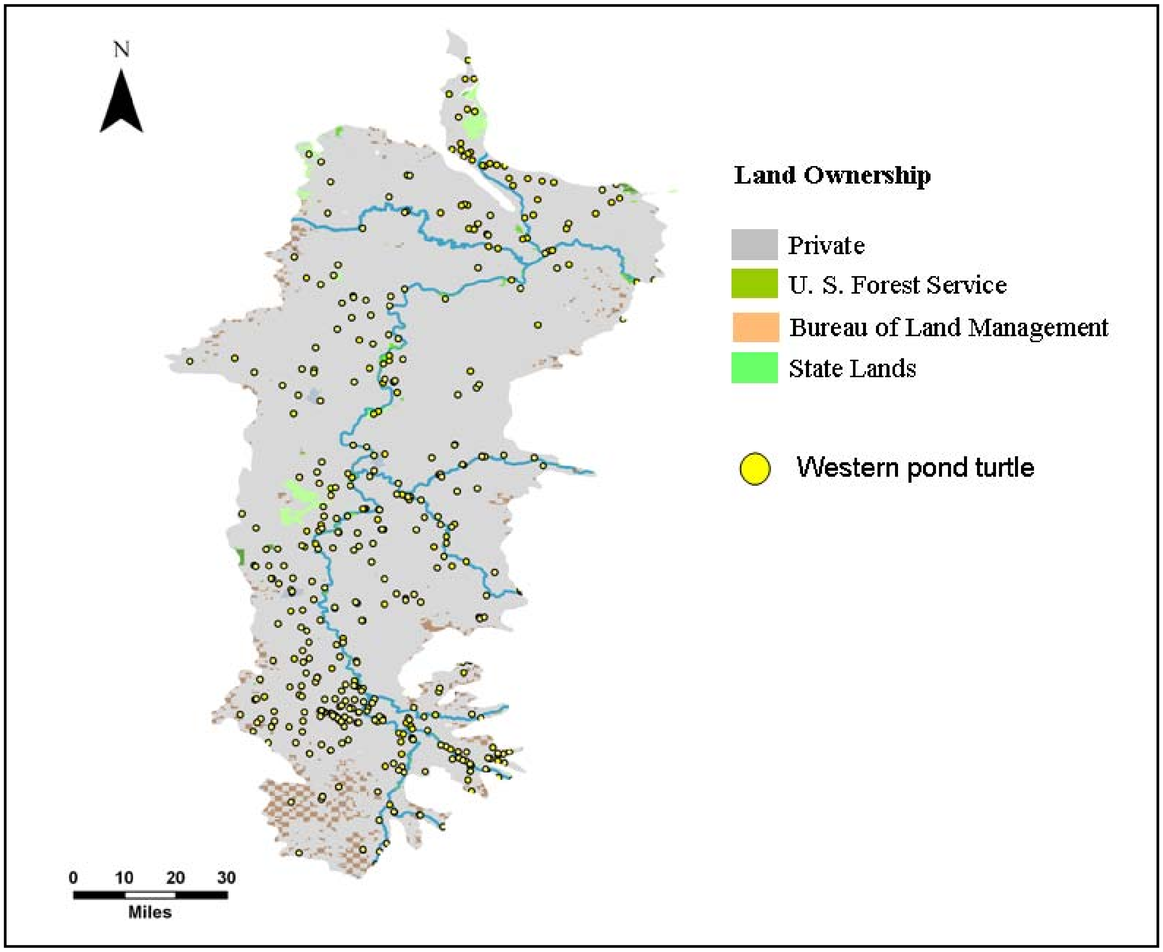

Figure 4. Coast Ranges Ecoregion: distribution of western pond turtle observations within public and private lands. Location records were obtained from ORNHIC, U.S.D.A. Forest Service, U.S.D.I. Bureau of Land Management, Oregon Department of Fish and Wildlife, and other respondents to our request for location data. Each circle represents records of one or more western pond turtles. Distribution as depicted from these observations is a function of both occupancy by turtles and the survey effort. See Table 2 for summary of sources of location records.

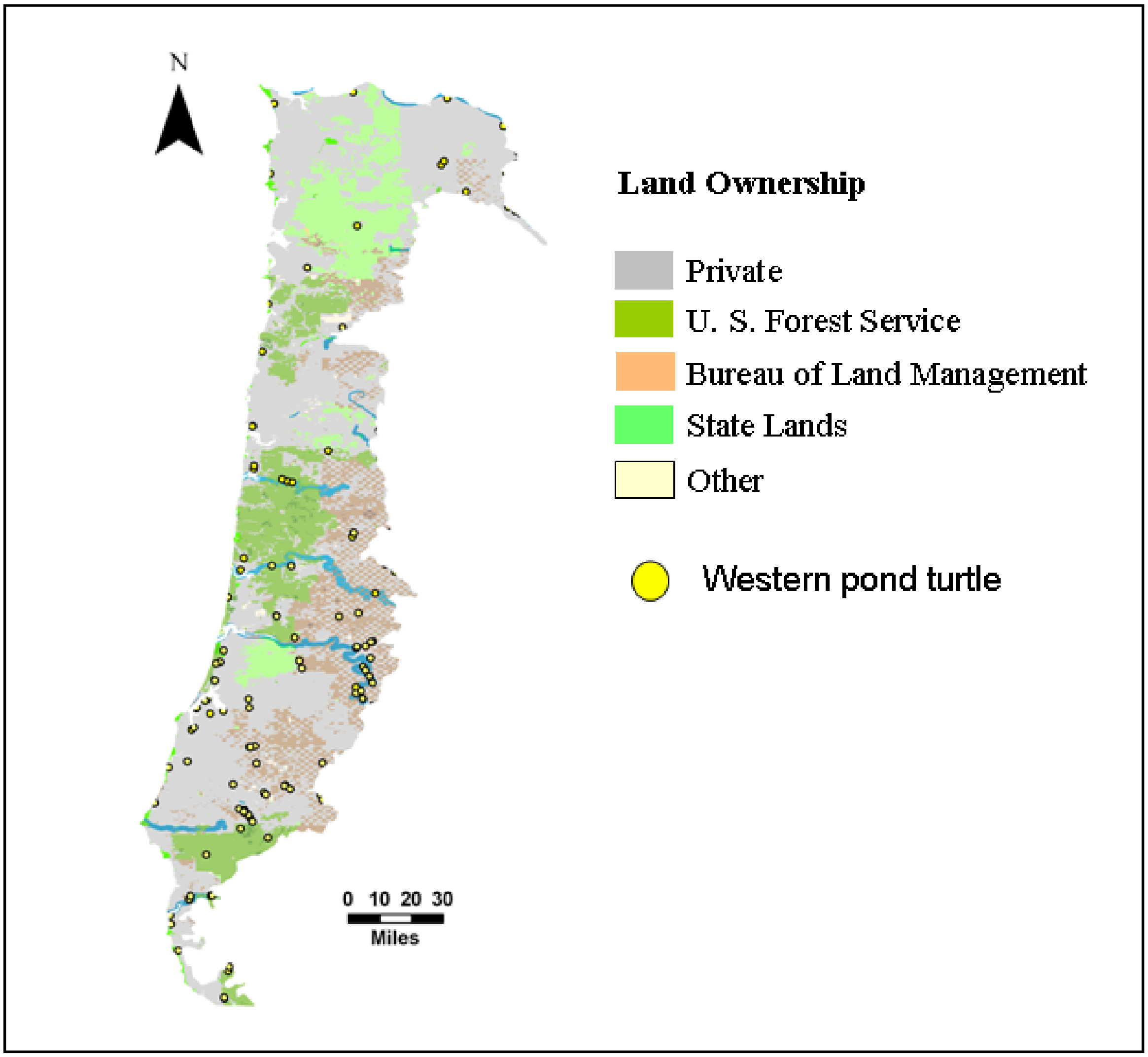

Figure 5. Klamath Mountains Ecoregion: distribution of western pond turtle observations within public and private lands. Location records were obtained from ORNHIC, U.S.D.A. Forest Service, U.S.D.I. Bureau of Land Management, Oregon Department of Fish and Wildlife, and other respondents to our request for location data. Each circle represents records of one or more western pond turtles. Distribution as depicted from these observations is a function of both occupancy by turtles and the survey effort. See Table 2 for summary of sources of location records.

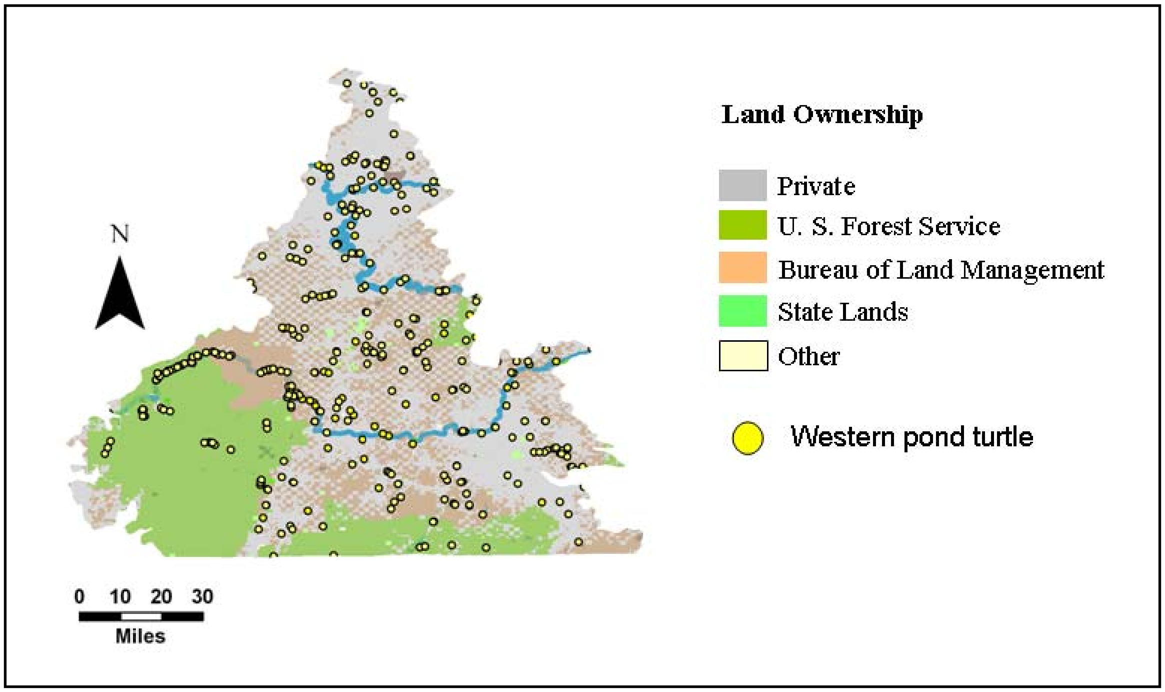

Figure 6. East Cascades Ecoregion: distribution of western pond turtle observations within public and private lands. Location records were obtained from ORNHIC, U.S.D.A. Forest Service, U.S.D.I. Bureau of Land Management, Oregon Department of Fish and Wildlife, and other respondents to our request for location data. Each circle represents records of one or more western pond turtles. Distribution as depicted from these observations is a function of both occupancy by turtles and the survey effort. See Table 2 for summary of sources of location records.

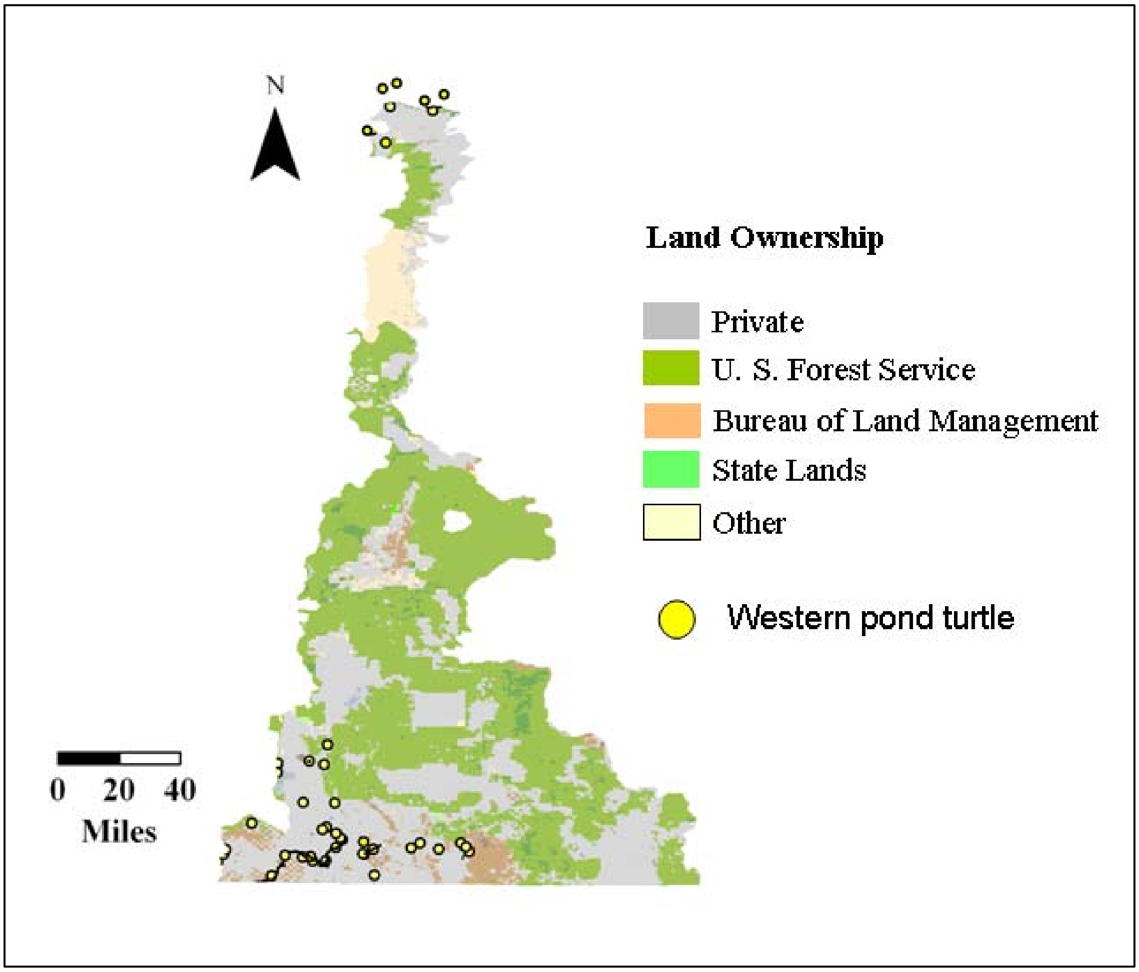

Figure 7. West Cascades Ecoregion: distribution of western pond turtle observations within public and private lands. Location records were obtained from ORNHIC, U.S.D.A. Forest Service, U.S.D.I. Bureau of Land Management, Oregon Department of Fish and Wildlife, and other respondents to our request for location data. Each circle represents records of one or more western pond turtles. Distribution as depicted from these observations is a function of both occupancy by turtles and the survey effort. See Table 2 for summary of sources of location records.

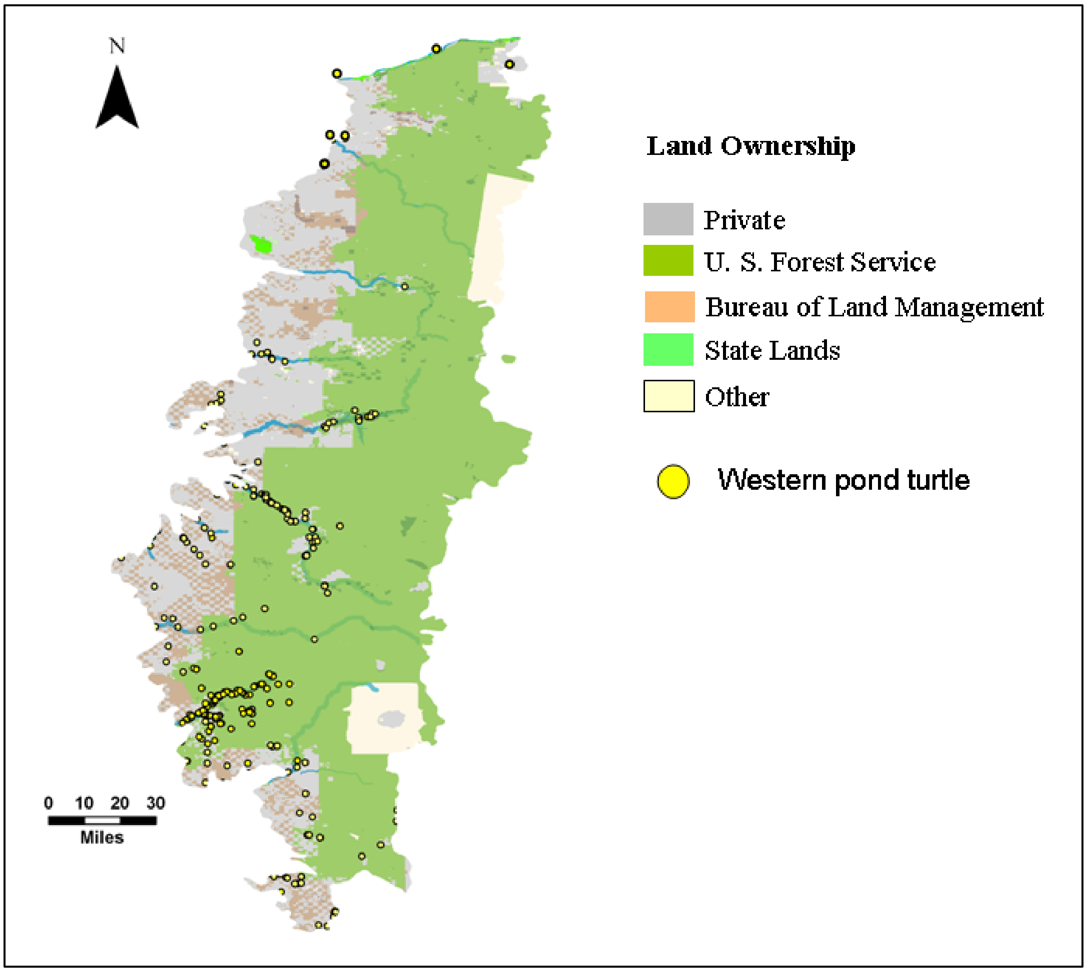

Figure 8. Distribution of western pond turtle observations within and near selected urban centers in Oregon. Locations of western pond turtles were often within 12.5 miles of urban centers. Location records were obtained from ORNHIC, U.S.D.A. Forest Service, U.S.D.I. Bureau of Land Management, Oregon Department of Fish and Wildlife, and other respondents to our request for location data. Each circle represents records of one or more western pond turtles. Distribution as depicted from these observations is a function of both occupancy by turtles and the survey effort. See Table 2 for summary of sources of location records.