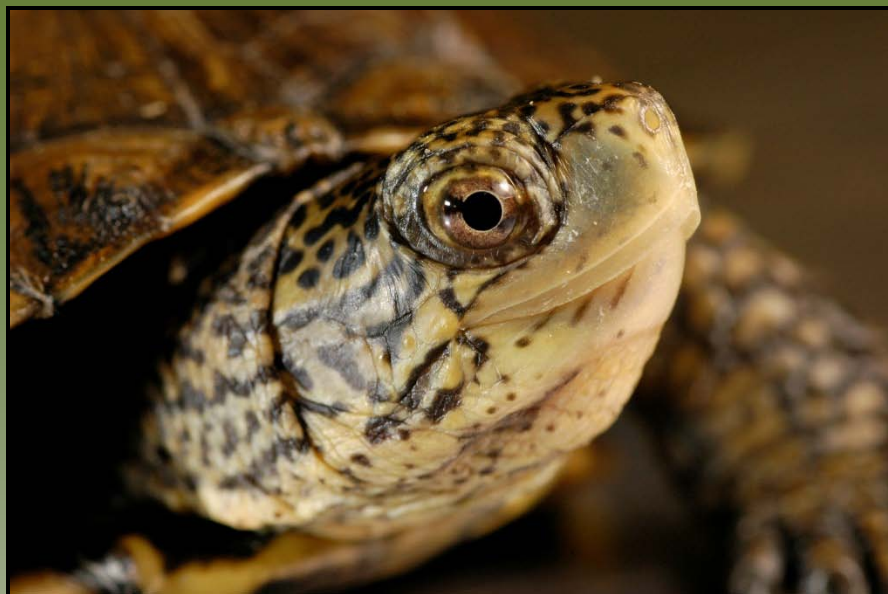


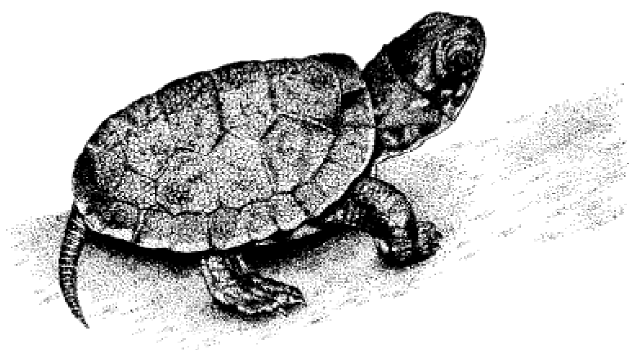
The Western Pond Turtle in Washington

A Population and Habitat Viability Assessment

The Western Pond Turtle in Washington: A Population and Habitat Viability Assessment

13 – 15 November 2012
Olympia, Washington

WORKSHOP REPORT



Workshop Organization:

Woodland Park Zoo

Workshop Design and Facilitation:

IUCN / SSC Conservation Breeding Specialist Group

Workshop Support:

Woodland Park Zoo
Northwest Zoo and Aquarium Alliance
Oregon Zoo
Washington Department of Fish and Wildlife

Photos courtesy of Ryan Hawk and Fred Koontz, Woodland Park Zoo.

A contribution of the IUCN/SSC Conservation Breeding Specialist Group, in collaboration with Woodland Park Zoo.

Pramuk, J. F. Koontz, M. Tirhi, S. Zeigler, K. Schwartz, and P. Miller (eds.) 2013. *The Western Pond Turtle in Washington: A Population and Habitat Viability Assessment.* IUCN/SSC Conservation Breeding Specialist Group, Apple Valley, MN.

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The Western Pond Turtle in Washington:
A Population and Habitat Viability Assessment

13 – 15 November 2012
Olympia, Washington

Workshop Report

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A Population and Habitat Viability Assessment

13 – 15 November 2012
Olympia, Washington

Section 1
Executive Summary

The Western Pond Turtle in Washington: A Population and Habitat Viability Assessment

Executive Summary

Introduction

The western pond turtle (*Actinemys marmorata*) can be found in the lowlands of Puget Sound, southward through western Oregon and California into the northernmost areas of the Baja California peninsula. The species can be found in slow streams, wetlands, ponds and lakes. Where still extant, the species is typically found in small isolated populations across its range. By 1990, the western pond turtle population in the state of Washington declined to an estimated 150 animals remaining in the wild, prompting the Washington Department of Fish and Wildlife (WDFW) to classify the species as "Endangered" in 1993. Habitat degradation, disease, and predation by invasive bullfrogs were identified as the primary factors causing the population declines across the species' range.

For the past 22 years, Seattle's Woodland Park Zoo (WPZ) and WDFW have collaborated on a head-starting program in which turtle eggs or recently-emerged hatchlings are collected from the wild, hatchlings are reared over the winter in controlled conditions at the zoo, and juveniles are released into wild habitats when they reach about ten months of age. Oregon Zoo joined the collaboration several years later. In accordance with guidelines set out in the 1999 Washington State Recovery Plan for the species, four populations are to be established in the Columbia River Gorge and three in Puget Sound. This Western Pond Turtle Recovery Project is a collaborative effort among partners from Woodland Park Zoo, Oregon Zoo, Washington Department of Fish and Wildlife, U.S. Fish and Wildlife Service, U.S. Forest Service and Washington State Parks.

As a result of this intensive recovery effort, researchers estimate the western pond turtle population in Washington to be approximately 1,200 – 1,500 individuals. The turtles are found today at six sites: two in South Puget Sound (SPS), the "Mason County site" and "Pierce County site"; and four along the Columbia River Gorge (CRG), the "Sondino site", the "Bergen site", the "Pierce National Wildlife Refuge (NWR) site" and the "Homestead site" (more precise locations are not identified in this report for security reasons). Despite this success, project managers remain concerned about the continued predation threat posed by invasive bullfrogs and other predators and limited extent of habitat available for population recovery. Additionally, recent observation of ulcerative shell disease that may affect 30% or more of animals released to the wild is an increasing cause for concern. Project managers are interested in a current evaluation of the Western Pond Turtle Recovery Project to assess threats to the species using the best available scientific information and tools, thereby further strengthening prospects for recovery in the wild.

To initiate and inform this effort, species conservation staff from the WPZ sought the assistance of the Conservation Breeding Specialist Group (CBSG), part of the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN), to design and facilitate a Population and Habitat Viability Assessment (PHVA) workshop process with members of Washington's Western Pond Turtle Recovery Team and associated species experts and stakeholders.

The western pond turtle PHVA workshop was designed to achieve the following species conservation objectives:

- Evaluate the current status of the species in the wild in Washington and the existing conservation program, primarily in the context of the 1999 Washington State Recovery Plan.
- Identify biologically optimal management alternatives to enhance species viability in the wild. For example, discussions and analyses among workshop participants would help determine the relative efficacy of continued head-start efforts, intensive habitat management and directed efforts at reducing the population abundance of invasive bullfrogs and other predators.
- Clarify the Recovery Team's future research agenda – where to allocate limited financial resources to most effectively expand our knowledge base on the species and its conservation.
- Identify areas of collaborative inefficiency among Recovery Team member organizations and make recommendations for improving inter-organizational communication and operation for the benefit of western pond turtle conservation management.

The Workshop Process

The PHVA workshop began on 13 November 2012 with approximately 30 people in attendance. Each participant was asked to specify their individual goal for the workshop and their own view on the primary challenges facing management of the western pond turtle in Washington. Many people were interested in evaluating the success of current management strategies throughout the state and identifying new ways to improve the viability of the turtle across multiple populations. Additionally, many participants identified the very low levels of natural recruitment in wild populations as the primary challenge to long-term recovery and the dwindling habitat availability across the state. The remainder of the morning was devoted to presentations by local biologists and management authorities, giving updates on the status of specific western pond turtle populations and ongoing management efforts. In addition, a report was given on the population viability analysis for the species, conducted by CBSG staff in anticipation of the workshop with the dedicated collaboration of a number of Recovery Team members. Results of demographic sensitivity analyses were presented at this time, which demonstrated that western pond turtle population growth is driven most directly by adult survivorship – typical for a species with a long lifespan.

The afternoon began with a plenary activity designed to elicit additional information on the threats and challenges influencing the survival of the western pond turtle in Washington. The resulting threats diagram was used to identify four different working groups that would carry on detailed discussions around the relevant specific threats and challenges previously identified:

1. Western pond turtle populations
2. Western pond turtle habitat
3. Western pond turtle population viability analysis
4. Western pond turtle husbandry

All workshop participants were invited to choose which group they wanted to join. Through this process of self-selection, workshop participants were provided with the opportunity to contribute their expertise and perspective in the most effective and productive way. Participants were also invited to move between groups for shorter periods of time, thereby providing their insight and knowledge to the appropriate group at the right time.

Following this plenary exercise, the working groups began moving through a set of structured tasks set forth by the workshop facilitator. First, each group was asked to amplify those relevant issues / challenge statements identified earlier, to identify new challenges of importance to their specific topic, and to prioritize them according to an agreed criterion. The groups were then brought together in a plenary session where each working group shared their information and provided commentary and perspective with their peers. This process of working group sessions, followed by plenary reports and discussion, continued throughout the workshop.

Once issues were identified and prioritized, the working groups met to review the collective body of knowledge around the primary activities that may impact western pond turtle population viability. Throughout this process, the group placed an emphasis on separating known facts from assumptions, identifying the important justifications around each assumption, and (perhaps most importantly) flagging areas where potentially important information was missing. Through this process, the subsequent identification of management and / or research priorities was greatly enhanced.

Once information assembly was complete, each working group was asked to brainstorm, refine and prioritize goals specifically designed to address the issues identified previously. Each group brought their prioritized goals to a plenary session on the afternoon of workshop Day 2, and the entire group was then asked to provide an overall sense of priority for these objectives based on the importance of achieving them for successful management of western pond turtles in Washington. This task was accomplished by giving each participant five colored adhesive dots and asking them to distribute those dots amongst those objectives they viewed as most important to resolve. Since these objectives are directly tied to the issues identified in the early stages of the workshop, the workshop design facilitates the resolution of the needs of the diverse stakeholder domains that are present.

With objectives in hand, each working group then began the task of identifying specific actions that would achieve those goals. These actions are intended to include important details such as the individual responsible for moving the action forward, a timeline for completing the action, important collaborators, and specific obstacles to be overcome if the action is to be completed. With this level of detail, those agencies responsible for managing and recovering the species have a valuable set of comprehensive recommendations that can be used to guide future management activity.

Summary of Working Group Tasks and Workshop Findings

Each of the four working groups followed the same basic process, working through the specific tasks outlined below:

TASK 1. **Brainstorm Problems/Issues** for your group’s topic, based on the “mind map” generated in plenary.
Consolidate the ideas and problems generated in the first step into a smaller number of topics. Write a one or two sentence ‘problem statement’ for each problem.
Prioritize the problem statements. This process promotes careful examination of each statement and possible further consolidation or better definition. It also assists making choices for the next step if time is limited.

TASK 2. **Data assembly and analysis.** Begin a systematic process to determine the facts and assumptions that are pertinent to your group’s issues. What do we *know*? What do we *assume* we know? How do we justify our assumptions? What do we *need* to know?

TASK 3. **Prepare short-term (1 year) and long-term (5 years) goals** (minimum and maximum for each problem. Goals are intended to guide actions to help solve the problem. Prioritize your goals across each problem you have identified.
High-priority working group goals are brought to plenary and the entire set of goals is prioritized by the full body of workshop participants under a single set of criteria.

TASK 4. Develop and prioritize Action Steps for each of the high priority goals identified by the full body of workshop participants. These priority actions will form the body of the recommendations from the workshop.

The Populations Working Group identified very low recruitment of young individuals – likely due largely to predation by invasive bullfrogs and other predators – as a primary threat to long-term population viability. This leads to the potential for low population genetic diversity that can further erode long-term viability. The group also identified data sources and gaps to inform site-specific population viability models.

Once issues were identified and relevant information was assembled, the group derived a set of prioritized goals to guide future action. The emerging threat from ulcerative shell disease (also called "shell disease" in this report) was a major concern to the group, and they set a goal of understanding the epidemiology of this disease, the survival rate of affected individuals, and the potential impact to reproductive capacity of infected adults. To better inform evolving population models, the group sought to obtain and improve estimates of *in situ* hatchling and juvenile survival rates at each population site, and to better catalog cause-specific mortality for adults. Detailed actions were listed for each of these high-priority conservation goals.

The Habitat Working Group recognized that there are an insufficient number of sites to recover the western pond turtle, and that resources are limited to create and maintain a suitable network of habitat at occupied sites. In addition, they noted that recovery objectives for individual sites and the full Recovery Plan for the species in Washington needs to be updated. They developed a comprehensive tabular analysis of specific threats at each currently occupied site, and began preliminary evaluation of sites that may be used to establish new western pond turtle populations in the near future.

The group recommended that management authorities work to identify and establish one new site in Puget Sound within the next 5 years to introduce the western pond turtle into a new habitat patch. They also want to identify a back-up site in the Columbia River Gorge for possible re-introduction, and to minimize impact to western pond turtles from salmon habitat restoration at the Pierce National Wildlife Refuge site.

The Population Viability Analysis Working Group used the *VORTEX* demographic simulation software to build a model of western pond turtle population dynamics to test the efficacy of current and future alternative management strategies. Prior to the PHVA, a document was circulated amongst pond turtle experts to select the most appropriate baseline demographic parameters for use in the PVA models.

Through the demographic data assembly process, the group determined that little is known regarding (1) mortality rates of key demographic stages, particularly for hatchlings reared in the wild and adults, and (2) the nature and intensity of threats acting on these demographic stages. It will be particularly important to better understand threats that impact adults and resulting adult mortality because changes to the number of individuals in this stage class have disproportionately large impacts on the persistence of western pond turtle populations. Thus, if future field research shows that adult mortality is high, conservation efforts that focus on reducing this mortality will have a stronger effect on stabilizing populations than programs that focus on other demographic stages (*e.g.*, head-starting programs that only raise hatchling survival).

PVA scenarios also showed that, assuming hatchling mortality in the wild is very high (*i.e.*, 95%), western pond turtle populations can only sustain a cessation of the head-starting program if wild hatchling mortality rates are lowered. For example, populations were stable or increasing if concurrent conservation programs lowered wild hatchling mortality rate to 85% (assuming an adult mortality of 10%) as the head-starting program was discontinued. In addition, even small populations can persist without a head-starting program as long as annual adult mortality is ≤ 12.5% and annual hatchling mortality is ≤ 80%. Thus, the persistence of WPT populations in Washington State is critically dependent on (1) understanding what processes are negatively impacting these populations and how they are acting on specific demographic stages and (2) lowering adult mortality rates to the degree possible.

The Husbandry Working Group noted a crucial absence of adequate communication and standardization between stakeholder institutions that limits contributions to species recovery. Moreover, it became apparent to the working group members that current husbandry is largely based on historical precedent rather than emerging scientific methods. To begin addressing these issues, the group began putting together a comprehensive comparison of captive care protocols that will no doubt be a very useful tool for future reference and as an aid to communication.

Towards that end, the group set as a goal the need to more effectively share husbandry and field data among primary and secondary stakeholders through an improved communication strategy. In addition, they recommended the development of a standardized set of best husbandry practices for purposes of creating more and healthy individuals to bolster wild populations through release. Specific actions were identified to achieve these high-priority goals.

The full participant body reviewed all the goals identified by each working group and was asked by the workshop facilitator to express their individual views about priority across the complete set of goal statements. While all goals were endorsed by the workshop participants as important for western pond turtle recovery in Washington, a subset stood out as more urgent for the species' survival in the state:

1. Understand shell disease epidemiology, survival rate of affected individuals, and effects on reproduction.
2. More effectively share husbandry and field data among primary and secondary stakeholders through an improved communication strategy.
3. Identify and establish one new site in Puget Sound within the next 5 years to re-establish western pond turtle populations.
4. Continue bullfrog eradication at the Sondino site.
5. Minimize impact of salmon habitat restoration on western pond turtles at the Pierce NWR site.

This PHVA report and the recommendations within it are considered advisory to the local and regional management teams for the western pond turtle and other collaborators to help guide actions thought to be beneficial to the long-term survival of the species in Washington.

PHVA workshop participants engaged in prioritization of working group goals in plenary session.

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Section 2
Workshop Participant Goals, Statements of Conservation Challenges

Workshop Participant Goals, Statements of Conservation Challenges

At the beginning of the workshop, each participant was asked to state their personal goals for attending the meeting, and to provide their perspective on what they thought were the major challenges to effective management of western pond turtles in Washington state over the next 25 years. These statements, in no particular order, are recorded below.

Workshop Participant Goals

- Provide and seek information on Western pond turtle health.
- To get a better understanding of the history of the program and future management options in relation to a population biology framework.
- To understand the PHVA process.
- To create a clear roadmap for sustainability of Western pond turtles in Washington.
- To obtain clear research goals.
- To update the Recovery Plan.
- To identify the future role of head-starting.
- To obtain information on other pond turtle activities.
- To clarify the role of zoos in recovery efforts – is headstarting currently the best practice?
- To have a clear direction for the western pond turtle project for the next 20 years.
- To get feedback from other participants and share my data with the group.
- To put the pieces together for a successful species management plan.
- To experience the PHVA process and get a broader grasp on species recovery programs.
- To better understand the PHVA process – to identify if sufficient data exist to conduct a PVA for the Western pond turtle.
- To gain an understanding of the species' needs in both captivity and the wild.
- To gain a better understanding of the threat that bullfrogs pose to western pond turtle viability.
- To learn more about PVA and current technologies for its application.
- To identify critical data gaps in our knowledge of western pond turtle biology.
- To develop a consensus field protocol.
- To better understand the PVA process for future use in California.
- To learn about challenges and solution processes that can help to guide a fledgling program in California.
- To obtain guidance on the trajectory of recovery for the species in Washington.
- To learn more about limiting factors for successful re-establishment of western pond turtles in the Puget Sound area.
- To gain insight into the process and content of the PHVA approach.
- To determine the number of pond turtles needed to maintain viable populations in Washington.
- To better understand the next steps for western pond turtle recovery and the ways in which it can be accomplished given the existing challenges facing the species.
- To identify next steps for recovery and to evaluate the program to date.
- To determine if we are on the right track for a successful long-term recovery of the species.

Challenges to WPT Management

- Integration of population, health and environment topics along entire range of the western pond turtle: funding, coordination, communication, standardization.
- Finding the time and money to conduct the science needed to make effective management actions and strategies.
- Habitat, invasive species (bullfrog) control. Need for appropriate research to fill knowledge gaps, and the funding to make it all possible.
- Finding sustainable habitat for population recovery.
- Resolve current disease issue, identify additional habitat.
- The primary challenge is lack of suitable protected habitat in the Puget trough.
- Identify the primary challenges to successful pond turtle conservation management.
- Shared knowledge and a comprehensive working plan.
- Communication between stakeholders.
- Modulating predator influence on nests and hatchlings. Climate change (specifically high levels of precipitation) on nest development.
- Providing and maintaining adequate habitat for survival.
- Genetics and captive breeding of West Washington populations.
- Natural recruitment sufficient to maintain populations.
- For western pond turtles to survive they need to coexist with people.
- Not enough knowledge about the species; but hope to be able to bring back information on PVA to other program as we look to expand in the future. Need to be smart about expansion and working with California Department of Fish and Game.
- How to recover self-sustaining populations of the western pond turtle in Washington, considering the high urbanization of the recovery zone. Habitat is not limited; rather it is not secured from people, contaminants, or introduced predators. Can we ever walk away or what reduced staffing level will be necessary?
- Safe locations for re-establishment.
- Availability of suitable, functioning habitat of sufficient extent and distribution.
- Expand habitat management especially for nesting and predator control (e.g. bullfrogs).
- Low juvenile recruitment.
- Habitat: Securing adequate habitat and ongoing multiple use/demands on finite resources.
- Limited habitat in the Puget Sound; juvenile recruitment; funding and staff resources; disease.
- Lack of suitable habitat availability for reintroduction; refining management techniques to work towards self-sustaining populations (natural recruitment, disease processes).

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Section 3
Western Pond Turtle Threats Analysis

Western Pond Turtle Threats Analysis

On the first afternoon of the workshop, participants were asked to brainstorm their views of the threats and challenges to western pond turtle management in Washington. These issues were presented graphically on a wall in the main plenary meeting room, with each participant writing their own idea on a small card and "pasting" it to the evolving diagram. Arrows were used to illustrate proposed causal relationships among factors that affect pond turtle population viability either directly or indirectly. The participatory nature of the activity is an important component of the overall workshop process, instilling ownership of species management among all those attending the workshop. The final diagram is presented on the next page of this report (Figure 3-1).

Once the threats diagram was developed, it was possible to identify clusters of related issues that could form the basis of working groups that could discuss the issues in more detail. The working groups included:

1. Western pond turtle populations
2. Western pond turtle habitat
3. Western pond turtle population viability analysis
4. Western pond turtle husbandry

Each of the four working groups followed the same basic process, working through the specific tasks outlined below:

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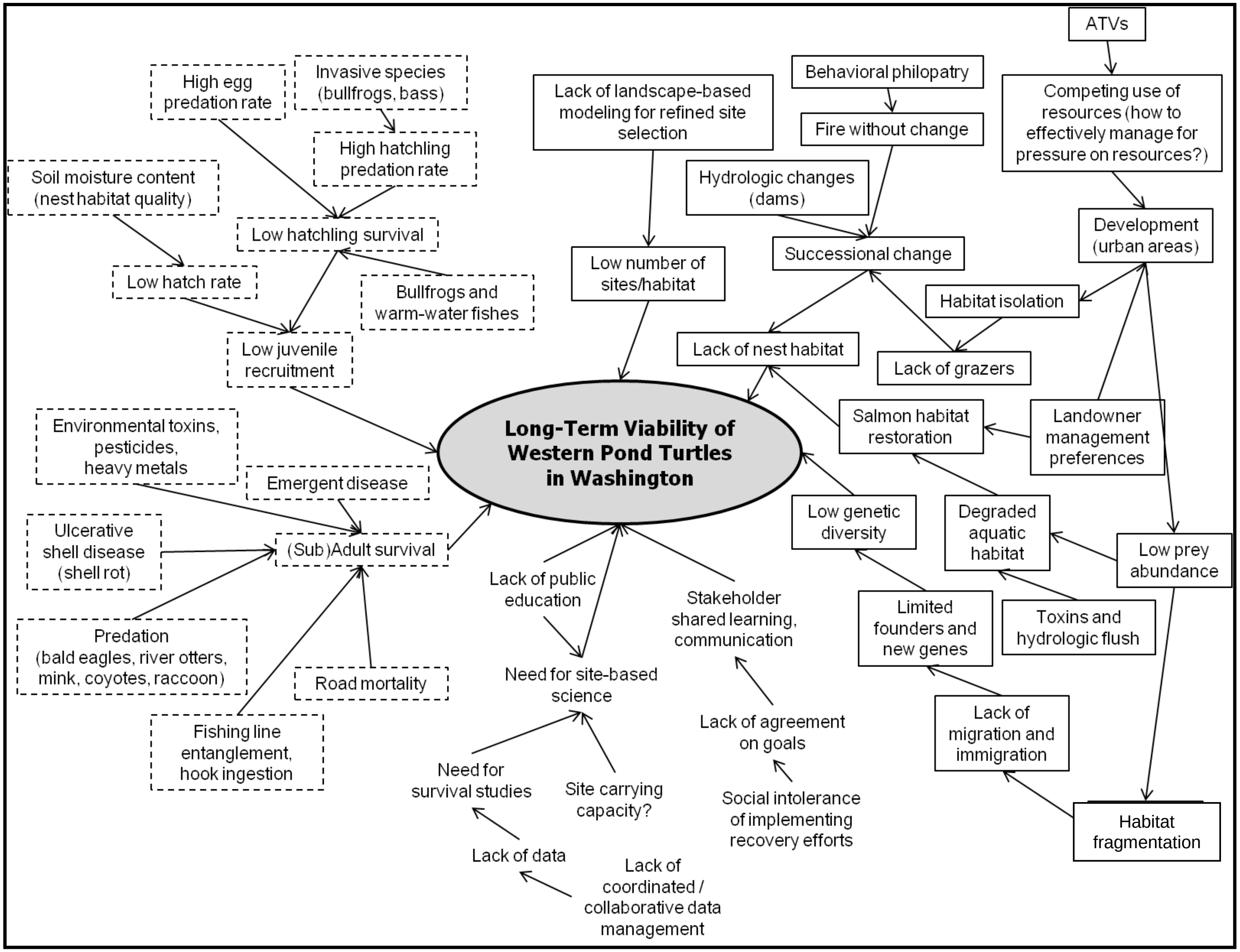
Reports from each of these working groups are to be found in the following sections of this report.

Figure 3-1. Diagrammatic representation of threats confronting the western pond turtle in Washington state. Dashed boxes indicate threats linked generally to population-based processes, while solid boxes indicate threats linked generally to habitat-based processes. Statements without boxes refer to threats based largely on social processes. See accompanying text for more information.



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Olympia, Washington

Section 4
Western Pond Turtle Population Viability Analysis Report

Western Pond Turtle Population Viability Analysis Report

Working Group members:
Philip Miller, CBSG
Sara Zeigler, CBSG
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Introduction

The western pond turtle (*Actinemys marmorata*) inhabits slow streams, wetlands, ponds, and lakes in the lowlands of Puget Sound, southward through western Oregon and California into the northernmost areas of the Baja California peninsula. Where still extant, the species is typically found in small, isolated populations across its range. By 1990, only 150 turtles remained in the wild in the state of Washington, prompting the Washington Department of Fish and Wildlife (WDFW) to classify the species as "Endangered" in 1993. Habitat degradation, disease, and predation by invasive bullfrogs were identified as the primary factors causing population declines in Washington.

For the past 22 years, Seattle's Woodland Park Zoo (WPZ) and WDFW have collaborated on a head-starting program in which turtle eggs or recently-emerged hatchlings are collected from the wild, hatchlings are reared over the winter in controlled conditions at the zoo, and juveniles are released into wild habitats when they reach about ten months of age. In accord with guidelines set out in the 1999 Washington State Recovery Plan, four populations are to be established in the Columbia River Gorge and three in Puget Sound. This Western Pond Turtle Recovery Project is a collaborative effort among partners from Woodland Park Zoo, Oregon Zoo, Washington Department of Fish and Wildlife, U.S. Fish and Wildlife Service, U.S. Forest Service and Washington State Parks.

As a result of the intensive recovery effort through the head-starting program, researchers estimate the western pond turtle population in Washington to be approximately 1,200 – 1,500 individuals. Despite this success, project managers remain concerned about the continued predation threat posed by invasive bullfrogs (*Lithobates catesbeianus*). Additionally, the recent discovery of an apparent infection of unknown etiology among wild and head-started individuals, leading to a condition known as ulcerative shell disease that may reach a prevalence of 30% or more of the animals released to the wild, is a new and increasing cause for concern.

In response to the goals set forth at the beginning of the Population and Habitat Viability Assessment (PHVA) workshop, we conducted a population viability analysis (PVA) using the software package *VORTEX* to better understand long-term population trends and management needs for the western pond turtle. The *VORTEX* package is a simulation of the effects of a number of different natural and human-mediated forces – some, by definition, acting unpredictably from year to year – on the health and integrity of wildlife populations. *VORTEX* models population dynamics as discrete sequential events (e.g., births, deaths, sex ratios among offspring, catastrophes, etc.) that occur according to defined probabilities. The probabilities of events are modeled as constants or random variables that follow specified distributions. The package simulates a population by recreating the essential series of events that describe the typical life cycles of sexually reproducing organisms. In general, *VORTEX* is a flexible and accessible tool that can be adapted to a wide variety of species types and life histories as the situation warrants. The program has been used around the world in both teaching and research applications and is a trusted method for assisting in the definition of practical wildlife management methodologies. For a more detailed explanation of *VORTEX* and its use in population viability analysis, refer to Lacy (2000) and Miller and Lacy (2005).

PVA methodologies such as the *VORTEX* system are not intended to give absolute and accurate "answers" for what the future will bring for a given wildlife species or population. This limitation arises simply from two fundamental facts about the natural world: it is inherently unpredictable in its detailed behavior; and we will never fully understand its precise mechanics. Consequently, many researchers have cautioned against the exclusive use of absolute results from a PVA in order to promote specific management actions for threatened populations (e.g., Ludwig 1999; Beissinger and McCullough 2002; Reed et al. 2002; Ellner et al. 2002; Lotts et al. 2004). Instead, the true value of an analysis of this type lies in the assembly and critical analysis of the available information on the species and its ecology and in the ability to compare the quantitative metrics of population performance that emerge from a suite of simulations, with each simulation representing a specific scenario and its inherent assumptions about the available data and a proposed method of population and/or landscape management. Interpretation of this type of output depends strongly upon our knowledge of western pond turtle biology, the environmental conditions affecting the species, and possible future changes in these conditions.

Primary Questions for PVA Modeling

Members of the Population Modeling Working Group identified the following questions that could be appropriately addressed with PVA model construction and implementation:

- What life history parameters and vital rates characterize populations of western pond turtles in Washington State (i.e., development of baseline model)?
- Which life history stages are most important for the stability and growth of western pond turtle populations?
- What are the impacts of head-starting or bull-frog mitigation programs on western pond turtle population extinction risk?
- What survival rates for hatchlings and adults would be required to maintain stable or increasing western pond turtle populations that are not supplemented through a head-starting program?

Baseline Parameters for PVA models

Prior to this PHVA workshop, a document was circulated amongst species experts (listed above) to select the most appropriate baseline parameters for use in PVA models. Baseline parameters listed below are based on the consensus of these experts.

The historical range of this species was formerly from British Columbia south to San Francisco Bay where the *A. marmorata marmorata* subspecies intergrades with *Actinemys marmorata pallida*. This PHVA workshop (and PVA) focused only on populations in Washington State, including two remnant populations and two introduced populations in Skamania and Klickitat Counties, collectively the Columbia River Gorge sites, as well as reintroduced populations in Mason and Pierce Counties that are known collectively as the South Puget Sound sites (Figure 6-1). Accordingly, parameters in this model are applicable to the life history and vital rates for these Washington populations. In addition, PVA models were not site-specific at this time, and modeling results were intended to be generally applicable to all Washington populations. Minor variations in vital rates, initial population sizes, carrying capacities, and numbers of individuals removed from or added to populations through the head-starting program may vary between populations and impact absolute PVA results (to be explored in future models).

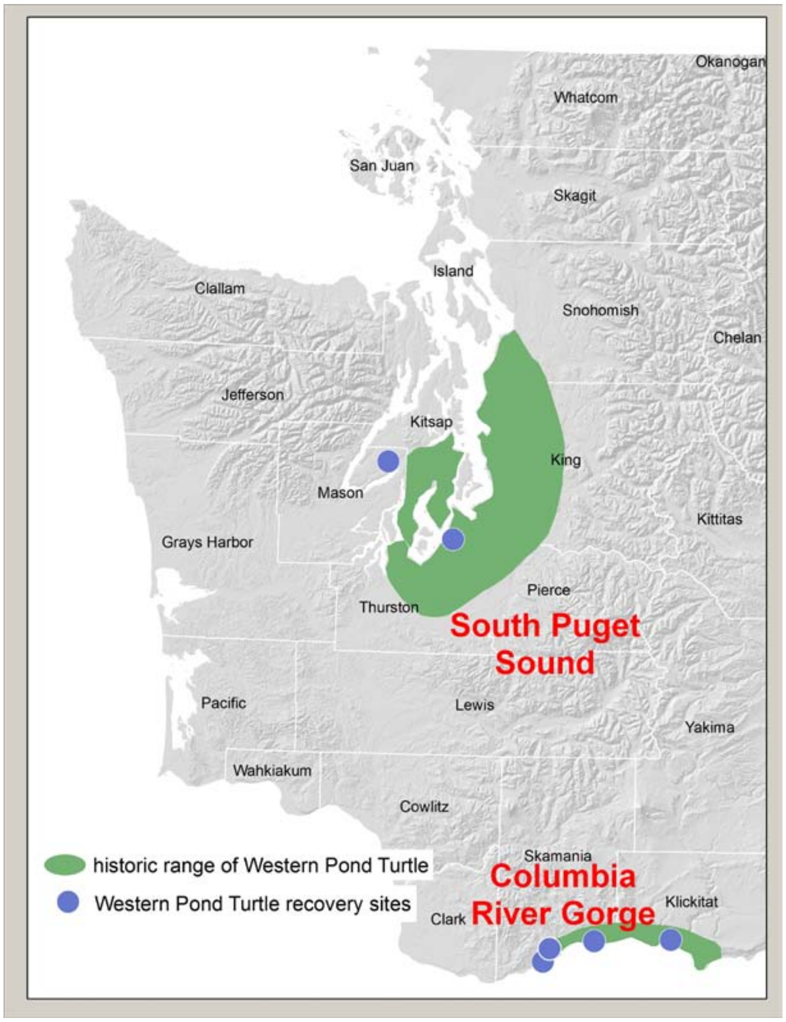

Figure 6-1. Map of western Washington state showing the two areas of distribution for *Actimemys marmorata*. Approximate locations of species recovery sites are identified with blue dots.

Iterations and Years of Projection: Because VORTEX is a stochastic simulation model – one that explicitly incorporates realistic levels of random variability in annual rates of reproduction and survival – multiple runs of the model with a specific set of input data will actually yield different results as mean rates of birth and death vary through time. We therefore need to replicate the model run many times in order to gain insight into the range of possible outcomes for a given input dataset. All population projections (scenarios) were simulated 1000 times, with each projection extending to 100 years (1 time step = 1 year). All simulations were conducted using *VORTEX* version 9.99b (May 2010).

Dispersal/Metapopulation Structure: As indicated above, PVA models were intended to reflect the dynamics of a 'general' western pond turtle population in Washington State and were not intended to represent a specific population. Thus, we assumed a single, closed population without the input of individuals through immigration or loss of individuals through emigration.

Breeding System: Paternity in the western pond turtle is poorly understood. For other freshwater chelonians, however, polyandry has been recorded for some tortoises and freshwater turtle species (Ostentoski 2001). Moreover, long-term storage of sperm is known for many reptile species, including turtles (Pearse and Avise 2001). We assumed that western pond turtles generally display a polygynous breeding system, where a single male may mate with multiple females during a given year. While not completely faithful to a polyandrous breeding system, the dynamics resulting from this assumption will be demographically indistinguishable from a polyandrous system.

Age of First Offspring: VORTEX considers the age of first reproduction as the age at which the first nest of hatchlings is born, not simply the onset of sexual maturity. We assumed that both females and males produce their first offspring at 10 years of age (Germano and Bury 2001).

Maximum Age of Reproduction: In its simplest form, *VORTEX* assumed that animals can reproduce at a normal rate throughout their adult life. We assumed that individuals stop breeding at 50 years. While this is set as the maximum age of reproduction, age-specific mortality rates may be set so that the probability of actually reaching this age is quite small.

Clutches per Year: Based on field observations, we assumed that 10% of adult females who nest in a given year will produce two clutches (not dependent on the first clutch failing) and that 90% will produce a single clutch.

Maximum Progeny per Clutch: Based on field observations at Columbia River Gorge and Pierce County sites, we assumed that a maximum of 12 hatchlings can be born in a clutch (mean: 6.25 hatchlings per clutch).

Offspring Sex Ratio: Although sex determination likely is temperature-dependent in this species, without data to the contrary we assumed that hatchlings do not deviate from a 50:50 sex ratio.

% Adult Females Breeding: This describes the average proportion of females that reproduce in a year. WDFW records indicate that most adult females (i.e., those of reproductive size) reproduce annually, perhaps at a rate of 90% of the adult female population per year (F. Slavens 2012 pers. comm.; WDFW 2012 western pond turtle unpublished records). Thus, we assumed that 90% of adult females reproduce each year.

Environmental Variation (EV) in % Breeding: Annual environmental variation in female reproductive success is modeled in *VORTEX* by specifying a standard deviation (SD) for the proportion of adult females that successfully produce offspring in a given year. In the absence of specific data for this parameter, we assumed 10% variation in the percentage females breeding each year. This is thought to be reasonable for variability in reproductive success for this species.

Distribution of Clutch Size: The table below gives the probability of a given breeding female producing a clutch of the specified size (Table 6-1). These values are based on expert judgment in the absence of specific field data for the species.

Table 6-1. Distribution of western pond turtle clutch sizes used in the PVA.

Number of Offspring	Probability (%)
1	1.2
2	1.2
3	3.3
4	9.0
5	16.6
6	25.9
7	18.7
8	14.8
9	6.3
10	1.8
11	0.9
12	0.3

Mate Monopolization: In many species, some adult males may be socially restricted from breeding despite being physiologically capable. This can be modeled in *VORTEX* by specifying a portion of the total pool of adult males that may be considered "available" for breeding each year. Without evidence to the contrary, we assumed that all males (100%) were capable of breeding in a given year.

Mortality Rates: VORTEX defines mortality as the annual rate of age-specific death from year x to x + 1; in the language of life-table analysis, this is equivalent to q(x). Very little quantitative data exist on population size trends and specific mortality rates for this species. Thus, we estimated mortality rates from limited telemetry data as well as from data collected from the head-starting program.

In addition, the head-starting program is currently an integral part of almost all western pond turtle populations in Washington State, where managers collect some proportion of a site's total egg production and raise those eggs in an *ex situ* environment. When the hatchlings are large enough to escape the majority of predation threats in the wild (typically around 50g which corresponds to about 9–11 months of age when raised in captivity, and three years when raised in the wild), they are returned to their natal site. Therefore, the demographic nature of head-starting is best described by a partitioned mortality that takes into account both those eggs that were collected for the head-starting program and those that were hatched and lived in the wild for that first year. Specifically, the total survival rate for all eggs (year 0 – 1), both head-started and wild, can be expressed as a weighted average according to:

$$P_{Tot} = (P_{HS}*S_{HS}) + ((1-P_{HS})*S_W)$$

where P_{HS} is the proportion of eggs collected for head-starting, S_{HS} is the survival rate of individuals from head-started egg to date of release (simply speaking, one year), $(1-P_{HS})$ is the proportion of eggs left in the wild, and S_W is the survival rate of wild individuals from egg to one year. In many small turtle populations, managers are able to find and collect all the eggs from a given site, so P_{HS} =1.0. However, as the population grows and head-started individuals (recruits) ultimately begin reproducing, the number of nests at the site each year will increase. If there is a limit to the number of nests/eggs a zoo can head-start, P_{HS} will begin to decline and the overall survival rate of eggs to one year will likewise decline as predators begin to find hatchlings that were not collected for the head-start program. Thus, under the assumption of limited head-starting capacity there would be a type of "diminishing return" for a fixed head-starting effort as the population increases.

For our models, we needed to be able to calculate P_{HS} for any given scenario, which requires knowing the total number of nests that are produced by a cohort of adult females in a given year as well as the number of nests from which eggs can be pulled for the head-start program. To do this, we defined a Global State Variable *HSNestMax*, which describes the maximum number of nests that a head-start program can bring out of the wild in a given year. This can remain static over time or vary over time as a program is expanded or terminated at any specific point in time. Next we needed to know the total number of nests that the adult female population produced each year, which can be tracked through the *VORTEX* variable *BROODS*. With these two parameters, we defined a Population State Variable *PropHS* that calculated the proportion of all nests (broods) that were removed for the head-start program:

$$\text{PropHS} = \text{MIN}((\text{BROODS}>0)*(\ \text{HSNestMax}/(\text{BROODS}+0.001)):1)$$

The MIN function constrained the variable to the range 0 – 1, so that when, for example, *HSNestMax* is set at 40 but there are only 10 wild nests, the value of *PropHS* is not set at 4.0. Instead, it is more realistically set at 1.0 – assuming that population managers are able to find and collect all nests produced that year. The (*BROODS*>0) component of the function forced the value of *PropHS* to be equal to 0.0 when the number of nests produced by a population in a given year is equal to 0. Finally, the small addition of 0.001 to *BROODS* in the denominator allowed for proper resolution of the function when reproduction was absent from the population in a given year (i.e., *BROODS* = 0).

We could then more easily express hatchling survival ($\text{Surv}_{0\text{-}1}$) as:

$$\text{Surv}_{0\text{-}1}=(\text{PropHS}*45)+((1\text{-PropHS})*\ 10)\ ,$$

where the baseline mean survival rate for hatchlings that were reared in captivity was 45% (estimated derived from data provided in Table 2 of Schmidt and Tirhi (2011)), and the baseline mean survival rate for hatchlings left in the wild was 5% (estimate derived from expert judgment of workshop participants). Mean survival estimates derived from telemetry studies suggest mean rates of second-year individuals (age 1-2) of between approximately 85 – 75%, leading us to set our baseline annual rate for the 1-2 year age class at 80%. We assume that individuals age 2 years and older will have a mean survival rate of approximately 10%, again based roughly on telemetry studies of head-started turtles followed across multiple years. Finally, we assume no differences in age-specific survival between males and females. A summary of survival rates used in our baseline model is presented in Table 6-2.

Table 6-2. Age-specific survival rates for male and female western pond turtles in Washington State.

Age (years)	Survival Rate (%) (standard deviation)
0 – 1 (head-started)	45 (5)
0 – 1 (not head-started)	5 (5)
1 – 2	80 (4)
> 2	10 (3)

In specific scenarios, we removed the impact of the head-starting program and adjusted hatchling (year 0 – 1) and adult (age > 10 years) mortality to investigate maximum rates that would allow for stable or increasing population trends should the head-starting program be discontinued.

Inbreeding Depression: VORTEX includes the ability to model the detrimental effects of inbreeding, most directly through reduced survival of offspring through their first year. Because of lack of data to support this parameter, we assumed that inbreeding depression was not acting on the population.

Catastrophes: Catastrophes are singular environmental events that are outside the bounds of normal environmental variation affecting reproduction and/or survival. Natural catastrophes can be tornadoes, floods, droughts, disease, or similar events. These events are modeled in *VORTEX* by assigning an annual probability of occurrence as well as a pair of severity factors describing their impact on mortality (across all age-sex classes) and the proportion of females successfully breeding in a given year. These factors range from 0.0 (maximum or absolute effect) to 1.0 (no effect) and, in its most basic implementation in *VORTEX*, are imposed during the single year of the catastrophe, after which time the demographic rates rebound to their baseline values.

As of this early stage in the long-term development of this PVA effort, we have not included any type of catastrophic event in our model. Additional work in the future could be focused on identifying the utility of adding an event such as disease (*e.g.*, shell disease, respiratory disease), human hydrology modifications, toxic spills, or fertilizer/pesticide runoff.

Initial Population Size: For this ‘general’ model of western pond turtle population dynamics, we assumed an initial population size of 194 individuals (reflective of the Pierce County site population) at a stable age distribution. However, reasonably detailed population census results are available for the other populations in Washington state, which may be useful in subsequent site-specific modeling exercises. In addition, we explored the impact of population size (with various mortality rates for the hatchling and adult stage classes) on extinction risk in specific scenarios.

Carrying Capacity: Carrying capacity (*K*), which represents the number of individuals that a specific site could support given available space and resources, is unknown for all population locations in Washington State. For this model, we assumed a *K* of 500 individuals.

Sensitivity Testing of Baseline Demographic Rates

In general, it is recommended that perturbation analyses (e.g., sensitivity or elasticity analysis) be conducted on PVA models to explore the importance of certain parameters on estimates of extinction risk (Beissinger 2002; Beissinger and Westphal 1998; Holmes et al. 2007). By identifying model parameters or life history stages that have a disproportionately strong impact on population trajectories, sensitivity analysis can direct management actions and research efforts (Crouse et al. 1987; Mills and Lindberg 2002; Schemske et al. 1994). It can also highlight the impact of parameter uncertainty on estimates of extinction risk and other model results.

Using the baseline parameters listed above, we varied survival rates for hatchling (year 0 – 1), juvenile (year 1 – 2), sub-adult (year 3 – 9), and adult (year $\geq$10) stage classes as well as age of first reproduction, maximum age of reproduction, and the percentage of females breeding each year by +10% and -10% (Table 3). We then ran independent *VORTEX* simulations where each parameter was replaced by the +10% or -10% value while all other parameters were kept at baseline values to determine the new annual population growth rate (λ) associated with a change in that parameter (Table 6-3).

Table 6-3. Changes in key parameter values and the associated change in annual population growth rate (λ).

Vortex Parameter	Parameter Values			Lambda Values		
	Baseline	*+10%*	*-10%*	*Baseline*	*+10%*	*-10%*
Hatchling (0-1 yr) survival	10	11	9	1.002	1.007	0.996
Juvenile (1-2 yr) survival	80	88	72	1.002	1.007	0.996
Sub-adult (2+ yr) survival	90	99	81	1.002	1.049	0.956
Adult (10+ yr) survival	90	99	81	1.002	1.052	0.955
Age of first reproduction	10	11	9	1.002	0.996	1.008
Maximum age of reproduction	50	55	45	1.002	1.002	1.001
Percentage females breeding	90	99	81	1.002	1.006	0.996

We then calculated elasticity value, which is a measure of the proportional change in a population's intrinsic growth rate given a change in a specific parameter while all other parameters remain constant (Caswell 1989). Thus, small changes to parameters with high elasticity values will result in large changes in extinction risk or population growth compared to parameters with low elasticity values. Elasticity value (E) for each parameter tested was determined through the following equation:

$$E = \frac{|\lambda(Base + 10\%) - \lambda(Base - 10\%)|}{0.2 * \lambda(Base)}$$

where $\lambda(Base{+}10\%)$ is the lambda value associated with the simulation that used the baseline parameter increased by 10% for the parameter tested, $\lambda(Base{-}10\%)$ is the lambda value associated with the simulation that used the baseline parameter decreased by 10% for the parameter tested, and $\lambda(Base)$ is the lambda value associated with the simulation where all parameters were held at baseline values.

Figure 6-2 shows the results of the elasticity analysis for parameters in our PVA model. Our baseline WPT model was highly sensitive to changes in the survival rates of adult (E = 0.49) and subadult (0.46) stage classes and less sensitive to changes in hatchling survival (0.055), juvenile survival (0.055), age of first reproduction (0.06), and maximum age of reproduction (0.005).

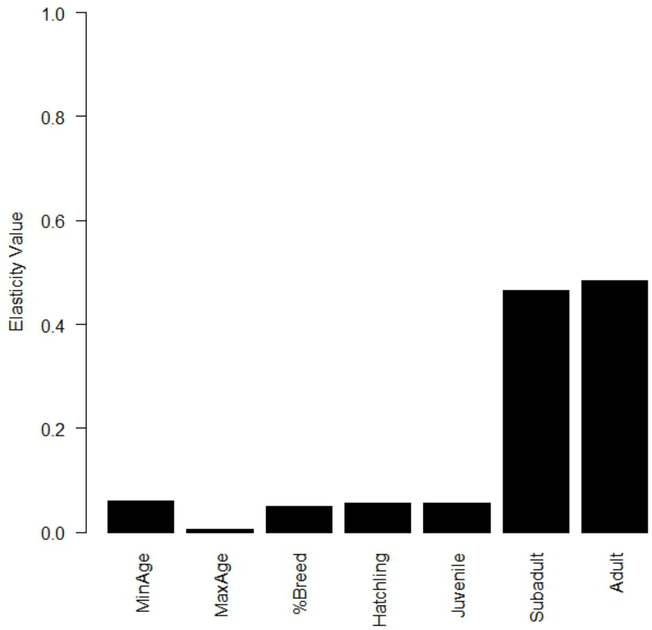

Figure 6-2. Elasticity values for model parameters for age of first reproduction (“MinAge”), maximum age of reproduction (“MaxAge”), percentage females breeding (“%Breed”), hatchling survival (“Hatchling”), juvenile survival (“Juvenile”), sub-adult survival (“Subadult”), and adult survival (“Adult”).

This information is important for guiding both future data collection and management of the species. Because parameters for adult and subadult survival have major impacts on modeling results, it is important to understand the value of these parameters with high levels of certainty. At the time of this PHVA workshop, little was known regarding the survival of these stage classes in wild WPT populations, and studies that target information regarding survival rates and threats acting on these stage classes specifically could be disproportionately valuable for science-based conservation of the species.

Likewise, management efforts that target adult and subadult stage classes could have disproportionately greater impacts on the persistence of wild populations. At this time, the majority of conservation funding and effort has been allocated to the head-starting program, which only directly impacts the hatchling stage class. However, as shown in our elasticity analysis and those for other long-lived turtle species (Heppell et al. 1996), efforts focused entirely on improving survival for early stage classes may be ineffective. For these species, models predict that head-starting cannot compensate for even small losses of adults or subadults, and, alternatively, small increases in adult and subadult survival provide greater benefits to population persistence than increases in survival of earlier stage classes (Heppell et al. 1996). Given this, limited conservation efforts and funding could be better allocated to increasing adult survival and limiting threats (*e.g*., ulcerative shell disease) that act specifically on the adult age class. Continued research efforts that investigate adult mortality in general and the impact of shell disease on adult mortality more specifically will allow conservationists to better understand the tradeoffs between allocating continued funding to the head-starting program vs. other programs that focus on minimizing adult mortality.

It should be noted, however, that care should be taken in using elasticity values to guide management efforts (Mills et al. 2001). Although elasticity values can provide predictions regarding which stages *should* be most important for population growth, the largest threats to a species may not be acting on a highly sensitive life history stage. In this case, management efforts should be focused on the vulnerable stage, not the one with the highest elasticity value. For western pond turtles, the largest threats are not well known. If intense predation on the hatchling stage class is the largest driver of population decline, then conservationists will be best served in allocating funding to reducing losses due to predation through head-starting or some other mechanism. Research that elucidates how threats are acting on populations will help to determine the best allocation of conservation resources.

Impact of Head-starting and Bullfrog Mitigation Programs on Western Pond Turtle Population Persistence

In order to better understand the impact of major conservation efforts, such as head-starting and bullfrog mitigation programs, on turtle population dynamics, we explored a series of scenarios with varying levels of hatchling mortality. In each simulation, we used baseline values for all parameters except for the proportion of hatchlings head-started each year (*PropHS*) and hatchling mortality. [**Note**: while we will deviate from our previous focus on describing age-specific *survival* and instead now move to discussing age-specific *mortality*, the underlying values used in the models are complimentary and consistent.] Scenarios included:

1. <u>No head-starting program</u>. In this scenario, we assumed that no hatchlings were reared in captivity (*PropHS* = 0), and hatchlings were instead subject to "wild" mortality rates at 95%.
2. <u>100% head-starting program</u>: Here, we assumed that all hatchlings were reared in captivity (*PropHS* = 1.0) and returned to the wild after 1 year. Because turtles were not exposed to predation during their most vulnerable year of life, hatchling mortality was simulated at 55%.
3. <u>Temporary head-starting program</u>: In this scenario, we assumed that the head-starting program would be phased out after 20 years. During those first 20 years, managers are able to gather and rear hatchlings from 20 nests per year (*HSNestMax* = 20, which is used in the model to determine *PropHS*), during which time hatchlings experience a mortality rate of 55%. Hatchlings left in the wild and all hatchlings after 20 years experience the "wild" mortality rate of 95% per year.
4. <u>Temporary head-starting program with bullfrog mitigation</u>: In this scenario, we used the same conditions as in Scenario 3; however, we also assumed that a concurrent bullfrog mitigation program lowered the "wild" hatchling mortality rate to 85% per year.

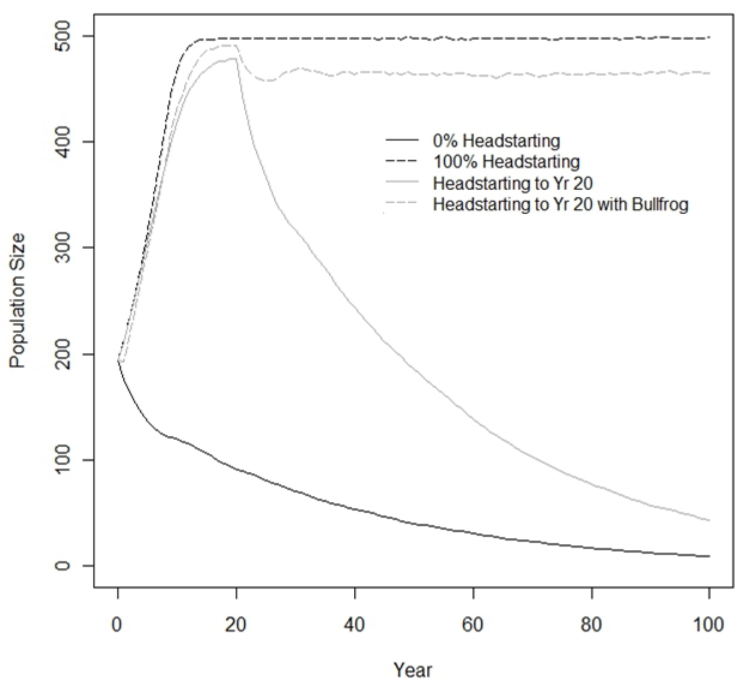

Figure 6-3. Population size through time as modeled in the population viability analysis (PVA) program VORTEX under scenarios where (a) no hatchlings were head-started ("0% Head-starting"; solid black line), (b) all hatchlings were head-started indefinitely ("100% Head-starting"; dashed black line), (c) hatchlings from 20 nests were head-started each year for the first 20 years ("Head-starting to Yr 20"; solid gray line), and (d) hatchlings from 20 nests were head-started each year for the first 20 years and bullfrog mitigation reduced wild hatchling mortality rate to 85% per year ("Head-starting to Yr 20 with Bullfrog"; dashed gray line).

Trends in population size through time for each of these scenarios are shown in Figure 6-3. When head-starting was absent (solid black line), the population declined rapidly towards extinction. At the other extreme, when all hatchlings were reared in captivity through a head-starting program indefinitely (dashed black line), then the population was able to expand rapidly and reach habitat carrying capacity in less than 20 years. A head-starting program that was capped at 20 nests per year (solid gray line) led to a substantial population increase for the first 20 years, but at a rate that is slightly less than the 100% head-starting scenario as some nests remained exposed to wild mortality. When the program was terminated after 20 years, the population was fully exposed to wild mortality and was then predicted to decline rapidly. Finally, if the head-starting program was terminated at year 20 but a bullfrog mitigation program was also conducted concurrently, a reduction in hatchling mortality of just 10% (from 95% to 85%) resulted in a population that was able to sustain itself over the long-term (dashed gray line).

When we examined trajectories for the number of females in the population for each scenario (Figure 6-4), we observed "discontinuities" in these abundances that reflected the transition of individuals from the sub-adult to adult stages. For example, under the 0% head-starting scenario (solid black line), the number of adult females continued to increase even as the overall population declined. This pattern occurred because the main mechanism of population decline was through the near elimination of hatchlings with a yearly mortality rate of 95%, which did not immediately impact the number of adults. The initial population had an existing group of sub-adults – that are now large enough to escape bullfrog predation – that were gradually added to the adult cohort from years 1-10. After that time, the lack of recruitment in the early years led to a steady drain in the number of adult females through adult mortality, with little to no addition of adults from earlier cohorts. We noted the same behavior when the head-starting program was discontinued at year 20 (solid gray line). In comparison, for scenarios where all individuals were head-started indefinitely (dashed black line) or where bullfrog mitigation programs lowered wild hatchling mortality (dashed gray line), recruitment from early stages to the adult stage was high enough to sustain a stable number of adults. These patterns indicate that, in scenarios where recruitment is largely diminished, a time lag may occur before the number of adults begins to diminish after which this portion of the population will decline rapidly.

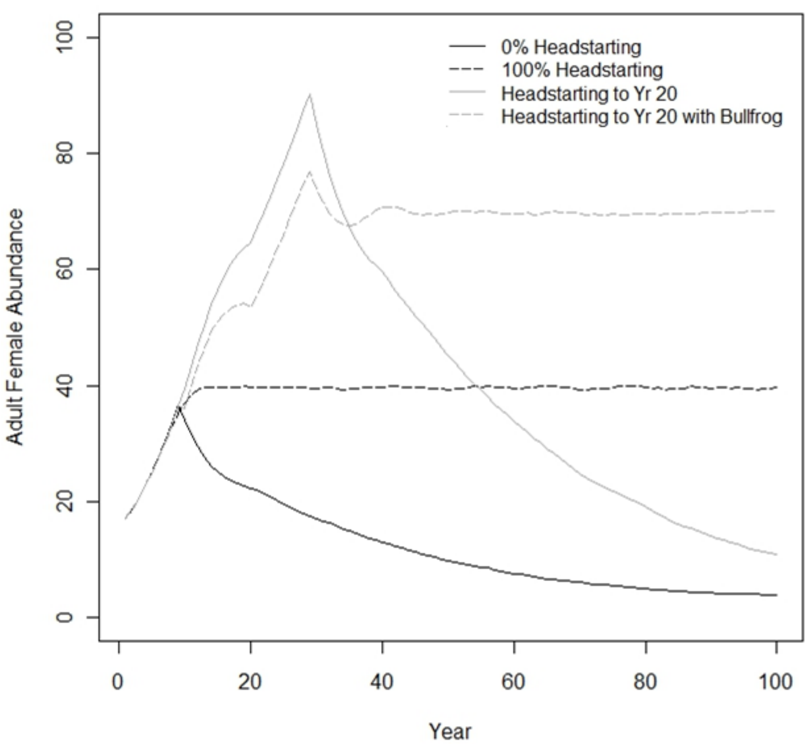

Figure 6-4. Adult female abundance through time as modeled in the population viability analysis (PVA) program *VORTEX* under scenarios where (a) no hatchlings were head-started ("0% Head-starting"; solid black line), (b) all hatchlings were head-started indefinitely ("100% Head-starting"; dashed black line), (c) hatchlings from 20 nests were head-started each year for the first 20 years ("Head-starting to Yr 20"; solid gray line), and (d) hatchlings from 20 nests were head-started each year for the first 20 years and bullfrog mitigation reduced wild hatchling mortality rate to 85% per year ("Head-starting to Yr 20 with Bullfrog"; dashed gray line).

Survival Rates Needed for Population Persistence in the Absence of Head-starting

Given the high cost of the head-starting program, participants in the PHVA workshop requested that we explore what levels of mortality the population could withstand assuming that the head-starting program was discontinued. To do this, we simulated population dynamics in *VORTEX* using baseline values for all parameters except for hatchling and adult mortality. For these parameters, we used hatchling mortality rates of 80, 85, 90, and 95% and adult mortality rates of 10, 12.5, 15, 17.5, and 20%, and PVA simulations were conducted for every combination of hatchling and adult mortality. Finally, we repeated these simulations at initial population sizes of 50, 200, and 400 individuals in a stable age distribution.

At a small initial population size (N = 50; Figure 6-5), the population was stable or increasing when adult mortality was ≤ 12.5% and hatchling mortality was ≤ 80%.

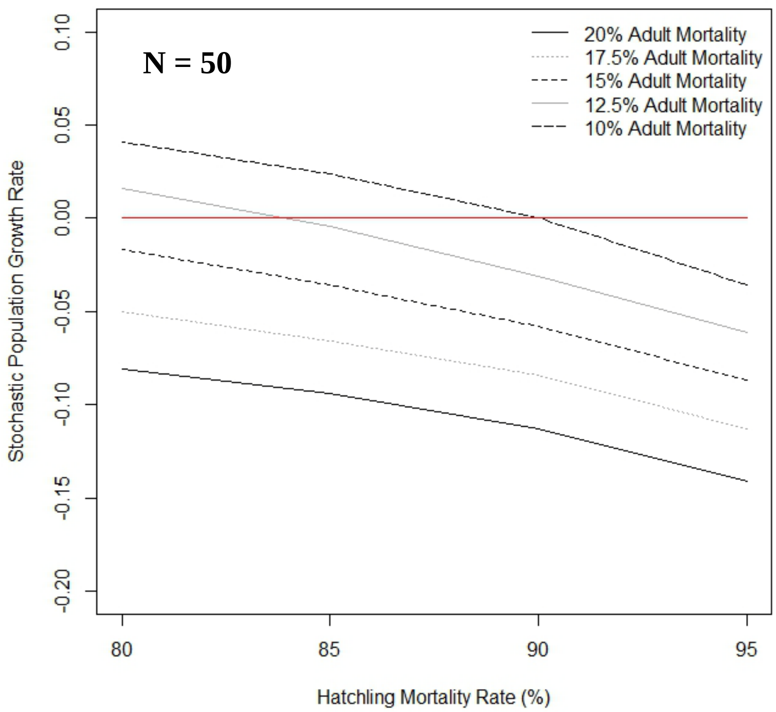

Figure 6-5. Stochastic population growth rate resulting from different combinations of adult mortality (ranging from 10% average annual mortality, uppermost dashed line to 20% mortality, lowermost solid line) and hatchling mortality (ranging from 80%-95%, range of X-axis values) assuming an initial population size of 50 individuals. A growth rate greater than 0.0 (horizontal red line) is indicative of a growing population while a rate less than 0.0 is indicative of a declining population.

At a more moderate initial population size (N = 200; Figure 6-6), we observed similar population dynamics as those seen with the small initial population size. However, the population could now withstand a slightly higher combination of adult and hatchling mortality; the stochastic population growth rate was positive at a hatchling mortality ≤ 85% and an adult mortality ≤ 12.5%.

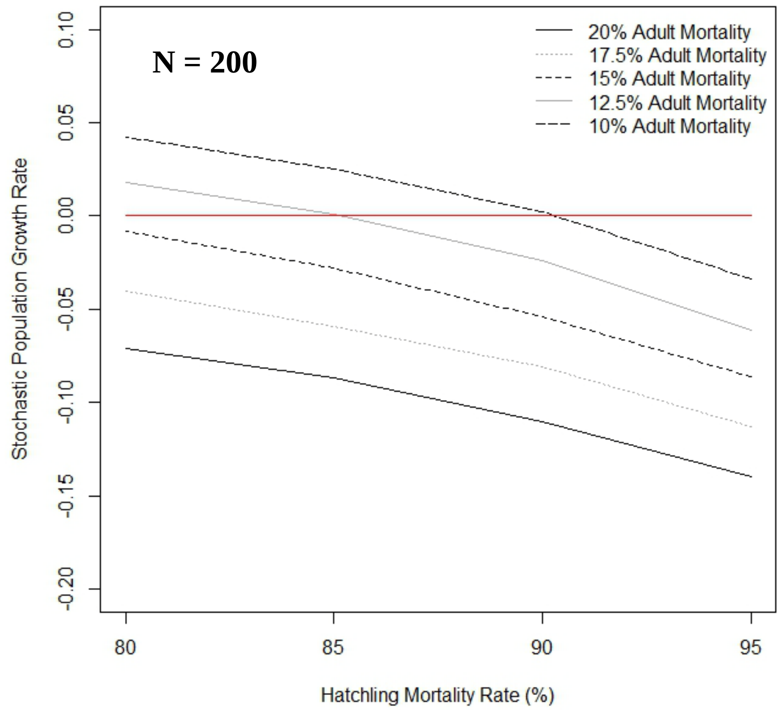

Figure 6-6. Stochastic population growth rate resulting from different combinations of adult mortality (ranging from 10% average annual mortality, uppermost dashed line to 20% mortality, lowermost solid line) and hatchling mortality (ranging from 80%-95%) assuming an initial population size of 200 individuals. A growth rate greater than 0.0 (horizontal red line) is indicative of a growing population while a rate less than 0.0 is indicative of a declining population.

Finally, at a large population size (N = 400; Figure 6-7), we saw very similar population dynamics at the various combinations of hatchling and adult mortality as those seen for the moderately sized population. Again, the population was stable or increasing when hatchling mortality was ≤ 85% and adult mortality was ≤ 12.5%.

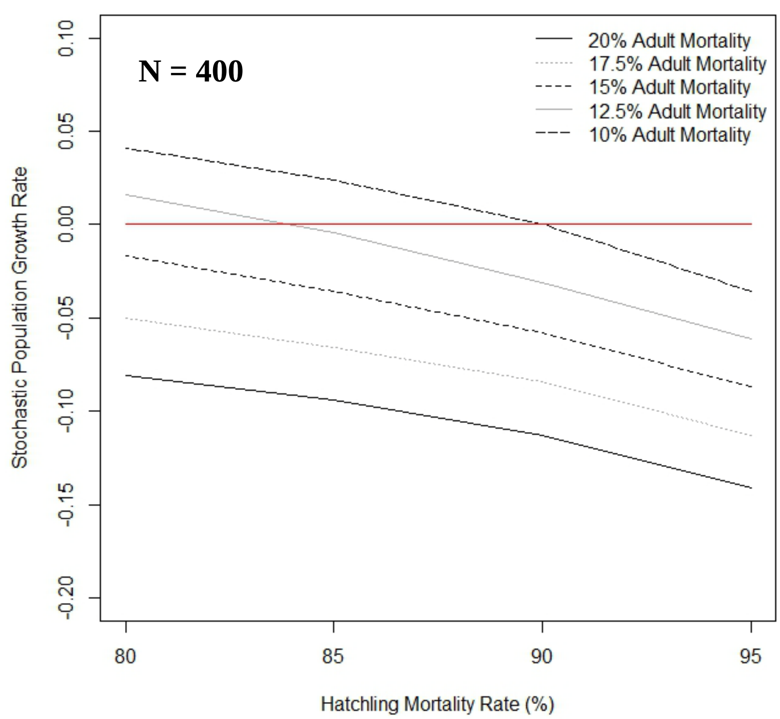

Figure 6-7. Stochastic population growth rate resulting from different combinations of adult mortality (ranging from 10% average annual mortality, uppermost dashed line to 20% mortality, lowermost solid line) and hatchling mortality (ranging from 80%-95%) assuming an initial population size of 400 individuals. A growth rate greater than 0.0 (horizontal red line) is indicative of a growing population while a rate less than 0.0 is indicative of a declining population.

In summary, these scenarios reiterate that adult mortality rates are particularly important for maintaining stable or increasing population dynamics for western pond turtles, especially in the absence of a head-starting program. Populations could never sustain an adult mortality rate that was over 12.5%, even at large total population sizes. However, as long as the adult mortality rate was relatively low, the population could still sustain higher levels of hatchling mortality at all population sizes. At an adult mortality rate $\leq$ 12.5%, the population could sustain a hatchling mortality rate of 85% at moderate to large population sizes and a hatchling mortality rate of 80% at small population sizes. If turtle recovery teams choose to discontinue the head-starting program, other conservation programs may need to be put in place to reduce adult and/or hatchling mortality to acceptable levels. Because mortality rates and the impacts of specific threats on these age classes are unknown, it is also currently unclear regarding what type and intensity are needed for conservation programs to achieve acceptable mortality rates.

Future Modeling

PVA models simulated as part of this PHVA workshop were relatively limited by the amount of available data. As such, many parameters were estimated as averages across populations or from expert opinion. In addition, we did not incorporate catastrophes or other systemic threat processes such as disease. Finally, no PVA model was specific to a single western pond turtle population in Washington State. Populations for this species can vary considerably depending on site-specific demographic rates and on whether individuals are harvested or supplemented as part of the head-starting program, adults are subject to disease (e.g., shell disease, respiratory disease), or certain conservation programs are implemented on the site (e.g., bull frog mitigation). At the PHVA workshop, efforts were initiated to begin to collate this population-specific information (see Appendix at the end of the section). Future models that incorporate site-specific demographic data and management actions as well as the direct effects of threats like disease will be important for understanding the conservation needs of individual populations and the species as a whole in this part of its distribution.

Conclusions

We determined baseline demographic rates for populations of western pond turtles throughout Washington state and highlighted knowledge gaps for the species. Of greatest importance, we determined that little is known regarding (1) mortality rates of key demographic stages, particularly for hatchlings reared in the wild and adults, and (2) the nature and intensity of threats acting on these demographic stages. It will be particularly important to better understand threats that impact adults and resulting adult mortality because changes to the number of individuals in this stage class have disproportionately large impacts on the persistence of turtle populations. Thus, if future field research shows that adult mortality is high, conservation efforts that focus on reducing this mortality will have a stronger effect on stabilizing populations than programs that focus on other demographic stages (*e.g.*, headstarting programs that only raise hatchling survival).

PVA scenarios also showed that, assuming hatchling mortality in the wild is very high (*i.e.*, 95%), western pond turtle populations can only sustain a discontinuation of the head-starting program if wild hatchling mortality rates are lowered. For example, populations were stable or increasing if concurrent conservation programs lowered wild hatchling mortality rate to 85% (assuming an adult mortality of 10%) as the head-starting program was discontinued. In addition, even small populations can persist without a head-starting program as long as adult mortality is $\leq$ 12.5% and hatchling mortality is $\leq$ 80%. Thus, the persistence of western pond turtle populations in Washington state is critically dependent on (1) understanding what processes are negatively impacting these populations and how they are acting on specific demographic stages and (2) lowering adult mortality rates to the degree possible.

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Appendix A: Site-Specific Demographic Parameters

		Columbia River Gorge				South Puget Sound	
Parameter	**Baseline**	**Sondino**	**Bergen**	**Pierce NWR**	**Homestead**	**Pierce County**	**Mason County**
Population Structure	Single population						
Number of Populations	1						
Breeding System	Polygynous						
Age of First Breeding – Female (years)	10						
Age of First Breeding – Male (years)	10						
Maximum Breeding Age (Longevity)	50						
% Adult Females Breeding Annually (SD)	90 (10)	90 (10)	90 (10)	90 (10)	90 (10)	90 (10)	90 (10)
Sex Ratio of Offspring at Birth	50:50	50:50	50:50	50:50	50:50	50:50	50:50
Maximum No. Clutches / Female / Year	2	2	2	2	2	2	2
Females with one clutch	90%	90%	90%	90%	90%	90%	90%
Females with two clutches	10%	10%	10%	10%	10%	10%	10%
Maximum Clutch Size	12	12	12	12	12	12	12
Clutch Size Distribution (%)							
1 offspring	1.2	1.2	1.2	1.2	1.2	1.2	1.2
2 offspring	1.2	1.2	1.2	1.2	1.2	1.2	1.2
3 offspring	3.3	3.3	3.3	3.3	3.3	3.3	3.3
4 offspring	9.0	9.0	9.0	9.0	9.0	9.0	9.0
5 offspring	16.6	16.6	16.6	16.6	16.6	16.6	16.6
6 offspring	25.9	25.9	25.9	25.9	25.9	25.9	25.9
7 offspring	18.7	18.7	18.7	18.7	18.7	18.7	18.7
8 offspring	14.8	14.8	14.8	14.8	14.8	14.8	14.8
9 offspring	6.3	6.3	6.3	6.3	6.3	6.3	6.3
10 offspring	1.8	1.8	1.8	1.8	1.8	1.8	1.8
11 offspring	0.9	0.9	0.9	0.9	0.9	0.9	0.9
12 offspring	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Female Mortality (%)(SD)							
0 – 1 Year (hatchling)	90 (5)	90 (5)	90 (5)	90 (5)	90 (5)	90 (5)	90 (5)
1 – 2 Year (juvenile)	20 (4)	24 (3)	20 (3)	16 (3)	20 (3)	8 (3)	20 (3)
2 - 3	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
3 – 4	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
4 – 5	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
5 – 6	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
6 – 7	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
7 – 8	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
8 – 9	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
9 – 10	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
10+ (adult)	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
Male Mortality (%)(SD)							
0 – 1 Year (hatchling)	20 (4)	90 (5)	90 (5)	90 (5)	90 (5)	90 (5)	90 (5)

		Columbia River Gorge				South Puget Sound	
Parameter	**Baseline**	**Sondino**	**Bergen**	**Pierce NWR**	**Homestead**	**Pierce County**	**Mason County**
1 – 2 Year (juvenile)	10 (3)	24 (3)	20 (3)	16 (3)	20 (3)	8 (3)	20 (3)
2 - 3	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
3 – 4	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
4 – 5	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
5 – 6	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
6 – 7	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
7 – 8	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
8 – 9	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
9 – 10	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
10+ (adult)	10 (3)	12 (3)	10 (3)	7 (3)	10 (3)	4 (3)	10 (3)
Inbreeding Depression?	No	No	No	No	No	No	No
EV Concordance in Survival, Reproduction?	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Catastrophes?	No	No	No	No	No	No	No
Males in Breeding Pool (%)	100	100	100	100	100	100	100
Current Population Size	194	246	86	41			
Carrying Capacity	500						

The Western Pond Turtle in Washington: A Population and Habitat Viability Assessment

13 – 15 November 2012
Olympia, Washington

Section 5
Western Pond Turtle Populations Working Group Report

Western Pond Turtle Populations Working Group Report

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Problems and Issues

The Population Working Group identified three primary problems:

1. Low juvenile recruitment of wild western pond turtles is a problem because the population cannot be self-sustaining without improved juvenile survivability. The low recruitment we believe is due to:
    a. Low hatch rate at some sites (e.g., Mason County) and in some years (e.g., Pierce County), based on anecdotal evidence, low hatch rate is probably due to poor nest conditions, nest predation, low fertility, egg infection and poor adult nutrition.
    b. Low hatchling survival - juvenile mortality appears to be high because of high predation, especially by invasive bullfrogs and bass; reduced habitat and food; possibly toxins; and human activities, such as recreational ATVs and management activities like vegetation removal. An important related issue is that we do not have robust site specific estimates of the factors affecting juvenile recruitment at our six population locations.

2. Adult and sub-adult survival is important for sustaining a healthy western pond turtle population. Five issues possibly affecting their survival rates are of concern:
    a. Disease, especially ulcerative shell disease.
    b. Water quality, including toxins.
    c. Mortality from road kill.
    d. High predation (e.g., mink, otters, bald eagles and coyotes).
    e. Disruptive site management activities.

    Unknown details of these concerns include the uncertainty about the cause of shell disease or its ultimate impact on the population (e.g., adult mortality or reduced reproduction) and the risk of disease from our management activities, both *in-situ* and *ex-situ*.

3. Because of a small founder population of just 10 animals, genetic diversity is probably low at the Pierce County and Mason County sites. This low diversity could affect fitness of individuals and long-term population viability because of deformed individuals and other factors reducing survival and population numbers.

Data Assembly

Problem 1: Low juvenile recruitment

Factor	Facts or Evidence	Assumptions	How we justify assumptions	Missing data that would help us
Low hatch rate	No hatch rate estimate for wild population as we headstart all eggs. The average captive hatch rate for the Pierce County site is about 46%.	Hatch rate is low in wild and in captivity because of variable environmental events, poor egg condition and/or issues associated with captive incubation and husbandry.	Data collected on hatch rates of head-started eggs only.	Determine wild hatch rates and factors influencing them. Determine causes of low hatch rates in head-started eggs.
Low hatchling survivability	Wild hatchlings – no data available. Head-starts have high survivability while in captivity (90% at WPZ) and in first year after release to wild (75% for the Pierce County site).	First-year hatchling survival will be higher in head-started turtles than in wild turtles [due to their larger size at release date].	Data collected on hatchling survival rates from head-started turtles. Information on bullfrog, bass and other predator predation rates on hatchling western pond turtles.	Survival rate estimates of wild hatchlings from hatching to second year. Causes of mortality of wild hatchlings. Hatchling survival at sites without bullfrogs or bass.

Problem 2: Adult and Sub-adult Survival Concerns

Factor	Facts or Evidence	Assumptions	How we justify assumptions	Missing data that would help us
Disease	Ulcerative shell disease is known at two of the six recovery sites. Ulcerative shell disease is progressive and normally causes death in advanced stages.	Disease could have significant effects on morbidity and mortality. Diseased animals may have lower fitness, survival and reproductive potential.	Case reports.	Epidemiology of disease. Survival and reproduction rates of infected turtles.
Water quality, including toxins	The affect of poor water quality on captive turtles and other aquatic species reported in	Poor water quality is likely affecting turtle health in a negative way at	Based on reports in the literature and observations of ulcerative shell disease at two sites.	Water quality data for each site.

	literature.	the Pierce County site.		
Road kill	Low concern			
High predation	Low concern			
Disruptive management	Low concern			

Problem 3. Low Genetic Diversity

Factor	Facts or Evidence	Assumptions	How we justify assumptions	Missing data that would help us
Low genetic diversity at Pierce and Mason County sites.	The population was started with only 10 founders and very skewed founder representation.	With this low genetic base there is strong possibility of reduced population fitness.	Genetic and population biology. Knowledge of founding population.	Update pedigree analysis and need to increase genetic diversity.

Do we have site-specific data that can more effectively inform our *VORTEX* models?

	South Puget Sound Sites		Columbia River Gorge Sites			
Parameter	**Pierce County**	**Mason County**	**Sondino**	**Pierce**	**Bergen**	**Homestead**
% Adult Breeders	Yes	Yes	Yes	No	No	No
% Double Clutch	Yes	?	No	No	No	No
Eggs/Nest	Yes	Yes	Yes	No	Yes	No
Hatchling sex ratio	No	No	No	No	No	No
Hatching mortality for head-start	Yes	Yes	Yes	No	No	No
Hatching mortality for wild	No	No	No	No	No	No
Juvenile mortality (1-2 year old)	Yes (one study)	No	No	Yes	No	No
Sub adult (2-10 years) and adult (10+ years) mortality	Yes	No	Yes	Yes	Yes	No
Initial population size	Yes	Yes	Yes	Yes	Yes	Yes
Carrying capacity (rough)	Yes	Yes	Yes	Yes	Yes	Yes

Goals

For each of the problem statements described earlier in this section, the working group participants developed management goals to address these problems. Finally, the group placed these goals in order of priority in terms of their effectiveness in advancing western pond turtle conservation in Washington state.

<u>Improve juvenile recruitment</u>

- Obtain or improve estimates of hatchling and juvenile age class survival rates at each population site.
- Better understand how soil conditions affect nesting success and hatch rate.
- Better understand predation, especially the impact of bullfrogs and bass.
- Obtain estimates of wild hatch rate at each population site.

<u>Adult and sub adult survival</u>

- Understand the epidemiology of shell disease, survival rate of affected individuals, and effects on reproduction.
- Develop guidelines from the literature for key water quality factors and monitor key factors at the Pierce County site [note that Pierce County is the only recovery site largely surrounded by development, primarily housing].
- Estimate cause specific mortality rates for adults.
- Develop a policy for predator control.
- Schedule management actions to avoid impacting turtles.

<u>Low genetic diversity</u>

- Assess and determine if management/research actions should be taken to address genetics.

Priority Goals

1. Understand the epidemiology of shell disease, survival rate of affected individuals, and effects on reproduction.
2. Obtain or improve estimates of hatchling and juvenile age class survival rates at each population site.
3. Estimate cause-specific mortality rates for adults.
4. Develop guidelines from the literature for key water quality factors and monitor key factors at Pierce County.
5. Better understand predation, especially the impact of bullfrogs and bass on hatchling and small juvenile turtles.

Actions

Problem Statement 1
Adult and sub adult survival are important for sustaining a healthy western pond turtle population; five issues affecting their survival rates are of concern: 1) disease, especially shell disease; 2) water quality, including toxins; 3) road kill; 4) high predation (e.g., mink, otters, bald eagles and coyotes); and 5) disruptive site management activities.

Goal 1 (Priority 1)
Understand the epidemiology of shell disease, the survival rate of affected individuals, and effects on reproduction.

Action 1: <u>Begin an epidemiological review of shell disease by pulling together and summarizing existing information from our own data (e.g., WDFW, WPZ, OZ). Make recommendations.</u>

Responsible Parties: Kristin Mansfield and Harriet Allen (and/or find a consultant to do this).
Timeline: One year (began this season—2013—at the Pierce County and Mason County sites, and one Columbia River Gorge site)
Outcome: Some expected outcomes: Determine the incidence at the sites. Determine the severity of the issue and determine next steps. Help design needed research.
Collaborators: Darin Collins, Tim Storms, Tammy Schmidt, Fred Koontz, other outside experts (e.g., Dr. Adolf Maas).
Costs: Mostly staff time and possible cost of consultants.
Consequences: Necessary step to understand and address the disease.
Obstacles: Not prioritizing and not meeting deadline.

Action 2: <u>Create a standardized shell disease field assessment and monitoring plan for field biologists.</u>

Responsible Parties: Regional biologists, stakeholder veterinarians and outside partners.
Timeline: April 2013.
Outcome: Better knowledge for better health management.
Collaborators: Mike Gardner – Northwest ZooPath, the contract pathologist used by Oregon Zoo and Woodland Park Zoo.
Costs: Staff time, lab analysis.
Consequences: Inconsistent data collection among sites will impede our ability to better understand shell disease.
Obstacles: Additional workload on WDFW biologists, veterinarians, etc.

Action 3: <u>Create an intervention and treatment plan for infected turtles. For example, at what point do you bring in animals from the field?</u>

Responsible Parties: Zoo vets (Darin Collins and Tim Storms).
Timeline: April 2013 to 2014.
Outcome: More standardized and consistent treatment based on a decision tree resulting in higher turtle survival.
Collaborators: Kristin Mansfield, zoo veterinarians, other outside experts (e.g. Dr. Adolf Maas)
Costs: Staff time and treatment costs, husbandry costs.
Consequences: Turtles might be better cared for with increased survival and we will better understand the disease.
Obstacles: With a better plan we will have more follow up and a better understanding of costs.

Action 4: Create a Health Team for the WPT Working Team.

Responsible Parties: Vets from the stakeholder's intuitions and some regional biologists.
Timeline: February 2013 and then on-going.
Outcome: Ensure that health relevant data (including annual estimates of morbidity and mortality) are regularly reviewed so that this information and the Health Team's recommendations are incorporated in the adaptive management of western pond turtles in both the wild and captivity.
Collaborators: Tammy Schmidt, nutritionist, and epidemiologist.
Costs: Staff time, which could be significant.
Consequences: The team would serve as an advisory team for the WPT Working Team.
Obstacles: Scheduling.

Goal 2 (Priority 3)
Estimate cause-specific mortality rates for adults.

Action 1: Design a study to estimate rates and causes of mortality for adults at the Sondino site or Bergen site (both Columbia River Gorge) and/or the Pierce County site.

Responsible Parties: Matt Vander Haegen and collaborators.
Timeline: October 2013.
Outcome: Summarize data we already have on the issue, which should enable us to determine if a full research proposal is needed including age and sex cohort mortality rates.
Collaborators: David Anderson, Eric Holman, Shannon Knapp, Fred Koontz, Michelle Tirhi, David Shepherdson, Jeff Skriletz, and Jerry Novak.
Costs: Staff time and potential research funding.
Consequences: Study costs – aim for 2014.
Obstacles: Fitting into staff work plan.

Discussion**:** Estimating cause-specific mortality rates for juveniles was done by tracking head-started juveniles with telemetry at the Pierce NWR site in the Columbia River Gorge. The study tracked 2–5-year age class turtles. We have not evaluated reproductive animals; WDFW has regularly monitored females to find nest sites. Pierce County and Mason County sites each had about 35 females with radio-transmitters deployed in 2012 (the number of females tracked increases over the years as more females reach sexual maturity). The PVA portion of this workshop has emphasized the importance of adults to the overall viability of the population. This leads us to wonder if our mortality rates might be unacceptable (e.g., too high). To determine cause of death we must get to the animals quickly. Is predation often the cause of death, or are they predated post-mortem? Mortality sensors might help to reduce labor costs. Any dead animals should have a necropsy performed. Aim is to have the study start in 2014.

Goal 3 (Priority 4)
Develop guidelines from the literature for key water quality factors and monitor water quality at the Pierce County site.

Action 1: Identify water quality parameters and develop a plan to monitor water quality relevant to western pond turtle health.

Responsible Parties: Michelle Tirhi.
Timeline: February 2013.
Outcome: Better scope of work for monitoring water quality and costs.
Collaborators: Veterinarians from Health Team; aquatic specialist.

Costs: Staff time, but implementation would include kits and analyses.
Consequences: Improved understanding of water quality and its impacts on western pond turtles.
Obstacles: None.

Discussion: We need to consult with our Health Team and experts to determine water parameters to be tested that might be affecting turtles. Which sites should we study? How difficult and how expensive would it be? We might need another meeting with veterinarians – especially relevant to shell disease. In addition, we can measure water quality parameter for bullfrogs. This could perhaps be important to understand their population-level requirements, and how to manage bullfrogs more effectively. Be sure to link this information to the shell disease issue.

Goal 4 (Priority 5)
Better understand predation on western pond turtles, especially the impact of bullfrogs and bass.

Action 1: Conduct a literature review and consult with fish experts to better judge if bass can be a significant cause of mortality for hatchlings.

Responsible Parties:
Timeline:
Outcome: Understand whether removal of bass thru potential seining may be appropriate at current and proposed recovery sites and whether bass release at or near these sites should be discontinued. Also, correct any misconceptions about the contribution of bass to western pond turtle mortality.
Collaborators: WDFW Fisheries biologists
Costs: none expected
Consequences: We could rule this issue out or know if we need to pursue.
Obstacles: staff time

Discussion: There is a technique to measure a water chemistry factor or environmental DNA (eDNA) to confirm the presence of bullfrogs – will give high, low or absent. Should we spend our time on bass? Check the literature.

Problem Statement 2
Low juvenile recruitment of wild western pond turtles is a problem because the population cannot be self-sustaining without improved juvenile survivability.

Goal 1(Priority 2)
Obtain or improve estimates of hatchling and juvenile age class survival rates at each population site.

Action 1: Design a study to estimate wild hatchling survival, probably at the Sondino site or Bergen site in the Columbia River Gorge and/or the Pierce County site in South Puget Sound.

Responsible Parties: Matt Van der Haegen and collaborators.
Timeline: October 2013.
Outcome: We will know if we can conduct a study.
Collaborators: Shannon Knapp, Michelle Tirhi, David Anderson, Jeff Skriletz, Jerry Novak
Costs: Staff time.
Consequences: Wild hatchling survival rates can be compared to head-start hatchling survival and allow us to determine if either is more conducive to recovery efforts.
Obstacles: Fitting into staff workplan.

Discussion: In the past, hatchling survival was zero or near zero, but now we are finding hatchlings at the Sondino site of the Columbia River Gorge (e.g. Jerry found 30 in 2012), and one at the Pierce County site. We could possibly remove fewer eggs and follow the hatchlings (how?) which results in fewer animals for head-starting.

Assumption: The Sondino site and Bergen site of the Columbia River Gorge have wild hatchlings that could be studied.
Hatchling in nest; travel to pond; in pond. We could mark with permanent bead dots and assume that after 2 – 3 years they could be captured. At the Pierce County site we might be able just enclose the nest and collect the hatchlings. It might be possible to track the hatchlings. Do we need survival estimates at both first and second year? We know head-started juvenile survival is high but we do not know wild juvenile (1 – 2 years) survival because the head-started turtles are larger (functionally older). Jerry is able to collect hatchlings in the ponds by walking perimeter or by kayak. Jerry works 3 – 5 hours a day between early May to June (he stops looking for nesting females in June). Michelle does not have time at her site. At the Sondino site some hatchlings are collected, and at the Pierce County site they track females and find nests. Woodland Park Zoo is reaching capacity with their head-start program and so might not be able to send all eggs from the Pierce County site to Woodland Park Zoo for head-starting. We also could consider use of drift fences to catch hatchlings. Mortality of hatchlings might include land management activities that occur while the turtles are moving from the nest to the pond, which takes at least nine days. Shannon warns us that independence for statistical analysis is a problem for this type of study because the animals in one nest are a problem.

Action 2: Design a study to estimate juvenile (1 – 2 years old) survival probably at either Sondino or Bergen site of the Columbia River Gorge, and/or Pierce County.

Responsible Parties: Matt Vander Haegen and collaborators.
Timeline: October 2013.
Outcome: We will know if we can conduct a study on this issue.
Collaborators: Shannon Knapp, Michelle Tirhi, David Anderson, Jeff Skriletz, Jerry Novak.
Costs: Staff time.
Consequences: A better understanding of juvenile survivorship.
Obstacles: Fitting into staff work plan.

Problem Statement 3

Because of a small founder population of 10 animals, genetic diversity is probably low at the Pierce County and Mason County sites. This low diversity could affect fitness of individuals and long-term population viability because of deformed individuals and other factors reducing survival and population numbers.

Action 1: Investigate the probable consequences of small founder population at the Pierce County and Mason county sites; estimate genetic base of Columbia River Gorge populations; and report recommendations to the Working Group. [Statement added after the workshop.]
Responsible Parties: Fred Koontz.
Timeline: February 2014.
Outcome: Recommended follow-up actions.
Collaborators: Michelle Tirhi, David Anderson, Jeff Skriletz.
Costs: Staff time.
Consequences: Improved genetic management.
Obstacles: Fitting into staff work schedules.

The Western Pond Turtle in Washington:
A Population and Habitat Viability Assessment

13 – 15 November 2012
Olympia, Washington

Section 6
Western Pond Turtle Habitat Working Group Report

Western Pond Turtle Habitat Working Group Report

Working Group members:
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Problems and Issues

Working group participants used a brainstorming session to develop the following list of problems and issues related to habitat concerns for western pond turtle conservation in Washington:

- Lack of nesting habitat (lack of habitat)
- Succession change
- Lack of habitat at landscape level
- Lack of habitat at existing/occupied site level
- Fire suppression
- Hydrologic alteration/Toxics
- Loss of grazers
- Salmon habitat restoration = loss of habitat
- Development
- Landowner management preferences
- Competing use of resources
- ATVs
- Behavior philopatry
- Private lands (land management practices)
- Degraded aquatic habitat
- Lack of habitat control
- Lack of connectivity/Low migration/Immigration
- Low genetic diversity
- Low prey abundance

<u>Management Issues</u>
Lack of influence on habitat quality, management constraints, lack of management control at occupied sites, competing use of different resources, landowner preference of management, ownership, MOUs – why is lack of control a problem? WDFW can't implement management options if they don't have management authority on the habitat. Ownership may limit management flexibility. Not site specific – a generalization that encompasses the problems that arise for the whole of recovery. Management of nesting habitat is needed. Multiple landowners with multiple objectives make management difficult.

The group then synthesized this list into four primary issue statements:

1. There are an insufficient number of sites to reach the goal of seven sites as identified in the Western Pond Turtle Recovery Plan.
2. Resources are limited to create and maintain enough suitable habitat at occupied sites.
3. Managers experience an inability to control all habitat (land/water/people) management at sites.
4. The recovery objectives for individual sites and the full recovery plan need to be updated.

<u>Issues at the site / landscape level</u>
To recover the western pond turtle in Washington**:**
In the 30 years since species recovery was initiated, finding sites with suitable aquatic and terrestrial habitat have proved challenging; without sufficient sites, recovery cannot be achieved. Some occupied sites lack suitable nesting habitat and may be limited in aspects of aquatic habitat. Resources are limited to create/maintain enough suitable habitat. Sufficient nesting habitat in particular has been difficult to maintain.

We have a certain number of sites as a target – but there are an insufficient number of sites to achieve the recovery objectives.

Conflicting issues: Some occupied sites do not contain appropriate conditions. There is a lack of actual nesting habitat. Aquatic habitat may be unsuitable. Some sites have inappropriate habitat for successful nesting.

At the end of their deliberation, the group developed the following problem statements:

1. Since western pond turtle recovery was initiated, finding sites with suitable aquatic and terrestrial habitat has proved challenging because historic habitat has been lost (e.g., prairie and backwater channels) and remaining habitat is suboptimal and has not met all site suitability criteria (e.g., ownership issues, nesting habitat availability). Without sufficient sites, recovery cannot be achieved.

2. Many threats to western pond turtle habitat exist at occupied sites. Financial, ecological, and human resources are limited to create/maintain enough suitable habitat; in particular some occupied sites lack suitable nesting habitat.

3. Due to multiple landowner objectives, there is an inability to effectively manage western pond turtle habitat.

Data Assembly

1. Not enough sites to recover the western pond turtle.
Site challenges: Available sites are sub-optimal. Some may not be (natural or) historical habitat. This applies to the sites we have. Sites with potential don't meet all the criteria, or we can't get access. Possible sites are degraded or destroyed.

2. Resources are limited to create and maintain enough suitable habitat at occupied sites.
Resources are defined as financial, ecological, and human.

3. Inability to control all habitat (land/water/people) management at sites.
A variety of landowner challenges exist (e.g., Joint Base Lewis-McChord). The recent tough economy has slowed sprawl, once the economy improves it is likely that the remaining available land will be developed. What's lost is the historic habitat. What we have to choose from is a remnant of the original wetlands habitat.

Discussion: There likely are insufficient data to do a site suitability analysis – this should be included in our goal statements. Locating more sites is important. There is no historic habitat – the remaining habitat is suboptimal, so we know we have to pick suboptimal sites moving forward. Suitable habitat is but one element of a sufficient site. There may be numerous suitable habitat sites, but we need to obtain and control them. We need to find sufficient sites. Not limited to finding suitable sites in the Columbia River Gorge. We need to identify two more sites in Puget Sound for reintroduction. Money is one of the key factors prohibiting achieving our recovery goals. Short-term and long-term goals – perhaps adding one site within the next five years in Puget Sound? We also need to address the salmon issue right now, i.e., salmon habitat restoration at Pierce NWR in the Columbia River Gorge. Nisqually Tribe representatives remember that turtles were there historically – has WDFW followed up on that opportunity? At some point do we need to just allow turtles to hatch out and see what happens? Off-road vehicle enthusiasts in Mason County area are ruining the trails and the habitat – the capacity for retaliation is great given the circumstances – haven't been a huge problem yet, but the potential is there – several boats have been stolen so far.

Goals

For each of the problem statements described earlier in this section, the working group participants developed management goals to address these problems. Finally, the group placed these goals in order of priority in terms of their effectiveness in advancing western pond turtle conservation in Washington state.

Inadequate number of sites
- To identify and establish one new site in Puget Sound within the next five years, to re-establish western pond turtle populations.
- Identify a back-up site in the Columbia River Gorge (another possible site for reintroduction).

Limited resources
- Address the key factors limiting recovery at each site in Puget Sound and the Columbia River Gorge.
- Identify and manage for nesting habitat at Bergen, Pierce NWR, and Homestead sites in the Columbia River Gorge, and the Mason County site in South Puget Sound.
- Minimize the impact of salmon habitat restoration on western pond turtles at Pierce NWR in the Columbia River Gorge.
- Expand population capacity at the Pierce County site in South Puget Sound.
- Continue bullfrog eradication at the Sondino site in the Columbia River Gorge.

Inability to control management
- Develop a land management plan between WDFW and US Forest Service for management of the Bergen site in the Columbia River Gorge.
- Acquire remaining private property/ownership as part of the Bergen site in the Columbia River Gorge.

Priority goal list

- To identify and establish one new site in Puget Sound within the next five years, to re-establish western pond turtle populations.
- Identify a back-up site in the Columbia River Gorge (another possible site for reintroduction).
- Minimize impact of salmon habitat restoration on western pond turtles at Pierce site of the Columbia River Gorge.
- Address the key factors limiting recovery at each site.
- Identify and manage for nesting habitat at Columbia River Gorge's Bergen and Homestead sites and at Pierce County and Mason County sites.
- Develop a land management plan between WDFW and US Forest Service for management of the Bergen site in the Columbia River Gorge.
- Expand population capacity at the Pierce County site.
- Acquire remaining private property/ownership as part of the Bergen site in the Columbia Gorge.
- Continue bullfrog eradication at the Sondino site of the Columbia River Gorge.

Actions

Discussion: Homeowner associations – can they be a possible option for sites given the more insular nature of the locations? Richfield National Wildlife Refuge – is that a better option? This site having a different manager presents an issue. Should we revise our top goal to look at sites that are in the "west" as opposed to Puget Sound? Can a new site sustain itself over time? It is our intent that all recovery sites are self-sustaining. Rainfall at the Pierce County site is higher than any other location – the consequences of this on turtle development and hatchling survival is unknown currently. We're already at the northern edge of the species' distribution and range; trying to force a new site into the Puget Sound footprint may be compounding a problem. If we change the goal from Puget Sound, that frees us up rather than limits us – should we look beyond Puget Sound? If we're serious about maintaining populations in Puget Sound, we can't wait another 5–10 years, especially given the rate and impact of development. We need to develop background information that prevents Puget Sound from being a black hole in recovery. Does a site evaluation plan exist for new sites? Does it need more than what currently exists – predicts probability of potential sites? Site visits should take seasonal variability into consideration. Once a population is established should we cease headstarting and allow for natural, undisturbed nesting and hatching?

Problem Statement 1
Not enough sites to recover the western pond turtle.

Goal 1(Priority 1)
Identify and establish one new site on the west side within next five years to re-establish western pond turtle populations.

Action 1: Compile a list of potential sites for consideration

- Perform GIS analysis using established criteria
- Request professional insight (include landowners, NGOs)
- Evaluate GIS info
- Perform site visits to verify features

Responsible Parties: District biologists, WDFW, other turtle experts
Outcome: A list of selected sites.
Timeline: Completed by June 2013.

Responsibility: Harriet Allen, WDFW GIS shop.
Total Cost : $15,000 – to include GIS, District Bio, experts and species manager.
Consequences: These don't get done.
Obstacles: GIS staffing (maybe).

Action 2: Conduct evaluation of selected sites (from Action above)

- Identify source population and begin headstarting.
- Secure funding for head-starting (estimated $25,000).
- Evaluate each site using developed protocols and identify any site management needs.
- Select sites.

Responsible Parties: WDFW and experts / head-starting responsibility lies with zoos.
Timeline: June 2015.
Cost: $45,000.
Consequences: Sites.
Obstacles: None.

Action 3: Secure the site(s) – obtain: acquisition, MOU, easements

Responsible Parties: WDFW regional staff.
Timeline : June 2015 to June 2016.
Cost : $15,000 if no acquisition, if acquisition – unknown.
Obstacles: landowner management or preference issues.
Consequences: securing site.
Collaborators: landowners.

Action 4: Perform site preparation and translocate turtles to site.

- Vegetation management, habitat enhancement (basking logs, fencing).
- Coordinate with zoos (animal handling and identification, disease evaluation) (estimated $5,000).
- Implement monitoring protocols.

Responsible Parties: Zoos, WDFW, experts.
Timeline: No later than 5 years – August, 2017.
Cost: $10,000 – $25,000.
Obstacles: No source turtles, funding, disease issues, no translocation.
Consequences: Site prepping and translocating.

Problem Statement 2
Resources are limited to create and maintain enough suitable habitat at occupied sites.

Goal 1 (Priority 3)
Identify and manage for nesting habitat at Columbia River Gorge's Bergen and Homestead sites and South Puget Sound's Pierce County and Mason County sites.

Action 1: Identify turtle nesting areas at Pierce and Homestead sites in the Columbia River Gorge. Radio track gravid females to locate nesting sites.

Responsible Parties: WDFW.
Timeline: 7 years.
Outcome: Successfully identify nests.
Collaborators: USFWS.
Cost: Telemetry - $140,000.
Consequences: Better understanding of nesting habitat/use at these sites.
Obstacles: No funding for telemetry.

Action 2: Manage for suitable nesting habitat conditions (grass/forb dominance) at Bergen, Pierce NWR, and Homestead sites in the Columbia River Gorge and the Pierce and Mason county sites in South Puget Sound and maintain travel corridors.

- Conduct annual habitat management at known nest sites to prevent overgrowth of problematic vegetation, as needed per site.
- Manipulate/supplement nesting substrate to promote nesting use.
- Implement monitoring for nesting success (no consensus on this item).

Responsible Parties: WDFW.
Timeline: Annual.
Outcome: Nesting habitat is maintained.
Collaborators: USFS, DNR, WCC, FWS, SPKs.
Cost: $10,000 per year.
Consequences: Improve nesting habitat.
Obstacles: Funding.

Goal 2 (Priority 9)
Continue bullfrog elimination at the Sondino site.

Action 1: Capture and euthanize all life stages of bullfrogs at the Sondino site in the Columbia River Gorge.

- Remove egg masses.
- Timeline: June/July specific.
- Remove tadpoles.
- Remove newly metamporphed froglets / subadults.
- Remove adults.
- If bullfrogs are eliminated – monitor for reinvasion.

Responsible parties: WDFW.
Timeline: Ongoing.
Outcome: Increased survival of hatchling & juvenile turtles.
Collaborators: Woodland Park Zoo (egg mass removal only).
Cost: $20,000/year.
Consequences: Enhanced likelihood of self-sustaining population.
Obstacles: Difficulty of the task, coming to consensus on the protocols.

Problem Statement 3
Inability to control all habitat (land/water/people) management at sites.

Goal 1 (Priority 2)
Prevent adverse impacts of the proposed salmon restoration on the western pond turtle habitat at Pierce National Wildlife Refuge site in the Columbia River Gorge.

Action 1: Ensure viability of suitable western pond turtle habitat at Pierce National Wildlife Refuge.

- <u>Participate in interagency salmon restoration feasibility analysis.</u>
- <u>Provide biological data on western pond turtle habitat needs.</u>
- <u>Ensure western pond turtle wildlife values are incorporated into project analysis.</u>

Responsible Parties: WDFW (David Anderson).
Timeline: 2012 thru 2013.
Cost: $3,000.
Outcome: Maintain WPT habitat at Pierce.
Collaborators: USFWS, USACE, BPA.
Consequences: Preserving pond turtle habitat, inaction would lose recovery site.
Obstacles: Fish and Wildlife Service priorities for managing the refuge.

Table 5-1a. Data assembly and analysis for Habitat Working Group.

Problem 1 - Site: Puget Sound				
Facts	**Assumptions**	**Information Gaps**	**Regional Specificity**	**Bibliography**
Two sites currently managed, haven't been able to identify alternate public sites	The majority of historic habitat (prairie) is either gone or unavailable for translocation	Need GIS analysis of Puget Sound. Uncertainty about other geographic locations to consider.	Lower Puget Sound - includes King, Pierce, Mason, Thurston Counties	
		Uncertainty of geographical extent of areas that should be considered	Kitsap, Snohomish and Lewis Counties	
Problem 1 - Site: Columbia River Gorge				
Facts	**Assumptions**	**Information Gaps**	**Regional Specificity**	**Bibliography**
4 sites currently managed				
4 sites require active land management	Even the historic habitat is suboptimal and requires management because of invasive flora and fauna	Extent and use of nesting habitat is uncertain.	Skamania County	David Anderson / Slavens
3 historic sites historic, 2 newly-established sites	Alternative sites are available but need management	Landscape level analysis for the Gorge - suitable habitat. (GIS analysis)	Skamania County	David Anderson / Slavens

Table 5-1b. Data assembly and analysis for Habitat Working Group.

H = High Threat
M = Medium Threat
L = Low Threat
Recommendations: how much effort needs to go into management of sites to maximize its benefit and how much into finding new sites. Rank by giving rough qualitative value of Low/Medium/High.

Problem 2 & 3									
	Sondino site in the Columbia River Gorge (WDFW)	**Bergen site in the Columbia River Gorge (USFS)**	**Pierce site in the Columbia River Gorge (NWR)**	**Homestead site in the Columbia River Gorge (SP)**	**Pierce County site (WDFW) in South Puget Sound**	**Mason County site (DNR) in South Puget Sound**	**New Puget Sound Site**	**New Columbia River Gorge Site**	**Potential new site at Wolf Haven in Thurston County (private)**
Successional change (natural shrubs, trees)	L	H	M	M	L	M			M
Hydrologic alternatives	M	L	H	M	NA	L			L
Salmon habitat restoration	L	L	H (considered for chum restoration project)	L	L	L			L
Development	L	L	L	L	L	L	H	L	H if not acquired
Landowner management preferences	L	M	H	L	L	H	H (Fort Lewis)	M	L-M dependant on owner
Competing resource uses	L (manage specifically for turtles)	H (elk hunting, land owners)	H	L	M (hatchery/ dog walkers)	H	H	M	M
Degraded aquatic habitat (toxins, hydraulic flush)	L	L	H (connected to the Columbia so concerns)	L	M	L	M		Unk
Lack of nesting habitat	L	M	Unknown	Unknown	L (nesting success at site if weather is right)	H	Unknown	Unknown	M
Invasive species: Flora	L	H (blackberry)	M	M	H (scotch broom, blackberry)	H	M (grasses, scotch broom, etc)	M	L

	Sondino site in the Columbia River Gorge (WDFW)	**Bergen site in the Columbia River Gorge (USFS)**	**Pierce site in the Columbia River Gorge (NWR)**	**Homestead site in the Columbia River Gorge (SP)**	**Pierce County site (WDFW) in South Puget Sound**	**Mason County site (DNR) in South Puget Sound**	**New Puget Sound Site**	**New Columbia River Gorge Site**	**Potential new site at Wolf Haven in Thurston County (private)**
Invasive species Fauna	H (Bullfrog)	H (Bullfrog)	M (Nutria)		L	L	H		H (bullfrog)
Climate change					H	H	H - ?	M	
Low impact recreational use	M (human disturbance, fishing)	M	L	M (open to the public)	L	H			L
High impact recreational use	L	M (some ATV, private land issues)	L	L	L	H (ATV)			L
Malicious vandalism toward the turtles (intent)	M (nests stolen, turtle shot)	M (turtle shot, habitat)	L	Too new to know	L	M (potential is there)			L
Roads / ORV trails / railroad tracks	H	H	M	H (Roads)	M (roads next to ponds, possibility of collecting turtles from there)	H			L
Uncontrolled access by people	M (fenced)	H (open to the public)	L	H	L	H			M
Site size related to carrying capacity	L	L	L	L	M (only 2 ponds - trying for a third)	L	Unknown	M	

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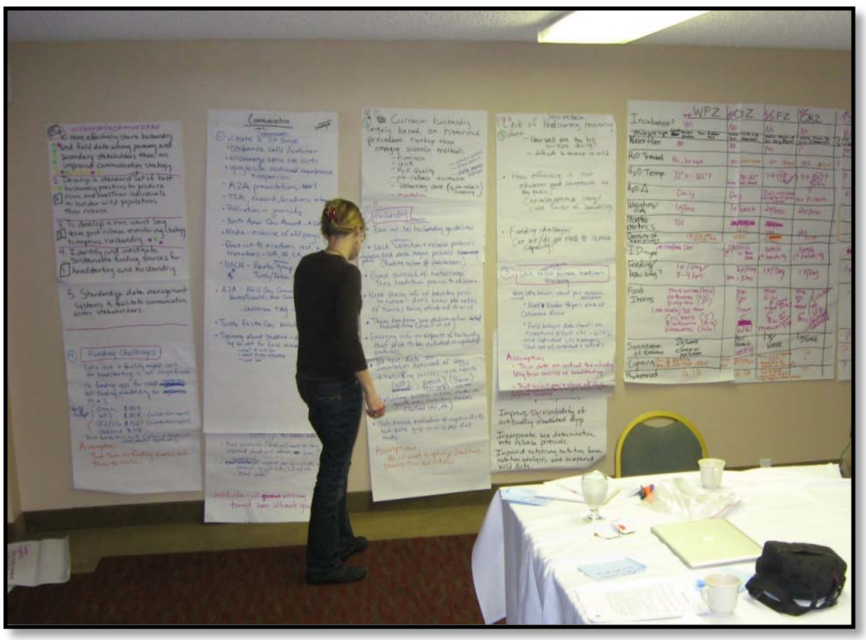

Section 7
Western Pond Turtle Husbandry Working Group Report

Western Pond Turtle Husbandry Working Group Report

Working Group members:
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Nick Geist, Sonoma State University
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Jerry Novak, Turtleworks, consultant for Woodland Park Zoo
Jenny Pramuk, Woodland Park Zoo
Karin Schwartz, Conservation Breeding Specialist Group
David Shepherdson, Oregon Zoo
Jeff Skriletz, Washington Department of Fish and Wildlife

Introduction

For the past 22 years, Seattle's Woodland Park Zoo (WPZ) and Oregon Zoo (ORZ) have conducted a headstarting program in which turtle eggs and/or hatchlings are collected from the wild, hatchlings are reared over the winter in controlled conditions, and juveniles are released back into wild habitats in Washington state when they reach about ten months of age in captivity (which is roughly equivalent to about three years of age when raised in the wild).

In California, San Francisco Zoo (SFZ), Oakland Zoo (OakZ), and Turtle Bay Exploration Park (Reading, CA) are involved in western pond turtle recovery through head-started releases in Northern California. They work together as one group, and also gain assistance from San Diego Zoo (SDZ).

Others that care for captive turtles or that study the species in the wild, but are not directly involved in any head-starting efforts include:

- Chelonian Conservation.
- Presidio Trust (arm of US Forest Service).
- Oregon Department of Fish and Wildlife.
- Oregon State University.
- Researchers at other academic institutions (UC Davis/UCLA).
- Sacramento Zoo.

The Husbandry Working Group discussed issues related to the *ex situ* component of the western pond turtle recovery program.

Problems and Issues

1. <u>There is a lack of adequate communication and standardization between stakeholder institutions that limits maximizing contributions to species recovery.</u>

Background:
Institutions involved in head-starting include:
Oregon

- Oregon Zoo (OrZ).

Washington

- Woodland Park Zoo (WPZ).

California

- San Francisco Zoo (SFZ).

- Oakland Zoo (OakZ).
- Turtle Bay Exploration Park (Reading, non-AZA).
- San Diego Zoo (SDZ).

There has been limited information exchange between institutions involved in head-starting programs, especially between zoos in different states. Husbandry and head-starting and release protocols differ between institutions.

2. Current husbandry is largely based on historical precedent rather than emerging scientific methods. Husbandry protocols include:
   - Nutrition.
   - Water quality.
   - Ultraviolet B radiation (short-wave rays).
   - Pre-release acclimation.
   - Veterinary care (e.g., pre-release screening).
   - Incubation.

Background:
Optimal nutrition for *ex situ* hatchlings is not well studied. Some papers on wild diet demonstrate that this species is carnivorous and an opportunistic predator. This species consumes dragonfly larvae and has a high protein, varied diet. Adults like to eat vegetation.

At WPZ, the diet protocol did not change until 2012. OrZ had a hatchling diet that was different from that being offered at WPZ. Some oily fish (*e.g.*, herring) might encourage poor water quality.
It has been suggested that hatchlings might be more susceptible to ulcerative shell disease once they are released to the wild because of suboptimal shell growth from inadequate nutrition or poor water quality. What is the optimal growth rate? The challenge is growing turtles for release in one year that are a minimum of 50 grams (WDFW cut-off for release), yet not so fast as to weaken the shell and underlying bone. There are no data on growth rate of hatchlings in the wild.

Are the calcium/sulfur blocks useful?

WPZ – Noticed that shells of captive-raised hatchlings are flatter and less colorful than wild hatchlings. Basking in natural sunlight seems to be important for optimal bone growth and coloration but no controlled studies have been performed on wild or captive hatchlings to test this. This is difficult to determine since wild hatchlings are cryptic and it is not known if or how often they are basking. UVB lights (e.g., ZooMed fluorescent bulbs and Powersun UVB/heat bulbs) have been used for captive raised hatchlings.

Currently, captive-raised hatchlings have to acclimate to the wild without a transitional period. Would it be helpful to include an acclimation period that is outdoors with varying temperatures prior to release? Now, they may have only brief exposure to natural sunlight and UVB bulbs are not as effective.

Pre-release health checks and screening that is performed differs between institutions. SFZ performs endoscopy for sex determination before release and included radiographs only one year. WPZ performs visual health exams and radiographs but does not perform endoscopy for sex determination. Oregon Zoo does not perform radiograph checks or endoscopy.

3. <u>There is a lack of monitoring data on post-release head-started hatchlings.</u>

Background:
Survival data would be useful to have to inform managers on success of releases and for adaptive management practice dependent on results.

Unfortunately, this species is very secretive and released hatchlings are difficult to monitor in the wild. Trapping is done in the spring with data sheets used to maintain monitoring records. There is a bias towards trapping bigger animals that are easier to catch. For example, >40% of last year's released animals would not have been captured.

4. <u>There are disease processes of uncertain origin affecting WPTs that might be originating during the head-starting process in captivity.</u>

Background:
Approximately 30% of adult turtles found at the Pierce County and Sondino sites show signs of ulcerative shell disease, with a greater percentage of females than males showing symptoms of the disease. The origin and characterization of the disease is unknown, with the possibility that head-starting conditions may pre-dispose these animals to contracting the disease as adults.

5. <u>There exist many areas of uncertainty regarding artificial incubation science.</u>

Background:
Incubation - incubation temperature affects sex determination

- Refining temperature fluctuation as per natural incubation might be important for survivorship and health of hatchlings.
- Sex ratios - sex is checked via endoscopy by SFZ prior to release.
  What is optimal sex ratio for release (in WA State, partner institutions have been rearing South Puget Sound hatchlings for a higher proportion of females; is this still optimal)?
- Refine current incubation parameters.
- Increase hatchability and decrease number of deformed hatchlings.
- Investigate optimal humidity.
- Soil moisture parameters in wild (different at different sites).
- Gestation – variable: 60 – 80 days. Eggs collected after 70 days by CA zoos.
- Are egg collection protocols different across institutions?

Other issues (no priority score)

<u>Lack of agreement on need for WPT captive breeding program by various stakeholders.</u>

Background:
Captive breeding component of WPZ WPT program was discontinued in 2010 with long-term captive breeding adults released back to the wild. Other institutions do not do captive breeding for release. Would captive breeding for release help increase genetic diversity of the wild population?

Are zoo education and outreach programs on WPT conservation effective for the public?

Background:
The conservation story is compelling and can capitalize/optimize with the "cute" factor of hatchlings.

Funding challenges: can we/do we need to increase capacity?

Background: Funding is always a challenge for head-starting programs: labor, electrical, feeding, release (SFZ - 50 animals/year, WPZ - >100 this year).
What are the cost-benefit considerations? OrZ has no evidence that head-started turtles fail to survive after release. But there's a lack of data so we don't really know how successful the head-starting efforts are.

Data Assembly

Discussion
Seems that cost-benefit should be a higher priority.

Shell disease will affect the whole program as this may compromise adult survivability and/or reproduction.

Communication
If ulcerative shell disease (UCD) is a problem, we need to communicate about this with all stakeholders. Shell disease wasn't even considered in California, but now scientists there will be looking for it. Communication is essential, and we need to be aware if there is some commonality between what is going on in the different sites and different head-starting institutions and that it might be possible that the protocols are contributing to this problem. It is unclear if ulcerative shell disease occurs spontaneously in wild populations.

Data gap: We do not understand the origin, cause, or epidemiology of UCD. We need more vets working on this issue and to perform biopsies and necropsies.

We need the field biologists to have a clear search image of UCD, and to survey CA populations for it. Besides communication, we need more active interaction between stakeholders.

WPZ held a meeting of the Washington Western Pond Turtle Working Group in September 2012 to discuss issues surrounding ulcerative shell disease in released animals. Minutes of this health meeting are available from Woodland Park Zoo's Field Conservation Department. Action steps to address the disease were made at this meeting. Dr. Kristin Mansfield, WDFW State Veterinarian, offered to develop guidelines and recommendations. One conclusion of the meeting was that stakeholders need to be proactive and submit grant proposals to support this work (*e.g.*, someone to do this as part of their graduate program or as a paid position).

Communication
WPZ writes a report every year. We could conduct conference calls to discuss what needs to be developed for a pond turtle list serve.

There may be a correlation between mortality and protocols for head-starting. We agree that incubation is really important; however, the incubation protocols differ between head-starting institutions. OrZ receives hatchlings collected from the wild. In Washington, only WPZ incubates WPT eggs. The SFZ program is linked to graduate student projects. Programs are working in two locations (CA) that are very different. SFZ collects eggs just prior to hatching and perform the last couple of weeks of incubation at a laboratory at Sonoma State. Gestation is 70–75 days. We recommend placing temperature sensors (e.g., Hobo dataloggers) in the wild nests. At Sonoma State, the turtle eggs are incubated at 28–29 degrees C. At Sonoma State, the shells of individual hatchlings are notched for identification. In the past, SFZ was unable to source bee dots (small plastic beads marked with different numbers for identifying individual turtles, used at WPZ and OrZ).

SFZoo group clips the hatchlings' shells when soft, when shell hardens, reinforce with shell glue. Bee dots are put on after a month of growth when available.

Morphometrics: only SFZ does them, should all zoos follow suit?
Many things affect morphometrics. Is it important to take those measurements to help inform biologists? Should this be standard protocol between institutions? CA institutions (OakZ and SFZ) have baseline of growth data. It is not that hard to take morphometric measurements. This could help determine optimal growth and thus an indication of growing too slowly or too quickly.

SFZ uses water filters on tanks and does not slope the tubs (as do OrZ and WPZ); last year SFZ didn't have enough water to run filters well, but the deeper water level encouraged hatchlings to move around more, even in small tanks. WPZ and OrZ do not use filters on their tubs, but rather use a dump-and-fill protocol with complete daily water changes.

1. <u>There is a lack of adequate communication and standardization between stakeholder institutions that limits maximizing contributions to species recovery.</u>

Who are the stakeholders?

Field work done by U. S. Geological Survey (USGS)

Head-starting organizations:
Animals released into Washington sites: Woodland Park Zoo, Oregon Zoo and WDFW

California:
San Francisco Zoo/Oakland Zoo
San Diego Zoo - husbandry protocols have not been provided
CA Fish and Game
USGS (works with SDZoo)

Not presently involved:
Sacramento Zoo (as per ISIS holdings: 6.1.89 {males.females.unknowns})
Private holders
Chelonian Conservation
Presidio Trust (arm of National Forest Service - doing restoration of site, providing care)
Oregon State University
Researchers at other academic institutions (UC Davis/UCLA)
Oregon Dept Fish and Wildlife
Turtle Town (may have western pond turtles)

Veterinarians - Adrian Mutlow (SFZ), Andrea Goodnight (OakZ), Darin Collins (WPZ), Mitch Finnegan and Tim Storms (OrZ). SFZ and Oakland are experts on endoscopy.

Currently there is no effective communication system between stakeholders.

Standardization:
Husbandry protocols need to be standardized and expanded.
Have husbandry manuals for SFZ, OrZ, WPZ; SDZ (promised but not received); OakZ (promised but not received).

Egg collection protocols and release protocols currently are not standardized and/or shared.
Data Management processes are not currently standardized.
Some institutions accession hatchlings, keep some records in ISIS but also use Excel spreadsheets for certain records, whereas other institutions do not keep records in ISIS even though they are ISIS members; some are using Zoological Information Management System (ZIMS), others are not.

Assumptions:
All stakeholders want to communicate more. No one is proprietary about information and all are open to information sharing.
All institutions use ISIS (ZIMS) or other data management system to facilitate information sharing.
Biologists (field, etc.) want to stay informed by *ex situ* managers and vice versa.
Communication can improve easily with little effort and at low cost (email, Google site, listerv).
Obvious justification is that we all have the same goal: working towards WPT conservation.

2. <u>Current husbandry is largely based on historical precedent rather than emerging scientific methods.</u>

Each institution has husbandry guidelines.
There has been good survival of hatchlings through the head-start process.
There has been sex determination research done (Geist et al., in press).
We know that work has been done in various aspects of husbandry (Dallara and Geist, manuscript in preparation).
Have data on incubation survival of eggs, hatching success (*in situ* and *ex situ*). Have incubation parameters effect on success - temperature, range, humidity.
Hatchling success to release.
Hatching success - growth rates (weights, but not all have morphometrics). Nutritional evaluations of diet.

Data gaps:
Lack shared incubation, egg collection and release protocols and data management protocols (see Table 2).
Different marking (identifying) system by stakeholders.
Not all release institutions know the sex of released hatchlings.
Nutrition studies have not been performed in the wild.

Assumptions:
Everyone has the common goal of trying to optimize the head-starting process through actions.

3. <u>There is a lack of monitoring data on post-release head-started hatchlings.</u>

Matt Vander Haegen's (WDFW) work at Columbia River sites; annual capture data (WDFW and WPZ) and long term (Murphie et al. 2012).

Data gap is huge. Need to know from population demographic view, and for head-starting success.

Assumptions:
These data are critical to evaluating long term success of head-starting.
We will pool and share all data and that will be a major factor to improve success.

4. Funding Challenges
Labor cost and facility management costs for head-starting are significant.
Few funding opportunities exist for staff salaries but funding is availability for materials and supplies.

Annual budgets
OrZ: $20,000 (*ex situ* component only)
WPZ: $80,000 (includes field support)
SFZ/Sonoma State University: $15,000 (includes field support)
OakZ: $10,000

Data gaps:
We don't know the true cost (salaried staff, vet care, volunteer support, etc.)

Assumptions:
There are funding sources out there to access.

Funding will be easier to access if we can quantitatively demonstrate success and progress toward the goal of self-sustaining WPT populations.

Add to matrix:
Source of eggs/hatchlings for each *ex situ* institution.
Where do hatchlings go following their release?

Genetics: the data are there, and there is a possibility for analysis; however we need to determine pedigrees in order to determine genetic diversity within the Washington population. There is a potential use for ZIMS to track genetics.

Husbandry: methodological standardization, communication

Goals

For each of the problem statements described earlier in this section, the working group participants developed management goals to address these problems. Finally, the group placed these goals in order of priority in terms of their effectiveness in advancing western pond turtle conservation in Washington state.

Lack of adequate communication

1. To more effectively share husbandry and field data among primary and secondary stakeholders through an improved communication strategy.

Husbandry is largely based on historical precedent

2. Develop a standardized set of best husbandry practices for purposes of creating more and healthy individuals to bolster wild populations through release.

Lack of monitoring data on post-release head-started hatchlings

3. Encourage development of a more robust long-term post release monitoring strategy to improve husbandry.

Funding challenges

4. Investigate and identify sustainable funding resources to maintain head-starting and husbandry practices.

Many areas of uncertainty exist regarding artificial incubation science

5. Standardize data management systems to facilitate communication among stakeholders.

Actions

Problem Statement 1
There is a lack of adequate communication and standardization between stakeholder institutions that limits maximizing contributions to species recovery.

Goal 1 (Priority 1)
To more effectively share husbandry and field data among primary and secondary stakeholders through an improved communication strategy.

Brainstorm list of actions

Create a listserve (created: wpondturtle@lists.aza.org).
Conference calls/webinar/ Skyping
Encourage cross-site visits
Continue maintenance and expansion of a Western Pond Turtle Google site
Chelonian TAG/AZA – talk and involvement
(a report out was presented at the Chelonian TAG on 20 March, 2013, Detroit, MI)
TSA annual meeting
Publication – dissemination (WAZA Magazine article on Western Pond Turtle PHVA submitted)
North American Conservation Award - AZA (Jenny has previous application; will submit in 2014?)
Media (also notify them of this meeting)
Reach out to academic institutions and researchers - WA, OR, CA
IUCN Species Survival Commission - Reintroduction Specialist Group, Chelonian Specialist Group
AZA – Field Conservation Committee, Reintroduction Scientific Advisory Group
Turtle *ex situ* conservation workshop
Training about ulcerative shell disease - at a zoo by zoo vet for field researchers
What to look for?
What to do (e.g., how to treat cases)?

Action 1: Create method of electronic communication amongst all stakeholders. Develop listserve, webinar/conference calls, Google site
Responsible Party: Jenny Pramuk.
Timeline: November 2012 and ongoing.
Outcome: Increase number of people participating and volume of communication.
Resources: Jenny's time.
Consequences: Improved communication leading to increased collaboration for program success.
Obstacles: Lack of participation, time constraints.

Action 2: Disseminate information through professional meetings and organization, including
AZA - Field Conservation Committee, Reintroduction SAG, Chelonian TAG
Turtle Survival Alliance, Herpetological Society
IUCN/SSC - Reintroduction Specialist Group, Conservation Breeding Specialist Group, Chelonian Specialist Group, Peer-reviewed publications

Responsible Parties: All in Husbandry Working Group.
Timeline: immediately and ongoing.
Measured by: # publication and presentation and other products.
Resource: travel, time, $.
Consequences: increased knowledge of our actions.
Cost: time and funding.

Action 3: Disseminate information through appropriate media outlets
Responsible Parties: All in Husbandry Working Group.
Timeline: immediately and ongoing.
Measured by: # media hits, amount of volunteer hours, #educational programs.
Resource: travel, time, funding.
Consequences: increased knowledge of our actions.
Cost: time and funding.

Action 4: Capacity building around *ex situ* turtle conservation, including across-site visits, workshops, health care and/or ulcerative shell disease training.
(Contact for training: Sharon Deem, DVM - Institute for Conservation Medicine, WildCare Institute/St. Louis Zoo)
Responsible Parties: WPZ: Jenny Pramuk and Bill McDowell.
OrZ: David Shepherdson.
SFZ: Jessie Bushell.
SSU: Nick Geist.

Timeline: Winter 2013 to investigate.
Measured by: Number of people with improved knowledge of *ex situ* care (# meetings/workshops and # of participants).
Resources: time, number, availability of sites, potential sponsorships and funding community.
Consequences: better informed turtle care and health and expanding.
Obstacles: time, $ institutional budget, lack of interest/economic hardship, location availability.

Action 5: Develop knowledge base of all current and past WPT research at academic institutions in WA, OR and CA and establish connection to them.
Responsible Party: Nick Geist.
Timeline: Immediately and ongoing.
Measured by: Completed/updated literature review, gain additional data of other marked WPT in other programs.
Resources: Nick's time.
Consequences: Increased level of collaborators and amount of research.
Obstacles: Nick's time, dissenting views.

Problem Statement 2
Current husbandry is largely based on historical precedent rather than emerging scientific methods.

Goal 2 (Priority 2)
Develop a standardized set of best husbandry practices for purposes of creating more and healthy individuals to bolster wild populations through release.

Brainstorm list
Standardize best practices by developing a standardized husbandry manual for WPT head-start programs. Include release protocols and data management protocols.

Refer to and incorporate language of IUCN reintroduction guidelines into the husbandry/care manual.
Develop a scientific research task force to propose care-related questions for further study.

Diet/nutrition study
Rearing temperature
UVB/D3 levels
Endoscopy protocols +/- inclusion at other zoos
Health screening of wild populations (blood draws/x-rays/shell biopsy, euthanasia of sick animal for necropsy)
Collaboration with WPZ, OrZ and SFZ vets, compare latitudinal properties in WA/Or + CA
Share samples for genetics (#sires per clutch)
Climate change research
Tease out incubation protocols

Action 1: Draft a standardized best practices animal care manual for WPT head-start programs, including IUCN Reintroduction Guidelines, incubation protocols, etc.
(modeled on AZA Animal Care Manuals).
Responsible Parties: WPZ – Bill McDowell.
OrZ - Amy Cutting (Curator) and David Shepherdson.
SFZ/Oakland Zoo – Jessie Bushell.
SSU – Nick Geist.
Timeline: Underway; current practices by Spring 2013.
Measured by: Completed on time with all primary stakeholder contribution.
Resources: Time.
Consequences: Consistent and improved animal care.
Obstacles: time and breakdown in communication, participant contribution.

Action 2: Develop scientific research task force to propose care related research questions for further study. Research topics include:

- Diet studies/nutrition
- Incubation success @ variable temperatures
- Rearing temperature
- Optimal UVB levels
- Endoscopy protocol for sexing head-starts
- Optimal water quality parameters.

Responsible Parties: Jenny Pramuk and Jerry Novak.
Timeline: Spring 2013 (once PHVA report is out).
Measured by: Improvement in turtle health through revised captive care manuals.
Consequences: Direction for needed research, creating research questions and opportunities.
Obstacles: Time and collaboration.

Action 3: Create a task force to institute a health screening of wild populations, including regular blood draws, radiographs, shell biopsies, euthanasia of sick animals.

- Meet with vet staff
- Formulate screening needs/wants
- Look for funding
- Formulate protocol
- Begin sample collection.

Responsible Parties: Nick Geist – CA.
Jenny Pramuk – WA.
David Shepherdson – OrZ.

Timeline: After PHVA report finalized; Spring 2013 and expect 2 – 3 year project.
Measured by: Data will establish baseline values.
Resources: $$$$, vet time and assistance, WDFW and California office of Fish and Game, cost $10,000 to $100,000.
Consequences: inform health decisions and captive care (especially ulcerative shell disease).
Obstacles: Capturing animals gaining permission/permits, time, funding.

Problem Statement 3
There is a lack of monitoring data on post-release head-started hatchlings.

Goal 3 (Priority 3)
Develop a more robust long-term post release monitoring strategy – defer to Population Working Group

Problem Statement 4
Funding challenges: Labor cost and facility management costs for head-starting are significant. There are few to no funding opportunities for staff salaries but funding may be available for materials and supplies.

Goal 4 (Priority 4)
Investigate and identify sustainable funding resources to maintain head-starting and husbandry practices.

Brainstorm list
- Develop fundraising opportunities (e.g., a children's coloring book "Paul and Paula the Pond Turtles") at zoos or at other venues?
- Collaborate between institutions acquire larger grants =/long term grants (health studies, field).
- Potential funding agencies:
  - Turtle Survival Alliance
  - USFWS
  - Morris Foundation
  - AZA Conservation Endowment Fund
  - Turtle Conservancy
  - National Science Foundation
  - Corporate sponsor
  - Alaskan Air
  - ZooMed
- Develop a Memorandum of Understanding or other formalized agreements between WDFW and stakeholder institutions.

Action 1: <u>Collaborate between stakeholders to develop fundraising opportunities such as grants and other funding sources.</u>
Responsible Parties: Institutional administrative staff involved with WPT recovery:
SSU – Nick Geist
SFZ - Jessie Bushell
WPZ – Jenny Pramuk
OrZ - David Shepherdson
Measured by: Funding acquired /number of funded proposals.
Timeline: Ongoing.
Resources: Time; input from each institution, expertise for grant writing.
Consequences: Funding for program and its expansion; make program financially of the project.
Obstacles: Time; lack of grant writing expertise.

Action 2: Create MOUs or agreements between WDFW and stakeholders
Responsible Parties: OrZ – David Shepherdson
WDFW – Nick Geist
WPZ – Fred Koontz
Measured by: Signed MOUs.
Consequences: Stability of program.
Timeline of expectation and program duration: Undetermined.
Obstacles: Politics, red tape.

Action 3: Create project wide budget and business plan.
Responsible Parties: David Shepherdson, Jenny Pramuk, Jessie Bushell.
Timeline: Jan 2013 for next fiscal season to complete by July 2013.
Measured by: Completed business plan.
Resources: Time.
Consequences: A product to benefit grant submissions.
Obstacles: Time.

Problem Statement 5
There are many areas of uncertainty exist regarding artificial incubation science.

Goal 5 (Priority 5)
Standardize data management systems to facilitate communication among stakeholders.

Brainstorm list of actions:
- Standardized use of Zoological Information Management System
- Develop standardized data management protocols
  - Types of data collected
  - Morphometric measurements
  - Field data (Institution/WDFW/field #s) - many #s
- Pit Tag database across states/programs

Action 1: Standardize data collection and management for WPT Programs across institutions. Develop a data management protocol for the animal care manual
Responsible party: Karin Schwartz.
Timeline: Start immediately with 1st draft by Spring 2013.
Measured by: A usable product to manage data.
Collaborators: Head-starting animal caretakers and institutional registrars.
Resources: Time.
Consequences: Global data access and data standardization.
Obstacles: Inability to integrate existing data systems from all stakeholders; Karin's time - lack of funding.

Table 7-1. Comparison of captive care protocols for the western pond turtle (*Actinemys marmorata*) among stakeholder institutions.

	Woodland Park Zoo	Oregon Zoo	San Francisco Zoo	Oakland Zoo	San Diego Zoo
Incubation	Yes	No	No	No	Yes
Enclosure type	Hatch.: Plastic sweaterbox Juv.: 120g Rubbermaid tub	Hatch.: Plastic sweaterbox Juv.: 120g Rubbermaid tub	Hatch.: Plastic sweaterbox Juv.: 40g aquarium	Hatch.: Plastic sweaterbox Juv.: Rubbermaid	Hatch.: ? Juv.: Rubbermaid
Water filter	No	No	Yes	?	Yes
Water treated	No, but aged	Yes (Stress Coat)	Yes (Amquel)	Yes (Amquel)	?
Water temp	72–82 ºF	78–82 ºF, some tanks heated	74–92º 92 (basking)	74–92º 92 (basking)	?
Water change	Daily	Daily	Daily until 2 mos: moved to filtered tanks	No filters, not sure how often water changes occur	Filters, not sure how often water changes occur
Weights/frequency	1X/mo.	1X/week	2X/month	2X/month	?
Morphometrics	No	No	Yes	Yes	?
Hatchling density	18–20 per tub	18–20	10–20	10–20	?
ID Type	@ 1 mo: bee dot	Hatchlings: nail polish; @ 1 mo: bee dot	Notch @ hatching	Notch @ hatching	?
Feeding/how long	1X/day / 3–4 hours	2X/day / 3 hours	1X/day / 2–3 hours	1X/day / 2–3 hours?	1X/day
Food items	Mealworms (MW) Earthworms (EW) Pinky mice (P) Lake smelt Crickets (C) Bloodworms (BW) Waxworms (WW)	MW EW P Trout (T) C WW	MW EW P (and rat pinks) Trout (T) C BW Rotation WW for young hatchlings only	MW EW P (and rat pinks) Trout (T) C BW Rotation WW for young hatchlings only (similar to SF)	?
Sanitization of enclosure	2X/week Clorox or Nolvasan	1X/week 16% bleach	1X/week	1X/week	?
Lighting	Fluorescent: Reptisun Basking: 2 ZooMed 150W	Fluorescent: Reptisun, blacklight Basking:	Fluorescent: 1, 10.0 Zoomed: 1, 5.0 Zoomed Basking: 1 MegaRay 1 Power Sun (Zoo Med)	?	?
Photoperiod	12:12	12:12	Skylight (Natural photoperiod); lights on timer mimic natural light	?	?

Literature Cited

Dallara, Z., and N.R. Geist. The role of maternal effect, incubation temperature, and gender on juvenile growth of captive-raised Western pond turtles, *Emys marmorata*. *Journal of Herpetology*, in prep.

Geist, N.R., Z. Dallara, and R. Gordon. The role of incubation temperature and clutch effects in development and phenotype of head-started Western pond turtles (*Emys marmorata*). *Herpetological Conservation and Biology*, in press.

Murphie, B., J. Skriletz, and J. Anthony. 2012. Progress Report: Western Pond Turtle Head-Starting and Reintroduction, Mason County, April 2005 – October 2012. Washington Department of Fish and Wildlife. Wildlife Program. Region 6/District 15. Montesano, WA

The Western Pond Turtle in Washington:
A Population and Habitat Viability Assessment

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Section 8
Group Prioritization of Goal Statements

Group Prioritization of Goal Statements

Once the working groups had developed all of their goals, they presented and discussed these goals with the rest of the workshop participants in plenary so that all participants were able to have input into all issue and goals. Goals were examined across the four groups and were consolidated, split, or otherwise refined to equalize the level of action and to increase clarity. This resulted in a total of 24 goals endorsed by the workshop participants, all of which are recommended to benefit the western pond turtle in Washington State.

An overall prioritization of all workshop goals helps to guide working groups in developing recommended actions, especially if resources (funding, time, staff) are limited, and can help focus attention on the primary issues of concern. Once the goals were finalized and the results of the population modeling had been presented and discussed, the participants were asked to consider the importance of each goal in terms of its expected impact on western pond turtle population management.

<u>The goals were displayed on flip charts, and participants were asked to prioritize these goals with respect to a common criterion: The greatest immediate positive impact on western pond turtle population viability and conservation</u>.

It is again important to recognize that all conservation goals have been endorsed and deemed important to achieve within the larger context of western pond turtle conservation. The relative ranking presented here gives a sense of the urgency and/or priority of all goals when compared as a whole.

Goal Statement	Participant Score
Understand shell disease epidemiology, survival rate of affected individuals, and effects on reproduction.	**19**
To more effectively share husbandry and field data among primary and secondary stakeholders through an improved communication strategy.	**15**
To identify and establish one new site in Puget Sound within the next 5 years, to re-establish western pond turtle populations.	**14**
Continue bullfrog eradication at the Sondino site of the Columbia River Gorge.	**9**
Minimize impact of salmon habitat restoration on western pond turtles at Pierce National Wildlife Refuge.	**8**
Identify and manage for nesting habitat at Columbia River Gorge's Bergen and Homestead sites and at Pierce County and Mason County sites.	**8**
Obtain or improve estimates of hatchling and juvenile age class survival rates at each population site.	6
Better understand predation, especially the impact of bullfrogs and bass.	4
Develop guidelines from the literature for key water quality factors, and monitor key factors at the Pierce County site.	4
Develop a more robust long-term post release monitoring strategy to improve husbandry.	3
Estimate cause specific mortality rates for adults.	2
Schedule management actions so as to avoid negatively impacting turtles.	2
Address the key factors limiting recovery at each site in South Puget Sound and the Columbia River Gorge.	2
Develop a standardized set of best husbandry practices for purposes of creating more and healthy individuals to bolster wild populations through release.	2
Investigate and identify sustainable funding resources to maintain head-starting and husbandry practices.	1
Acquire remaining private property/ownership as part of Bergen site of the Columbia River Gorge western pond turtle population.	1
Expand population capacity at the Pierce County site.	1
Standardize data management systems to facilitate communication among stakeholders.	0
Identify a back-up site in the Columbia River Gorge. (Another possible site for reintroduction)	0
Develop a policy of predator control.	0
Better understand how soil conditions affect nesting success and hatch rate.	0
Assess and determine if management/research actions should be taken to address genetics.	0
Obtain estimates of wild hatch rate at each population site.	0
Develop a land management plan between WDFW and US Forest Service for management of the Bergen site of the Columbia River Gorge turtle population.	0

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Appendix I
Workshop Participants and Agenda

Workshop Participants

Name	Affiliation
Harriet Allen	WA Department of Fish and Wildlife
David Anderson	WA Department of Fish and Wildlife
Jessie Bushell	San Francisco Zoo
Darin Collins	Woodland Park Zoo
Mick Cope	WA Department of Fish and Wildlife
Ron Gagliardo	Amphibian Ark
Nick Geist	Sonoma State University
Lisa Hallock	WA Department of Fish and Wildlife
Marc Hayes	WA Department of Fish and Wildlife
Sandra Jonker	WA Department of Fish and Wildlife
Shannon Knapp	WA Department of Fish and Wildlife
Fred Koontz	Woodland Park Zoo
Frank Slavens	Independent conservation biologist
Kate Slavens	Independent conservation biologist
Bill McDowell	Woodland Park Zoo
Bobbi Miller	Woodland Park Zoo
Phil Miller	Conservation Breeding Specialist Group
Bryan Murphie	WA Department of Fish and Wildlife
Jerry Novak	PNW Turtleworks
Jennifer Pramuk	Woodland Park Zoo
David Shepherdson	Oregon Zoo
Tammy Schmidt	WA Department of Fish and Wildlife
Karin Schwartz	Conservation Breeding Specialist Group
Jeffrey Skriletz	WA Department of Fish and Wildlife
Derek Stinson	WA Department of Fish and Wildlife
Bruce Thompson	WA Department of Fish and Wildlife
Michelle Tirhi	WA Department of Fish and Wildlife
Matt Vander Haegen	WA Department of Fish and Wildlife
Sara Ziegler	Conservation Breeding Specialist Group

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Workshop Agenda

Tuesday, 13 November

8:30	Workshop Opening – *Jennifer Pramuk (Woodland Park Zoo), Harriet Allen (WDFW)* Participant Introductions
9:00	Introduction to CBSG and PHVA workshop process – *Phil Miller (CBSG)*
9:30	History of WPT population trend and recovery process in WA State – *Harriet Allen*
10:00	Introduction to PVA modeling and *VORTEX* – *Phil Miller*
11:00	Preliminary PVA results and implications for WPT recovery in WA State – *Phil Miller*
12:30	Lunch
1:30	Plenary Session I: Issue generation (mind mapping)
2:30	Working group identification and formation
3:00	Working Group Session I: Issue generation and prioritization
5:00	Adjourn

Wednesday, 14 November

8:30	Plenary Session II: Presentation of prioritized issues
9:30	Working Group Session II: Identifying information/data gaps on species biology, management
11:00	Plenary Session III: Presentation of information/data gaps
12:00	Working Group Session III: Developing recovery goals
12:30	Lunch
1:15	Working Group Session III: Developing recovery goals (cont'd.)
4:00	Plenary Session IV: Presentation and group prioritization of recovery goals
5:00	Adjourn

Thursday, 15 November

8:30	Working Group Session IV: Developing recovery actions
12:30	Lunch
1:15	Plenary Session V: Presentation of recovery actions
3:00	Funding needs and options – *Fred Koontz*
3:30	Next steps: Timelines for action – *Phil Miller*
4:30	Workshop Closing – *Harriet Allen & Fred Koontz*