Status of and Potential Recovery Options for Oregon Spotted Frogs in the Willamette Valley, Oregon

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I. Problem Statement

The Oregon spotted frog (*Rana pretiosa*, hereafter OSF) is a candidate species for listing under the US Endangered Species Act. It is listed as Endangered in Washington and British Columbia. The range of OSF has declined notably since widespread alteration of wetland habitats and the spread of non-native competitors and predators.

Recent survey efforts have identified previously unknown populations, including several in agricultural areas in the Puget Sound lowlands in Washington, and in several regions in Oregon. These recent survey efforts have dramatically improved the outlook for recovery of OSF populations within their historic range. There may be similar opportunities in the Willamette Valley of Oregon. However, there has been no extensive survey effort in part because the Oregon Department of Fish and Wildlife considers the species extirpated from the Willamette Valley. Although determination as extirpated may have been reasonable given the information at the time, recent advances in understanding the distribution of OSF suggest further work is required to support this conclusion. I argue that the determination of OSF as extirpated in the Willamette Valley is no longer defensible and may limit recovery options by discounting the potential for extant populations. Although the determination that the OSF is extirpated in the Willamette Valley is unsubstantiated, it has important consequences for conservation action. Strategic surveys, targeted at the most likely remaining OSF habitat, are urgently needed as the initial step to recover OSF in the Willamette Valley.

II. Background on Oregon Spotted Frogs

A. Range-wide Status

The OSF is a highly aquatic ranid frog that is endemic to the Pacific Northwest, historically including portions of British Columbia, Washington, Oregon, and California. Under earlier nomenclature, OSF was considered a subspecies, *R. p. pretiosa* (Dumas 1966). This taxon was elevated as a separate species (Green *et al.* 1997), distinct from what is now classified as the Columbia spotted frog (*R. luteiventris*). The number of populations of OSF throughout their range is thought to be considerably reduced and warranted listing the species under the Endangered Species Act (prior to separation of *R. luteiventris*, Federal Register 1993 Vol. 58, No. 87:22760-22763). OSF are currently under review for listing under the Endangered Species Act and a decision is expected in late 2013 (Federal Register 2012 Vol. 77, No. 225:70019). They are currently state listed as Endangered in Washington (Hallock 2013), and listed as Endangered in British Columbia (Haycock 2000). OSF is also listed as a Sensitive-Critical species by the Oregon Department of Fish and Wildlife, and a Strategy Species under their Conservation Strategy (ODFW 2006).

The range of the OSF has declined presumably because of extensive land use changes that affected wetland habitats and by increased predation and competition by non-native predators, such as bullfrogs (*Lithobates catesbeianus*). Dams, reservoirs, and stream channelization that reduced the marsh and floodplain wetlands are likely the key structural changes that reduced OSF habitat, whereas the extensive invasion of aquatic habitat by non-native predators presumably increased mortality rates and resulted in loss of populations (Cushman and Pearl 2007). Currently, OSF is believed extirpated from California, and its range within Oregon, Washington, and British Columbia has declined (McAllister *et al.* 1993, Hayes 1994a, b; Hayes 1997, Haycock 2000). The magnitude of declines throughout the species' range has been

estimated primarily from resurveys of historic locations (Hayes 1994a,b; Hayes 1997). Based on these resurveys, Hayes (1994b) concluded that OSF "has disappeared from over 90% of its historic range in this region." Numerous papers and reviews describe the biology and hypotheses for range reduction, which are summarized by Cushman and Pearl (2007).

In part because the status of this species has been largely based on resurveys of locations where the OSF was known to occur historically, there is confusion in the literature regarding the terminology regarding sites, locations, and populations. Defining a biological population can be difficult without knowledge of movement patterns, and it remains a challenge in population ecology. In this document, with few exceptions, I use terminology regarding "site", "location", and "population" as they were used in the original sources cited.

B. Habitat

The habitat associations of OSF were reviewed by Pearl and Hayes (2004) and more recently summarized in Cushman and Pearl (2007). The brief description provided here is largely taken from Pearl and Hayes (2004), and augmented with recent work in agricultural areas of northwestern Washington (Bohannon et al. 2012) that are most similar to the Willamette Valley. OSF occupies a rather narrow set of wetland conditions, dependent upon the life-stage. They are almost entirely aquatic, and are considered the most aquatic of the native ranid frogs within their range. Breeding (oviposition) occurs during February and March in lowland areas, typically in ephemeral inundated marshes with shallow water (6-30 cm) that have extensive submerged vegetation, warm daytime temperatures, and are usually hdrologically connected to permanent water. Eggs are often laid where vegetation is low or sparse but within aquatic habitat that has extensive submerged vegetation. Following breeding, summer habitat consists of wetlands with standing water that have a high density of vegetation to provide cover from predation. The importance of cover and other structural attributes of habitat are likely to be particularly important where bullfrogs and other predators are common, such as in the Willamette Valley. Factors that affect the type of overwinter habitat used are not well understood, but there are likely strong differences between habitats that are in colder, higher elevation areas versus lowland and warmer environments such as in the Willamette Valley. Open water environments are used for overwintering more often than during the breeding season but shallow areas may be selected especially in lowland areas. High density of submerged vegetation in well oxygenated water has been associated with many of the known overwinter habitats.

In the Puget Sound lowlands, OSF inhabit seasonally flooded pastures, emergent and scrub-shrub wetlands, and riparian habitat in agricultural areas (Bohannon et al. 2012, Hallock 2013). Mowing and grazing take place at many of these sites and may be partially responsible for maintaining the early successional vegetation communities that are important as breeding habitat for OSF, consistent with the experimental work of White (2002).

C. Threats

Putative reasons for population declines include altered hydrology, wetland loss, contaminants, predation and competition from non-native predators (Hayes 1997, Cushman and Pearl 2007, Pearl et al. 2009a). In addition, Chytrid fungus (*Batrachochytrium dendrobatidis*) has been found frequently associated with OSF (Pearl et al. 2009b) and remains a potential threat. The most likely threats in the Willamette Valley are site-specific effects that may include alteration of hydrology that affects their aquatic habitat for each life-stage, and elevated predation and

competition by introduced species including bullfrogs and warm-water fish such as small-mouth bass (*Micropterus dolomieu*). Dense areas of reed canary grass (*Phalaris arundinacea*) may reduce habitat quality by creating impenetrable thatch. These factors may be manageable through modifications of topography and water-control devices, by manipulating aquatic vegetation to favor OSF over warm water fish and bullfrogs, and vegetation control. Managing bullfrogs via modification of hydrology may be difficult (Maret et al. 2006, Adams and Pearl 2007, Cook et al. 2013), because both bullfrogs and OSF typically require permanent water. Further research on approaches to manage for co-existence of OSF with non-native predators, such as bullfrogs and bass, will contribute to finding solutions for recovery of OSF in the Willamette Valley. Loss of extensive wetlands and degradation of OSF habitat will remain as current and future threats.

III. Status in the Willamette Valley

A. Overview of Habitat Conditions and Status

The extensive loss of wetlands in the Willamette Valley, particularly those associated with off-channel flooding (Taft and Haig 2003) has undoubtedly resulted in the loss of most of the potential OSF habitat in this region. Approximately 96% of the Willamette Valley is in private ownership, with a large portion of this area (41%) in agriculture (ODFW 2006:235). Although vastly reduced from historic conditions, there are numerous sloughs and wetlands that remain and are hydrologically connected to the Willamette River, experiencing frequent flooding (Sedell and Froggatt 1984, ODFW 2006). These features appear at least generally similar to the agricultural areas where OSF were found in western Washington (J. Bohannon, 2013, pers. commun.). There have been recent efforts to restore floodplain habitats in the Willamette Valley for protection of biological diversity, especially for riparian and wetland areas (http://www.dfw.state.or.us/wildlife/willamette_wmp/docs/WL_Mitigation_AR.pdf). Within the Willamette Valley, there have been no surveys specifically designed to locate OSF populations other than the few historic sites surveyed by Hayes (1994b). However, these floodplains and low-gradient off-channel aquatic habitats along the Willamette River, and its tributaries, may still provide habitat for OSF.

Historic records imply that OSF may have occurred in sloughs and other wetlands scattered across most of the Willamette Valley. There are a total of 10 historic records that were verified by Hayes (1994) as accurate within the Willamette Valley. The last specimens that were collected and included in historic records occurred in the early 1960s (M. Hayes, 2013, pers. commun.). Jewett (1936) commented on OSF in the Portland area: "*Rana pretiosa* Baird and Girard.-Common along the sloughs of the Willamette and Columbia rivers. It is mainly aquatic, seldom leaving water." Similarly, Graf et al. (1939) reported that OSF were common in the Willamette Valley south of Salem.

The Oregon Department of Fish and Wildlife considers the OSF extirpated in the Willamette Valley (ODFW 2006:318). Their determination follows the conclusions provided by Hayes (1994a, 1997) and other herpetologists (Storm 1966, 1974, Nussbaum et al. 1983, St John 1987, Pearl et al. 2005, Cushman and Pearl 2007). This conclusion was presumably based on the lack of recent records and that OSF were not found in any of the resurveys of previously occupied sites or other wetland locations in the Willamette Valley.

The view that OSF might be extirpated in the Willamette Valley has a long history. Jewett (1936) and Graf et al. (1939) published the last statements that I am aware of that stated OSF were common in the Willamette Valley. By the mid-1960s, Dr. Robert Storm, perhaps the most active herpetologist in the Valley at that time, voiced concern over their status: "Formerly common in the valleys of western Oregon, it has been nearly or completely exterminated there by the introduced bullfrog" (Storm 1966). Storm (1974) reiterated the same message 8 years later. In the early 1980s, Dr. Storm and his colleagues (Nussbaum et al. 1983:183) expressed similar concern: "Although now apparently exterminated in the Willamette Valley of Oregon by introduced bullfrogs…" A few years later, St. John (1987:13) failed to find OSF in his surveys, which were conducted at sites selected to yield a large number of amphibian and reptile species rather than target OSF habitat: "The spotted frog has not been seen in the Willamette Valley for many years and has presumably been exterminated there by the introduced bullfrog, with possible complications from crop sprays and other contaminants."

This general view of extirpation in the Willamette Valley was based on the lack of recent records. It wasn't until Hayes (1994b) conducted surveys of all of the verifiable historic locations that any formal surveys were conducted for OSF in the Willamette Valley. Hayes (1994b:5) concluded that failure to detect OSF at any of the 10 historic locations, or nearby areas, supported the earlier claims that OSF may be extirpated in the Willamette Valley, though he noted the uncertainty of that finding given that survey efforts were only directed towards a very small area: "...this finding should especially not be used to discourage additional searches for this frog in the lowland Willamette Valley, especially where appropriate habitat pockets may exist". Although surveys were conducted for other amphibian species between Hayes (1994a,b) work and the early 2000s, there were no efforts that I am aware of that targeted surveys to locate OSF. Pearl et al. (2005) conducted one of the most extensive amphibian surveys in the Willamette Valley, visiting 85 wetlands between Eugene and Portland. They did not detect OSF at these sites, and cite Hayes (1994b) that the OSF is presumed extirpated from the region. However, the areas Pearl et al. sampled were not selected to target OSF habitat (C. Pearl, 2013, pers. commun.). Cushman and Pearl (2007:14) state that surveys in the Willamette Valley "have not been exhaustive" but conclude that the species "appears to be extirpated". ODFW 's (2006) determination of extirpation is thus consistent with the literature, other than the fact that there have not been strategic surveys that could lead to discovery of remnant populations. The primary OSF experts currently working in Oregon, Dr. Marc Hayes and Mr. Chris Pearl, and Dr. Storm who was working on this and related species since the 1960s, all agree that the determination of extirpation of OSF in the Willamette Valley is premature, particularly in light of recently found populations elsewhere including the agricultural area of the Puget lowlands (M. Hayes, 2013, pers. commun., C. Pearl, 2013, pers. commun.; R. Storm, 2013, pers. commun).

B. Determination of Extirpation is Inappropriate Given Existing Evidence

The primary basis for the view that the OSF is extirpated from the Willamette Valley is three-fold: loss of a large proportion of wetlands that could provide habitat; OSF were not found in contemporary surveys of the 10 historic locations where OSF was reported in the Willamette Valley; and the lack of any recent location records. Recent work on amphibians and on OSF in particular, demonstrates that the basis for the determination of extirpation of OSF in the Willamette Valley is premature for the following reasons.

1. Estimates of Declines Based on Resurveys of Historic Locations are Negatively Biased

Estimates of population declines, and thus species' status, from resurveys of historic locations are almost always negatively biased. Only two outcomes are possible when making inferences from resurveys of historic locations. If the species is relocated at all historic sites, then the species is considered "stable". More likely, individuals are no longer present at some or even most of the sites and the observers conclude there is a decline in the distribution of the species (Strayer and Fetterman 1999, Skelly et al. 2003). Amphibians often exhibit spatially structured populations (e.g., Sjögren-Gulve and Ray 1996), where the existence of local subpopulations is dynamic, but the larger population remains extant (Hanski 1999). This can lead to a negative bias of estimates of population declines if conclusions are drawn solely based on the loss of a subpopulation without considering colonization of new subpopulations. Purported declines from resurveys of historic locations can be further exacerbated by less-than-perfect detectability of the target organism during surveys: if individuals exist at a location but none are detected, an incorrect conclusion of local extirpation is made, thus increasing the magnitude of the perceived decline. The scientific literature gives strong support to negative biases in estimates of decline as a result of resurveys of historic locations and less than perfect detectability (Skelly et al. 2003 and references therein).

The magnitude of the negative bias should be greatest for species occupying early successional habitats, such as wetlands that OSF frequently occupy. Many examples of OSF occupying early stages of dynamic habitats exist. OSF occupy marshes, which often mature into meadows and then are no longer suitable for OSF. For example, Hayes (1997:12) reported the loss of OSF habitat of a marsh maturing to a meadow based on comparison of 1990s conditions with a 1940s aerial photograph. Another example of loss of OSF habitat from succession occurs with beaver ponds, a wetland type that can provide breeding habitat for OSF (C. Pearl, 2013, pers. commun.). Such habitat is short-lived because beaver, which create and maintain the pond, eventually move to unoccupied habitat where their food resources have not been reduced through their foraging. OSF habitat is often early succession wetlands (Haycock 2000), and thus one would predict that populations of OSF would be lost as the habitat matures (Hayes1997:12, Haycock 2000).

2. Historic Locations Were Not Based on Representative Surveys

Another frequently overlooked problem when interpreting results from resurveys of historic sites is that historic locations were rarely obtained from a representative sample. That is certainly the case for OSF historic locations in the Willamette Valley where OSF observations resulted from work on other species or from searching for amphibians in easy to access areas, often near or adjacent to areas frequented by local herpetologists (R. Storm, 2013, pers. commun.). Therefore, inference beyond the individual historic locations regarding declines is inappropriate. This is particularly true when the number of locations is few, such as in the Willamette Valley where only 10 verified records exist.

3. Little Knowledge of OSF Outside of Historic Sites in the Willamette Valley

The issues described above, negative bias of declines based on resurveys of historic locations, lack of strategic surveys, reliance on a small set of historic locations that were not drawn from a representative sample, and that the vast majority of potential OSF habitat in the Willamette Valley exists in hard-to-access wetlands that are on private lands, demonstrates that the determination that OSF are extirpated in the Willamette Valley is premature. Lack of knowledge of existing OSF populations is not a problem confined to the Willamette Valley. Haycock

(2000:19) stated the same for British Columbia and suggested that further recognition of this fact would facilitate management. Indeed, it was this recognition that motivated Bohannon et al. (2012) to conduct the strategic surveys that resulted in newly discovered OSF populations in agricultural areas of the northern Puget Trough inwestern Washington, an area where OSF were not seen since the 1930s (Bohannon et al. 2012), an even longer period of presumed absence than the Willamette Valley.

IV. Other Willamette Valley Species Initially Thought to be Nearly Extirpated

Several species that live in sloughs and other off-channel aquatic areas in the Willamette Valley were assumed to have been very rare or nearly extirpated. This is not surprising given the extensive loss of wetlands and off-channel aquatic habitats. It is also not surprising that few records existed in the Willamette Valley because almost all of the area is in private ownership, access is difficult, and some species are difficult to detect and /or similar to other more common species, much like the OSF. Below, I illustrate how intensive and extensive strategic surveys of two species in the Willamette Valley, northern red-legged frog (*Rana aurora*) and Oregon chub (*Oregonichthys crameri*), demonstrated that these species were more widely distributed than previously believed.

A. Northern Red-Legged Frog

The northern red-legged frog was considered precariously rare in the Willamette Valley prior to recent surveys. Early as the 1980s, St. John (1987:12) found only three red-legged frogs in his surveys in the Willamette Valley, and concluded the species was "… on the decline in the Willamette Valley in recent years. It is feared that they may be heading in the direction of the spotted frog….". Blaustein (1994:90), using red-legged frogs in the Willamette Valley as an example of amphibian declines, stated that red-legged frogs were historically "…extremely abundant in the Willamette Valley of Oregon… is now extremely rare, and breeding populations have not been observed for at least 20 years in the Willamette Valley..". His view was echoed elsewhere, including the Atlas of Oregon Wildlife (Csuti et al. 1997:25): "This species is declining seriously in the Willamette Valley. Several recent surveys have failed to detect this species at sites in the valley where it was once common to abundant." Even as recent as 2001, red-legged frogs were thought to be very rare in the Willamette Valley and declining based on surveys at historic sites (Kiesecker et al. 2001).

Concern over amphibian declines and threats within the Willamette Valley have resulted in more systematic and comprehensive surveys. These surveys have demonstrated that northern red-legged frogs are much more common than previously believed. For example, northern red-legged frogs were found at 40 of 85 (47%) wetlands within the Willamette Valley (Pearl et al. 2005). Similarly, recent surveys in the Portland metropolitan region resulted in locating numerous occupied sites (Figure 1). The same was found throughout the Willamette Valley as documented from locations reported to Oregon Department of Fish and Wildlife (ODFW, unpubl. data received 2013). A simple comparison of historic sites, most believed to be unoccupied in recent times, to those Metro has located and those reported to ODFW (Figure 1) demonstrates that until systematic surveys in appropriate habitat are conducted, determination of status is highly uncertain.

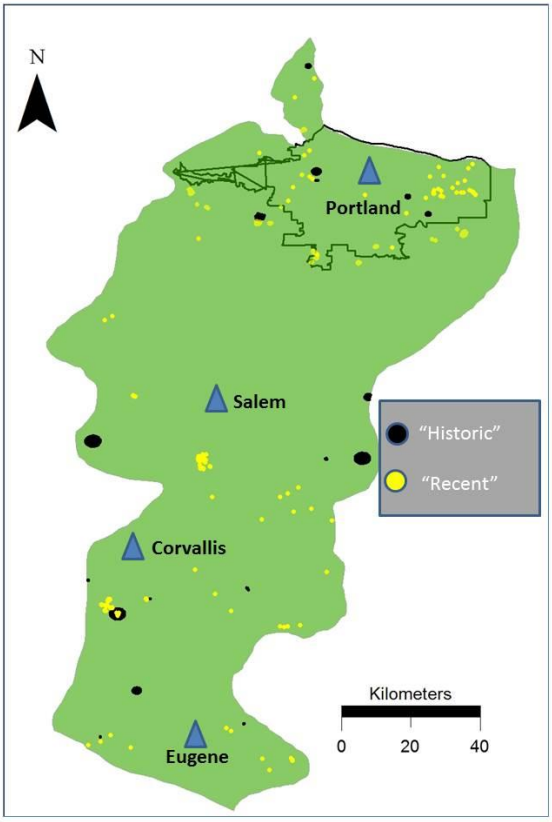

Figure 1. Distribution of red-legged frogs in the Willamette Valley. Historic records up until 1999 are shown in black; observation after 1999 are in yellow. The change in the known distribution patterns between historic (prior to 1999) and recent (after 1999) records reflects increased sampling effort, particularly in the Portland Metro area(outlined in black). Data are from Oregon Biodiversity Information Center, Oregon Department of Fish and Wildlife, and Metro.

B. Oregon Chub

The Oregon chub is a small minnow endemic to a portion of the Willamette River basin. The Oregon chub primarily inhabits off-channel habitats that are often connected to streams and rivers at high water (http://oregonstate.edu/dept/ODFW/NativeFish/OregonChub.htm). Most known Oregon chub sites are on private lands. Such areas were not well surveyed prior to the listing of the species as Endangered. When the species was listed under the Endangered Species Act in 1993, only 8 extant populations were known (http://oregonstate.edu/dept/ODFW/NativeFish/OregonChub.htm). However, with extensive survey efforts, 57 sites (not including those introduced as part of the recovery effort) were known occupied in 2012 (Bangs et al. 2012). This parallels the situation with red-legged frogs in the Willamette Valley: only with an intensive and extensive strategic survey of potential habitat was it recognized that populations had a greater distribution than previously realized.

V. Recent Surveys Increased Number of Known Oregon Spotted Frog Locations

The change in the perspective of Oregon chub and red-legged frogs from nearly extirpated to a much greater distribution of extant populations than previously believed was a result of increased efforts to locate these species. The same has been true for OSF outside of the Willamette Valley. Although the species still remains vulnerable to extinction, recent strategic surveys have resulted in a much larger number of known populations than previously believed. This will provide many more recovery options than otherwise would have been thought possible. Although there have been recent efforts to survey new areas that have potentially suitable habitat for OSF, no surveys

have been conducted in the Willamette Valley at sites most likely to provide suitable habitat. Below, I summarize the surveys conducted to locate OSF populations throughout their range.

A. Perspectives: 1990s

Surveys conducted in the mid-1990s added 11 new sites (BC=1,CA=0, OR=8, WA=2) to the 61 historic (pre-1970) sites. This resulted in a total of 72 sites as of the timing of Hayes' (1997) report. The 61 historic records, verified by Hayes (1994a,b; 1997) were distributed as follows: 1 in BC, 3 in CA, 44 in Oregon, and 13 in WA. Hayes (1997) considered only 13 of the historic locations (21.3%) as currently occupied at the time of his surveys (12 in OR, 1 in WA, and none in California and Canada), resulting in 24 known extant populations. Thus, the 1990 surveys almost doubled the number of known extant populations from the number of extant populations at historic sites. As of Hayes' (1997) report, the 24 populations considered extant included the 11 newly found populations and 13 of the historic populations, distributed as follows: (BC=1, OR=20, WA = 3; of OR, 13 sites in Deschutes basin, 5 in Klamath basin, and 2 in the upper Willamette basin). None of these were located in the Willamette Valley and only the 10 historic sites or adjacent areas were surveyed.

A review of the status of OSF was conducted for Washington populations in 1997 (McAllister and Leonard 1997). McAllister and Leonard concluded that there were 11 historic records in Washington that were verifiable based on museum and published records, two of which were located in the northernmost portion of the Willamette Valley. As of the date of their report, there were only 1 historic and 2 recently discovered populations that were known extant in Washington. McAllister and Leonard (1997) note that the two recently (as of 1997) discovered populations were both very large and one was even discovered at a USFWS wildlife refuge (Conboy Lake National Wildlife Refuge). The fact that large populations were newly discovered, some even in areas that presumably would have had observers with some familiarity of amphibians (e.g., Conboy Lake NWR), demonstrates how easily OSF populations, including sizeable ones, can be overlooked.

B. Perspectives: 2007-2012

There was considerable work conducted after Hayes (1994a,b; 1997) and McAllister and Leonard's (1997) work. Cushman and Pearl (2007) synthesized the existing survey data and research of the ecology and distribution of OSF. They reported 34 extant sites in the United States. Survey work in Canada reported that none of the 3 historic sites were occupied but 3 new populations were located during *ad hoc* surveys (Haycock 2000). Thus, as of 2007, a total of 37 extant sites were known and verified as occupied. Additional populations have been found since Cushman and Pearl's 2007 report. As of 2011, 44 sites were known to be occupied by OSF (4 in BC, 8 in WA, and 32 in OR; USFWS 2011).

Most recently, Bohannon et al. (2012) conducted surveys on mostly private land in the north Puget Sound area of western Washington, an area where the OSF had not been reported since the 1930s (Figure 2; Bohannon et al. 2012). This was the only survey effort that I am aware of that was conducted almost entirely on private lands. Bohannon et al. (2012) located OSF at 11 sites, all found in watersheds where there were no previous records of OSF. Several of these sites were adjacent or close to one another. However, the 11 sites were located among 3 watersheds. For the purpose of our review and noting the difficult determination of what constitutes a "population" for comparative purposes with the earlier reports, I will use the conservative number of "populations" found during these surveys to be the number of watersheds, thus 3

populations. Bohannon's et al. (2012) survey thus brings the most recent number of reported extant populations to a total of 46.

The expansion of the number of known extant OSF locations represents the greater effort on surveying potential habitat, including areas formerly considered as unlikely to harbor OSF. Additional breeding locations beyond that described in this review have been located in the last few years (C. Pearl, pers. commun., 2013). Even ignoring these recent additions, the number of known extant populations of OSF has increased from 24 from the 1990s to 46 (Haycock 2002, Cushman and Pearl 2007, USFWS 2011, Bohannon et al. 2012). This represents an increase of over 90%. The success of Bohannon et al. (2012) in finding OSF in agricultural areas of western Washington where they were not previously seen since the 1930s provides the strongest argument to initiate similar efforts in the Willamette Valley.

VI. Concluding Comments on Population Status in the Willamette Valley

The determination that the OSF is extirpated in the Willamette Valley is based on weak evidence, but has important consequences. First and foremost, OSF do not receive any consideration in conservation planning and habitat restoration efforts in the Willamette Valley. It also makes it very difficult to obtain funding from any source because of the predetermination that OSF is absent. Ultimately, determination as extirpated removes any motivation to locate remnant populations which could be an important aspect for recovery of OSF in the Willamette Valley and thus range wide. stopped

Figure 2. Photograph of an agricultural site with a slough occupied by OSF in the North Puget Sound lowlands. Photo: Jennifer Bohannon

VII. Recovery Options

There are several potential pathways for recovery of OSF in the Willamette Valley, all of which are difficult or impossible to evaluate without a more thorough understanding of OSF status in the region which is only possible by conducting strategic surveys. Strategic surveys would allow a formal approach to evaluate whether or not there is sufficient evidence to consider the OSF extirpated from the region and would provide data on potential habitat and ability to sustain OSF populations in the Willamette Valley should they be reintroduced.

A. Strategic Surveys to Identify Populations and Potential Habitat For Recovery

Because surveys have not been conducted to locate OSF beyond the few historic sites and neighboring areas, the first step is to identify potential habitat, prioritize those areas, and conduct intensive and probabilistic-based surveys in the most highly ranked sites. Such an approach has been conducted successfully in lowlands in northwestern Washington. Public agencies in Washington have been actively identifying potential OSF habitat in response to their state listing as Endangered and the recognition of previously unknown but extant populations. Several efforts have attempted to identify habitat via GIS-based habitat models. The Department of

Transportation in Washington developed a model to evaluate potential areas of wetland sites in western Washington for supporting populations of OSF (Germaine and Cosentino 2004). Similarly, Bohannon et al. (2012) developed a GIS-based habitat suitability model, applied to National Wetlands Inventory data. These efforts, combined with recent improvements in our understanding of habitat use by OSF in lowland and agricultural areas (e.g, Watson et al. 2000, White 2002, Pearl et al. 2009a, Bohannon et al. 2012), can be used to guide development of a habitat suitability model to prioritize the most likely sites to locate existing OSF populations. The assessment of these selected sites would also guide selection of areas for potential reintroduction from within the Willamette Valley or other regions if that were to become a future priority.

B. Reintroduction

Both translocations —moving individuals from one location to another— and the release of captive-raised individuals have been used as tools to improve recovery of OSF. Applicability and methodological approaches for these techniques requires additional evaluation, and will have to address fundamental issues. ODFW (2006:337) recognized the need to conduct feasibility studies on reintroduction of OSF. Fortunately, much has been learned regarding factors affecting success rates from two primary efforts: translocation of OSF into Dilman Meadow in central Oregon (Chelgren et al. 2008) and release of captive-raised OSF into Dailman Lake at US Army Joint Base Lewis-McChord in the South Puget lowlands (M. Hayes pers. commun., 2013) There is also a wealth of experience in developing criteria for evaluating potential reintroduction success (e.g., Dunham et al. 2011). The first critical step is to evaluate the existence of remnant populations as those populations would be the foundation for any translocation or captive-rearing efforts. One of the key criteria for successful reintroduction is assessing areas to provide suitable habitat for viable populations (Dunham et al. 2011). This assessment should be incorporated into the design of the surveys for OSF. Because most of the potential habitat in the Willamette Valley will likely be on private lands, it will be important to include landowners in the entire process, similar to the approach of Watson et al. (2000) and Bohannon et al. (2012). Watershed Councils and county Soil and Water Conservation Districts will likely be important partners to ensure success.

VIII. Recommendations

A. Remove Classification as Extirpated in Willamette Valley

The Oregon Conservation Strategy (ODFW 2006:318) identifies OSF as extirpated in the Willamette Valley. Although this determination was likely an appropriate one based on the information available at the time of preparing the Conservation Strategy, existing evidence as provided in this report demonstrates such a determination is premature. I recommend ODFW modify their determination of the status of OSF in the Willamette Valley to reflect the uncertainty.

B. Design and Conduct Strategic Surveys and Habitat Assessments

I believe the most essential initial step for OSF recovery in the Willamette Valley is to formally conduct a survey to (1) locate remnant OSF populations, (2) evaluate the likelihood that the species is extirpated, and (3) evaluate potential habitat as release sites for supplementation of an already existing population in the Willamette Valley or for reintroduction if survey results provide strong evidence that the OSF is extirpated. I recommend an initial pilot study be

conducted to develop a GIS-based habitat suitability model for the Willamette Valley, followed by surveys at the most highly ranked sites within a limited area (e.g., Benton and Linn counties) prior to a Valley-wide effort. From the results of the pilot study, I recommend evaluating and modifying the habitat model and survey approach to improve efficiency, and conducting surveys throughout highly ranked areas of the Willamette Valley.

C. Feasibility Assessment of Reintroduction or Supplementation for Recovery

Based on the findings from the strategic surveys throughout the Willamette Valley, it would then be productive to conduct a formal feasibility assessment of how to best achieve recovery goals for OSF in the Willamette Valley.

D. Relevant Research for Recovery in Willamette Valley

Invasive bullfrogs and warm-water predatory fish may present the greatest threats to OSF population viability and successful reintroduction. Because it is extremely unlikely that bullfrogs can be removed from even a small number of selected sites, research on methods to facilitate co-existence and to favor OSF over bullfrogs is probably among the most relevant areas for research to benefit recovery of OSF in the Willamette Valley. Co-existence of bullfrogs and OSF at Conboy Lake National Wildlife Refuge (M. Hayes, pers. commun., 2013) provides an important example. Efforts to better understand this relationship may be key to recovery in the Willamette Valley. Similar efforts to understand factors contributing to co-existence of warm water fish and OSF are also needed.

Understanding how changes in water levels affect habitat, behavior, and survival rates of various life-stages of OSF is an important area for research that can contribute to recovery within the Willamette Valley. The focus will need to be on aspects of the hydrology for which the land manager can control if the research is truly going to inform management.

Because maintaining early successional habitat and controlling reed canary grass in the absence of natural disturbance has been an important issue in the agricultural areas of western Washington (J. Bohannon, pers. commun., 2013), research on cost-effective methods to achieve these outcomes is needed.

IX. Concluding Comments

The OSF is currently being reviewed for listing under the Endangered Species Act, is state listed in Washington as *Endangered,* and in British Columbia emergency listed as *Endangered.* Collectively, most of the known populations occur on public lands within Oregon and Washington, including U.S. Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, and Washington Department of Natural Resources. With the recently discovered populations in western Washington, most known populations in Washington occur on private lands.

Early evidence suggested OSF was extirpated in the Willamette Valley of western Oregon, prompting ODFW to consider the species as extirpated in that region. As demonstrated in this report, there is insufficient evidence to consider this population extirpated. The large extent of the Willamette Valley, coupled with recent conservation efforts to protect and restore the floodplain of the Willamette River, can provide important areas for OSF range-wide recovery. Using methods adapted from recent strategic survey work that led to the identification of extant

populations of OSF on private lands in western Washington, the distribution of remnant populations of OSF in the Willamette Valley can be determined. From such efforts, appropriate strategies can be developed for the recovery of OSF in parts of their former range in the Willamette Valley.

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