A Conservation Assessment for the Oregon Spotted Frog (*Rana pretiosa*)

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Disclaimer

This Conservation Assessment was prepared as a compilation of published and unpublished information regarding the biology and status of the Oregon spotted frog (*Rana pretiosa*). This assessment does not represent a management decision by the US Forest Service (FS Region 6) or Bureau of Land Management (OR/WA BLM). This report draws upon primary sources, summary articles, literature compilations, and observations from field researchers. Although the best scientific information available was used in preparation of this document, it is expected that new information will be forthcoming. Questions or information updates related to this document should be directed to the Interagency Special Status and Sensitive Species Conservation Planning Coordinator (Forest Service Region 6 and OR/WA BLM) in Portland, Oregon: www.fs.fed.us/r6/sfpnw/issssp/contactus/.

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Executive Summary

This document is presented in two parts. Part 1, A Conservation Assessment for the Oregon spotted frog (*Rana pretiosa*), summarizes species biology, status, threats, and general management considerations for the conservation of the species. Part II outlines research, inventory, and monitoring needs and opportunities for the species, as identified and compiled by the Oregon Spotted Frog Working Group. The Working Group was convened by the Interagency Special Status/Sensitive Species Program (ISSSSP) in 2005 to collect and assess literature and field data pertaining to the status of the Oregon spotted frog.

Species, Range, and Habitat
The Oregon spotted frog, *Rana pretiosa*, is a member of the Family Ranidae, Order Anura, Class Amphibia. The Oregon spotted frog is endemic to the Pacific Northwest and historically ranged from southwestern British Columbia to northeast California. The species is currently known from <50 sites in southwestern British Columbia, western and south-central Washington, and western, central, and south-central Oregon; no populations are known to persist in California. Revisits of historic localities suggest the species is lost from 70-90% of its historic range. The elevation range of the Oregon spotted frog is from < 50m above sea level in British Columbia to just over 1500m in Oregon. Breeding habitats used by Oregon spotted frog are generally moderate to large wetlands "…with extensive emergent marsh coverage that warms substantially during seasons when Oregon spotted frogs are active at the surface. …sites always include some permanent water juxtaposed to seasonally inundated habitat…"(Pearl and Hayes 2004, p. 3). Thirty of the 34 Oregon spotted frog localities evaluated as part of this Assessment are at least partially on Federal land (Table 1).

Management Status
The Oregon spotted frog is considered a Candidate species by the US Fish and Wildlife Service (USFWS). The USFWS Species Assessment and Listing Priority Assignment Form (October 2005) is available at http://ecos.fws.gov/docs/candforms_pdf/r1/D02A_V01.pdf. The Oregon Natural Heritage Information Center (previously the Oregon Natural Heritage Program; ONHP 2003) gives the Oregon spotted frog a Global rank of G2 (globally imperiled) and a State rank of S2 (imperiled because of rarity). The Oregon spotted frog is also ranked as a List 1 species in Oregon (taxa threatened with extinction or presumed to be extinct throughout their entire range; ONHP 2003). The Washington Natural Heritage Program (WNHP) gives the species a State rank of S1 (critically imperiled). The Oregon spotted frog is ranked as a State Endangered species by the Washington Dept. of Fish and Wildlife (WDFW 2005); Sensitive-Critical by Oregon Dept. of Fish and Wildlife (ONHP 2003); Special Status Species by Oregon BLM (March 2005 List); and Sensitive by the US Forest Service Region 6 (Regional Forester's Sensitive Animal List 2004).

Threats
Several characteristics of Oregon spotted frogs and their current distribution combine to suggest a relatively high overall vulnerability of the species: 1) limited and highly fragmented extant distribution with extensive losses from their historic range, 2) strong association with emergent marshes and seasonally used microhabitats within wetland complexes, 3) limited ability to move long distances, particularly in non-aquatic environments, and 4) aspects of their behavior and life

history are likely to result in high local mortality. The following factors have been identified as likely or potential threats to Oregon spotted frog populations:

- Direct loss of marsh habitat, particularly through conversion to other land uses;
- Alteration of hydrological regimes in extant marshes (*e.g.*, from dam construction, channel simplification, groundwater recession, hydroperiod modification);
- Interactions with non-native fishes and American bullfrogs;
- Vegetation changes such as succession and invasion by non-native species;
- Livestock grazing, particularly in circumstances of high livestock density and duration, and where Oregon spotted frog habitat is area-limited or in more arid parts of range;
- Degraded water quality;
- Isolation from other Oregon spotted frog populations;
- Drought effects, both direct and indirect.

Management Considerations

The following actions are offered for consideration toward maintaining or improving local habitat conditions likely to benefit Oregon spotted frog persistence:

- Restore or maintain intact hydrological regimes where Oregon spotted frog may be detrimentally affected;
- Protect and restore ephemeral and permanent wetlands near existing Oregon spotted frog sites;
- Restore or maintain open water and early seral vegetation communities;
- Reevaluate or discontinue local fish-stocking practices;
- Limit the spread and effects of American bullfrog in areas occupied or potentially suitable for reintroduction of Oregon spotted frog;
- Develop comprehensive grazing strategies or adaptive management plans where livestock will occur in Oregon spotted frog habitat;
- Work locally and cooperatively to maintain or restore habitat conditions, and to monitor outcomes of management actions directed toward Oregon spotted frogs.

Research, Inventory, and Monitoring Opportunities

Selected information gaps include:

- Attributes of habitats that allow co-existence of Oregon spotted frog with non-native predators (e.g. fish and bullfrogs)
- Conditions that facilitate movements between populations and between seasonally important habitats within populations
- Data on population trends and population responses to habitat restoration
- Key habitat criteria needed to promote successful reintroductions, and the impacts of translocation on populations.

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Introduction

Goal

The goal of this Conservation Assessment (CA) is to summarize existing knowledge about the Oregon spotted frog (*Rana pretiosa* Baird and Girard, 1853). Included is information on biology and ecology, and threats to the species. The CA also identifies potentially important information gaps, and offers a list of considerations that may help agency personnel better manage populations and habitats. This document focuses on Oregon spotted frog habitats on public land.

A great deal of new information has been generated regarding this species in the last few years, especially with respect to distribution and habitat. Still, gaps in understanding of the basic biology and ecology of Oregon spotted frog remain, and information updates will be necessary to keep this assessment current. Threats are those currently known or suspected, and may change with time and additional information. Management considerations may be applied to specific sites, though some large-scale issues such as population connectivity and range-wide concerns are listed. Uncertainty and inference are acknowledged where appropriate, and care has been taken to limit considerations to those supported by current literature and direct observations.

Scope

The geographic scope of this assessment includes the historic, known and suspected range of the Oregon spotted frog within the US: from the westernmost Canadian border south through Washington's Puget Sound and Portland Basin into Oregon's Willamette Valley, and straddling the Cascade Range from south-central Washington through the upper Willamette, Deschutes, and Klamath drainages (Figure 1). The southern extent of the range is in very northeastern California. Populations also exist in southern British Columbia. With the exception of inclusion of their basic biology, the British Columbia populations are excluded from discussion in this document.

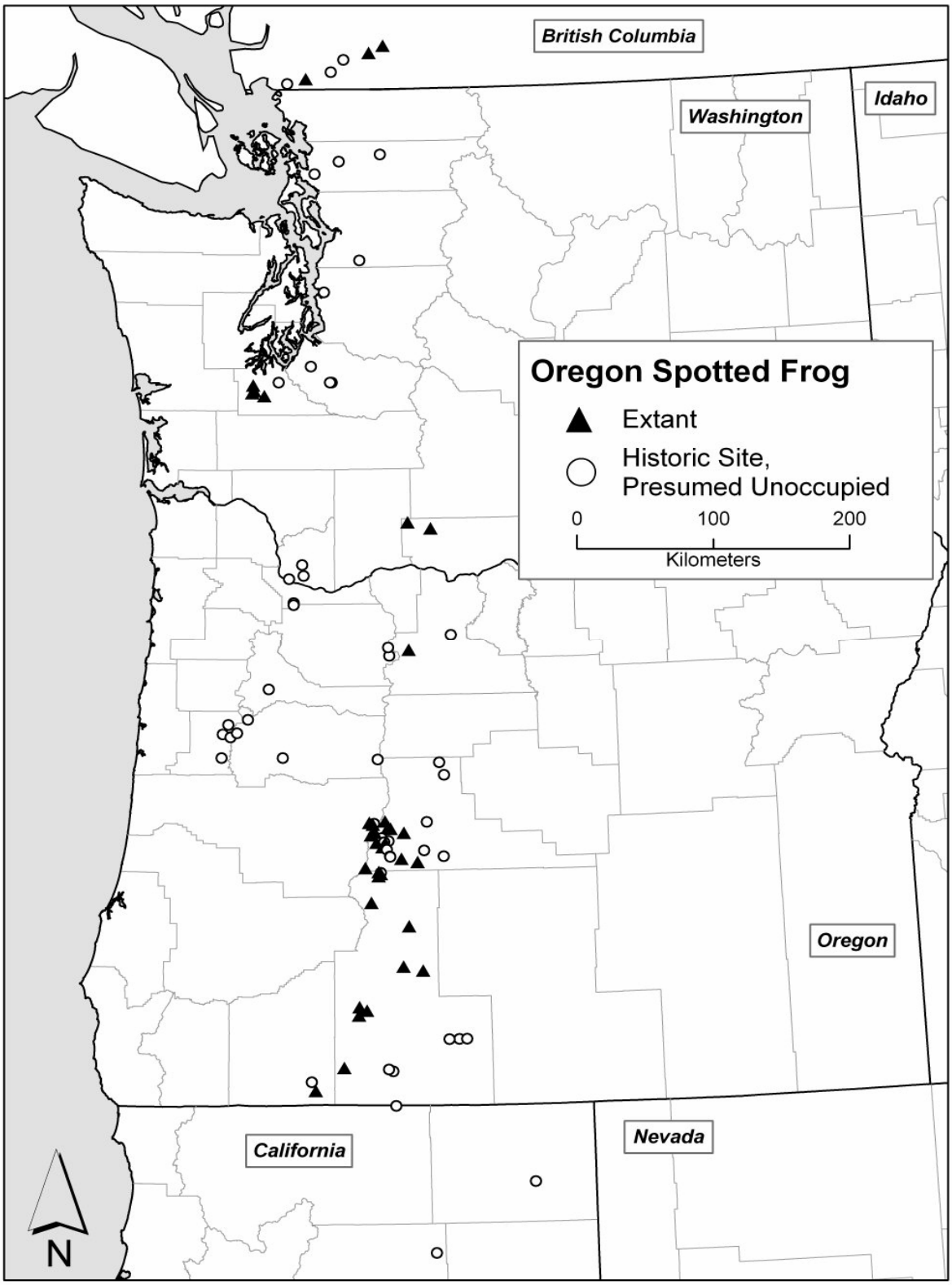
Management Status

The US Fish and Wildlife Service (USFWS) considers the Oregon spotted frog a Candidate species for listing under the Endangered Species Act. The Natural Heritage Network considers the Oregon spotted frog to be a G2 species (globally) "Imperiled because of rarity or because other factors demonstrably make it very vulnerable to extinction" (http://www.natureserve.org/explorer/servlet/NatureServe?searchName=Rana+pretiosa). The Washington Natural Heritage Program summarizes the frog's federal and Washington state status as a (federal) Candidate species for listing under the Endangered Species Act, a Washington State Endangered species, and a Washington State rank of S1 (critically imperiled) (http://www.dnr.wa.gov/nhp/refdesk/lists/animal_ranks.html). The Oregon Natural Heritage Information Center gives the Oregon spotted frog an Oregon State Rank of 2 ("Imperiled because of rarity"), and considers it an Oregon List 1 species (taxa threatened with extinction or presumed to be extinct throughout their entire range)

(http://oregonstate.edu/ornhic/2004_t&e_book.pdf). The Oregon spotted frog is included on the Oregon BLM Special Status Species List (March 2005) and on the US Forest Service Region 6 Regional Forester's Sensitive Animal List (2004).

Federal management for this species follows Region 6 Forest Service Sensitive Species policy and OR/WA BLM Special Status Species (SSS) policy. For OR/WA BLM administered lands, SSS policy details the need to manage for species conservation. For Region 6 Forest Service administered lands, the Sensitive Species policy requires the agency to maintain viable populations of all native and desired non-native wildlife, fish, and plant species in habitats distributed throughout their geographic range on National Forest lands. Management "must not result in a loss of species viability or create significant trends toward federal listing" (FSM 2670.32) for any identified sensitive species.

Figure 1. Oregon spotted frog distribution in the Pacific Northwest. Locality data are from McAllister et al. (1993), Hayes (1994, 1997), Haycock (2000), and C. Pearl, unpubl.data.



Classification and Description

Systematics and Synonymy

The Oregon spotted frog (*Rana pretiosa*) was first described from specimens collected in 1853 by Baird and Girard from the general locality of "Puget Sound" in Washington. As a member of the order Anura, and the family Ranidae, the genus *Rana* comprises the true frogs, which includes most of North America's larger frog species. Accounts and observations of "spotted frogs" prior to 1996 may not be reliably attributed to Oregon spotted frog because Green's genetic work revealed two species of "spotted frogs" where only one had been considered previously (Green et al. 1996 and 1997).

Allozyme work delineated a species from the vicinity of the type locality that was conspecific with species from south-central Washington and the Oregon Cascade Mountains, as well as with frogs from southwestern British Columbia. "These populations comprise *R. pretiosa* Baird and Girard, 1853 *sensu stricto*. ("Oregon spotted frog")" (Green et al. 1997, p. 1) Morphometric studies showed that spotted frog populations from other parts of British Columbia, Washington, Oregon, Montana, Wyoming, Nevada, and Utah belong to a distinct species, *Rana luteiventris* Thompson, 1913 n. comb. "Columbia spotted frog" (Green et al. 1997). Although Green et al. (1997) note that species of the (former) *R. pretiosa* complex are morphologically similar, they can be differentiated biochemically by allozyme differences through a multiple discriminant function analysis. A reasonable conclusion from this work (Green et al. 1996, 1997) would seem to be that spotted frog studies prior to 1996 might warrant some degree of re-interpretation, especially in areas along the interface of the two currently recognized species. The range of *R. pretiosa* Baird and Girard, 1853 *sensu stricto* is depicted in Figure 1. Additional maps that summarize the relationship between ranges of *R. pretiosa* and *R. luteiventris* reside in Green et al. (1996, 1997), Pearl and Hayes (2005), and Reaser and Pilliod (2005). Sympatric populations of Oregon and Columbia spotted frogs are not currently known (McAllister and Leonard 1997).

Natural hybridization between *R. cascadae* (Cascade frog) and *R. pretiosa* was reported by Green (1985) at one locality in Oregon (Gold Lake near Willamette Pass). Though evidence indicated the two species interbred at least once at this location, significant genetic and morphological differences distinguish the species, and the two species co-occur infrequently. At the few sites where hybridization may occur, identification of individuals should be done with particular care.

Species Description

Leonard and McAllister (2005, p. 210) provide the following description for Oregon spotted frogs:

"This robust frog is olive, brown or brick red, with large, irregularly shaped spots on the back, sides and legs. The spots, which frequently have light centers, have indistinct edges. Small bumps and tubercles sometimes cover the back, and a dorsolateral fold runs along each side of the back. The chartreuse-colored eyes are decidedly upturned. The lower abdomen and

undersides of the hind legs are colored with varying amounts of a red or orange pigment that appears painted on. The groin is not mottled. The hind legs are relatively short, and when a leg is adpressed forward, the heel does not extend beyond the nostrils. There is extensive webbing between the toes on the hind feet. Sexually mature females range between 60 and 100 mm SVL and males between 45 and 75mm SVL. Recently metamorphosed Oregon Spotted Frogs range from 20-30 mm SVL."

Juveniles may have red or orange pigments confined to the underside of their hind legs (Leonard and McAllister 2005). This ventral reddening generally increases in opacity with age of the frog. Adult Oregon spotted frog, particularly females, can attain substantial reddening over dorsal surfaces. Photographs and useful discussions on similarities with other species, especially the Columbia spotted frog (*Rana luteiventris*), are presented in field guides and reviews, including Corkran and Thoms (1996), McAllister and Leonard (1997), and Leonard and McAllister (2005).

Biology and Ecology

Life History and Reproductive Biology

The timing of egg laying varies with elevation, latitude, and rate of snowpack thaw (Licht 1969, McAllister and Leonard 1997, Pearl and Hayes 2004). Breeding occurs in February or March at lower elevations (Licht 1969, Leonard and McAllister 2005). Breeding in higher elevations generally begins within days to weeks after breeding areas are clear of ice; near 1500 m elevation in Oregon, breeding can extend into late May or early June in high snow years (C. Pearl, unpubl. data). Specific triggers for the initiation of breeding are incompletely known, but observations from British Columbia and central Oregon suggest they include some combination of day length and water temperatures (see Licht 1969). At Big Marsh in central Oregon, breeding appears to begin in earnest when water temperature approaches 10°C (J. Kittrell, pers. obs.), and similar observations have been made at Jack Creek (J. Oertley, pers. comm.). Licht (1969) reported that breeding could begin in ponds when water temperatures exceeded 6°C. At other Oregon sites, breeding has not started until after water temperature has exceeded 10°C, so it is likely that this trait varies between populations, or that other cues are involved (J. Bowerman and C. Pearl, unpubl. data).

Females often oviposit communally (interspersed with previously deposited egg masses): groups of > 20 egg masses are not uncommon in large populations and groups of > 100 egg masses have been observed (C. Pearl, pers. obs.; M. Hayes, pers. comm.). Groups of males often congregate near larger oviposition sites prior to the arrival of females (J. Bowerman, pers. comm.), similar to Columbia spotted frogs (*R. luteiventris*: e.g., Davis and Verrell 2005). The same oviposition sites are often used year after year (Leonard et al. 1993; C. Pearl, pers. obs.).

Ova of Oregon spotted frogs in British Columbia average 2.3 mm (Licht 1971). The outer capsule of Oregon spotted frog eggs in Washington average 8 mm in diameter (Leonard and McAllister 2005). Egg masses are globular and contain as many as 1500 eggs (C. Pearl and J.

Bowerman, pers. obs.). Oregon spotted frog eggs survive and develop better in warmer waters than other northwestern ranids such as Northern red-legged frogs (*R. aurora*; Licht 1971). Oviposition sites are generally shallow (< 35 cm depth), gently sloping, and associated with previous years emergent vegetation (reviewed in Pearl and Hayes 2004). This breeding habit makes Oregon spotted frog eggs and hatchling larvae vulnerable to desiccation (Licht 1974, McAllister and Leonard 1997, Watson et al. 2000). Exposed eggs can also be damaged by freezing. However, even when the upper eggs are frozen, the lower portions of egg masses can remain healthy. Shallow areas where egg masses are deposited often dry by late summer, and it is assumed that some tadpoles are able to follow the receding water line (Pearl and Hayes 2004, J. Kittrell, pers. comm.).

Most of the extant range of the Oregon spotted frog is east of the Cascade Range in Oregon, where precipitation falls mainly as snow. Observations from Big Marsh and other sites along the Cascade crest suggest that duration and quantity of snowmelt influences the amount of water available for egg laying and tadpole rearing (J. Kittrell, C. Pearl, pers. obs.): if snowmelt is protracted, water in breeding shallows is likely to remain deep enough to minimize stranding of egg masses and tadpoles. Within the lower-elevation western range of Oregon spotted frogs, where breeding is earlier, rainfall can contribute to keeping oviposition and larval rearing sites inundated. Throughout the range of Oregon spotted frogs, rapidly falling water levels can result in large scale mortality of eggs (Licht 1971).

The duration of the larval stage in Oregon spotted frogs (hatchlings to juvenile froglets) has not been well studied in the field, but is thought to range from approximately 3 to 5 months depending on water temperatures (Licht 1974; J. Bowerman, pers. comm.). Overwintering has not been verified in Oregon spotted frog larvae.

Similar to many North American pond breeding anurans, abundance of larval and post-metamorphic Oregon spotted frogs can be strongly affected by predation. Survival of Oregon spotted frogs from egg to metamorphosis has been estimated at.5% (Licht 1974), an estimate congruent to survival estimates for early stages of red-legged frogs (*Rana aurora;* Licht 1974) and wood frogs (*R. sylvatica*; Herreid and Kinney 1966). The heaviest losses to predation are thought to occur shortly after tadpoles emerge from eggs and are relatively exposed and poor swimmers (Licht 1974). The odds of survival appear to increase as tadpoles grow in size and aquatic vegetation matures (Licht 1974). Native predators of tadpoles include garter snakes (*Thamnophis* spp.), fish, leeches, and larval salamanders, water beetles, giant water bugs, and dragonflies (Licht 1974). Non-native fish are likely predators of tadpoles, but direct observations are lacking (further discussion in 'Threats', next section).

Mortality rates of juvenile and adult Oregon spotted frogs are thought to be lower than those for embryos and tadpoles (*e.g*., Licht 1974, Watson et al. 2000). Adult male spotted frogs appear to experience higher mortality rates than females: this may be related to their smaller body size and prolonged exposure to predators during the breeding season. Males often gather at breeding sites for days or weeks, and are active diurnally. In contrast, females appear to remain at breeding sites only long enough to lay eggs (Licht 1974, Leonard and McAllister 2005). Smaller body size of males is likely to translate into greater vulnerability to gape-limited predators. Garter snakes are likely an important predator of post-metamorphic Oregon

spotted frogs: they often are common at spotted frog sites and have been observed consuming spotted frogs on multiple occasions (Licht 1974; Pearl and Hayes 2002, D. Clayton, pers. comm.). Other confirmed predators of adult spotted frogs include blue herons (Licht 1974) and river otters (Hayes et al. 2005). Likely predators of juveniles and adults include fish, mustelid mammals (esp. mink) and wading birds. Sandhill cranes co-occur with Oregon spotted frogs at multiple sites and have been repeatedly observed hunting in areas where frogs occur (C. Pearl, pers. obs.; T. Forbes, J. Engler, pers. comm.). Non-native American bullfrogs consume juvenile and adult spotted frogs (M. Hayes, J. Engler, pers. comm.).

Adult Oregon spotted frogs avoid predators by hopping directly toward the water, where they often swim to the bottom to take cover in soft substrates or vegetation (Licht 1986b, McAllister and Leonard 1997).

Activity Patterns, Movements, and Habitat Use

Information on adult Oregon spotted frog habitat use derives from observations across the species range and telemetry studies in Washington. Relatively little is known about Oregon spotted frog movements at larger between-site and landscape scales. However, recent work in Washington (Dempsey Creek and Trout Lake Wetland Natural Area Preserve) has provided initial understanding of within-wetland movements and begun to underscore the importance of aquatic and semi-aquatic movement routes. Similar work is needed in higher elevation habitats that represent the bulk of the species extant range in Oregon.

Watson et al. (2003) used radiotelemetry on adults to identify seasonal habitat associations by adult Oregon spotted frogs in the Dempsey Creek wetland complex in Washington. In addition to habitat use patterns, Watson et al. (2003) described two classes of movements by Oregon spotted frogs: infrequent movements between widely separated pools, and more frequent movement between pools in closer proximity. Home ranges averaged 2.2 ha., and frogs moved 5 – 7 meters per day throughout the year (Watson et al. 2003). During the breeding season (February–May), frogs used about half the area used during the rest of the year. During the dry season (June–August), frogs moved to deeper, permanent pools, and occupied the smallest range of any season. Frogs with transmitters moved back toward their former breeding range during the wet season (September–January). Frogs used dense vegetation in shallow ice-covered water during cold weather. Frogs appeared to select sedges (*Carex* spp.) and rushes (*Juncus* spp.) in breeding habitat. During the summer in British Columbia and central Oregon, adult Oregon spotted frogs are often observed near the water surface basking and feeding in beds of floating and submerged vegetation (Licht 1986a, Pearl and Hayes 2002, Pearl et al. 2005). Adult Oregon spotted frog will also forage in moist wetland fringes among moderate-density vegetation such as sedges (Licht 1986, Pearl and Hayes 2002).

At the Trout Lake Wetland Natural Area Preserve in south central Washington, a similar telemetry study found that Oregon spotted frogs with transmitters usually did not move more than 400 m from their original capture location (Hallock and Pearson 2001). Similar to the Dempsey Creek frogs, movements averaged 6 m per day. The longest distance from original capture by any Oregon spotted frog was 437 m. Oregon spotted frogs used emergent and aquatic bed vegetation types in fall, particularly areas of emergent cover with lesser component

of aquatic bed vegetation. Frogs also used unvegetated substrates, presumably because these openings allow easy movement. Overall, frogs appeared to select areas of accumulated organic matter: these sites are thought to provide valuable cover (Hallock and Pearson 2001).

Areas clearly identifiable as 'hibernation' sites were not detected during the year of telemetry at Trout Lake Wetland, even during cold periods in December–January (Hallock and Pearson 2001). Frogs remained active despite low temperatures and individuals that survived to the end of the study tended not to lose appreciable weight. Hallock and Pearson (2001) hypothesized that a wintertime exodus of frogs from emergent/aquatic bed habitats may have been related to low dissolved oxygen under snow and ice. Several recent studies of other North American ranid frogs (cited in Hallock and Pearson 2001) have found that over-wintering frogs prefer areas with well-oxygenated water.

Long distance movements were detected in a mark-recapture study at Jack Creek in central Oregon (Forbes and Peterson 1999). In contrast to the aforementioned wetlands, habitat used by Oregon spotted frogs at Jack Creek stretches along a stream corridor and interspersed montane meadows. Two young juvenile frogs toe clipped in late summer were recaptured the following year 1245 m and 1375 m downstream from where they were initially marked (M. Hayes, pers. comm.). In 1999, one adult female with a Passive Integrated Transponder (PIT) moved 2530 m (straight line) and 2799 m (estimated stream distance) downstream from its initial marking location. While long-distance movements appear to be infrequent, they have been documented at Jack Creek (Forbes and Peterson 1999) and Dempsey Creek in Washington (Watson et al. 2003).

Food Habits

Oregon spotted frog larvae are thought to be generalist grazers. They possess rough tooth rows, which allow them to scrape leaf surfaces and ingest plant tissue and bacteria (McAllister and Leonard 1997). For tadpoles and frogs living in productive wetland habitats, food is not usually a limiting factor. Oregon spotted frog tadpoles can survive in tanks for several weeks without food, suggesting that starvation due to food limitation is not likely in the field (Licht 1974).

Adult Oregon spotted frogs consume a wide variety of invertebrate prey, including slugs, snails, spiders, crickets, grasshoppers, dragonflies, damselflies, true bugs, beetles, butterflies, moths, flies, bees, ants, and wasps (Licht 1986a). A similar diversity of prey items was reported for Columbia spotted frogs in northeastern Oregon (Bull 2003). In southwestern British Columbia, Oregon spotted frogs fed mainly while floating among aquatic vegetation at the surface of ponds, rain pools, or slow rivers (Licht 1986a). Frogs often fed with bodies almost completely submerged except for their heads, or half concealed in pondweed. These frogs remained still until movement from suitable prey prompted an orientation response, at which time the frog lunged for the prey if it was near enough (Pearl and Hayes 2002, Pearl et al. 2005). If prey was located on the water surface the frogs swam toward it with only their head and eyes above water. Pearl et al. (2005; p. 37) reported "directed crawling and sub-surface swimming in vegetation mats" and use of "vertical structure to block direct observation by prey" at central Oregon sites.

Observations in Oregon document predation by Oregon spotted frog adults on juvenile western toads (*Bufo boreas*; Pearl and Hayes 2002, Pearl et al. 2005). Adult Oregon spotted frogs appear to be unaffected by toxins in dermal glands of juvenile toads (Pearl and Hayes 2002). Consumption of unpalatable bufonid toads appears to distinguish Oregon spotted frogs from most other North American ranid frogs (Pearl and Hayes 2002).

Range, Distribution, and Abundance

Oregon spotted frogs are endemic to the Pacific Northwest, historically ranging from southwestern British Columbia to northeast California. While surveys have not been exhaustive, the Oregon spotted frog appears to be extirpated from its range in northeastern California and the Willamette Valley of western Oregon (Nussbaum et al. 1983; Hayes 1994, 1997). Confirmable records and museum specimens identify 58 localities in the US where the Oregon spotted frog historically occurred in Oregon (N=44; Hayes 1994, 1997), California (N=3; Hayes 1997) and Washington (N=11; McAllister and Leonard 1997). Recent surveys (within last 20 yrs) suggest that Oregon spotted frogs remain at 22% (13/58) of these historic sites (McAllister and Leonard 1997, Hayes 1994, 1997).

Based on microsatellite and mtDNA analyses, Blouin (2000) concluded that the Klamath Basin, central Oregon Cascades, and Washington populations should be provisionally regarded as separate genetic units for management purposes. Oregon spotted frogs sampled from the Klamath Basin populations (Klamath Marsh, Upper Williamson, Jack Creek, Wood River and Buck Lake) appear to compose a genetic unit more divergent from the other sampled populations than any of the other populations are from one another (Blouin 2000). The preliminary genetic data suggest that Klamath Basin populations linked by at least seasonal aquatic connections (Upper Williamson, East and West Klamath Marsh) are more closely related than the more isolated populations such as Buck Lake and Jack Creek (Blouin 2000). The Camas Prairie population in the northern Deschutes Basin appears to be especially distinct from the others (Blouin 2000).

Of the 34 Oregon spotted frog localities evaluated as part of this Assessment, 30 are partially or completely on Federal land (Table 1). Two sites are partially managed by the State of Washington, and two sites are situated on private land. It should be noted that surveys have been much more complete on public than on private lands throughout the species range. A gradient of protection exists among the federally managed sites. Three of the sites evaluated in Table 1 are within Wilderness areas managed by the US Forest Service. Large segments of two sites (Conboy, Klamath Marsh) are on National Wildlife Refuges administered by the US Fish and Wildlife Service; portions of three additional sites are also administered by the US Fish and Wildlife. One site is on a US Forest Service Research Natural Area. The rest of the sites at least partly on public lands are on US Forest Service and Bureau of Land Management holdings lacking the previous designations.

Habitat

Oregon spotted frogs are the most aquatic of the native ranid frogs in the Pacific Northwest (Leonard et al. 1993, and others). Licht (1986) noted that the frog's eye placement and degree of webbing on the hind feet suggest that the frog is ideally suited for aquatic behavior. Observations of feeding behavior at multiple sites in Oregon support Licht's contention (Pearl and Hayes 2002, Pearl et al. 2005). Post-metamorphic stages are usually found among herbaceous wetland vegetation (*e.g.* sedges, rushes, grasses or floating mats of submergent plants) in or near perennial water (Licht 1986 a,b; Watson et al. 2003). These habitats often include areas of warm water (McAllister and Leonard 1997). Post-metamorphic Oregon spotted frogs can also utilize pools, ponds and small floodplain wetlands associated with permanent bodies of water, but where breeding rarely occurs (McAllister and Leonard 1997; C. Pearl, pers. obs.). A comprehensive summary of earlier literature on habitat associations is presented in Pearl and Hayes (2004).

Based on their study of a population in western Washington, Watson et al. (2003) summarized conditions required for completion of Oregon spotted frog life cycle as: shallow water areas for egg and tadpole survival, perennial deep moderately vegetated pools for adult and juvenile survival in the dry season, and perennial water for protecting all age classes during cold wet weather. Pearl and Hayes (2004) provided additional information on Oregon spotted frog habitats range-wide and noted (p. 3) that "Oregon spotted frogs are generally associated with wetland complexes greater than 4 ha in size with extensive emergent marsh coverage that warms substantially during seasons when Oregon spotted frogs are active at the surface. …sites always include some permanent water juxtaposed to seasonally inundated habitat." There is little indication from literature or extant sites that suggest Oregon spotted frogs can persist at sites that dry regularly.

Oregon spotted frogs typically breed in water 2-30 cm deep (Licht 1969, 1974). Grasses, sedges, and rushes are usually present, though eggs are laid where the vegetation is low or sparse (McAllister and Leonard 1997). In central Oregon, Oregon spotted frogs are found in lakes and marshes up to 1575 m elevation, where snow and ice cover their habitat for months (Pearl and Hayes 2004). In at least some sites, Oregon spotted frogs are known to overwinter in perennially flowing springs or channels that do not freeze completely (M. Hayes quoted in McAllister and Leonard 1997; C. Pearl and J. Bowerman, unpubl. data;).

Studies by Licht (1969, 1971, 1974, 1975, and 1986a,b) provide details on life history characteristics of Oregon spotted frogs from southwestern British Columbia. Other summaries of breeding ecology and habitat use are Watson et al. (2003) and Pearl and Hayes (2004, 2005).

Historic and extant localities suggest Oregon spotted frogs occurred at higher maximum elevations toward the southern end of their range. Oregon spotted frogs are known only from sites < 300 m above sea level in British Columbia and very northwestern Washington and British Columbia (Pearl and Hayes 2004). In contrast, Oregon spotted frogs are known to have occurred > 1575 m elevation in southern Oregon (Pearl and Hayes 2004). Whether this cline in maximum elevations reflects habitat availability, physiological tolerance of the species, or some combination of the two, is not known. Extensive loss and alteration of marsh habitats in

Oregon's Willamette Valley and Washington's Puget Lowlands has resulted from human activities, and has likely resulted in disproportionate loss of populations in the lower elevations of the species historic range (Hayes 1994, 1997; Pearl and Hayes 2004).

Conservation

Potential threats to Oregon spotted frogs

Multiple aspects of Oregon spotted frog distribution and biology suggest the species is vulnerable to multiple threats (Hayes 1997, Pearl and Hayes 2004, Pearl and Hayes 2005): 1) extensive losses from their historic range and a limited and highly fragmented extant distribution, 2) relatively specific habitat requirements and seasonally used microhabitats within wetland complexes, 3) limited ability to move long distances, particularly across non-aquatic environments, and 4) aspects of their behavior and life history that are likely to result in high local mortality (*e.g.*, communal breeding can result in large reproductive losses via desiccation; habitat overlap with nonnative American bullfrogs and warm-water fish is likely to subject Oregon spotted frogs to predation by those invaders).

The following discussion of potential threats is focused on those that have been directly suggested as having negative effects on Oregon spotted frogs. A variety of other factors have been identified as stressors on other pond-breeding anurans within the range of the Oregon spotted frog but information is currently insufficient to gauge their effects on Oregon spotted frog (Pearl and Hayes 2005). For example, ultraviolet-b (UV-B) radiation can act as a stressor to other amphibians in selected situations, but the limited data available on Oregon spotted frogs suggest current levels do not increase mortality in eggs (Blaustein et al. 1999). Forestry practices have negative effects on some pond-breeding anurans in other regions (reviewed in de Maynadier and Hunter 1995). This report does not devote specific attention to that potential threat since information addressing potential effects of forestry on Oregon spotted frogs is lacking. Part II of this document identifies forestry practices among the information gaps for Oregon spotted frogs.

Diseases such as pathogenic fungi have been implicated as affecting other Northwestern species, and this discussion includes a brief discussion of disease as a potential stressor on Oregon spotted frog populations. It should be noted that investigation of disease in Oregon spotted frogs is very recent. Both fungal diseases mentioned below are known to occur in Oregon spotted frog populations in Oregon and Washington (Pearl et al., in press; J. Petrisko et al., unpubl. data; J. Bowerman, M. Hayes, pers. comm.), but how they are affecting those populations is currently unknown.

• **Loss and alteration of marsh habitat**: Hydrological alteration and direct destruction of wetlands have been extensive since Euro-American settlement in the Pacific Northwest (Benner and Seddell 1997, Kjelstrom and Williams 2000, Kentula et al. 2004). These changes are likely to be primary causes of Oregon spotted frog population losses (Hayes 1994, 1997; McAllister and Leonard 1997, Pearl and Hayes 2004, 2005). Regions where Oregon spotted frogs appear to have declined most significantly (*e.g.*, Washington's Puget

Lowlands and Oregon's Willamette Valley and Klamath Basin) have experienced dramatic losses and alteration of emergent wetlands (Canning and Stevens 1989, Dahl 1990, Christy et al. 2000, Hulse et al. 2002). Wetlands have commonly been modified to facilitate agricultural uses; other reasons were to reduce potential flooding, allow urban expansion, and impound water in reservoirs. Direct modifications associated with these changes in land use have commonly been accompanied by other stressors such as livestock grazing, water quality changes, and establishment of non-native fish and American bullfrogs (discussed below). Hydrological changes have included shifts from landscapes dominated by seasonal wetlands to those dominated by permanent ones (extensive loss of temporary wetlands and gains of permanent ponds and reservoirs; Kentula et al. 1992). Separating the direct effects of this conversion from those effects related to expansion of nonnative predators with these permanent wetlands remains difficult (Hayes and Jennings 1986, Adams 1999).

• **Plant succession and other vegetation changes**: Due to their breeding habitat requirement of exposed, shallowly sloping sites for oviposition, Oregon spotted frog populations are vulnerable to loss of these microhabitats to changes such as vegetation succession (Hayes 1997, Pearl and Hayes 2004). Succession by native and non-native vegetation has potential to modify conditions at wetlands occupied by Oregon spotted frog. Hayes (1997) scored a list of risk factors (exotic species, hydrological alteration, risk of drought, livestock management, exotic vegetation, succession) to Oregon spotted frog populations at a subset of sites across the species' range. Categories were Not Detected (=0), Low (=1), Moderate (=2), or High (=3; Hayes 1997). Pearl (1999) followed the same system for 4 additional occupied Oregon spotted frog breeding sites. Pooling these 2 assessments, succession was ranked as a Moderate or High threat at 22 of 28 Oregon spotted frog sites (Hayes 1997, Pearl 1999). Encroachment around and into marshes by lodgepole pine and other woody vegetation is occurring at multiple sites in Oregon, and is likely facilitated by ditching and draining of wetter sites to improve grazing (*e.g.*, Big Marsh; J. Kittrell, pers. comm.). Much of the range of the Oregon spotted frog (particularly Deschutes and Klamath Basins, as well as parts of the Willamette Valley and Puget Lowlands) is in areas thought to have frequent historical burning (both lightning and native American ignitions). In addition to fires, beaver and active floodplain meanders were natural disturbances that were historically more common in the range of the Oregon spotted frog. Both would have acted to periodically create open habitat and maintain openings in riparian forests.

Selected native and non-native plants can form dense monocultures (*e.g.*, cattail [*Typha* spp.], reed canary grass, [*Phalaris arundinacea*], common reed [*Phragmites* spp.]) and modify the structure of invaded littoral zones. Hayes (1997) ranked risks posed by exotic vegetation as 'Moderate' or 'High' at 12 of 24 sites. Reed canary grass represents a major threat, and is present or increasing in several Oregon spotted frog sites (*e.g.*, Dempsey Creek, 110th and 123rd Ave., Conboy Lake NWR in Washington; Big Marsh, Wood River and other Oregon sites; Hayes 1997; C. Pearl, pers. obs.; Table 1). A significant threat is the establishment of reed canary grass in shallowly sloping wetland benches favored by Oregon spotted frog for oviposition. At one site in Washington where reed canary grass is among the dominant vegetation types, a preliminary study suggested that breeding Oregon spotted frog adults selected mowed treatment plots over neighboring areas of taller, denser reed canary grass (White 2002). At another western Washington site invaded by reed canary grass (>

30% of the wetland; Watson et al. 2003), adult Oregon spotted frog fitted with transmitters were detected in microhabitats dominated by reed canary grass less frequently than would be expected based on the coverage of canary grass in the site, suggesting avoidance (Watson et al. 2003).

Additional work is needed to clarify direct and indirect effects of invasive wetland plants on Oregon spotted frog, which may be impacted in multiple portions of their life cycle. Studies of other invasive plants document a wide range of effects on wetland systems, including altered transpiration and local hydrology, basal trophic productivity and composition or availability of invertebrates (Read and Barmuta 1999, Ehrenfeld et al. 2001, Greenwood et al. 2004). Maerz et al. (2005) found that feeding was reduced among green frogs (*R. clamitans*) in riparian systems dominated by invasive Japanese knotweed. Further research is also needed on actions such as water level management that may exacerbate invasions by these plants, as well as outcomes of restoration practices (*e.g*., Paveglio and Kilbride 2000). This includes identification of the effects of herbicides that are used in controlling nonnative plants.

• Interactions with nonnative fishes and American bullfrogs: Many potential Oregon spotted frog predators that are native to eastern North America have been introduced into the range of Oregon spotted frogs over the last ca. 130 years (see Lampman 1946, Hayes and Jennings 1986, Bahls 1992, Altman et al. 1997, Hayes 1997). These introductions have occurred concurrently with wetland loss and alteration described above. Modifications have included construction of permanent ponds for livestock, flood control, and recreation, as well as conversion of seasonally flooded wetlands to agriculture and permanent impoundments. These trends have increased the availability of habitat for nonnative predators that require permanent waters. Fish are fundamental structuring agents of amphibian communities (*e.g*. Hecnar and M'Closkey 1997, Wellborn et al. 1996). Introduced fish are known to impact other pond breeding amphibians in the western USA (e.g., Bradford et al. 1993, Kiesecker and Blaustein 1998, Tyler et al. 1998, Adams 1999, Monello and Wright 1999, Knapp and Matthews 2000, Matthews et al. 2001, Pilliod and Peterson 2001, Vredenburg 2004, Pearl et al. 2005). Many lentic habitats in the range of the Oregon spotted frog historically lacked large-bodied predatory fish (*e.g*., Bahls 1992). It is not known whether Oregon spotted frog life stages can reduce risky behaviors in the presence of novel predators (per Kats et al. 1988, Kiesecker and Blaustein 1997). A variety of non-native fish are now established across the range of Oregon spotted frog, many of which are successful predators of amphibians (*e.g*., representatives of families Centrarchidae [sunfish and bass] and salmonidae [charr]). Oregon spotted frogs presently co-occur with non-native fish in multiple sites, but these sites are often characterized by high structural complexity and microhabitats that are less accessible to fish (*e.g*., heavy vegetation cover or isolation from deeper habitats preferred by some fish). The effects of nonnative fish on Oregon spotted frog in field conditions and the mediating effects of habitat complexity on this relationship should be a priority for further research.

Abundance of the related Columbia spotted frog (*Rana luteiventris*) is negatively associated with presence of nonnative fish in study areas in lowland and montane Idaho (Monello and Wright 1999, Pilliod and Peterson 2001). Reaser (2000) concluded that introduced trout are one of the main limitations on Columbia spotted frog distribution in Nevada. Bull and Marx

(2002) did not detect any effect of trout presence in eastern Oregon ponds and lakes, but Columbia spotted frogs were associated with littoral vegetation along north shores. Such a pattern is consistent with an ability of spotted frogs to coexist with fish in sites with cover for breeding and rearing. Similar comparative studies at the landscape scale are difficult with Oregon spotted frog due to the small number of sites occupied by this species.

The American bullfrog (*Rana catesbeiana*) is native in eastern North America, but has been introduced around the world. Since its introductions began in the late 1800's, the bullfrog has expanded its range in the Pacific Northwest, and now occurs in much of the range of the Oregon spotted frog. Their large size (>180 mm), broad diets including vertebrates, and ability to establish dense populations have raised the concern that bullfrogs can impact native ranid frogs (*e.g*., Moyle 1973, Hammerson 1982, Hayes and Jennings 1986). Licht (1974) predicted that Oregon spotted frog would suffer more than the northern red-legged frog (*R. aurora*) as bullfrogs expanded their range in lowland British Columbia. Licht's (1974) prediction was based on presumed higher habitat overlap between Oregon spotted frogs and bullfrogs than between red-legged frogs and bullfrogs. Pearl et al. (2004) used lab studies and field data to examine this hypothesis further. Their lab tests found that juvenile Oregon spotted frog use shallow habitat similar to bullfrogs, whereas red-legged frog juveniles are more terrestrial. Oregon spotted frogs also survived less well in arenas with bullfrogs than did red-legged frogs, which may reflect the habitat overlap as well as their lesser jumping ability (Pearl et al. 2004). Field records also show that red-legged frogs have persisted in habitats invaded with bullfrogs more successfully than have Oregon spotted frog.

The combination of bullfrogs and widely introduced warm-water fish like sunfish and bass may create wetland communities strongly unfavorable to Oregon spotted frog persistence (*e.g*., Hayes and Jennings 1986). Kiesecker and Blaustein (1998) showed that bullfrogs displaced northern red-legged frog larvae into deeper water, where they are at greater risk of predation by fish. In addition, nonnative fish such as centrarchids can increase the success of nonnative bullfrogs. Experimental and field evidence from the Willamette Valley indicates that sunfish predation reduces dragonfly nymphs (Adams et al. 2003). Sunfish and bass generally find bullfrog tadpoles distasteful (Kruse and Francis 1977), while dragonflies consume them more frequently (Werner and McPeek 1994).

• Livestock grazing: Livestock grazing has been a common use of emergent marsh habitats within the range of the Oregon spotted frog. Managed grazing has often followed hydrological modification via ditching or draining. Several sites where Oregon spotted frog are extant are currently grazed (Table 1). Hayes (1997) ranked livestock management as Moderate at 8 of the 14 Oregon spotted frog sites at which evidence of grazing was detected; two sites (Klamath Marsh and La Pine) were assessed at High risk. Effects of grazing vary among sites and are likely to depend on a suite of factors including but not limited to timing, intensity, duration, and how these factors interact with seasonal habitat use patterns of Oregon spotted frog.

Potential effects of grazing can be considered in at least three categories: 1) direct trampling of Oregon spotted frog, 2) impacts on vegetation and related secondary effects (*e.g.*, thermal changes, reduction of cover from predators, alteration of prey abundance or distribution,

facilitation of invasive plants), and 3) water quality changes (particularly bacterial loads, nitrogenous wastes, and consequent biochemical oxygen demand/depletion). Cause-and-effect information is lacking on all of these, and an understanding of their variation among sites is central to managing impacts on Oregon spotted frog. Two studies address relationships between livestock grazing and Oregon spotted frog. A telemetry study at Jack Creek (Klamath Basin, Fremont-Winema National Forest) compared Oregon spotted frog use of grazed and ungrazed sections of stream/riparian wetlands (Shovlain 2005; J. Oertley and T. Simpson, pers. comm.). A preliminary analysis of those data implies that Oregon spotted frogs preferred ungrazed exclosures as grazing pressure increased through summer (A. Shovlain, pers. comm.). A telemetry study at Dempsey Creek in western Washington found that adult Oregon spotted frog were located in grazed areas more commonly than would be expected by the simple distribution of that land use within the study area (Watson et al. 2003). However, native sedge-rush vegetation was grazed more extensively than the other cover types (reed canarygrass and *Spiraea*), so it was not possible to separate the effects of cover type from grazing regime on Oregon spotted frog habitat use. Experimental work is needed to determine whether managed grazing can be used to maintain or improve habitat conditions for Oregon spotted frog in sites where vegetation succession is reducing the mid- and low-density vegetation types favored by Oregon spotted frogs. Assessments of other potential grazing effects (*e.g*., changes in vegetation, nitrogenous wastes, prey base, and local hydrology), and closer examination of management that will minimize those effects while helping to maintain open habitat (*e.g*., cooperative management of timing and intensity of livestock use) will assist in the development of grazing prescriptions where Oregon spotted frog conservation is a priority.

Considerable attention has also been directed at relationships between livestock grazing and the Oregon spotted frogs close relative, the Columbia spotted frog (*Rana luteiventris*). Grazing is a common land use in much of the range of the Columbia spotted frog in the Columbia and Great Basins. We caution that responses of Columbia spotted frog to grazing should not be extrapolated to Oregon spotted frog because the two species differ in demography, habitat use, and their capacity to move terrestrially (*e.g*., Licht 1975, Pilliod et al. 2002). Evidence is mixed on the effects of grazing on Columbia spotted frog, and as with Oregon spotted frogs, effects are likely to vary between sites. For example, Reaser (2000) concluded that livestock grazing and its resultant effects on habitat is one of the primary factors affecting Columbia spotted frog in Nevada. In contrast, Bull and Hayes (2000) did not detect negative associations between livestock grazing and Columbia spotted frog breeding in Oregon. That study was correlative and did not address potential influences of grazing timing or intensity. Other work addressing grazing and Columbia spotted frog directly or indirectly include Reaser (1996), Bull et al. (2001), and Wente et al. (2005).

• **Water quality degradation**: Pesticides, herbicides, heavy metals, and nitrogenous by-products of fertilizers have recently attracted attention for their potential effects on amphibians (e.g., Boyer and Grue 1995, Marco et al. 1999, Hayes et al. 2002, Davidson 2004, Boone et al. 2005, Relyea 2005a,b). These and other pollutants are often associated with urban and agricultural land uses. Oregon spotted frogs are highly aquatic throughout their life cycle, and are thus likely to experience extended exposure to waterborne contaminants. The paucity of published data regarding Oregon spotted frog ecotoxicology

hinders assessing the risk posed by these factors. To our knowledge, only 2 trials have investigated effects of potential water quality stressors on Oregon spotted frog. Marco et al. (1999) found that larval Oregon spotted frog were the most susceptible of 4 tested northwestern pond breeding amphibians to chronic doses of nitrate and nitrite, which are common derivatives of nitrogenous fertilizers. Nitrite rarely persists in wetlands for long before oxidizing to nitrate. Eutrophication associated with elevated nitrogen (and phosphorous) has also been linked with increased snail populations, which in turn can be linked to parasites that use frogs such as Oregon spotted frogs as alternate hosts (Johnson et al. 2002, Johnson and Chase 2004). This parasitism can result in limb deformities in a variety of anurans including Oregon spotted frog (Bowerman and Johnson 2003), and has potential to reduce survivorship of post-metamorphic frogs.

Oregon spotted frog tadpoles from one population in Washington were relatively tolerant among 9 tested species of ranid frogs to carbaryl, which is a common agricultural pesticide (Bridges and Semlitsch 2000). Given the potential for Oregon spotted frog populations in British Columbia, western Washington, and the Klamath Basin of Oregon to occur in areas with water quality degradation, more work on the species' ecotoxicology is warranted. Controlled laboratory studies of effects of water chemistry parameters related to livestock grazing (*e.g.*, nitrogenous compounds, biochemical oxygen demand, bacterial concentrations) are needed to inform grazing management options at Oregon spotted frog sites where livestock occur. The most useful laboratory tests would include examination of direct and indirect effects on multiple Oregon spotted frog life stages and should be done at field-relevant doses.

• Isolation: An assessment of threats posed by isolation should consider factors likely to reduce intersite movements of reproductive individuals, as well as any factors that might reduce breeding success of frogs that reach a new site (*e.g.*, Henein and Merriam 1990, Stevens et al. 2004). For a highly aquatic species such as Oregon spotted frog, which breeds in specific wetland types and exists in a landscape often substantially altered from historic conditions, these factors are likely to include: distance, permeability of habitat between source site and nearest breeding site, frequency of dispersal movements, and risks to/vulnerability of animals moving between potential breeding sites (*e.g.*, exotic predators, culverts, etc.). In the closely related Columbia spotted frog, populations separated by ridges or large elevational differences show more genetic differentiation (Funk et al. 2005). Data addressing these aspects of dispersal and isolation for Oregon spotted frog are currently very sparse. Distances separating most of the known Oregon spotted frog populations are substantial. With the exception of upper Deschutes Basin sites, known breeding populations are generally at least 2 km from one another (C. Pearl, unpubl. data). Long distance movements by Oregon spotted frog appear to be infrequent, and more importantly, appear strongly linked to aquatic corridors. Modifications of potential aquatic corridors between Oregon spotted frog breeding sites is widespread, and include direct habitat alteration as well as introduction of nonnative predators such as fish.

Existing data support the general hypothesis that dispersal resulting in genetic exchange between breeding populations is limited. Blouin (2000) sampled mitochondrial DNA from 14 Oregon spotted frog populations across the species' range and found evidence of very low gene flow. The genetic data also suggested a broad range of genetic diversity within populations, which generally corresponded with estimated population size: smaller

populations such as Camas Prairie have lower average heterozygosity (Blouin 2000). In addition, sampled Oregon spotted frog populations clustered in 3 main groups: Washington, central Oregon Cascades, and Klamath Basin (Blouin 2000). The Klamath Basin populations appear to be the most distinct of the three (Blouin 2000). Among these three genetically clustered groups, landscape conditions make it very unlikely that the Washington population group can interact with either of the Oregon groups. There is greater potential for the two Oregon clusters to have some interchange, but physical habitat linkages between them are limited. Further investigation into the fitness effects of limited genetic interchange among Oregon spotted frog populations is needed.

• Drought: Few data are available to evaluate risks to Oregon spotted frog populations associated with drought, but the species' dependence on aquatic habitats for development and movement suggests they deserve further analysis. Effects of drought are likely to be site specific and depend on factors such as local and regional hydrologic systems, presence and abundance of non-native predators, and physical site structure and refuge availability (Hayes 1997, Pearl 1999, Pearl and Hayes 2004). Hayes (1997) ascribed Moderate or High risk of negative effects due to drought to 14 of 24 extant Oregon spotted frog sites. Pearl (1999) categorized drought risks as Moderate or High at 3 of an additional 4 Oregon spotted frog sites. Direct effects of dewatering have been documented via stranding of large proportions of eggs or larvae (Licht 1974). Egg masses in shallower water or exposed to air experience greater temperature ranges and maxima, and lower temperature minima, which can increase mortality (*e.g.*, Licht 1971). Mechanisms by which drought could exacerbate other stressors require further investigation. The affinity of Oregon spotted frogs for aquatic microhabitats has potential to concentrate individuals under restricted surface water conditions. This has potential to increase their vulnerability to a variety of stressors. Both Hayes (1997) and Pearl (1999) hypothesized that low water conditions have the potential to increase overlap between Oregon spotted frog and nonnative predators such as brook trout and American bullfrogs. Increased overlap in habitat use between Oregon spotted frog and nonnative predators is likely to result in greater loss to predation (*e.g.*, Pearl et al. 2004). Kiesecker et al. (2001a) concluded that low water in breeding microhabitats due to low snow pack can expose eggs to increased UV radiation and higher mortality associated with egg pathogens.

• Diseases: Few data currently exist to assess risks to Oregon spotted frog (populations) from disease. However, at least two pathogens that have been linked to declines in other amphibians are known to occur in Oregon spotted frog. Their origin, distribution within the range of Oregon spotted frog, and effects on Oregon spotted frog populations are currently unknown. Oomycete fungi (including *Saprolegnia* sp.) have been documented on eggs of Oregon spotted frog at two sites in Oregon (J. Petrisko et al., in prep.). This group of fungi may be pathogenic to eggs of other northwestern amphibians, and its occurrence on eggs can be increased with other stressors such as drought-induced low water or UV radiation (Kiesecker et al. 2001a). It has also been suggested that this group of fungi can be transported from hatchery fish to lakes via trout stocking (Kiesecker et al. 2001b).

The pathogenic fungus *Batrachochytrium dendrobatatidis* has been found in Oregon spotted frog at two sites in Oregon (Pearl et al. 2007, J. Bowerman, pers. comm.). Infection by *Batrachochytrium dendrobatatidis* (chytridiomycosis) has been linked with amphibian declines in multiple continents, especially Central America and Australia (Berger et al. 1998,

Pounds et al. 2006). Recent work suggests amphibian losses in Colorado and California may also be related to chytridiomycosis (Muths et al. 2003, Rachowicz et al. 2006). Mortality due to chytridiomycosis appears to occur mainly in juvenile and adult life stages (*e.g.*, Briggs et al. 2005). Demographic modeling suggests that factors that influence survivorship of post-metamorphic stages are more likely to result in population changes than those that affect only egg and larval stages (Biek et al. 2002, Vonesh and de la Cruz 2002). In the absence of additional data on these diseases, it is not possible to assess their threat to Oregon spotted frog populations.

Conservation Status

The failure of surveyors to detect Oregon spotted frog at sites where they were known to occur suggests the species may be extirpated from as much as 70-90% of their historical range (Hayes 1994, 1997, McAllister et al. 1993, Pearl and Hayes 2005). These resurveys of historic localities suggest the severity of Oregon spotted frog decline varies by region: losses appear to be most pronounced in the Willamette Valley of western Oregon and Puget Lowlands of western Washington. The limited number of historic records and correlation among factors make a ranking of threats difficult. However, loss and alteration of wetland habitat have been extensive over the last 150 years, and are likely to have exerted strong influence on Oregon spotted frog (Hayes 1997, McAllister and Leonard 1997, Pearl and Hayes 2004).

Most of the known Oregon spotted frog populations occur on lands at least partially managed by state or federal agencies. However, portions of at least 13 populations are within private ownership. Table 1 includes a qualitative assessment of site-specific threats on Federal land based on available data and consultation with biologists most familiar with those populations and sites. It is meant to update previous assessments (Hayes 1997, Pearl 1999). This assessment does not address threats associated with privately-owned properties. This discussion should be considered a preliminary assessment of threats: a more quantitative assessment is needed to prioritize threats across the species' range.

Existing Management Approaches

To our knowledge, all Oregon spotted frog conservation planning has focused on population scales. Broader management actions and goals appear to be lacking. However, a few management actions geared directly toward Oregon spotted frogs have the potential to influence populations at selected sites.

One example of a management approach directed toward maintaining an Oregon spotted frog population is at Big Marsh on the Deschutes National Forest in central Oregon. Big Marsh was in private ownership and used for grazing until the 1980's. Ditches had been constructed around the perimeter of the marsh in 1946 to decrease flooding and increase forage for cattle. The Forest Service acquired the marsh in 1982 and continued grazing on parts of the Marsh until 1989. Big Marsh Restoration Project Environmental Assessment (EA) was completed in 1988 and provided for a progressive reversion of water back to the marsh. A 2001 Wild and Scenic River Plan for Big Marsh Creek and the Little Deschutes River provided for protection,

continued hydrological and vegetation restoration as well as a monitoring requirement. Specific actions taken over the years to accomplish restoration goals include removal of historic diversion structures and berms to improve surface water flow to the marsh, pond creation, removal of encroaching lodgepole pine at marsh edges, and fall burning to stimulate growth of native sedges and willows (P. Miller, 2005, J. Kittrell, 2006, pers. comm.). Crescent Ranger District staff have completed breeding surveys in portions of the marsh to gauge general Oregon spotted frog response to these habitat changes.

Another management action directed at Oregon spotted frog was the translocation of a small population from a ditch at the base of the Wickiup Reservoir dam. Retrofitting of the dam required the loss of the ditch habitat. An Interagency group (US Bureau of Reclamation, US Forest Service, US Fish and Wildlife Service, US Geological Survey, Sunriver Nature Center, and Oregon Department of Fish and Wildlife) collaborated to scope potential receiving sites, create ponds in the selected site (Dilman Meadow), relocate the Oregon spotted frogs from the ditch, and monitor short term responses of the population at the new site. Egg mass counts have increased to 4-5 times the counts in the original habitat over the 4 years following the translocation (C. Pearl, J. Bowerman, R. B. Bury, unpubl. data). While the short term response has been favorable, vegetation is encroaching on the original ponds, and management actions may be needed to maintain open water.

Other examples of management approaches that address Oregon spotted frogs include: introduction of Oregon spotted frogs to a lake and bog complex with the objective of establishing a 4th population in British Columbia (R. Haycock et al.), mowing vegetation with the objective of improving oviposition microhabitat (H. White, K. McAllister, Beaver Creek, Washington; M. Hayes, J. Engler, Conboy National Wildlife Refuge, Washington), reduction of nonnative predators (American bullfrog at Sunriver, Oregon and Conboy National Wildlife Refuge, Washington; nonnative trout in Mink Lake Basin, Oregon), and management of flooding duration to enhance Oregon spotted frog recruitment (J. Bowerman at Sunriver, Oregon; M. Hayes, J. Engler at Conboy National Wildlife Refuge, Washington; R. Roninger at Wood River, Oregon). Documenting and distributing results of these activities will assist managers considering similar approaches across the species' range.

In Oregon, two assessment and agreement documents have been completed which either address or include consideration for the Oregon spotted frog. On the west side of the Cascades, a Conservation Agreement for the Oregon Spotted Frog, Mink Lake Basin Oregon spotted frog Population, was completed in July 2000, with USFWS, Oregon Department of Fish and Wildlife (ODFW), and the USFS as partners (USFWS 2000). The agreement extends for 10 years, and covers monitoring, site protection, public education, habitat surveys, evaluation of potential impacts from recreation activities, and identifying spotted frog conservation areas within Mink Lake Basin.

On the east side of the Cascades, a joint assessment between the Prineville District of Bureau of Land Management and the Deschutes and Ochoco National Forests addresses impacts of projects on federal lands within these jurisdictions. The joint assessment calls for conference on actions that could impact species that are Candidates or Petitioned for Federal listing under the ESA (USDI, BLM Prineville District and USDA Forest Service, Deschutes and Ochoco National

Forests, 2006). The joint BLM/FS assessment also outlines Project Design Criteria for both Oregon and Columbia spotted frogs, including direction ***not*** to:

- fragment or convert wetland habitat to upland habitat through management activities like water diversions, road construction, maintenance, or recreational activities;
- degrade wetland habitat or water quality
- change the hydrology of a stream, spring, lake, or wetland unless it is for restoration purposes
- allow activities in the channel migration zone which might harm floodplain functions
- use pesticides, herbicides or other contaminants in or immediately adjacent to wetland habitat.

Several Habitat Conservation Plans (HCP) in Washington State have been approved by the US Fish and Wildlife Service and include the Oregon spotted frog (http://ecos.fws.gov/species_profile/servlet/gov.doi.species_profile.servlets.SpeciesProfile). Habitat Conservation Plans such as these confer some benefits to covered species: examples are emphasis on habitat acquisition or restoration, or enhancement to offset unavoidable effects of proposed actions. An annotated list of the Washington HCPs that extend specific recognition to Oregon spotted frogs is below. Further details on how each HCP relates to Oregon spotted frogs should be available through respective lead agencies.

- Cedar River Watershed HCP, applies to 90,500 acres of forested watershed lands, protecting aquatic and riparian habitat for Oregon spotted frogs (among other species)

- City of Tacoma, Tacoma Water HCP, applies to 14,800 acres of forested watershed lands, protecting aquatic and riparian habitat associated with the Green River for Oregon spotted frogs (among other species)

- Shoredahl's Daybreak Mine Expansions and Habitat Enhancement Project HCP, applies to 291 acres for surface mining activities, protecting aquatic and riparian habitat adjacent to the East Fork of the Lewis River for Oregon spotted frogs (among other species)

- Washington Department of Natural Resources Forest Lands HCP, applies to 1,600,000 acres of forest lands managed for timber production, gas and oil, and recreational activities, protecting wetlands, aquatic and riparian habitat associated with all stream and special habitat types, for Oregon spotted frogs (among other species).

Management Considerations

This section outlines management considerations for agencies or personnel tasked with conserving habitats occupied by Oregon spotted frog or sites under consideration for restoration or re-establishment of Oregon spotted frog populations. This list is based on data available as of early 2006. The list should not be considered exhaustive, and is likely to be refined with a more detailed understanding of Oregon spotted frog ecology and population biology.

The wide variety of site and population-specific conditions, some resulting from historical site alterations, suggests that management of each site should be considered individually rather than as part of a broader prescription. To prioritize management or conservation measures and understand broader responses of Oregon spotted frog to stressors will require updated standardized and comparable assessments across sites with clear criteria for prioritization. Despite site and population differences, each of the following considerations is offered toward the general goal of maintaining or improving local habitat conditions likely to benefit Oregon spotted frogs.

• **Restore or maintain hydrological regimes where Oregon spotted frog may be detrimentally affected.** Hydrological monitoring may be advisable at occupied sites or sites under consideration for population reintroduction. Duration and stability of flooding in breeding areas are important correlates of early life stage survival: sites supporting robust Oregon spotted frog populations tend to have extensive shallow benches for oviposition and larval development in warm water. Information on stranding of eggs or larvae and late summer low-water conditions is likely to be useful in formulating conservation plans.

• **Protect and restore ephemeral and permanent wetlands near existing Oregon spotted frog sites.** Current data suggest that long distance movements by Oregon spotted frogs across terrestrial environs are rare. Retention of quality wetland habitat around Oregon spotted frog sites, particularly those peripheral sites connected with seasonal or permanent aquatic corridors, may facilitate seasonal usage of a broader area or be related to dispersal success.

• **Restore or maintain open water and early seral vegetation communities.** This may include control of invasive plants that can dominate native emergent species such as reed canary grass (*Phalaris)*, purple loosestrife (*Lythrum salicaria*), or common reed (*Phragmites*). Native species such as lodgepole pine or willow that can expand in the absence of fire or beavers also may warrant management. Many aquatic amphibians are sensitive to herbicides (Boyer and Grue 1995, Hayes et al. 2002, Davidson 2004, Boone et al. 2005, Relyea 2005a,b), so careful research on timing of applications and formulations (active ingredients, carriers, surfactants, etc.) is needed if herbicides are used for management. Oregon spotted frog and habitat responses to vegetation management should be investigated through a well-designed monitoring program. Monitoring can help identify population responses of Oregon spotted frog, concerns regarding broader application of the management technique, and indirect or unpredicted effects on habitat conditions or Oregon spotted frog populations.

• **Evaluate or discontinue local fish-stocking practices.** Maintaining sites that lack nonnative fish in that condition is advisable. Fish removal may be practicable in some circumstances. Other options may include a change in species, density, or frequency of fish stocking at sites known to host Oregon spotted frog as well as those that are connected hydrologically with Oregon spotted frog sites.

• **Limit the spread and effects of American bullfrogs in areas occupied or potentially suitable for reintroduction of Oregon spotted frogs.** Bullfrogs are likely to interact negatively with Oregon spotted frog in a number of ways (*e.g.*, predation, competition, disease vectors) and thus must be considered a threat to Oregon spotted frog. The severity of the

bullfrog threat is likely to vary with the condition of the habitat at the site (*e.g.*, availability of vegetation refuges for Oregon spotted frog) and whether bullfrogs are able to establish breeding populations and higher densities. Well-designed studies of bullfrog control are lacking, and additional work is needed to understand the biological and cost efficiencies of various techniques. There is potential for control efforts to be expensive and have little effect on bullfrog densities, so bullfrog management actions must be thoroughly considered and carefully monitored.

• **Develop comprehensive grazing strategies or adaptive management plans where livestock will occur in Oregon spotted frog habitat.** Where possible, monitor conditions of vegetation and water quality, as well as Oregon spotted frog responses to grazing intensity and duration. Adaptive management of grazing offers potential to maintain desired habitat conditions, and to segregate livestock and vulnerable life stages of Oregon spotted frogs. Physical vegetation buffers or seasonal rotations of livestock may be advisable depending on habitat, equipment (e.g., availability of fencing) and staffing.

• **Work locally and cooperatively to maintain or restore conditions beneficial to Oregon spotted frog reproduction and viability.** Create site management plans for each population site, including a site-specific threat assessment. Wherever possible, management and restoration plans should include carefully designed monitoring plans and means of disseminating results. Involve as many stakeholders as practicable in hopes of generating interest in conservation of the species.

A Conservation Strategy is proposed for initial development in FY 2008, and will build on the information foundation presented in this document to provide more detailed descriptions regarding site management. Information products anticipated from Working Group teams will be instrumental in supporting relevant site management.

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Table 1. Attributes of sites in US with extant Oregon spotted frog (*Rana pretiosa*) populations, with a qualitative assessment of threats. N.D. = Not Detected during previous surveys. Blank cells indicate a lack of information.

Site Name	County	Ownership	Nonnative Predators [1]	Grazing [2]	Vegetation Succession [3]	Comments	Information Sources
Washington							
Beaver Creek	Thurston	WA State, Private	N.D.	No	Yes	A portion of the site is used in gravel mining operations	McAllister and White 2001, White 2002; K. McAllister, pers. comm.
Conboy Lake Natl. Wildlife Refuge	Klickitat	USFWS, Private	Bullhead, Bullfrog	Yes	Portions (see Comments)	Vegetation accumulation, incl. reed canarygrass, is present in some areas; it is limited in some of the seasonally flooded breeding areas by regular hay harvesting	Hayes 1997
Dempsey Creek	Thurston	USFWS, Private (Tree Farm), Capital Land Trust	Pumpkinseed sunfish, Largemouth bass	Yes	Yes	Seasonal grazing may help limit vegetation succession in selected egg-laying habitats	Watson et al. 2000, 2003; K. McAllister, pers. comm.
Stony Creek	Thurston	Private (Dairy)	N.D.	Yes	Yes		K. McAllister, pers. comm.
Trout Lake Wetland Natural Area Preserve	Klickitat	WA State, Private					Hayes 1997; K. McAllister, pers. comm.
Trout Creek Beaver Ponds	Skamania	Gifford Pinchot NF			Yes		K. McAllister, pers. comm.
110th Avenue	Thurston	USFWS	Bullfrog	No	Yes	Likely to benefit from management that increases open water habitat	K. McAllister, pers. comm.
123rd Avenue	Thurston	USFWS	N.D.	No	Yes	Some vegetation management and pond creation completed	K. McAllister, pers. comm.

Site Name	County	Ownership	Nonnative Predators [1]	Grazing [2]	Vegetation Succession [3]	Comments	Information Sources
Oregon							
Big Marsh	Deschutes	Deschutes NF	Brook Trout		Yes, mainly Lodgepole pine; *Phalaris* present but limited	Historically ditched to improve pasture for livestock; FS is blocking ditches to restore hydrology	J. Kittrell and P. Miller, pers. comm.; Hayes 1997
Buck Lake	Klamath	Fremont-Winema NF,BLM, Private	Brook Trout Bullhead Tui Chub	Yes		Grazing is mainly on historical lake floor, which is private, and represents the majority of present Buck Lake; OSF habitat concentrated around the site periphery	Hayes 1997; Hayes 1998b
Camas Prairie	Wasco	Mt Hood NF	N.D.	Yes	Yes	Historically ditched to improve pasture for livestock – hydrological modification may be contributing to vegetation succession	Hayes 1997
Crane Prairie Reservoir (Quinn River CG)	Deschutes	Deschutes NF	Brook Trout Lgm & Sm Bass Bullhead Stickleback	N.D.		Heavy angling and recreational use (*e.g.* camping, boating)	Hayes 1997; C Pearl pers. obs.
Cultus Creek Gravel Pit Pond	Deschutes	Deschutes NF	N.D.	N.D.		Anthropogenic pond habitat	Hayes 1997
Dilman Meadow	Deschutes	Deschutes NF	N.D.	N.D.	Yes	Population translocated from original location in Wickiup ditch	C. Pearl, pers. obs.
Fourmile Creek and Marsh	Klamath	BLM	Brook Trout	N.D.[4]			Hayes 1997, 1998c; R. Roninger pers. comm.; C. Pearl pers. obs.
Crystal Spring, Seven Mile Creek, Crane Creek	Klamath	Fremont-Winema NF, BLM, Private	Brook Trout Brown Trout	Yes		It is presently unclear how much OSF from these sites, along with Fourmile, interact.	Hayes 1997, 1998

Site Name	County	Ownership	Nonnative Predators [1]	Grazing [2]	Vegetation Succession [3]	Comments	Information Sources
Gold Lake Bog	Lane	Willamette NF	Brook Trout Rainbow Trout	N.D.		Unknown is whether lodgepole pine establishment is increasing in the wetland	Hayes 1997; C. Pearl, pers. obs.
Hosmer Lake	Deschutes	Deschutes NF	Brook Trout Atlantic Salmon	N.D.		Extensive shallow margins may be susceptible to drought	Hayes 1997; C. Pearl pers. obs.
Jack Creek	Klamath	Fremont-Winema NF, Private	N.D.	Yes		Livestock pressure and low water in dry yrs have potential to interact negatively for OSF; large portion of breeding historically was on private property;	Hayes 1997, 1998a; Forbes and Peterson 1999; J. Oertley and T. Simpson, pers. comm.
Klamath Marsh Natl. Wildlife Refuge	Klamath	USFWS Private	Brook Trout Bullhead Fathead Minnow	Yes		Extent of population is poorly known; water diversions are prominent and drought can affect large portions of the Marsh; bullfrogs not recently found, but reports in last 20 yr	Hayes 1997, Ross and Mausser 2000 and pers. comm.; C. Pearl, pers. obs.
Long Prairie/LaPine	Klamath	BLM Private	Bullfrog Stickleback[5]	Yes	Yes	Draining of much of complex likely linked with vegetation succession and loss of marsh habitat	Hayes 1997, R. Demmer, pers. comm.
Lava Lake	Deschutes	Deschutes NF	Brook Trout Tui chub	N.D.		High recreational use (camping, fishing, boating); peripheral breeding areas likely vulnerable to drought	Hayes 1997, C. Pearl, pers. obs.
Little Cultus Lake	Deschutes	Deschutes NF	Brook Trout	N.D.		High recreational use of nearby areas; succession may become a threat if beaver not retained	Hayes 1997, C. Pearl, pers. obs.
Little Lava Lake	Deschutes	Deschutes NF	Brook Trout Tui chub	N.D.		Reed canarygrass present near outlet	Hayes 1997, C. Pearl, pers. obs.
Unnamed Marsh	Lane	Willamette NF	Brook Trout	N.D.	Yes	Lodgepole pine encroachment; drought + Nonnative fish are likely negative interaction for OSF at the site	Pearl 1999, C. Pearl, pers. obs.

Site Name	County	Ownership	Nonnative Predators [1]	Grazing [2]	Vegetation Succession [3]	Comments	Information Sources
Muskrat Lake	Deschutes	Willamette NF	Brook Trout	N.D.		High recreational use; drought + Nonnative fish are likely negative interaction for OSF at the site	C. Pearl, pers. obs.
Odell Creek at Davis Lake [6]	Deschutes	Deschutes NF	Brook Trout	N.D.		Davis Lake experiences heavy recreational use and large water level fluctuations; site is within 2002 Davis Fire	Hayes 1997; C. Pearl, pers. obs.
Odell Creek at 4660 Road [6]	Deschutes	Deschutes NF	Brook Trout	N.D.		Area experiences heavy recreational use; site is within 2002 Davis Fire	Hayes 1997; C. Pearl, pers. obs.
Parsnip Lakes	Jackson	Medford BLM	N.D.	Yes	Yes	Portions of habitat experience recreational use and are likely vulnerable to succession and drought	M. Parker, Southern Oregon Univ.; C. Pearl, pers. obs.
Penn Lake	Lane	Willamette NF	Brook Trout Rainbow Trout	N.D.		Portions of habitat used by adults in summer are likely vulnerable to succession and drought	Hayes 1994; C. Pearl, pers. obs.
Ranger Creek at Davis Lake [6]	Deschutes	Deschutes NF	Brook Trout	N.D		Area experiences recreational use; site is within 2002 Davis Fire	Hayes 1995, 1997; C. Pearl, pers. obs.
Sunriver	Deschutes	Private	Stickleback [Bullfrog nearby]	N.D.		Fully private ownership and management	J. Bowerman, Sunriver Nature Ctr
Wood River Wetland	Klamath	BLM Private	Brook Trout Bullhead Bullfrog	Yes		Channelized reach with expanding reed canarygrass; additional nonnative fish present in area; water supply and distribution is central management premise	Hayes 1995, 1997; R. Roninger pers. comm.; C. Pearl pers. obs.
Upper Williamson River	Klamath	Fremont-Winema NF Private		Yes		Additional survey information needed to assess site	Ross 2000; J. Oertley, pers. comm;

[1] Information includes nonnative species considered present at the site based upon visual surveys of herpetologists, fish stocking records, and observations by other biologists familiar with the sites. This list should be considered preliminary, and it is likely that some sites have additional nonnative predators.

[2] Indicates whether livestock grazing is present at the site. Effects of grazing are likely complex and site-dependent: understanding whether it represents a threat or potential benefit to OSF requires local research.

[3] Indicates whether there is field-documented evidence that vegetation succession is reducing or likely to reduce in near future the coverage of habitats favored by OSF: open water and shallows of moderate native vegetation density. Comments indicate whether Reed Canary grass (*Phalaris arundinaceae*) is known at the site.

[4] Grazing was present historically on portions of the BLM parcel that includes part of the Fourmile-Jack Spring complex.

[5] Distribution of non-natives in the complex is incompletely resolved, and there is high potential for additional nonnative fish species toward town of LaPine.

[6] Location of breeding areas associated with these occurrences of adult OSF are unresolved, and require further investigation.

PART II: Research, Inventory, and Monitoring Opportunities Identified by the Oregon Spotted Frog Working Group

The Oregon Spotted Frog Working Group was convened in 2005 as an interagency team focused on the collection and assessment of current field data on *Rana pretiosa*. Members of the group were Rob Huff (R6/BLM Conservation Planning Coordinator), Kelli Van Norman (R6/BLM Inventory Coordinator), David Clayton (Rogue River – Siskiyou National Forest), Kathy Cushman (Fremont-Winema National Forest), Cheryl Friesen (Willamette National Forest), Nancy Gilbert (US Fish and Wildlife Service), Christopher Pearl (US Geological Survey), Rob Roninger (Bureau of Land Management, Klamath Falls Resource Area), Terry Simpson (Fremont-Winema National Forest), and Lauri Turner (Deschutes National Forest).

As one of its assignments, the Oregon spotted frog Working Group was tasked with the identification of research, inventory, and monitoring needs likely to be relevant to federal land managers. The following are examples, although the list is not intended to be exhaustive. The Working Group prioritized the list, and several of these tasks are being addressed by small on-going teams during fiscal years 2006-08.

Research needs for Oregon spotted frog biology and management on federal lands include:

1) What types of habitats allow co-existence with non-native predators (e.g. fish and bullfrogs)?

2) What conditions might facilitate inter-site movements (e.g., extent of site connectivity or use of aquatic corridors)?

3) Is there an on-the-ground delineation line between populations of Oregon and Columbia spotted frogs or is there some location (yet to be discovered) where the two species might coexist?

Additional data are needed to define variables that predict habitat suitability for Oregon spotted frogs:

1) Microhabitat conditions required by Oregon spotted frogs, especially water quality criteria for amphibians;

2) Responses of Oregon spotted frogs to various land management activities that typically occur within its range, including timber harvest/fuel reduction actions, and natural and prescribed fire;

3) Aspects of movement ecology that can help clarify colonization potential, particularly as related to breeding, foraging, and other seasonal uses;

4) Relationships between local population trends and Oregon spotted frog status at the broader landscape scale;

5) Roles of Oregon spotted frogs in ecosystem processes.

Inventory needs for Oregon spotted frogs include:

1) Standardized systematic (and thus comparable) survey protocol for determining presence or absence at a site;

2) Compilation of survey efforts, including information on intensity and timing of surveys, and predictors of presence and abundance;

3) Map of potential and occupied habitat across the species' range, including such information as minimum habitat size, description, and regional variations.

Monitoring needs for Oregon spotted frogs include:

1) Information on population trends, including a monitoring plan for individual sites and watersheds;

2) Monitoring the effectiveness of conservation agreements and the actions associated with them;

3) Studies to monitor population responses to habitat restoration: discerning the effects of management actions versus what might have naturally occurred in a population;

4) Key habitat criteria needed to promote successful reintroductions, and the impacts of translocation on populations.