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Screening Model for Determining Likelihood of Site Occupancy by Oregon Spotted Frogs (*Rana pretiosa*) in Washington State

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EXECUTIVE SUMMARY

The Oregon spotted frog (*Rana pretiosa*; OSF) is a Washington State Endangered species and a Federal Endangered Species Act candidate. Historic abundance and distribution of Oregon spotted frogs within Washington are poorly understood (McAllister and Leonard 1993). However, Oregon spotted frog populations have declined markedly since Euro-American settlement of the coastal Pacific Northwest region, and <10 extant sites are presently known to be occupied in Washington (WDFW unpublished data). Putative reasons for population declines include altered hydrology, wetland loss, predation and competition from exotic fish and amphibians, altered water chemistry, and ultraviolet radiation (Hayes et al. 1997).

Beginning May 2003, the Washington State Department of Transportation (WDOT) funded the Washington Department of Fish and Wildlife to conduct an exhaustive literature review on the Oregon spotted frog. The goal of this review was to synthesize existing information into a comprehensive document describing Oregon spotted frog ecology and habitat associations, and to develop a screen for determining potential suitability of wetland sites in western Washington for supporting populations of Oregon spotted frogs.

The wetland screening model is presented here. This model is explicitly designed to evaluate wetland sites on a case-by-case basis and determine whether they contain habitat characteristics that make them potentially suitable for supporting an established and successfully reproducing population of Oregon spotted frogs. It does not address, nor are ample data available to determine, site suitability for occupancy and survival by dispersing individuals. Because the sample size from which to draw inferences within Washington was prohibitively small (n < 10), we included data from currently occupied wetlands in Oregon and British Columbia, Canada. Since features of occupied sites such as elevation and site size are known to vary with latitude over the species' geographic range, the model focuses on data relevant to Washington State in instances where range-wide values far exceed those of Washington.

The screening model has a two-tier hierarchy. Each tier contains variables known or believed (based on the literature synthesis and professional expert opinion) to influence site suitability for Oregon spotted frogs. Parameters of variables in Tier 1 are the maximum and minimum observed values for each variable in the tier. Since the region-wide number of known occupied sites was small (n <40) and relevant data often were not available for all of these sites, we expanded parameter bounds by 25% as a buffer to minimize the error of failing to recognize a suitable wetland due to potentially artificially narrow variable bounds.

Tier 1 addresses landscape-level factors known to influence wetland hydrology, floristics, structure, and function, and is quantitative in nature. Tier 1 evaluates candidate wetland suitability based on soils, elevation, U.S.F.W.S. National Wetland Inventory habitat classification, wetland size, U.S.G.S. National Land Cover Descriptions, and the potential influence of connectivity to adjacent wetlands. Suitable wetlands in western Washington

are expected to contain: loams, mucks, loamy sands, and/or poorly drained fibrisols, mesisols, organic cryosols, gleysols, or humisols; occur from the upper hydrologic limit of brackish water influence – 2,624 ft (800 m); have Palustrine emergent habitat present; be at least 8.9 ac (3.6 ha) in size; and have ≤9.8 % area within a 1.6 km radius developed for residential, commercial, industrial, and/or transportation use. Wetlands smaller than 8.9 ac may be considered suitable if connected by surface water and <1 km from an adjacent wetland, with both wetlands (using pooled data) mutually satisfying all Tier 1 criteria.

If a wetland meets all Tier 1 criteria then we recommend using Tier 2 screening. Tier 2 is qualitative in nature and describes habitat characteristics of occupied sites during 3 seasons; breeding, summer, and winter.

Wetlands suitable during breeding season are expected to contain vernal shallows 5 – 30 cm in depth; be dominated by native submergent and emergent vegetation, (*Typha* and/or *Phalaris* are typically present, but usually not dominant at occupied sites unless domestic livestock grazing also occurs); have >10% bottom substrate covered by submergent, floating, or low emergent vegetation; have low overhead canopy closure by woody-stemmed shrubs and trees; and remain surface-connected to summer habitat until after larvae hatch (usually by April 31) in an average year.

Suitable summer habitats will have perennial lentic pools within 1 km of breeding habitat; be dominated by native vegetation in low emergent, floating, or submerged form; have palustrine forested habitat capable of providing partial or greater amounts of shade; and be surface-water connected to suitable winter habitat during fall.

Suitable winter sites will be <1 km from summer sites; exceed 15 cm depth; have aquatic bed, emergent, or scrub-shrub, and unconsolidated bottom habitat present in areas not scoured by winter floods; and have springs or upwellings present in sites where average winter ice-cap persists for >1-2 weeks.

Wetlands that meet all Tier 1 and 2 criteria are considered potentially suitable Oregon spotted frog habitat, and we recommend on-site Oregon spotted frog surveys prior to activities that may disturb these sites.

INTRODUCTION

The model presented here is designed to serve as a screen for evaluating potential suitability of wetland sites for occupancy by Oregon spotted frogs (*Rana pretiosa*) within their historic range in Washington State. The intent of the model is to evaluate individual wetland sites and, based on characteristics of existing habitat, determine potential for on-site occupancy by populations of Oregon spotted frogs that are established and reproducing. The model was not designed to address the likelihood of site occupancy by dispersing, dispersed, or other individual Oregon spotted frogs.

This model was derived from published descriptions of wetland characteristics at sites where established populations of Oregon spotted frogs are known to occur, from summaries of landscape scale data acquired from county, state, federal, and provincial government sources, and from input/clarification from biologists who have studied Oregon spotted frog ecology. Due to the rarity of Oregon spotted frogs throughout their occupied range, data from Oregon, Washington, and British Columbia, Canada were used to generate bounds on model variables. However, the intended focus of the screen is for use in Washington State and in assisting in habitat analysis used in satisfying Endangered Species Act Section 7 consultation requirements. Therefore, in instances where range-wide values for relevant variables (e.g., elevation) far exceed known parameters within Washington State, bounds appropriate for Washington State were reported in addition to range-wide bounds. Range-wide bounds for model variables are presented so that the model may be used in Oregon and British Columbia, and because the model may have secondary value as a tool for prioritizing candidate sites for translocations or reintroductions at some future time.

The model is separated into two tiers, each of which addresses habitat composition at a unique spatial scale. Tier 1 is designed to enable remote assessment of site suitability by a GIS analyst prior to an on-site visit. Tier 1 screens wetlands based on abiotic variables (e.g., underlying soils) or generalized descriptors compiled from biotic variables (e.g., National Wetlands Inventory habitat composition [U. S. Fish and Wildlife Service; http://wetlands.fws.gov]), which are discernable at landscape scale. Tier 1 also incorporates National Land Cover Description data (U. S. Geological Survey; **http://landcover.usgs.gov/classes.asp**), which describes levels of human development of lands surrounding candidate wetlands. Tier 2 is an on-site wetland screen, intended for use by a qualified wildlife biologist (or similarly qualified professional). Tier 2 model parameters were drawn from reports describing wetland sites occupied by Oregon spotted frogs, and include both abiotic and biotic descriptors of on-site characteristics reported as important to Oregon spotted frogs. Due to differences in data collection methods and variables that were considered in the studies from which we drew information, Tier 2 of this model is qualitative in nature.

The model, which is hierarchical in its application, is designed to evaluate site-suitability at a large spatial scale first, than at a smaller, more refined scale. Therefore, a Tier 1 assessment should precede that of Tier 2. Tier variables should be evaluated in the order presented, proceeding to the next model variable only if conditions of the candidate site

being evaluated meet model criteria for the variable under consideration. Only if ALL conditions of Tier 1 are satisfied should Tier 2 be consulted. For screening model purposes, in any instance where conditions of a candidate site fail to meet stated model criteria in either tier, the site should be considered poorly suited and unlikely to support a reproducing population of Oregon spotted frogs.

Model Explanation

Tier 1 is designed for screening in a GIS setting prior to an on-site visit (Appendix E). Tier 1 screens candidate wetlands against characteristics of variables estimated at occupied sites. Screening variables are soils, elevation, National Wetlands Inventory (NWI) habitat classification, size, connectivity, and amount of adjacent developed land (using National Land Cover Definition [NLCD] data).

- Soils data (Appendix A) were derived from digital soils maps and a qualitative list of soil types present at occupied wetlands.
- Elevation data (Appendix B) were acquired directly from published reports or from digital elevation models.
- National Wetland Inventory habitat summaries (Appendix C) were generated from overlays of extant frog locations on digital NWI habitat data. NWI wetland habitat types were pooled into the following categories: palustrine emergent, palustrine forested, palustrine scrub-shrub, palustrine open water, palustrine aquatic bed, palustrine unconsolidated bottom, lacustrine (intermittently – permanently flooded), or riverine (intermittent, low, and high gradient flows). Type and number of NWI habitat types present at each site were determined.
- Wetland size (Appendix C) was estimated by pooling contiguous NWI polygons at each occupied site.
- NLCD landscape composition (Appendix D) was summarized within a 1-mi (1.6-km) buffer extending from the perimeter of each occupied wetland, as defined by NWI polygons. NLCD residential and commercial/industrial/transportation classes were summed to generate percentage estimates of developed land surrounding occupied sites.
- Connectivity: wetlands that satisfy the Tier 1 screen excepting they are below the minimal size threshold need be visited by a qualified biologist to determine if they are connected at least intermittently by surface-water to, and within reasonable inter-seasonal movement distance (1 km) of an adjacent wetland. If these conditions are met as described in the model, the candidate wetland would then be considered potentially habitable, and both wetlands will be assessed jointly during Tier 1 and 2 screening.

Maxima and minima of quantitative variables (elevation, NWI classification, size, NLCD composition) describing occupied sites were expanded ±25 % to minimize risk of a Type II assessment error during screening. A Type II error would be excluding a candidate wetland as unsuitable when it is in fact suitable, because variable parameter estimates were too narrow. Narrow parameter estimates can result when the number of original

sites from which estimates were generated is small. These estimates, plus the soils list, form the basis for screening in Tier 1. Parameter estimates were generated using data from Washington, Oregon, and British Columbia, with the following exceptions:

1) British Columbia site data contributed only to soils, elevation, and wetland size descriptions. National Wetlands Inventory and National Land Cover Definition data do not cover Canada, and we found no Canadian digital data with sufficiently similar habitat designations.

2) Oregon sites were not included in soils data summarization because digital data were not available. National Wetland Inventory digital data were not available for 10 of the 27 Oregon sites. Therefore, wetland size and NLCD landscape composition also were not estimated at these sites.

Tier 2 is an on-site screen, to be performed by a qualified biologist. Tier 2 variables are based on reported OSF habitat associations for breeding, post-breeding summer, and winter seasons. Tier 2 is partitioned accordingly. Tier 2 does not warrant a site-visit during each season, but does require knowledge of the candidate wetlands' seasonal hydroperiod, plant species composition, and vegetative growth forms. Relevant biological seasons are defined using relevant factors such as water temperature and ice formation and persistence, reducing reliance on calendar dates, which vary by latitude, elevation, etc.

SCREENING MODEL

Tier 1- candidate wetlands should satisfy each the following criteria, assessed via Geographic Information System, to be further considered potential OSF sites.

Soils (Appendix A): soils underlying wetlands should consist of loams (silt, clay, fine sandy, gravelly, cobbly, and stony), mucks (e.g., Semiahmoo, Mukilteo), loamy sands, or other poorly drained fibrisols, mesisols, organic cryosols, gleysols, and humisols, and

Elevation (Appendix B): range-wide potentially habitable elevations range from sea level (above the influence of seawater) to 1962 m (6,615 ft) above sea level. In Washington, Oregon spotted frogs have been found at habitable elevations ranging between 43 – 640 m (141 – 2099 ft). Adding ± 25% buffer produces a potentially suitable elevation estimate of sea level, above tidally influenced brackish waters – 800 m (2624 ft)[(1)], and

NWI classification (Appendix C): Palustrine emergent habitat was the only type present at every occupied site for which NWI data were available. A wetland containing palustrine emergent habitat, alone or in any combination with ≥1 additional palustrine, lacustrine, or riverine habitat type in listed the attached appendix should be considered potential OSF habitat, and

Wetland size (Appendix B): Minimum known wetland size at an occupied and reproductively active site in Washington State, determined by aerial extent of NWI vegetation, was 4.8 ha (11.9 ac). Buffering this value by 25%, any wetland ≥3.6 ha (8.9 ac) should be considered potentially habitable, and

NLCD Landscape composition (Appendix D): Between 0 – 7.8% of all area within 1.6 km (1 mi) of occupied wetland sites contained developed classes of NLCD. Buffering by 25% produced an upper estimate of ≤9.8 % of the area within 1.6 km of a candidate wetland perimeter that may be developed for residential, commercial, industrial, and/or transportation purposes, and

Connectivity adjustment to size: Wetlands that satisfy all other criteria stated in Tier 1 above but which are <3.6 ha in size should be considered suitable if ALL of the following conditions exist:

A) located <1 km[(2)] (0.63 mi) from, and connected by surface water during intermittent (as defined in USFWS National Wetland Inventory) or more-frequent flooding to, an adjacent wetland, and

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(1) The upper elevation limit may need upwards revision if new sites are discovered above current known elevations. A potentially occupied site exists near Conboy Reservoir at approximately 2,600' elevation (M. P. Hayes, personal communication)

(2) Hallock and Pearson (2001) observed 2-3 Oregon spotted frogs that moved ~1 km between fall and winter locations. These were presumably seasonal movements, not juvenile dispersal.

B) the combined size of both wetlands is ≥3.6 ha, and
C) at least one of the wetlands contains palustrine emergent habitat.

Wetlands that satisfy all criteria of the Tier 1 screen will be visited by a WSDOT Biologist who will perform an on-site review (Tier 2). If any condition in Tier 1 is not met, the site is not considered potentially suitable for Oregon spotted frog presence.

Tier 2- IF a wetland satisfies Tier 1 criteria for potential suitability for OSF, it must contain each of the following seasonal on-site characteristics, within the specified descriptions, to be further considered potential OSF habitat.

Breeding habitat criteria (*best current information suggests these conditions must be present as springtime wetland water temperatures reach 7 – 10 C*)

1) contains low gradient shallows that:
    a. have an average depth between 5 – 30 cm (Hayes et al. 2000, Leonard 1997, McAllister and White 2001, Watson et al. 2003), in areas that

    b. are dominated by (constituting >50 % of existing vegetative cover) native wetland vegetation such as *Carex*, *Eleocharis, Juncus, Potamogeton, Ranunculus, Scirpus*, *Sparganium, Utricularia,* filamentous algae, and/or native grasses, but which may also contain subdominant vegetation including *Typha, Phalaris* (*Typha* or *Phalaris* may be dominant at occupied sites where livestock grazing reduces the canopy), or other plant species having an upright submergent or emergent growth form (Lewis et al. 2001, Risenhoover et al. 2001, personal communication with M. Hayes and C. Pearl), and

    c. have >10 % plant coverage of bottom substrate, primarily in submergent and emergent growth forms (Lewis et al. 2001, McAllister and White 2001), and

    d. have low surface and above-water canopy closure in the form of woody-stemmed shrubs and trees, such that Palustrine Forested and ungrazed *Phalaris*-dominated habitats are not suitable (Watson et al. 2000, personal communication with B. Leonard), and,

    e. remain hydrologically surface-connected to summer-season habitat until post-hatching in an average year (Backhouse 2002, personal communication with M. Hayes, K. McAllister, and C. Pearl). This period will be 5 – 8 weeks from the date of egg deposition, and will usually occur by April 31 in an average year.

If answers to a – e are "Yes", screen for suitable Summer-season features. If any condition of Breeding habitat is not met, the site is not considered potentially suitable for Oregon spotted frog presence.

Summer-season habitat criteria

1) contains persistent (perennial) lentic pools that:
    a. are in close proximity to breeding habitat (present in same wetland and <1 km distant, or surface-water connected during breeding-summer season and <1 km distant; Hallock and Pearson 2001, personal communication with K. McAllister and C. Pearl), and

    b. have *Carex, Eleocharis, Juncus, Phalaris, Sparganuim, Spiraea*, *Potamogeton*, *Utricularia*, *Ranunculus*, or other wetland vegetation present in emergent, floating, or submergent growth form (Watson et al. 2000, 2003, personal communication with M. Hayes, B. Leonard, K. McAllister, C. Pearl), and

    c. have Palustrine Forested vegetation including *Spiraea*, *Salix*, or *Alnus* in shrub or tree form, or upland shrub-tree form vegetation present and within a distance to provide at least partial shading (Watson et al. 2000, 2003, personal communication with M. Hayes, B. Leonard, K. McAllister, C. Pearl), and

    d. are/become surface-water connected to suitable winter habitat during fall (Hallock and Pearson 2001, Backhouse 2002; personal communication with M. Hayes, K. McAllister, and C. Pearl).

If answers to a – d are "Yes" screen for suitable Winter-season features. If any condition of Summer habitat is not met, the site is not considered potentially suitable for Oregon spotted frog presence.

Winter habitat criteria

1) contains ponded, pooled, or channeled areas of either lotic or lentic water that:
    a. are in close proximity (present in same wetland, or surface-water connected during fall migratory season and <1 km) to both breeding and summer season habitat during the appropriate season (Watson et al. 2000, Hallock and Pearson 2001, Hayes et al. 2001, Backhouse 2002), and

    b. exceed 15 cm depth (Hallock and Pearson 2001, Hayes et al. 2001), and

c. have some combination of Aquatic Bed, Emergent, and Scrub-shrub vegetation present and intermixed with Unconsolidated Bottom habitat (Watson et al. 2000, 2003), and

d. are not scoured (scoured = having flows capable of removing rooted vegetation or re-arranging distribution of large-grained sand and gravel substrates) by winter storm-related flows during an average year (Cowardin et al. 1979).

e. IF site elevation is such that ice cap persists for >1-2 weeks during an average winter, then in-channel flow or springs/upwelling must be present in habitat described in item C (Hayes et al. 2001, Hallock and Pearson 2001, Backhouse 2002, personal communication with M. Hayes and C. Pearl).

If answers to a – e are "Yes", surveys for *Rana pretiosa* are warranted. If any condition of Winter habitat is not met, the site is not considered potentially suitable for Oregon spotted frog presence.

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Appendix A. Soils present at wetland sites occupied by Oregon spotted frogs (*Rana pretiosa*) in Washington and British Columbia.

WA soils data provided by NRSC-Spokane via ftp.
Soils: Thurston County = SSURGO
Soils: Klickitat County = soils are in draft form; original source is WDNR

Conboy Reservoir, WA
Conboy clay loam, 0 to 1 percent slopes
Fanal sandy loam, 2 to 8 percent slopes
Firoke stony fine sandy loam, 5 to 30 percent slopes
Glen sandy loam, 0 to 2 percent slopes
Grayland silty clay loam, 0 to 1 percent slopes
Guler stony sandy loam, 2 to 20 percent slopes
Kaiders stony loam, 5 to 30 percent slopes
Kreft sandy loam, 0 to 2 percent slopes
Mazdale very stony loam, 30 to 75 percent slopes
Panak loam, 5 to 30 percent slopes
Pinbit stony loam, 2 to 10 percent slopes
Pinbit very stony sandy loam, 2 to 8 percent slopes
Segidal sandy loam, 0 to 2 percent slopes
Underwood loam, 2 to 8 percent slopes

Dempsey Creek, WA
Alderwood gravelly sandy loam, 0 to 3 percent slopes
Alderwood gravelly sandy loam, 3 to 15 percent slopes
Bellingham silty clay loam
Everett very gravelly sandy loam, 0 to 3 percent slopes
Everett very gravelly sandy loam, 3 to 15 percent slopes
Everson clay loam
Giles silt loam, 3 to 15 percent slopes
Godfrey silty clay loam
Kapowsin silt loam, 3 to 15 percent slopes
McKenna gravelly silt loam, 0 to 5 percent slopes
Norma silt loam
Semiahmoo muck
Spanaway gravelly sandy loam, 0 to 3 percent slopes
Tenino gravelly loam, 3 to 15 percent slopes
Yelm fine sandy loam, 3 to 15 percent slopes

Rocky Prairie, WA
Alderwood gravelly sandy loam, 0 to 3 percent slopes
Alderwood gravelly sandy loam, 15 to 30 percent slopes
Alderwood gravelly sandy loam, 3 to 15 percent slopes
Alderwood gravelly sandy loam, 30 to 50 percent slopes
Cagey loamy sand
Cathcart gravelly loam, 15 to 35 percent slopes

Rocky Prairie, WA, continued
Cathcart gravelly loam, 3 to 15 percent slopes
Everett very gravelly sandy loam, 0 to 3 percent slopes
Everson clay loam
Indianola loamy sand, 0 to 3 percent slopes
Indianola loamy sand, 3 to 15 percent slopes
Kapowsin silt loam, 0 to 3 percent slopes
Mukilteo muck, drained
Norma fine sandy loam
Norma silt loam
Semiahmoo muck
Spanaway gravelly sandy loam, 0 to 3 percent slopes
Spanaway-Nisqually complex, 2 to 10 percent slopes
Tisch silt loam

Trout Lake, WA, West Unit
No soils data available

Trout Lake, WA, East Unit
Chemawa loam, 2 to 8 percent slopes
Flotag gravelly sandy loam, 0 to 2 percent slopes
Fluvaquentic endoqualls, nearly level
Kinftain cobbly loam, 30 to 65 percent slopes
Troutlake loam, 1 to 5 percent slopes

BC soils data provided by: Ward, P., K. Moore, and R. Kistritz. 1992. Wetlands of the Fraser Lowland, 1989: An inventory. Tech. Rep. Series No. 146, Canadian Wildlife Service, Pacific and Yukon Region, British Columbia, Canada.

Fraser River Valley, British Columbia, Canada
No site-specific data available. However, Fraser lowland wetlands lie on poorly drained fibrisols, mesisols, organic cryosols, gleysols, and humisols, and these soil types should be considered indicative of suitable habitat.

Appendix B. Site name, size, and elevations (m) for wetlands occupied by Oregon spotted frogs (*Rana pretiosa*) in Washington, Oregon, and British Columbia.

Site	Location	Elev (ft)	Elev (m)	Size (Ha)
Conboy Reservoir	WA	1840.0	560.8	2452.0
Dempsey Creek	WA	141.0	43.0	444.8
Rocky Prairie	WA	220.0	67.1	225.3
Trout Lake East	WA	1952.0	595.0	396.3
Trout Lake West	WA	2099.0	639.8	4.8
Big Marsh	OR	4778.1	1417.0	-
Buck Lake	OR	4997.3	1482.0	715.0
Camas Prairie	OR	3186.5	945.0	40.1
Crane Creek*	OR	4289.2	1272.0	24834.9
Crane Prairie/"Quinn R Campgr(Hayes1997)"	OR	4494.9	1333.0	-
Cross Water	OR	4225.1	1253.0	-
Cultus Cr Gravel Pit Pond	OR	4515.1	1339.0	-
Fourmile Creek*	OR	4198.1	1245.0	-
Gold Lake Bog	OR	4865.8	1443.0	-
Goose Lake	OR	4892.8	1451.0	10.4
Hosmer Lake	OR	5020.9	1489.0	107.6
Jack Creek	OR	5321.0	1578.0	309.9
Klamath Marsh Wildlife Refuge	OR	4633.1	1374.0	26852.9
Lapine Pond	OR	4346.5	1289.0	-
Lava Lake	OR	4795.0	1422.0	156.8
Little Cultus Lake	OR	4815.2	1428.0	43.2
Little Deschutes/Casey Tract	OR	4265.6	1265.0	-
Little Lava Lake	OR	4791.6	1421.0	107.8
Long Prairie	OR	4400.5	1305.0	-
Muskrat Lake	OR	5041.1	1495.0	5.5
Penn Lake	OR	4852.3	1439.0	16.4
Sunriver	OR	4242.0	1258.0	-
Unnamed Marsh/Mud Lake	OR	4852.3	1439.0	4.1
Upper Williamson River	OR	4724.2	1401.0	-
Wickiup Reservoir drainage ditch	OR	4370.1	1296.0	-
Wickiup Reservoir Proper	OR	4383.6	1300.0	-
Winopee Lake	OR	5054.6	1499.0	56.0
Wood River*	OR	4191.4	1243.0	-
Campbell Valley Regional Park	BC	492.1	<150.0	279.4
Mountain Slough	BC	492.1	<150.0	49.3
NRS Aldergrove (MS1 West)	BC	492.1	<150.0	6.6
Seabird Island (Maria Slough)	BC	492.1	<150.0	122.0

* these sites pooled for size data; - = data not available

Appendix C. National Wetland Inventory (NWI) habitat types* present at wetland sites occupied by Oregon spotted frogs (*Rana pretiosa*) in Washington and Oregon.

Location	NWI	Acres
Washington sites		
Conboy Reservoir	L1OWHH	24.14
	PAB4HH	3.04
	PEM/FO1C	45.00
	PEM/SS1C	7.78
	PEM1A	173.55
	PEM1AD	1,252.18
	PEM1B	4.20
	PEM1BD	31.25
	PEM1C	109.00
	PEM1CD	3,575.67
	PEM1F	4.75
	PEM1FD	8.60
	PEM1FH	36.91
	PEMA	24.98
	PEMC	200.24
	PFO/EM1C	56.78
	PFO/SS1C	13.71
	PFO/SS1CH	4.63
	PFO1A	2.18
	PFO1C	199.64
	PFO1CD	8.03
	PFO1CH	2.85
	PFO4/1C	36.29
	PFO4/EM1C	8.49
	PFO4C	23.70
	PFO5/4C	21.44
	PFO5/EM1C	38.47
	PFOA	80.36
	PFOC	4.72
	POW/FO5F	0.54
	POWF	0.34
	POWFH	0.28
	PSS/EM1C	1.75
	PSS1C	24.34
	PSS1CH	0.22
	PSSC	26.42
Dempsey Creek	L2ABH	7.67
	PEM1Y	126.34
	PEMC	7.24
	PFO/SS1Y	23.80

	NWI	Acres
Dempsey Creek, continued	PFO/SSC	123.71
	PFO1W	11.10
	PFO1Y	268.01
	PFOC	129.77
	POWZ	1.04
	PSS/EM1Y	26.77
	PSS/EMC	13.36
	PSS1Y	7.09
	PSSC	352.35
	R2OWZ	0.49
Rocky Prairie	PEMA	3.45
	PEMC	130.37
	PEMF	57.35
	PFOA	4.67
	PFOC	137.61
	PSSC	223.14
Trout Lake, East Unit	PABH	4.52
	PEMA	34.91
	PEMC	75.68
	PEMF	101.19
	PEMH	14.38
	PFOA	100.48
	PFOC	158.09
	PSS/EMF	62.85
	PSSA	36.70
	PSSC	370.05
	PSSF	10.33
	R3USC	9.56
Trout Lake, West Unit	PEMF	2.37
	POWHB	1.77
	PSSC	7.70
Oregon sites		
Penn Lake	PABH	14.08
	PEMC	3.38
	PEMF	22.22
	PUBH	0.76
Unnamed Marsh/Mud Lake	PEMF	10.09
Winopee Lake	L1UBH	23.48
	L2ABH	35.45
	PABF	2.75
	PABH	1.63

	NWI	Acres
Winopee Lake, continued	PEMF	0.39
	PEMC	38.00
	PFOC	15.74
	PSSC	20.79
		0.00
Jack Creek	PEMA	2.04
	PEMC	470.99
	PFOA	6.02
	PFOC	275.36
	PSSA	1.93
	PSSC	9.10
Lava Lake	L1UBH	333.63
	PABF	4.43
	PABH	0.53
	PEMC	5.12
	PEMF	9.23
	PEMH	27.33
	PFOC	7.04
Little Lava Lake	L1UBH	111.64
	PABF	2.85
	PEMC	45.00
	PEMF	33.30
	PEMH	13.75
	PFOC	15.16
	PSSC	1.38
	PUBH	0.59
	R3UBH	42.65
Hosmer Lake	L1UBH	114.47
	PABH	11.27
	PEMC	6.89
	PEMF	108.09
	PEMH	24.34
	PUBH	0.77
Muskrat Lake	L1UBH	4.73
	PEMC	1.96
	PEMF	6.80
Little Cultus Lake	L1UBH	70.53
	PEMC	36.06
	PUBH	0.14

	NWI	Acres
Klamath Marsh N.W.R.	L1ABH	453.77
	PABFh	11.26
	PABF	137.94
	PABFx	4.74
	PEMA	14,986.57
	PEMB	2.02
	PEMC	34,888.93
	PEMCh	40.64
	PEMCx	0.21
	PEMF	14,347.27
	PEMFh	4.28
	PEMG	388.19
	PFOA	248.11
	PFOB	1.49
	PFOC	167.22
	PSSA	290.76
	PSSC	31.84
	PUBF	33.27
	PUBFx	1.16
	PUBG	5.81
	PUBGh	0.76
	PUBGx	1.55
	PUSCx	0.22
	R3ABH	6.80
	R3UBH	271.84
Crane Cr., Fourmile Cr., Wood River	L1ABHh	84.16
	L1UBG	85.17
	L1UBGh	51.56
	L1UBHh	419.10
	L1UBHx	1.65
	L2ABFh	50.54
	L2ABGh	1,217.43
	L2ABHh	154.77
	L2UBHh	6.28
	PABF	418.78
	PABFh	41.37
	PABFx	0.98
	PABG	9.18
	PABGh	217.60
	PABGx	0.31
	PABH	6.33
	PABHh	3.68
	PEMA	802.29
	PEMAh	38.24

	NWI	Acres
Crane Cr., Fourmile Cr., Wood River	PEMB	2.14
	PEMC	29,058.43
	PEMCdh	6,930.01
	PEMCd	9,101.04
	PEMCh	96.31
	PEMCx	0.31
	PEMF	2,834.72
	PEMFh	6,611.01
	PEMG	2.70
	PEMGh	700.31
	PFOA	388.00
	PFOAh	9.94
	PFOB	1.08
	PFOC	770.27
	PSSA	24.52
	PSSC	687.01
	PSSCh	54.35
	PSSF	15.18
	PSSFh	31.33
	PUBFx	0.54
	PUBH	10.88
	PUBHh	5.32
	PUBHx	4.98
	R2ABFx	71.49
	R2ABHx	22.28
	R2UBFx	19.57
	R2UBH	89.18
	R2UBHx	136.28
	R3UBH	40.23
	R4SBFx	13.36
Buck Lake	PEMA	36.14
	PEMAd	106.42
	PEMB	8.01
	PEMC	78.42
	PEMCb	2.81
	PEMCd	1,130.10
	PEMF	10.08
	PEMFd	164.66
	PFOA	2.64
	PFOC	80.02
	PSSB	0.75
	PSSC	115.79
	PUBF	0.35
	PUSC	24.16

	NWI	Acres
Buck Lake, cont.	R2UBH	5.62
Camas Prairie	PEMA	2.47
Camas Prairie, continued	PFOC	16.87
	PEMC	65.68
	PSSC	13.77
	PUBH	0.17
Goose Lake	PEMC	5.04
	PFOC	11.51
	PSSC	4.30
	PUBH	4.75

*NWI habitat descriptions available at http://wetlands.fws.gov/

Appendix D. National land cover definition (NLCD) habitat types* surrounding wetland sites occupied by Oregon spotted frogs (*Rana pretiosa*) in Washington and Oregon.

Washington Locations	**NLCD CLASS**	**Acres**
Conboy Reservoir	bare rock/sand/clay	4.0
	Commercial/industrial/transportation	78.3
	deciduous forest	287.8
	emergent herbaceous wetlands	0.4
	evergreen forest	15626.7
	fallow	96.5
	grassland/herbaceous	117.4
	low-intensity residential	8.9
	mixed forest	435.4
	open water	53.2
	orchards/vineyards/other	15.6
	pasture/hay	4365.8
	quarries/mines/gravel pits	3.8
	row crops	72.9
	shrubland	181.3
	small grains	294.9
	transitional	2830.0
	woody wetlands	27.6
Dempsey Creek	commercial/industrial/transportation	215.1
	deciduous forest	3341.0
	emergent herbaceous wetlands	188.4
	evergreen forest	2481.2
	grassland/herbaceous	112.1
	low-intensity residential	826.9
	mixed forest	2798.6
	open water	316.0
	orchards/vineyards/other	18.0
	pasture/hay	1685.7
	row crops	1.1
	shrubland	347.8
	transitional	616.9
	woody wetlands	378.5
Rocky Prairie	bare rock/sand/clay	2.9
	commercial/industrial/transportation	282.9
	deciduous forest	4004.4
	emergent herbaceous wetlands	0.2
	evergreen forest	2560.4
	grassland/herbaceous	245.5
	low-intensity residential	144.8
	mixed forest	2896.9
Rocky Prairie	open water	80.3

	orchards/vineyards/other	19.6
	pasture/hay	1368.6
	quarries/mines/gravel pits	1.3
	row crops	334.0
	shrubland	454.4
	transitional	137.0
	urban/recreational grass	54.7
	woody wetlands	575.1
Trout Lake East	bare rock/sand/clay	3.3
	commercial/industrial/transportation	18.0
	deciduous forest	464.8
	evergreen forest	8632.9
	fallow	3.1
	grassland/herbaceous	40.9
	low-intensity residential	36.3
	mixed forest	153.0
	open water	50.7
	orchards/vineyards/other	262.6
	pasture/hay	828.2
	quarries/mines/gravel pits	2.2
	row crops	19.3
	shrubland	113.0
	small grains	51.6
	transitional	1391.7
	woody wetlands	44.7
Trout Lake West	bare rock/sand/clay	2.4
	commercial/industrial/transportation	0.2
	deciduous forest	119.2
	evergreen forest	2721.7
	grassland/herbaceous	2.4
	mixed forest	59.6
	open water	9.3
	shrubland	3.8
	transitional	185.5
	woody wetlands	18.7
Oregon Locations		
Buck Lake	commercial/industrial/transportation	1.6
	deciduous forest	10.5
	emergent herbaceous wetlands	197.5
	evergreen forest	7090.4
	grassland/herbaceous	596.0
	mixed forest	23.6
	open water	12.5
	shrubland	639.6
Buck Lake	transitional	400.5

	woody wetlands	34.7
Camas Prairie	deciduous forest	32.0
	emergent herbaceous wetlands	8.7
	evergreen forest	3224.3
	grassland/herbaceous	229.7
	mixed forest	48.3
	shrubland	14.0
	transitional	48.7
	woody wetlands	4.0
Crane Cr., Fourmile Cr., Wood R.	bare rock/sand/clay	84.5
	commercial/industrial/transportation	110.8
	deciduous forest	109.0
	emergent herbaceous wetlands	1726.7
	evergreen forest	24978.6
	grassland/herbaceous	1042.4
	low-intensity residential	11.1
	mixed forest	275.5
	open water	11888.5
	pasture/hay	3769.4
	row crops	240.2
	shrubland	667.4
	small grains	577.1
	transitional	664.3
	woody wetlands	160.8
Goose Lake	bare rock/sand/clay	0.9
	deciduous forest	6.4
	emergent herbaceous wetlands	26.5
	evergreen forest	2437.7
	grassland/herbaceous	5.1
	mixed forest	2.0
	open water	208.2
	shrubland	4.9
	woody wetlands	0.7
Hosmer Lake	bare rock/sand/clay	6.7
	commercial/industrial/transportation	2.9
	deciduous forest	0.7
	emergent herbaceous wetlands	47.8
	evergreen forest	4630.7
	grassland/herbaceous	24.5
	mixed forest	2.4
	open water	240.4
	shrubland	37.8
	transitional	6.4
	woody wetlands	0.4
Jack Creek	bare rock/sand/clay	79.8

	commercial/industrial/transportation	12.7
	deciduous forest	1.1
	emergent herbaceous wetlands	389.0
	evergreen forest	14928.0
	grassland/herbaceous	1079.7
	mixed forest	6.9
	open water	4.7
	shrubland	1119.3
	transitional	727.2
	woody wetlands	200.6
Klamath Marsh N.W.R.	bare rock/sand/clay	114.5
	commercial/industrial/transportation	220.4
	deciduous forest	6.0
	emergent herbaceous wetlands	3903.2
	evergreen forest	68473.5
	grassland/herbaceous	4663.8
	mixed forest	23.8
	open water	71.2
	pasture/hay	5751.1
	quarries/mines/gravel pits	7.3
	row crops	1.1
	shrubland	1233.4
	small grains	93.6
	transitional	1040.8
	woody wetlands	178.1
Lava Lake	bare rock/sand/clay	2.2
	commercial/industrial/transportation	4.9
	deciduous forest	2.0
	emergent herbaceous wetlands	68.9
	evergreen forest	3993.5
	grassland/herbaceous	27.4
	mixed forest	4.9
	open water	185.5
	pasture/hay	2.2
	shrubland	6.4
	transitional	56.7
	woody wetlands	1.1
Little Cultus Lake	bare rock/sand/clay	1.3
	deciduous forest	5.8
	emergent herbaceous wetlands	20.2
	evergreen forest	3300.3
	grassland/herbaceous	13.8
	mixed forest	4.2
	open water	212.4
Little Cultus Lake	shrubland	30.2

	transitional	83.8
	woody wetlands	8.0
Little Lava Lake	bare rock/sand/clay	4.7
	commercial/industrial/transportation	3.8
	deciduous forest	2.2
	emergent herbaceous wetlands	46.0
	evergreen forest	5289.2
	grassland/herbaceous	36.9
	mixed forest	3.6
	open water	316.5
	pasture/hay	0.4
	shrubland	17.3
	transitional	109.2
	woody wetlands	1.1
Muskrat Lake	bare rock/sand/clay	0.4
	deciduous forest	1.6
	emergent herbaceous wetlands	14.5
	evergreen forest	2308.7
	grassland/herbaceous	3.6
	mixed forest	1.1
	open water	69.4
	shrubland	1.6
	woody wetlands	2.4
Penn Lake	deciduous forest	6.0
	emergent herbaceous wetlands	27.8
	evergreen forest	2837.5
	grassland/herbaceous	2.7
	mixed forest	8.2
	open water	92.1
	shrubland	9.8
	woody wetlands	0.4
Unnamed Marsh/Mud Lake	deciduous forest	5.8
	emergent herbaceous wetlands	21.6
	evergreen forest	2046.9
	grassland/herbaceous	3.6
	mixed forest	2.4
	open water	280.2
	shrubland	4.0
	woody wetlands	0.2
Winopee Lake	bare rock/sand/clay	0.9
	deciduous forest	4.4
	emergent herbaceous wetlands	12.7
	evergreen forest	3653.3
	grassland/herbaceous	6.0
Winopee Lake	mixed forest	1.6

open water	95.6
shrubland	2.0
woody wetlands	3.3

*NLCD definitions available at: http://landcover.usgs.gov/classes.asp

Appendix E. Summary GIS Statistics Extraction.

Oregon spotted frog Point Data Preparation

For the Washington locations, Oregon spotted frog observations were selected from the Heritage Database using Year of observation greater than or equal to 1990. The Oregon spotted frog locations generally clustered into five geographic areas. Oregon and British Columbia locations were provided by

Wetland Polygon Location Attribution and Aggregation

The wetland polygon covers used in the data summaries were manually encoded with a location attribute specifying Oregon spotted frog cluster locations. Once these procedures were completed it was possible to summarize the spatially contiguous, connected wetland polygons, by Oregon spotted frog geographic location.

Washington. NWI data were extracted from the WDFW GIS library. Guided by the geographic clustering of the Oregon spotted frog observations, the NWI polygon coverage was encoded with a location attribute: LOC. The LOC labels were: Dempsey(10) Rocky Prairie(20), Trout Lake East(30), Trout Lake West(31), and Conboy(40).

Oregon. NWI data were extracted from the NWI website. The geographic location of the Oregon Oregon spotted frog points were reviewed on-screen with the NWI polygon cover. A geographic grouping ID value was placed in the LOC attribute of the Oregon NWI polygon cover. Moving from north to south, the LOC values were: 20, 21, 22, 23,24,25,26,27,28,40,50,60,70,80. Most areas had complete NWI coverage.

British Columbia. Wetland polygons were acquired for the lower Fraser River from Environment Canada, Canadian Wildlife Service. Oregon spotted frog points were reviewed on-screen and the wetland polygons encoded: Campbell Regional Park (10), NRS Aldergrove(20), Mountain Slough(30), Seabird Island (40). Feature interpretation and map compilation procedures differed between the Canadian and American wetland maps therefore causing data summary procedures to differ between the two countries. Many Oregon spotted frog locations did not fall within a wetland polygon, therefore, polygons were manually attributed (LOC) that were in close proximity to the Oregon spotted frog locations.

Soil DataSummary

Soil polygons were acquired from USDA NRCS. Data in Klickitat County were provided by NRSC in draft form. The Trout Lake West location did not have soils information. The NWI contiguous polygons were intersected with the soils polygons and summarized. Availability of Oregon soils data within the aggregated NWI polygons was highly inconsistent. An Oregon summary was not performed due soil data limitations. Soil data were not available to the project for the Fraser River, BC area as well.

Elevation Data Summary
Elevation data were extracted from 10-meter DEMs for the Washington and Oregon Oregon spotted frog points. Digital elevation data were not available to the project for Fraser River, BC area.

Land Cover Data Summary.
Land cover data were generated from the USGS National Land Cover Data (NLCD). Land cover data were originally processed from Landsat Thematic Mapper satellite imagery, ca. 1992, with a pixel size of 30 meters. A 5314.95-foot buffer was generated for each set of contiguous NWI polygons in Washington and Oregon. For each contiguous NWI buffer, an overlay was performed to extract the raster land cover. The interior area within each buffer (“donut hole”) was excluded from the data summary. Land cover was not processed for the British Columbia area.