CHAPTER 5 AMPHIBIAN DISTRIBUTION, ABUNDANCE AND HABITAT USE

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INTRODUCTION

Amphibians are a diverse vertebrate class in forests, wetlands and undisturbed areas. Although their role in ecosystem dynamics has not been intensively studied, their potential abundance suggest significant roles in energy transfers and nutrient cycling. Burton and Likens (1975) in the Hubbard Brook Experimental Forest of New Hampshire found salamander (primarily Plethodon cinereus) numbers to regularly exceed 2,000 per hectare, with concomitant biomass at 1.65 kg per hectare, equaling that of small mammals and twice that of birds. Amphibians also reduce eutrophication of wetlands by their net export of nitrogen. At some wetlands the nitrogen in tadpoles is more than double that of residual pond nitrogen. Furthermore, amphibians in some wetlands (e.g., Rana pipiens, R. catesbeiana, and Ambystoma spp.) collectively export six to 12 times more nitrogen from the ponds than imported through spawning by breeding adults (Seale 1980). Finally, tadpoles also reduce the biomass of nitrogen-fixing blue-green algae and primary production by feeding on all forms of algae (Seale 1980, Beebee 1996).

Some King County wetlands are used by breeding western toads (Bufo boreas) and red-legged frogs (Rana aurora) that produce thousands of eggs and larvae and hundreds of metamorphs and juveniles. At these sites algae-grazing frog and toad tadpoles may significantly influence water nutrient and energy dynamics and provide food for larger aquatic invertebrates and fish. Although salamanders spawn fewer eggs than frogs and toads, their invertebrate-eating larvae also play important roles in aquatic composition and predator-prey relationships. Hundreds of metamorphs are pivotal in transferring biomass from wetland to adjacent terrestrial systems and become prey for reptiles, birds and mammals.

Along with our recognition of the increasing ecological importance of amphibians, studies have shown significant decreases of some populations and extinctions of others (Corn 1994). These declines, however, have been difficult to document because of inadequate information on the geographic distributions and abundances of populations.

The occurrence of Northwest amphibians noted on range maps (Leonard et al. 1993) and spot maps (Nussbaum et al. 1983) indicates a potential of 14 species in King County, 12 of which are associated with aquatic environments and 10 particularly with marshes, swamps, bogs and other wetlands. Recently, we (Richter and Azous 1995) sighted 10 species (e.g., seven lentic-breeding, one lotic-breeding and two terrestrial-breeding) during a two-year survey of 19 wetlands in the Puget Sound Basin. Furthermore, we reported that their distribution was unrelated to wetland characteristics of size, vegetation classes, presence of vertebrate predators and water permanence. Correspondingly, from our watershed land cover analysis we found that larger water level fluctuations resulting from higher impervious areas in highly urbanized watersheds accounted for decreasing species richness.

This paper describes the geographic distribution and relative abundance of amphibians within these 19 palustrine wetlands after an additional two years of surveys in 1993, and

1995. Its companion paper, Chapter 12, reports on the effects of watershed development and habitat conditions on amphibian populations within these wetlands.

METHODS

Information about the locations and physical, hydrologic, chemical and vegetative conditions found in the study wetlands is presented in Section 1 and Chapters 1, 2, and 3 of Section 2.

We determined the distribution of amphibians primarily by autumn pitfall trapping when amphibians are more active than during the summer, and during which time animals migrate to winter hibernacula,. Egg mass sightings, aquatic funnel trapping and fortuitous observations by knowledgeable biologists at the sites for other monitoring purposes augment our distribution data. Relative abundances of trapable species (no Pacific treefrogs) were determined from the results of 14-day autumn pitfall trapping surveys standardized for equal trap nights and for favorable climatic conditions such as temperatures above 4°C (Beebee 1996). Site selection and trap installation procedures are described in Richter and Azous (1995). Trapped amphibians were identified to species and released.

Spring egg surveys were used to determine amphibian breeding in wetlands. Briefly, these included February through April searches of shoreline to 1-m deep palustrine aquatic bed (PAB) and shoreline palustrine scrub-shrub (PSS), palustrine emergent (PEM) and palustrine forested (PFO) habitat types. Detailed survey descriptions are provided in Richter and Roughgarden (1995). We also captured some species in aquatic funnel traps (Richter 1995) within some wetlands to augment diversity data.

We determined wetland boundaries, wetland size, habitat types and land cover conditions within the wetland's watershed and within select distances of each wetland. This data was obtained from King County's Wetlands Inventory, King County Surface Water Management Division's GIS system , and the 1992 Landsat Thematic Mapper for the Puget Sound Region (King County 1990, Puget Sound Regional Council 1994). From Landsat images we identified and characterized ten cover types: 1) impervious surfaces, 2) freeway/parking/gravel areas, 3) cleared land, 4) grasslands/golf courses, 5) multi-family housing, 6) single family residential, 7) single family forest, 8) agriculture/pasture lands, 9) forests, and 10) open water. These were collapsed into favorable amphibian breeding, feeding, migration and hibernation habitat (cover types 7-10) and unfavorable types (cover types 1-6).

We identified habitat structure categories (e.g., aquatic bed, herbs, shrubs and trees) according to Cowardin et al. (1979) from aerial photos recorded on maps (King County 1987), and refined those designations with field surveys that sampled vegetation along transects that crossed the hydrologic gradients represented in the wetlands. Life history characteristics discussed in the text were taken from Nussbaum et al. (1983) and our own observations (Richter and Roughgarden 1995, Richter 1996a, Richter 1996b).

RESULTS

Ten amphibian species, representing all but one (spotted frog) of the regional amphibian fauna, were identified at the 19 wetlands studied. Eight amphibian species was the highest richness found (at SR24) and included the introduced bullfrog. Seven species, the greatest number of native species at a wetland, and representing 70% of the total potential native amphibian species, were identified at HC13, PC12 and SR24 east of Lake Sammamish. ELW1 had only one species captured, the bullfrog. Most wetlands exhibited five (50%) of the total potential native species. The most urbanized and isolated wetlands (B3I, FC1 and ELW1) had the lowest richness. Unexpected, however was the low richness at TC13 and RR5, relatively large wetlands in watersheds without extensive development. The proportional distribution of native amphibian richness within all wetlands is provided in Figure 5-1.

Sighted at 18 out of 19 wetland, the Pacific treefrog is likely the most broadly distributed amphibian (Table 5-1). Red-legged frogs, Northwestern salamanders, and long-toed salamanders were found in 16, 15 and 13 (84%, 79% and 68%respectively) of the wetlands surveyed. Of the two terrestrial-breeding buffer species Ensatina was found in 11 (58%) and Western red-backed salamanders in nine (47%) of wetlands.

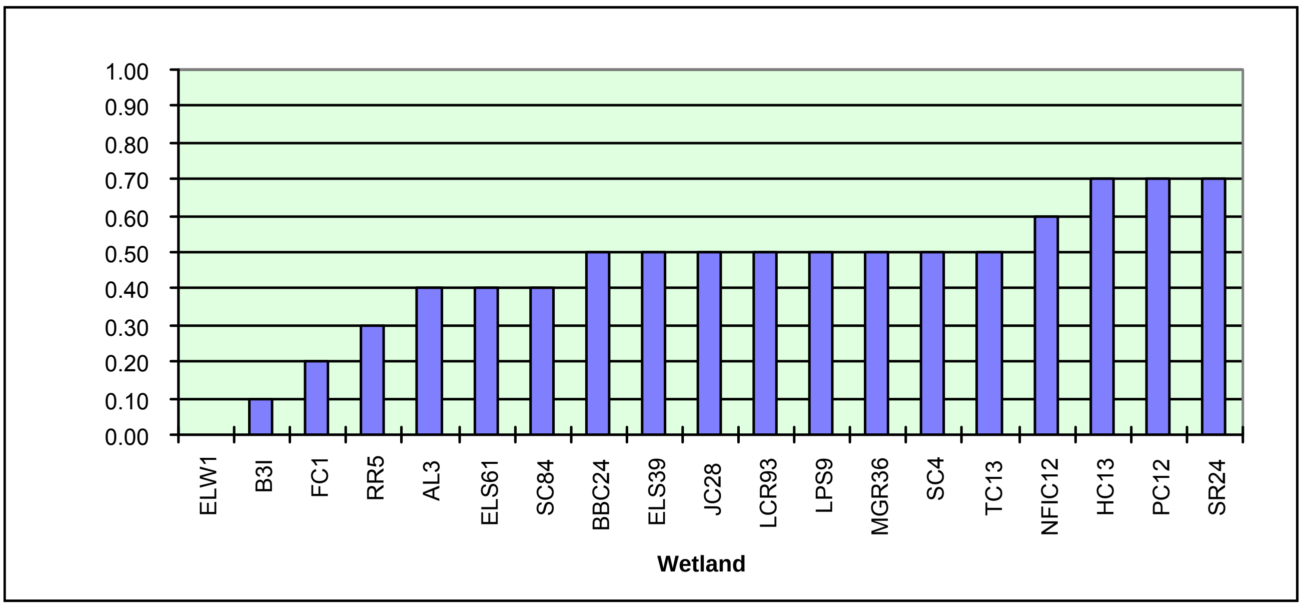

Figure 5-1. Proportional distribution of native amphibian richness within wetlands.

Table 5-1. Total amphibian fauna found in palustrine wetlands of the Puget Sound Basin.

Common Name	Scientific Name	Ames Lake 3	Bellevue 3I	Big Bear Creek 24	East Lake Sammamish 39	East Lake Sammamish 61	East Lake Washington 1	Forbes Creek 1	Harris Creek 13	Jenkin's Creek 28	Lower Cedar River 93	Lower Puget Sound 9	Middle Green River 24	North Fork Issaquah Creek 12	Patterson Creek 12	Raging River 5	Snoqualmie River 24	Soos Creek 4	Soos Creek 84	Tuck Creek 13	Percent of All Wetlands Species Was Present
Bullfrog	*Rana catesbeiana*			●		●	●	●	●					●			●			●	0.42
Ensatina	*Ensatina eschscholtzii*	●		●	●			●	●	●	●			●	●		●	●			0.58
Long-toed Salamander	*Ambystoma macrodactylu*	●	●		●	●		●	●		●	●	●		●		●		●	●	0.68
Northwestern Salamande	*Ambystoma gracile*			●	●	●			●	●	●	●	●	●	●	●	●	●	●	●	0.79
Pacific Giant Salamander	*Dicamptodon tenebrosus*														●		●				0.11
Pacific Treefrog	*Pseudacris regilla*	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	0.95
Red-legged Frog	*Rana aurora*	●		●	●	●			●	●	●	●	●	●	●	●	●	●	●	●	0.84
Roughskin Newt	*Taricha granulosa*			●		●				●											0.16
Western Red-backed Sa	*Plethodon vehiculum*	●		●					●	●	●	●	●					●	●		0.47
Western Toad	*Bufo boreas*								●						●	●	●				0.21

Spawn of the eggs of four species with large and readily identifiable eggs (Northwestern salamander, long-toed salamander, red-legged frog and Pacific treefrog) were identified at four wetlands, confirming breeding by these species at these sites. In contrast, eggs of the Western toad were not observed at any wetland, although metamorphs were sighted at BBC24 and RR5, corroborating that these wetlands are used by breeding toads. Though historically considered wide-spread (Nussbaum et al. 1983) roughskin newts were sighted in only three (16%) wetlands.

Lentic breeding species, as expected, were largely absent from wetlands with higher current velocities and channelized flows to which they are not well suited. High current velocity and water level fluctuations may thwart successful spawning, embryogenesis or larval survival of lentic breeding species. However, one lotic-breeding species, the Pacific giant salamander, was captured at PC12. Presumably, this animal was spawned in adjoining Patterson Creek, a cool, fast-running stream, similar to ones in which this species traditionally breeds.

We did not find spotted frogs, a native species. Historically never abundant in the Puget Sound Basin (McAllister and Leonard 1990, McAllister and Leonard 1991) spotted frogs were, nevertheless, expected at remote and undisturbed wetlands such as LCR93, MGR36, SR24 and RR5.

Bullfrogs were identified in several wetlands and in several drainages including Lake Sammamish (ELS61, NFIC12), Bear Creek (BBC24), Snoqualmie River (SR24), Tuck Creek (TC13), East Lake Washington (ELW1) and Harris Creek (HC13) drainages. Green frogs, another introduced species known to be in King County, were not seen within our wetlands. No native amphibians were captured in ELW1 although Pacific treefrogs were heard vocalizing. Although adult red-legged frogs were captured in pitfalls at AL3, neither spawn nor juveniles were observed during spring egg searches and summer site visits.

There were significant differences between the abundance of species captured within wetlands between 1988 and 1995. 1988 and 1989 were ranked similarly with average capture rates of 2.8 and 4.1 individuals per 100 trap nights respectively but differed significantly from 1993 and 1995 in which average capture rates were 0.8 and 1.5, respectively (Friedman test, $\chi 2 = 19.6$, $p = .0002$). Over the study period, the number of amphibian captures per 100 trap nights declined in 12 of the 19 wetlands. Six wetlands showed the highest capture rates in 1989 and then declined. Only one wetland, SC84, showed a slight 0.3 increase in capture rate between 1988 and 1995 (Figure 5-2).

Overall, the most abundant amphibian captured in pitfall traps was the red-legged frog, with particularly high capture rates in 1988 and 1989. Long-toed salamanders, Northwestern salamanders and Western red-backed salamanders were also numerically important. Capture rates of individual species in wetlands for each study year ranged from a high of 9.7, representing 29 Northwestern salamander captured in one night at one wetland, BBC24, in 1989 to the most frequent capture rate of 0.33, representing one individual of one species captured in a wetland for one year's trapping period. Captures of the same species in different years was unpredictable. The number of captures per 100 trap nights, summarized for each species across all wetlands in Figure 5-3, varied but statistical significance could not be evaluated due to the low number of captures. With the exception of Northwestern salamander, long-toed salamander, Ensatina and red-legged frog, species capture rates were 2 individuals or fewer most years. Appendix Table 5-1 gives the capture rates of individual species for each study year in individual wetlands.

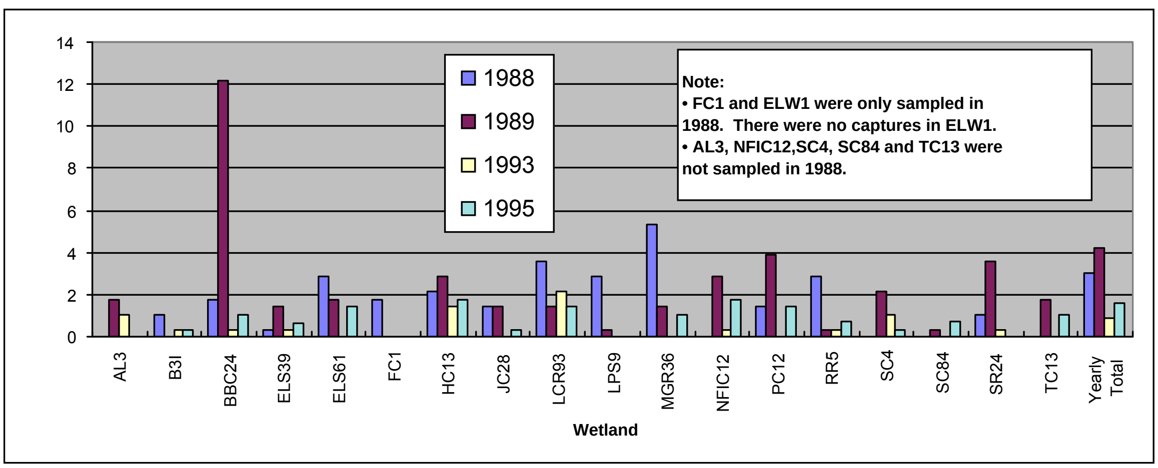

Figure 5-2. The number of total amphibian captures per 100 trap nights by wetland for each year of the study.

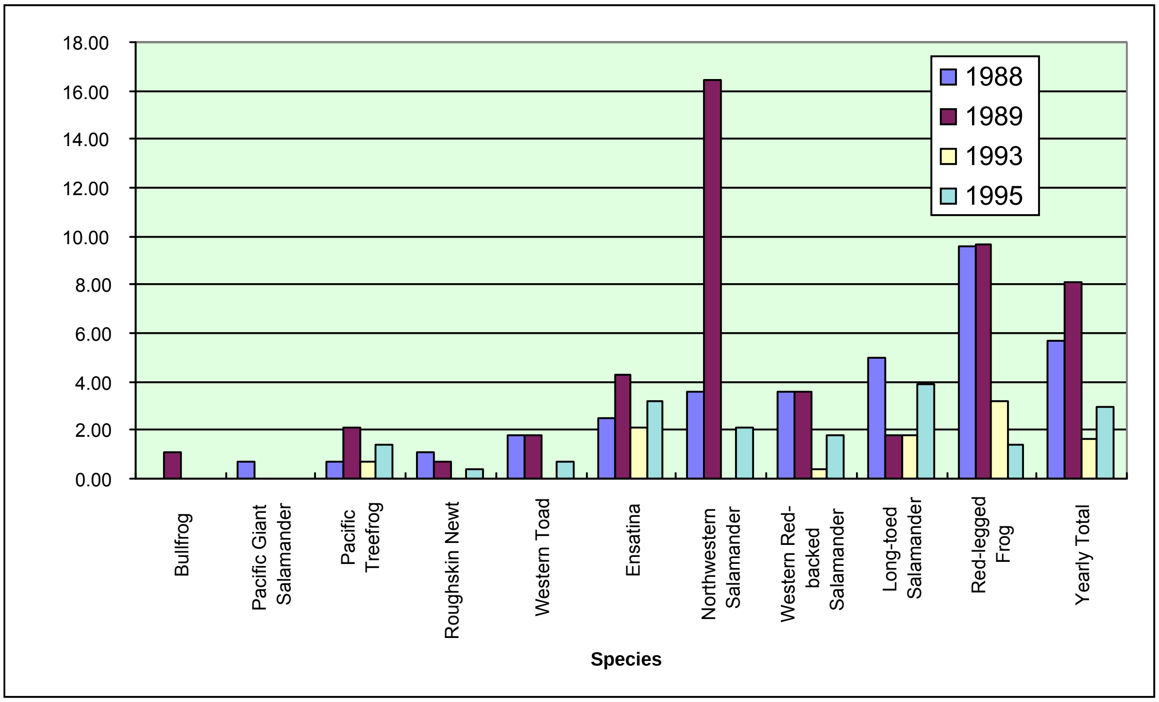

Figure 5-3. Number of captures per 100 trap nights for each species.

Land use in the watersheds of wetlands was related to amphibian richness. Wetlands with contributing watersheds in which more than 40 % of the land area was developed (usually housing with some commercial developments) were significantly more likely to have low amphibian richness of less than four species than wetlands within less urbanized watersheds, (Figure 5-4) ($\chi 2$, $P < 0.01$). Three wetlands with the highest native amphibian richness of more than 60% of all species observed, had very low watershed urbanization (less than 5%). Thirteen wetlands with medium amphibian richness of 40% to 60% of all species observed had urbanization ranging up to 90%. Three of the five wetlands with the highest urbanization had four or fewer species.

Since land use within the watershed wetland would directly affect hydrologic patterns in a wetland, we also evaluated whether minimum water levels, maximum water levels or the average range of fluctuation affected the richness of amphibian communities. Only average water level fluctuation (WLF) showed a statistically significant relationship with amphibian richness. When average WLF was 20 cm or more during the year, the number of amphibian species averaged three or fewer. Wetlands with lower WLFs (less than 20 cm) were significantly more likely to have a higher proportion of the potential amphibian richness, averaging five species (Mann Whitney, $p = 0.047$) (Figure 5-5).

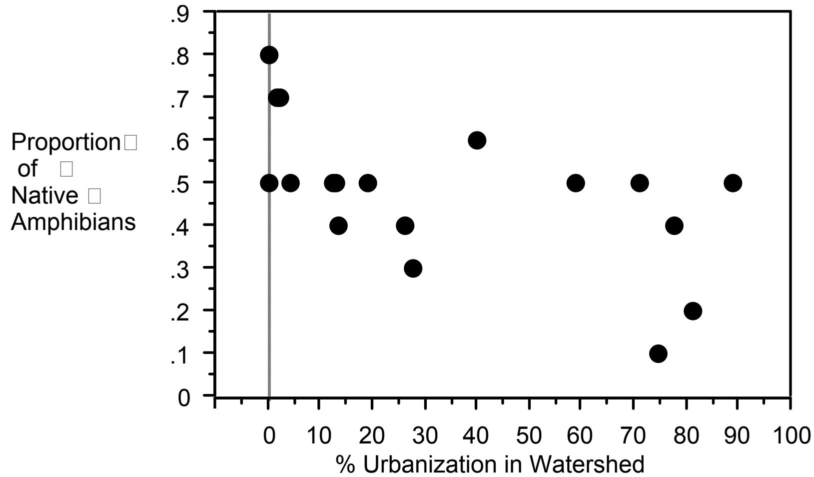

Figure 5-4. Relationship between the percent of native amphibian species present and percent of watershed urbanization.

Land use adjacent to a wetland was also found to be related to the richness of native amphibian populations. When land use within concentric areas of 10, 100, 500 and 1000 meters from the wetland were examined for statistically significant relations with amphibian richness we found that, within the distance encompassed by the 10 to 1000 M radii, amphibian richness was related to the percentage of favorable land available. Figure 5-6 shows the proportion of native species observed related to the percent of forest land within 10, 100, 500 and 1000 M of the wetland edge. In general, those wetlands which are adjacent to a high percentage of forest land were more likely to have richer populations of native amphibians. The significance of this relationship was weakest at 10 M ($R = 0.57$, $p = 0.01$) and strongest at 500 M ($R = 0.66$, $P = 0.004$). The graph shows that almost all wetlands had high proportions of forest land within 10 M and to a lesser extent at 100 M. But amphibian richness is highest in wetlands that retain at least 60% of adjacent area in forest land up to and exceeding 500 M. from the wetland and lowest in the wetlands that had a high proportion of forest land within 10 or 100 M but dropped significantly at 500 M and further from the wetland.

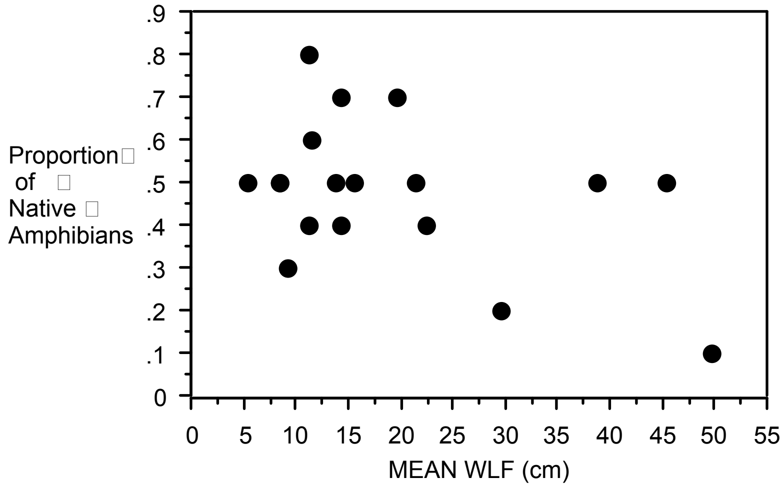

Figure 5-5. Relationship between the percent of possible amphibian species and average water level fluctuation.

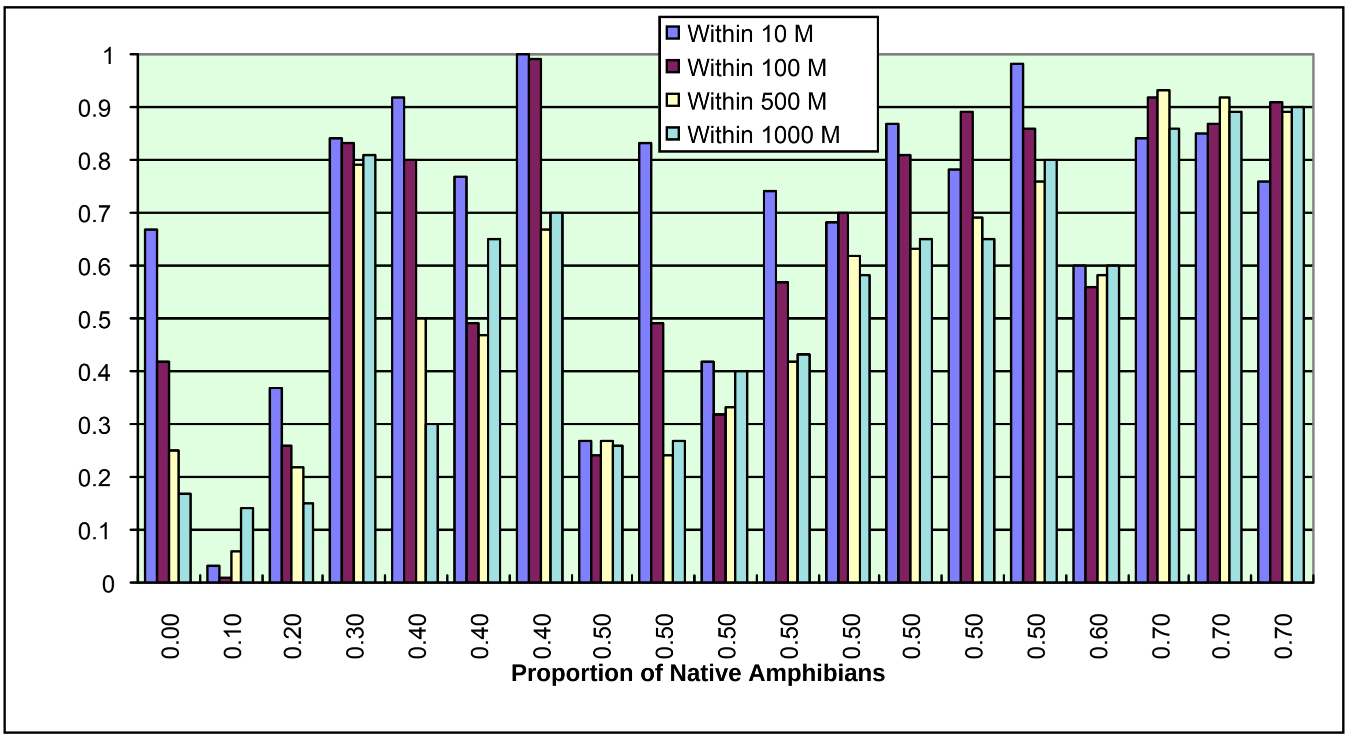

Figure 5-6. Plot of amphibian richness and the percent of favorable adjacent land.

DISCUSSION

Despite the low overall richness of amphibians within Puget Sound lowland palustrine wetlands when compared to the southeast (Gibbons and Semlitsch 1991) and central states (Clarke 1958, Clawson and Baskett 1982), the biomass of existing species may be high. The capture of 29 Northwestern salamander at one wetland on one night clearly shows the numerical importance of this salamander, and underscores the ecological significance of amphibians in general, moreover, it demonstrates the abundance of this species at a site which, when censused on other nights, would falsely suggest fewer individuals. Other species are also likely to be significantly more abundant than the capture data suggest.

This research supports our earlier analysis of capture and observation data collected from 1988 to 1991 (Richter and Azous 1995) in that no new species were identified in 1993 or 1995. Consequently, our recent studies also show no relationships between the number of amphibian species and wetland size or the number of Cowardin et al. (1979) habitat classes. These data also confirmed the relationship we found in earlier years between spawning and select vegetation classes, showing that amphibians spawn within the thin stemmed (non-cattail) emergent zone and with salamanders particularly selecting thin-stemmed emergent vegetation and tiny branches and root hairs of submerged vegetation on which to spawn (Richter and Roughgarden 1995).

Our study shows large differences in amphibian richness, using diverse survey techniques, and varying abundance (captures per 100 trap nights) between the survey years suggesting that multiple year studies are a prerequisite to the accurate identification of a wetlands' amphibian fauna. Explanations accounting for the dramatic differences could be weather related, as almost all the wetlands we studied responded with similar declines in richness and abundance over the study period. Pechmann et al. (1991) and Hairston (1987), in analyzing data from long term studies, show that for many amphibians, populations normally fluctuate dramatically over short periods but remain stable over longer periods of five to ten years. The extent to which distinct local populations, such as those found in our wetlands, vary asynchronously within a given year and for what reasons remain to be investigated.

We also found differences in amphibians identified at wetlands depending on survey technique, suggesting that multiple methods should be employed to accurately assess a wetland's amphibian population. For example, Pacific treefrogs were not captured in pitfalls anywhere, and large numbers of Northwestern salamanders that were breeding at SR24 were never captured in pitfalls. Similarly, we captured roughskin newts in funnel traps at ELS61 in early spring but never saw or captured them in pitfall traps. Also significant is that wetlands in which adults were captured in pitfalls were not observed to have spawn. Pitfalls on either side of drift fences totally encircling wetlands would be a good method of capturing most species and measuring abundances but was not feasible in a study of thisd many wetlands.

Our estimates of the number of captures per 100 trap nights appear similar to amphibian capture data elsewhere in the Northwest (McComb et al. 1993a, McComb et al. 1993b, Aubry and Hall 1991). However, differences in habitats used, timing of censuses and field techniques, including the possibility of counting recaptures in our study, do not allow direct statistical comparisons of our results with those of others.

The reduced richness of amphibians in wetlands with highly urbanized watersheds is likely due, in part, to differences in hydrologic patterns related to land use. Average WLF increases as the frequency of peak flood events increases. Such conditions may result in a frequently wet buffer affecting habitat for terrestrial breeders which prefer well drained soils that are not extremely wet, and tend to avoid soaked or flooded sites (Aubry and Hall 1991, Gilbert and Allwine 1991). Low numbers in wet riparian as opposed to dryer upland habitats have, for example, been documented with Ensatina (E.

eschscholtzii) in red alder (McComb et al. 1993a, McComb et al. 1993b), second-growth conifer (Gomez and Anthony 1996) and unmanaged Douglas-fir (Aubry and Hall 1991, Gilbert and Allwine 1991) stands. Aquatic and semi-aquatic breeders may be similarly affected by the increased frequency of flooding in that flooded habitats with high water level fluctuation may have less large downed woody material, litter and other organic material that provide food, cover and oviposition sites. Clearly, hydrology may account for the richness of the amphibian communities in the wetlands we studied, but may, in addition, be related to the proportion of adjacent area comprised of favorable habitat.

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APPENDIX TABLE 5-1. CAPTURE RATES OF AMPHIBIANS EACH YEAR IN INDIVIDUAL WETLANDS.

		Year			
Wetland	Data	Capture Rate 1988	Capture Rate 1989	Capture Rate 1993	Capture Rate 1995
AL3	AMGR				
	AMMA				
	ENES		0.667	0.333	
	BUBO				
	DITE				
	TAGR				
	RAAU		0.333		
	PSRE		0.333	0.333	
	PLVE		0.333	0.333	
	ENES		0.667	0.333	
B3I	AMGR				
	AMMA	1.000		0.333	0.333
	ENES				
	BUBO				
	DITE				
	TAGR				
	RAAU				
	PSRE				
	PLVE				
	ENES				
BBC24	AMGR	0.672	9.667		0.333
	AMMA	0.336	0.333		
	ENES		0.333	0.333	0.333
	BUBO				
	DITE				
	TAGR				0.333
	RAAU	0.672	1.000		
	PSRE				
	PLVE				
	ENES		0.333	0.333	0.333
ELS39	AMGR		0.333		
	AMMA				0.357
	ENES		0.667	0.333	0.357
	BUBO				
	DITE				
	TAGR				
	RAAU	0.333			
	PSRE		0.333		
	PLVE				
	ENES		0.667	0.333	0.357

Appendix Table 5-1 cont. Capture rates of amphibians each year in individual wetlands.

Wetland	Data	Capture Rate 1988	Capture Rate 1989	Capture Rate 1993	Capture Rate 1995
ELS61	AMGR	1.000	0.667		0.333
	AMMA	0.667	0.333		1.000
	ENES				
	BUBO				
	DITE				
	TAGR				
	RAAU	1.000	0.667		
	PSRE				
	PLVE				
	ENES				
ELW1	AMGR				
	AMMA				
	ENES				
	BUBO				
	DITE				
	TAGR				
	RAAU				
	PSRE				
	PLVE				
	ENES				
FC1	AMGR				
	AMMA	1.333			
	ENES	0.333			
	BUBO				
	DITE				
	TAGR				
	RAAU				
	PSRE				
	PLVE				
	ENES	0.333			
HC13	AMGR	0.333			
	AMMA			0.667	0.364
	ENES				0.364
	BUBO		0.333		
	DITE				
	TAGR				
	RAAU	1.357	1.667	0.667	0.727
	PSRE		0.333		
	PLVE	0.333	0.333		0.364
	ENES				0.364
JC28	AMGR	0.333			
	AMMA				
	ENES	0.333			
	BUBO				
	DITE				
	TAGR	0.333			
	RAAU		0.333		
	PSRE				
	PLVE	0.333	1.000		0.333
	ENES	0.333			

Appendix Table 5-1 cont. Capture rates of amphibians each year in individual wetlands.

Wetland	Data	Capture Rate 1988	Capture Rate 1989	Capture Rate 1993	Capture Rate 1995
LCR93	AMGR				
	AMMA		0.333		0.667
	ENES	0.333			0.333
	BUBO				
	DITE				
	TAGR				
	RAAU	2.333	0.667	2.000	0.357
	PSRE	0.333			
	PLVE	0.333	0.333		
	ENES	0.333			0.333
LPS9	AMGR	0.333			
	AMMA	1.000			
	ENES				
	BUBO				
	DITE				
	TAGR				
	RAAU	0.690	0.571		
	PSRE	0.333			
	PLVE	0.333			
	ENES				
MGR36	AMGR	0.333	0.667		0.333
	AMMA	0.333			
	ENES	1.000			
	BUBO				
	DITE				
	TAGR				
	RAAU	1.333			
	PSRE				
	PLVE	2.000	0.667		0.667
	ENES	1.000			
NFIC12	AMGR		1.345		
	AMMA				
	ENES		0.336	0.333	1.000
	BUBO				
	DITE				
	TAGR				
	RAAU		1.008		
	PSRE				0.333
	PLVE				0.333
	ENES		0.336	0.333	1.000
PC12	AMGR		0.667		
	AMMA				1.014
	ENES	0.333			
	BUBO		0.667		
	DITE	0.333			
	TAGR				
	RAAU	0.667	2.000		
	PSRE		0.333		0.338
	PLVE				
	ENES	0.333			

Appendix Table 5-1 cont. Capture rates of amphibians each year in individual wetlands.

Wetland	Data	Capture Rate 1988	Capture Rate 1989	Capture Rate 1993	Capture Rate 1995
RR5	AMGR	0.336	0.345		
	AMMA				
	ENES				
	BUBO	1.681			0.694
	DITE				
	TAGR				
	RAAU	0.672		0.333	
	PSRE				
	PLVE				
	ENES				
SC4	AMGR		1.000		0.333
	AMMA			0.333	
	ENES		0.667	0.333	
	BUBO				
	DITE				
	TAGR				
	RAAU				
	PSRE			0.333	
	PLVE		0.333		
	ENES		0.667	0.333	
SC84	AMGR				0.333
	AMMA				
	ENES				
	BUBO				
	DITE				
	TAGR				
	RAAU				0.392
	PSRE				
	PLVE		0.333		
	ENES				
SR24	AMGR				
	AMMA			0.333	
	ENES		1.000		
	BUBO		0.667		
	DITE	0.333			
	TAGR	0.667	0.667		
	RAAU		0.333		
	PSRE		0.667		
	PLVE				
	ENES		1.000		
TC13	AMGR		0.333		
	AMMA		0.333		
	ENES		0.333		0.667
	BUBO				
	DITE				
	TAGR				
	RAAU		0.667		
	PSRE				0.333
	PLVE				
	ENES		0.333		0.667