King County Wetland-Breeding Amphibian Monitoring Program

1993-1997 Summary Report

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by:

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Cover photo: breeding Pacific treefrogs (Hyla regilla) and their spawn. By Klaus O. Richter.

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EXECUTIVE SUMMARY

This summary report describes the purpose, implementation and initial findings of King County's Wetland-Breeding Amphibian Monitoring Program. This program is designed to provide the County with long-term amphibian, wetland and landscape information for planning and regulatory purposes. It aims to do this through an active public outreach, education and wetland stewardship effort.

From 1993 through 1997 we used 126 trained volunteers to census amphibian eggs, juveniles and adults in 81 freshwater palustrine wetlands of 26 watersheds in King County. We regularly monitored selected wetlands in three rapidly urbanizing priority watershed basins: East Lake Sammamish, Big Bear Creek and Evans Creek as well as wetlands outside these targeted areas. We analyzed the data firstly by determining species distribution, population trends and amphibian health, and secondly, by using these biological attributes of amphibians to assess wetland and watershed condition.

We found broad variations in the distribution of amphibians, population trends and reproductive health among wetlands and watersheds within the County. Several wetlands were without amphibians, most had two to four native species, and some had up to five native species. In general, amphibian diversity was high and equally rich within the priority watersheds of unincorporated east King County that exhibited the least and relatively recent disturbances. Concurrently, we found amphibian richness significantly lower in more heavily urbanized watersheds of cities in which wetlands have been impacted and isolated from other wetlands for longer periods of time. Nevertheless, even within our priority watersheds amphibian richness varied widely, with some wetlands having only one or two species and others exhibiting the full complement of five native species.

Unfortunately, we did not detect the Oregon spotted frog, a state Endangered and Federal Category 1 listed species, further raising concerns regarding its extinction from its former historic range. An unexpected finding was the ubiquitous distribution of non-native bullfrogs on the east side of Lake Washington. Bullfrogs were identified at 49% of our priority wetlands but only in 15% of our other surveyed wetlands. Despite their wide distribution throughout the County, our species richness data at this time does not indicate competitive exclusion of native breeding species by invasive bullfrogs.

We were able to track the continued presence of our easily identifiable wetland-breeding species at wetlands throughout the county. Two of these species, the red-legged frog and the Pacific treefrog, were not found at over 25% of the wetlands they had formerly occupied, and the long-toed salamander, which can be difficult to see, was absent at half of the wetlands it had been seen during earlier surveys. The northwestern salamander distribution appeared to be somewhat more stable, remaining at 85% of the wetlands in which it had bred.

We identified 13 (32%) wetlands in priority basins with potentially decreasing amphibian populations and 9 (22%) wetlands in these same basins with significant egg mortality.

Although the causes for these findings remain unidentified, changing land use patterns and concomitant alterations to wetland hydrodynamics, hydrology and water quality are suspected. Ongoing amphibian and habitat monitoring specifically targeting these wetlands of concern are planned.

These interim survey results have been utilized in several habitat preservation and wetland restoration projects. Our work has also been used in assessing the likely distribution of amphibians at development sites and in suggesting proposed mitigation to protect wetlands and their functions. The Federal Oregon spotted frog listing may be upgraded to endangered and there is a growing concern over the perceived decline of western toads. Consequently, our surveys may discover remnant populations of Oregon spotted frogs or confirm its possible extinction, and confirm suspicions of declining western toad populations. In addition, the survey program has become one of the most popular and successful volunteer education programs offered by King County, with volunteers representing Federal agencies, other counties, cities, private consulting firms, parks departments, local zoos, schools, youth groups, and others. State and federal agencies are interested in using these data as well. The continuation of the program is recommended to provide data with which to make informed decisions regarding the management of specific sites and watersheds, and for the education of the citizens of King County.

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INTRODUCTION

The protection of open space, natural drainage systems and wetlands and their wildlife have consistently been rated as major natural resource issues of concern by residents throughout King County (King County 1991b). Recognizing this concern, as early as 1979, Ordinance 4365 of the King County Code 21.04 - the Sensitive Areas Ordinance (SAO) - was passed to protect wetlands for their open space amenities, flood and water quality functions, food, cover and breeding habitat for wildlife, and sociological benefits including recreation, education and research (King County 1990). More recently in 1994, wetlands were incorporated as critical core reserves within the County's mapped regional Wildlife Habitat Network (King County 1994a) because of their unique ecological functions. Simultaneously, watershed basin studies acknowledged the pivotal role of wetlands in surface and ground water management and identified them and their recharge areas for special protection in Basin and Nonpoint Action Plans (King County 1994c).

Numerous studies confirm and continue to demonstrate wetlands' critical importance to citizens of the county (see review edited by Azous and Horner 1997). Wetlands are recognized foremost as essential landscape components of integrated aquatic ecosystems that include ground water, lakes, streams, and estuaries, with their hydrology and water quality linked to that of our ground and surface waters. Thus the water from which we drink, the lakes in which we swim, and the streams in which we fish depend on the health of our wetlands.

Fish and wildlife also directly depend on wetlands. Wetlands protect salmon habitat in streams by maintaining base flows. Some salmonids use alluvial floodplains and off-channel wetlands for various stages of their lives, including spawning and rearing (Swales et. al 1986, 1988; Swales and Levings 1989, Independent Scientific Group 1996). For example, overwintering coho salmon (*Oncorhynchus kisutch*) use streamside wetlands as rearing habitat (Nickelson et al. 1992, Peterson and Reid 1984) whereas other salmonids (e.g., cutthroat trout, rainbow trout) and spiny rayed fish (bass, sunfish, sticklebacks) may spend part or all of their lives in wetlands (Fuerstenberg, Lucchetti personal communication, Cederholm and Scarlett 1981).

Amphibians, birds and mammals at wetlands far exceed the numbers and abundances found in other habitats (Richter and Azous 1997a,b and c, respectively). For example, 94 bird species were encountered at wetlands, compared to fewer than 60 species at several upland habitats. More than 21 small mammal species were also identified at wetlands. Wetlands are critical as breeding and rearing habitats for pond-breeding amphibians which feed on nuisance mosquitoes, midges and other small invertebrates. In turn, amphibians are fed on by invertebrates (dragonflies, leeches, crayfish), fish (salmonid and spiny rayed fish), reptiles (turtles and snakes), wading birds (Great Blue Herons, American Bitterns) and mammals (weasels, otter, and raccoons). This dual role makes amphibians pivotal to wetland dynamics.

In King County the SAO provides extensive guidance over the interaction between human activity and wetlands (King County 1990). The SAO provides protection to wetlands through requirements for buffers and through limitations to the types of alterations that can occur within wetlands and their buffers. In some areas however, the SAO alone may not be sufficient to sustain the long-term ecological health and natural complexity of wetlands. In fact, an increasing number of studies have shown that wetlands may be severely altered by activities beyond their regulated boundaries (Azous and Horner 1997 and references therein). Consequently, the County has prepared Basin and Nonpoint Action Plans in an attempt to provide environmental protection in the landscape. These plans describe current watershed conditions, emphasizing problems such as flooding, erosion, and declining salmon and steelhead runs (e.g., King County 1994b) and how these impacts can be minimized. They also provide guidance on maintaining water quality and groundwater aquifers, and protecting wetlands and habitat for terrestrial species on a watershed scale.

Although all these efforts stem wetland losses, wetlands continue to be threatened from anthropogenic activities (Mitsch and Gosselink 1993). Wetlands are still impacted by filling, removal of buffer vegetation, discharge of untreated runoff, introduction of toxic substances and the disposal of trash and other materials. In rapidly urbanizing King County, wetlands are also indirectly changed by development within their watersheds, with their hydrology, e.g., the movement, collection and storage of water, being the first characteristic to be altered by humans (Azous and Horner 1997). Development increases the imperviousness of watersheds thus altering discharge processes (Booth 1991, Booth and Jackson 1994, Booth and Reinelt 1993) which, in turn, decreases water quality and simplifies wetland vegetation and its dependent wildlife communities.

To protect, restore and create wetlands, policies, regulations and mitigation methods based on scientifically defensible information are required. Currently, however, inadequate information about baseline and other resource conditions make recommendations, enforcement, protection and adequate mitigation difficult. Regulations are being formulated, impact assessments and mitigation plans accepted, and permits approved or denied based on incomplete information. County requests of developers to obtain relevant site-specific data have been contentious because of the time and cost required to obtain up-to-date field data and other necessary information to adequately describe existing conditions, accurately assess the potential impacts of projected developments and make appropriate mitigation recommendations. Consequently, Environmental Impact Statements are challenged because of their inadequate coverage of environmental issues, particularly those potentially influencing wetlands. Challenges are heard by Hearing Examiners, who decide on the adequacy of impact statements, the need for additional work and the final mitigation requirements.

The development of a County-wide mitigation banking and wetland restoration program also would have benefited from better wetland wildlife data than that found in the wetland inventory (King County 1991a), which fails to provide any information on amphibians at wetlands, but does list one-time sightings of birds and large mammals.

Finally, under the Federal Clean Water Act the biological integrity of wetland water quality is protected. Consequently, biomonitoring is now directly applied to assess water quality and anthropogenic impacts to prevent harm to human health (Adamus 1996, Danielson 1998). Amphibians, especially, are considered an early warning signal of water quality deterioration. For example, their distribution, abundance and richness are considered sensitive indicators of overall changes in water regimes, sedimentation, water quality and landscape stress. Unexpected deaths, physical deformities and altered fecundity have catapulted amphibians into a nationwide effort to link amphibian health to wetland condition and to human health (Adamus 1996, Danielson 1998). In Minnesota and Quebec, frog deformities have been directly linked to water quality (Souder 1998, Quellet et al. 1997, respectively). Here in King County, unexpected frog mortality has occurred and been attributed to pond water quality while deformities in salamanders from undetermined causes have also been documented. Wetland breeding amphibians have been shown to be especially susceptible to wetland changes attributable to urbanization (Azous 1991, Richter and Azous 1995, Richter and Azous 1997a). The state endangered Oregon spotted frog (*Rana pretiosa*), for example, most likely has disappeared from King County wetlands because of land use and associated aquatic habitat changes (McAllister and Leonard 1997).

MONITORING GOALS

Our main objective for the Amphibian Monitoring Program is to provide King County and its citizens with long-term, up-to-date amphibian and wetland information for planning and regulatory purposes through an active public outreach and education program. Our specific goals are to:

- Identify the occurrence of the State-endangered Oregon spotted frog, which requires special consideration for environmental protection in Washington State and King County's permit review program.
- Determine land uses compatible with wetland and amphibian conservation objectives, including protection and recovery of wetland and wetland buffer habitats and amphibian species most sensitive to human activities.
- Provide data to help develop and implement regulations for the protection of amphibians and their habitats.
- Identify the population distribution status of other County declining species, such as the western toad (*Bufo boreas*), red-legged frog (*Rana aurora*), and northwestern salamander (*Ambystoma gracile*).
- Obtain standardized baseline inventory data on the distribution, abundance and health of amphibians in King County wetlands and then to continue to monitor over regular intervals to assess amphibian, wetland and watershed health.
- Provide information to King County, Washington State Department of Fish and Wildlife, Washington State Department of Ecology, and Federal Resource Agencies for developing regional wetland and wildlife management programs (e.g., GIS Data-Base Systems and GAP-Analysis Programs).
- Develop an effective public outreach and education program to train citizens to monitor amphibians and wetland conditions and to foster wetland stewardship.

METHODS

PUBLIC OUTREACH AND EDUCATION

We initiated our Amphibian Monitoring Program by targeting wetlands in the East Lake Sammamish Basin in 1993. This geographic location was chosen because it exhibited one of the highest development rates in the County and because of the large numbers of wetlands that were expected to be impacted by development. Moreover, since we were developing an entirely new program we felt it would be best to initially start within one specific area to develop our citizen outreach and technical survey protocols prior to expanding the program to other watersheds. In 1994 we added wetlands in the Big Bear Creek watershed, and in 1995 wetlands in the Evans Creek watershed because of increasing development pressures in these watersheds and increased volunteer interest.

Within each watershed we initially selected wetlands with open water, aquatic bed and emergent vegetation habitat classes from the King County Wetland Inventory (King County 1991a). Wetlands with these habitat classes were chosen because of their high probability of supporting breeding amphibians (Richter 1998). We then chose a subset of wetlands from each watershed with accessibility, supportive property owners, and an absence of dogs and fencing. Wetlands without breeding amphibians were surveyed only one or two years.

After the first year we surveyed additional wetlands to accommodate rising volunteer participation and to provide data on as many wetlands in rapidly developing King County as feasible. Consequently, we surveyed additional wetlands in the East Lake Sammamish Basin and added wetlands in two other east-side basins as part of our targeted priority basin surveys. Concomitantly, we initiated surveys outside our three priority basins as volunteer participation increased. This enabled us to obtain information from a broader geographical area, document additional sites of interest and provide educational opportunities to volunteers for monitoring wetlands in their neighborhoods and jurisdictions. Specifically, we added 38 wetlands in 23 basins in greater King County to the Amphibian Monitoring Program since 1994. In the majority of these basins however, only one wetland was surveyed because we did not attempt to comprehensively survey these watersheds. Generally, these single wetlands were near a volunteer's residence or they had special value as amphibian habitat, some supporting several native species. Twenty of these wetlands were only monitored once; the remaining 18 wetlands were monitored for two to four, but not always consecutive, years. At 15 (83%) of the wetlands that were monitored more than one year, the same volunteers monitored the same wetland for at least two of the years.

Although our outreach and education program targeted citizens in the three priority basins, we included volunteers from throughout the Puget lowland region within King County. We recruited participants through public announcements of the Volunteer Monitoring Program in the Surface Water Management and WLR Newsletter, Downstream News, and the Water Tenders Newsletter (reaching Bear Creek volunteers). We also used personal contacts by Tina Miller, the East Lake Sammamish

Basin Steward, and word of mouth between County employees, volunteers and educators. In February of each monitoring year brochures were sent to previous volunteers announcing trainings and asking them to continue in the program. We conducted follow-up phone calls to anyone who did not respond. An evening refresher course was offered in 1996 to familiarize past volunteers with amphibian identification and to provide clarification on additional information asked for in refined data sheets.

We held a one-day workshop in late February or early March just prior to each survey season. For the workshop we prepared a standardized package that included a field equipment list, waterproof survey data sheets, diagnostic amphibian identification guidelines, egg development charts, keys to larvae, copies of relevant articles, sampling protocols and maps to the assigned wetlands. This educational package is attached as Appendix A.

The morning of each workshop was dedicated to a slide presentation and hands-on laboratory session describing amphibian ecology and discussing adult, egg and larval identification. We emphasized the species characteristics for identifying all potentially occurring subadult and adult wetland-breeding amphibians (Plates 1 and 2), particularly differences between similar species (i.e., Oregon spotted and red-legged frogs, northwestern and long-toed (*Ambystoma macrodactylum*) salamanders, and long-toed and western red-backed (*Plethodon vehiculum*) salamanders). We also highlighted the identification of large, easily spotted egg masses of northwestern salamander, red-legged frog and western toad as well as the smaller egg masses of the long-toed salamander and Pacific treefrog (*Hyla regilla*). Volunteers were provided with laminated photographs of red-legged frog, Pacific treefrog, northwestern and long-toed salamander egg masses for use for field identification. Hence we are confident of the identification of species using egg mass characteristics and adult morphology. Unless sightings of juveniles or adults of the Oregon spotted frog were confirmed by us, we assumed all ranid (true frog) clutches found in February to April to be those of red-legged frogs. We also described identifying characteristics of bullfrogs and their eggs and suggested these be recorded if positively identified during designated surveys or sighted at other times of the year. There is very little chance of confusing bullfrog eggs with those of the native species given their different egg mass characteristics (e.g., large size and number of eggs) and time of breeding (e.g., summer in the Puget Sound Basin).

In the afternoon of each workshop, we visited select wetlands to demonstrate monitoring protocols. We practiced methods for searching for, identifying and censusing adult and amphibian egg masses, clarified the description of habitats and other important wetland features, and filled out wetland survey data forms.

Each participant was assigned one wetland (or more) to monitor. New volunteers re-surveying wetlands previously surveyed were provided with the earlier surveyor's field notes to facilitate monitoring and to guide re-censusing of known breeding locations. Volunteers were either assigned a partner from within the program or encouraged to invite another interested person. Consequently, two people were always at a wetland to help each other in case of emergencies, to assist with surveys, and to provide companionship. Volunteers checked with private property owners prior to surveys. If property owners did not want volunteers at their wetland, we assigned volunteers to a different site.

FIELD SURVEYS

Upon arrival at a wetland we instructed volunteers to conduct a visual search of the shoreline and shallow standing water with binoculars. We then asked volunteers to slowly wade and look for amphibians and eggs in slow-flowing or still water up to 90 cm (~3 ft) deep among areas of thin-stemmed emergent and thin-stemmed woody vegetation. At potentially favorable sites, volunteers were specifically instructed to carefully search for amphibian eggs attached to vegetation below or at the water's surface. These search methods are similar to those recommended by scientists for basic amphibian surveys (Thoms et. al., 1997) and are abstracted in the training materials (Appendix A).

From 1993 through 1995 we used original IUCN/SSC's Declining Amphibian Populations Task Force Pacific Northwest Working Group Amphibian Survey Data Sheets, developed by Stephen Corn. We altered these forms in 1996 to better reflect King County wetland habitats and to clarify user ambiguities (Appendix B). Specifically, in the site description section, we replaced stream order, primary substrate, and north shoreline characters fields with drainage class, hydrogeomorphic class (after Brinson 1993) and habitat class (after Cowardin et al. 1979) to reflect the hypothesized importance of these wetland traits. We also added a hydrology section. Finally, we reduced the species tally section to one side of the paper to facilitate the collection and analysis of data.

Our distribution of some long-toed salamanders and all western toads and bullfrogs are primarily based on visual sightings of larvae, subadults and adults because these species generally breed prior to, or after, our spring surveys targeting red-legged frogs and northwest salamanders. Rough-skinned newts (*Taricha granulosa*) attach their eggs singly on plants and often hide them within thick vegetation, consequently, our distribution of this species is also from fortuitous subadult and adult sightings. All sightings may be affected by weather during the survey and thereby may be an underestimate of species presence. If time permitted, volunteers searched under downed woody debris and logs adjacent to wetlands to record sightings of terrestrial breeding species such as Ensatina (*Ensatina eschscholtzii*) and western red-backed salamander.

The health of amphibian populations was assessed by examining egg masses. Volunteers noted and described unusual egg conditions including sterile eggs, dead embryos and fungal material in egg capsules, all of which suggest death (Plate 3). We assumed egg mortality values exceeding 5% of total eggs as abnormal based on other surveys that have shown at least some mortality among most egg masses (Richter, unpublished manuscripts).

We visited a number of East Lake Sammamish wetlands in late summer of 1996 to determine whether they exhibited persistent or perennial hydrology and whether they were colonized by bullfrogs. Bullfrog presence was determined by sight, vocalizations and dipnetting.

We considered wetlands and watersheds to be impaired when detection of native species declined within a wetland, adults were sighted but no eggs were found, the percentage of unhealthy clutches to that of total clutches exceeded 5% of all masses surveyed, or if bullfrogs were present.

DATA ANALYSIS

We entered field data into Access and Excel PC application programs. We calculated descriptive statistics using scientific calculators and statistical application programs. Maps were created using Arcview 3.0 and Adobe Illustrator. Wetlands located digitally in 1981 were pulled from the King County Sensitive Areas Ordinance GIS database. We located wetlands not in the King County Inventory by using a Trimble Global Positioning System (GPS) receiver. Data were downloaded from the receiver in NAD-83 datum using Washington North FIPS zone, a state-plane coordinate system. The data were differentially corrected by post-processing. It is estimated that the wetlands located using the Trimble GPS receiver are accurate to within 10 meters.

QUALITY ASSURANCE/QUALITY CONTROL

We deliberately selected easily sighted and identifiable life stages (i.e., adults and species with large, unique egg masses) to minimize the chances of misidentification. We also checked field volunteer's surveys and recordings for unusual observations. Any unusual sightings were verified by checking documentary photographs and with follow-up site visits by qualified staff. In 1997 staff dip-netted larvae at ELS 26 (Discovery Elementary wetland) and Soos Creek 87 (Meridian Meadows) to confirm amphibian use identified by volunteers.

We also visited a number of East Lake Sammamish wetlands in late summer of 1996 to determine water permanence. This first hand knowledge of water permanence enabled us to confirm the possibility of northwestern salamander and bullfrog sightings at wetlands as both these species require wetlands with year-round standing water for successful reproduction.

RESULTS

PUBLIC OUTREACH AND EDUCATION

From 1993 through 1997 our Amphibian Monitoring Program had 126 volunteers survey a total of 81 wetlands (Plate 4). Initially 10 volunteers participated in 1993, then 43 in 1994, 51 in 1995, 33 in 1996, and 64 in 1997. Thirty-two new volunteers participated in 1997. The average volunteer participated for nearly two years (mean 1.75). With the exception of 1993, the demand for participation exceeded acceptances. Preference was given to monitors within priority watersheds, thus volunteers wishing to monitor in other locations were sometimes turned away. A list of the wetlands surveyed and volunteers and staff who monitored them during respective years is shown in Appendix C.

Our volunteers come from many diverse backgrounds. They include nature enthusiasts, men and women with young children, elementary, junior and senior high school students, members of service organizations, people interested in changing careers, students desiring community service, citizen activists, residents curious about the wetland in their own backyard or down the street, and people wanting to help restore amphibian populations. Some volunteers are wetland consultants, engineers, elementary, junior and senior high school teachers, government employees and other professionals.

GEOGRAPHIC COVERAGE

We surveyed a total of 81 wetlands within 26 watershed basins (Appendix C). Of these, 41 are within our three Priority Watershed Basins of Big Bear Creek, Evans Creek, and East Lake Sammamish (Figure 1). This sample represents 50, 33 and 92 percent of total wetlands identified with high potential breeding populations as characterized by palustrine open water, aquatic bed and emergent habitats in King County's Wetlands Inventory within these three basins, respectively. Six of the 18 monitored East Lake Sammamish wetlands and one of the Big Bear Creek wetlands, however, were not identified in the King County Inventory; these were either small ponds or newly constructed wetlands. We also surveyed one to seven wetlands in each of the Green River, Duwamish, Hylebos, Coal Creek, Lower Cedar River, Tolt River, North Fork Issaquah Creek, Little Bear Creek, McAleer Creek, Juanita Creek, and Patterson Creek basins. Photos of three wetlands with typical amphibian breeding habitat are shown on Plate 5.

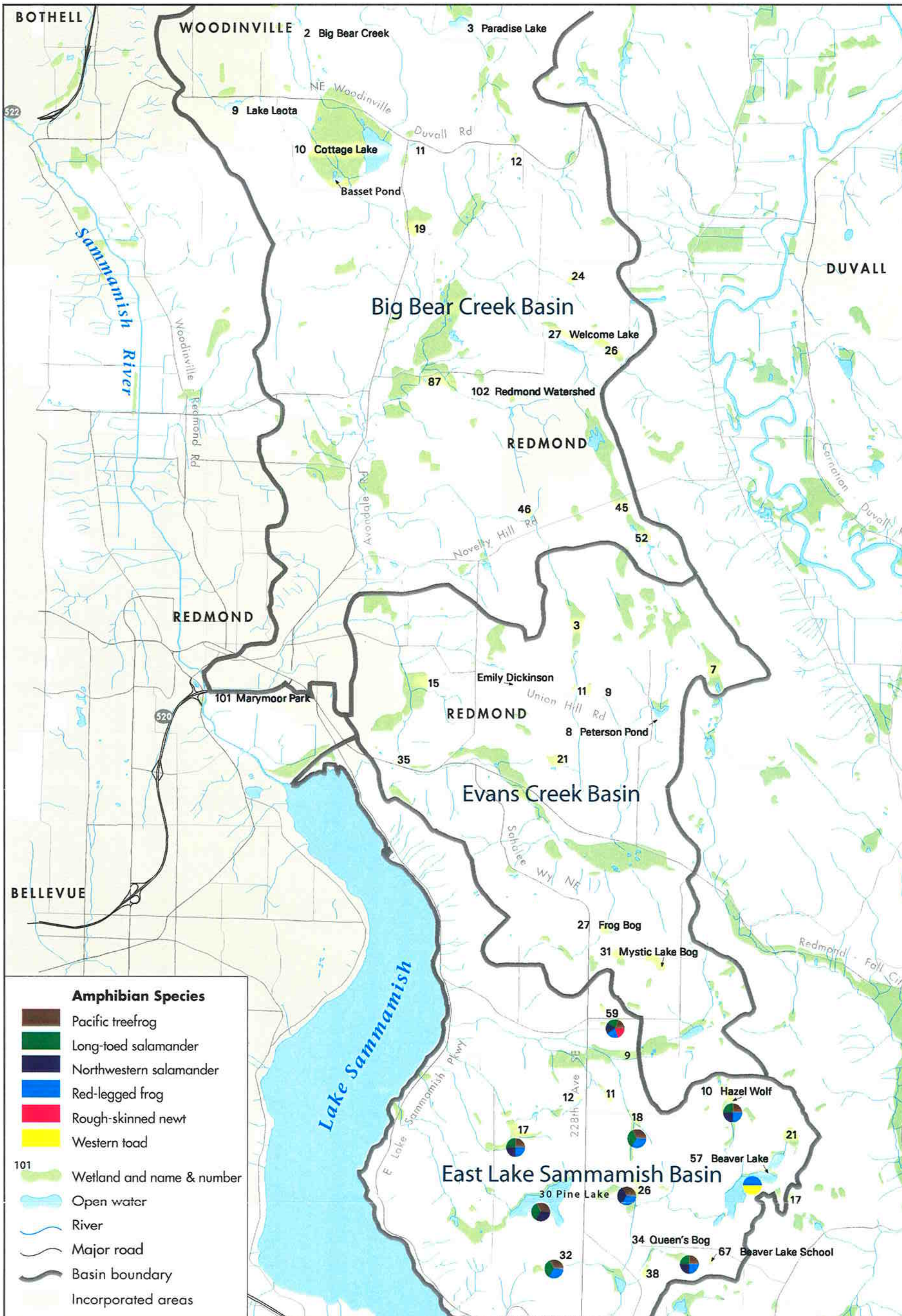

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Figure 1

1993 Distribution of Amphibians within Surveyed Wetlands Priority Basins

N

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KING COUNTY
Department of Natural Resources

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February, 1999

DISTRIBUTION WITHIN PRIORITY BASINS

We identified a total of six native species as eggs, subadults and/or adults within wetlands of priority basins (Appendix D). These included three anurans: Pacific treefrog, red-legged frog and western toad, and three caudates: northwestern salamander, long-toed salamander and rough-skinned newt. We did not find the Oregon spotted frog, an anuran whose range formerly encompassed our survey region. We did, however, find the non-native bullfrog in half (49%) of the wetlands within our priority basins. Currently, native species richness is equal in wetlands with and without bullfrogs (Figure 2). Results of surveys for 1993, 1994, 1995, 1996 and 1997 are shown in Figures 1, 3, 4, 5 and 6, respectively.

East Lake Sammamish Basin

Distribution.—We found amphibians in every wetland surveyed in the East Lake Sammamish Basin (Appendix D). We also sighted all wetland breeding species identified in a thorough 10-year County-wide survey of 19 wetlands (Richter and Azous 1995). Of the 18 wetlands surveyed by volunteers, 17 (94%) had at least 1 native species. Six wetlands (33%) had populations of non-native bullfrogs; in East Lake Sammamish 12 (ELS12) the bullfrog was the only species found (Appendix D). The most widely distributed amphibian was the Pacific treefrog. It was found in 15 (83%) of the basin's surveyed wetlands. As expected because of the seasonality of our surveys, the least observed species were the western toad and rough-skinned newt, both of which were sighted at only two (11%) wetlands (Figure 12).

Population Trends.—Amphibian species were observed in our early surveys but not in later ones at seven wetlands within this basin (Table 1, Figures 1, 3-6). Specifically, red-legged frogs were seen at ELS18 in 1993 but not in 1996 or 1997. Also, northwestern salamanders were initially sighted at ELS40 and ELS90 but not during subsequent survey years. Finally, long-toed salamanders and Pacific treefrogs were seen at several wetlands in early surveys of the program but not during later surveys (Table 2).

At several wetlands we sighted juvenile and adult amphibians but not eggs (Table 1). For example, at ELS18 we found red-legged frogs, Pacific treefrogs and long-toed salamander subadults or adults but were unable to find their spawn. At several other wetlands (i.e., ELS9, 11, 28, 30 & 40) we either heard or saw Pacific treefrogs but never found their eggs (Appendix D, Table 1).

Amphibian Egg Mass Condition.—We found 10 of 18 (56%) wetlands within the East Lake Sammamish basin to have amphibian egg masses with impaired health. Significant mortality in red legged frog eggs was observed at ELS17 and ELS26. This represents 15% of the wetlands in this basin with breeding red-legged frogs (Table 3). We identified mortality in northwestern salamander eggs in ELS30, 34 and 38 representing 23% of the surveyed wetlands with breeding northwestern salamanders. A total of 27% of wetlands with breeding Pacific treefrogs also exhibited egg masses with dead and dying embryos. Finally, we found one wetland (ELS32) with long-toed salamander clutch mortality.

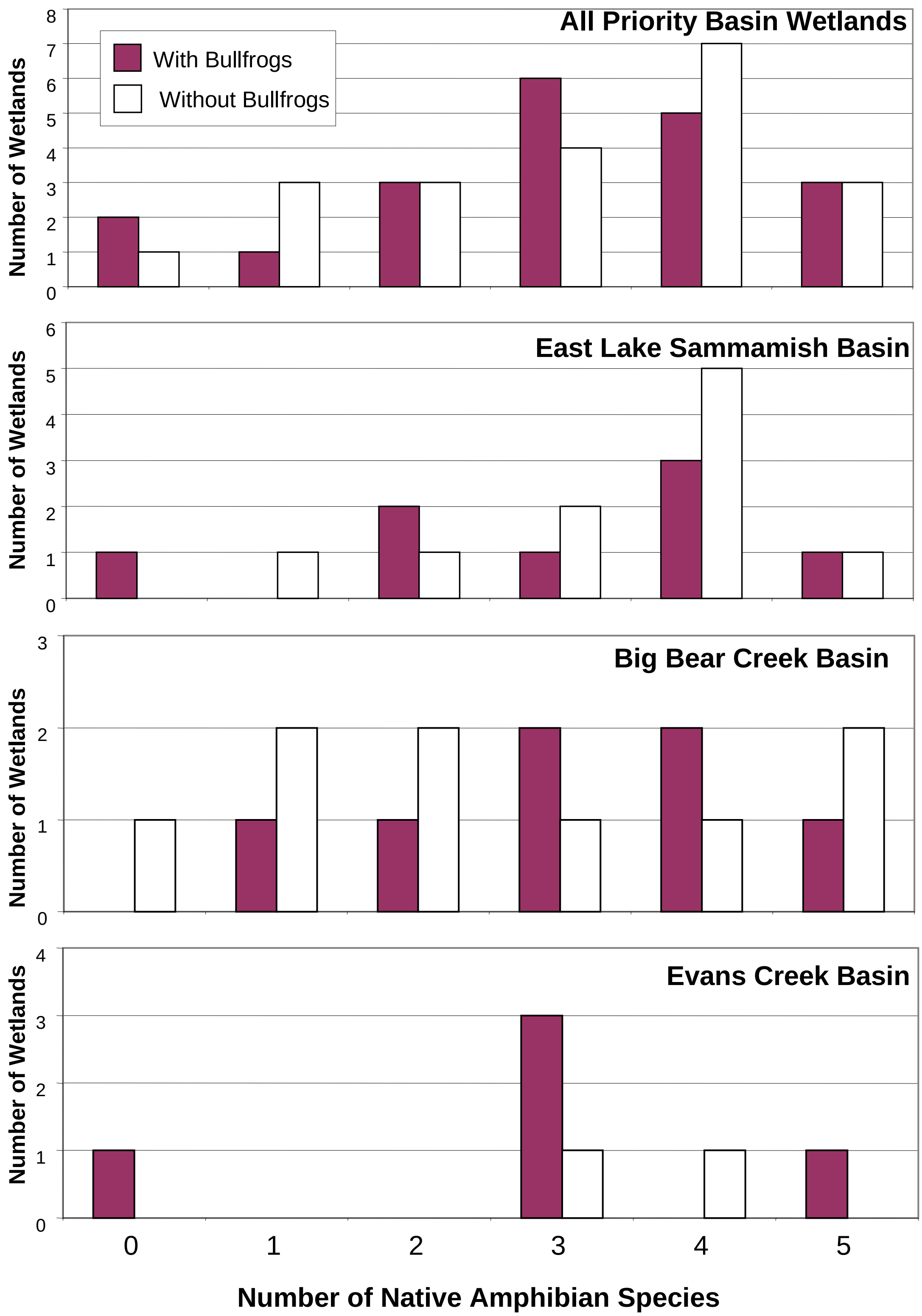

Figure 2. Native amphibian richness within priority basin wetlands with and without bullfrogs.

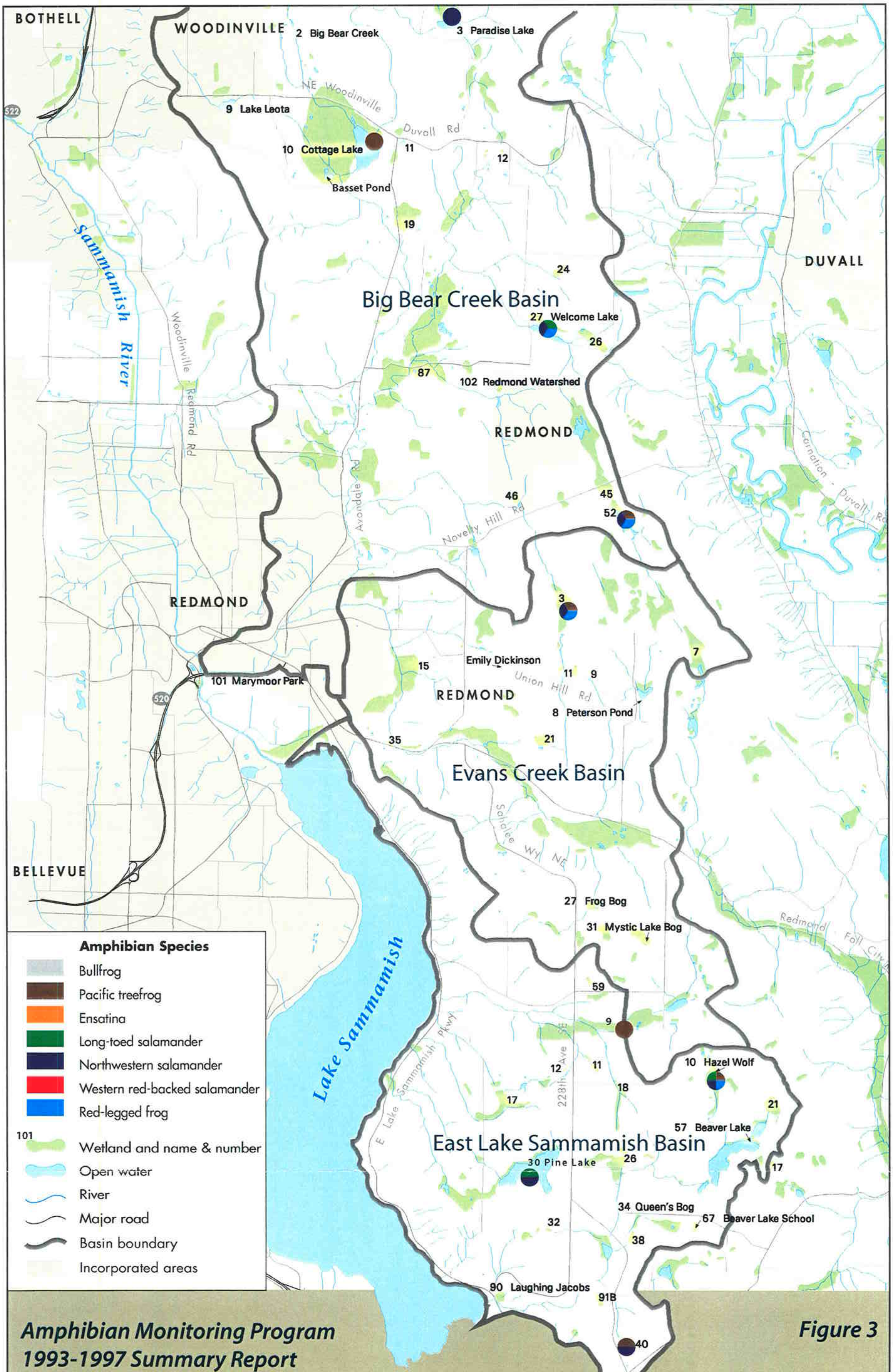

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Figure 3

1994 Distribution of Amphibians within Surveyed Wetlands
Priority Basins

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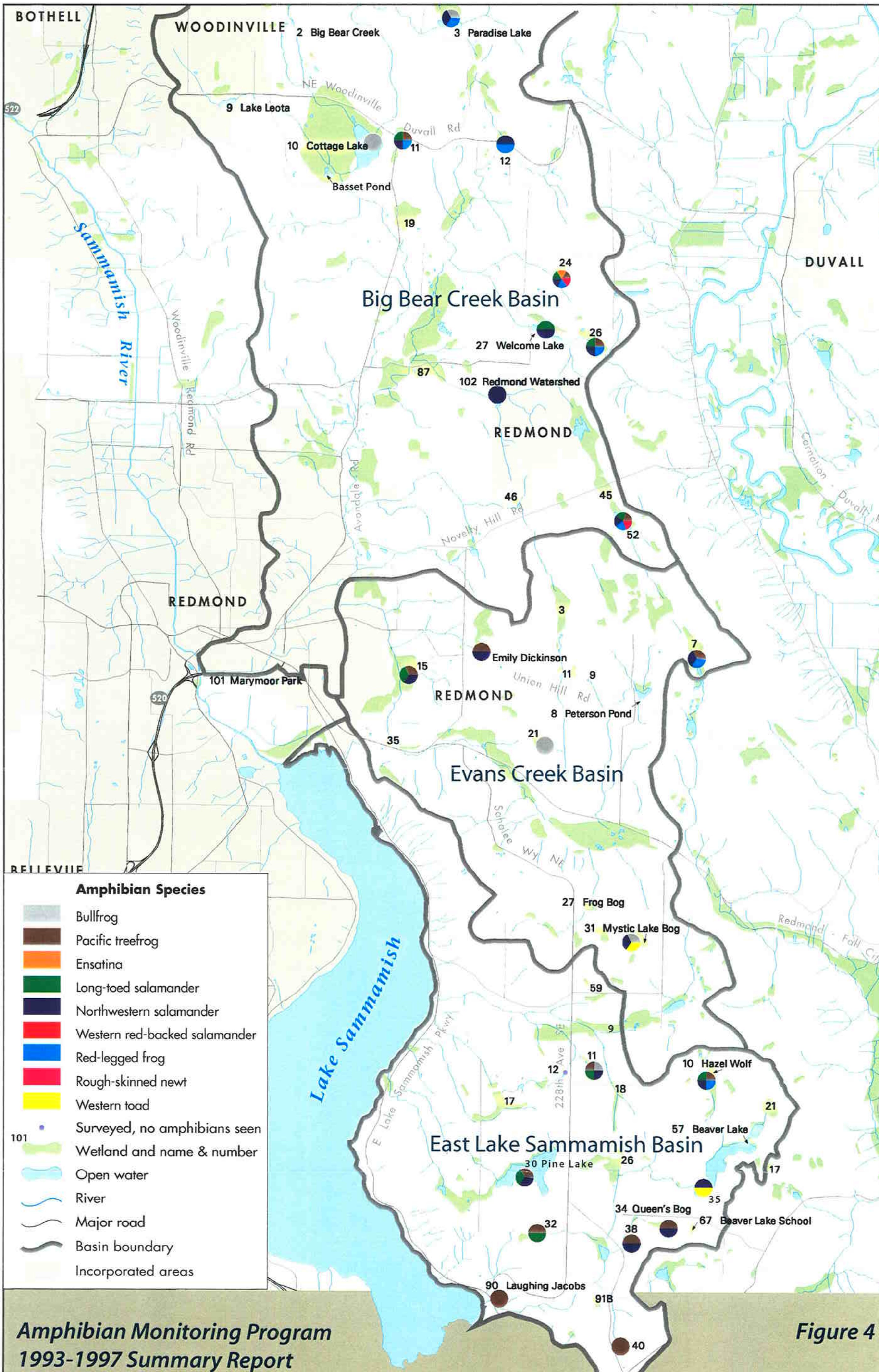

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Figure 4

1995 Distribution of Amphibians within Surveyed Wetlands
Priority Basins

KING COUNTY
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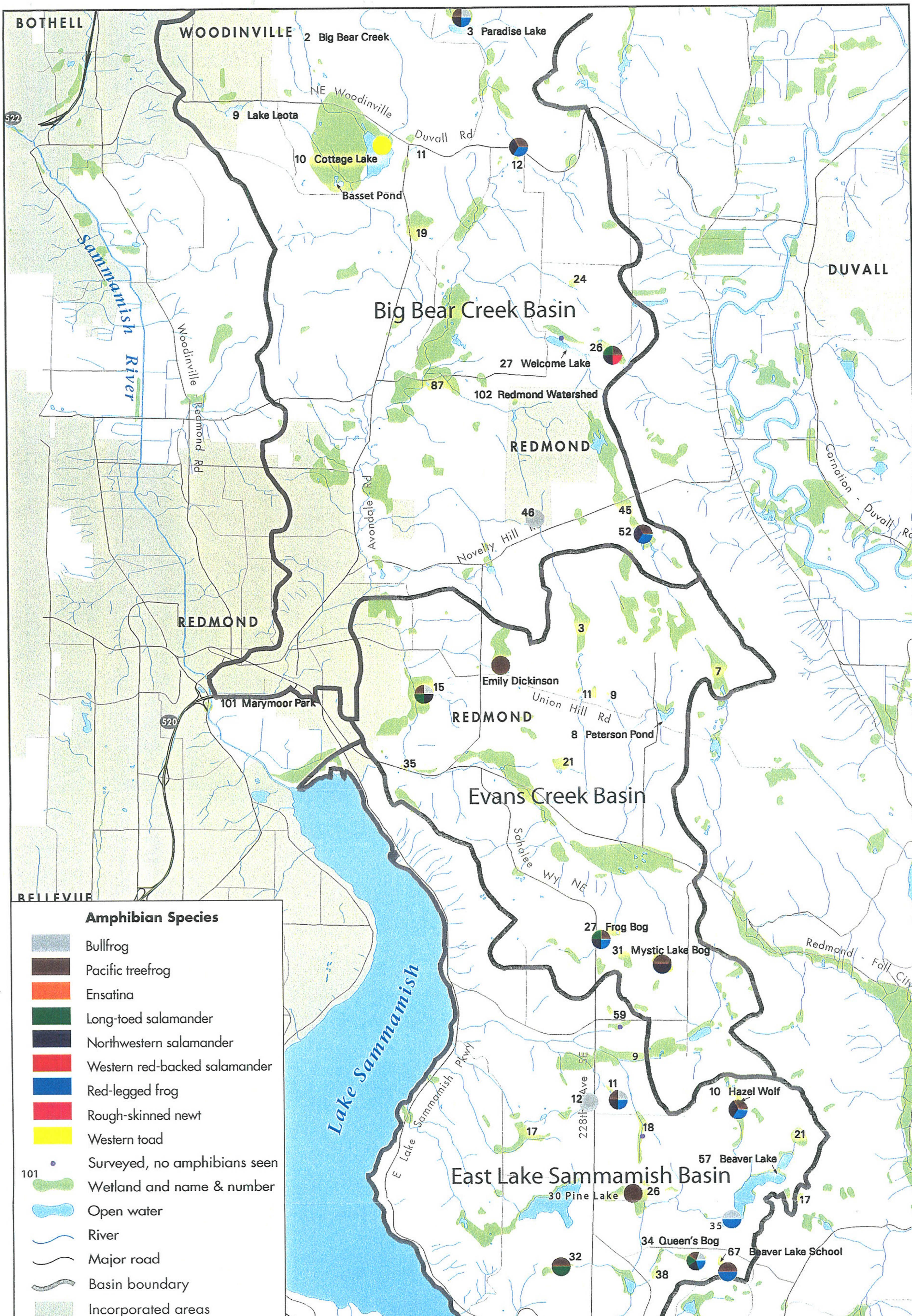

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Figure 5

1996 Distribution of Amphibians within Surveyed Wetlands Priority Basins

KING COUNTY
Department of Natural Resources

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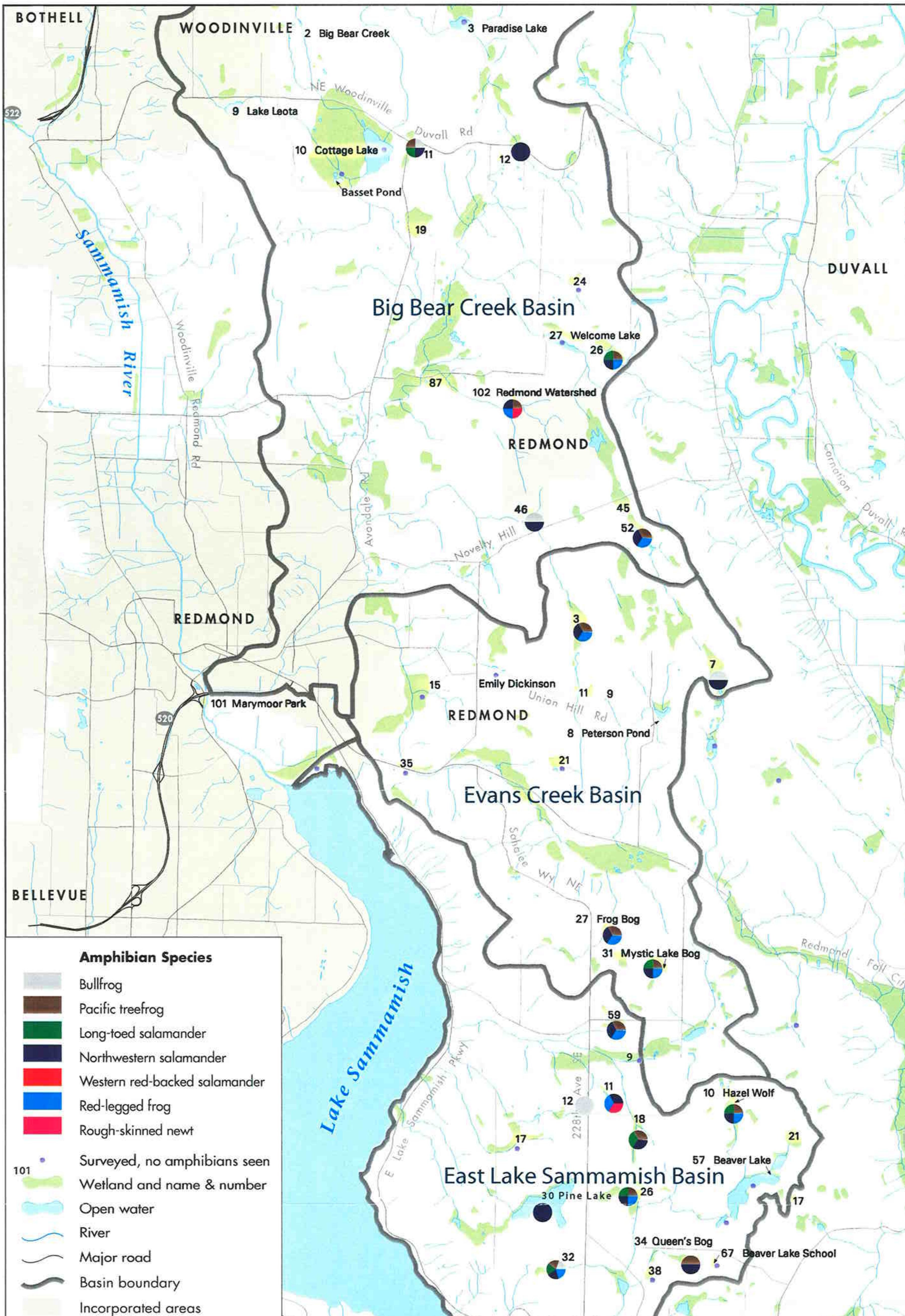

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Figure 6

1997 Distribution of Amphibians within Surveyed Wetlands
Priority Basins

KING COUNTY
Department of Natural Resources

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February, 1999

Big Bear Creek Basin

Distribution.—Of the 16 wetlands surveyed, 15 (94%) had populations of at least one amphibian species (Appendix D). We found five (31%) wetlands with bullfrogs. We identified Pacific treefrogs and northwestern salamanders as the most widely distributed amphibians, each being encountered in 12 (75%) of the surveyed wetlands (Figure 7).

Population Trends.—Red-legged frogs were sighted in 9 (56%) of the wetlands. At Big Bear Creek 11 (BBC11), BBC12 and BBC27 the results suggest declines for the survey period in red-legged frogs as determined from surveys of egg masses (Table 1). Specifically, we identified eggs in 1995 but not 1997 at BBC11, eggs in both 1995 and 1996 but not in 1997 in BBC12, and eggs during the 1994 survey but not the 1996 survey at BBC27 (Appendix D).

Although we sighted juvenile or adult red-legged frogs at BBC26, 87 and 102 during early survey years, we did not document breeding (i.e., eggs) within these wetlands during later years (Table 2, Figures 4-6).

Amphibian Egg Mass Condition.—We identified only two (BBC3 and 11) of the 16 (12%) wetlands with amphibians in this watershed basin to be characterized by spawn with significant mortality. Both red-legged frog and northwestern salamander egg health was impaired at BBC3, whereas only long-toed salamander spawn at BBC11 was impaired (Table 1). Nevertheless, these values represent 11, eight and 14 % of the wetlands surveyed in which red-legged frog, northwestern salamander and long-toed salamander, respectively, breed.

Evans Creek Basin

Distribution.—All but one wetland (Evans Creek 21, EC21) of the seven surveyed had native amphibians (Appendix D). Each wetland had at least three native species with the exception of EC21, which had only invasive bullfrogs. The rough-skinned newt was not sighted at any wetland. As expected, the most widely distributed species again were the Pacific treefrog and northwestern salamander, both of which were found in six (86%) of surveyed wetlands.

Population Trends.— EC7 may be exhibiting declining breeding because we found both red-legged and Pacific treefrogs breeding in early survey years but not later survey years (Table 2). At Marymoor Park, surveys indicate that long-toed salamanders and Pacific treefrogs are in decline, as were long-toed salamanders at Frog Bog (EC27). Also, we found Pacific treefrogs at EC3, and northwestern salamander and long-toed salamanders at EC101, but no eggs (Table 1). Northwestern salamander populations appear to be stable at all other wetlands in the Evans Creek watershed (Figures 3-6).

Amphibian Egg Mass Condition.—We found Pacific treefrog eggs with impaired health at only EC14, which represents 14% of total surveyed wetlands in this watershed with treefrogs (Table 3).

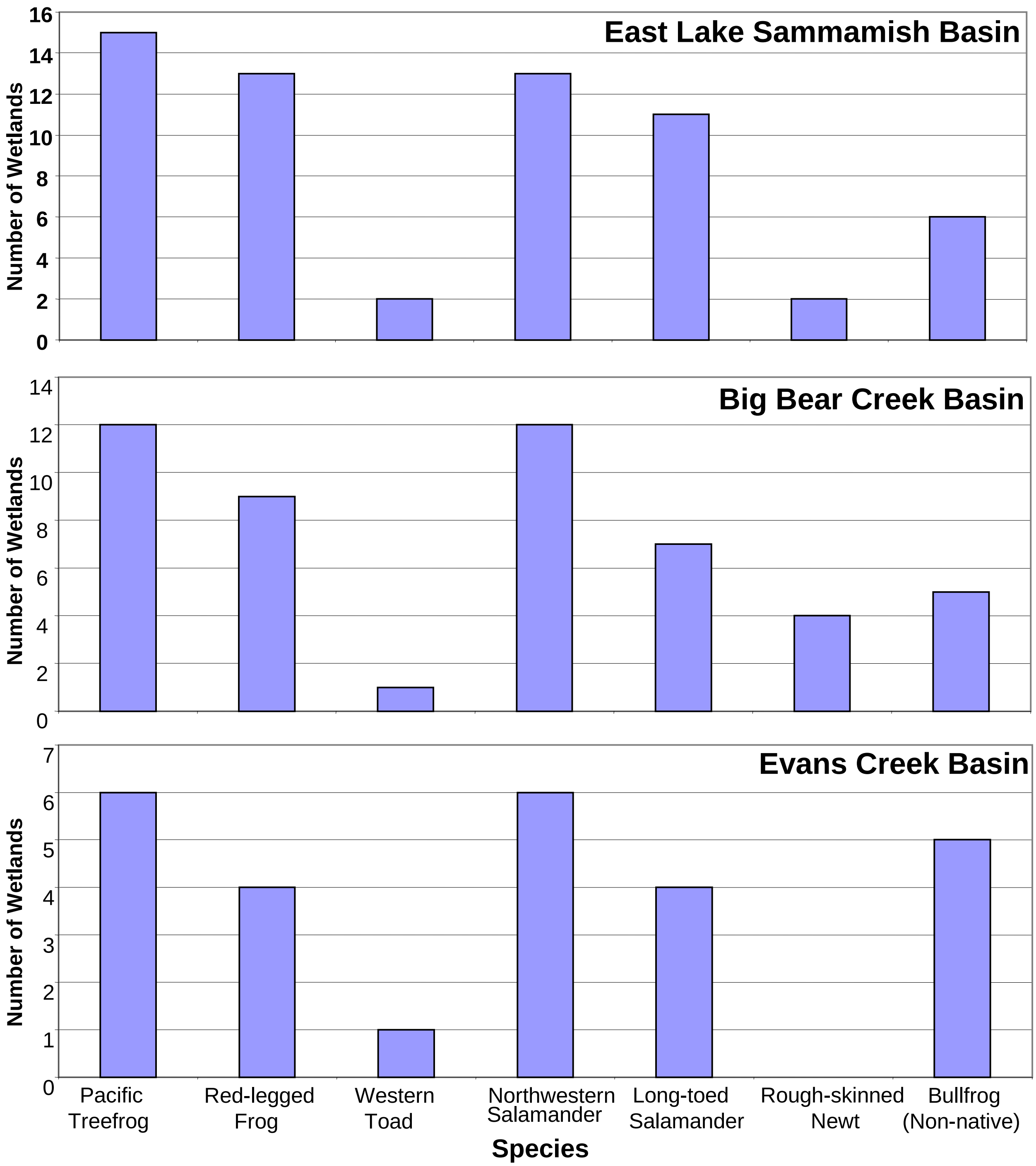


Figure 7. Summary of amphibian species richness in wetlands within priority basins.

Table 1. Wetlands and amphibian sightings of interest.
(PTFR = Pacific Treefrog, RLFR = Red-legged Frog, LTSA = Long-toed Salamander, NWSA = Northwestern Salamander).

Basin	Wetland Number and Species			
	Declining Breeding	**Adult Sightings, No Spawn**	**Inconsistent Sightings**	**Consistent Sightings**
East Lake Sammamish	11 – PTFR	9 – PTFR	11 – RLFR	10
	18 – RLFR	11 – PTFR	30 – PTFR	26
	30 – LTSA	18 – PTFR, LTSA, RLFR	34 – LTSA, RLFR	32
	35 – LTSA	28 – PTFR	59 – PTFR, NWSA, RLFR	
	40 – PTFR, NWSA	30 – PTFR	90 – PTFR, LTSA	
	59 – LTSA	40 – PTFR		
	90 – NWSA			
Total # ELS Wetlands	**7**	**6**	**5**	**3**
Big Bear Creek	10 – PTFR	24 – PTFR, LTSA		3
	11 – RLFR	26 – RLFR		24
	12 – PTFR, RLFR	45 – PTFR		46
	27 – LTSA, NWSA, RLFR	87 – LTSA		52
	52 – LTSA	101 – PTFR		87
		102 – PTFR, RLFR		102
				200
Total # BBC Wetlands	**5**	**6**	**0**	**7**
Evans Creek	7 – PTFR, RLFR	3 – PTFR		3
		7 – PTFR		15
		101 – LTSA, NWSA		27
				31
Total # EC Wetlands	**1**	**3**	**0**	**4**
Total # Wetlands	**13**	**15**	**5**	**14**

Table 2. Amphibian species detection trends in priority basins in wetlands surveyed more than two years.
(↑ = appeared; ↓ = disappeared; β = present in multiple survey years; blank = never detected)

Wetland	Amphibian species						
	Long-Toed Salamander	**Northwestern Salamander**	**Pacific Treefrog**	**Red-Legged Frog**	**Bullfrog**	**Western Toad**	**Rough-skinned Newt**
ELS 10	β	β	β	β			
ELS 11	↓	β	↓	↑	β		↑
ELS 12					↑		
ELS 18	β	↑	β	↓			
ELS 26	↑	↑	β	β			
ELS 30	↓	β	↓				
ELS 32	β	↑	β	β	↑		
ELS 34	↓	β	β		↓		
ELS 35		↓		↑	↑	↓	
ELS 40		↓	↓		↑		
ELS 59	↓	β	β	β			↓
ELS 90	β	↓	β	↑			
BBC 3		β	↓	↑	β		
BBC 10			↓		β	↑	
BBC 11	β	β	β	↓	↑		
BBC 12		β	↓	↓			
BBC 24	β	β	β	β	↑		↓
BBC 26	β	β	β	β			↓
BBC 27	↓	↓		↓	↑		
BBC 46		↑			β		
BBC 52	↓	β	β	β			↓
BBC 87	↓	β	β	β	β		
BBC 102		β	↑	↑			↑
BBC 200		↓	β				
Evans Creek 3		β	β	β			
Evans Creek 7		β	↓	↓	↑		
Evans Creek 15	β	β	β		↑		
Evans Creek 27	↓	β	β	β			
Evans Creek 31		β	↑	↑	↓	↓	
Evans Creek 101	↓	β	↓		↑		
Appeared	**1**	**4**	**2**	**6**	**10**	**1**	**2**
Disappeared	**9**	**5**	**8**	**5**	**2**	**2**	**4**
Same	**8**	**19**	**16**	**10**	**5**	**0**	**0**

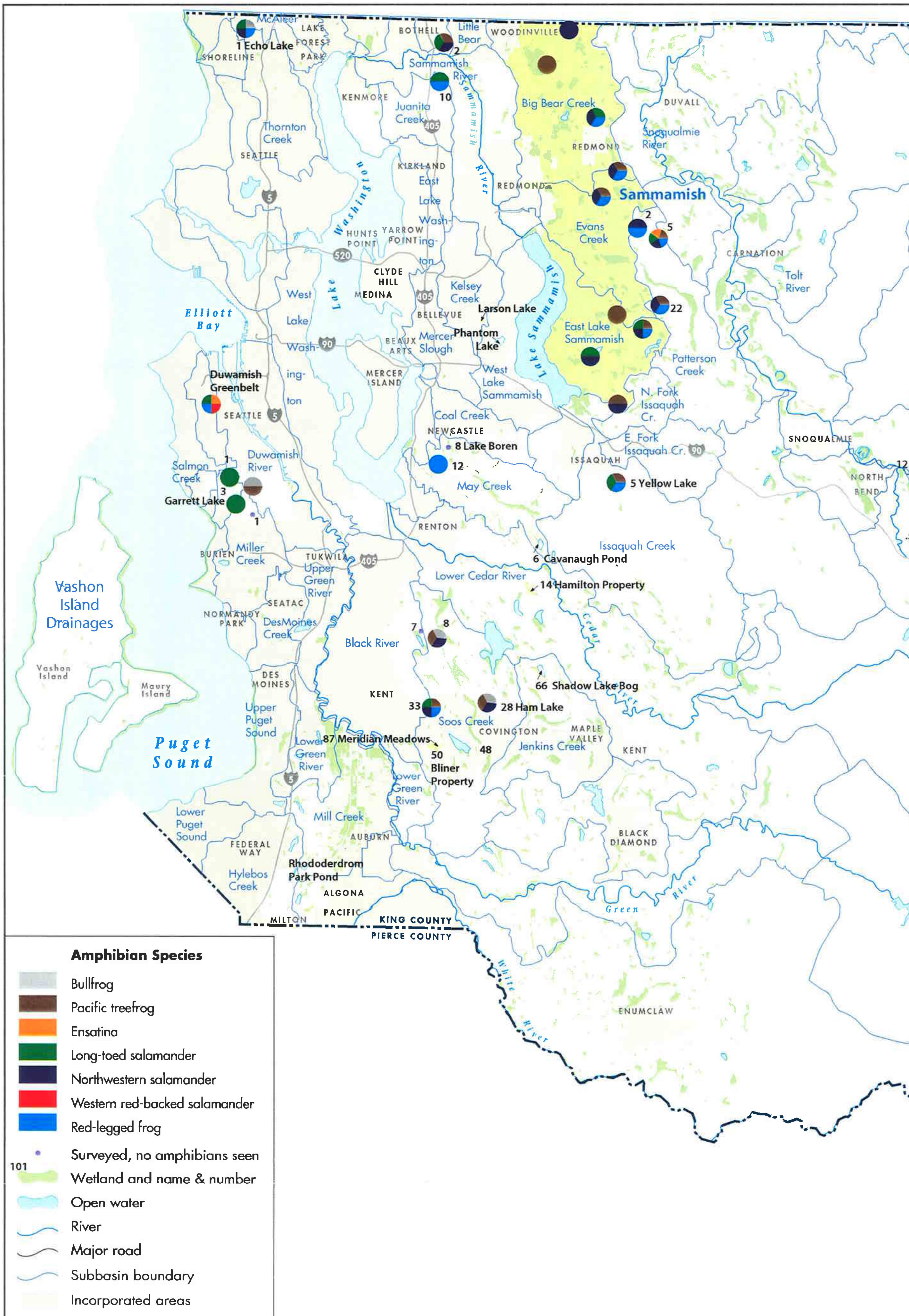
Table 3. Priority basin wetlands that exhibit greater than five percent of amphibian egg mortality. (Percentage value indicates the wetlands out of the total number of wetlands in the basin in which eggs of respective species were identified.) (PTFR = Pacific Treefrog, RLFR = Red-legged Frog, NWSA = Northwestern Salamander)

Basin	Wetland #	Species	# Wetlands Impaired per Basin	% of Total Wetlands w/ Impaired Eggs
East Lake Sammamish	17,26	RLFR	2	15
	30, 34, 38	NWSA	3	23
	32	LTSA	1	9
	10, 17, 26, 59	PTFR	4	27
Big Bear Creek	3	RLFR	1	11
	3	NWSA	1	8
	11	LTSA	1	14
Evans Creek	101	PTFR	1	14

DISTRIBUTIONS WITHIN GREATER KING COUNTY

We found up to five species of amphibian in the 38 wetlands surveyed outside the three priority basins in greater King County (Appendix E). Results for the years 1994, 1995, 1996 and 1997 are shown on Figures 8, 9, 10 and 11, respectively. Native species seen included the Pacific treefrog, red-legged frog, western toad, northwestern salamander, long-toed salamander, rough-skinned newt and western red-backed salamander. We also saw the non-native bullfrog in seven of the wetlands. Sightings of bullfrog, rough-skinned newt, western toad and western red-backed salamander were fortuitous given our goal of monitoring springtime wetland-breeding species. Of these, rough-skinned newts, western red-backed salamanders, and western toads were each seen at only one wetland.

Eleven wetlands (29%) had at least four amphibian species, 17 wetlands (45%) had at least three species, and 27 of the wetlands (71%) had at least two species (Figure 12).



Amphibian Monitoring Program 1993-1997 Summary Report — *Figure 8*

1994 Distribution of Amphibians within Surveyed Wetlands Greater King County

King County Department of Natural Resources

Produced by: Visual Communication and GIS Unit, Department of Natural Resources

File Name: 9901WKCAmphibianMap94.ai MD

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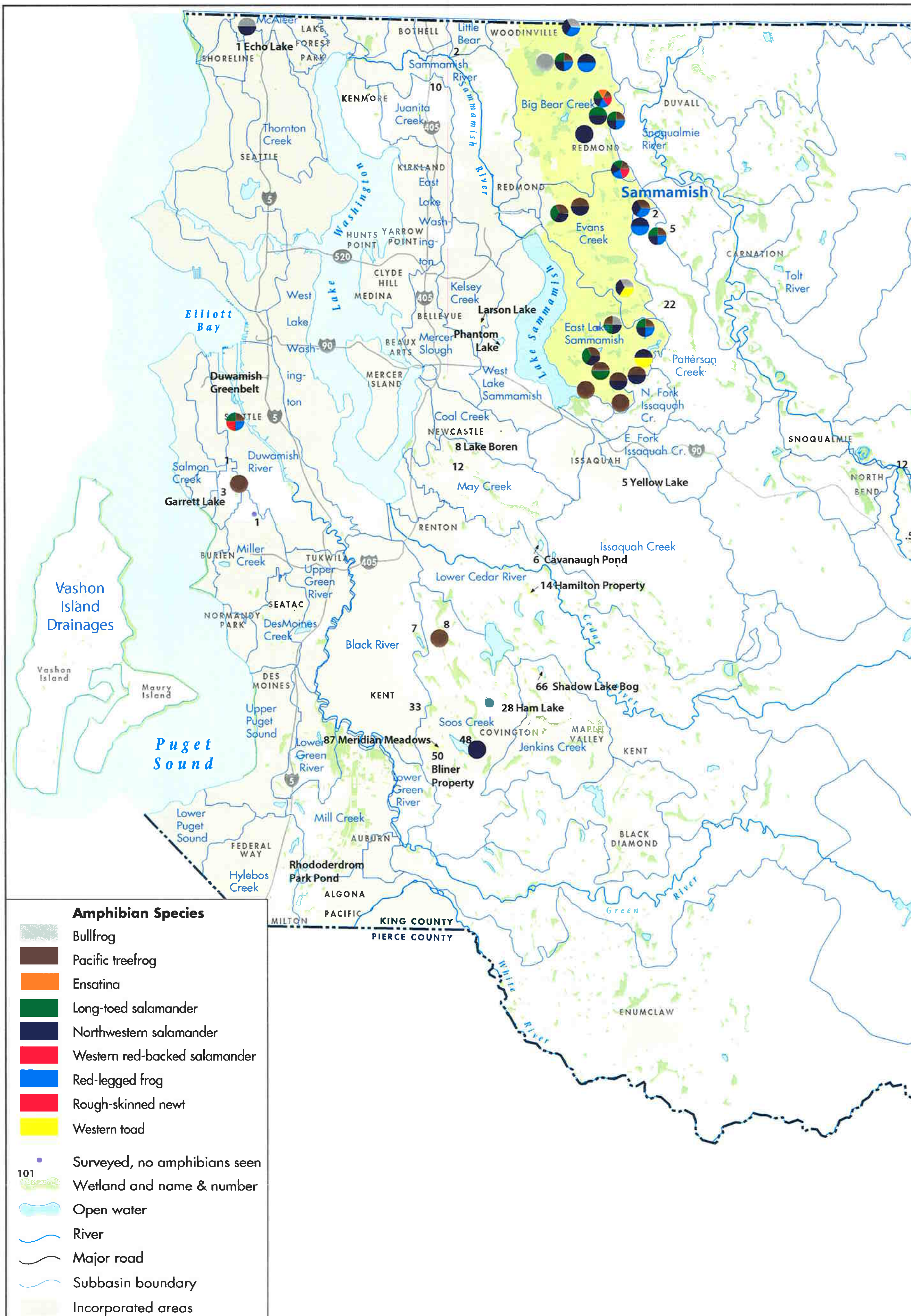
February, 1999



Amphibian Monitoring Program 1993-1997 Summary Report — *Figure 9*

1995 Distribution of Amphibians within Surveyed Wetlands Greater King County

KING COUNTY
Department of Natural Resources

Produced by: Visual Communication and GIS Unit, Department of Natural Resources

File Name: 9901WKCAmphibianMap95.ai MD

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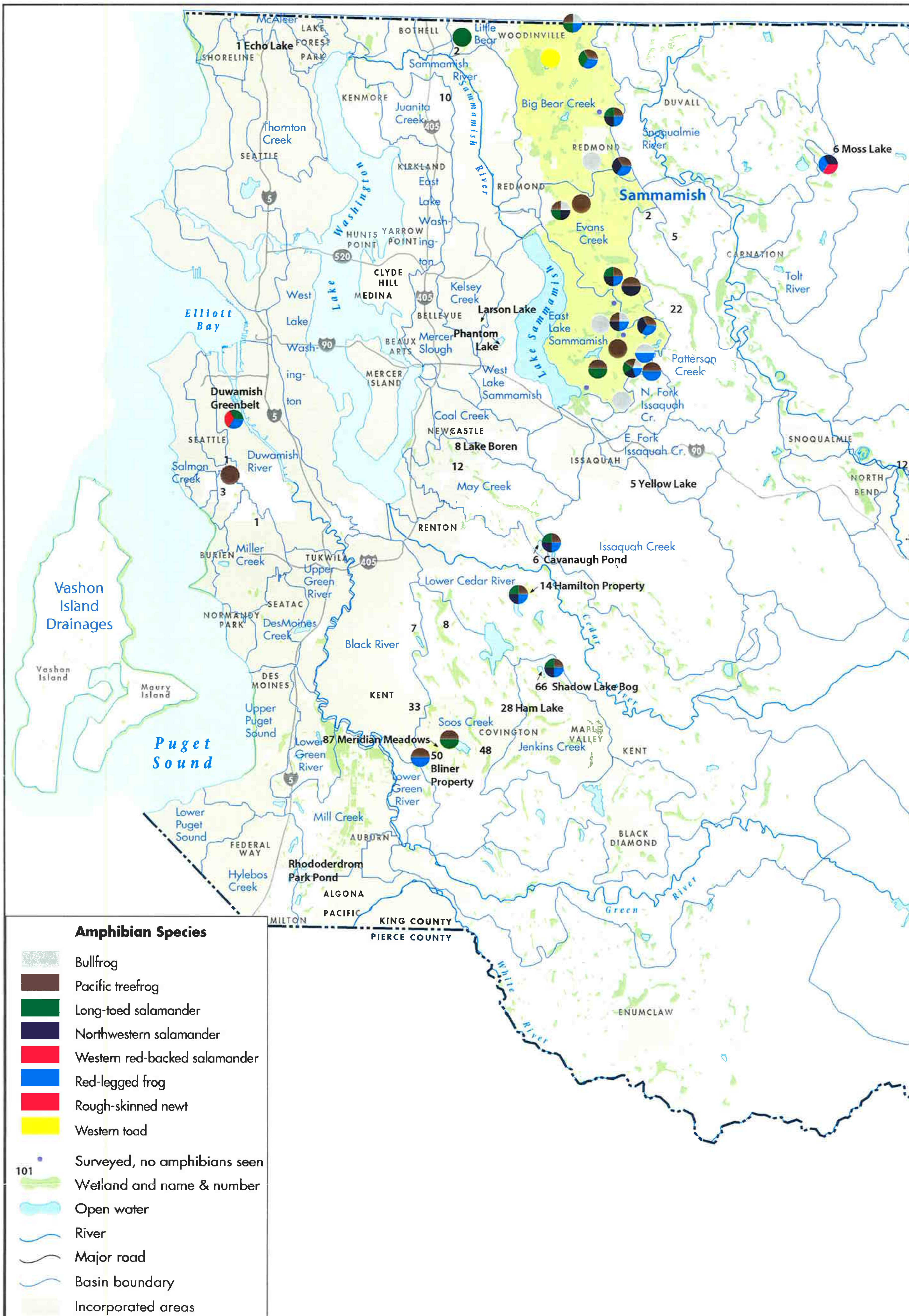

Amphibian Monitoring Program 1993-1997 Summary Report ***Figure 10***

1996 Distribution of Amphibians within Surveyed Wetlands Greater King County

King County Department of Natural Resources

Produced by: Visual Communication and GIS Unit, Department of Natural Resources

File Name: 9901WKCAmphibianMap96.ai MD

0 2 4 6 Miles

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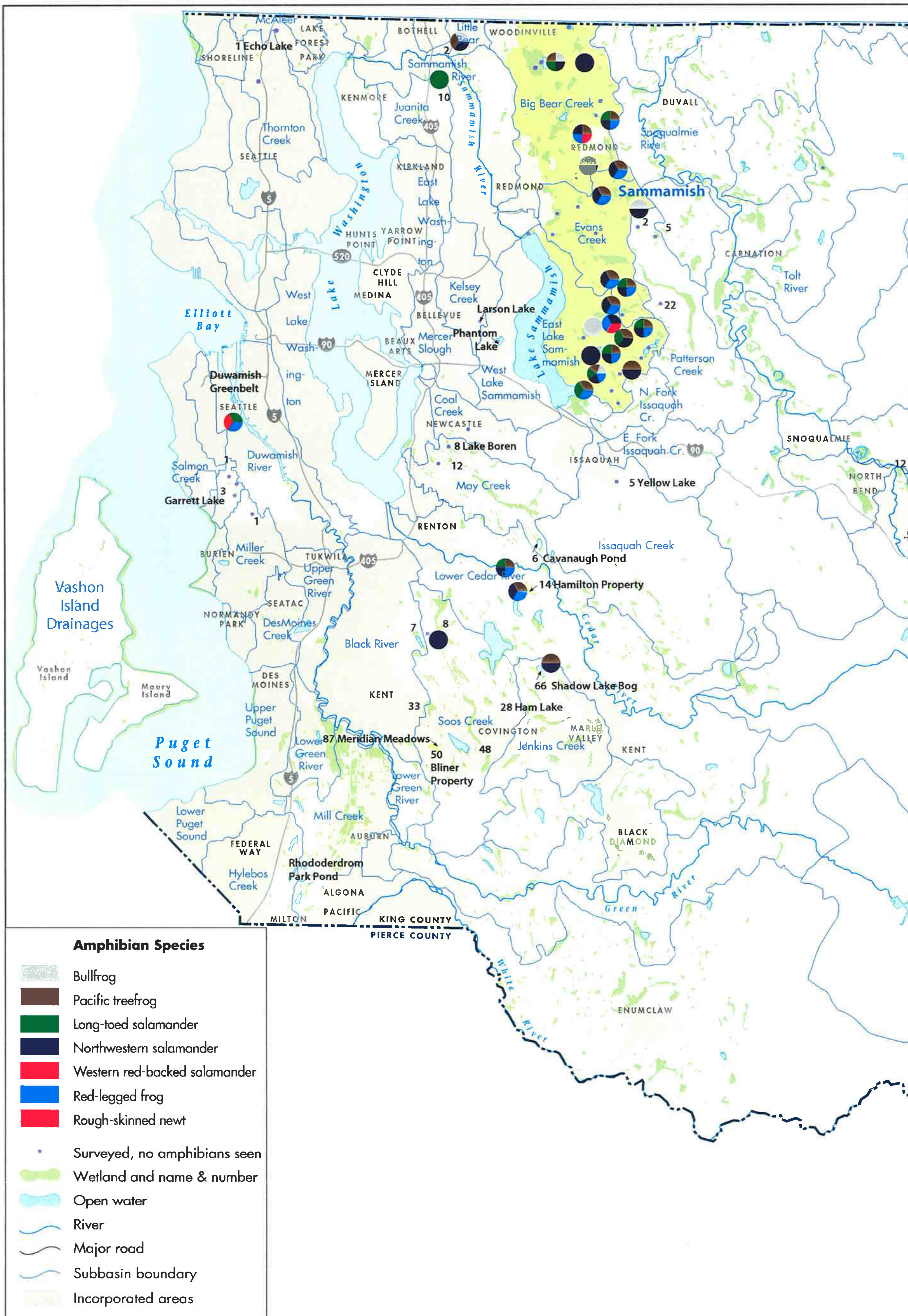
February, 1999



Amphibian Monitoring Program 1993-1997 Summary Report — *Figure 11*

1997 Distribution of Amphibians within Surveyed Wetlands
Greater King County

KING COUNTY
Department of Natural Resources

Produced by: Visual Communication and GIS Unit, Department of Natural Resources
File Name: 9901WKCAmphibianMap97.ai MD

N
0 2 4 6 Miles

February, 1999

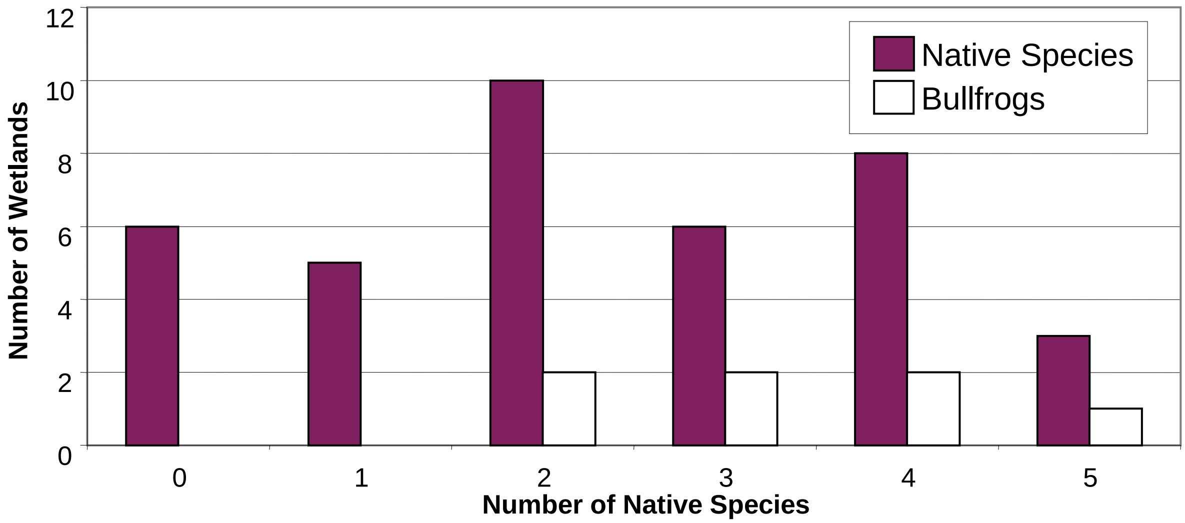


Figure 12. Amphibian species diversity in basins in greater King County.

Table 4 shows the number of wetlands and basins in which each species was observed; Figure 13 shows the percentage of wetlands and basins in which each species was observed. These surveys were focused on four native species (the Pacific treefrog, red-legged frog, northwestern salamander and long-toed salamander), results also focus on these species. Pacific treefrogs were the most abundant of all the

Table 4. Greater King County wetlands and amphibian species richness. (38 wetlands in 23 basins.)

Status	Species	# Wetlands	# Basins
Native Frogs/Toads:			
	Pacific Treefrog	23	16
	Red-legged Frog	20	15
	Western Toad	1	1
Native Salamanders/Newts:			
	Long-toed Salamander	16	13
	Northwestern Salamander	19	13
	Rough-skinned Newt	1	1
	Western Red-backed Salamander	1	1
Exotic Frogs/Toads:			
	Bullfrog	7	6
None:		6	4

species, found in 23 wetlands (61%) in 16 basins (70%). The least common of the four focus species was the long-toed salamander, which was seen at 16 wetlands (42%) in 13 basins (57%). The long-toed salamander also has the smallest egg masses of the four focus species, and often breeds very early in the season, before the beginning of the volunteer program. Consequently, it may not have been as readily detected as other species. The northwestern salamander was seen at half of the wetlands (19) in 13 of the watersheds (57%), and the red-legged frog was observed at 20 wetlands (53%) in 15 basins (65%). We did not observe amphibians at six of the 38 wetlands (16%), in four (17%) basins (Appendix E), including May Creek 8, Miller Creek 1, Sammamish River 52, Soos Creek 7, and South Fork Snoqualmie 3 and 4. Many of these wetlands were surveyed only once; they either appear to be lacking in suitable amphibian breeding habitat, or are surrounded by development, and lack suitable upland habitat.

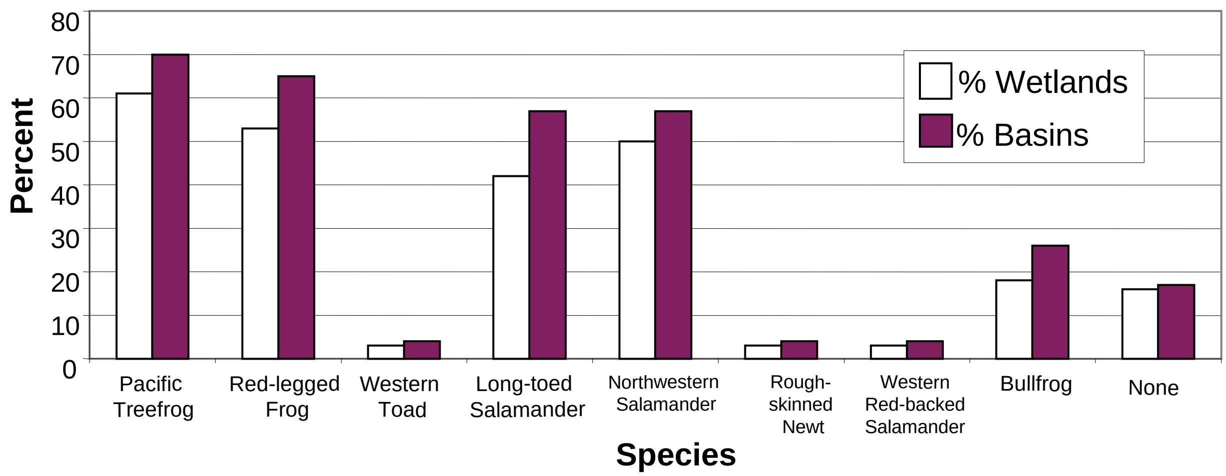


Figure 13. Amphibian species richness by percent within wetlands and basins in greater King County.

Bullfrogs were the only non-native species observed, and were seen in seven of the 38 wetlands (18%), and in six of the 23 watersheds (26%). Surveys specific to bullfrogs were not conducted; we suspect that many more of the wetlands have bullfrogs, because bullfrogs require perennial standing water for their larvae to develop. It appears that under normal conditions, 34 of the 38 wetlands have standing water year-round.

The presence of bullfrogs did not appear to affect the total number of species at a wetland. Their presence also did not appear to affect the presence of any particular species, although definitive results cannot be produced until surveys for bullfrogs are conducted in the early summer. The presence of permanent water did not correspond to native species diversity at a wetland. None of the seasonally ponded wetlands, however, had bullfrogs.

Population Trends.--- Of the 18 wetlands that were surveyed for two or more years in greater King County, six wetlands (33%) had no change in the number of amphibian species sighted between years. Two wetlands (11%) had an increase in the number of species observed, and ten wetlands (55%) had a decrease in the number of species observed. Figure 14 shows the number of amphibian species at each wetland surveyed more than one year for each year surveyed. At Ham Lake, we saw three species in 1994, but did not observe any during surveys in 1995.

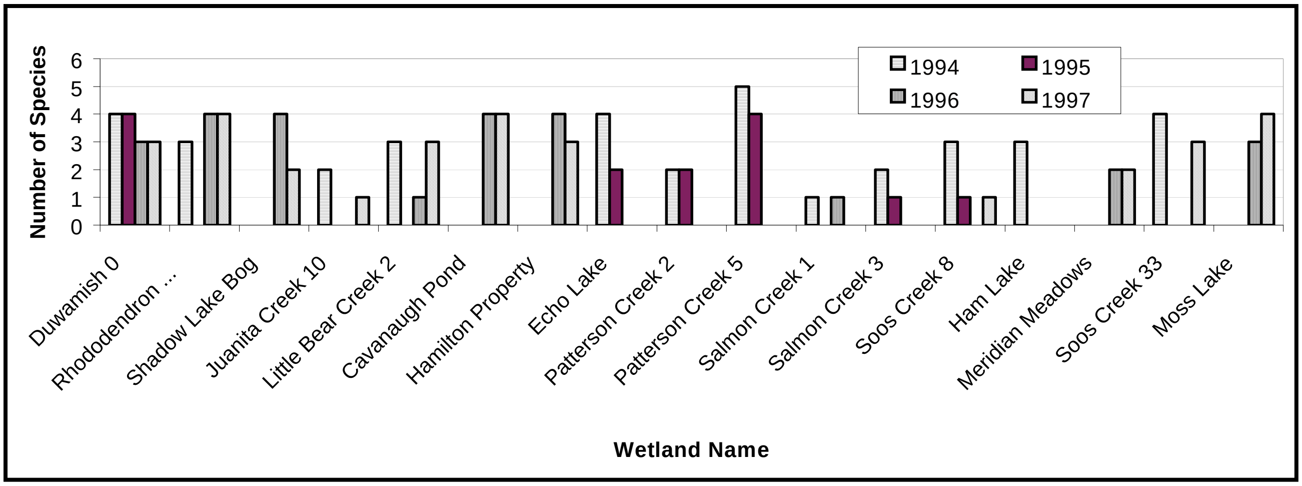


Figure 14. Number of amphibian species detected in each wetland surveyed a minimum of two years.

Individual species have had different patterns of presence or absence at the wetlands over the years. Changes in presence or absence were evaluated for each of the species found over the entire four-year survey period (Table 5). Northwestern salamanders have proved the most hardy, with their presence staying the same over the four years in 12 wetlands, and disappearing from only one wetland. Pacific treefrogs and red-legged frogs have been fairly consistently sighted, but are not doing quite as well. The treefrogs have remained present at eight wetlands, disappeared from three, and appeared at two wetlands over the survey years, while red-legged frogs have remained at seven wetlands and disappeared from three. Long-toed salamanders have done the most poorly, disappearing from six wetlands, remaining at five, and appearing at one.

These declines may be due to species' sensitivity to environmental stresses, the timing of censuses, changes in climate between the years, or, in the case of the long-toed salamander, because the eggs are among the most difficult to find. Most of these wetlands had the same observers going back during the same time of year for repeat surveys, so our observations were consistent. Moreover, spring weather conditions were similar during these survey years; these factors are not considered to account for observed declines.

According to survey results, the non-native bullfrog disappeared from three wetlands, appeared at two, and remained at one. However, because surveys were not conducted during the bullfrog's active breeding season, it is assumed that bullfrogs remain at each of these wetlands. Similarly, the western toad disappeared at one wetland, but surveys were conducted prior to its breeding season. The western red-backed salamander remained at the Duwamish wetland over all four years of surveys, and was in fact found under the same log.

Table 5. Amphibian detection trends in basins of greater King County.
(↑ = appeared; ↓ = disappeared; β = present in multiple survey years; blank = never detected)

Wetland	Amphibian Species						
	Long-Toed Salamander	Northwestern Salamander	Pacific Treefrog	Red-Legged Frog	Bullfrog	Western Toad	Western Red-Backed Salamander
Duwamish 0	β		↓	β			β
Rhody Pond	↑	β	β	β			
Shadow Lk Bog	↓	β	β	↓			
Juanita Cr. 10	β			↓			
LBC 2	↓	β	β		↑		
Cavanaugh Pond	β	β	β	β			
Hamilton	↓	β	β	β			
Echo Lake	↓	β		↓	β		
Miller Cr 1							
PC 2		β		β			
PC 5	β	β	β	β			
Salmon Cr 1	↓		↑				
Salmon Cr 3			β		↓		
Soos 8		β	↓		↓		
Soos 28		↓	↓		↓		
Soos 33	↓	β	β	β			
Meridian Meadows	β	β					
Tolt 6 (Moss Lk)		β	↑		↑	↓	
Appeared	**1**	**0**	**2**	**0**	**2**	**0**	**0**
Disappeared	**6**	**1**	**3**	**3**	**3**	**1**	**0**
Same	**5**	**12**	**8**	**7**	**1**	**0**	**1**

Amphibian Egg Mass Health.---Wetlands with significant egg mortality in the basins of greater King County are listed in Table 6. For three of the four years the Duwamish wetland was surveyed, there has been red-legged frog and long-toed salamander mortality. Northwestern salamander eggs have been subject to mortality at several wetlands, including Little Bear Creek 2, SF Snoqualmie 5, and Snoqualmie River 37. Dead Pacific treefrog eggs were found at LBC2 and Ham Lake (Soos Creek 28).

Table 6. Wetlands with amphibians experiencing egg mortality in greater King County. (LTSA = long-toed salamander; PATR = Pacific treefrog; NWSA = northwestern salamander; RLFR = red-legged frog).

Wetland	Species	# Years Surveyed	# Years Mortality
Duwamish 0	RLFR	4	3
	LTSA	4	3
Little Bear Creek 2	PATR	3	1
	NWSA	3	2
Soos Cr. 28 – Ham Lake	PATR	2	1
SF Snoqualmie 5	NWSA	1	1
Snoqualmie River 37	NWSA	1	1

QUALITY ASSURANCE/QUALITY CONTROL

We initiated an on-site Data Quality Assurance/Quality Control (QA/QC) program in 1996. During mid-spring adult and egg surveys, volunteers identified all of the species confirmed by us to be present from dip-net surveys on May 14 at ELS26 and Soos Creek 87 (Table 7). Dip-netting in fact did not detect one species that was seen by volunteers; the long-toed salamander at ELS26. This may have been either because long-toed salamander larvae were misidentified as northwestern salamander larvae (the two salamanders have a very similar larval form), or because very few salamander larvae were captured in dip-nets.

Table 7. Quality Assurance/Quality Control data from two wetlands in the volunteer Amphibian Breeding Survey Program in 1997. (**V** = species seen by volunteer; **S** = species seen by staff)

Species	East Lake Sammamish 26	Soos Creek 87
Long-toed Salamander	**V**	**V S**
Pacific Treefrog	**V S**	**V S**
Northwestern Salamander	**V S**	n/a
Red-legged Frog	**V S**	n/a

POPULATION TRENDS, ALL WETLANDS

The bullfrog had by far the largest increase in number of wetlands in which it was found, possibly a function of when we conducted our bullfrog surveys. Our breeding surveys were conducted in early spring, before the onset of the bullfrog breeding season, and we surveyed specifically for bullfrogs only in 1996.

According to the survey results, the long-toed salamander appears to be the most sensitive to disturbance, discontinuing breeding at 15 wetlands, or half of those in which it was formerly seen (Table 8). However, other factors may be that they are less detectable than other species using our survey method, and timing; our surveys may occur after the long-toed salamanders breed. The Pacific treefrog was also missing from 11 wetlands (28%) it formerly occupied. The northwestern salamander was the most stable amphibian, remaining at 31 wetlands (61%), and not found at only six (15%) it had formerly occupied. The red-legged frog was stable at approximately half (55%) of its wetlands, and was not seen at eight (26%).

Table 8. Summary of amphibian population trends in all wetlands surveyed more than two years.

Presence Trend – All Wetlands	Number of Wetlands							
	Bullfrog	Long-Toed Salamander	Northwestern Salamander	Pacific Treefrog	Red-Legged Frog	Rough-skinned Newt	Western Toad	Western Red-Backed Salamander
Appeared	12	2	4	4	6	2	1	0
Disappeared	5	15	6	11	8	4	3	0
Same	6	13	31	24	17	0	0	1
Total # Wetlands	23	30	41	39	31	6	4	1

DISCUSSION

Volunteer participation in environmental monitoring is becoming increasingly important in providing information to public agencies with multiple demands and tight budgets. While our impacts on the environment continue to increase with growth and development, our ability to monitor changes has been diminished because of the effort and expense required to assess complex interactive environmental changes. This program demonstrates that volunteer participation significantly contributes valuable information to resource agencies for environmental planning and impact assessment.

Since its inception in 1993, the Amphibian Monitoring Program has become one of the most successful volunteer education programs offered by King County. Citizen volunteers from all over the County have been eager to participate in the workshops. Specifically, to monitor amphibians in order to learn about their ecology, distribution and health, and also to assess the wetland conditions in which they live. Nevertheless, participation in our program was limited by qualified staff, program preparation, teaching time, available facilities, and our goal of providing a “hands-on-program” with a field monitoring component that minimizes wetland disturbance. Volunteers representing federal agencies, other counties, cities, private consulting firms, parks departments, local zoos, schools, and youth groups all participated in the program and educated their constituents.

This program has trained volunteers in the identification of amphibians and their eggs, increased the awareness of the ecological significance of amphibians in wetland ecosystems and demonstrated the role of amphibians as biological indicators of wetland and watershed health. Concurrently, field reports returned by volunteers have been invaluable to King County in establishing the distribution and abundance of amphibians in rapidly developing landscapes. These reports also provide the only regularly gathered survey data on the status of amphibians and select wetland conditions in urbanizing King County. For the first time, we have up-to-date field data on the actual distribution, relative abundance and health of amphibian populations as well as information on wetland vegetation, water characteristics and other habitat factors. Moreover, regularly gathered data is providing us with information on changing amphibian and wetland conditions from which we are able to determine whether our land use activities, policies and regulations are consistent with our goals of wetland protection and responsible development.

The seven wetland breeding species of amphibians observed by volunteers are consistent with the seven species found during 10-year intensive surveys of 19 wetlands throughout King County using multiple census techniques (Richter and Azous 1995). Volunteers usually did not detect western toads or bullfrogs during early spring surveys, consequently the presence of these species was determined from additional surveys in late spring and summer. Our surveys document the presence of amphibian species at wetlands but do not necessarily indicate the absence of others. Hence, there may be more species at monitored wetlands than identified, although it is suspected their numbers may be low. For example, our monitoring program has not documented the presence of the Oregon spotted frog. This is unfortunate in light of the facts that the lower Puget Sound basin of King County encompassed the range of this species, which is currently listed as endangered in Washington state, and is being considered for listing by the U. S. Fish and Wildlife Service as a federally endangered species. Many wetlands providing potential habitat for this species remain unsurveyed and may yet contain isolated populations of this species.

Our surveys suggest that the overall environmental health of some wetlands or their watersheds may be impaired whereas others remain in relatively good condition. For example, with all other wetland characteristics being equal, wetlands in the Evans Creek watershed basin may be considered impaired as determined by the high number of wetlands with bullfrogs - a non-native species generally associated with eutrophic water conditions. The East Lake Sammamish wetlands exhibited relatively high numbers of impaired eggs, suggesting that changes in hydrology, water quality, or other factors, may be impacting these wetlands.

Outside the three priority watersheds there have also been signs of impaired amphibian health. Six (16%) wetlands of the 38 had no amphibians. Although these may not historically have had amphibians, it is interesting to note these wetlands were generally in the most urbanized areas, where lack of upland habitat, the proximity of pets, wetland hydrology, and water quality may limit amphibians. Over half of the surveyed wetlands in greater King County had decreases in the number of species over two or more survey years. All four of the most widespread species (northwestern salamander, long-toed salamander, Pacific treefrog and red-legged frog) apparently declined in at least one wetland. Significant numbers of red-legged frog and long-toed salamander eggs were seen dead in three of four survey years at the Duwamish Greenbelt wetland, perhaps a result of water quality impairment. Finally, sightings of philopatric (returning to natal wetlands) native adult amphibians at a wetland but no eggs (as described above) suggest a population may be in decline, possibly attributable to either changing hydrology or water quality condition. Impaired wetlands also include sites in which early baseline surveys found amphibians spawning but subsequent surveys found no sign of spawning, and surveyors found amphibians but no eggs. Thus, adult red-legged frogs in the absence of eggs at BBC26 and BBC102 may signify changes in the hydrodynamics (e.g., current velocity) hydrology (depth, duration or frequency of flooding), water quality (increasing sediment and deteriorating chemistry) or vegetation community (colonization by aggressive cattail) of these wetlands. The hypothesized causes of these findings need to be identified and verified through additional work so that steps can be taken to prevent the further decline of amphibians and wetland health.

Sightings of damaged and dead eggs also may indicate impaired wetland condition. Our surveys suggest that many amphibian egg masses are characterized by a small amount (<5% of total eggs) of mortality but that dead eggs and dying embryos exceeding this value may be attributable to changes to wetland water level fluctuations exposing eggs to freezing and desiccation, poor water quality resulting in attacks by fungi and disease, or by a combination of physical and biological stressors associated with other changes in wetland condition. Alternatively, observations of sterile eggs may indicate amphibian infertility attributable to adult condition, water quality or watershed land use activities.

Some wetlands showed both increasing and decreasing sightings of adults and eggs in certain years but not others. Such fluctuating observations may be an indication of stochastic processes including winter mortality and inconsistent breeding attributable to weather, such as flooding, drought or other climatic phenomenon. Alternately, such findings may be attributable to habitat changes and land use activities away from wetlands within the greater watershed. These findings may also reflect variations resulting from the weather on the days surveys were conducted and/or survey timing relative to the timing of breeding. Only further monitoring and analysis will help us clarify the cause of these findings.

Wetlands are essential to the health of streams and groundwater, which in turn provide habitat for salmon and drinking water for communities. Since amphibians are responsive to wetland changes, monitoring wetland amphibians provides us with information on wetland health and the potential status of streams and groundwater. Such information may be especially valuable in the preparation of a Puget Sound Salmon Habitat Conservation Plan in response to the potential listing of chinook salmon and bulltrout under the Endangered Species Act. Clearly, wetland hydrology, water quality, vegetation and other conditions that influence amphibian populations also impact fish. However, amphibians are easier to monitor, and because they breed in wetlands, may provide an early warning system for detrimental impacts to streams and lakes.

This program is already making valuable contributions to County planning activities. Amphibian surveys, in conjunction with hydrologic and wetland habitat descriptions at Lower Cedar River 14 (the Hamilton Property) by Ray Griffin and Stan Haralson continues to be instrumental in environmental review and site restoration strategies for this recently purchased County property. Ongoing amphibian sightings there have documented a wide diversity of wildlife and resulted in additional lands being considered for purchase. Survey data collected by Rita Bailie, Linda Bartlett, Marianne Earl and John Giordenango at Jenkins Creek 66 (Shadow Lake Bog) was instrumental in the recent construction of an amphibian breeding pond and the restoration of upland wildlife habitat. Similarly, amphibian data collected by Mary Roberts and Carol Beach at Weyerhaeuser Company's Rhododendron Species Garden Pond is providing guidelines for pond maintenance and fountain construction. Finally, amphibian data collected by Dave Johnson, Doug Weber and Andy Solberg at Paradise Lake, Bassett Pond, and BBC12, and by Tom Bosakowski, Linda Storm, Paul Bannick and Laura Thel at BBC87 has been used by the Waterways 2000 program to develop management plans for these sites.

Despite these initial benefits, this program is still only beginning to provide rigorous, scientifically-defensible population and amphibian health trend information. Our review of field notes, familiarity with many of the wetlands and our QA/QC results suggest that our volunteer data is reliable and that our early findings are highly valuable for some planning purposes.

RECOMMENDATIONS

This program has been invaluable in educating citizens of the County regarding the importance of amphibians as wetland biota and as indicators of wetland health. The following are recommendations based on the information provided by the Amphibian Monitoring Program.

Program Information

- Print and distribute report of amphibian monitoring program to participants as acknowledgment and appreciation of their participation and to demonstrate how their information is compiled, analyzed and used for environmental planning.
- Distribute report to County watershed stewards, planners, ecologists and regulators, and state agencies (Department of Ecology and WDFW) for immediate use, and meet with them directly to brief them on its highlights.
- Enter report information (e.g., wetland characteristics, amphibian distribution, amphibian health) into King County's Computerized Sensitive Area database and make it available to all County employees.
- Enter maps and selected amphibian data into a King County Web Page for use by County employees, interested citizens, students, other agencies, etc. Provide annual updates to the web page from yearly surveys.
- Analyze distribution, abundance and health of amphibian data in context of wetland condition, watershed land uses and development activities.
- Determine cause(s) of wetland impairment at wetlands where amphibian richness is declining, adults no longer breed, and egg mortality is high.
- Investigate the relationship between wetland and amphibian condition to associated stream and salmonid condition.

Monitoring Program

- Continue yearly volunteer surveys to document changes in distribution and abundance of amphibians and wetland conditions, focusing on previously surveyed wetlands.
- Develop and implement a rigorous quality assurance quality control component to the program.
- Adjust survey schedules to increase the chances of seeing target species (i.e., earlier for long-toed salamander sightings, and May and June to see western toads and bullfrogs).
- Apply program to other rapidly changing County basins.
- Survey for the cause of amphibian population and health declines at wetlands identified as exhibiting significant changes (Table 1, Table 3, Table 5 and Table 6). Specifically determine if differences are attributable to inadequate County environmental regulations and policies or caused by other factors.
- Investigate the ability to which our amphibian and wetland data serves as an indicator or early warning system of stream deterioration, salmonid survival and watershed health by comparing our amphibian findings to Benthic Index of Biotic Integrity scores and salmon spawning survey results.

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