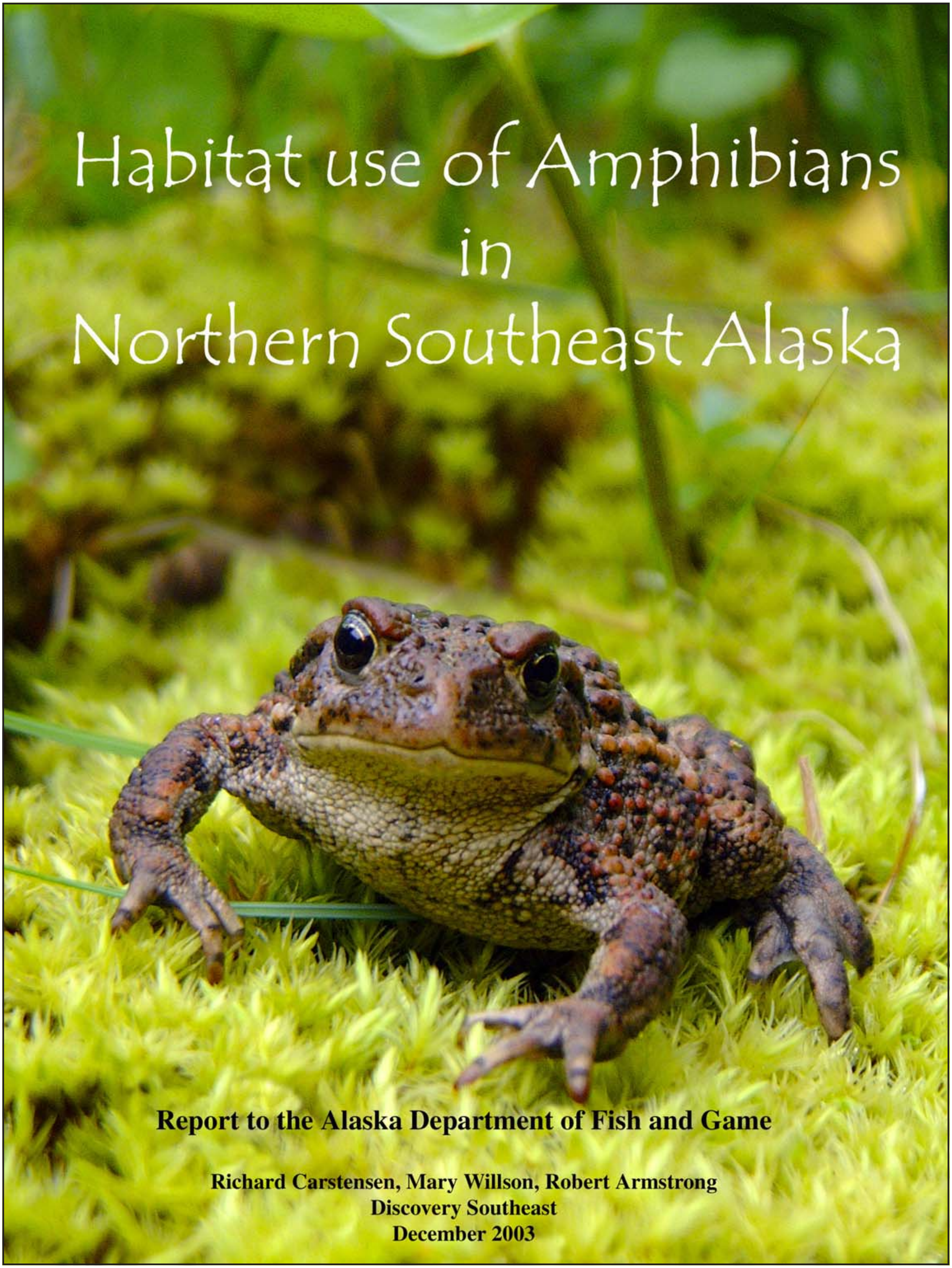

Habitat use of Amphibians in Northern Southeast Alaska

Report to the Alaska Department of Fish and Game

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Discovery Southeast
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Discovery Southeast

Founded in 1989 in Juneau and serving communities throughout Southeast Alaska, Discovery Southeast is a nonprofit organization that promotes direct, hands-on learning from nature through natural science and outdoor education programs for youth and adults, students and teachers. Discovery Southeast naturalists aim to deepen the bonds between people and nature.

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Contents

Introduction

Southeast Alaska's amphibians Six species of amphibian are considered native to Southeast Alaska. The three known anurans are western toad* (*Bufo boreas*), wood frog (*Rana sylvatica*), and Columbia spotted frog (*R. luteiventris*). Three known urodeles are rough-skinned newt (*Taricha granulosa*), long-toed salamander (*Ambystoma macrodactylum*) and northwestern salamander (*A. gracile*). In addition to these native species, two frogs from the Pacific Northwest have been introduced: Pacific chorus frog (*Pseudacris regilla*, formerly *Hyla regilla*) and red-legged frog (*Rana aurora*).

Of the 8 species of amphibians documented in Southeast Alaska, only western toad and rough-skinned newt are widely distributed throughout the mainland and islands of the Alexander Archipelago. Wood and spotted frog and long-toed salamander are reported chiefly in areas with transmontane river systems such as the Taku and Stikine that connect Southeast Alaska to centers of their distribution. Local populations of all but wood frog are near the northern edges of their geographic ranges.

All 8 Southeast Alaskan amphibian species require ponds or other still waters for breeding. But the ecology of small ponds – particularly those lacking perennial connections to fish streams – has received almost no scientific study in our region. Amphibian conservation (and that of other pond organisms such as dragonflies) demands a better understanding of pond morphology, function, origin and diversity in Southeast Alaska.

Populations of amphibians have declined dramatically around the world in recent decades. A variety of possible causes have been cited, including habitat loss, increased UV-B radiation, fungal infection, intensified predation by introduced fish and nonnative frogs, climate change, increased risk of disease, damage to immune systems resulting from pollutants such as pesticides, and combinations of these factors.

Many large islands in Southeast Alaska have never been surveyed for amphibians, and only rudimentary species range maps are available for this region. But anecdotal reports from Ketchikan to Haines point to a dramatic drop in numbers of western toad, a species with well-documented declines elsewhere in its range. In light of growing amphibian conservation concerns both locally and worldwide, there is a need for basic information on population status and the kinds of habitats that are occupied in Southeast Alaska, where exceptionally pristine areas alternate with heavily roaded and logged watersheds. There is an equally strong need for conservation assessment and recommendations, especially in areas of high human activity.

Checking traps at a rough-skinned newt breeding pond, June 11, 2003. Bog buckbean in lower left, yellow pond lily in lower right.

Habitat-based study From April 2002 to October 2003, on contract with the Alaska Dept of Fish and Game (ADF&G) we studied 5 native and one introduced amphibian species and their habitats near Juneau. The primary objectives of our studies were:

1) to describe amphibian breeding distribution and the diversity of available pond habitats in the Juneau area and;

2) to refine habitat-based survey methods to be used across Southeast Alaska in the future.

* Alaskan literature including O'Clair et al. (1996) generally refers to *Bufo boreas* as the "boreal toad." While this name has more flair than plain old "western toad," we have decided to use the latter name for two reasons. First, while the range of *B. boreas* does extend slightly into boreal latitudes within interior British Columbia and extreme southern Yukon, the bulk of its distribution is within the western United States. Second, until recently this species has been largely neglected by northern researchers, whereas many papers have come out of California, Colorado, New Mexico, Oregon, Utah and Wyoming, especially in reference to the toad's decline (Stebbins and Cohen, 1995). Most of these papers (Colorado excepted) call *B. boreas* the western toad.

Most of the diverse pond types used by breeding amphibians in Southeast Alaska can be found along the Juneau road system. Results from our fairly localized study should help in the design of future more widespread surveys, and in the interim, give some predictive power to land managers concerned with possible impacts of habitat disturbances to amphibian populations.

Belle Mickleson's 6th grade class rehearses for the 2002 Alaska Folk Festival. There are many ways to get the word out about amphibian conservation issues.

We assembled detailed habitat descriptions of 95 occupied and unoccupied ponds and lakes in northern Southeast Alaska. Most were within one half mile of Juneau roads. Juneau allows quick access to many amphibian habitats at a logistically feasible level, particularly important as we refined effective and efficient survey methods. In addition, we spent 5 days surveying ponds on Taku River near the Canadian border, comparing Juneau's rainy-climate pond types with others in an area transitional to drier, more interior habitats. The Taku River surveys also added two species – spotted frog and long-toed salamander – that are absent (at least as native populations) from Juneau. Our amphibian searches were always accompanied by systematic habitat assessments. We hope that our methods and findings will prove useful to others assessing amphibian populations elsewhere in coastal Alaska.

Apparent reduced range and vulnerability of western toad Of 81 fully assessed ponds and 202 additional ponds scanned briefly for amphibians in the Juneau area, we located only 7 active breeding ponds for western toad in 2002 and 2003. Presence of adults and juveniles in several locations where we have not yet discovered larvae indicates there could be a few more. Still, this is probably just a fraction of the toad ponds that were occupied prior to the widely noted "crash" in the late 1980s and early 1990s. Although scientifically collected data are lacking, our own experiences and those of dozens of Juneau residents leave little doubt that western toad is in serious trouble in our area.

Although some of the suspected causes of population decline cited above seem unlikely to apply to Southeast Alaska, an increase of disease seems a good candidate. Chytridiomycosis – an unusual fungal infection caused by a parasitic water mold that attacks keratin in amphibian skin – is a possible proximate cause of regional declines, possibly exacerbated by warming climate.

Some of the western toad larval aggregations we located are so small and easily captured that collectors seeking pets or educational specimens could inadvertently wipe out remnant populations. Spring mating clusters representing most of the adult toads from large areas are especially vulnerable. Perhaps even more threatening is the possibility that captive amphibians might be released into or near the breeding ponds. The fact that this is illegal is not widely recognized. Even if those captives were originally taken from that pond, the possibility of disease transmission is very real. In Australia, government officials have banned the import of amphibians into the Northern Territory in an effort to prevent the spread of a chytrid fungus implicated in mass deaths of native frogs (Malakoff 2000). The same or related fungi are now firmly linked to the decline of western toads in Colorado (Daszak and Berger 1999).

In the face of these threats, we feel it would be irresponsible to identify the locations of Juneau's remaining toad breeding ponds. Our report offers photos and descriptions but no mapped locations of these ponds. The ArcMap database containing that information will be presented on CD to Federal, State and Borough regulatory agencies. The locations of breeding ponds are important information for land-use planning in the Juneau area.

Growing attention to amphibians While we have grave concerns about western toad, we are also gratified by the recent surge of interest in Southeast Alaska's amphibians. As news of our study spread through the media and word of mouth, we began to receive a steady stream of amphibian reports. Meanwhile, Lance Lerum, US Forest Service, has initiated amphibian monitoring projects on Admiralty Island. An amphibian listserve was created by Kim Hastings of USFWS, through which researchers keep each other up to date on recent findings. Several visiting herpetologists passed through Southeast Alaska in summer 2003. The Juneau School District and ADF&G are collaborating on an amphibian educational curriculum. Five

Extended Learning classrooms in Juneau have chosen amphibian issues as a focal topic for the 2003-04 school year.

All of this is good news for amphibians. Increased public awareness is necessary before amphibian conservation will be addressed in land use planning or in regulations addressing such problems as the spread of disease.

Methods evaluation A primary objective of our study was to refine habitat-based survey methods to be used across Southeast Alaska in the future. The methods section of our report is therefore quite extensive, in hopes of stimulating further work, and of contributing to a standardized field protocol for our region. We did not try to "reinvent the wheel," but rather based our field methods on those developed by herpetologists working in the Pacific Northwest. We relied especially on Olson et al 1997, *Sampling amphibians in lentic habitats: methods and approaches for the Pacific Northwest*.

Southeast Alaska is not famed for its herpetological expertise. In fact we are unaware of a single full-time practising herpetologist in our region. But "Southeast" does have a wealth of seasoned field workers, poking into aquatic nooks and crannies from Dixon Entrance to Yakutat. Because of the low amphibian species diversity, especially on Southeast islands, identification generally presents no great challenges, and amateurs such as ourselves can make valuable contributions. Perhaps fisheries biologists on remote islands, conveniently equipped with water quality equipment, might be willing to take a few moments from a watershed exploration to fill out a pond assessment form (appendix A) and notify *coordinator@alaskaherps.info*. School groups might map potential breeding ponds on field outings, or throw a "toad party" (page 15) to gather amphibian reports from their community. Our methods evaluation has these and other outcomes in mind.

Because pond habitat assessment is such a holistic and multidisciplinary process, we have tried to make this report a kind of primer on general pond natural history, including ID sketches of aquatic plants, diagrams for homemade bottle traps (requiring permits from ADF&G) and tips on pond mapping and pond classification from air photography. Amphibian hunting and habitat study is truly an exciting endeavor for a naturalist, fully as rewarding as birding. We hope it catches on*.

Measurements used in this report:

We have tried to adhere to standards common in the various intersecting fields of research relevant to amphibian and habitat studies. Sometimes that results in "crossovers" from metric to English systems. For example, most of the amphibian (as well as local fisheries) literature reports water temperatures in degrees Celsius, whereas the National Weather Service reports air temperatures in degrees Fahrenheit, the system with which Alaskans are most comfortable.

Similarly, we use metric measures for amphibian lengths (25 mm SVL = snout/vent length) and pond dimensions (depth in decimeters, area in square meters, etc), but revert to the more traditional English measure for elevations, since both USGS topographic maps and NOAA tide tables express heights in feet.

In GIS applications such as ArcView, dates are expressed as a single unhyphenated 8-digit number. For example, "20030825" means August 25th, 2003. The great advantage of this year-month-day format is that it sorts by year without formating difficulties in a spreadsheet. On some of the charts in this report, the last three digits of this format are used: thus "517" means May 17th. When time of day is also needed, two more digits representing military time are appended to the date. For example, "2003082515" means 3:00 pm on August 25th, 2003.

* Although more Alaskan amphibian study is badly needed, the prospect of many more humans wading into buckbean marshes is somewhat unsettling. The dark side of amphibian research is animal harassment and increased risk of disease transmission to currently uninfected populations.

1 Methods

For each of the following components of our study we first describe rationale, procedures and equipment. At the end of each description is a brief evaluation, in some cases with recommendations for improvements in future surveys.

Initial pond mapping with GIS (Geographic Information Systems) and stereo photo-interpretation

In the planning stages of our study we created an ArcMap GIS project to identify prospective study ponds and lakes within 1/2 mile (800 m) of Juneau's major "trunk" road and primary spur roads. On NASA digital orthoquads (DOQs) all ponds larger than 10 meters on the long axis were mapped and classified into one of 7 different "origin types," described below. With the exception of a few small ponds hidden under forest canopy, we feel that this initial GIS exercise identified all of the ponds (*n* = 171) of more than 75 m^2 within our selected study area. Amphibians do breed in ponds smaller than this, however, so we scanned ponds of all sizes whenever encountering them on our hikes.

The NASA DOQs are digitized and georeferenced high-elevation air photos. Initially taken as color-infrareds in July 1996, these 6-foot-pixel DOQs have been converted to black & white (Fig 1.1a).

Older large scale (1:15,840) USFS true-color photos from August 1984 were compared with the DOQs in stereo to improve the accuracy of pond mapping (Fig 1.1b). Many small ponds are rapidly closing over with tree foliage, and on the earlier photography some ponds show more clearly than in the recent imagery. In pond mapping, as in other photo-interpretive work, it is valuable to consult as many different kinds of imagery as possible. In the age of computer-based mapping, it is easy to neglect the "old-fashioned" methods of photo analysis under a stereoscope. Three-dimensional views offer information that no digital orthoquad can provide, however fine the resolution.

For some areas, we did have access to finer-detail low-elevation color-infrared DOQs (Fig 1.1c) commissioned in August 2001 by SWCA Consultants and the City and Borough of Juneau (CBJ). Examples of the 3 kinds of photography give a sense of the relative resolution.

Evaluation *The value of GIS and stereo photo-interpretation increase in proportion to the size of the area to be surveyed. GIS provided an excellent*

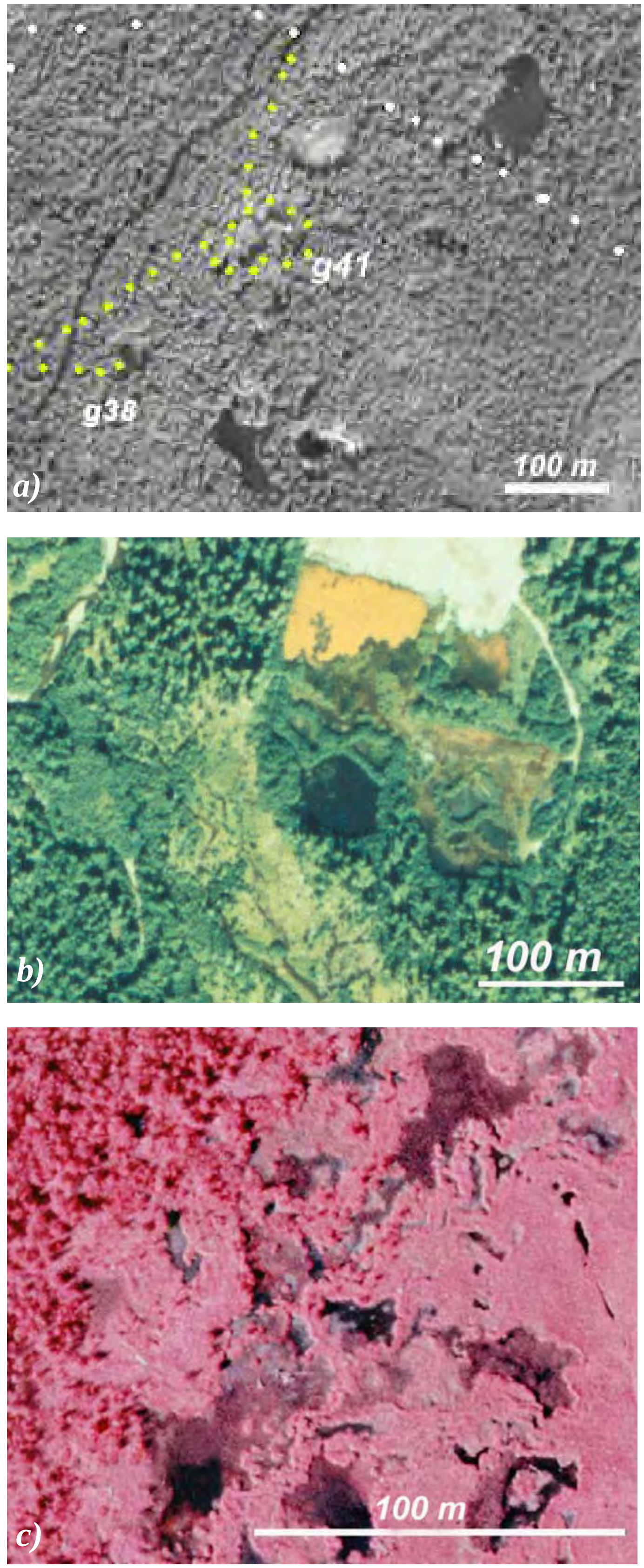


Fig 1.1, a, b&c *Comparison of 3 kinds of imagery used in pond mapping during our project, with examples of (from top to bottom) glacial, human and uplift ponds. Scale bars show increasing resolution from top to bottom:* ***a)*** *NASA 1996 B&W, from color-infrared originals, georeferenced by USFS and used as base DOQs for our ArcMap project.* ***b)*** *True color aerials, USFS, 1984, 1:15,840. A complete stereo set of these was collected for our 42 selected ponds, used in field navigation and assessments.* ***c)*** *Color-infrared imagery commissioned in 2001 by SWCA consultants and CBJ.*

Fig 1.2 *1979 NASA color infrared aerial, 1:63,360. On this vintage photography (but less so on subsequent CIRs) the wettest portions of sphagnum bogs with greatest density of small ponds can be identified from greenish tints. These patches are outlined here with white dots. Fens are distinguishable from bogs by their paler peach color.*

foundation for a comprehensive survey of ponds throughout a large area like the Juneau road system. It would be less critical for surveys of smaller areas where all potential breeding ponds were already well known to the researchers.

Fine scale photography is best for pond mapping. If we had access to the SWCA/CBJ CIR digital orthophotos (Fig 1.1c) for the entire Juneau road system, we could have mapped ponds in finer detail. It is also possible to manipulate bands in that recent CIR imagery to make water stand out in strong contrast to vegetation. This is useful in detecting small ponds overhung by brush or trees.

One-meter hyperspectral imagery has been used in Yellowstone to detect small algal ponds important to breeding amphibians (Carey et al. 2001)

Selection of study ponds

Ponds (and a few lakes) were classified according to geomorphic origin. The types are described at length in *Pond origin types*. Locally available types include:

human – anthropogenic

glacial – kettles and intermorainal swale ponds generally younger than 150 years

uplift – ponds on raised former tideland and behind recent storm berms

beaver – created and actively maintained by beaver

fen – ponds in level or gently sloping sedge/herb dominated peatlands

bog – ponds in sphagnum-dominated peatlands

bedrock – controlled by bedrock

A total of 171 ponds (in the case of bogs, pond *complexes* – as described below) were mapped within the half mile road buffer. From each geomorphic origin type, 6 were randomly selected for assessment, providing a total of 42 study ponds. To achieve geographic spread among selected ponds, we subdivided the Juneau road system into 6 units, and randomly selected one pond for each origin type within each spatial unit. If a pond type was missing entirely from a geographic unit, we selected a second one from the unit containing the most ponds of that type. If the pond type was missing from more than one geographic unit, for the next selection we went to the unit with the second highest number of ponds of that type, and so forth. For some pond types with patchy distribution – such as bedrock-controlled and glacial – we had to select all 6 ponds within only 3 geographic units.

The many ponds sprinkled through sphagnum bogs are too small to be individually mapped from high elevation air photos. Even the lower elevation 1:15,840 photos show only the largest peatland ponds. In order to randomly select 6 bog ponds we worked from 1:63,360-scale 1979 color-infrared images in stereo. These photos have distinctly different colors for bogs versus fens (definitions of these peatland types are found in *Pond origin types*). They also show a subtle but recognizable greenish tone in the wettest portions of sphagnum bogs. These are the areas most likely to contain abundant bog ponds. We began by drawing polygons not around individual ponds, as with all other pond origin types, but around these wettest portions of bogs. A total of 33 of these wetland pond complexes were mapped. From these we made our 6 random selections.

On arrival at the bog site, we measured pH in a range of ponds within the selected complex, to identify the most acidic for assessment. Bogs and fens are opposing ends of a wetland spectrum, and it's sometimes hard to assign a category to peatland ponds of intermediate character. Our goal was to sample near the ends of the spectrum, and pH seemed the best single measurement by which to define the bog extreme.

Fig 1.3 *Scanned and assessed ponds by origin type.*

	full assessments	**quick scans**	**total**
human	10	10	20
beaver	15	3	18
glacial	9	6	15
uplift	23	43	66
fen	13	59	72
bog	9	117	126
bedrock	8	2	10
river	8	17	25
	95	**257**	**352**

Fig 1.4 *GPS unit and stereo slide viewer. The 1984 true color aerials (Fig 1.1b) were copied as 35 mm slides and inserted into this viewer, providing a 3D terrain image useful in field navigation.*

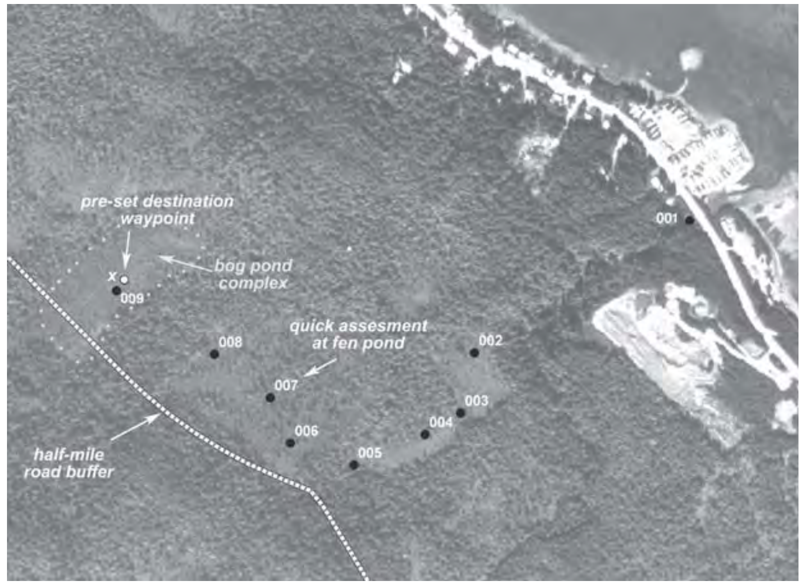


Fig 1.5 *Sample of uploaded and downloaded waypoints on digital orthoquad, for use in navigating to a selected study pond. Coordinates for the white dot (x) were uploaded to GPS before the bushwack. Waypoints 001 through 009 (black dots) were taken en route, later downloaded onto the DOQ. Waypoint 009 marks the selected (most acidic) bog pond. At point 007 an additional assessment was conducted at a small fen pond (Fig 4.25)*

In the case of glacial ponds, we made an exception to the rule of selecting within ½ mile of Juneau roads. For glacial ponds the half-mile limitation would have forced our selections into a narrow geographic range – the upper Mendenhall Valley. To give wider geographic spread and to include ponds with less human impact, we mapped 16 more ponds along the upper Herbert and Eagle Glacier trails, well “inside” of the terminal moraines, and therefore less than 150 years old.

Adding these 16 remote ponds to the 171 mapped within 1/2 mile of Juneau roads resulted in a total pool of 187 ponds (pond *systems* in the case of bogs) from which the random selections were made.

In addition to the 42 randomly selected ponds, we conducted 53 full assessments at ponds near and away from Juneau, creating a total of 95 assessed ponds. In many cases, ponds in the additional group of 53 were assessed specifically because they *did* contain breeding amphibians. Therefore, data from the total pool of 95 assessed ponds cannot be used for such purposes as predicting frequency of amphibian-occupied ponds in various origin types. A great deal was learned, however, from close examination of these additional ponds.

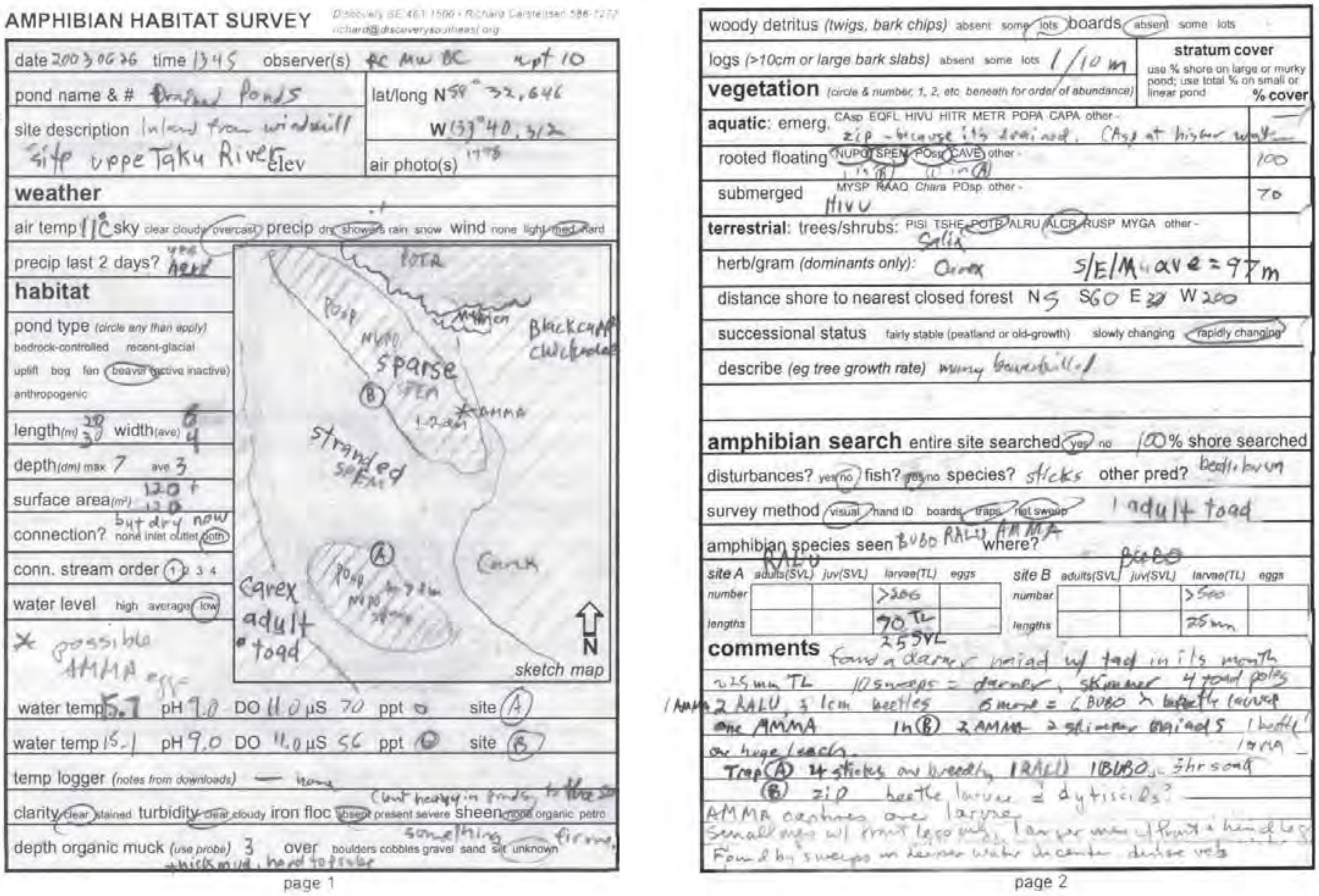
Throughout 2002 and 2003 we paused to quickly scan ponds of all kinds while enroute to selected ponds. In a few cases this turned up new amphibian breeding ponds, which were always given a full assessment. But negative data are also valuable, and these “quick scans” added another 257 ponds that we think – usually with reasonable confidence – were unoccupied, (Fig 1.3)

Evaluation *Because our goal was to describe the full range of amphibian breeding ponds in northern Southeast Alaska, we traded statistical focus for breadth. Increasing the number of randomly selected ponds per origin class would allow stronger correlations of amphibian presence/ absence with pond origin type, and with habitat parameters such as water quality and pond morphology. An equivalent study on a southern Southeast Alaskan island with good road access for logistical feasibility - such as northern Kuiu or Prince of Wales - would encounter fewer pond origin classes, allowing more pond assessments per class.*

As for the assessment of ponds that are not identified in the random selection process, these do not contribute as much to predictive power. However, we recommend conducting assessments at any pond containing western toad larvae, or other amphibians considered regionally uncommon, to provide baseline data for comparison to future repeat surveys.

Navigation to ponds

Most of the randomly selected ponds were already familiar to us. But 17 of them required bushwacks through fairly featureless terrain – country we would never have considered visiting if the random selection process had not pointed us there. To find these ponds, the combination of GIS with GPS (Global Positioning System) technology proved helpful. Figure 1.5 illustrates the process. We created a point shapefile, identifying the coordinates of the center of a randomly selected bog complex, and uploaded the coordinates into the GPS unit. In the field, we logged waypoint 001 at the road departure point. The GPS then gave the distance and bearing to the selected waypoint X. A straight-line bushwack from waypoint 001 to x would have been unpleasant, however. Instead, we consulted a stereo slide viewer with large scale true-color air photos (Fig 1.4) to thread a lovely series of fens and bogs leading in more



AMPHIBIAN HABITAT SURVEY

date 20030626 time 1345 observer(s)
pond name & #
lat/long
site description
elev
air photo(s)
weather
air temp sky clear cloudy overcast precip dry showers rain snow wind none light med hard
precip last 2 days?
habitat
pond type (circle any that apply) bedrock-controlled recent-glacial uplift bog fen beaver (active inactive) anthropogenic
length(m) width(ave)
depth(dm) max ave
surface area(m²)
connection? none inlet outlet both
conn. stream order 1 2 3 4
water level high average low
sketch map
water temp pH DO µS ppt site A
water temp pH DO µS ppt site B
temp logger (notes from downloads)
clarity clear stained turbidity clear cloudy iron floc absent present severe sheen none organic petro
depth organic muck (use probe) over boulders cobbles gravel sand silt unknown

page 1

woody detritus (twigs, bark chips) absent some lots boards absent some lots
logs (>10cm or large bark slabs) absent some lots
vegetation (circle & number, 1, 2, etc. beneath for order of abundance)
stratum cover: use % shore on large or murky pond; use total % on small or linear pond — % cover
aquatic: emerg. CAsp EQFL HIVU HITR METR POPA CAPA other -
rooted floating NUPO SPEN POsp CAVE other -
submerged MYSP RAAQ Chara POsp other -
terrestrial: trees/shrubs: PISI TSHE POTR ALRU ALCR RUSP MYGA other -
herb/gram (dominants only):
distance shore to nearest closed forest N S E W
successional status fairly stable (peatland or old-growth) slowly changing rapidly changing
describe (eg tree growth rate)
amphibian search entire site searched? yes no % shore searched
disturbances? yes no fish? yes no species? other pred?
survey method visual hand ID boards traps net sweep
amphibian species seen where?

site A	adults(SVL)	juv(SVL)	larvae(TL)	eggs	site B	adults(SVL)	juv(SVL)	larvae(TL)	eggs
number			>206		number			>500	
lengths			70 TL		lengths			25 mm	

comments

page 2

Fig 1.6 Sample of two-sided data form used for full assessments. Shorter forms were used for repeat visits to ponds, or for rapid "on-the-fly" assessments. Data were transfered from these field forms into excel spreadsheets (*blank form in Appendix A*).

roundabout fashion to waypoint x. En route, we logged more waypoints, comparing their position on the GPS map screen to the 3D slides. At waypoint 006 the GPS informed us that point X was 1300 feet away at a bearing of 310°. A compass then pointed us to the final destination.

Back at the computer, the day's waypoints, including sites of two assessed ponds (007 and 009) were downloaded onto the ArcMap project, and shapefiles saved with the daily journal entries.

Evaluation *Locating small ponds far from roads or trails is challenging even for experienced outdoorspeople. The described navigation procedure evolved over the course of our study, and we noticed improved efficiency at pond location. Uploading a destination waypoint prior to the hike minimizes the "trial-and-error" meanderings often associated with off-trail travel. GPS data displayed in ArcMap will assist future researchers in locating study ponds, essentially making them "permanent plots" without need for physical markers.*

Our method is primitive, however, compared with that developed by Bob Christensen of SEAWEAD for bear habitat mapping. Using ArcPad technology that integrates a Pocket PC with GPS, the digital orthoquad can be viewed in the field with the hiker's position shown in real time. Data forms are integrated as pulldown menus.

Pond habitat assessments

We created 3 different habitat assessment forms for differing survey intensities. The most detailed was called the "amphibian habitat survey," to be used on a first visit to a pond (Fig 1.6). On this form we recorded "perennial" features that remain fairly constant over time (location, vegetation at maximum summer cover, number of logs per unit shoreline, distance to nearest closed forest, etc.) as well as constantly changing parameters (water quality, amphibian sightings, etc.).

On return visits to sites for which the "amphibian habitat survey" had already been filled out, we used an "amphibian repeat survey" form. This form ignored the "perennial" details and listed only weather, water quality, amphibian search information, etc, – all items that need to be recorded on each survey.

A third assessment form was called the "quick pond survey." We often used this form when encountering a small, unmapped pond while enroute to other study ponds. It required only a few minutes to complete, yet allowed us to rapidly build up the total number of ponds scanned for presence/absence of amphibians.

The habitat survey form is presented in appendix A. A sample of a full assessment from upper Taku River is shown in Figure 1.6.

On the amphibian habitat assessment form we recorded the following information:

Location GPS waypoints were taken at all ponds, and later downloaded onto DOQs in several ArcMap projects for the Juneau road system and for outlying areas like Taku River, Saint James Bay and Admiralty Island.

Pond size Greatest length, average width and surface area were estimated in the field for very small ponds. Larger ponds and lakes were measured in ArcMap. We did not attempt soundings on the deeper ponds, and only recorded maximum depths that we could check visually – never more than 20 decimeters. For average depth of larger ponds and lakes we considered not the entire pond but the marginal area out to lowest visible submerged vegetation. This is the area where amphibian larvae concentrate (Olson et al. 1997)

Water level Described as high, medium or low, relative to annual fluctuations, as revealed by marginal vegetation, debris lines, etc.

Water temperature, dissolved oxygen, temperature compensated conductivity, and salinity Measured at approximately one decimeter depth along shorelines with a YSI multiprobe, model 85/25, on loan from USFWS.

pH Measured with ThermoOrion probe, on loan from ADF&G.

Temperature loggers Described separately below.

Clarity and turbidity - Under clarity, water was described as either clear or stained, usually from tannins. Turbidity is a measure of suspended particles. We did not quantify turbidity as it was rarely encountered in still-water ponds.

Depth of organic muck Probed with staff or handle of dip net to determine depth to firmer underlying sediment or bedrock. We did not have the means to probe much deeper than 10 or 12 decimeters, so an entry of “10” in this category simply means a minimum of one meter of muck above coarser or firmer substrate. When possible, we indicated the character of the underlying materials, which could often be brought up adhering to the tip of the probe.

Woody detritus Simple note on amount of fine branches, leaves, small bark pieces, etc

Boards For ponds near human development. In a few places these served as cover for newts.

Logs We recorded the number of logs over 10 cm diameter per 10 m of shoreline.

Bank vegetation (not on sample data form) This is a field we added retroactively from field notes and photos to distinguish vegetation above all but the highest water levels from other plants normally wetted and “emergent.” Within this higher terrestrial nearshore zone we estimated percent cover of herbaceous vegetation, as opposed to bare ground, shrubs, or forest. For definitions of this and the following aquatic plant zones, see *Aquatic vegetation.*

Emergents, floating-leaved and submerged vegetation For each of these marginal vegetation zones we listed the dominant species (numbered according to abundance) and estimated percent cover of the pond’s shoreline in that zone. For submerged species we did not include in the cover estimate those areas too deep to see. Amphibian larvae rarely use the deeper, colder parts of large ponds or lakes (Olson et al. 1997)

Terrestrial trees and shrubs Identifies the dominant nearby species. As with aquatic plant species and amphibians, 4-letter acronyms were used on field forms. The first 2 letters of genus are followed by the first 2 letters of species. Eg: SPEM = *Sparganium emersum*, or burreed; AMMA = *Ambystoma macrodactylum*, or long-toed salamander.

Distance from shore to nearest closed (conifer) forest We estimated this distance in meters along the 4 cardinal directions, either in the field for short distances or later in ArcMap for longer ones. This measure is significant for two reasons. Adult amphibians may need forest cover where frost depth is shallower for winter hibernacula. Secondly, trees cast shade on ponds. To create an index of sun exposure, we later averaged the distances in south, east and west directions.

Successional status This refers to both the pond and its immediate terrestrial surroundings. We ranked ponds either as “stable” (e.g., peatland ponds), “slowly changing” or “rapidly changing” (e.g., young glacial or human ponds). Additional notes capture features such as growth rate of surrounding trees, estimated from inter-whorl distances on spruces. This gives a good prediction for how long the pond will remain suitable as amphibian breeding habitat.

Amphibian search We recorded whether the entire pond margin was searched, and if not, what percentage. We also noted whether the pond might have been recently disturbed by people or wildlife, affecting the observability of amphibians.

Fish species From visual ID, or from incidental capture in amphibian traps. Other potential predators on amphibian larvae, such as dragonfly naiads, predaceous diving beetle larve and leeches, were also noted.

Survey method For shallow clear ponds with fairly sparse aquatic vegetation, we felt that visual scans were sufficient for determining presence/absence of western toad or wood frog larvae. Other methods we used included cover boards, traps and net sweeps. These methods are described below.

Amphibian species seen We recorded numbers, age class (egg, larva, metamorph, yearling, subadult, adult) and size (SVL = snout/vent length, TL = total length). Details follow in the section on amphibian surveys.

Comments For notes on net sweeps, trapping

Fig 1.7 Checking results of a net sweep in beaver-backwatered slough near Eagle River.

results and general natural history observations.

> ***Evaluation*** *The illustrated data form (Fig 1.6) evolved over the course of two years and required no alterations during the last several months of the study. We feel that it captures the habitat parameters most relevant to breeding and rearing amphibians in our area.*

Amphibian surveys

We used a variety of methods to find amphibians in and near the surveyed ponds. These methods included visual searches, net sweeps, trapping, cover boards, occasionally listening for their calls, and tracking (not all methods were used at each site). We chose whatever methods seemed best suited to the habitat. For example, many bog, fen and uplift ponds were small and shallow enough that a visual search was sufficient. On the other hand, beaver ponds, which were often deep and difficult to see into, required a combination of visual searches, trapping, and numerous net sweeps.

Visual searches At each pond we attempted to look for amphibians over as much of the area as was physically possible. At most sites we searched the entire shoreline, often looking under logs and debris, and scanning the pond with binoculars. Shoreline searches covered the water as well as adjacent land. At some sites, especially extensive beaver ponds and sloughs, we could not cover the entire system in a one-day visit. When we couldn't visually search the entire shoreline we attempted to cover the shallower areas most apt to harbor amphibians. When possible we also crisscrossed ponds, visually searching wherever we could, often examining the complete shoreline of small islands. Deeper water crossings and searches were aided by the use of chest waders.

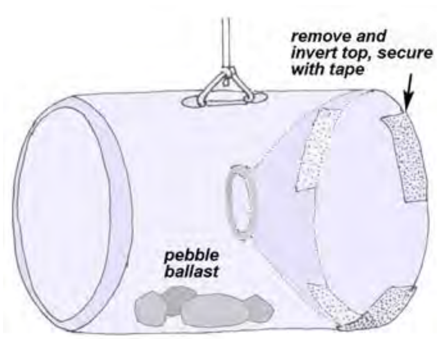


Fig 1.8 *Homemade bottle trap. Use requires ADF&G permit.*

In addition to aquatic searches we also scanned open terrestrial habitats such as meadows and marshes for western toads. The age classes most frequently found, in order of abundance, were:

1) yearling toads (~20 to 40 mm SVL, born the previous summer)

2) fresh metamorphs (~10 to 28 mm SVL) in late summer and early fall

3) probable adults (>70 mm SVL)

4) probable subadults (45 to 65 mm SVL)

All of the fresh metamorphs that we found were very close to their natal pond. The larger yearlings, subadults, and adults were sometimes encountered at greater distances from any possible breeding pond. Yearlings were typically seen on warm, sunny days, and always seemed to be close to water of some kind, possibly because of a more frequent need to rehydrate (Fig 5.13). On cool, overcast or rainy days, we almost never found yearlings, even in places where we knew them to occur.

Net sweeps While conducting the visual searches we also would frequently sweep a 13" x 7", long-handled net along the bottom. We paid particular attention to areas of heavy vegetation and muddy, debris-covered bottoms where amphibians might hide. We kept track of the number of sweeps made and recorded what we captured on the field data forms (Fig 1.7).

Trapping We used traps in ponds where visual searching was impractical or gave limited assurance of amphibian presence/absence. Initially we used two types of traps, metal Gee minnow traps (the model widely used in fisheries studies) and plastic home-made bottle traps. The bottle traps were constructed out of beverage bottles by cutting off the open end, inverting it and securing it with duct tape (Fig 1.8). In 2002, our first season of testing, the traps were deployed with and without bait. Baits used were canned clams, cat food, and nightcrawler paste. The traps were set for varying lengths of time, usually 2-8 hours and occasionally overnight. Eventually we used only unbaited

Fig 1.9 *Walking track of western toad in mud. Straddle of adult female is about 65 mm*

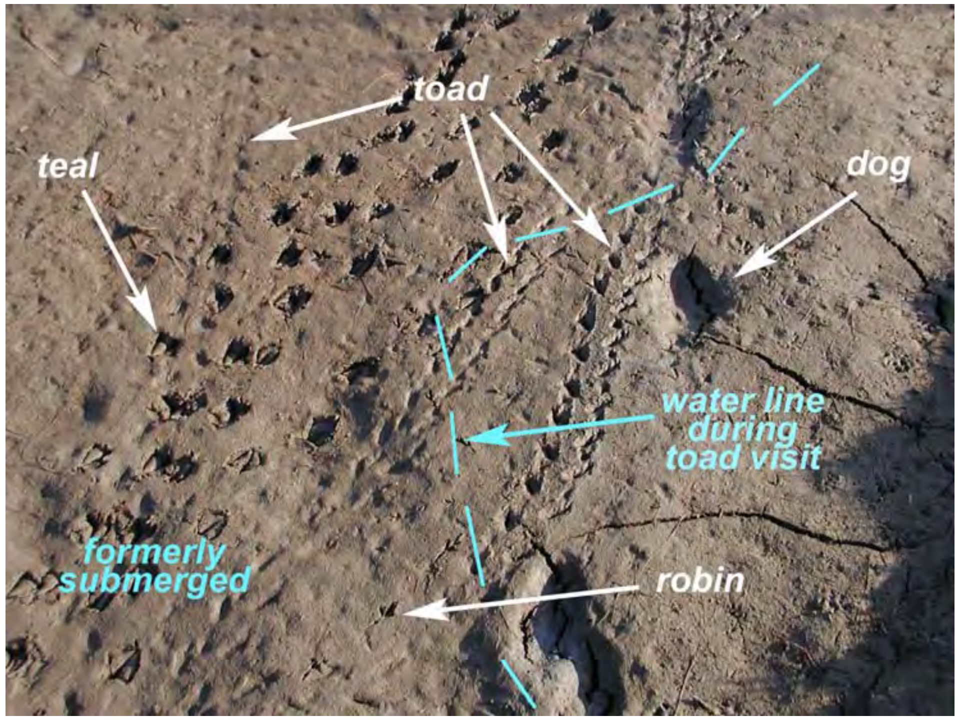


Fig 1.10 *Evidence of an unsuccessful toad spawning attempt during prolonged drought that gradually dewatered a traditional breeding pond. Photo May 3, 2003. The two toad track lines on the left with muted features were laid down in shallow water that has since evaporated. Most of the sharper-edged toad track line on the right was made on "dry" land. Near these tracks were the remains of stranded egg stringers. Well-defined robin and teal tracks were left after dewatering; perhaps they were feeding on eggs. We arrived after adult toads departed, so these tracks were helpful in reconstructing the event. Very few adults participated - apparently between 5 and 10. Broad straddle (distance across the gait) suggested mostly females.*

traps, and upgraded to a collapsible shrimp and minnow trap from Memphis Net and Twine Company (www.memphisnet.net). These traps were compact and light when collapsed (1" x 10" x 10") yet unfolded to 10" x 10" x 17" and were covered with a fine brown mesh that could hold any size amphibian (Fig 3.10). After each day's use, the traps were dipped in a Clorox solution to help avoid any spread of disease between ponds. Trapping amphibians, as with fish, requires a research or educational permit from the Alaska Department of Fish and Game.

Cover boards We used cover boards (24" x 18", half-inch plywood) at three sites with known populations of amphibians. This was done mainly to determine their effectiveness and to help gather information on different stages of amphibian development. At 3 different ponds, 3 to 9 cover boards were employed. One of these ponds contained rough-skinned newts; one contained western toad larvae; and one contained wood frogs. At each site we placed boards both in the shallow water and on land. These were left at each site throughout our study and examined periodically.

Listening for calls We visited three sites where known populations of amphibians were breeding and recorded their calls. This was done mainly to familiarize ourselves with their calls and to gather further information on their life history. The sites were visited in the evening after sunset and included one breeding location for western toads, one for wood frog and one to locate a calling Pacific chorus frog.

Tracking Toads leave walking tracks in mud that can be useful under certain conditions (Fig 1.9). Spring of 2003 was exceptionally dry. Total precipitation in April at Juneau Airport was only 0.86 inches, and no rain fell in May until the 11th. Many shrinking ponds were surrounded by soft mud that created ideal tracking conditions. The lack of rain meant that tracks of birds, mammals and amphibians persisted in this mud for weeks.

In one case (Fig 1.10), toad tracks allowed us to reconstruct a failed spawning attempt. This was an area where we had followed toad larval development during the previous year. However, in a total of about 15 visits to that site over two years, we never encountered an adult toad there, and tracking gave us our only insights into numbers of adults in the breeding population.

Just as useful as the presence of toad tracks is their *absence*, if conditions are suitable. During the second week of May, 2003, just before the drought broke, we surveyed several dewatering ponds that had broad rims of exposed soft mud with very high density of bird, mustelid, rodent, deer, and bear tracks. Complete absence of toad tracks allowed us to say with reasonable confidence that no breeding attempts had occured in these ponds. For thinly dispersed and frequently night-active species like western toad, it is sometimes much easier to find tracks than the animals themselves.

Evaluation

With the exception of trapping, we made no attempt to systematically evaluate the different search methods. However, we gathered enough information to present opinions on what seemed to work best.

***Visual searching** was the most productive method for locating western toads. All toad populations were first located by sight. This was especially true for the tadpole stage, where they tended to concentrate in shallow water, and later when the toadlets were dispersing.*

Wood frog and spotted frog larvae were also located visually. Wood frog larvae were sometimes more difficult to find visually than western toad larvae. We knew of only one small pond that held them, and on several visits we failed to find them there.They were probably hiding in the loose bottom flocculent.

Rough-skinned newts at several locations were found by turning over logs. Of interest is a night-time visit by Clayton Fischer to a known newt pond on April 7, 2003. With a flashlight, Fischer saw numerous newts swimming around in plain view. During daylight at that early date, newts were seldom visible in the pond.

Searches for terrestrial forms, especially yearling toads, should take weather-dependent activity into account. This age class appears to be more active on sunny days, thereby influencing results of visual searches.

***Net sweeps** did not work well for locating anuran larvae. They were helpful, however, in capturing them once they had been located visually. Net sweeps were the only method that captured larval rough-skinned newt and larval long-toed salamander, and the only method by which a newt egg was found. Net sweeps were good for determining the presence of potential amphibian predators such as dragonfly naiads and fish.*

***Trapping** was the best method for determining the presence of adult rough -skinned newts in ponds, where they tended to reside amongst heavy vegetation or in deeper water. Whether or not a trap was baited did not appear to make any difference but our sample size was very small. In a test of a pond with a known newt population we averaged 18 newts per Gee Minnow Trap (n = 4) and 3.75 newts per bottle trap (n = 4). All traps were set for 28 hours. Traps with bait (cat food or night crawler paste) averaged 10 per trap (n = 6). Traps without bait averaged 13.5 per trap (n = 2). All newts captured were adults averaging around 71 – 77 mm snout to vent length. The traps set 20 to 30 feet from shore tended to capture more newts than traps set near shore. No larval newts were captured by trapping. Since adults prey on their young the presence or odor of adults in traps probably discouraged their young from entering (Robert Hodge pers. comm.). We attempted to narrow the trap entrance to exclude adults but were unsuccessful (not narrow enough). Perhaps traps made especially for larvae, and free from adult odors, would work.*

	close to swarm		**far from swarm**	
type	baited	unbaited	baited	unbaited
Gee	130			
Gee	90			
bottle	225	12	14	42
bottle	35	14		

Fig 1.11 *Number of western toad larvae captured in 8 traps of different type and bait, near and at 12 meters distance from a swarm of several thousand, July 29, 2002. Two-hour soak. Bait used was nightcrawler paste.*

Trapping worked well for capturing western toad tadpoles, but only after they had first been located visually. Both Gee traps and bottle traps caught tadpoles (Fig 1.11). In 8 traps set for about 2 hours near a known concentration of tadpoles we captured 572 tadpoles for an average of 71.5 per trap. Gee Minnow traps caught an average of 110 tadpoles and bottle traps captured an average of 59 tadpoles per trap. Both baited and unbaited traps captured tadpoles (Fig 1.11).

We concluded that traps have limited value in detecting western toad tadpoles. These larvae are nearly black, gregarious, and throughout most of the spring and summer are quite detectable during visual scans. Larval swarms usually *seem to be very sedentary, so that in a pond of unknown occupancy, saturation trapping would be necessary in order to be sure that larvae were absent. Although traps placed 12 meters away from a swarm did capture larvae in one test (Fig 1.11), in another test on June 6, 2003, a trap placed only 2 meters away from a swarm captured no larvae after a 90 minute soak.*

Under some cover conditions, traps could be useful for detection of toad larvae. On July 10, 2003, we revisited a 3 decimeter-deep pond where *tadpoles had been clearly visible one month previously. In the interval, water milfoil had choked the pond, reaching the surface and completely obscuring the bottom. Ten minutes of random net sweeps failed to capture larvae. Only by standing still in the pond for 5 minutes did we eventually spot a tadpole at the surface. If we had not already known that tadpoles were present, we probably would not have persisted here until one was seen. Overnight trapping would be the only way to sample such a pond.*

Traps worked well for determining the presence of potential predators, especially fish and predacious diving beetles. Both seemed to be easily captured whether or not bait was used.

***Cover boards** were successful at attracting adult newts, an occasional wood frog, and toadlets. All cover boards were used in and adjacent to areas where we had known concentrations of amphibians. Cover boards were successful in attracting adult newts from June 15, 2002 (50 seen) through early September (up to 5 seen). Two wood frog tadpoles were found under one cover board placed on the shore of their pond in early July, 2002. An adult wood frog was using that board on May 2, 2003, about a week after calling and spawning ended. Only one adult western toad was found under a cover board. However on Sept. 2, 02 we observed around 1,000 toad metamorphs (most still with partial tails)* on top of *a cover board (Fig 5.10).*

***Listening** for amphibian calls was successful in the three areas where we knew they were breeding. Western toad calls are fairly faint and you need to be quite close for detection. Wood frog calls, on the other hand, are loud and can be detected from several hundred feet away. The same was true for the one calling Pacific chorus frog we found. Approaching too close would cause all three species to quit calling. In the case of wood frogs they never did resume calling during a one-hour wait. Recording and playback seemed to stimulate both western toads and the Pacific chorus frog to resume calling. It seemed to have no effect on wood frogs.*

***Tracking** searches for amphibians were useful only in special circumstances. But when those circumstances applied, it was our best method for certifying the* absence *of adult toad breeding attempts, and for reconstructing an attempted breeding event.*

Specimen collection

ADF&G regulations prohibit holding, transporting or releasing of any native amphibian without a state permit. For the most part, our study did not require specimen collection. We discouraged a visiting researcher from collecting western toads near Juneau, because we felt the adult populations on all of our known sites were critically low. Our research permit, did, however, allow us to collect in the event of locating 1) diseased or deformed amphibians, or 2) amphibians of uncertain identification.

In two instances we found ranid frogs near Juneau that we could not identify with certainty. Herpetologist Robert Hodges asked us to send him specimens, because they represented range extensions, and because of concern that they might be non-native red-legged frogs (*Rana aurora*) that have recently been introduced near Hoonah. The first of our collections proved to be wood frog (*R. sylvatica*), and the second was spotted frog (*R. luteiventris*).

On July 10, 2003, we assisted Anne Post of ADF&G in collection of 7 western toad tadpoles for educational purposes. Post is preparing an amphibian curriculum in collaboration with the Juneau School District, and she acquired a permit for collection of limited numbers of 3 native species to be housed in a terrarium that could be loaned to Juneau teachers.

Evaluation *No collected amphibian can legally be returned to the wild. It must be destroyed, preserved as a scientific specimen, or spend its life in captivity. This should cause any researcher or educator to think seriously about the responsibility of collection. In the case of educational specimens, Anne Post emphasizes that maintenance of the toad terrarium is labor intensive, probably more work than most teachers could commit to. Of 7 tadpoles collected just prior to metamorphosis, only one survived. Toads can live for many years in captivity, however. If this one does, it could be seen and enjoyed by thousands of students, and its educational value could be very high.*

For educators contemplating permitted collection of western toad, we recommend that no adult or subadult be taken. Natural mortality is very high in larval and post-larval life stages, and these individuals are more appropriate for collection if taken from a pond with at least a thousand larvae or recent metamorphs. Given the low numbers of all life stages that we observed along the Juneau road system one could argue that even tadpoles should not be collected.

Temperature loggers

For amphibians, temperature may be the most significant of the water quality measures we recorded, but it is also the most variable over time. After a clear night the difference between morning and evening temperatures in small ponds might range as high as 14^{o}C (Fig 4.31). This means that the temperature recorded during a brief pond assessment tells only part of the story of amphibian habitat quality.

For the 2003 field season, we borrowed 14 Onset temperature loggers from the USFWS and the Forestry Sciences Laboratory. Models ranged from the newer sealed

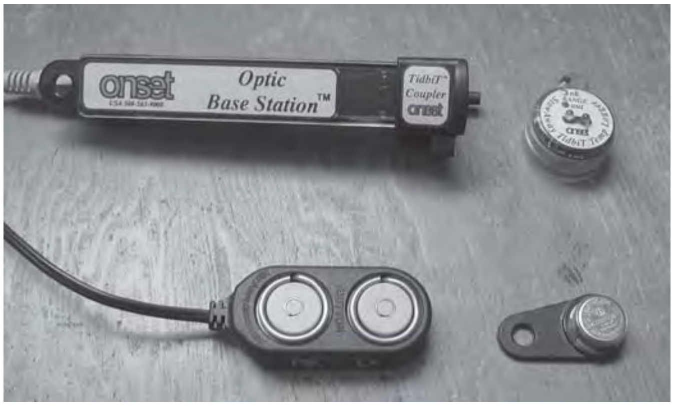


Fig 1.12 *Temperature loggers and downloading devices. Above, the Tidbit, by Onset, with optic data transmission (www.onsetcomp.com). Below, the ibutton, by Thermochron (www. ibutton.com)*

tidbit units, the size of household fuses, to older non-waterproof units housed in containers. All performed flawlessly, even some that were well beyond their predicted battery life.

Onset loggers cost roughly $100 each, not including the optical relay equipment needed to download data to computers. We also field-tested a much cheaper temperature logger by Thermochron called the ibutton. These are tiny devices resembling watch batteries that cost $10 each. Downloading to computer through the associated software worked as smoothly as with the Onset loggers, and the test unit tethered beside an Onset logger closely matched its temperature record. The ibutton measures temperature only to the nearest 1/2^{o}C, and so a daily temperature chart is "jagged" compared to that of the Onset loggers that read to the nearest 1/100^{o}C.

We programmed the Onset loggers to take temperature once per hour. Since the ibuttons often registered the "same" temperature over the course of several hours (i.e. not more than 1/2^{o}C change), we programed our test unit to read once every 3 hours.

Each logger was tethered to a stick driven into the mud of the pond bottom, as deep as we could reach from the shoreline. This varied from 2 decimeters in the case of small shallow ponds, to 6 decimeters off steeper shorelines. We tried to avoid placement in locations that seemed likely to go dry. This did happen briefly in a few locations, causing the pond thermometer to become an "air" thermometer. The period of dewatering would then register clearly from the more widely fluctuating temperature record.

We placed one logger in a representative pond from each of our geomorphic origin classes. The rest we deployed in known amphibian breeding ponds, or ponds representing certain extremes among our habitats, such as elevation or surface area.

Evaluation *Water temperature* regime *is much more important than single measurements in amphibian habitat assessments, and temperature loggers are valuable. If we'd had access to more loggers, we could have placed them at various depths and shade conditions for within-pond as well as between-pond comparisons. We could also have instrumented all of our 42 randomly selected ponds, for more thorough analysis of temperature regime by pond origin type.*

We recommend that researchers run trial comparisons of Onset and Thermochron devices before investing in numerous units. For many applications the reduced temperature sensitivity of the ibuttons may not be a problem. The ibutton may be especially useful on sites where theft or vandalism is a concern, or for projects with limited budgets. Ten times as many ibuttons as Onset loggers can be deployed for the same price.

Relocating submerged loggers placed in purposefully cryptic locations to deter vandalism can be challenging. Detailed sketch maps and photos of locations are helpful.

Photography

We thoroughly photographed every aspect of the amphibian study, from landscapes to newt eggs. The convenience of digital photography allowed immediate incorporation of images into each day's field journal. Later, the photos enhanced our ability to reconstruct details of habitat or amphibian appearance in the project summary phase, when the hundreds of examined ponds would otherwise have faded from memory.

For example, on all but the smallest ponds we took panoramic photos (up to 8 individual shots sometimes covering a 180^{o} sweep) of the entire pond margin, later seamed together in a photostitch program. When we decided to retroactively add a fourth vegetation zone, for terrestrial margins, we were able to estimate percent cover in that zone from the panoramic photos. Many examples of the panoramas are included in this report. Because they are composites, resolution is very high, allowing any portion to be enlarged on screen for plant identification, etc.

Photos served to document the locations of hidden temperature loggers whose position we did not want to reveal with flagging. We photographed details of bank structure and vegetation closeups, especially near larval aggregations. On regularly visited ponds, we assembled collections of retakes showing phenologic change, from ice-out to autumn senescence (Fig 4.27).

We photographed every adult and subadult toad we encountered, either undisturbed on the ground or in hand (We never picked up toads if we had sunscreen or insect repellant on our skin). Like human fingerprints or humpback whale tails, patterns of bumps on the backs of toads are individually distinctive and persist over the course of years (Greg Pauley, pers. comm. Compare Fig 5.15, A-D). Future researchers may wish to compare photos of toads from areas where we worked, to gain insights into home range and longevity. We felt that photography was a less invasive practise than toe-clipping, better suited to a short-term study in which future work was not assured.

When water clarity permitted, we photographed aggregations of larval toads and frogs. In several cases this later improved the accuracy of our numbers estimate. For closeups of larvae we briefly removed them from the water with a net and photographed them in shallow containers. Larvae should not be handled.

Photos helped in the case of identification challenges. When we found frogs on three different sites in Juneau, we first emailed photographs to Robert Hodge for verification. In one case (Pacific chorus frog, *Pseudacris regilla*) the photo was adequate for ID. In the other two cases, we were asked to collect and mail specimens.

> ***Evaluation*** *We recommend that researchers photodocument ponds where assessments are conducted, for use in future studies. It is also helpful to create a photo library of all adult and subadult toads encountered, for comparison with future toad photos taken nearby. Any amphibian of uncertain identification should be photographed from top, side and bottom, as well as macros of feet, extended leg, etc. It is impossible for a non-professional to remember all of the key field marks for all of the possible species, even in Alaska. In the case of our spotted/red-legged (?) frogs, two of us took multiple photos of numerous individuals, and these still did not provide the necessary detail, and specimens eventually had to be taken. When in doubt, take more photos!*

Field journals

After each field excursion we usually spent several hours downloading photos and GPS waypoints, and incorporating the results into daily journals that collected thoughts and experiences not entered into the field data forms.

Field journalling is a tool more characteristic of the naturalist than of the quantitative field ecologist. Research contracts rarely pay for this aspect of field studies, and it is sometimes considered to be merely a hobby. However, for some kinds of studies, journalling can be a very useful exercise. We describe it here in case there are readers of similar bent who are interested in enriching their daily harvest by the time-honored methods of Burroughs and Thoreau.

Journalling not only *captures* observed patterns and ideas and questions; it *generates* them. Only in the evening quiet, sifting through the day's photo- or specimen-stimulated memories or field-scribbled reminders, carefully writing down the day's adventures, do certain kinds of synthesis take place. We can't expect to hatch these insights in the excitement of the field, nor will some of them survive if we put off journalling until other field days have inserted themselves, displacing the thoughts that were waiting to emerge. If the synthesis of ideas does not begin until months or years later in preparation of the final report, a goldmine goes untapped.

In writing a daily entry, earlier entries are referred to, hypotheses are refined, mistakes corrected, and photos compared. We often plucked a journal page from the notebook and carried it back to the field in a ziplock when it contained maps, reference photos or logger location notes needed on a return visit to that site. One example of a journal entry from Taku River can be seen on the Discovery Southeast website at www.discoverysoutheast.org.

In the data-synthesis phase of our study, the text from 73 daily journals was extracted and merged into a single word document. Within this file, searches were conducted by keyword, for example "tad," "egg," "newt" etc.

> ***Evaluation*** *Field journals are obviously a matter of personal style. The three authors of this report have widely divergent styles. There are clearly tradeoffs in expenditure of effort. Aside from style, one important question is whether a study is essentially descriptive or hypothesis-oriented. Time spent journalling is time that could have been spent visiting more ponds, increasing the number of randomly selected ponds per origin class, thereby strengthening the statistical power of the study.*

Atlas of SE Alaskan amphibian records

Concurrently with our amphibian habitat study, the Juneau Field Office of the U.S. Fish and Wildlife Service contracted with Steve MacDonald to create a handbook and atlas of Alaskan amphibians. *The Amphibians and Reptiles of Alaska: a Field Handbook* is now available on CD, or on the web at *www.alaskaherps.info.*

During our 2002-03 study, we supplemented the MacDonald atlas project by soliciting more reports of amphibian sightings, both recent and historical. This improved our odds of tracking down all existing Juneau-area populations and also gave a sense of where amphibians (primarily western toad in our area) once occurred. It soon became apparent that Juneau residents were a wealth of anecdotal information, and we decided to enter all reports into a GIS database. Reports began to come in from all over Southeast. This collection now includes 117 records for the Juneau road system, and 313 records for all of Southeast Alaska.

One event that contributed many records to our database was a "toad party" held at Mendenhall Public Library in November 2002, with help from Karla Hart at ADF&G.. Two digital projectors were running during this gathering - one with a rotating slide show of Southeast amphibians at all life stages, and another with the ArcMap database file. After watching the life history sequence to confirm their identifications, those with observations to report could click on a map or digital orthoquad to which a number was assigned in the point shapefile. They next visited a table with data forms, entered the ArcMap ID number for their record, followed by date, place, species and habitat information, etc. We found this process to be highly effective, not only at collecting amphibian sightings, but in public outreach as well. Participants left better informed, and better prepared for future amphibian searches.

Fig 1.13 shows amphibian records from our Southeast database. At the time of this report submission it has not been decided whether or how the database will be maintained in the future. Meantime, those with amphibian observations to report should fill out the data form in *The Amphibians and Reptiles of Alaska* (MacDonald, 2003). Reports should be sent to:

Alaska Herp Coordinator
Juneau Fish & Wildlife Service Office
3000 Vintage Blvd., Suite 201
Juneau, Alaska 99801-7100
(907) 586-7240
coordinator@alaskaherps.info

Evaluation *Many of the reports in our collection are from inexperienced observers, and would not have been appropriate for inclusion in the MacDonald atlas. When we lacked precise geographic locations for observations, we entered a "best guess" dot in the shapefile anyway. Thus, the quality of observations varies greatly. However, we feel that this larger database is a valuable supplement to the more formal atlas. Because our database has a field for date of observation, we can query for historical versus current distributions, and examine the results spatially in ArcMap. There is potential to expand this database to eventually include thousands of amphibian records from throughout Southeast Alaska.*

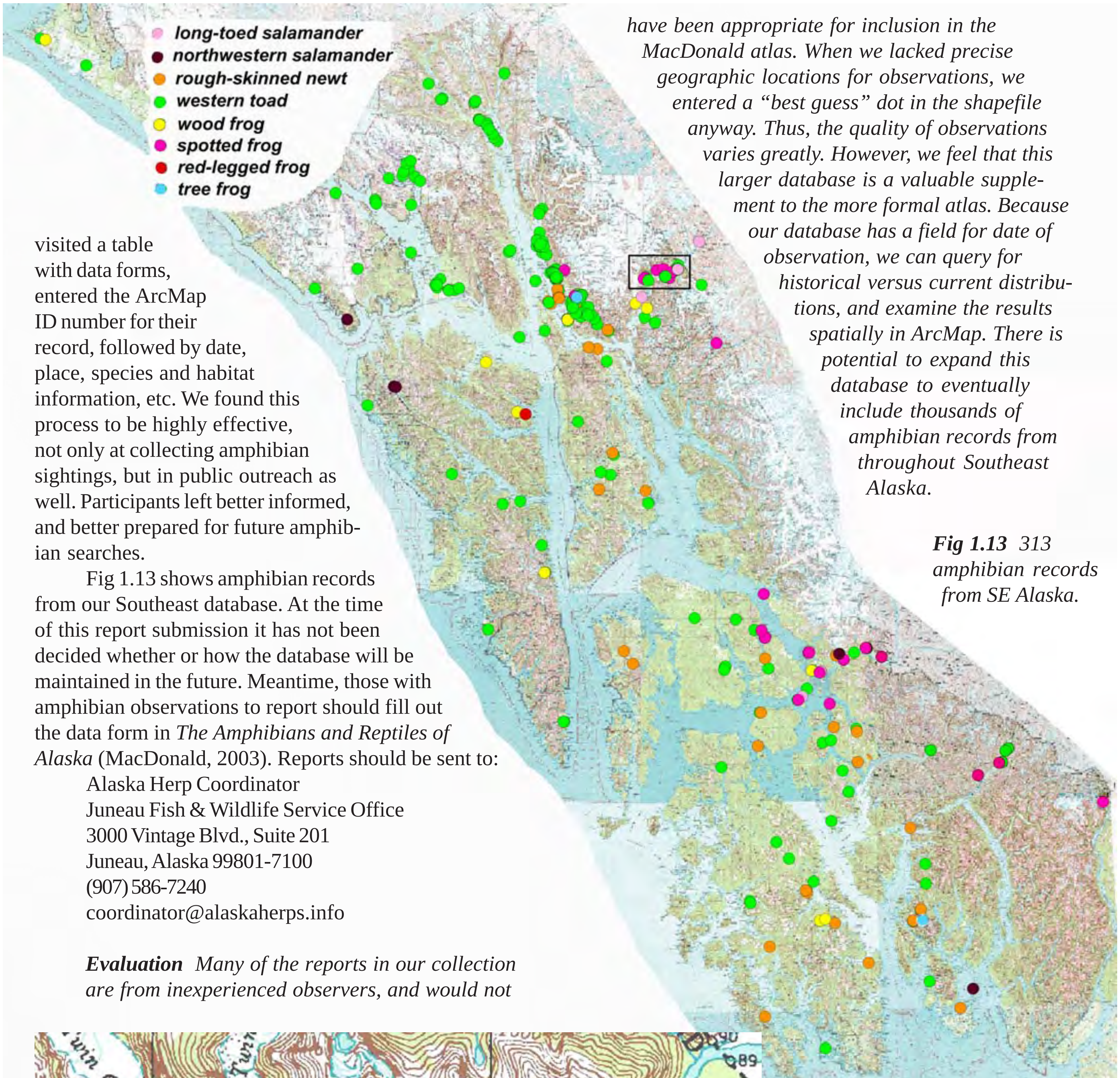


Fig 1.13 *313 amphibian records from SE Alaska.*

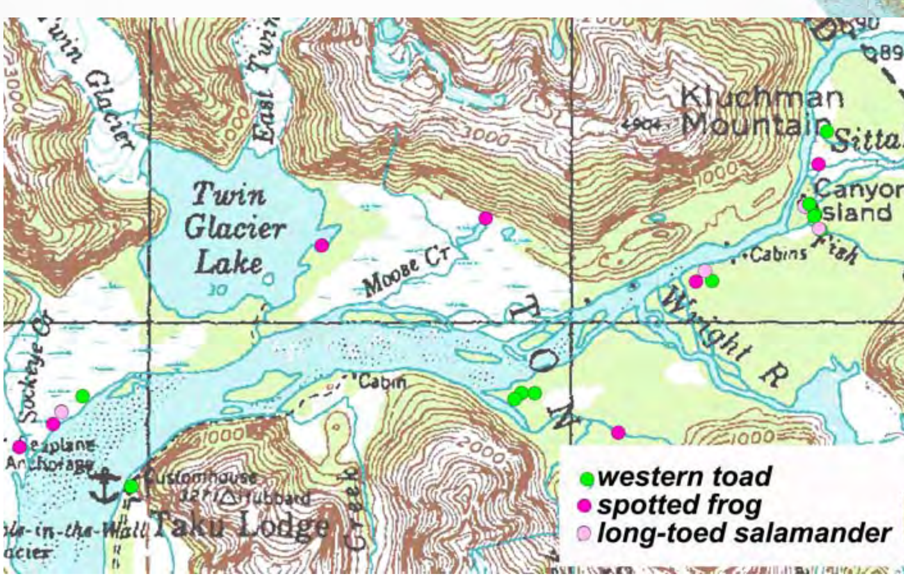


Fig 1.14 *Closeup from Fig. 1.13 (see rectangle) for Taku River near the Canadian Border. Sources for these observations include published literature, reports from Juneau residents, and our own records.*

Table 2.1 *Land area in 6 subunits of the Juneau study area. Water and tidelands within the half-mile buffer are not included. Area for the Eagle unit includes 333 hectares in off-buffer units with glacial ponds.*

subunit	hectares	acres	sq miles
north	1941	4808	7.5
eagle	1858	4602	7.2
lena	1782	4414	6.9
mendenhall	5614	13906	21.7
ne douglas	1216	3012	4.7
nw douglas	2395	5932	9.3
	14806	**36674**	**57.3**

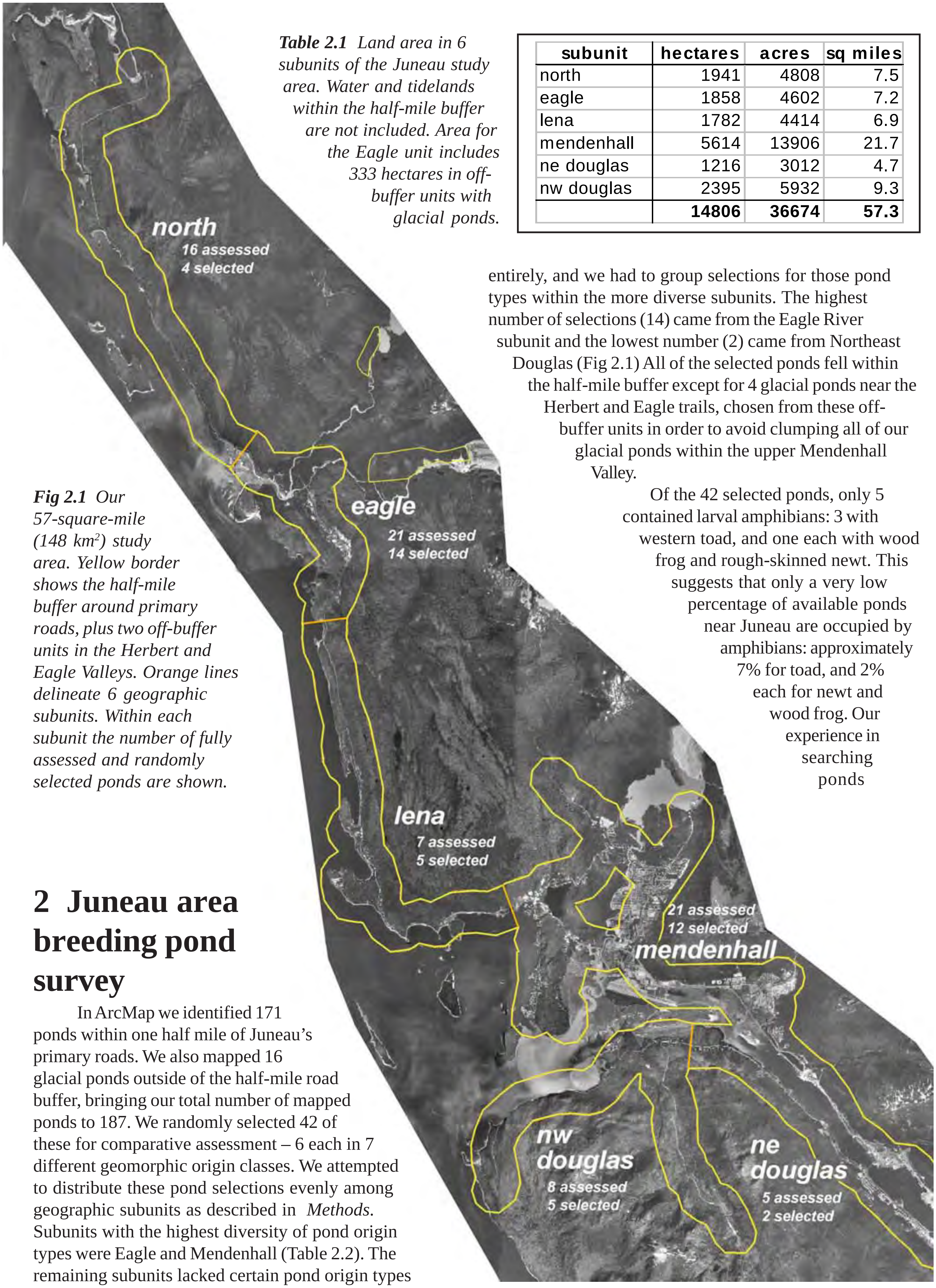


Fig 2.1 *Our 57-square-mile (148 km^2) study area. Yellow border shows the half-mile buffer around primary roads, plus two off-buffer units in the Herbert and Eagle Valleys. Orange lines delineate 6 geographic subunits. Within each subunit the number of fully assessed and randomly selected ponds are shown.*

2 Juneau area breeding pond survey

In ArcMap we identified 171 ponds within one half mile of Juneau's primary roads. We also mapped 16 glacial ponds outside of the half-mile road buffer, bringing our total number of mapped ponds to 187. We randomly selected 42 of these for comparative assessment – 6 each in 7 different geomorphic origin classes. We attempted to distribute these pond selections evenly among geographic subunits as described in *Methods*. Subunits with the highest diversity of pond origin types were Eagle and Mendenhall (Table 2.2). The remaining subunits lacked certain pond origin types entirely, and we had to group selections for those pond types within the more diverse subunits. The highest number of selections (14) came from the Eagle River subunit and the lowest number (2) came from Northeast Douglas (Fig 2.1) All of the selected ponds fell within the half-mile buffer except for 4 glacial ponds near the Herbert and Eagle trails, chosen from these off-buffer units in order to avoid clumping all of our glacial ponds within the upper Mendenhall Valley.

Of the 42 selected ponds, only 5 contained larval amphibians: 3 with western toad, and one each with wood frog and rough-skinned newt. This suggests that only a very low percentage of available ponds near Juneau are occupied by amphibians: approximately 7% for toad, and 2% each for newt and wood frog. Our experience in searching ponds

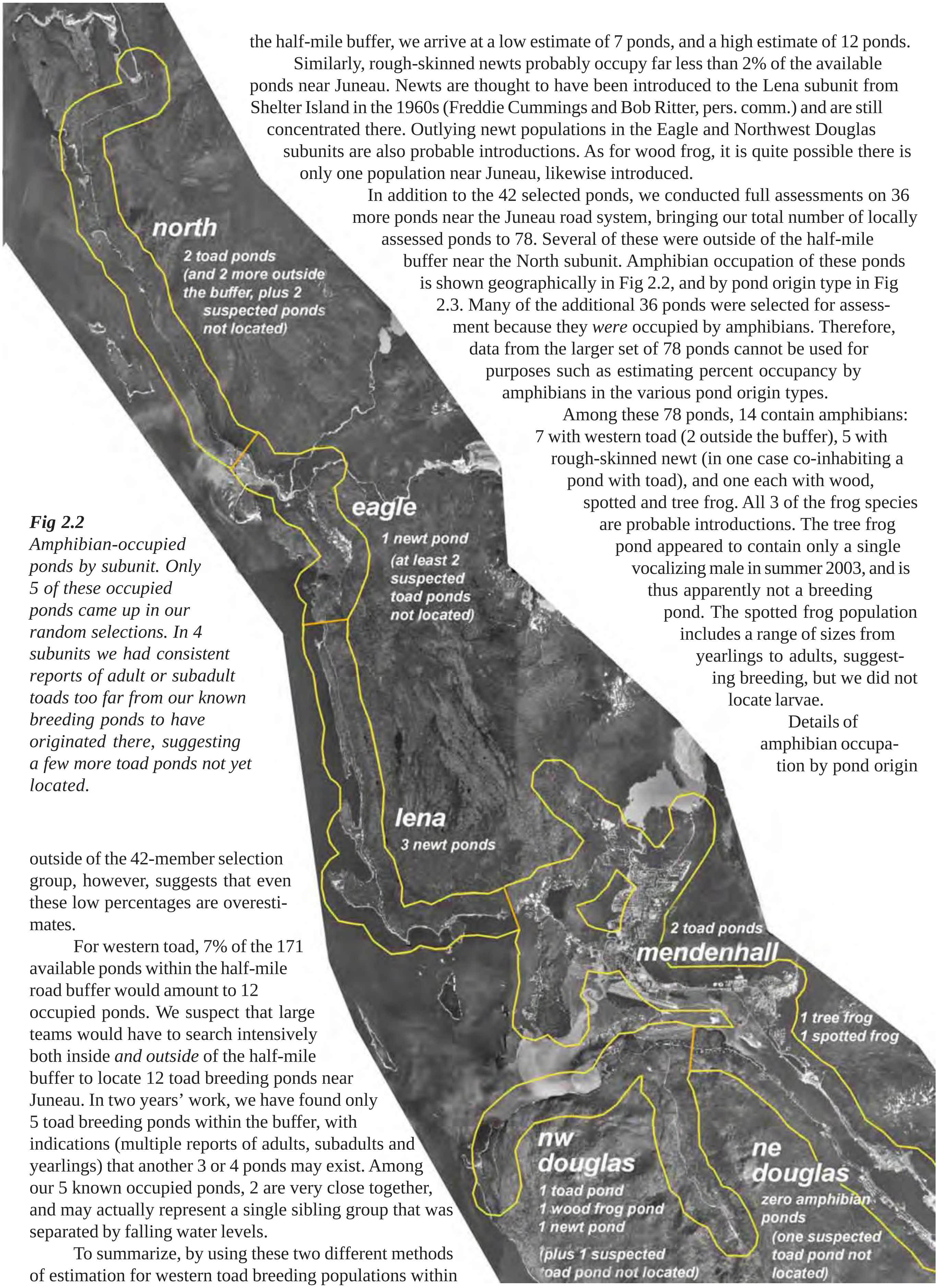


Fig 2.2
Amphibian-occupied ponds by subunit. Only 5 of these occupied ponds came up in our random selections. In 4 subunits we had consistent reports of adult or subadult toads too far from our known breeding ponds to have originated there, suggesting a few more toad ponds not yet located.

outside of the 42-member selection group, however, suggests that even these low percentages are overestimates.

For western toad, 7% of the 171 available ponds within the half-mile road buffer would amount to 12 occupied ponds. We suspect that large teams would have to search intensively both inside *and outside* of the half-mile buffer to locate 12 toad breeding ponds near Juneau. In two years' work, we have found only 5 toad breeding ponds within the buffer, with indications (multiple reports of adults, subadults and yearlings) that another 3 or 4 ponds may exist. Among our 5 known occupied ponds, 2 are very close together, and may actually represent a single sibling group that was separated by falling water levels.

To summarize, by using these two different methods of estimation for western toad breeding populations within the half-mile buffer, we arrive at a low estimate of 7 ponds, and a high estimate of 12 ponds.

Similarly, rough-skinned newts probably occupy far less than 2% of the available ponds near Juneau. Newts are thought to have been introduced to the Lena subunit from Shelter Island in the 1960s (Freddie Cummings and Bob Ritter, pers. comm.) and are still concentrated there. Outlying newt populations in the Eagle and Northwest Douglas subunits are also probable introductions. As for wood frog, it is quite possible there is only one population near Juneau, likewise introduced.

In addition to the 42 selected ponds, we conducted full assessments on 36 more ponds near the Juneau road system, bringing our total number of locally assessed ponds to 78. Several of these were outside of the half-mile buffer near the North subunit. Amphibian occupation of these ponds is shown geographically in Fig 2.2, and by pond origin type in Fig 2.3. Many of the additional 36 ponds were selected for assessment because they *were* occupied by amphibians. Therefore, data from the larger set of 78 ponds cannot be used for purposes such as estimating percent occupancy by amphibians in the various pond origin types.

Among these 78 ponds, 14 contain amphibians: 7 with western toad (2 outside the buffer), 5 with rough-skinned newt (in one case co-inhabiting a pond with toad), and one each with wood, spotted and tree frog. All 3 of the frog species are probable introductions. The tree frog pond appeared to contain only a single vocalizing male in summer 2003, and is thus apparently not a breeding pond. The spotted frog population includes a range of sizes from yearlings to adults, suggesting breeding, but we did not locate larvae.

Details of amphibian occupation by pond origin

subunit	human	glacial	uplift	beaver	fen	bog	bedrock	total
north	1		3	3		3		10
eagle	4	16	6	2	9	1	1	39
lena	1					3	9	13
mendenhall	23	38	22	2	3	3	1	92
ne douglas	3					14		17
nw douglas	1		2		3	10		16
	33	**54**	**33**	**7**	**15**	**34**	**11**	**187**

Table 2.2 *Number of ponds in 6 geographic subunits by origin type. The 16 glacial ponds shown in the Eagle subunit are outside of the half-mile buffer. All others are within the buffer.*

subunit	km^2	# ponds	ponds/km^2	ponds/mi^2
north	19.4	10	0.52	1.33
eagle	18.6	39	2.10	5.44
lena	17.8	13	0.73	1.89
mendenhall	56.1	92	1.64	4.25
ne douglas	12.2	17	1.40	3.62
nw douglas	24.0	16	0.67	1.73
total	148.1	187	1.26	3.27

Table 2.3 *Pond density in 6 geographic subunits. Highest density is in the Eagle and Mendenhall subunits. Northeast Douglas also has high pond density, but this is due almost entirely to bog ponds (Table 2.2), of little or no value to amphibians.*

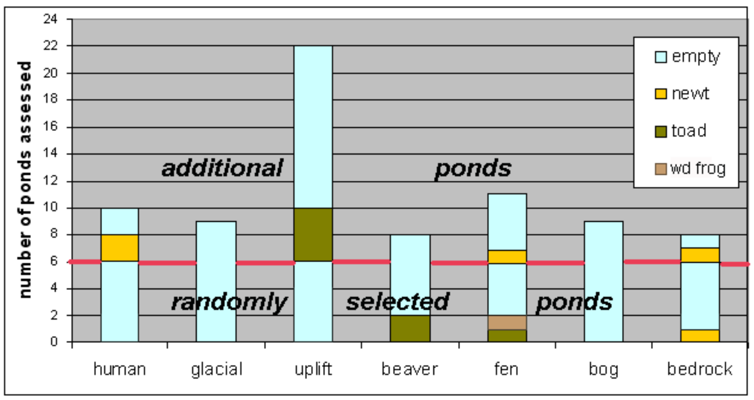


Fig 2.3 *Amphibian-occupied ponds by origin type. Among 42 randomly selected ponds, 5 were occupied. Among 78 total ponds assessed near the Juneau road system, 14 were occupied.*

type follow in *Pond origin types*. Here, we present only the overall pattern (Fig 2.3). Considering all 78 assessed ponds in the Juneau area, 27% of fen ponds were occupied by amphibians, 25% each of beaver ponds and bedrock ponds, 20% of human-origin ponds, and 18% of uplift ponds; no amphibians were found in glacial or bog ponds. Occupancy by western toads was highest in beaver (25%) and uplift (18%) ponds, followed by fen ponds (9%). (Again, these percentages are much higher than the actual toad or amphibian occupancy rates, and are only useful in suggesting relative importance of the different pond types.)

Pond density is very important to amphibians, especially in the case of declining species like western toad. Historically, this species, keyed to early seral pond habitats, has adapted to a “blinking lights” metapopulation strategy. Small breeding groups, interconnected by immigration, appear and disappear in response to disturbance and successional change. Recolonization of this sort may become impossible when ponds are isolated by human development, or in areas with naturally low pond density.

> “Specific environmental factors may explain the decline or loss of amphibians in particular cases, but the ultimate cause for large scale loss may be reduced opportunities for colonization and increased frequency of extinction”. (Hecnar and M’Closkey, 1996)

Now that the last western toad breeding ponds are so few and far between, the best hope for this species’ recovery is probably in areas densely sprinkled with potential breeding ponds. The Eagle subunit, with 2.1 ponds per km^2 (5.4/mi^2), and the Mendenhall, with 1.6 ponds/km^2 (4.25/mi^2), have the highest pond density near the Juneau road system. The Eagle unit is far less developed than the Mendenhall, with fewer barriers to amphibian movements between ponds. This area would offer the best prospects for re-introduction efforts, such as those now taking place at Rocky Mountain National Park (Colorado Herpetological Society, 2002). Another worthy candidate is the North subunit. This area has a low pond density overall, but at its northern limits there is a good diversity of uplift and beaver ponds - two of the most attractive pond types for amphians. Northward beyond the road buffer is some of the highest pond density near Juneau.

As explained in our introduction, we cannot in good conscience divulge the locations of Juneau’s last amphibian breeding ponds in this report. But we will close this section with a closeup look at a place where we did *not* find larval ponds – a former western toad hotspot.

Figure 2.4 shows an area south of Herbert River with an exceptionally high density of ponds, as well as a high diversity of pond origin types. It includes most of the recent purchase, orchestrated by the Southeast Alaska Land Trust, through which the land was conveyed to

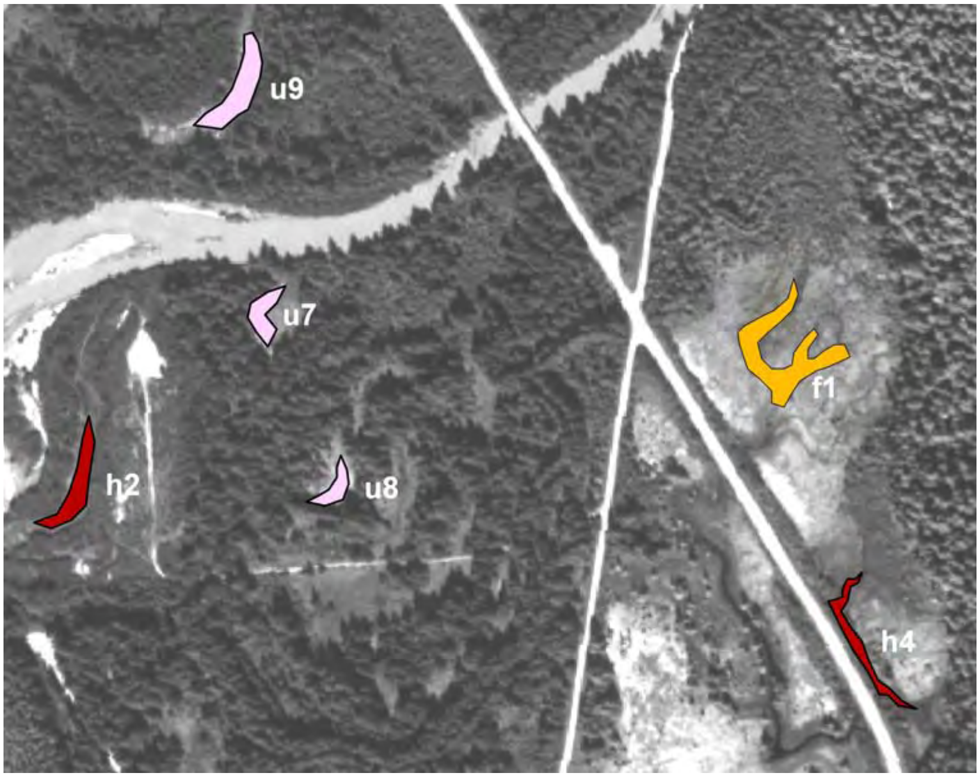


Fig 2.4 *Example of pond mapping from the ArcMap project. Herbert River Bridge in top center. Boy Scout trailhead in lower left.*

u = uplift pond; f = fen pond; h = human pond.

public ownership. Although we did not locate a toad breeding pond here during our study, we suspect there is one. Two large females were observed here in summer of 2003. In addition to the larger mapped ponds, there are many smaller seasonal ponds, roadside ditches, and meandering uplift sloughs. Much of the area is poorly drained. Warm shallow water filled with lush aquatic vegetation is attractive to breeding toads. Beaver come and go here, creating the ephemeral but productive aquatic habitats to which toads are well adapted. We know that this is prime toad country; pond h2 is a former gravel dredge pit that supported tadpoles and mating aggregations into the late 1980s. Our field notes from the 1980s indicate that on evening walks out the Boy Scout trail it was common to encounter 10 to 20 adult toads, more than the three of us managed to find throughout northern Southeast Alaska (outside of breeding congregations) during our entire two-year amphibian study.

In short, the lower Herbert River is western toad paradise minus the toads (with a few hardy exceptions). In our view, this tragedy-in-progress is one of the most serious ecological maladies facing Southeast Alaska. One commonly hears the claim that Southeast, unlike nearly every other ecoregion of North America, still retains its full pre-European complement of flora and fauna. Western toad could become the first blemish on that reputation.

Fig 2.5 *June 21, 2003, 90 mm adult female western toad near irony abandoned gravel pond east of the Eagle River Boy Scout trailhead.*

3 Aquatic vegetation

Aquatic plants occupy the shallow margins of ponds and lakes out to a depth of about 2 meters. The amphibian sampling and habitat literature refers to this variably as the “littoral zone,” “shallow water zone” or “wadeable water” (Olson et al. 1997, Heyer et al. 1994). Beyond that depth is the “limnetic” or “deep water” zone where amphibians – at least the known Alaskan species – rarely venture.

Most Southeast Alaskan amphibians spend the first part of their lives in the cover of submerged, floating-leaved or emergent aquatic plants. At the time of spawning, these plants may only be apparent as overwintered stems and runners. By mid June, however, the expanded blades and leaves sometimes cast extensive cover over the shallow margins of breeding ponds. Aquatic plants provide hiding cover, buffer the water temperatures, filter out pollutants, oxygenate the water, and reduce wave action on margins of larger ponds and lakes. Aquatic vascular plants are also coated with a film of epiphytic algae that directly feed omnivorous anuran larvae. In some ponds, extensive loose mats of green algae form at the surface by mid summer, held in place by the leaves of vascular aquatics.

Aquatic plants are also sensitive indicators of seasonal water level changes, bottom type, pH, salinity, and flow regime or periodic scouring. All of these features are important to breeding amphibians. It therefore may be difficult to say whether amphibian presence is keyed more strongly to the plants themselves or to associated physical features or processes.

To characterize aquatic vegetation in our assessed ponds, we initially estimated percent cover in 3 marginal zones: submerged, floating-leaved and emergent (Fig 3.2). Growth forms of these plant groups are generally quite distinct, and the 3 classic zones are widely recognized in aquatic studies (although often not addressed in amphibian sampling protocol). Later, when examining our pond habitat data, we added a 4th zone, called bank vegetation* which helped to fine-tune our description of the transition from aquatic to terrestrial habitats.

Fig 3.1 *Yearling toadlet swimming over submerged water milfoil, May 26, 2003. On this sunny day we saw several toadlets that were apparently hydrating by returning to water. While breeding was not documented in this particular uplift pond, we did locate tadpoles in a nearby pond that had similarly thick cover of milfoil on the bottom (Fig 4.19).*

Submerged aquatic plants grow entirely beneath the surface except for flowering parts. They generally have very small, filiform leaves. Dense mats of submerged plants provide excellent hiding cover for larval amphibians. In addition to vascular submerged plants we occasionally recorded sphagnum moss or loose mats of algae in the submerged zone, but we did not include these non-vasculars in the cover analysis.

Only a third of our 96 fully assessed ponds had measurable cover of submerged vascular plants. Similarly, 9 of 42 randomly selected ponds

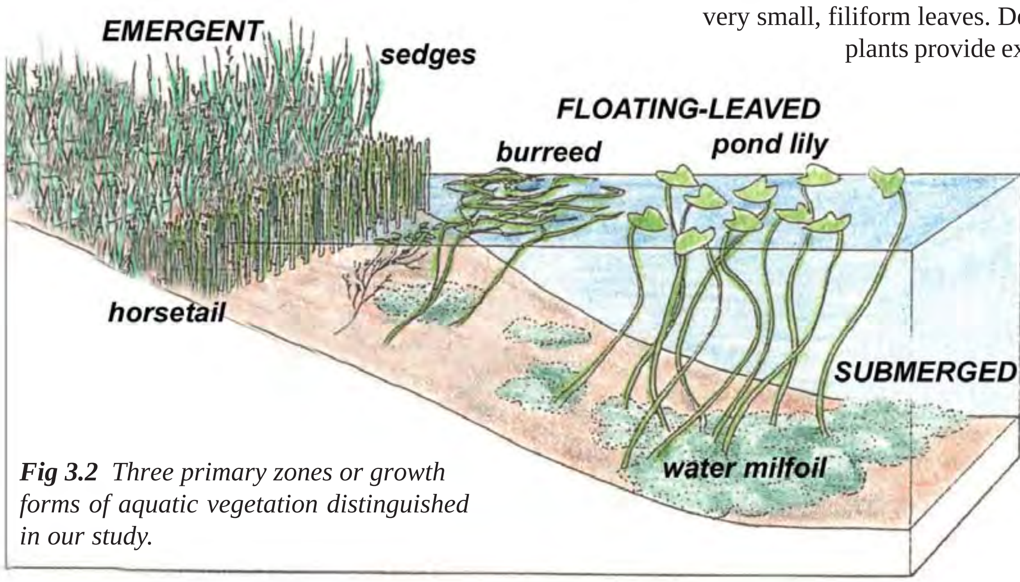


Fig 3.2 *Three primary zones or growth forms of aquatic vegetation distinguished in our study.*

* The chapter on habitat-based amphibian pond monitoring by Charles Crisafulli in Olson et al. 1997 refers this near-shore terrestrial belt as the “riparian zone,” as distinct from the “littoral” or “shallow-water zone,” of truly aquatic plants. We felt that the term “riparian” is so strongly linked to streams and rivers that it would be confusing, and instead chose the more general term “bank vegetation.”

Fig 3.3 *Submerged aquatic vegetation. All are vascular plants except for the alga Chara.*

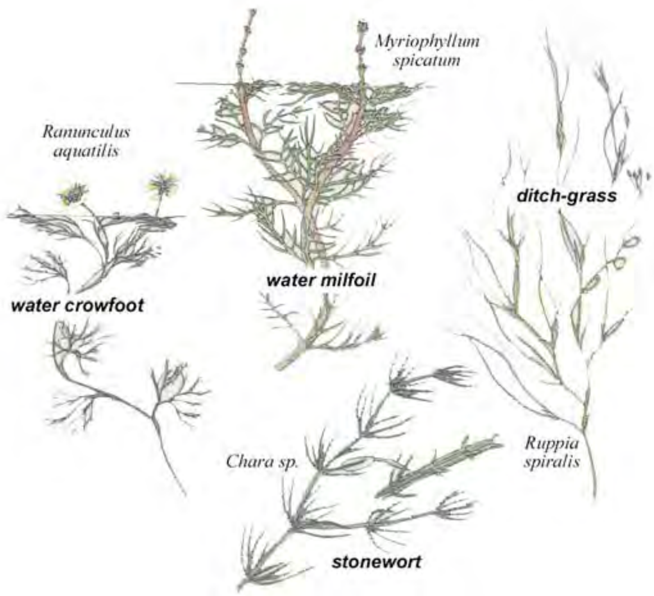
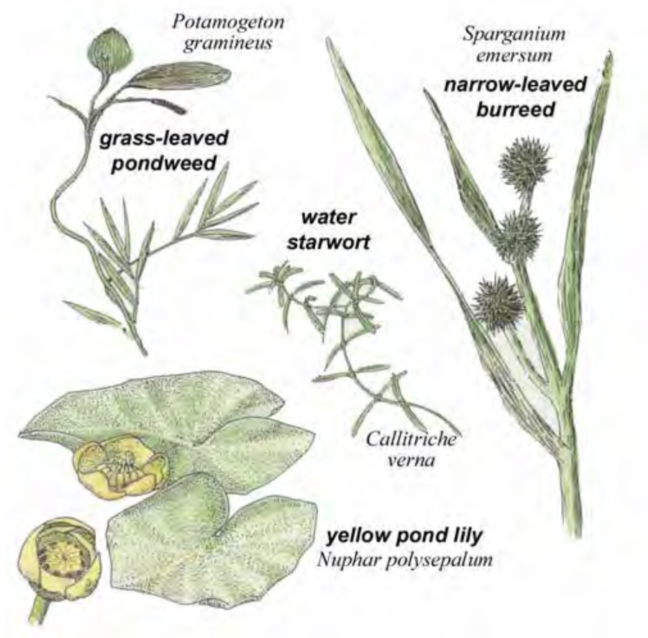


Fig 3.4 *Floating-leaved vascular aquatic vegetation.*



(21%) had submerged vasculars. The greatest frequency and percent cover of submerged plants was found among the "riverside" ponds we studied along the upper Taku River (Fig 3.7). The lowest frequency and cover occurred in fen, bog and bedrock ponds.

The most common submerged plant in our study ponds was water milfoil (Fig 3.1, 3.3). It can grow as deep as 2 meters below the surface, and is more tolerant of turbidity than the similar-appearing water crowfoot, which we only found in a few very clear-water ponds. There is some confusion in Juneau as to whether the dense growth of milfoil choking created ponds like Twin Lakes is the native species – *Myriophyllum spicatum* – or an invasive – *M. exalbescens*. Only an expert can tell the difference.

Waters (1992), in an amphibian survey of the Stikine River, noted that "*Ceratophyllum*" was the most abundant aquatic plant in "outwash ponds." Waters identified these outwash ponds - a grab-bag of human-blasted, oxbow and tidally influenced ponds - as the most suitable habitat for amphibians of the surveyed pond types. Hultén's *Flora of Alaska* shows only two isolated state collections for *Ceratophyllum demersum*, or "coontail," both in central Alaska and probably introduced there. We suspect the Stikine plants are the similar-appearing *Myriophyllum*, much more common at our latitude.

Either way, it is worth noting that abundant growth of submerged plants was strongly linked to the best amphibian breeding habitats on this mainland river survey. Our Taku River surveys (Fig 4.52) showed similar results. Of 8 ponds where we found larval toad, spotted frog, or long-toed salamander, all but two had high percent cover of submerged aquatics, ranging from 30% to 70%.

Stonewort is actually an alga, *Chara sp.*, masquerading as a submerged vascular plant. In the 4 ponds we assessed containing stonewort, pH values ranged from 7.1 to 8.6. The most basic of these ponds had formed in an abandoned river oxbow in Saint James Bay. It contained one of the largest swarms of western toad larvae we

Fig 3.5 *Toad larvae basking in 1 cm water on pond lily leaf, June 14, 2002.*

Fig 3.6 *July 4, 2003. Shallow end of a large beaver pond. Structurally diverse mix of floating-leaved yellow pond lily, and emergent bog buckbean and common marestail. Pond deepens to the upper left.*

encountered during our survey - an estimated 6000 tadpoles. Another Mendenhall Valley pond rich in stonewort and high in pH was a prolific producer of toad larvae until their disappearance in the late 1970s (Richard Gordon, pers. comm.)

Ditch-grass is the most salt-tolerant of the submerged vascular aquatic plants that we found in Southeast Alaskan ponds. Although it probably does not require salinity we have not found it in ponds free of tidal influence. Nor have we found plants that we considered "freshwater aquatics" mingling with ditch-grass in coastal ponds. Western toad – the most salt-tolerant of Alaskan amphibians (Taylor 1983, MacDonald 2003) – can breed in ponds with low but measureable levels of salinity. We do not have salinity readings from ditch-grass ponds, but our observations in summer 2003 suggest that ditch-grass probably serves as an indicator of conditions too saline for amphibian reproduction. For more information on pond salinity and its relation to plant and amphibian distribution, see page 36.

Several times during our study we were puzzled by submerged plants that turned out to be underwater forms of species we knew better as floating-leaved or emergent plants. In some cases, such as burreed and pondweed, described below, it was a matter of timing; at a later date the floating portion would be visible. In other cases, water was too deep for the plant ever to achieve its "typical" stature. A good example is marestail in deep sloughs near the Taku River.

Floating-leaved plants have a wider variety of leaf shapes than do submerged plants, ranging from the straplike blades of burreed to tiny leaves of starwort, to the huge plates of pond-lilies. Regardless of shape, the leaves lie mostly flat on the water surface (Fig 3.4). Additional leaves may be suspended below the surface, as in the pondweed genus. Stems are hollow and limp, and do not support the plant above water. If the pond bottom goes dry, the entire plant lies prostrate in the mud. Several of the floating-leaved species like burreed and some pondweeds do not reach the surface until mid summer, and until then could be mistaken for submerged aquatics.

Average percent cover of floating-leaved plants was greatest in bedrock and river ponds, and least in glacial and bog ponds (Fig 3.7). Of 95 fully assessed ponds, only 10 had greater than 50% cover of floating-leaved plants. Six of those 10 ponds contained larval newts, toads or frogs, a high percentage considering that only one quarter of the 95 fully assessed ponds held amphibian larvae.

Yellow pond lily creates a distinctive habitat for amphibians, fish, and aquatic birds and mammals. It was the dominant species in the floating-leaved zone in 22 of our 95 fully-assessed ponds, and was found in all 8 of the bedrock-controlled ponds and lakes. It was almost entirely lacking from riverside ponds on our Taku surveys, where burreed and pondweed are much more common. Pond lily was not found in our shallowest ponds, and its presence generally indicates that the pond will not go entirely dry during what passes for "drought" in Southeast Alaska. In a few of our ponds with strongest water-level fluctuations, pond lily did survive brief dewatering episodes.

Pond lily leaves are so large that they create distinctive microclimates for amphibians. Western toad larvae, like their terrestrial counterparts, are avid seekers of the warmest temperatures, and on sunny days we often found them concentrating in the uppermost decimeter of the water column. Even warmer are the extreme shallows on top of cupped pond lily leaves. Here, tadpoles can bask without the risks associated with entering equivalently shallow depths along the pond margin (Fig 3.5).

Emergent aquatic plants are those with enough fiber in supporting stems to stand erect from the shallows at pond edges (Fig 3.8). The commonest emergents in our study ponds were sedges of several species, swamp horsetail, bog buckbean, marsh fivefinger, small-fruit bullrush, and 2 species of marestail.

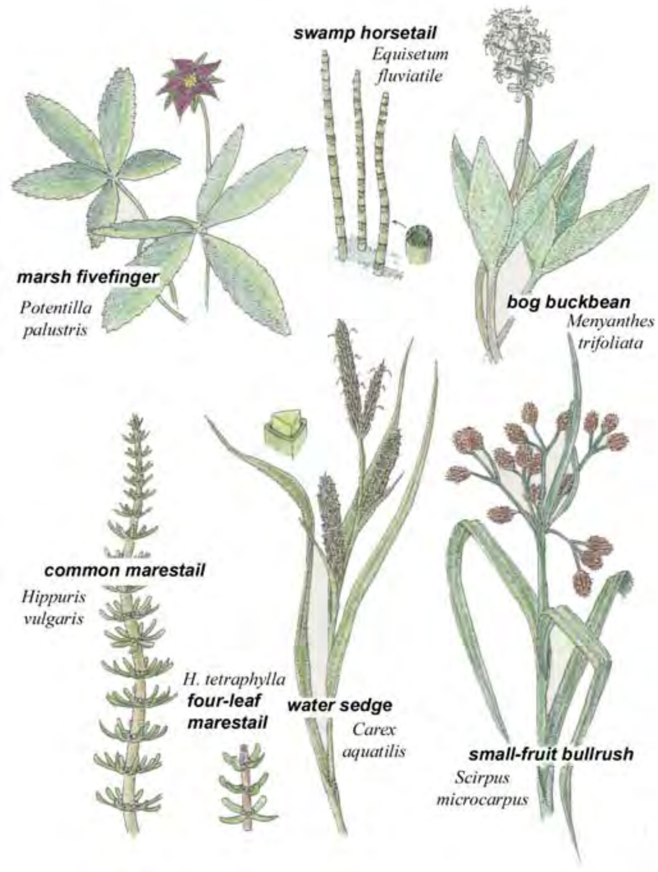
Emergent plant cover was by far the greatest in shallow fen ponds, and least in bog ponds (Fig 3.7). This alone serves to underscore the liabilities of lumping these two pond types as "muskeg ponds" (Figs 4.25 and 4.26)

In the 5 of our 42 randomly selected ponds near Juneau that held larval amphibians (3 western toad ponds, 1 rough-skinned newt pond, and 1 wood frog pond) emergent cover was very high, ranging from 70 to 95%. This pattern may be an artifact of small sample size, however, because in an additional 19 amphibian breeding ponds from northern Southeast Alaska (13 toad ponds, 5 newt ponds and 6 spotted frog ponds, with some containing more than one species), emergent plant cover ranged much more widely, from 0% to 90%. Western toad is especially plastic in its choice of breeding ponds. On Taku River we found toad larvae in one utterly plantless "moonscape" pond, feeding apparently on the invisible biofilm coating the gravel-cobble bottom (Fig 4.46). Of course we have no data for survival of these larvae up to and after metamorphosis. We suspect that ultimate reproductive success is much higher in ponds with better developed aquatic and nearby terrestrial vegetation.

Emergent plants may occupy the most important of the 3 aquatic zones to rearing amphibians, simply because this is the shallowest and warmest water, boosting larval metabolic rate and accelerating the growth of algal food.

Among our 24 assessed ponds supporting larval amphibians and adult newts, sedges (*spp*) and bog buckbean were the most frequent dominants in the emergent plant zone (9 and 5 occurrences, respectively). Swamp horsetail and marestail were each dominant in only two

Fig 3.8 *Emergent vascular aquatic vegetation.*



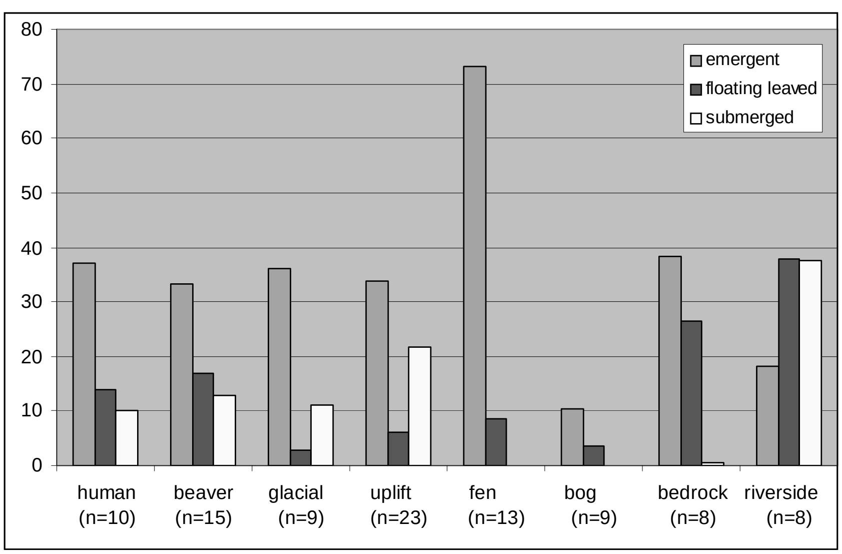


Fig 3.7 *Average percent cover of aquatic plants in three zones among 95 ponds of different origin types. (Only minor differences result from limiting these data to the 42 randomly selected ponds, except that group did not include riverside ponds)*

ponds where amphibians were found. These data, however, do not reflect the microsite locations of larval swarms or adult newt sightings, but rather the overall plant cover dominant for each pond. They also do not reflect the mix of subdominant plant species within the emergent zone, which was often fairly diverse.

In addition to their direct value to amphibian habitat, several emergent species serve as indicators of physical conditions important to larvae and breeding adults. Two species of marestail were found in our assessed ponds: *Hippuris vulgaris* and *H. tetraphylla*. The latter is mildly tolerant of salinity. We found it to be a good indicator of brackish conditions that begin to exclude most other aquatic plants. *H. tetraphylla* or four-leaf marestail occurred in one uplift pond where we measured salinity of 0.3 ppt. Water milfoil, by comparison, only appeared tolerant of 0.1 ppt. We found toad larvae in ponds with salinities of both 0.1 and 0.3 ppt. Those from the more saline pond, however, grew more slowly and reached metamorphosis later. These data are sketchy; pond salinities fluctuate and should ideally be monitored over time. Because such recordings are time-consuming and expensive, plant indicators of salinity *regime* are especially valuable.

Brooklime (*Veronica americana*, not illustrated) is a common emergent in situations such as roadside ditches. Its presence, however, hints that at least occasionally the water is subject to flushing during storms. We rarely found brooklime in the still-water habitats we scanned for amphibians. Brooklime is probably a good indicator of conditions too hydrologically unstable for amphibian rearing, just as ditch-grass indicates occasionally intolerable salinity.

Fig 3.9 *Steep banks maintained by beaver with 100% cover of sedges and bullrush. Virtually no true emergents according to our revised classification.*

Fig 3.10 *Gently shoaling pond margins with plentiful emergent sedge and buckbean. About 2000 toad larvae were swarming here on June 8, 2003. (At right foreground is the collapsing trap described in* Methods*.)*

Bank vegetation As our work progressed, it became apparent that the topographic configuration of pond banks could lead to very different vegetational cover within the zone typically characterized as “emergent.” Many of our ponds lacked the smoothly-shoaling bottom profile shown in Figure 3.2. Beaver ponds, for example, are steep sided along the outlet portions, often a meter or more deep right off the bank. While the outermost steep-bank sedges shown in Figure 3.9 might technically be considered “emergent,” this pond morphology is far inferior as tadpole habitat to that of the emergent sedge and buckbean in Figure 3.10. The steep-banked ponds are probably more difficult for freshly metamorphosed toadlets to navigate at that critical moment in their life cycle.

Because these differences are important to amphibians, we retroactively added a 4th zone called “bank vegetation.” Because we had documented the margins of our study ponds with panoramic photos, we were able to add an estimate of percent cover of lush herbaceous plants and sedges in the “bank veg” zone. Coverage in the other 3 zones had already been estimated in the field.

By separating “bank” from emergent vegetation, we removed the more terrestrial sedges such as those in Fig 3.9 from the emergent zone in our cover estimates. Aquatic plants were only measured in the “emergent” zone if they stood away from the bank. The primary purpose of separating emergent from bank vegetation was to “weed out” misleadingly high cover values from our original estimates for the emergent zone. It also allowed us to characterize the terrestrial habitats available for recent metamorphs and returning adult spawners.

4 Pond origin types

Southeast Alaska – so far at least – appears to lack amphibian species such as tailed frog (*Ascaphus truei*) and giant salamander (*Dicamptodon spp.*) that are adapted to swiftly moving water. While *Ascaphus* is known from Kitmat, BC, very near Alaska's southern border, we did not search streams for amphibians near Juneau, feeling that our time was better spent in still-water habitats.

Because of the extreme importance of salmon fisheries to our region, the ecology of Southeast Alaska's streams and rivers has received intensive study. In contrast, there have been almost no studies of small bodies of still water, especially shallow, warm ponds without fish access that offer the best breeding habitat for our known amphibian species.

We began our study by building a tentative classification of Southeast Alaskan ponds and lakes according to their geomorphic origin. This approach is well suited to amphibian habitat studies:

1) Pond disturbance regimes and successional trajectories are important to breeding amphibians. While certain pond types appear very stable over centuries and even millennia, other pond types are undergoing rapid change, easily perceptible over the span of decades or even years. To understand successional pathways it helps to consider ponds in terms of the forces that created them.

2) It is usually fairly easy to identify pond origin type from a close examination of air photos. This permits mapping of potential habitat, preparatory to ground surveys, and offers some predictive power for land managers wishing to avoid impacts to potential amphibian ponds.

Of 171 ponds within 1/2 mile of the Juneau road system that we identified from digital orthoquads and stereo air photo interpretation, each could be assigned to one of the following categories. In several cases, we changed a pond classification after visiting it in the field, but generally our initial photo-interpreted call proved correct. The pond types below are listed very roughly in order from most recent (and rapidly changing) to most ancient (and successionally stable):

human – anthropogenic

beaver – created and actively maintained by beaver

glacial – kettles, intermorainal swale ponds uncovered since peak of the Little Ice Age

uplift – ponds on former tideland and behind recent storm berms, also developed since Little Ice Age

fen – ponds in level or gently sloping sedge/herb dominated peatlands

bog – ponds in sphagnum-dominated peatlands

bedrock – controlled by bedrock, excludes recently deglaciated bedrock ponds

Most of the pond origin types found throughout the Tongass National Forest are present in large numbers along the Juneau road system, in a spectrum from ancient to freshly created. Islands of the Alexander Archipelago often lack several of the pond types we are able to study near Juneau (Table 4.1). And some of those types – especially early successional ponds linked to disturbances unique to the mainland – are among the most attractive to breeding amphibians. Juneau's array of pond types – easily accessible and now well-mapped – is also well suited to a long-term amphibian monitoring program, should others wish to return to our surveyed ponds in coming years.

There are 3 additional pond types of which we are currently aware that are absent from Juneau yet appear to be important regionally for amphibians. The first is a unique type of long-lasting beaver pond that develops in fens on the archipelago. We describe this type below in the section on fen ponds.

A second pond type (or array of types) not available for study in Juneau is found on karst topography. Karst refers to the special landscape developing on soluble bedrock like limestone or marble. It is uncommon near Juneau but well expressed on the broad belt of Alexander Terrane rocks that extends from Glacier Bay to Prince of Wales. While surface water is much less abundant on the internally-drained karst topography, streams and ponds on karst are exceptionally productive for invertebrates and fish, and we expect them to be productive for amphibians as well. Amphibian surveys of karst ponds are needed.

A third array of locally unavailable pond types is associated with large mainland rivers such as the Taku. For that reason we spent a week in late June, 2003, surveying Taku River ponds near the Canadian border. Such riverside breeding ponds offer transitional conditions between the rainy coast and drier interior, and also lie along key lowland corridors through which amphibians are colonizing Southeast Alaska. Although we have not developed a

	human	beaver	glacial	uplift	fen	fen/beaver	bog	bedrock	karst	riverside
northern mainland	common	common	common	common	common	rare	common	common	rare	absent
archipelago	rare	common	absent	absent	common	common	common	common	common	absent
transmontane rivers	rare	common	common	rare	common	rare	rare	common	rare	common

Table 4.1 Distribution of pond origin types by region. *Juneau exemplifies the "northern mainland" where a more pronounced recent Little Ice Age episode has resulted in numerous ponds created by glaciers and post-glacial uplift. "Archipelago" refers to Southeast Alaska's island chain where recent glacial and uplift ponds are essentially absent. "Transmontane rivers" include the Tatshenshini/Alsek, Chilkat system, Taku, Stikine, and Unuk, and to a lesser degree some of the smaller rivers like the Whiting and Chickamin that have lowland corridors but do not connect with extensive watersheds in British Columbia*

comprehensive classification framework for these riverside ponds, we present some preliminary impressions at the end of this section.

The amphibian surveys conducted in Southeast prior to our work were focused primarily on mainland river corridors (Waters 1992, Norman and Hassler, 1996, Lindell and Grossman, 1998). Only on the large rivers can Southeast's full amphibian species diversity be found. The river focus was also due in part to prioritization of spotted frog research in the 1990s; this species is apparently limited to mainland rivers and a few nearby islands.

While mainland rivers have received recent attention, large gaps remain in our knowledge of amphibian distribution and habitat use on the hundreds of Southeast Alaskan islands and in mainland areas distant from large transboundary rivers. This is a critical gap because our most common amphibian, the western toad, appears to be declining as dramatically in Alaska as in the rest of its range. For any species, an island population is more susceptible to local extinction than is a mainland population with stronger genetic interchange. Understanding of island pond habitats and island amphibian species (and subspecies) distributions will become increasingly important to land managers.

Pond origin types

Ponds are described below beginning with the 7 types available to us near the Juneau road system. These are listed roughly in order from most recent and rapidly changing, to most ancient and successionally stable. Following these 7 types we report on some of the ponds we assessed on the upper Taku River, for which we do not yet have a comprehensive classification system.

Human Ponds

Anthropogenic or "created" ponds and lakes near Juneau range in age from freshly dug pits and ditches only a few years old to ponds resulting from mining and road construction in the early 1900s. None of our 6 randomly selected human ponds held breeding amphibians. However, two of those ponds once held huge numbers of western toad larvae. And of the additional 4 human-origin ponds in our survey, two contained breeding rough-skinned newts, and another hosted adult and subadult spotted frogs, an apparently introduced population that probably did not actually spawn there. Clearly, humans have the ability to create habitat for certain amphibians, and this should be of some small encouragement to us as we face responsibility for amphibian crashes around the world.

Fig 4.1 *Active gravel extraction pond at Dyea, near Skagway. Toads were breeding here June 6, 2003. Photo by Greg Pauly*

In keeping with our conceptual framework of origin type, let's consider human ponds according to the means – purposeful or accidental – by which they were created.

Locally, gravel extraction has created the largest number of anthropogenic ponds. Because the intent is to acquire coarse, well-drained material for construction, gravel pits usually occur on sorted, coarse-sediment landforms like alluvial fans, river floodplains and raised deltas. Two of Juneau's best known toad-producing water bodies – once-prolific but recently toadless – originated as gravel pits: Mendenhall Valley's Dredge Lake, created in the 1940s, and Douglas Island's Fish Creek Pond, created in the early 1960s (Figs 4.2 and 4.3). The size of dredge ponds varies widely, from large ponds like Dredge and Fish (2.3 and 2.9 hectares, respectively) that contributed gravel to major road-building projects, down to small pits a few meters long (Fig 4.1). Examination of high-resolution air photos of lower Mendenhall Valley in 1967 reveals scenes of aquatic mayhem that would not be tolerated by state or federal agencies today. Once-rich fish streams like Jordan and Duck Creeks became beaded necklaces of murky dredge pits. Still, according to Larry Hurlock who grew up here, western toad was "the most common non-insect life form in the valley" during the 1950s and 60s. We wonder: was the toad abundant not in spite of but *because* of all these early human diggings? The amount of still-water habitat was much increased by dredging compared to its natural availability. Seasonal anoxia and other dredge pond problems that prove fatal to fish may not have been prohibitive for toad larvae that evacuated the ponds by late summer.

Whether or not that is true, toads are now essentially extinct in Mendenhall Valley. Further speculation on their demise in this area is found in *Synthesis.*

We heard several reports from Juneau residents of western toads breeding in small pits and ditches in the 1960s and 70s within a few years of their creation. At Dyea, near Skagway, Greg Pauley (pers. comm.) observed toad spawning in extremely barren gravel pit ponds in early June, 2003 (Fig 4.1). Greg Streveler reports that the only amphibians he saw at Gustavus during wide-ranging field work in summer 2003 were tadpoles in a poorly drained ditch created only 4 to 5 years previously.

The simple presence of larvae in anthropogenic ponds does not necessarily mean that these ponds and

Fig 4.2 *Dredge pond at mouth of Fish Creek on Douglas Island, May 29, 2003. At high tide the pond is separated from seawater only by a narrow dike (right distance). Salinity at time of this photo was 0.1 ppt; pH was 8.8. Banks are mostly steep and overhung by alder, but shoals in the right foreground support emergent sedges – the former location of large tadpole swarms and emerging metamorphs that gradually declined through the late 1980s and early 1990s. (Steve Zimmerman, pers. comm.) Our last report was of a single yearling in 2002.*

Fig 4.3 *Dredge Lake, upper Mendenhall Valley, view east from "dog beach," Sept 7, 2003. This area was deglaciated in about 1885 and subsequently served as a glacial outwash channel. Outflow soon shifted to Mendenhall River, and the lake was dredged in the 1940s. Vegetation on the margins postdates the human disturbance. Dredge Lake was well loved by generations of Juneau tadpole- and toadlet-hunters. We surveyed all of the wadeable shallows of this lake in chest waders on July 7, 2003. Swamp horsetail, pondweed and submerged stonewort are the dominant aquatics. Although visibility was excellent, we found no tadpoles. Our last toad report from the Dredge Lake area was of 2 metamorphs collected by a teacher in 2001.*

their surroundings provide quality rearing and dispersal habitat for western toad. Tim Shields speculates that of about 50,000 tadpoles in a large gravel extraction pond near Klehini River north of Haines in 2003, few of the subsequent metamorphs successfully dispersed into vegetative cover. The barren surface surrounding the pond was so extensive that attrition to predators and desiccation was intense.

People dig not only to remove material for construction, but also to improve drainage conditions near roads and buildings. At sites with inadequate culverts or insufficient gradient, backwater ponds develop. These places tend to have finer sediments and thus muckier bottoms than gravel extraction ponds that naturally are sited on coarse materials. The location of such ditch ponds immediately next to highways is of course a liability for breeding adult and post-larval dispersing amphibians. Prior to Juneau's recent western toad crash, breeding probably occurred in many roadside ditches, especially along dirt roads with light traffic.

We did locate a breeding population of newts in one roadside pond (Fig 4.4).

Fig 4.4 *Roadside ditch with heavy cover of emergent swamp horsetail, grading to pond lilies in the deeper portion (in shadows at right) On June 6, 2003 we trapped two adult female rough-skinned newts here.*

Juneau's largest created lake is the Salmon Creek

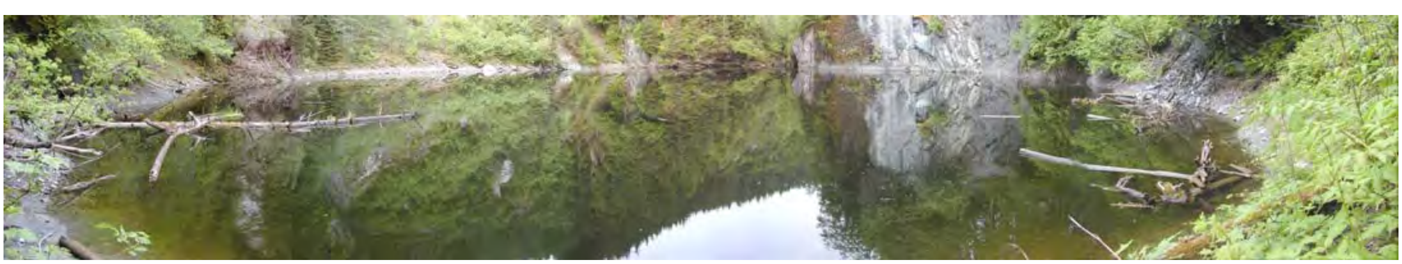


Fig 4.5 *Treadwell Glory Hole. Steep sides, cold, cliff-shaded water and near-total lack of aquatic vegetation offer very poor amphibian habitat. No larvae were found here.*

Fig 4.6 Small created garden pond on private property, July 24, 2003. We trapped two adult newts here and dip-netted one newt larva (photo, p 62) Newts colonized this pond soon after the owner created it. They probably came from nearby populations which in turn were introduced to the area in the 1960s by Sam Ritter (Bob Ritter, pers. comm.)

Fig 4.7 Measuring pH in "Tiretrack Pond," also on July 24, 2003. Surroundings are largely introduced grasses. This pond formed in the tire impressions of a large earthmoving vehicle. Extreme turbidity limited visibility to less than 3 cm, hiding a number of subadult spotted frogs.

reservoir. Because this lake was beyond our half-mile road buffer, we did not sample there, but amphibians are known from other community reservoirs, for example spotted frog at Wrangell (Vena Stough, pers. comm.).

At the turn of the century, the Treadwell Glory Hole (Fig 4.5) was an open pit mine. Now filled with water, this lake has such steeply plunging sides that we had to tie off our amphibian traps to rocks on the bank to prevent them from tumbling into the depths. Virtually no aquatic plants rim the shoreline, and we were not surprised when 6 traps soaked overnight caught zero amphibians or fish, and only 2 small water beetles.

Perhaps the most unexpected of the created amphibian ponds we documented in our study was a flooded tiretrack rut with extremely dark water that sheltered a rather sluggish and easily captured population of spotted frogs (Fig 4.7). These frogs were probably introduced to the site, but the wide range of sizes from 70-mm-SVL adults to 25-mm froglets suggests they had been breeding somewhere in the area for several years. Because we were not alerted to them until late summer, it is unclear where breeding occurred. Deborah Rudis (pers.comm.) heard amphibians vocalizing here on May 12, 2003, but our surveys soon afterward in nearby dredge and beaver ponds produced nothing.

In several cases beaver have colonized ponds that initially were created by people. In these cases we classified the ponds as "human," reserving the "beaver" type for ponds that were created and maintained strictly by beaver.

Beaver Ponds

Beaver inhabit almost all of our pond origin types except true bog ponds. However, we only gave ponds a "beaver" classification if they were created by damming of streams, and actively maintained at their current level by beaver.

Because people tend not to allow beaver too close to houses and roads, we were hard-pressed to identify our quota of 6 active beaver study ponds within the half-mile road buffer. Several ponds that we initially mapped from orthophotos as beaver ponds proved to be abandoned when we visited. In the end, we located a total of only 7 active beaver ponds within the buffer; therefore all but one of these joined the pool of 42 randomly selected ponds.

Two of those 6 selection ponds had breeding populations of western toad (Fig 2.3). Considering all 15 of our fully assessed beaver ponds, the amphibian-occupied portion was similar; 5 ponds containing amphibians (toad, newt and spotted frog), or 33%.

Fig 4.8 We found only minor signs of recent beaver activity here, July 14, 2003. Poor dam maintenance caused water to drop, exposing logs on the bottom and revealing steep-sided banks typical of beaver ponds. No amphibians were found.

Fig 4.9 *Beaver pond, Sept 5, 2003. Dispersing toad metamorphs 22- to 28 mm SVL were found among grasses in foreground. Because transformation occurred about a month earlier, these toadlets could have travelled some distance from the water they inhabited as larvae, so we still don't know the exact location of spawning and early tadpole development. Part of the controlling dam shows at extreme right, overgrown with sedges. Size of water-killed spruces indicates that no pond occurred on this site for at least 50 years prior to the current damming. State of snag decomposition (bark slipped, small branches shed, about half of trees fallen into water) suggests flooding about 30 years ago. On the 1979 color infrared aerials it appears that damming had begun, but the trees in today's opening were not yet completely defoliated .*

Outside of the half-mile road buffer, it was much easier to locate and assess a diverse spectrum of beaver ponds on Admiralty and Lincoln Islands, and on upper Taku River. Beaver workings are expressed quite differently from place to place depending on the landform they occupy, the stream or river type, availability of deciduous trees and shrubs, and exposure to predation and human influences,

Beaver ponds were the most difficult of all types for us to navigate. Surveying the margins, we straddled slippery logs one moment, and plunged to our navels in swampwater the next. To be happy in beaver country, you have to be amphibious. It's even better if you can also fly. Hooded mergansers and dragonflies are the ultimate beaver commensals.

Beaver gnaw down some trees and drown others, opening the canopy and reducing shade to their created ponds, which in turn raises water temperatures and enhances growth of aquatic plants. These changes generally improve amphibian breeding conditions. But a typical beaver pond differs greatly in morphology between inlet and outlet portions. Near the dam, beaver steepen the pond margins, creating deepwater escape habitat right off the bank. In these areas most frequented by beaver, aquatic plants like sedges, pondweed and pond lily are eaten as fast as they can grow. These outlet portions of beaver systems are usually poor amphibian habitat (Fig 3.9).

Even at the largest of our selected beaver ponds only ephemeral, first order streams fed the inlet portion (Fig 4.11). Here at the upper end, beaver ponds often feather off into more gently shoaling expanses of emergent sedges and buckbean. These areas are laced with beaver "canals,"

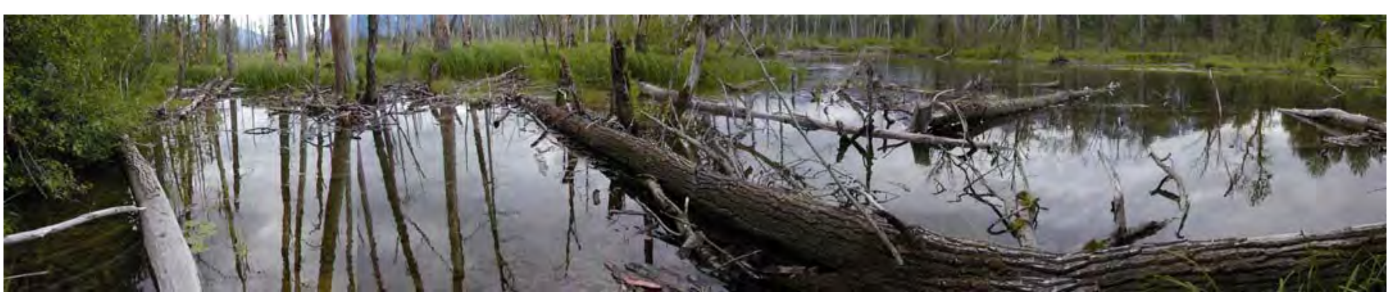


Fig 4.10 *Beaver pond surrounded by large cottonwoods on Taku River near Canadian border, June 23, 2003. Water crowfoot and bladderwort cover firm silt bottom, with pondweed out in the deeper areas. Unlike most toad breeding ponds we surveyed, where larvae swarmed in tight masses, here we found wandering solo tadpoles, cruising around in the knee-deep, exceptionally clear water.*

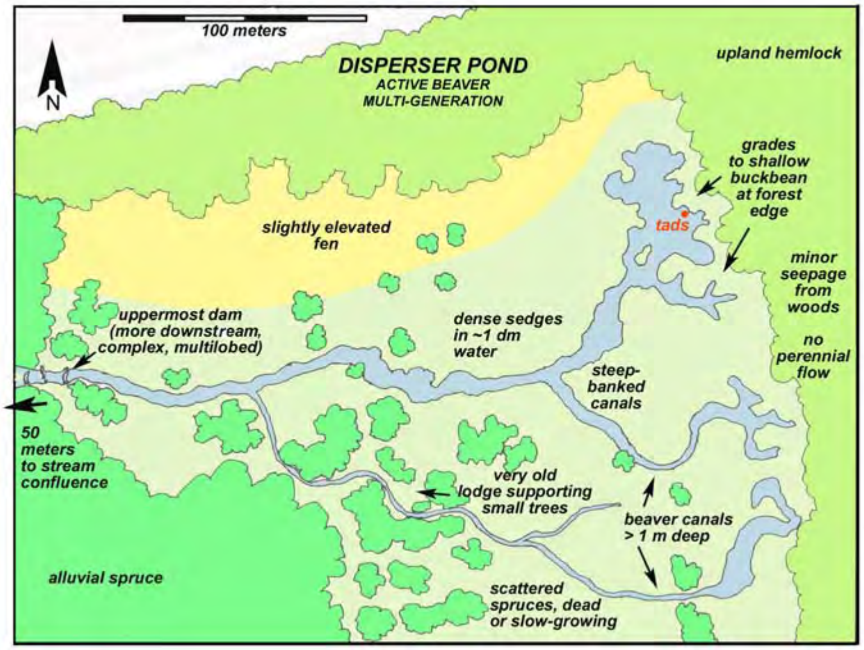


Fig 4.11 *Most "stable" of our selected beaver pond systems near Juneau roads. Beaver have apparently had a continuous presence here over the past 50 years or so. Best amphibian habitat is in the shallow, eastern margin. Red dot is tadpole swarm.*

dredged channels about a meter wide and a meter deep, providing some predator cover and making it possible to tow medium-sized branches back to the deeper portions of the pond. In the shallow, marshy matrix of this inlet area, where beaver herbivory is less intense, western toads find the best spawning and larval rearing habitat.

Most beaver ponds in the Juneau area are by nature ephemeral. When beaver colonize and dam a stream, marginal willows or cottonwoods are soon felled. If the site has not been dammed by beaver for many decades, conifers may have established, and these will be killed by flooding as backwaters expand.

In their heyday, beaver have plentiful deciduous wood for construction and winter food, combined with succulent aquatic vegetation to eat throughout the summer. But in most small and medium-sized beaver systems, the developers eventually deplete these resources and are forced to move on for lack of forage and dam-patching materials. Soon after abandonment, unmaintained dams leak, water levels drop, and willow and cottonwood advance back into the drained pond site. Eventually the stage is set for return of beaver.

This creates a "seesaw" effect over time to which amphibians have had to adapt. Perhaps beaver, along with drought, fickle sea levels, vacillating glaciers, and migrating rivers, have been part of the suite of selective forces that turned western toads into master generalists. With beaver in charge, toad populations become blinking lights; here today, gone tomorrow. But without beaver, stream margin habitats in the dense conifer rain forest are perennially too shady, and flows too strong, for any anuran but a tailed frog.

Like western toads, beaver move quickly into disturbed areas, as long as there is wet ground to develop. On Juneau's Montana Creek, beaver capitalized on clearcuts in the 1960s, retarding the recolonization of trees and creating what is now the best wildlife habitat in Mendenhall Valley. Beaver are also a prominent feature of postglacial succession; we were sometimes undecided whether to classify ponds as "beaver" or "glacial."

Similarly, hundreds of ponds are scattered throughout the rich, early successional bottomland of Taku River, and many – perhaps the majority – of them are beaver-created. As in postglacial landscapes, Taku beaver work in concert with alluvial landforms like abandoned oxbow depressions to backwater vast reaches of the floodplain. The Taku forest matrix is mixed spruce-cottonwood with abundant willow, supporting much higher beaver populations than does the upland hemlock-spruce forest that generally encloses Juneau's beaver workings. We describe Taku River valley amphibian habitats at the end of this section, but it should be noted here that beaver are responsible for a great deal of that area's amphibian richness.

We assessed several beaver ponds in fens on Admiralty and Lincoln Islands that have a very different character than either the Juneau mainland or Taku River beaver workings. It is possible to stand beside some of these island fen ponds without realizing that they were created by beaver, in some cases centuries ago (Figs 4.32, 4.33). Sedges completely overgrow the dams, their rhizomes binding the mud and retaining the water for years without need for continuous dam repair by beaver. Because beaver come and go from these pond complexes, leaving them fallow for lengthy periods, we describe this type below in the fen section.

On an even longer time scale of millennia, beaver probably played a role in the formation of many of today's bogs and fens. On the islands of the Panhandle, where ponds of glacial, uplift, human and big-river origin are missing or uncommon, beaver are the primary engineers of amphibian breeding habitat.

Glacial Ponds

For 250 years, since the culmination of the Little Ice Age, glaciers near Juneau have been steadily uncovering raw till and outwash surfaces that support the highest density of ponds and lakes of all local landform types. Glacial kettles are relatively steep-sided ponds that form where melting ice leaves a depression in the terrain that fills with water. Intermorainal ponds develop in swales between recessional moraines. They are typically more elongated and more shallow-margined than kettles, thus more suitable as amphibian habitat. We also classified several bedrock-controlled ponds on recently deglaciated terrain as “glacial” because they have more in common with young kettles and intermorainal ponds than with the much older bedrock-controlled ponds on terrain that has not been glaciated for millennia.

The 38 glacial ponds falling within ½ mile of Juneau roads are restricted to the upper Mendenhall Valley. Many of these ponds, especially the older ones south of the National Forest boundary, have been heavily impacted by development. In order to include among our samples several less impacted glacial ponds, we made an exception to our half mile buffer rule. We mapped 18 more postglacial ponds along the Herbert and Eagle Glacier Trails using GIS and stereo photography, then randomly selected two ponds each from the Eagle, Herbert, and Mendenhall systems.

Although the 3 glaciers continue to recede, in none of these valleys are young ponds being uncovered at their former rate. This is because each glacier has backed away from the broad, unconsolidated valley floor onto narrowly-constrained bedrock uplands. As a result, our selection ponds clustered at a middle successional age, from 90 to 150 years old. By this time, most post-glacial ponds are closely hemmed by

Successional development of ponds exposed by the retreating Mendenhall Glacier.

Fig 4.12 *View northwest to bedrock-controlled ponds near West Glacier Trail, July 27, 2001 (outside of our half-mile buffer). Larger pond was deglaciated in 1979. Its shores have scattered emergent rushes, but few submerged or floating-leaved plants. Lack of soil would probably make it impossible for toads to overwinter here.*

Fig 4.13 *View east to Visitor Center, Mendenhall Lake on left, April 29, 2002. Loon Lake (arrow) was deglaciated in about 1940. Due to closely overhanging spruce and alder, emergent sedges cover only 5% of the lake shore. Note increasing height of the maturing forest from left to right. Ice was still melting off lakes in this late April shot - a time when toads elsewhere emerged to spawn. (We heard of none in the entire Mendenhall Recreation Area in 2002-03)*

Fig 4.14 *View north over Moraine Lake, a “selection pond,” July 7, 2003. This lake is just downvalley (right) from Fig 4.13. Spruces about 80 feet tall rim this lake, deglaciated in 1910. Emergents in foreground are swamp horsetail, now covering 95% of the shallow lake margin, along with 5% of floating-leaved pondweed. In the 1960s, Moraine Lake, like many other glacial ponds nearby, had thousands of tadpoles swarming in the shallows (Jim Geraghty, pers. comm.). Our surveys in July 2003 turned up none.*

__Fig 4.15__ Campground Pond, June 2, 2003. Deglaciated in 1910, this pond now has a complete border of emergent swamp horsetail and bog buckbean, not yet fully expanded at time of this photo. The bottom was completely coated with green algae. As in other algae-rich ponds the water was basic - pH 8.2. Compared to our other 5 glacial selection ponds, this was the least shaded by surrounding conifers. We found no larval amphibians here, but the area was well known for abundant toads in the 1970s, so this likely was a breeding pond.

forest. On a sizable lake like Moraine (2.5 ha; 6 acres), enough sunlight reaches the shoreline in spite of tree cover to promote full cover of aquatic vegetation. Most of our ponds were much smaller, however, and with the exception of Campground Pond (Fig 4.15), the closely surrounding spruces allowed few aquatic plants.

Post-glacial succession of small ponds therefore in some ways resembles terrestrial succession; plant cover slowly increases for the first century providing steadily improving wildlife habitat, until closing conifer canopy turns ponds (and forest understories) into cool, shady environments with little cover or forage for most vertebrates including amphibians.

Younger ponds were apparently quite productive, however. Many shallow ponds in today's Mendenhall Recreation Area supported toad reproduction in the 1950s, 60s, and early 70s – a time when tall conifers did not dominate the moraines as much as they do now. "Tadpole Slough" near Dredge Lake had thousands of toad larvae between 1967 and 1975. By 1981, the large numbers were gone, and none were seen after 1990. (Rich Gordon, pers. comm.).

Although we have no reports of tadpoles in very young postglacial ponds in Mendenhall Valley, reports from Glacier Bay suggest that early surfaces are quickly colonized. Michael Zacharias and Anne Fuller photographed tadpoles in a 5 meter-long pond at 2000 feet on top of White Thunder Ridge in upper Glacier Bay on Sept 8, 1978. The area was surrounded by stagnating ice, and

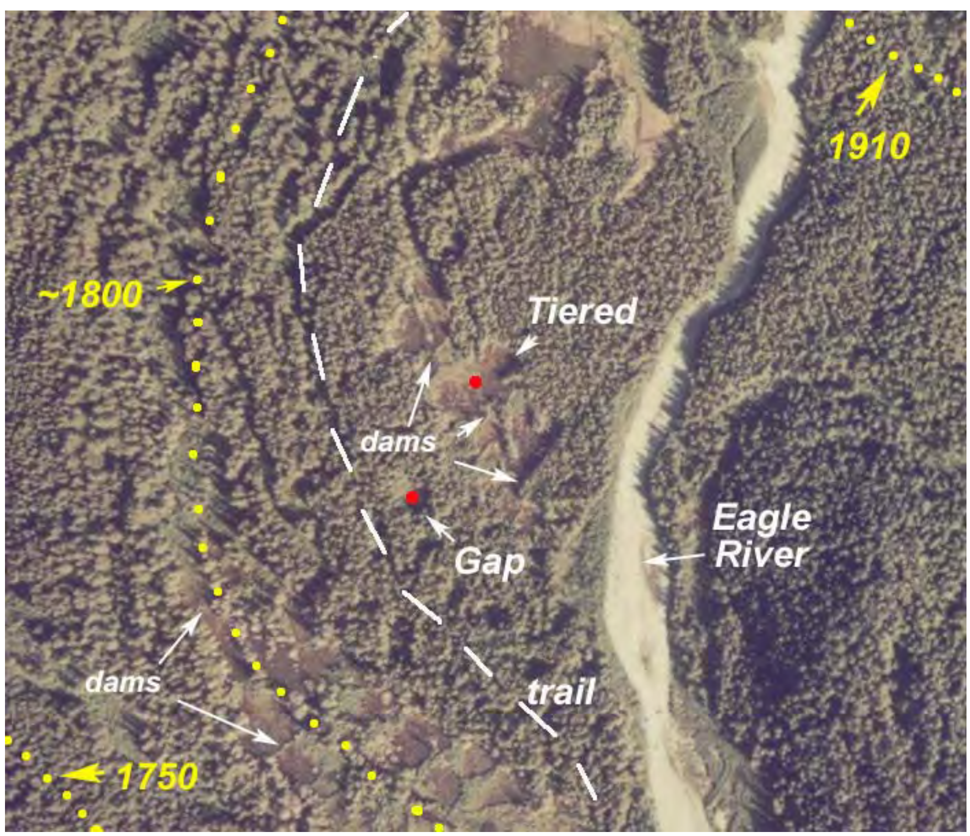


__Fig 4.16__ 1979 USFS aerial of the Eagle River Valley. Our selection ponds, Tiered and Gap, are indicated with red dots. Surface ages are less well known in the Eagle than in the Herbert and Mendenhall Valleys, but Tiered and Gap were deglaciated in the mid 1800s. Note the abundant beaver dams. On 1962 air photos, none of these beaver ponds was present.

Fig 4.17 *"Hybrid" glacial-beaver pond in Eagle River Valley, Aug 7, 2003. See "Tiered" pond network on Fig 4.16. Sedges in middle background cover the centermost of 3 controlling dams. Bleached beaver-flooded snags prove that much of the current pond area was well drained prior to beaver colonization.*

vegetation was open dryas and scattered willow. Numerous similar reports have come from the barrens of the upper bay, from observers startled to find toads in such inhospitable-appearing habitats.

An anecdote from Karla Hart gives a sense of how abundant toads once were in the upper Mendenhall Valley. In 1977, hiking back to the West Glacier trailhead after dark without a flashlight, she had to shuffle her feet in order to avoid stepping on the scores of adult toads. These toads had to have been breeding in ponds less than 60 years old.

Much of the best amphibian pond habitat in recently deglaciated landscapes has benefitted from additional tinkering by beaver. We made the rather arbitrary decision to classify these ponds as "glacial" rather than "beaver," because most originated through glacial processes. But we also found many ponds in young glacial country that had been mostly dry land before the arrival of beaver (Fig 4.17). In the Eagle River Valley, beaver have keyed their dams off of a convenient lacework of recessional moraines, in places like Figure 4.16 probably tripling the acreage of standing water.

Uplift Ponds

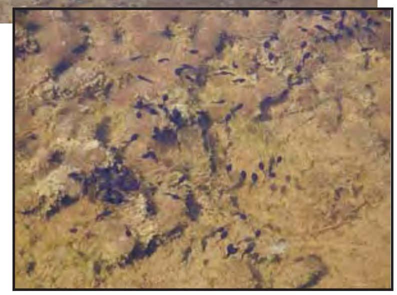
When glaciers began their retreat two centuries ago, land that had been depressed by ice throughout the northern panhandle started to rise. Today, uplift rates along the Juneau road system vary from 0.5 inches/year downtown to about 0.8 in/yr at Echo Cove (Hicks and Shofnos, 1965). On gently sloping salt marsh surfaces, former tidal sloughs and lagoons are eventually lifted above extreme high water. Some of these become freshwater or slightly brackish ponds. Other ponds (less common) form behind elevated storm berms (Fig 4.20). These become shaded by marginal conifers more rapidly than do the raised salt marsh ponds.

None of our 6 randomly selected uplift ponds had breeding amphibians. However, we did locate 4 uplift ponds near Juneau that contained western toad larvae (Fig 2.3). Two of these were within the half-mile buffer and two were outside. That makes more amphibian-occupied ponds in the uplift class than we found for any other pond origin type in the Juneau area. In addition, we have records of several other uplift ponds near Juneau that held toad larvae until the declines of the 1980s (Fig 4.18).

Succession in uplift ponds appears to have several alternate pathways, but we could describe a hypothetical sequence. Raised

Fig 4.18 *View northeast over the Eagle River estuary, Apr 29, 2002. Arrows show locations of uplift ponds that contained tadpoles in the 1970s and early 1980s. We found none in 2003. Pond on left may be partly controlled by the picnic area road berm. Pond on right is a former tidal slough, recently raised above extreme high water. We measured no salinity on June 11, 2003. The last recorded tadpoles here were in 1982 (Carstensen field notes). Both ponds are shallow and become quite warm in the afternoon sun.*

Fig 4.19 Uplift pond underlain by compacted silt, June 10, 2003. Water milfoil covered 80% of the bottom and four-leaf marestail was emergent on the margins. pH 7.5, DO 12 mg/L, salinity 0.1 ppt. Inset and arrow show tadpole swarm.



lagoons and sloughs that are still very close to extreme high water may remain variably brackish for several decades. At salinities of greater than 1.5 ppt, only ditch-grass can grow in the water. At 1.0 ppt, four-leaf marestail and occasional burreed may colonize, but in our limited experience, toad larvae are not found. Water milfoil is less tolerant, not colonizing until salinity drops to about 0.1 ppt.

The highest salinity we measured in a tadpole pond was 0.3 ppt. Comparing this to a nearby tadpole-occupied pond with 0.1 ppt., it appeared that larvae in the saltier pond were developing more slowly. At the pond in Figure 4.19 tadpoles reached metamorphosis in the third week of July, about the same timing as in occupied beaver and fen ponds elsewhere near Juneau. Meanwhile, larvae in the more saline pond (0.3 ppt) were still resorbing tails. These metamorphs did not leave the pond until early August, and probably entered fall dormancy at a smaller size.

The above scenario of plant and amphibian response to decreasing salinity is based on very few measurements during summer of 2003. We expect that salinity fluctuates considerably in uplift ponds close to extreme high water, and that more intensive measurements throughout spring and summer would probably alter our estimates of threshold tolerance values for aquatic plant species. If such work were done, it could result in a list of indicator species, directing future amphibian surveys to the most promising sites for breeding toads, and also providing land managers with better information on how to protect potential rearing habitat.

The changing dominance of aquatic plant species with uplift is paralleled by succession on a pond's terrestrial fringes. Thick growth of meadow species may delay colonization of woody species like alder and spruce, but ultimately these will surround the pond, and at some point

Fig 4.20 Mature uplift pond dammed behind forested storm berm on the left. The berm was probably built during higher sea levels at the peak of the Little Ice Age. Cover of emergent swamp horsetail and pond lily is decreasing over time as conifers shade the margins. Shade also lowers water temperatures and reduces algal growth, all combining to degrade habitat for larval amphibians. We have a 2001 report of a toad near this pond, but no breeding occurred here in 2002 or 2003. At time of this photo, May 29, 2003, pH was 6.6, DO 8, and salinity zero.Our traps caught only sticklebacks.

Fig 4.21 About 2000 tadpoles concentrated by shrinkage of an uplift pond, July 4, 2003. Although water was only about 5 mm deep, more than 90% were still alive. This was the last of 3 puddles into which the once-lengthy pond had separated. The other two had long since dried, developing mud cracks coated with the "tar spots" of desiccated toad larvae. Because no rain fell for 2 weeks after July 4, these larvae also certainly died.

Fig 4.22 *Our most frequently visited uplift pond, June 19, 2002. This was a former tidal slough. Few vascular aquatics. Dense mat of floating green algae. On July 29, 2002, we observed metamorphosis of at least 2000 toadlets at the edges of this pond.*

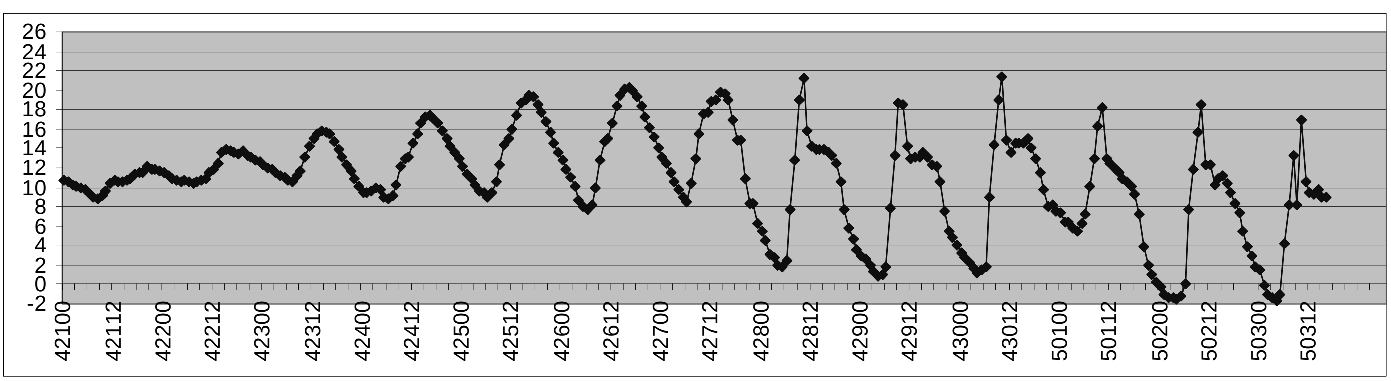
Fig 4.23 *Same pond in May 3, 2003. A prolonged spring dry spell shrivelled the pond, delaying spawning until apparently the last week in May. As pond levels changed, the water quality varied considerably; on one visit this normally acidic pond had pH of 8.2. In spite of the very inconsistent environment, about 2000 tadpoles were counted on July 4. A small number of these reached metamorphosis, with peak "exodus" on about July 22, 2003.*

put an end to its value to breeding amphibians (Fig 4.20).

Uplift, bog and fen ponds are the shallowest of our pond origin types, and as such most susceptible to dewatering during periods without rain. By July 9, 2003, water level in a large "backberm" pond had dropped nearly a meter from its April level, and some entire pond lily plants were resting exposed in the marginal mud. The pond in Figure 4.22 went mostly dry for two periods in summer 2003, as revealed by an exposed water temperature logger that suddenly began registering much lower nighttime (air) temperatures (Fig 4.24). In spite of the wide swings in water quality associated with such expansion and shrinkage of pond area, at least a few tadpoles survived to metamorphosis.

Such was not the case in a nearby uplift pond with even more drastic dewatering (Fig 4.21). In 2003 this pond was probably a complete failure. In 2002, July had 40% more rain (NOAA records for Juneau Airport) and pond levels were higher at time of dispersal. Still, we counted only 20 dispersing toadlets on July 29, 2002, a great

Fig 4.24 *Hourly water temperature readings (Celsius) in the pond shown above between April 21 and May 3, 2003, which appears to be the normal time for western toad spawning near Juneau. Daily water temperature fluctuations increased throughout the sunny days of late April. On the 28th, falling water levels exposed the temperature logger (Fig 4.23). Night time (air) temperatures dipped to around freezing until May 11, when rains brought the water up over the logger again. Another dewatering occurred in the 2nd week of August, but larvae had already transformed. Daytime water temperatures peaked in early July at 27°C (80°F). Daily fluctuations of up to 14°C occurred during clear weather. During cool, rainy spells, daily fluctuations were only 4° to 6°C.*



contrast to the thousands leaving the neighboring uplift pond (Fig 4.22) on the same day.

At the head of Saint James Bay, June 13-16, 2003, we found about 200 yearling toads dispersed throughout uplift meadows. Judging from their distribution, these toadlets (summer 2002 cohort) were born in probably more than one of the many uplift ponds scattered among the extensive meadows. We were unable to locate any tadpoles in these ponds (but see Fig 4.53 and discussion of very similar "riverside" ponds).

Uplift ponds may have played a role in dispersal of western toad throughout northern Southeast Alaska. This species has remarkable abilities to survive for long periods in salt water, especially well documented in Glacier Bay (Taylor, 1983). In July 2002, an adult toad was seen swimming well away from shore in Peril Strait near Lake Eva (Cheryl Van Dyke, pers.comm.). Over centuries and millennia these seagoing individuals could account for *Bufo's* widespread colonization of large and small islands.* A liberal sprinkling of uplift ponds just above the high tide line may have served both as welcome destination for recently arrived colonists and as a steady source of more saltwater wanderers. Considering the hordes of dispersing juveniles that (up until recent times at least) fan out from natal ponds, it seems probable that many ended up down on the beach, there to be swept away by rising tides.

Fen Ponds

Discussion of "fen-" and "bog ponds" first requires some definitions of wetland terminology. In Southeast Alaska, open, spongy wetland is usually refered to as "muskeg." Unfortunately, this label glosses over habitat distinctions critical to wildlife, including amphibians. The term "muskeg" is not indigenous to our region; it derives from the Athabascan name for boreal forested wetland with black spruce on top of permafrost (Terry Brock, pers. comm.). A better general term long-used by ecologists for ancient wetlands with deep peat is "peatland." If the peatland is dominated by sphagnum moss, it's called a bog (described below). Where lusher vegetation like sedges predominate, it's called a fen. Although peatland of intermediate character is sometimes difficult to pigeonhole into the category of bog or fen, the extremes in the spectrum are easy to recognize. Compare Figures 4.25 and 4.26.

Peatlands – especially bogs – are often dotted with very small ponds. On islands with mostly low-lying terrain like Kupreanof, peatland may offer the only widely-available stillwater ponds for breeding amphibians. It is generally recognized that "muskeg" (peatland) ponds are important for western toad, spotted frog and rough-skinned newt on islands near the Stikine River. But to our knowledge no studies have looked at relative importance of Alaskan fen and bog ponds to breeding amphibians.

We hypothesized that fens were likelier than bogs to support amphibian larvae. In order to avoid peatland ponds of intermediate character in our sampling, we selected bog ponds of lowest pH values, as described in *Methods*. Although our randomly selected ponds (6 each) did not provide a large enough sample size to fully resolve the question of value to breeding amphibians, we briefly scanned hundreds of fen and bog ponds over the course of our study. We are increasingly convinced that amphibian use is weighted toward the fen end of the peatland spectrum.

Both bogs and fens are defined by deep, undecomposed peat deposits accumulated over millennia, but fen peat is composed primarily of sedges. Fen plants like sedges and deer cabbage (*Fauria crista-galli*) are less

Fig 4.25 *Fen pond, Aug 6, 2003. Buckbean covers 25%, matrix of robust sedges and deer cabbage. pH 6.0, DO 7.3 mg/L.*

Fig 4.26 *Bog pond, July 14, 2003. No vascular aquatic species, matrix of sphagnum moss and small sedges. pH 4.6, DO 4.*

* More difficult to explain is how such an adventurous toad would find a mate upon arrival on a distant shore. Because fertilization is external, the "wandering pregnant female" hypothesis doesn't work with this species. Here we fall back on thoughts of Tlingit children traveling to fish camp with bentwood boxes containing multiple amphibian pets.

Fig 4.27 a, b & c *Seasonal changes in a poor fen pond. Vegetation is a mix of fen (sedges, buckbean, alder) and bog (sphagnum, bog tea, shore pine) affinities. Water was usually quite acid, with pH ranging from 4.6 to 5.1. Wood frogs spawned here in both 2002 and 2003. In 2002 larvae reached metamorphosis, but in 2003 we found no tadpoles after May 29.* ***a)*** *March 30, 2003. Still 95% ice covered. First opening (arrow) is where we had found a single frog egg mass on May 2 of the previous year.* ***b)*** *July 2, 2003, pond recovering from near-total dewatering in the spring drought. Some frog tadpoles survived in the wet muck until at least late May, but we could find none at time of this picture* ***c)*** *October 1, 2003. We found our last adult toad of 2003 nearby, but saw no adult or juvenile frogs.*

toxic and more palatable than bog plants to grazers, both mammalian and insect. Compared to bogs, fens are somewhat less acidic, and their groundwater is more mobile. Wetland ecologists speak of rich fens and poor fens; the latter are less productive and could be considered transitional to bog conditions.

Rich fens tend to occur on gently sloping surfaces such as the ancient raised marine terraces encompassing Douglas Island. Because groundwater flow is vigorous through these sloping fens, ponds are usually much less common than in bogs, where groundwater exchange is minimal, and "pit ponds" are frequently abundant. Most of the fen ponds that we mapped within Juneau's half-mile road buffer are on fairly flat terrain in the Amalga-Eagle area. Others were in the flat lowlands of the Mendenhall and Lemon Creek valleys. (Only by the agency of beaver do ponds become plentiful on sloping rich fens, and we did not find these pond types on the Juneau mainland or Douglas Island. We return to this phenomenon below.)

Two of our 6 randomly selected fen ponds had amphibian larvae (Fig 2.3): wood frog (Fig 4.27) and western toad (Fig 4.28). This high percentage is probably an artifact of small sample size. None of the 7 remaining Juneau fen ponds that we assessed contained amphibians. However, we do feel that many fen ponds probably held western toad larvae before the recent population crash. And we did find breeding newts in a shallow fen pond on

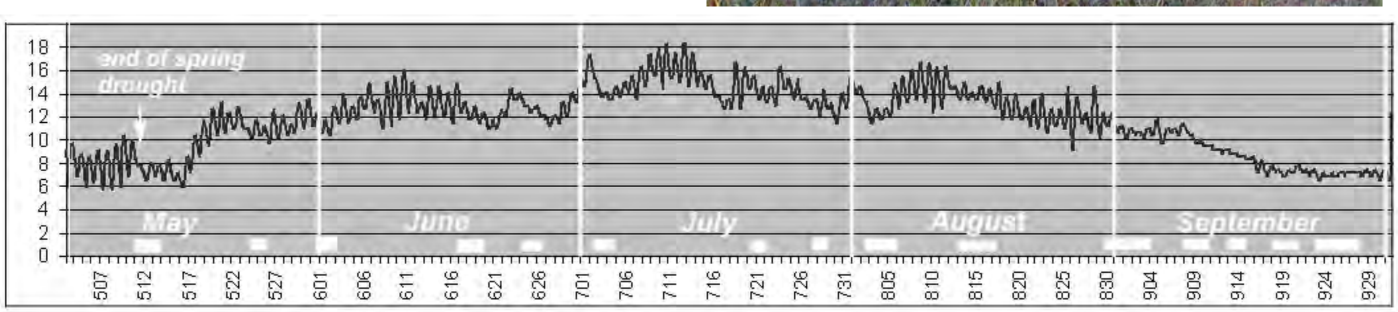


Fig 4.28 *Water temperature (Celsius) in frog pond (Fig 4.27), summer 2003. "507" = May 7th. Temperature logger was placed about 5 cm down into loose flocculent on the pond bottom. Bars across bottom show days with >0.2 inches of rain at Juneau Airport. Note correspondence of rainy periods with dampened water temperature fluctuations. As in most of our ponds, peak water temperatures were reached in early July. In September, increasing rains and overcast reduced the daily fluctuations.*

Fig 4.29 *Fen pond with early growth of pond lily and swamp horsetail, May 2, 2003. Water temperature 25°C, pH 7. About 6000 tiny toad larvae had just hatched from eggs laid 7 days earlier.*

Fig 4.30 *Emergents in shallow rich fen pond near Eagle River, June 4, 2003, pH 5.9. By mid summer the emergent buckbean, swamp horsetail and marsh fivefinger covered 100% of the pond. This pond had much shallower peat than the wood frog pond (Fig 4.27), resulting in much higher daytime and lower nightime temperatures (Fig 4.31)*

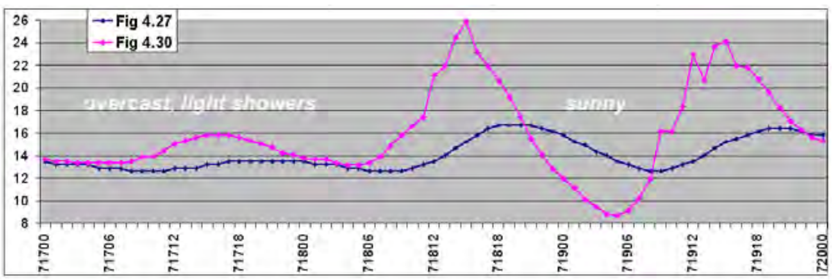


Fig 4.31 *Hourly water temperatures (Celsius) in a mature fen pond with deep peat (Fig 4.27) and a younger fen pond with shallow peat (Fig 4.30). "71700" = midnight, July 17.*

Fig 4.32 *Beaver/fen pond on Lincoln Island, May 26, 2003. Sedge-stabilized dam on left. Floating island with beaver haulout in center. Snags in background show that water occasionally rises ~1/2 meter higher. Crabapple and alder (left) are the only deciduous trees; beaver-favored cottonwood and willow are absent. Although we found no amphibians, newt, toad, and a rumored frog (sp?) occur on Lincoln Island.*

Admiralty Island with dense buckbean cover.

Fen ponds (with exception of the beaver/fen types described below) are the shallowest of our pond origin types. They have by far the highest percent cover of emergent plants such as buckbean (Fig 3.7), but because they are so shallow, there is relatively little cover of floating-leaved or submerged vegetation.

Like uplift ponds, many fen ponds are susceptible to dewatering during dry spells. The wood frog pond in Figure 4.27 lost all surface water by May 10th at the end of a month-long drought (Fig 4.28). But unlike the youthful uplift ponds developing on raised beach sand or silt, fen and bog ponds rest on deep, loose peat that never completely dries out. On May 29 the frog pond had regained about a decimeter of free water in the deeper portions, and contained 10 to 20 surviving tadpoles! These durable frog larvae had apparently rested in the damp organic muck for about a week until they were able to swim freely again.

Beaver/fen ponds On islands near Juneau we assessed several persistent ponds created long ago by beaver in rich fens. These ponds seem to be rare or absent along the Juneau mainland and on Douglas Island. Fens offer only marginal foraging opportunities for

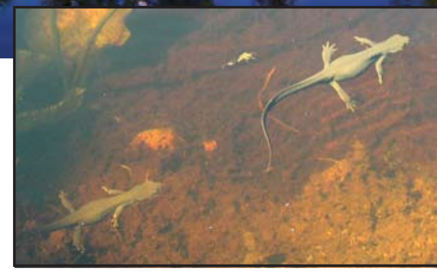


Fig 4.33 *Beaver/fen pond on Admiralty Island, July 7, 2003. Emergent sedges covered 5%, pond lily 5%, and submerged bladderwort 20%. Average depth 0.8 m. As in Fig 4.32, the sedge-bound beaver dam on far bank needs little maintenance to hold water. Haulout sign indicated light beaver activity. We counted at least 30 rough-skinned newts (inset) including an amplected pair.*

beaver, and we speculate that these beaver/fen pond systems may only develop in the absence of heavy predation. Both Lincoln and Admiralty Island lack wolves, and presumably experience lighter pressure from human trappers.

Beaver/fen ponds are found on moderately sloping ancient marine terraces and underlain by poorly drained sediments. Bogs and fens are intermixed on these surfaces. Groundwater movement through the rich fens would ordinarily be too strong for ponding to occur, but in many places beaver create networks of elongated ponds cross-wise to the slope (Fig 4.32, 4.33). The tall dams often hold water more than a meter above the trickle flows that emerge from their bases.

The Southeast islands generally lack willow and cottonwood that allow much higher beaver densities in places like Taku and Eagle River Valleys. In fact, the island beaver/fen ponds frequently appear abandoned. But over decades and even centuries*, sedge rhizomes thoroughly bind the dams, holding mud in place and making the barriers resistent to erosion even during periods of beaver absence. Fens rarely experience the high storm flows that beaver dams must contend with on streams, and so these elaborate pond networks become fairly permanent features.

Our limited experience with this pond type does not allow generalization about values to western toad or rough-skinned newt – the two amphibian species that occur widely on islands where these ponds are common. We located a cluster of adult newts in one Admiralty pond that was backwatered by a nearly continuous sedge-dam almost 200 meters long (Fig 4.33). Unlike the beaver ponds mapped in Figure 4.11, the upslope shorelines of the beaver/fen ponds are nearly as deep as on the downslope dam side. The relative lack of shoals with emergent plants may mean that ponds with this configuration are less than ideal for rearing toad larvae. But beaver/fen ponds come in a variety of shapes and shore profiles, and their abundance in some areas is clearly important to island amphibians.

Bog Ponds

Near Juneau, bogs generally occupy poorly drained, level or gently sloping marine terraces. These are much

Fig 4.34 *Bog pond at 1100 feet near Eaglecrest Road, April 24, 2003. pH 4.6, DO 5 mg/L. Low oxygen was typical of many ponds we measured at time of ice-out; by July 2, DO had risen to 7.5. Because of the higher elevation, ice melted later here than at sea-level bog and fen ponds. But within a week of this photo, water temperatures had risen as high as in the sea level ponds. This pond never achieved high cover of vascular aquatic plants; pond lily was 2%. We photographed an adult toad here in the early 1990s but do not know where breeding occurred.*

* The beaver of Admiralty Island are thought to be a unique subspecies, *Castor canadensis phaeus*. (MacDonald and Cook, 1996). This implies millennia of isolation on this canid-free island. Could a distinctive pond-engineering style have evolved in concert with the beaver's diverging morphology?

more common on Douglas Island than on the mainland. Groundwater is quite acid. The terrestrial plants in bogs are slow-growing, defended from herbivores by toxins, some of which may end up in the water of bog ponds. Bog ponds have the lowest percent cover of vascular aquatic vegetation of any of our pond origin types (Fig 3.7).

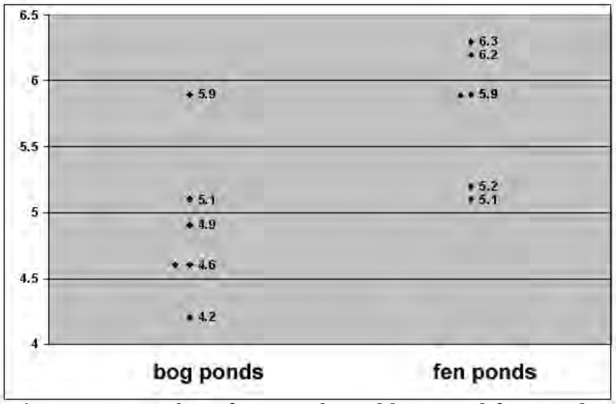


Fig 4.35 *pH values for 12 selected bog- and fen ponds*

It appears that bog ponds – at least those near the acidic extreme of the peatland spectrum – are much less suitable than fen ponds to breeding and rearing amphibians. We found no larval amphibians of any species in our assessed bog ponds, or in the 117 bog ponds that we scanned briefly during our study.

Many of the thousands of pit ponds in bogs are too small to be mapped on the 6-foot-pixel digital orthoquads, and therefore presented a challenge in the preliminary GIS mapping stage of our study. Rather than attempting to trace polygons around each bog pond, we simply outlined the perimeters of those portions of bogs containing numerous individual ponds. We consulted high-resolution 1979 color infrared air photos in stereo to select only the wettest portions of Juneau-area bogs (Fig 1.2). On arrival in the randomly selected polygon, we then measured pH in several ponds, and identified the most acidic for assessment. Even within a relatively small peatland unit, we often found acidity gradients, in some cases accompanied by obvious vegetative changes, and in other cases with little visual difference in water quality or plant community. Sometimes acidity increased downslope; sometimes it increased upslope.

In spite of our attempt to select the most acidic bog ponds, pH differences between these and our randomly selected fen ponds were not great (Fig 4.35). At the wood frog (poor-fen) pond (Fig 4.27), we measured pH as low as 4.7 in spring of both 2002 and 2003. In that pond, which might best be considered a "hybrid" bog/fen pond, the strongly acid environment did not prevent successful development of frog larvae.

In a Quebec study of wood frog pond water chemistry, egg mass density and hatching success were reduced in low-pH ponds. However, even in ponds with average pH as low as 4.3 and 4.7, hatching success was 47% and 80%, respectively. (Gascon and Planas, 1985). Thus, for wood

Fig 4.36 *Bog pond on Douglas Island, May 29, 2003. pH 4.2. Matrix of sphagnum moss and small sedges, no vascular aquatic plants. Temperature logger (Fig 4.37) was set about 5 cm into the loose bottom organics*

Fig 4.37 *Hourly water temperatures (Celsius) in fen pond (Fig 4.27) versus bog pond (Fig 4.36). "710" = July 10th, 2003. In this bog pond (and also in the higher elevation bog pond in Fig 4.34) daily amplitude rarely exceeded one degree C.*

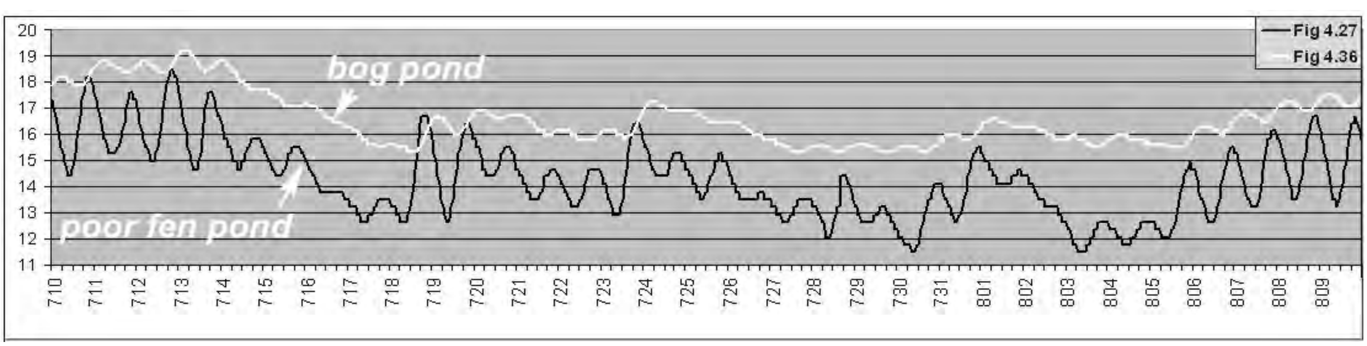


Fig 4.38 *View north along shallow bedrock-controlled lake on 1000-foot bench above 21-mile, Glacier Highway, Aug 8, 2003. Location is shown by arrow in Fig 4.39. Outlet is subterranean. Average depth of water visible from shoreline is only 5 decimeters. Exposed mud shoreline suggests erratic water levels. Aquatic vegetation – pond lily and burreed – is concentrated here at the south end of the lake, and only covers 1% of the total lake surface, probably because of the unstable water level. Most of our bedrock-controlled lakes had more stable water lines and more extensive cover of pond lily.*

frog, if not for western toad, the acidity of Southeast Alaskan bog ponds should be tolerable. If we are correct that bog ponds are less suitable than fen ponds for amphibian larvae, then there are probably other limiting factors in addition to water acidity. These might include plant-derived toxins, relative lack of aquatic vegetation, loss of eggs to mould, predators such as dragonfly naiads or giant water beetles, and the more dystrophic (food-poor) character of bog pond waters, possibly retarding growth of amphibian larvae.

Bedrock Ponds

Most of our pond origin types develop on relatively flat surficial deposits formed by marine, alluvial, or anthropogenic processes. Another category that includes our largest ponds and lakes occurs on upland sites in bedrock depressions. The primarily metamorphic rock types around Juneau are not conducive to high lake density. Granitic bedrock in places like Baranof Warm Springs or Misty Fiords results in greater concentrations of large, deep lakes.

Because highways follow paths of least resistance, the Juneau road system and its near surroundings are limited mostly to low-lying surficial landforms. There are only a few areas where upland slopes containing bedrock-controlled ponds fall within the half-mile buffer. Fig 4.39 shows a 1000-foot-high bench paralleling Glacier Highway from 18- to 27-mile. Four of our 6 randomly selected bedrock lakes fell on this bench.

Accessing these lakes resulted in some precipitous bushwacks. It was hard to imagine toads or newts navigating such terrain.

Bedrock-controlled ponds are by nature more isolated than ponds on flatter unconsolidated surfaces. The often-steep intervening terrain may present additional obstacles to amphibian recolonization, should a local population "blink out." We speculate that prior to the recent western toad declines, the species was so abundant that almost all ponds and lakes – bedrock included – received steady immigration. Now that only a small number of ponds near Juneau have toads, the odds of re-occupation for isolated bedrock lakes are severely reduced.

We only assessed 6 randomly selected bedrock ponds and lakes, plus an additional two – one within and one outside of the half-mile road buffer. One of our 6 selected ponds and one of the non-selected lakes held breeding rough-skinned newts (Fig 2.3). Three of the 8 surveyed bedrock ponds are

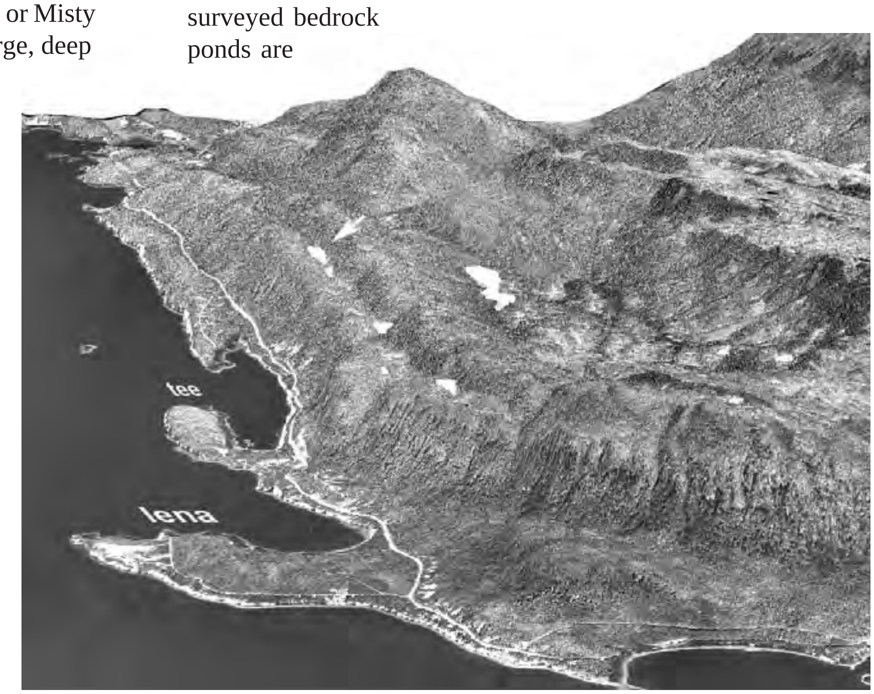


Fig 4.39 *Oblique view north to the Tee Harbor shoreline, generated in ArcScene from digital elevation model and 1996 digital orthoquad. Lakes dot the 1000-foot bench paralleling Glacier Highway. Arrow identifies 21-mile Lake shown in Fig 4.38. Largest is Peterson Lake, on the next plateau to the east.*

known to have formerly supported breeding western toads, but our surveys there in 2002 and 2003 failed to detect any larvae or adults.

Bedrock-controlled ponds and lakes tend to be deeper and therefore colder than those developing on surficial materials. Amphibian studies from the Pacific Northwest suggest that large bedrock-controlled ponds and lakes are less suitable than smaller ponds for breeding amphibians (Olson et al. 1996). In addition to cooler temperatures, lakes may harbor predators that are lacking in smaller ponds unconnected to streams.

Many lakes are accessible to fish that prey on amphibian eggs and larvae. In Southeast Alaska, even high elevation lakes that are not fish-accessible have often been stocked with native or exotic fish species. In a Sierra Nevada study (Bradford, 1989), lakes with introduced trout completely lacked the once widespread mountain yellow-legged frog. Western toad once occurred there as well but was not found at the time of the study. It is possible that the era of floatplane-based stocking of Southeast Alaska's high-country lakes had similar effects on our toad populations. Western toads can breed in bedrock lakes at surprisingly high elevations, for example "Border Lake" at 3000 feet above the Wright Glacier on the US-BC border, where hundreds of metamorphs were seen in summer of 1998 (Ed Buyarski, pers.comm.).

Auke Lake was by far the largest of our assessed lakes (69 hectares; 172 acres). From 1953 to 1973, toadlets dispersed every year in great numbers from "Picnic Point" on the lake shore (Lance Herrington, pers. comm.). On another lawn fringing the

Fig 4.40 *Shore of Auke Lake, July 3, 2003. Most of the shore is gently shoaling and the pond-lily/horsetail/sedge belt is only interrupted at docks and boat launch areas. Our last toad reports were in the 1980s.*

Fig 4.41 *Hourly water temperatures in Auke Lake compared to a small uplift pond, May 27 to June 10, 2003. The Auke Lake temperature logger was tethered in about 4 decimeters of water and pressed several centimeters into vegetative debris on the bottom. Because of its greater size, Auke Lake's water temperatures responded only minimally to changing weather conditions. Three days of clouds and rain in early June caused a dip in the small pond's temperature profile that hardly registered at Auke Lake, where water temperature cycled steadily higher into summer, independently of sun and rain..*

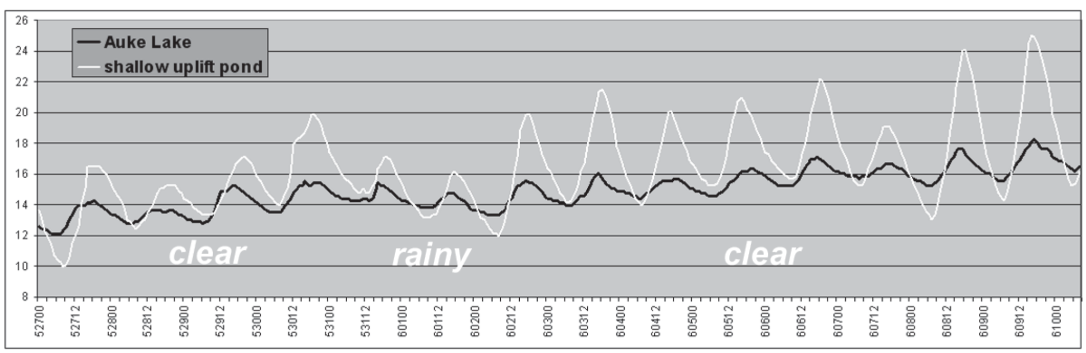


Fig 4.42 *View north over bedrock-controlled pond with diverse shoreline, June 14, 2002. Depth in center about 1 meter. Cover boards on the shores of this pond were often used by rough-skinned newts, and our traps caught dozens. The last western toad record we have for the area was a single adult in summer 2001. A nearby resident who grew up here says that when she was a girl, toads were abundant; we therefore assume that breeding occurred in the pond.*

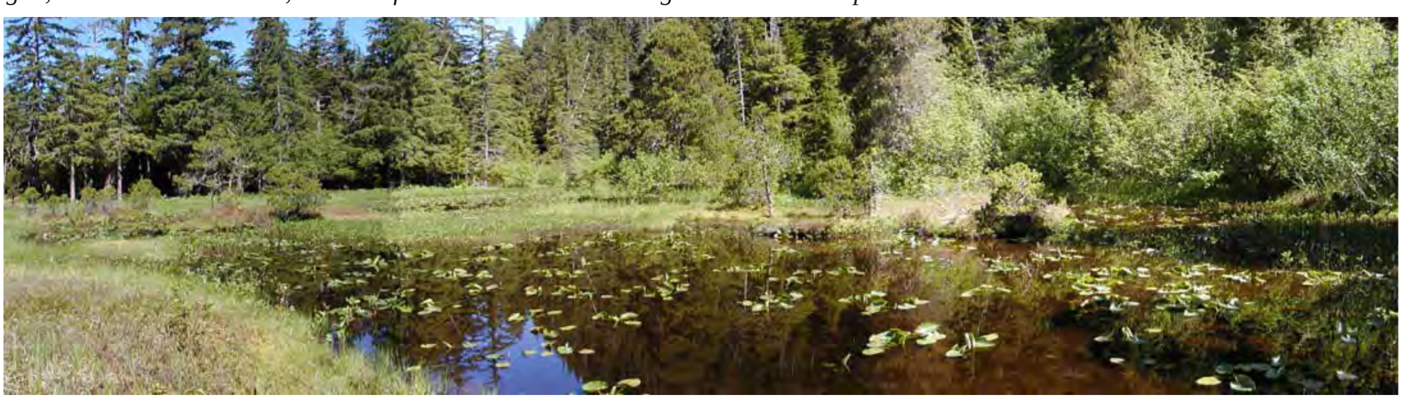


***Fig 4.43** Landslide-dammed pond and contiguous horsetail marsh on Douglas Island, July 29, 2002. No amphibians were seen on this visit, but several adult toads were observed here in August 2001.*

western shore, thousands of metamorphs migrated up from the lake each summer until about 1980, but have not since been seen in that location (Justine Bishop, pers. comm.). Our boat-based survey of the lake shore in July 2003 turned up no toad larvae.

Auke Lake is deep and has several species of salmonids that presumably prey on amphibians. Our amphibian traps incidentally caught large numbers of prickly sculpins (*Cottus asper*) from 60- to 150 mm in the same lake-fringe habitats where tadpoles apparently used to develop. According to fisheries biologist Gretchen Bishop, these sculpins were never captured in minnow traps in Auke Lake in the 1970s.

The lake's shallow margins have excellent tadpole rearing habitat – a nearly continuous belt of sedges, horsetails and pond lily. These are plants we continue to find associated with the surviving populations of toads breeding in much smaller ponds. The consistency of the pond lily/sedge belt along the shores of Auke Lake raises a question: Did western toads breed and rear in only a few loci around the lake shore, such as the above two reported examples, or did much of the lake shore give rise to this late summer invasion? If so, the total annual production of toadlets from Auke Lake may have been spectacular.

Bedrock-controlled ponds had the highest percent cover of floating-leaved aquatic plants of all pond origin types except riverside ponds (Fig 3.7). Among our bedrock ponds, pond lily was always the dominant species in this vegetation zone, ranging from 1% (Fig 4.38) to 60% cover.

Along with bog ponds, bedrock-controlled ponds are the most successionally stable of all our pond origin types. Unlike bog ponds, however, many bedrock ponds provide high quality amphibian habitat. While western toads seem well adapted to dynamically changing, early successional ponds, the down-side of such ponds is that many eventually become unsuitable when trees overhang and shade the margins. Over geologic time, availability of "young" ponds changes – high during times of deglaciation and glacial rebound, and low during times of climatic equilibration, such as the Hypsithermal, a warm interval prior to Neoglacial times. The continuous availability of bedrock-controlled ponds to spawning toads throughout the millennia since the Great Ice Age has probably had a stabilizing influence on western toad populations.

Pond origin types not included in our selection group

Landslide-dammed ponds – We know of two ponds backwatered behind small landslide deposits in the Juneau area. Both are outside the ½ mile road buffer. There were too few ponds of this type to merit inclusion in our series of selection ponds.

The two landslide ponds are of very different character. One is on Salmon Creek, about half way from the estuary to the reservoir. A fairly recent slide from the north valley wall crossed the access road and ponded the creek, drowning conifers in the valley bottom. This new pond is shaded by steep hillsides and nearby surviving trees. We did not survey there.

An older landslide-dammed pond on Douglas Island (Fig 4.43) has probably supported breeding toads within the last few years (Kathy Hocker, pers. comm.). Judging from the age of spruces on the moraine-like outer limits of the slide deposit, it occurred about a century ago. The slide swept down a steep hillside onto the back of a raised ancient marine terrace and continued about 250 meters out onto the poorly drained surface. Behind the outermost deposit is a shallow pond fringed with swamp horsetail and buckbean. Pond lily grows in the deeper sections. This pond appeared to be excellent amphibian habitat.

Riverside ponds

With logistical support from the US Fish and Wildlife Service and major assistance from Bob Christensen of SEAWEAD (Southeast Alaska Wilderness Exploration Analysis and Discovery), we were able to spend 5 days in late June, 2003 on the upper Taku River. Two goals of this trip were to gain experience with amphibian species unavailable to us in Juneau – particularly spotted frog and long-toed salamander – and to assess a variety of ponds on the Taku River floodplain to compare with those we studied along the Juneau road system.

We do not have enough familiarity with river-margin ponds to attempt to place them within our origin-type classification system. To do so would require more thorough GIS mapping of river and associated backwater systems, examination of beaver dams and other flow-obstructions, observation of seasonal changes in relation to river level, and also a better understanding of changes to these ponds over years and decades. We can, however,

Fig 4.46 *"Pebble Pond" on sand/cobble bar in side channel of Taku River. Unlike more mature ponds with aquatic vegetation, the larvae here were evenly dispersed over 120 m.*[2]

Fig 4.45 *Dispersed toad larvae in "Pebble Pond" (Fig 4.46).*

describe several ponds where we found amphibians, to illustrate some of the range of variation.

At the early successional extreme, certain riverside ponds help explain how western toad became pre-adapted to spawn in barren anthropogenic ponds such as gravel pits within a year of their creation. "Pebble Pond," (Fig 4.45 and 4.46) formed on a sand/cobble bar in a high-water channel on the back side of Canyon Island, 2.5 miles downriver from the Canadian border. The pond was devoid of vascular aquatic vegetation, and yet we found about 1500 toad larvae there on June 26, 2003. Unlike better vegetated ponds where we usually found tadpoles in dense swarms, larvae were spread evenly throughout Pebble Pond at a density of about 12 per square meter. Whether due to slower growth rate or later spawning, these larvae were smaller than those of better-vegetated ponds. Most were resting against the bottom, presumably feeding in the thin film of detritus. Although bedrock is poorly mapped along the international border, yellow dryas on the river bars and the high pondwater pH of 8.5 both suggested high carbonate content in the alluvium.

At the time of our visit the pond was roughly a meter above river level. But toad larvae in this pond, and others like it, would be flushed out during a high water event. In addition to the late summer high flows, the upper Taku is swept as often as three times per year by outburst floods from the Tulsequah Glacier. At these times, floods can even reach into riverside fireweed meadows (Keith Pahlke, pers. comm.). Virtually any pond close to the Taku mainstem would be emptied of amphibian larvae during such an outburst.

The pond in Figure 4.47 is slightly higher and more removed from the Taku, but still certainly vulnerable to outbursts and late summer high flows. Toad larvae had apparently spread from this natal pond through a narrow connecting slough out into the broad backwater channel that isolates Canyon Island. Water temperature in the shallow margins of this larger back channel was 7.6°C, far below optimum for rearing larvae. But the tadpoles were clearly mobile and probably even able to feed. This raises a question: Could flushing of river margin ponds by high flows serve under ideal circumstances as a dispersal mechanism for toad and frog larvae?

Our highest amphibian diversity came from "Drained Ponds" (Fig 4.48. See also the habitat assessment form for these ponds, Fig 1.4). At higher water they form a single elongated pond, but at the time of our visit they had divided into several, two of which are mapped on the

Fig 4.47 *Pond created by upwelling of ground water. Outflow connects to a back channel of Taku River in right distance. Tadpoles were swarming in the warmer water away from the upwelling. We also found dispersed tadpoles, possibly siblings from this natal pond, hugging the grassy margins of the Taku back channel. This pond contained small salmonids.*

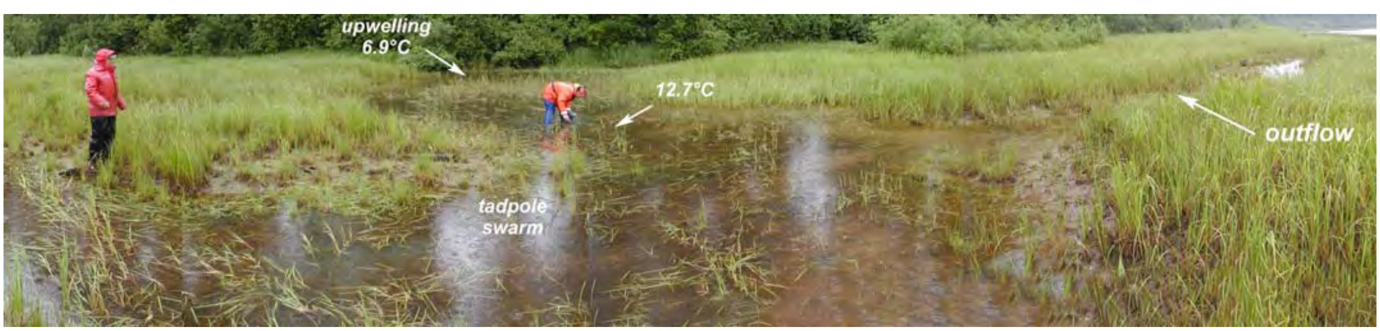


Fig 4.48 *"Drained Ponds" in a high-water swale connected by labyrinthian channels to Taku River. Toad, frog and salamander larvae co-inhabited this pond. Stranded burreed lies on the mud. Fig 4.49 shows vegetation.*

Fig 4.49 ***Above****: Pondweed and pond lily from the smaller of our two "Drained Ponds."* ***Below****: green algae from the bottom of another shrunken pond nearby that connects with Drained Ponds at higher water levels. We nicknamed it "oxygenweed" for the highest DO – 19 mg/L – measured during our project. An adult spotted frog dove into the algae to hide.*

assessment form. This pond system occupies a low swale that is currently blocked from the Taku back channel by a tall levee with mature cottonwoods. Flood waters enter this pond system in round-about fashion from a distant breach in the levee, and never achieve high velocities here, as evidenced by the fine, compacted muck exposed in this swale. Our probe struck an even firmer layer at 3 decimeters, so the ponds are probably not susceptible to complete dewatering. As with Pebble Pond, the water was very basic (pH 9.0).

Pond shrinkage evidently did not impair water quality. DO was very high. Nearly 100% of both ponds was covered with floating-leaved vegetation, primarily pondweed, but also pond lily and burreed. A dense mat of green algae (Fig 4.49) covered the bottom in some places, possibly responsible for the extremely high dissolved oxygen in those pools.

The thick vegetation made larval counts difficult, but we estimated more than 200 spotted frog and 500 western toad tadpoles in the smaller of the "Drained Ponds" pair. Net sweeps through vegetation in the deepest portions of both ponds yielded the first and only long-toed salamander larvae (Fig 5.27) of our study, ranging from 25 to 45 mm TL (total length).

The ponds were also full of potential predators on amphibian

Fig 4.50 *Halfway up Fatpole Slough from Yehring Creek (map in Fig 4.51). Floating burreed covers 30% of surface. A submerged species of pondweed covers 60%. This slough contained seemingly endless swarms of large toad larvae, cruising slowly against the emergent sedges. Eight traps set overnight captured hundreds of toad larvae and sticklebacks and a single spotted frog larva.*

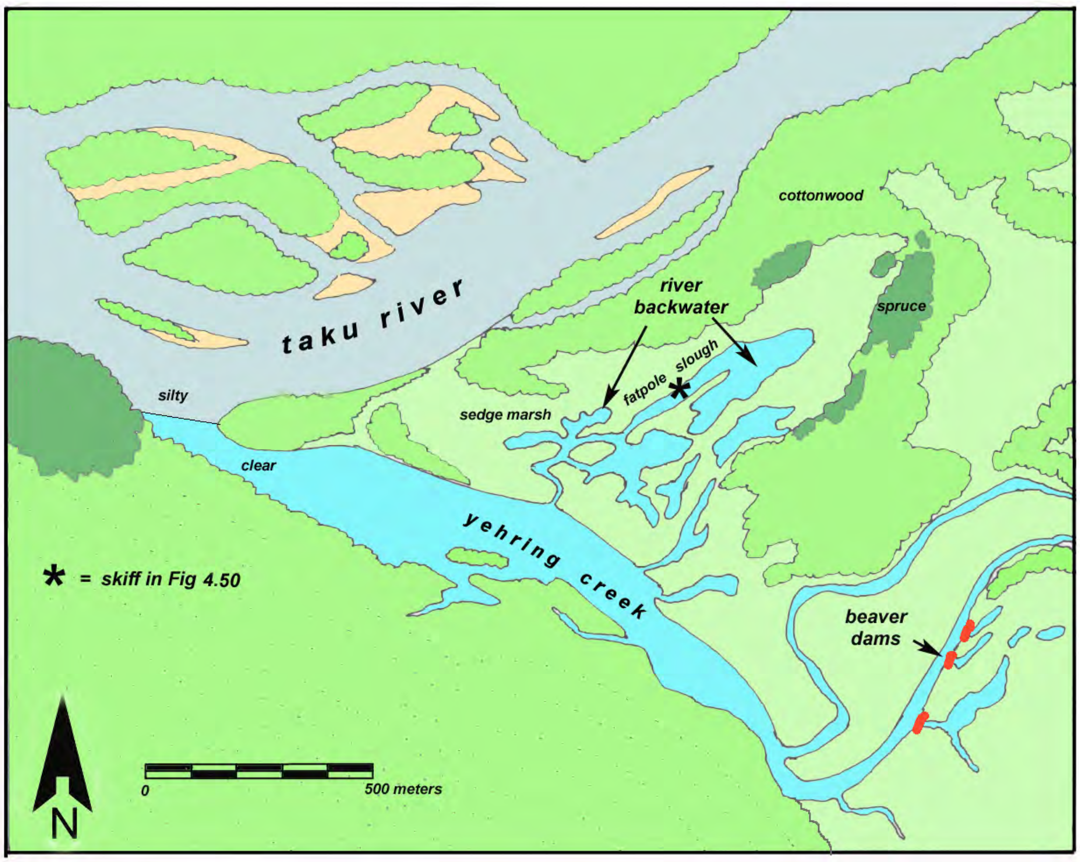


Fig 4.51 *Yehring Creek and Fatpole Slough, backwater systems of Taku River. On June 24, 2003, toad larvae were spread over 200 meters of the middle reaches of Fatpole slough. One spotted frog larva was trapped at the northeastern tip of the slough. Beaver-dammed ponds are indicated in the lower right, but we found no comparable dam at the junction of Yehring Creek and Fatpole Slough.*

larvae. Traps and net sweeps captured sticklebacks, skimmer and darner naiads, large leeches, and giant diving beetle larvae, one of which was dining on a captured toad tadpole. In the air above was the densest cloud of mosquitos we encountered in two summers of pond surveys. Apparently amphibian and invertebrate density are a package deal.

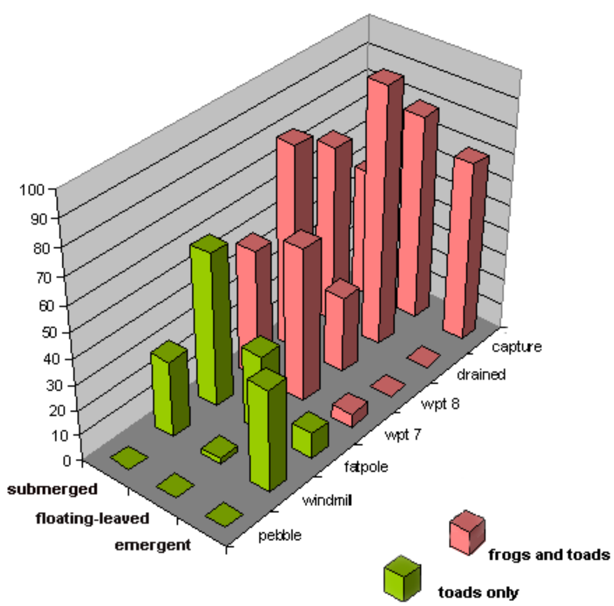


Fig 4.52 *Percent cover in 3 aquatic plant zones for 7 riverside ponds near Taku River containing larval western toad and spotted frog.*

At Yehring Creek, 8 miles downriver from the US/BC border, we investigated a much larger type of riverside larval rearing pond (Figs 4.50, 4.51). Poling our skiff up “Fatpole Slough,” we drifted over tens of thousands of plump, 40 mm-long toad larvae. The slough was rarely deeper than one meter, and floating-leaved burreed was present almost throughout. This was the greatest congregation of western toad tadpoles we encountered during our 2002-2003 study. One trap captured a spotted frog larva, but we have no estimate of how many inhabited the slough.

The water level of lower Yehring Creek is controlled by the height of the Taku River. Leaving the silty Taku mainstem, the water of Yehring Creek becomes quite clear. At the entry to Fatpole Slough, we noted no evidence of beaver dams. It is possible, however, that beaver played some role in the creation of this slough/marsh system. A stronger historical perspective is needed, because these poorly understood ponds and sloughs appear to support the healthiest remaining populations of a declining species.

The above 4 examples of amphibian-occupied ponds and sloughs illustrate the great range of aquatic habitats on the Taku River floodplain. What they have in common is *dynamism*: seasonal, successional, and hydraulic. The thriving amphibian populations on Taku River (At least they appeared that way to us after two seasons of amphibian work around Juneau, where we could go for days without finding amphibians.) suggest that the destructive aspects of this dynamism are outweighed by benefits. The very floods that extinguish some larval populations in small riverside ponds may float adults or yearlings or even larvae into new habitats, promoting genetic mixing and

Fig 4.53 *Abandoned side channel of "Saint James River," now an elongated pond about 50 meters long. On June 15, 2003, we estimated 5000 to 7000 toad larvae in several clusters (inset) were spread throughout the central reaches.*

increasing colonization rates.

Compared to ponds near Juneau, the Taku's riverside ponds and the surrounding terrestrial (adult) habitat also share a more continental climate. Perhaps the colder winters and longer-lasting snowpack improve the over-winter survival of toads. In the Yukon and northern BC, western toads "are limited to areas of high snowfall, where limited frost penetration allows safe hibernation." (Slough, no date). In *Synthesis and recommendations* we speculate on the possible connection between light-snow winters of the past decade and increased losses to disease in much of lowland coastal Southeast Alaska.

Early successional status of riverside ponds also leads in most cases to highly productive vegetation, both terrestrial and aquatic. On average, our riverside ponds had the highest percent cover of both submerged and floating-leaved aquatic plants of any of our pond origin types (Fig 3.7). Submerged aquatic species were diverse, including pondweed (varieties that had not reached the surface), water crowfoot, green algae (Fig 4.49) and limp-stemmed forms of marestail in water too deep for the plants to become emergent. In the floating-leaved zone, burreed and pondweed were usually the dominant species. (In contrast, bedrock ponds, with the second highest percent cover in the floating-leaved zone, were always dominated by pond lily.)

At the ponds' edges, emergent plants were often sparse or absent in our riverside ponds (Fig 4.52). In some riverside ponds water levels were unstable, and bands of bare mud surrounded them. Water fluctuation inhibited emergent plants (Fig 4.48).

The importance of aquatic plants to amphibian larvae has been described in *Aquatic vegetation*. The plant-rich ponds of the Taku River floodplain may be yet another factor contributing to the area's apparently high amphibian productivity. Among our small sample of 7 ponds (Fig 4.52) spotted frog larvae appeared restricted to ponds with plentiful cover in the floating-leaved and submerged zones. Western toad larvae co-inhabited these plant-rich frog ponds but were also found in a barren pond ("Pebble"). They probably tolerate a broader variety of pond conditions. However, the presence of toad larvae in a pond is not the final word on reproductive success. Mortality in larval and early post-larval stages may be higher in ponds lacking aquatic or even marginal terrestrial vegetation.

One other location where we were able to assess a "riverside" pond with toad larvae was in Saint James Bay. The river entering the head of this large bay northwest of Juneau has no name on topographic maps, but is large and active enough to divide into braids just above the estuary (Fig 4.54). This "Saint James River" has an easterly overflow channel that carries only a fraction of the mainstem's volume. That easterly braid is in turn paralleled by an abandoned channel, now ponded and isolated except during major flood events (Fig 4.53). It was here that we found tadpoles.

The large Saint James watershed contains no mapped karst, but extensive units occur to the northeast (Boat Harbor) and southwest. The river originates on bedrock typed as "Silurian sedimentary," which includes small unmapped areas of carbonate rocks.

The buffering influence of limestone in the floodplain is revealed in the tadpole pond's pH (8.6) and in the thick

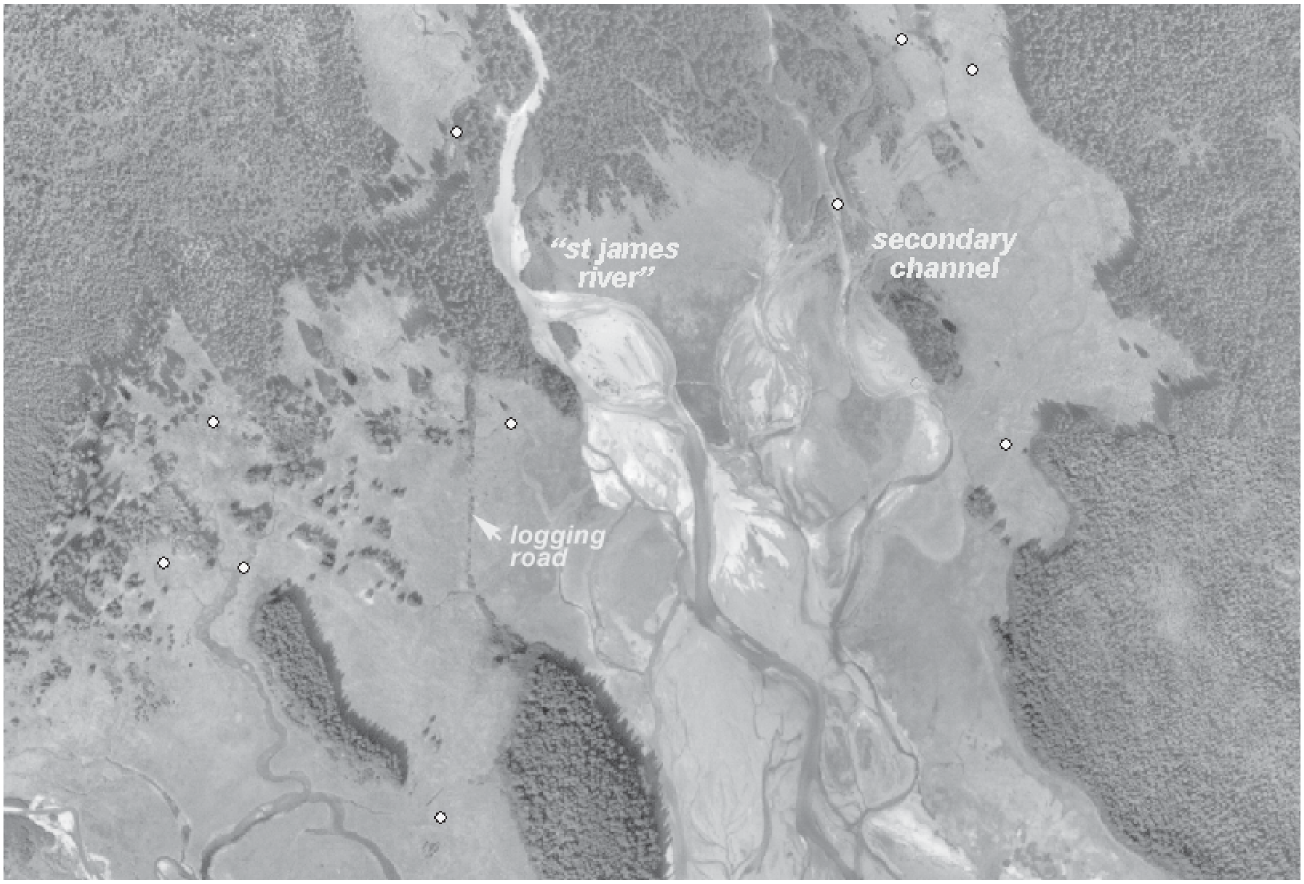


Fig 4.54 *Digital orthoquad for uplift meadows at the head of Saint James Bay. Dots are downloaded waypoints, mostly toadlet observations. Pond density is very high in the meadows.*

beds of stonewort (*Chara*) concentrated around upwellings in the pond's upper reaches. Emergent sedges and northern scouring rush (*Equisetum variegatum*) cover 20% of the pond margins. This is a different species of horsetail from the *E. fluviatile* that we commonly found in still-water ponds. It is a colonizer of raw surfaces including stream banks and active river floodplains. Northern scouring rush is an indicator of the relatively volatile seasonal regime and successional history of this pond. As on the Taku floodplain, the tadpoles in this pond could be swept away if a sudden flood were to overtop the adjacent secondary channel of Saint James River.

The 5000 to 7000 toad larvae we counted here were more than we found in any Juneau-area pond. Some were schooled in masses of up to a thousand in the warmest shallows less than a decimeter deep (22^{o}C; 70^{o}F). Others were spread out in slow-moving "caravans" in deeper, cooler water, mostly swimming in one direction. One cluster of ~50 larvae was feeding on the decomposing carcass of a 60 mm adult toad.

Like the Taku River Valley, Saint James Bay is considered a "snow hole." Perhaps overwintering toads here have more stable, ground-insulating snow cover. In addition to the toad larvae in the riverside pond, we saw about 200 yearlings, born the previous summer, scattered throughout uplift meadows at the head of the bay during 3 consecutive sunny days. This was by far the highest concentration of toadlets other than fresh metamorphs that we encountered during our 2002-2003 study. (Far more larval ponds were found on the Taku, but no toadlets. This however, was probably related to the cool rainy weather during our Taku sampling.) If we are correct in our impressions that toad populations at Taku and Saint James are healthier than at Juneau, there may be a suite of positive influences on toads, including floodplain dynamism, pond density, pond habitat quality, and climate.

Near Juneau there are several glacial rivers larger than the Saint James – the Mendenhall, Herbert and Eagle – but all are strongly incised in their middle and lower reaches. We did not find riverside ponds similar to those at Saint James and Taku in the former channels on the now-abandoned floodplains of these large glacial rivers. Probably the groundwater is too low in these incised systems to maintain water in the swales. Actively aggrading rivers seem to be a prerequisite for development of the kind of amphibian pond habitat we found at Saint James and Taku.

Both Saint James Bay and the Taku River floodplain have a high density of ponds of several origin types. As described in *Juneau area breeding ponds*, this probably leads to high colonization rates, a key feature for healthy populations of western toad.

5 Natural history observations

The purpose of our study was to determine the presence or absence of amphibians by habitat type, and to characterize those pond habitats. However, we did record many observations of amphibian natural history that might be useful in further studies. In fact, most of our field work in 2002 was directed simply at assembling local phenology information for western toad, wood frog and rough-skinned newt. Without these basic life history dates, it would have been very difficult to plan for the more intensive 2003 field season.

We hope that our natural history notes will be useful to those who may conduct amphibian-monitoring programs along the Juneau road system or elsewhere in Southeast Alaska. Our comments below refer primarily to the immediate Juneau area, with occasional examples from other areas we visited such as Taku River and Saint James Bay.

Fig 5.1 *Adult female western toad, July 26, 2002. Western Toads have numerous warts and pronounced parotoid glands at the back of the head. They can vary in color from brown, green or gray above, and white with dark mottling below.*

Western toad (*Bufo boreas*) – native and widespread in Southeast

Six stages in the life history of toads are described here. We typically give total length including tail (TL) for larvae, and snout-vent length (SVL) for terrestrial forms. The stages are:

1 eggs (1.5 mm diameter)

2 larvae (5-40 mm TL)

3 metamorphs (terrestrial forms in late summer of their first year, 9-25 mm SVL)

4 yearlings (small toadlets in their second summer, 20-45 mm SVL)

5 probable subadults (toads 45-65 mm SVL and presumably more than 2 years old)

6 probable adults (breeding sized, more than 65 mm SVL)

Mating and egg laying Adult toads congregate at ponds to mate and lay eggs. According to MacDonald (2003) breeding occurs in Southeast Alaska from May through July. However, our observations along the Juneau road system turned up breeding toads in late April.

Females lay long strings of bead-like eggs in shallow water, often around submerged vegetation. An individual female toad may carry thousands of eggs (Hodge 1976).

We observed toads mating at only one location on the Juneau road system. At this site about 10 to 12 individuals congregated on April 29, 2002. About 20 were seen the following year on April 24. In both years we observed several adults in their mating embrace (amplexus) and could hear the chirp-like calls of the males.

Toad egg strings were found at two locations near Juneau. At the first site eggs were seen on April 29, 2002, and earlier in spring of the following year – April 24, 2003. The latter eggs had hatched by May 2, 2003, about 8 days after they were laid. At the second toad breeding site, eggs were first seen on May 3, 2003. These eggs never hatched, due to drought and pond dewatering. There was a second

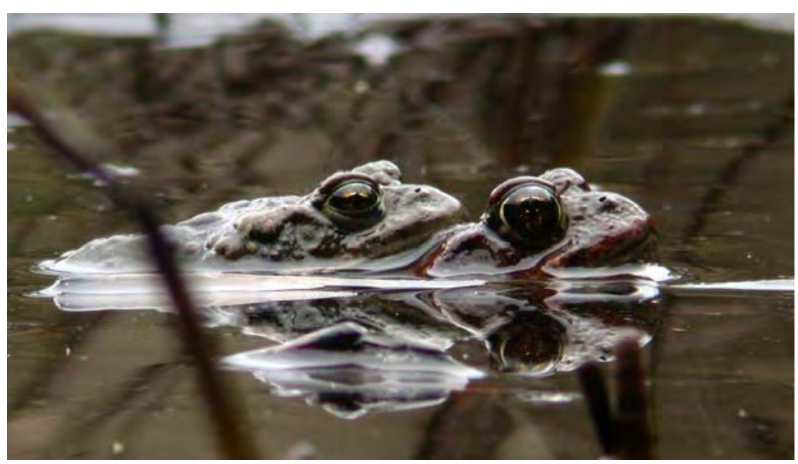


Fig 5.2 *A pair of western toads in amplexus (female in front, male back).*

Fig 5.3 *Fifty western toad eggs in a 20-cm segment of a single, 10 meter-long string that was stretched taut across a shallow uplift pond. The total number of eggs in the stringer is therefore estimated at 2500.*

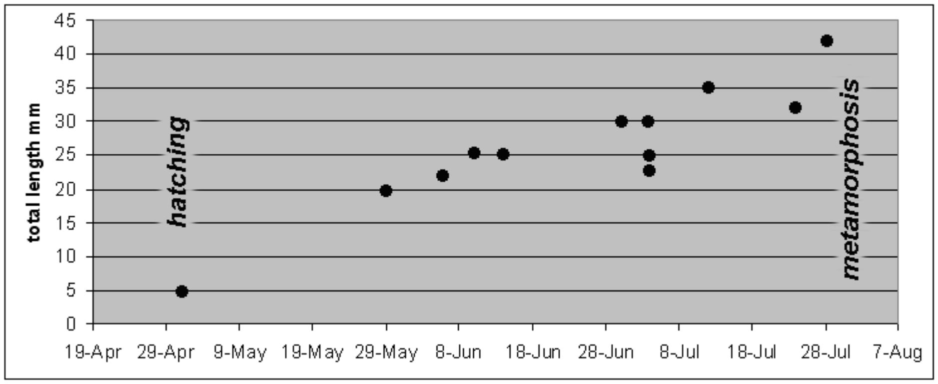


Fig 5.4 *Larval growth in millimeters TL between hatching and metamorphosis. Hatching occurred the first week in May. Dates of peak metamorphosis for 6 Juneau toad ponds ranged from July 20 to Aug 1.*

attempt, with eggs seen again on May 21, 2003.

Egg mass counts are a standard method for amphibian population estimates. In our limited experience, however, the long toad egg stringers that result from communal spawning are so thoroughly entertwined that counting the output of individual females is difficult. Lance Lerum (pers. comm.) had similar experience with toad egg masses on Admiralty in summer 2003. Another limitation of egg mass counts is the brevity of their existence. In censusing large areas it is very easy to miss the toad egg period. Perhaps egg census will become better targetted over time, now that location and approximate timing for the Juneau-area breeding ponds are known.

In only one place did we find two ponds in close proximity that contained toad larvae, and it is possible that those two (uplift) ponds were connected during periods of high water. Their tadpoles could therefore actually be siblings from the same original egg masses. Elsewhere, our toad breeding ponds were widely separated from each other. We speculate that with declining toad populations, mating adults from wide areas are drawn together into single spawning clusters in spring by vocalizations and possible olfactory cues. It would thus be unlikely for two nearby ponds to host rearing larvae, unless the mating congregations converged at different times.

Tadpoles Schools of small, black tadpoles were observed at 6 locations along the Juneau road system on 17 different dates. The earliest observation was on May 2, 2003 and the latest on July 38, 2003. The following observations are ordered chronologically by location, to provide a schedule of larval growth.

Fig 5.5 *May 2, 2002. Immediately post-hatch toad larvae are 5 mm total length (TL).*

Fig 5.6 *June 8, 2003. 20- to 25 mm TL. Toad larvae often school tightly in shallow, warm water*

<u>Uplift Pond #1.</u>

• June 19, 2002. Estimated 4,000 to 5,000 tadpoles in a 75 square meter area.

• July 4, 2002. Thousands of tadpoles present, ranging in size from 5-7 mm to over 1 cm snout-vent length (SVL). Longest legs about 3 mm. Even smallest tadpoles have leg buds.

• July 29, 2002. Only about 20 to 40 tadpoles remain in the ponds. They range from 24 to 42 mm TL. We also saw perhaps 20 dispersing juveniles ~12 mm SVL.

• (In 2003, pond was not visited between May 21, when egg stringers were seen in extremely shallow water – Fig 5.3 – and July 4.)

• July 4, 2003. One pond is shrunk to 1.5 m^2 and <1 cm deep and holds about 1500 dying tadpoles (Fig 4.21). They average 30 mm TL. Other completely dry ponds are dotted with the "tar-masses" of rotting larvae. Breeding in this pond

Fig 5.7 *July 26, 2002, 30 mm total length (TL). Western toad tadpoles are uniformly black or charcoal with dark tail musculature.*

Fig 5.8 *July 29, 2002. More than 1000 transforming larvae were using the* top *of our cover board!*

cluster was a complete failure in 2003.

Uplift Pond #2

• July 4, 2002. Legs present.

• July 29, 2002. Many tadpoles still present, hind and front legs evident, but most (thousands) have metamorphosed.

• (As at Uplift Pond #1, this pond was not visited in 2003 between May 21 and July 4.)

• July 4, 2003. About 2000 tadpoles present, averaging 25 mm TL, most with hind legs.

Uplift Pond #3

• June 10, 2003. About 1,000 tadpoles discovered, ~25 mm TL. Swarms of a few dozen to 200 (Fig 4.19)

• July 10, 2003. Pond choked with milfoil, so larval count impossible. Saw only about 20 tadpoles, ~35 mm TL. Hind legs 3-5 mm long, and beginnings of front leg buds.

• July 28, 2003. No larvae remaining, only metamorphs. See notes for adjacent uplift pond #4.

Uplift Pond #4

• July 28, 2003. Late larvae still present, while those in adjacent pond #3 are now completely terrestrial. Most are plump and have only buds for front legs. One group, still aquatic, is resorbing tails and becoming more angular in shape. This pond is more saline than pond #3, possibly accounting for the slower development.

Fig 5.9 *Recent metamorphs are quite small and skinny.*

Fen Pond #1

• June 6, 2002. Tadpoles about 22 mm TL.

• June 14, 2002. Tadpoles about 25 mm TL.

• June 22, 2002. Tadpoles present. Pond level down to only ~ 7 cm.

• June 30, 2002. Tadpoles have no sign of developing legs.

• July 12. 2002. Tadpoles have hind legs but no front legs evident.

• July 27, 2002. Tadpoles ~32 mm TL, hind legs ~8 mm long, some still without front legs. Dispersed and no longer clustered. Counted only 8, visibility obscured by pond lily.

• May 2, 2003. About 6,000 tadpoles observed, ~5 mm TL, immediately post-hatching (Fig 5.5) Remnants of egg jelly still present. Leeches and sticklebacks attending the swarm.

• May 29, 2003. Over 1,000 tadpoles observed, 18-22 mm TL.

• July 2, 2003. Over 200 tadpoles ~28-32 mm TL. Hind legs appearing.

• July 28, 2003. No larvae remaining, only metamorphs, 10-13 mm SVL.

Beaver Pond #1

• June 8, 2003. About 2000 tadpoles present, ~ 25 TL (Fig 5.6).

• July 27, 2003. No larvae remaining, only metamorphs, 15 mm SVL.

Metamorphs We saw recently metamorphosed toadlets at 7 locations along the Juneau road system. The earliest date that we observed metamorphs was on July 26, 2002. The latest date was September 9, 2003. Most metamorphs seen were only a few meters from their natal pond, except for one group in early September that had probably transformed a month earlier. These were about 50 meters from the pond.

As late larvae approach metamorphosis, resorbing tails and growing forelimbs, their shrinkage is dramatic. The toadlet in Fig 5.9 could rest on a human fingernail with room to spare.

Fig 5.10 July 29, 2002. Post-larval toadlets may aggregate in mounds. This is thought to help avoid desiccation

Uplift Pond #1

• July 29, 2002. About 20 dispersing metamorphs ~ 12 mm SVL.

• (In 2003 this pond failed due to drought that killed tadpoles in early July.)

Uplift Pond #2

• July 29, 2002. Thousands of metamorphs observed, many collected in mounds. (Fig 5.10; Discussion below.)

• July 27, 2003. Pond is shrinking in drought. Several dead tadpoles observed. A few metamorphs found, ~ 10- to 15 mm SVL. All have resorbed their tails. Two were found about 30 meters from the pond but most were at the pond's edge. It is possible we missed a large exodus, but more likely there was greater attrition among larvae here than in 2002, with far fewer individuals leaving the pond.

Uplift Pond #3

• July 28, 2003. Eight metamorphs found in mud and sparse vegetation at edge of pond, all were about 15 mm SVL.

• September 9, 2003. One metamorph found, 25 mm SVL.

Uplift Pond #4

• September 9, 2003. One metamorph found, 11 mm SVL. This is less than half the size of the individual near Pond #3, above, which is expectable considering that larvae in this pond were less advanced on July 28.

Fen Pond #1

• We never observed metamorphs at this pond in 2002, but it was not a complete failure. Several were seen by Koren Bosworth (pers. comm.) on a September visit.

• July 28, 2003. Found 4 metamorphs 10-13 mm SVL

Beaver Pond #1

• September 9, 2002 . About 50 metamorphs ~ 16-17 mm SVL, scattered along an opening in the forest, roughly 50 meters away from the natal pond that they presumably left about a month ago.

• July 27, 2003. Two metamorphs found ~ 15 mm SVL.

• September 5, 2003. One metamorph found ~25 mm SVL. This is considerably larger than those found here at this same time of year in 2002, but about the same size as the metamorphs from other ponds we've examined. We had more sun in August in 2003, which may account for more rapid post-larval growth.

Beaver Pond #2

• September 5, 2003. Several metamorphs found, 22 to 28 mm SVL.

The phenomenon of mounding in recent metamorphs. Mounded toadlets were observed at Uplift Pond #2 on July 29, 2002 (Fig 5.10). These mounds were 1 to 2 decimeters in diameter and several toadlets deep; some mounds consisted of hundreds of individuals. On close approach the toadlets would disperse but return after several minutes without disturbance. We found about 7 mounds at this site; all were within 2 meters of the water's edge. Most toadlets appeared to have recently metamorphosed with their tail mostly resorbed..

This mounding type of behavior is thought to be a response to the risk of desiccation. Experiments with the closely related *Bufo americanus* have shown that toads desiccated alone suffered greater weight loss and mortality than those desiccated in groups (Heinen 1993). Our observation of mounding occurred on a sunny day when desiccation could have been a problem.

Yearlings We refer here to toadlets in their second summer as yearlings. On emergence from winter dormancy these toadlets may be as small as 13 mm SVL. But generally by the time we see them in mid May, they range from 20 to 30 mm. Over the course of the summer they grow rapidly. On July 29, 2002, we found two yearling toadlets that measured 40- and 43 mm SVL. We did not weigh toads, but it is clear that this near-doubling in length during the

Fig 5.11 *Early yearling, 25 mm, May 26, 2003.*

Note: Toads should never be handled with sunscreen or insect repellant on the fingers.

Fig 5.12 *Late yearling, 43 mm, July 29, 2002.*

second summer represents far more than a doubling in weight. (Compare Figs 5.11 and 5.12.)

Effect of sun and temperature on toadlet activity At times, recently metamorphosed toadlets and yearlings in their second summer are highly observable in meadow or marsh environments, near or at some distance from standing water. At other times, we failed to locate them, even in areas where we knew them to occur.

According to Stebbins & Cohen (1995):

> "Recently metamorphosed anurans seem especially prone to expose themselves to sun when there is adequate soil moisture or opportunity to enter water. . . . Some young toads and toad tadpoles are notably diurnal compared with the adults. They elevate their body temperature by basking and thereby accelerate feeding, digestion, growth, and, in transformed individuals, deposition of fat prior to winter dormancy."

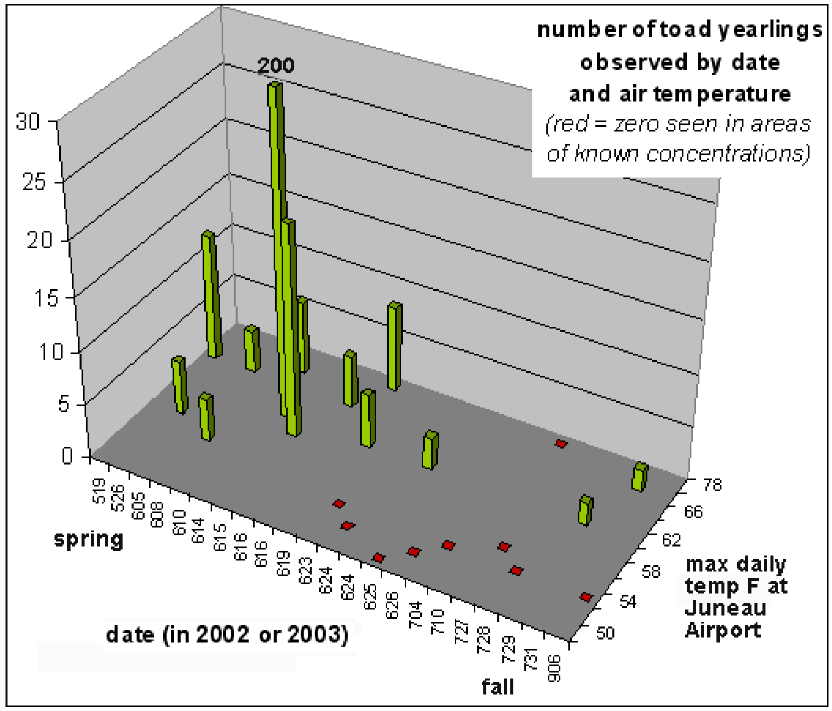


Fig 5.13 Yearlings were seen almost exclusively on warm, sunny days.

This pattern was especially strong for yearlings in our study. During 5 cold, rainy days on the upper Taku River in late June, 2003, we never saw a single yearling toadlet, in spite of the fact that we found breeding ponds with abundant tadpoles every day. In contrast, during a mostly sunny 4-day visit to Saint James Bay a week prior to the Taku trip, we encountered a total of about 200 yearling toadlets, hopping in meadow vegetation along barely supratidal "uplift" sloughs.

We observed yearlings on 13 occasions in 2002 and 2003 (Fig 5.13). Daily maximum temperatures ranged from 58° to 78°F on these days. On 9 days we searched unsuccessfully for yearlings in areas where they were known to occur. With one exception, the temperature on these "zero-yearling" days ranged from 50 to 56 degrees.

Plotting these observations by date and temperature also shows a pattern of less frequent sightings after mid June. This may result from increasingly dense vegetation in which small toads can hide. On especially sunny days, however, toadlets emerge from dense meadow vegetation to bask in small, mossy openings, or on the muddy edges of ponds and sloughs. They can be quite visible at these times, especially because of their seemingly maladaptive habit of hopping away from a human approacher, rather than freezing and relying on their camouflage.

Fig 5.14 Subadult, 55 mm SVL, July 4, 2003.

The sunny day/cool day pattern may also apply to more recent metamorphs during the period from late July to early September of their first year. But our data for sightings of first-year toadlets do not show a relationship to air temperature, probably because we made special efforts to visit known larval ponds at time of metamorphosis, and this event seemed to occur regardless of weather conditions. We did, however, find metamorphs (about one month after transformation) on rare sunny days in early September in both 2002 and 2003.

Sunny-day basking by yearlings and fresh metamorphs has implications for western toad surveys because these life stages are among the easiest to locate. In 2002 and 2003, including all areas we visited (Juneau, Saint James Bay, Taku River, and Kupreanof Island), we found approximately 270 yearlings and more than 2000 metamorphs. By comparison, if breeding aggregations are excluded, we found only 11 adults and 4 subadults between 50 and 55 mm SVL (Table 5.1).

While yearlings may have travelled some distance from their natal pond, fresh metamorphs have not had time to range very far. Sunny days between the last week in July and the first week in September are excellent times to hunt for terrestrial toadlets. The presence of fresh metamorphs in an area will suggest which ponds should be visited the following spring, in an attempt to locate breeding adults, eggs or early larvae.

Subadults This was our least-often observed size class (Fig 5.14, Table 5.1). We do not know how long it takes for toads to reach the size of the adults we observed in breeding congregations (about 65 mm + for males and 80 mm + for females). The fact that only 4 subadults were encountered during our work, compared to 11 adults, suggests that toads pass through the 45 mm to 65 mm size class fairly quickly, perhaps in their 3rd summer. If this is the case, breeding adults would be 4 years old or more.

Adults Breeding-sized adults ranged in snout-vent length from 68- to 100 mm (Table 5.1) . Measurements were not made on toads we found in spring mating groups because they were so few in number that we did not want to disturb them. Our impression was that in the mating groups, smallish individuals (~65-75 mm, probably male) outnumbered the larger ones (>80 mm, probably female). Even our photos of spawning are poor because we avoided close approach that might have disrupted the activity. One fuzzy evening shot suggests 5 amplected pairs in the space of a single square meter. At that time, there were at least another 5 male-sized individuals roaming around the periphery of the spawning pairs. Our estimate of total number was 20 adults. Koren Bosworth (pers. comm.) visited the pond earlier on the same day at 1400h and estimated about 40 adults. This is the only toad breeding pond we know of for many miles, and we do not

date	location	adult	subadult
20020606	juneau	1f (90)	
727	juneau	1f (90)	
902	juneau	1m (75)	
20030614	st james	1f (90)	2(50&55)
621	juneau	1f (90)	
626	taku	2f (80&80)	
704	juneau		1 (55)
715	kupreanof	1f (100)	
717	kupreanof	1f (85)	
718	kupreanof	1f (75)	
728	juneau		1 (50)
1001	juneau	1m (68)	
	total	11	4

Table 5.1 *Adult and subadult toads observed during our study, exclusive of spring breeding congregations. Length in mm SVL is given in parenthesis. f = female, m = male.*

Fig 5.15 *Adult toads from around Southeast Alaska. Note distinctive colors and patterns of bumps on the back. A) Eagle River, large female. Kristie Allen photo. B) Taku River, green phase. Greg Pauley photo. C) Kupreanof Island, 75 mm female. D) Taku River, 85 mm female.*

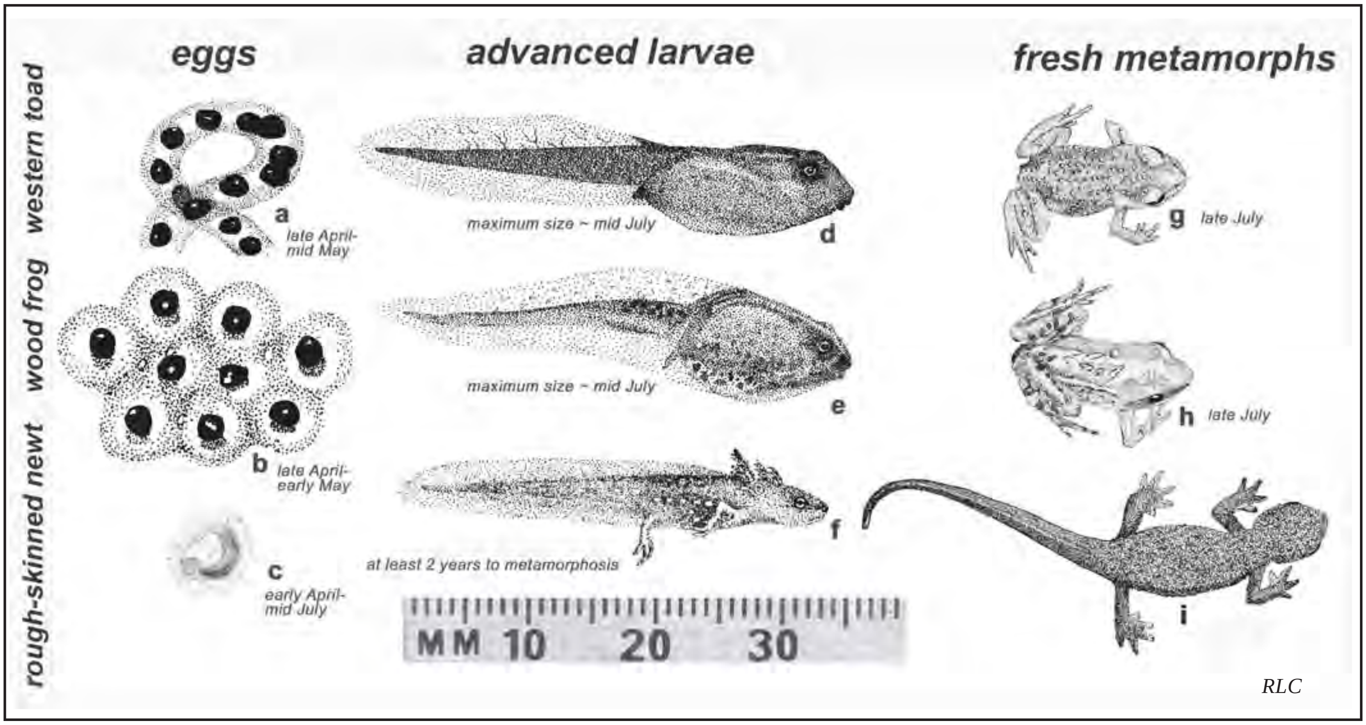


Fig 5.16 Life stages in 3 local amphibians. *All shown to same scale, from photos and measurements near Juneau. Note shrinkage of anurans with metamorphosis. Dates are from our observations and other local reports; variations on this timing may well occur. a) toad eggs in strings of jelly; b) wood frog eggs in softball-sized mass of several hundred, 9 shown; c) newt egg deposited singly - with coiled embryo soon to hatch; d) "toadpole" is dark charcoal - dorsal fin starts farther back than on larval frogs; e) "frogpole" more olive brown - dorsal fin attaches well forward of the tail: f) newt larva has antler-like gills; g) toadlet has fat, warty body and small hind legs: h) froglet has smoother skin and legs are already more muscular than on toadlets; i) newts metamorphose at about 25 mm SVL.*

know how far adults travel to join the activity.

Adult western toads occur in a variety of color shades, including bright green. We noted no geographic variation in coloring but our sample size was very small. The patterning of bumps on the backs of toads remains consistent from year to year on these long-lived animals (Greg Pauley, pers. comm.). Compare these patterns in Fig 5.14.

None of the adults we photographed were seen again on return visits to those sites. We have no data for life-span of Alaskan *Bufo boreas*. Marked individuals in the Rockies have lived for 13+ years (Greg Pauley, pers. comm.). Worldwide, there is a tendency for amphibians to be longer-lived at higher latitudes and elevations. One *Bufo bufo* lived 21 years in the wild (Hofrichter, 2000).

It is of some concern that, of 11 adult toads we found outside of breeding congregations in 2002 and 2003, only 2 were male. Preponderance of females in the population is one of the symptoms of deline from chytridiomycosis (Muths et al. 2003).

Wood frog (*Rana sylvatica*) – native and fairly common along mainland river valleys in Southeast

We found wood frogs in only one location within our Juneau study area. Because of concern that they might be the similar red-legged frogs that have been introduced near Hoonah, we sent one specimen to Robert Hodge for confirmation. Adult wood frogs (Fig 5.18) are distinguished from other Alaskan frogs by smaller size, presence of a dark triangular patch behind the eye, a light vertebral stripe, and by the absence of reddish color on the underparts (MacDonald 2003).

Mating and egg laying Wood frogs congregate for breeding in shallow bodies of water as soon as ponds have thawed, which is usually April in Alaska (MacDonald 2003). The eggs are deposited, usually communally, in barely-submerged globular masses.We found one softball-sized egg mass on May 5, 2002 (Fig 5.16). In 2003, in the same 50 m^2 pond (Fig 4.27), two baseball-sized egg clumps were observed repeatedly between on April 24 and 29. By May 2, 2003, most of these eggs were hatched but most of the 5-mm larvae were still nuzzled up to the dissolving jelly. The small number

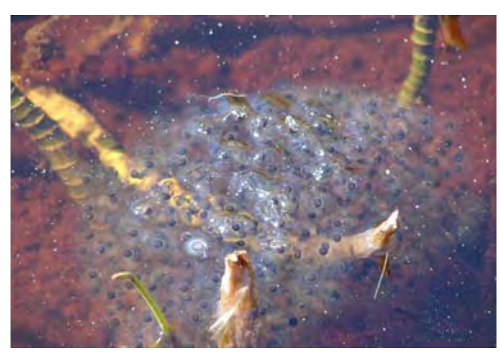


Fig 5.17 *Wood frog eggs, May 5, 2002*

Fig 5.18 Adult wood frog, ~50 mm SVL, May 25, 2002.

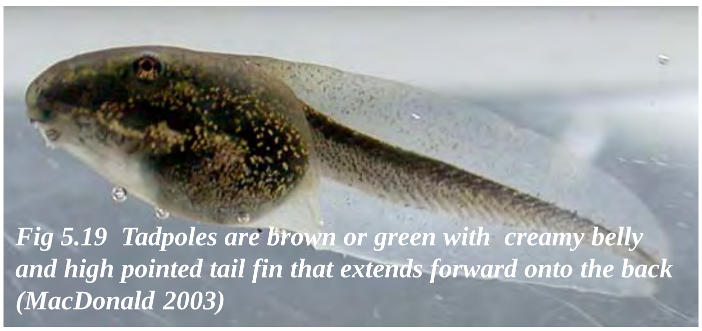


Fig 5.19 Tadpoles are brown or green with creamy belly and high pointed tail fin that extends forward onto the back (MacDonald 2003)

Fig 5.20 A recently metamorphosed wood frog.

of egg masses at this pond in both years suggests an extremely small population with possibly only two breeding females. By contrast, in a Quebec study, up to 336 wood frog egg masses were counted in a 475 m^2 pond (Gascon and Planas, 1986).

We heard and recorded the fairly loud duck-like quacks of the males on April 25 and 26, 2003, the same time at which western toads were vocalizing more softly.

Tadpoles Wood frog eggs hatched on May 2, 2003 about one week after we first found the eggs. This was slightly earlier than in 2002, when eggs were still probably a week away from hatching on May 2. This probably reflects the very warm and sunny spring weather in 2003.

Development from egg to tadpole to frog occurs at a very rapid rate, ensuring complete metamorphosis before fall freeze-up (MacDonald 2003). Small numbers of 30 mm TL tadpoles were observed in the pond on June 6, 2002. On June 22, larvae were still present even though the pond had shrunk to a depth of 5 cm. On June 30, we counted about 2 dozen larvae that were very skittish when approached, similar to the larvae of spotted frogs. Western toad larvae, in contrast, usually seem fairly oblivious to human presence. In addition to skittishness, the wood frog tadpoles often seemed to hide in the loose bottom flocculent of this poor fen pond, making accurate counts impossible.

On July 12, 2002, we found two 40-mm TL larvae under a coverboard. They had hind legs 12 mm long, but lacked front legs. These larvae reached metamorphosis at the end of the month (see below).

In 2003 we were less successful at following the progress of larval transformation in our wood frog pond. On May 10, a week after the eggs hatched, the pond completely dewatered, and only moist, tacky peat was present on the exposed bottom. We assumed that wood frog reproduction was a complete failure.

However, on a May 29 visit, after the drought had broken and a few centimeters of water had

Fig 5.21 A wood frog two weeks after metamorphosis.

Fig 5.22 A black mask is often the most distinguishing feature of wood frogs

Fig 5.23 Adult spotted frog, ~70 mm SVL, July 24, 2003

Fig 5.24 Spotted frog larva, ~70 mm TL, & 25 mm SVL, June 26, 2003

Fig 5.25 Spotted frog metamorph, ~25 mm SVL, July 28, 2003

returned to the pond, we were surprised to find a few surviving tadpoles that had obviously weathered the drought in the moist peat.

Subsequent visits, however, did not turn up any wood frog larvae in 2003 (Fig 4.27). This is not proof of complete reproductive failure, because the larvae are clearly able to hide among loose bottom materials. We noticed in this pond that the temperature about 2 decimeters under the bottom muck was much warmer than at the surface. This may have made burial an attractive option for frog larvae, especially on cooler days.

Dispersing Froglets We found a few recently metamorphosed young near the wood frog pond on July 26 and 27, 2002. All were about 15 mm SVL. One still had a short tail (Fig 5.18). No dispersers were seen in summer of 2003.

Adults Two adult wood frogs were found alongside the pond on May 25, 2002, about two weeks after the mating episode. On May 2, 2003, after the late April period of singing, mating and egg laying, we found another adult (~55 mm, not measured) under a cover board. Unlike western toads, this frog reacted with alarm to an approaching dip net and easily escaped into the bottom muck. On several other occasions in spring, we saw fast-moving ripples in the bottom muck that were probably adult frogs. We did not spend much time searching for adults because of the apparent small population size and the desire not to disturb them. Adults are thought to become sexually mature in 2 to 3 years (MacDonald 2003).

In winter wood frog adults hibernate in small nests under the forest litter and snow. They survive winter in a frozen state with no heartbeat, no circulation, no breathing, and no muscle movement. Yet upon thawing the heartbeat resumes and the frogs become active again. Wood frogs confine freezing to areas outside their cells as insects do but they freeze up to at least twice as fast. In combination with extracellular freezing the frog concentrates glucose antifreeze in and around the cells (MacDonald 2003).

Columbia spotted frog (*Rana luteiventris*) – native and fairly common along mainland river valleys in Southeast

The Columbia spotted frog is a somewhat bumpy-skinned, medium-sized frog with relatively short hind legs and fully webbed toes (MacDonald 2003). Adults have a covering of bright salmon or red on the lower abdomen and the undersurfaces of the hind legs.

We found spotted frogs at one location along the Juneau road system on July 23, 2003 (Fig 4.7). Most of the frogs appeared to be subadults with a few adults amongst them. We captured, measured and released 8 of them. Two adults were captured for species identification and sent on via Bruce Wing at National Marine Fisheries Service to Robert Hodge in Gig Harbor Washington. We needed to confirm the species identification because of the difficulty separating spotted frogs (native to Southeast) from the red-legged frog (introduced in Southeast). Robert Hodge, in conjunction with an authority on the spotted frog, was able to confirm the species I.D.

The frogs ranged in size from 25- to 70 mm SVL. They

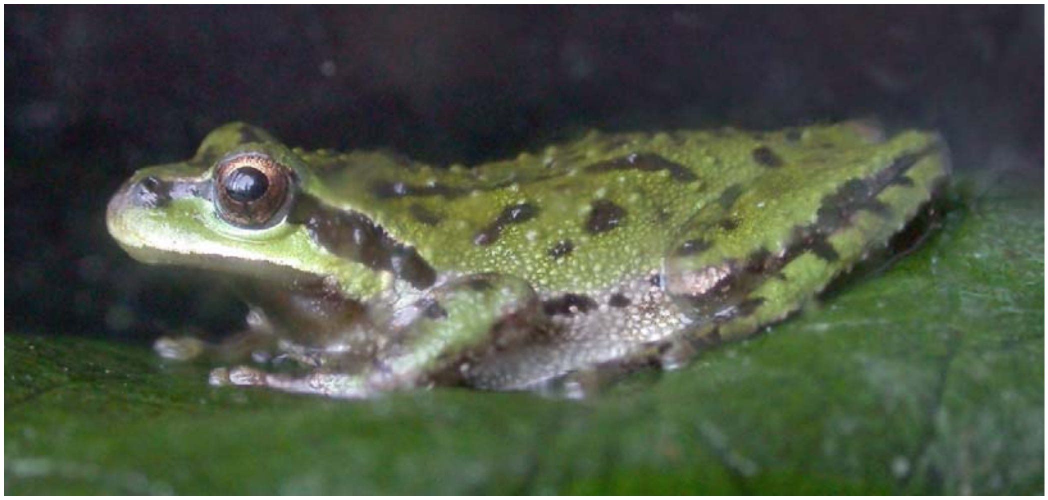


Fig 5.26 *Adult Pacific treefrogs are small with a rounded snout, large eyes, conspicuous dark mask, prominent toe pads and limited webbing between the toes (MacDonald 2003).*

were found in small human-made puddles of water (most appeared to be old tire track depressions in the mud). We searched nearby beaver ponds for evidence of breeding but found none.

Because this isolated group was the only population we encountered near Juneau, we suspect it was introduced. The great range in sizes, including probable recent metamorphs (Fig 5.25), suggests that these frogs have been breeding on the site for at least a few years.

From June 23 to 27, 2003, we examined native spotted frog habitat on the Taku River. Larvae of these frogs were seen in 5 "riverside" ponds and one beaver pond, always in association with western toad larvae. The spotted frog tadpoles were almost twice as large as the "toadpoles." We noticed that they were also spookier than toadpoles. If we approached the pond margin for photographs, loose clusters of larvae would dash for the bottom cover.

Adult frogs were similarly wary. Unlike the (introduced?) population in Juneau, adult spotted frogs on Taku River generally gave us only brief glimpses as they swam away. We netted just one, 75 mm SVL.

The mid-summer timing of our Taku visit did not allow observation of mating, eggs, or metamorphosis in spotted frogs.

Pacific chorus frog (*Pseudacris regilla*) – introduced to Juneau and Ketchikan.

We located one male Pacific chorus frog (also called Pacific treefrog) calling from a small pond in Mendenhall Valley. According to nearby residents this frog had been calling during most of July and into early August in 2003. We found and identified the frog on August 8, 2003.

Pacific chorus frogs were introduced to a group of peatland ponds near Ward Lake in Ketchikan around 1960. They seem to have been confined to this area, successfully breeding for over 30 years (MacDonald 2003). No doubt the one individual we found in Juneau was also introduced.

Long-toed salamander (*Ambystoma macrodactylum*) – native and fairly common along mainland river valleys in Southeast

We only found this species in larval form in one pond on the Taku River. The larvae were captured by net sweeps, deep in submerged vegetation in a very alkaline pond with high dissolved oxygen (Fig 4.48). They measured 30 to 45 mm TL. In contrast to anuran larvae, the front legs develop first, and the smaller ones we captured had no hind legs. These different-sized larvae probably represent two or more year classes. An Oregon study found that larvae at mid and high elevations did not reach metamorphosis until their third or fourth summer (Howard and Wallace, 1984).

Several hours of turning over logs and duff during our Taku River visit did not turn up any adult salamanders. Visiting herpetologist Greg Pauley captured an adult on the Taku River on a somewhat earlier trip in June 2003, and we were able to observe this one in captivity (Fig 5.28).

Fig 5.27 *Larval long-toed salamander, 45 mm TL, 22 mm SVL, Taku River, June 26, 2003. At this stage in development the legs are fairly effective in locomotion. Large head and mouth are characteristic of carnivorous larvae*

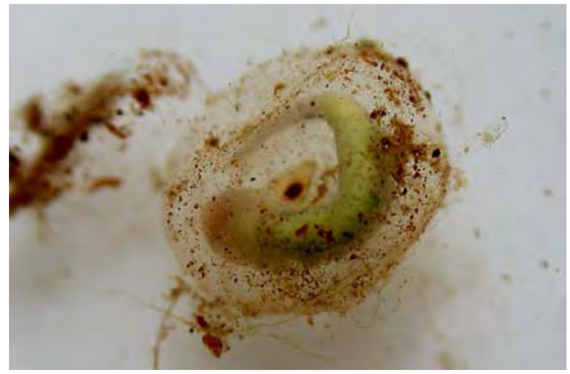


Fig 5.28 (left) Adult long-toed salamander from Taku River, June 16, 2003.

Fig 5.29 (above) Newt egg with coiled embryo, Aug 15, 2002

Fig 5.30 (below left) Adult rough-skinned newts dive into the bottom debris after their cover board is lifted.

Rough-skinned newt (*Taricha granulosa*) – native and fairly common throughout much of Southeast

Terrestrial rough-skinned newts usually have a rough and grainy skin surface. The skin of breeding males that have been in ponds for several weeks becomes smoother.

According to MacDonald (2003) newts are most often encountered in the spring when they congregate in ponds and small lakes to spawn. Breeding in Alaska probably commences in April and continues into June. Eggs are tiny and laid singly, attached to submerged plants, making them difficult to find. Hatching takes 5-10 weeks. Larvae may require two or more years to complete metamorphosis. Sexual maturity may take 4-5 years. Some transformed adults may remain in ponds year-round. We have also found adult newts under logs and rocks within the forest, up to 100 meters from known breeding ponds.

Many rough-skinned newt populations possess a potent neurotoxin that, if ingested, can cause death in most animals including humans. Rough-skinned newts sampled from one population along the Juneau road system turned out to be highly toxic (Brodie, pers comm.).

We found rough-skinned newts at five locations along the Juneau road system. In three of the ponds they appeared to be in very low numbers and in two of the ponds they appeared quite numerous, judging from the number obtained per trap.

We found only one newt egg (August 15, 2002) during our study along the Juneau road system. We made no concerted effort to find newt eggs but did examine our net sweeps through vegetation for eggs. Newt eggs are quite tiny, about 2 mm in diameter. They are laid singly, usually attached to submerged vegetation.

One larval newt was found on July 24, 2003 and another August 15, 2002 (Figs 5.33 and 5.31, respectively). Both were captured in random net sweeps. We were told by Robert Hodge that adult newts prey on their young, hence it is unlikely larvae and adults would be found in the same trap. Also, Hodge suggested that larval newts would not enter traps that had previously caught adult newts because of residual odor. We attempted to build bottle traps that would exclude adults by narrowing the entrance. This was unsuccessful because we did not get the entrance narrow enough to exclude all adults.

We made repeat visits to one newt pond throughout 2002 and 2003. Adult newts were found in the pond from as early as April 8, 2003 and as late as September 2, 2002. The pond was not checked for newts before or after these dates. Clayton Fischer made the April 8 observation at night by flashlight. During darkness the newts could be seen very easily as they swam about. During daylight they appear to hide amongst the vegetation and are sometimes difficult to spot.


Fig 5.31 Young newt larva 26 mm TL, 13 mm SVL, Aug 15, 2002


Fig 5.32 Metamorph, 28 mm SVL, Aug 6, 2003


Fig 5.33 Advanced newt larva ~60 mm TL, ~30 mm SVL, July 24, 2003


Fig 5.34 Adult female


Fig 5.35 Adult male

On August 1, 2002 we measured 79 newts caught in traps set underwater. The newts ranged from 50 to 90 mm SVL and averaged 73 mm. Male newts have elongated vents compared to females. Compare Figs 5.34 and 5.35.

Although newts emerged earlier in spring than any other local amphibians, breeding is probably more protracted than for our toads and frogs, as evidenced by the egg we found on August 15, 2002. On July 7, 2003, we saw large (breeding?) clusters of newts in a beaver pond on Admiralty Island, and captured an amplected pair.

On August 27, 2002, we captured 22 adults in traps, and all were male. Perhaps by this time most females have left the ponds.

The smallest newt we captured was 28 mm SVL, found under a board on Aug 6, 2003. We suspect this one had recently metamorphosed.

6 Synthesis and recommendations

To gain a sense of how little is known about the distribution of amphibians in Southeast Alaska, consider our most populated region – the City and Borough of Juneau. About half of the residents of Southeast live here. Because it is the state capitol and headquarters to many federal, state and borough natural resource managers and researchers, Juneau has an exceptionally high per-capita level of expertise in field biology. Discovery Southeast alone employs more professional naturalists than are found in any of the region's smaller cities and villages. Juneau also has the most elaborate network of backcountry trails in Southeast, which conducts large numbers of humans throughout a wide variety of amphibian habitats. Groups like Juneau Audubon and the web-based Eaglechat provide regular forums for outdoorspeople to share their observations. We ourselves - Armstrong, Carstensen and Willson - have spent a combined 78 years of active field work in Juneau. We are well tapped-into the "nature-gossip" network.

In spite of all of this, we were unaware that the Juneau vicinity had any amphibians other than western toad until about 4 years ago, when a student walked past one of us in Dzantik'i Heeni Middle School carrying a bowl of rough-skinned newts. At the outset of our study we knew of only one Juneau pond where toads still assembled in spring to breed. And as our study progressed, we were quite surprised to discover that Juneau had small (probably exotic) populations of wood frog, Columbia spotted frog, and Pacific chorus frog. Although we spent a great deal of time in the field around Juneau in 2002 and 2003, we only located the spotted and tree frogs toward the end of the project, thanks entirely to the "natural history grapevine."

Now contrast the above level of ignorance of Juneau's amphibian populations to the even cloudier situation near smaller communities or on remote and rarely traveled islands. Clearly, there is much work to be done before anyone can say with authority where amphibians occur, let alone whether populations are in trouble or why, or what kinds of human intervention might arrest population declines.

Findings

Considering the above-mentioned initial shortcomings in knowledge of Juneau's amphibian populations, the area is now fairly well surveyed. From our experience investigating amphibians in northern Southeast Alaska, the findings that seemed most pertinent and important to us are as follows:

Number of ponds with amphibians Overall, we looked for amphibians in 352 ponds in northern Southeast during 2002 and 2003 and conducted full assessments on 95 of them. In order to make comparisons by pond type we randomly selected 42 ponds along the Juneau road system for additional evaluation.

	selected	juneau	other	total
w toad	3	7	10	17
wd frog	1	1		1
sp frog		1	6	7
tr frog		1		1
lt salamander			1	1
rs newt	1	5	1	6
total amphib ponds	5	14*	11*	25*

** some ponds were occupied by more than one species*

Table 6.1 *Number of amphibian occupied ponds found during our study. Among 42 randomly selected ponds, 5 were occupied. Among 78 assessed ponds near Juneau, 14 were occupied. An additional 17 ponds assessed outside of the Juneau area turned up another 11 occupied ponds.*

Of the total 352 ponds examined in northern Southeast we found amphibians in 25 or 7% of them. Western toads were found in 17 ponds, wood frogs in one, Columbia spotted frog in 7, Pacific chorus frog and long-toed salamander in one each, and rough-skinned newt in 6.

Of the 95 fully assessed ponds throughout northern Southeast, the 25 occupied ponds amount to 26%. Many of these ponds were specifically selected for assessment because they *did* contain amphibians, so the high percentage of occupancy should not be taken to imply that a quarter of Southeast's ponds contain amphibians.

Along the Juneau road system we fully assessed 78 ponds. Of these, 14 contained amphibians: 7 with western toad, 5 with rough-skinned newt, and one each with wood, Columbia spotted and Pacific chorus frog. In addition to the fully assessed ponds, we visually examined 192 more ponds along the Juneau road system. We did not find amphibians in any of the ponds briefly looked at.

Of the 42 randomly selected ponds along the Juneau road system, only 5 contained larval amphibians: 3 with western toad, and one each with wood frog and rough-skinned newt. This suggests that only a very low percentage of available ponds near Juneau are used by breeding amphibians: about 7% for toad, and 2% each for newt and wood frog. Extrapolating that figure to the 171 mapped ponds within the half-mile road buffer, one would predict that about 12 of these might support breeding western toads. A more conservative estimate, based on the number of documented and suspected breeding ponds, would be about 7 toad ponds within the Juneau road buffer.

Even the high estimate of 12 breeding ponds is a very small number compared to the apparent former abundance of toad breeding populations. We have no direct quantitative data on historical breeding ponds, but some insight into their probable abundance can be gained through our database of anecdotal reports. Figure 6.1 is excerpted from this GIS project, showing the portion of our study area from Eagle River to Mendenhall Valley. The 40 sightings on this map are almost entirely of adults,

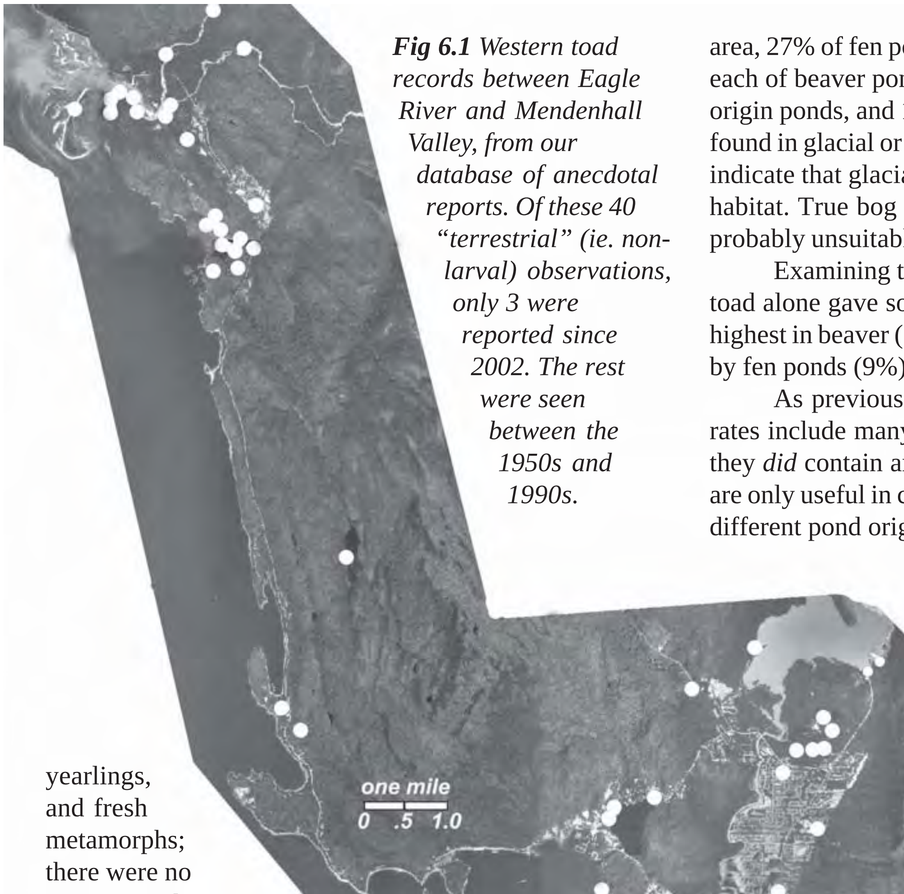


Fig 6.1 *Western toad records between Eagle River and Mendenhall Valley, from our database of anecdotal reports. Of these 40 "terrestrial" (ie. non-larval) observations, only 3 were reported since 2002. The rest were seen between the 1950s and 1990s.*

yearlings, and fresh metamorphs; there were no attempts to locate breeding ponds until recently. However, from studies of marked western toads in Colorado (Jones, no date) it is clear that terrestrial ranges of individual animals are very small.

The following assumptions may allow us to draw some limited conclusions about past distribution of toad breeding ponds near Juneau:

1) The restricted mobility of toads suggests that there was formerly a breeding pond within a one-half mile radius (more conservatively, a one-mile radius) of nearly every dot-record on Fig 6.1.

2) Disturbance and successional changes to ponds would lead to ephemeral occupancy in some but not all cases. Not all of the historical breeding ponds implied by Fig 6.1 were occupied continuously or simultaneously throughout the half-century span of these observations.

3) Further interviews with long-time residents could probably add many more dot-records throughout virtually all of the Juneau road and trail system.

4) Our habitat assessments at the remaining occupied ponds suggest a wide tolerance of environmental conditions; toads could *potentially* have reproduced in the majority of the 171 mapped ponds within the half-mile buffer of Juneau roads.

These assumptions lead to a rather bleak prognosis for western toads in Juneau. Something has eliminated them from the majority of their range.

Amphibians by pond origin type

Considering all 78 assessed ponds in the Juneau area, 27% of fen ponds were occupied by amphibians, 25% each of beaver ponds and bedrock ponds, 20% of human-origin ponds, and 18% of uplift ponds; no amphibians were found in glacial or bog ponds (Fig 2.3). Historical records indicate that glacial ponds may be good amphibian habitat. True bog ponds (as opposed to fen ponds) are probably unsuitable for larval amphibians.

Examining the above occupancy results for western toad alone gave somewhat different percentages; use was highest in beaver (25%) and uplift (18%) ponds, followed by fen ponds (9%).

As previously noted, the above percent occupancy rates include many ponds chosen non-randomly because they *did* contain amphibians. Therefore the percentages are only useful in comparing the relative importance of different pond origin types.

Aquatic vegetation Among the 24 assessed ponds supporting larval amphibians and adult newts, sedges and bog buckbean were the most frequent dominants in the emergent layer. Swamp horsetail was less often associated with larval amphibians. Floating-leaved vegetation associated with amphibians included yellow pond lily in bedrock-controlled ponds, and burreed and pondweed in riverside ponds. The most important submerged vegetation found in amphibian ponds was water milfoil and stonewort. We did find toad larvae in a few very barren ponds, completely lacking in vascular aquatic vegetation. Few larvae survived to metamorphosis in the barren pond that we monitored repeatedly.

Percent cover of emergent vegetation is highest in fen ponds. Cover in the floating-leaved zone is highest among riverside and bedrock ponds. Cover of submerged vegetation is highest in riverside and uplift ponds. Bog ponds have the least aquatic vegetation in all three structural zones (Fig 3.7)

Potential predators The literature suggests that populations of anuran larvae can be decimated by predatory fishes (Bradford 1989, Bull and Marx 2002) and that breeding adults may be able to avoid fish-infested waters (Hopey and Petranka 1994). We have non-quantitative data on potential predator occurrence for 18 of 25 amphibian-occupied ponds. Eleven of the 18 were co-occupied by sticklebacks (*Gasterosteus aculeatus*), which may not be serious predators. Six ponds were shared with odonate naiads, 7 with diving beetles (usually small), and 4 with leeches. Six ponds were co-occupied by juvenile salmonids, but only by very small numbers of them, or for very short periods of time (stream overflow), or by small young-of-the-year. Moreover, one of these 6 ponds was occupied by newts but not anurans, and newts may not be vulnerable to fish predation because of toxic exudates. These observations on co-occurrence of salmonids and amphib-

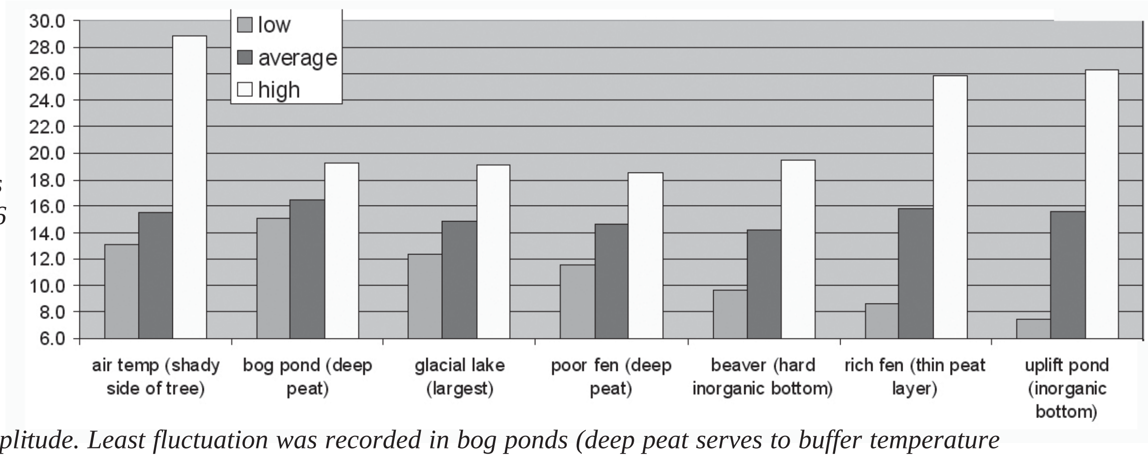


Fig 6.2 *Low, average and maximum July temperatures (°C), from hourly readings by one air and 6 water loggers. Ponds are arranged from left to right in order of increasing temperature amplitude. Least fluctuation was recorded in bog ponds (deep peat serves to buffer temperature swings) and large lakes. Greatest amplitude was in the shallowest ponds with the least organic material on the bottom. Average temperature varied only 2°C among these pond types.*

ian larvae tend to support the literature reports of negative interactions of predatory fishes with amphibian larvae.

Water quality Average temperature hardly varied between our pond types (Fig 6.2), but temperature *regime* is probably the most important aspect of water quality for pond-breeding amphibians. Most amphibians were found in shallow ponds with minimal organic material on the bottom, where temperature amplitude is highest. Beaver, rich fen and uplift ponds are most likely to provide these conditions. The lower minimum (night-time) temperatures in such ponds are probably not a problem. Diurnally feeding amphibians may even seek lower temperatures at night to recover from high daily metabolic demands (Stebbins and Cohen, 1995). On the other hand, the higher (late-afternoon) maximum temperatures in very shallow ponds serve to elevate larval metabolic rate and enhance algal food production.

A study of 13 amphibian species in southwestern Ontario noted high larval tolerance of acidity, and concluded that water chemistry was in general a poor predictor of species richness (Hecnar et al. 1996). In our surveys, we likewise found toad and wood frog larvae and rough-skinned newt adults in ponds with a wide range of acidity (Table 6.2). Certainly it appears that these species – especially wood frog – can survive in fairly acidic ponds.

It is noteworthy, however, that of 21 ponds supporting western toad and spotted frog larvae, 14 (66%) were neutral to strongly basic, and none had average pH of less than 6 (Fig 6.3). Considering that acidic ponds are probably the norm in conifer-dominated Southeast Alaska, this may indicate selection for a fairly limited habitat type on the part of these two species. Of course, the majority of the neutral-to-basic ponds were found not in the Juneau area but at Taku River and Saint James Bay, and there are several other environmental factors that may explain the greater success of toads and spotted frogs in those areas (see *Regional differences,* below). But the tendency of western toads to select neutral-to-basic ponds is further supported by our measurements from 5 additional Juneau ponds that are known to have contained large swarms of toad larvae in the past. In 2003, these ponds and lakes ranged in pH from 7.3 to 8.8.

The majority of our amphibian-occupied ponds had fairly high dissolved oxygen (Fig 6.4). We did measure DO of only 5 mg/L in a few ponds with western toad larvae. This is considered a minimum threshold for fish and some aquatic invertebrates. Amphibian larvae, however, can breathe through gills, skin, and (when approaching metamorphosis) lungs, and may be able to tolerate even lower oxygen levels, at least for brief periods.

Aquatic plants are good indicators of certain aspects of water quality. Stonewort and submerged green

Table 6.2 *Acidity ranges in 25 ponds with anuran larvae or adult newts*

	low pH	high pH
wood frog	4.5	5.5
rough-skinned newt	5.1	6.7
western toad	5.3	9.8
spotted frog	6.9	9.8

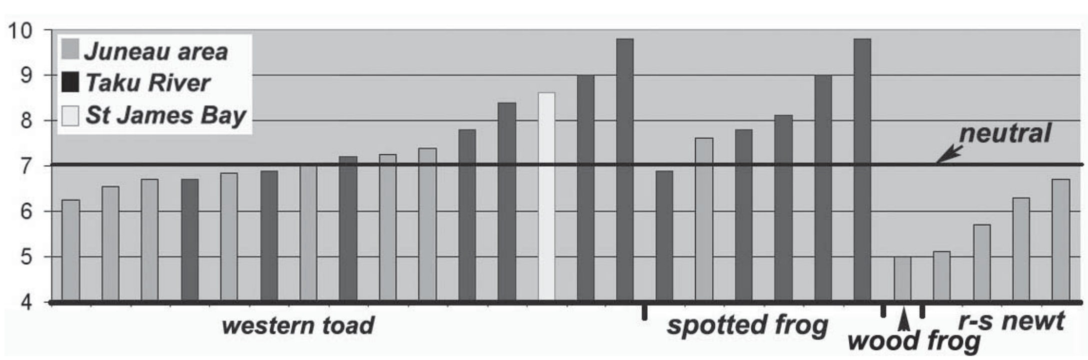
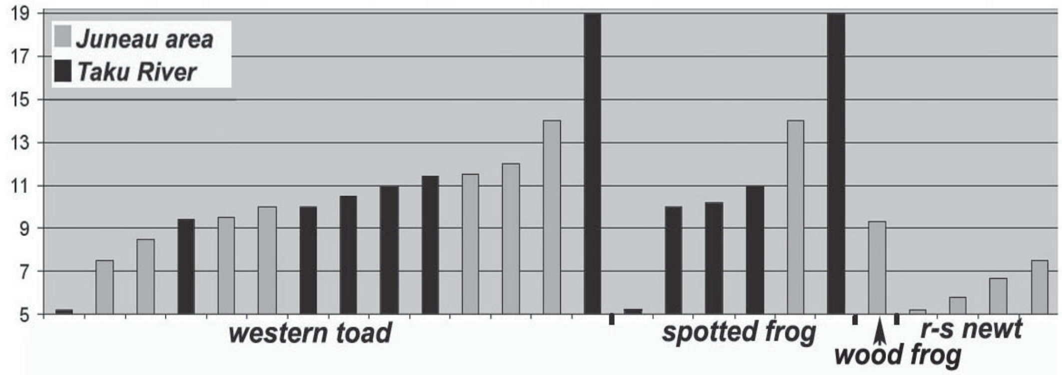


Fig 6.3 *Acidity in amphibian ponds of northern Southeast Alaska. For Juneau-area ponds with repeat visits the values are averages.*

Fig 6.4 *Dissolved oxygen (mg/L) in amphibian ponds of northern Southeast Alaska. For Juneau-area ponds with repeat visits the values are averages.*



algae indicate high pH. Four-leaf marestail and ditchgrass indicate occasional mild salinity.

Weather Prolonged dry weather in April and May of 2003 led to pond dewatering that delayed or prevented toad spawning in some ponds. Later in summer, dewatering killed several thousand toad larvae, and may have cancelled the wood frog reproductive effort in 2003.

Recently warming winters and associated shallower snow depth may be causing problems for western toads, which are not as tolerant as wood frogs of freezing conditions during dormancy. Adult western toads in Colorado hibernate at temperatures of about 5°C (41°F) (Jones, no date). Without insulating snow cover, it may be harder for dormant Alaskan toads to avoid dangerously cold temperatures.

Alternatively, it is possible that warming climate exacerbates other problems such as susceptibility to fungal infection (Frankland et al. 1996)

Regional differences in abundance of western toad We found more western toads in St. James Bay and the Taku River Valley than along the Juneau road system. Not only were more larval ponds discovered, but the numbers of larvae per pond were sometimes much higher than in any larval pond we found near Juneau. The reason for this is unclear but may relate to deeper insulating snow cover, higher number of ponds per unit area, higher pond pH, higher percent cover of aquatic vegetation in the ponds, and possibly lower exposure to pathogens such as chytrid fungi.

Decline of western toad The pathogenic fungus *Batrachochytrium dendrobatidis* has been implicated as the cause of significant population decline of amphibians in the Americas and Australia (Berger et al. 1998, Carey et al. 1999). Although we did not notice evidence of infected western toads during our study, we feel that this is a potential cause of widespread declines in Southeast Alaska. Timing of the toad decline in Southeast seems to have paralleled that observed in Colorado.

We have two reports of presumed dipteran parasitism on western toad in Southeast Alaska that we have not seen reported in any of the literature on decline for this species. In Gustavus in the early 1980s, Greg Streveler (pers. comm.) observed many adult toads with "maggots burrowed into the toads' flesh and anchored about 1/4" deep, with their posteriors extruding. Toads with these parasites were usually thin and lethargic." In summer of 2003, Alex Wertheimer (pers. comm.) also saw a large adult toad with maggots embedded in its back at Little Port Walter on Baranof Island.

Local habitat change is also important. The history of western toad in Mendenhall Valley offers some insights into the relationship of this animal with human development. Western toads were extremely abundant here in the 1950s and 60s. These toads may initially have actually benefited from the widespread creation of dredge ponds. At the same time, trees were being felled throughout the lower valley, providing more light to breeding pond waters. In the 1960s, the valley was not yet transected by roads and driveways that now make it impossible for a toad to travel 50 meters without risk of being squashed or collected.

Setting aside for a moment the problem of continent-wide declines that appear to be happening independently of local habitat impacts, we could hypothesize that western toad is a habitat generalist that initially responds well to some forms of human disturbance, but at increasing human densities it begins to suffer from barriers to movement in its terrestrial phases.

Best methods for locating amphibians Visual searching was the most productive method for locating western toads – especially tadpoles, concentrated in shallow water, and dispersing toadlets, usually near the water's edge. Yearling toads were most often found on sunny days. Wood frog and spotted frog tadpoles were also most easily found by visually scanning the shallows.

Trapping was the best method for determining the presence of adult rough-skinned newts. Unbaited collapsible shrimp and minnow traps were the easiest to use and worked as well or better than other types of traps tested. Other methods that helped determine the presence of newts included turning over boards and logs and scanning the pond edge by flashlight at night.

Precautionary note on adequacy of repeat surveys Skelly et al. (2002) evaluated amphibian surveys that reported declines relative to earlier work in the same areas. Because of year-to-year variation in amphibian abundance, single-year surveys were predicted to seriously overestimate the severity of amphibian declines, and multi-year surveys were recommended strongly.

Amphibian movement between breeding ponds and terrestrial surroundings. Most amphibians breed in aquatic habitats but also use terrestrial habitats for seasonal migrations to and from wetlands (between breeding and overwintering sites) and for foraging (this does not include juvenile dispersal from natal wetlands). The terrestrial area around a wetland that is used for migrations and foraging has been defined as a 'core terrestrial habitat' (Semlitsch and Bodie 2003). Adult amphibians are usually philopatric to individual wetlands.

From a review of the literature, Semlitsch and Bodie 2003 reported that the average minimum radius of the core terrestrial habitat for 19 species of frog was 205 m from the edge of the wetland, and the average maximum was 368 m. For salamanders (13 spp.), the corresponding values were 117 m and 218 m. For *Bufo boreas* in Colorado and Wyoming, the maximum core radius was 101 m, but for other *Bufo*s it ranged up to 480 m. For *Rana* spp., the maximum core radius ranged up to about 580 m for most species. For *Taricha torosa granulosa* in Oregon the modal radius was 185 m.

The greatest distance covered by a telemetered western toad in Colorado was 643 m (0.4 miles) in 28 days (Jones, no date). The average distance moved per day among males and females was 11.83 m. Clearly, suitable habitat for amphibians must include habitat appropriate for all segments of the life cycle. The necessary core terrestrial habitat for amphibians in Southeast Alaska is, however, not known.

Recommendations for future work

First order:

- In spring 2004, visit all 7 of the known western toad breeding ponds located by our study near Juneau in an effort to census spawning adults. The window for this activity appears to be the last week in April through the middle of May. An effort should also be made to locate the breeding ponds for several other locations where we have reports of adult and subadult toads. Another key time for monitoring of the same ponds is at the end of July, when larvae reach metamorphosis.
- Because migration distance and foraging ranges extending out from breeding ponds differ among amphibian species and geographically, study is needed to determine appropriate terrestrial buffer zones applicable in Southeast Alaska. Given their apparent declines, western toad breeding ponds and their surroundings should be protected from development.
- The Alaska Department of Fish and Game should contact researchers and administrators with the Colorado Division of Wildlife (CDOW) for recommendations on a course of research and monitoring to address the decline of western toad in Alaska. CDOW has the most progressive monitoring and restoration program for this species, including even a captive breeding facility and experimental re-introductions. We have no reason to believe that the decline in Alaskan western toads is any less deserving of attention by state and federal wildlife agencies.
- Equip and train fisheries field personnel to conduct opportunitistic amphibian pond searches.

Second order:

- Better information on aquatic plants as indicators of salinity will improve western toad surveys in uplift ponds throughout northern Southeast Alaska. Measure salinity in uplift ponds with a range of aquatic vegetation. Key species for which salinity tolerance should be more accurately determined are (in apparent order of tolerance) Lyngbye sedge, ditch-grass, four-leaf marestail, water milfoil. Because salinity will vary depending on tidal stage, this study should be done in an easily accessible area where numerous repeat visits can be made.
- Amphibian surveys of beaver/fen ponds (as described for Admiralty and Lincoln islands) are needed, along with GIS mapping of the distribution of this pond type. It would also be helpful to gain a better understanding of why these ponds occur where they do. Is lack of heavy predation on beaver by wolves and humans a factor?
- Succession in post-glacial ponds offers a valuable opportunity to compare amphibian habitats on surfaces of known age, outside of most human influences.
- Survey ponds on karst landscapes for breeding toads and newts. Because of high timber productivity, most of Southeast Alaska's karst has been heavily roaded, and a road-based survey out of Hoonah or Craig would be logistically feasible.

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8 Annotated references

The following annotations are not meant to be thorough reviews, but mention points relevant to Southeast Alaskan amphibian studies.

Armstrong, R. and M. Hermans. 2001. Newts in the rain forest. Alaskan Southeaster. November.

> Includes thoughts on toxins and the predator-prey arms race" (see Brodie and Brodie, 1999)

Beebee, T.C. 1996. Ecology and Conservation of Amphibians. Chapman & Hill.

> Chapter on kin recognition in tadpoles. Genes promoting individual self-sacrifice on condition that at least 2 siblings survive are likely to spread. Anuran larvae, especially if distasteful to predators, often congregate in shoals, usually conspecific. (*But there is no citation for the suggestion of toxins in the larval stage – see Benard and Fordyce 2003 who detected bufadienolides only in metamorphs of WESTERN TOAD*) Suggested reasons for schooling: thermoregulation, stirring up of detritus, and predator defense. Best examples are *Bufo americanus and boreus*, (tree frogs and most ranid larvae tend to disperse) *Bufo* larvae have weak kin recognition. Strongest recognition is in WOOD FROG, CASCADES FROG, and PLAINS SPADEFOOT TOAD. Cue is probably olfactory. Attacked WESTERN TOAD and CASCADES FROG tads release substances that cause alarm responses in kin. Possibly AMERICAN TOAD retains recognition into adulthood, which could help reduce inbreeding.

Beebee, T.C. 2002, Letter in Conservation Biology, vol 16, no. 6, pp. 1454-1455.

> Letter responding to Blaustien et al. 2001 who claim that Beebee's evidence for earlier amphibian breeding in response to climate change may be premature. Cites Gibbs and Breisch 2001 who found 4 of 6 NY amphibians were breeding earlier. Blaustein et al reply and backpedal.

Benard, M.F. and J.A. Fordyce. 2003. Are induced defenses costly? Consequences of predator-induced defenses in western toads, *Bufo boreas*. Ecology. 84(1), pp. 68-78.

> Induced defenses in WESTERN TOAD. Larvae were raised in presence or absence of nonlethal predator cues. Responses measured in larvae and postmetamorphs. Chemical defense is bufadienolides – present in the metamorphs (but not in larvae) reared with predator cues. No response in morphology or growth rates. Some invert predators ate fewer WESTERN TOAD larvae reared with predator cues, but the toxins didn't deter tiger salamanders.

Bervin, K.A. 1990. Factors affecting population fluctuations in larval and adult stages of the wood frog (*Rana sylvatica*). Ecology. 7(14). pp. 1599-1608.

> Maryland WOOD FROG study, 7 yrs, 2 ponds with drift fences. Breeding population size varied 10-fold, juvenile production 100-fold. Females matured 1 yr later than males, who bred at only 1 yr, so that 2.3x as many males survived to breed. Survival higher in juveniles that metamorphed early and were large at metamorphosis. Mean monthly rainfall affected adult survival.

Biek, R., W.C. Funk, B.A. Maxwell, and L.S. Mills. 2002. What is missing in amphibian decline research: Insights from ecological sensitivity analysis. Conservation Biology. vol 16, no 3, pp. 726 - 734.

> Used ecological sensitivity analysis to determine which vital rates have strongest influence on populations of WESTERN TOAD and common frogs (*R. temporaria*) – pond breeders that have declined in all portions of their ranges. Results suggest that post-metamorphic vital rates and highly variable vital rates have the strongest influence.

Blaustien, A.R., L.K. Belden, D.H. Olson, D.M. Green, T.L. Root, and J. M. Kiesecker. 2001. Amphibian breeding and climate change. Conservation Biology. 15:1804-1809.

> See Beebee, T.C. 2002

Blaustien, A.R. and P.T. Johnson. 2003. The complexity of deformed amphibians. Frontiers in Ecology 1 (2) 87-94.

> More than 60 species of amphibians have been found with severe abnormalities in the US and several other countries. Appears to be due to multiple causes, all human-related, including contamination, UV-B radiation, and parasitic infection. Coordinated multidisciplinary approach is needed

Bradford, D. 1989. Allotopic distribution of native frogs and introduced fishes in high Sierra Nevada lakes of California: implications of the negative effect of fish introductions. Copeia. 1989(3). pp. 775-778.

> High Sierra lakes with introduced trout completely lack the once widespread *Rana muscosa*, mtn yellow-legged frog and PACIFIC TREE FROG (WESTERN TOAD may be present but was not found). Of 67 lakes surveyed, 49 had either fish or tadpoles but none had both. MOUNTAIN YELLOW-LEGGED FROG larvae overwinter at least once, and in the nearly vegetation-less lakes they are extremely vulnerable. Overwintering fish and adult frogs use lakes >1.3 m deep because shallower ones cause winterkill from low DO. MOUNTAIN YELLOW-LEGGED FROG larvae can survive the anoxic conditions.

Brodie, E. D. III and E. D. Brodie Jr. 1999. Predator-prey arms races. BioScience 49: 557- 568.

> Where newts are most toxic, garter snakes have evolved defenses. Newt toxicity and snake resistance both decrease northward from San Francisco to Vancouver.

Bull, E.L. and D.B. Marx. 2002. Influence of fish and habitat on amphibian communities in high elevation lakes in northeastern Oregon.

> Surveyed 43 lakes. LONG-TOED SALAMANDER and PACIFIC TREE FROG negatively affected by introduced trout. WESTERN TOAD and COLUMBIA SPOTTED FROG eggs and larvae more influenced by habitat characteristics. High lake studies are useful because they narrow the range of human impacts. *Saprolegia ferax*, a water mold that affects fish, may be the culprit in one population of toad eggs in Oregon.

Carey, C. 1993. Hypothesis concerning the causes of the disappearance of boreal toads from the mountains of Colorado. Conservation Biology 7:355-362.

> Chytrid fungi implicated in local WESTERN TOAD extinctions. Although other environmental factors may have hastened this decline, Carey now doubts that global warming plays a role; "When frogs die due to temperature, it's because they're too cold."

Carey, C., W. R. Heyer, J./W. Ross, A. Alford, J. W. Arntzen, T. Halliday, L. Hungerford, K. R. Lips, E.M. Middleton, S.A. Orchard, and A.S. Rand. 2001. Amphibian Declines and Environmental Change: Use of Remote-Sensing Data to Identify Environmental Correlates. Conservation Biology. Vol. 15, No. 4.

> Use of hyperspectral imagery to map key amphibian breeding habitats such as algal ponds and sedge wetlands.

Colorado Herpetological Society. 2002. Hatchery-Reared Boreal Toads Released. The Cold Blooded News. vol 29, no 9

> Captive-reared WESTERN TOAD tadpoles were released in Rocky Mountain National Park. They came from a breeding population of 1000 toads at the Colorado Division of Wildlife's John W. Mumma Native Aquatic Species Restoration Facility. Researchers are looking for chytrid-free release sites.

Corkran, C.C and C.R. Thoms. 1996. Amphibians of Oregon, Washington and British Columbia. Lone Pine Publishing.

> Although range maps do not include Southeast Alaska this is a great amphibian field manual covering all of the species known from our area, plus others to the south.

Corn, P.S. and E. Muths. 2002. Variable breeding phenology affects the exposure of amphibian embryos to ultraviolet radiation.

> Studied *Pseudacris* at high elevation in Colorado. Reduced water depth has been proposed to interact with increased UVB and a pathogenic fungus to cause high embryo mortality. This study suggests that exposure to extreme temperatures is an alternative explanation for increased mortality in shallow water.

Corn, P.S. 2003. Amphibian breeding and climate change: importance of snow in the mountains. Conservation Biology. vol 17, no 2, pp. 622-625.

> Re-analyzes Blaustein et al. 2001 who related earlier breeding by WESTERN TOAD, CASCADES FROG and Pacific tree frog to air temps. Claims snow melt timing is more important. Blaustein et al. reply that he has missed the point – at 6 of 7 locations, amphibs show no temporal trend.

Daszak, P.; Berger, L.; Cunningham, AA.; Hyatt, AD.; Green, DE.; Speare, R. 1999. Emerging infectious diseases and amphibian population declines. Emerging Infectious Diseases 5: 735-749.

> An excellent discussion about Chytridiomycosis as an emerging panzootic fungal disease of amphibians, in particular western toads.

Duellman, W.E. and L. Trueb. 1994. The Biology of Amphibians. Johns Hopkins University Press.

> Every aspect of amphibian biology

Frankland, J. C., N. Magan, and G. M. Gadd (eds.) 1996. Fungi and environmental change. Cambridge Univ. Press, Cambridge. 351 pp.

> This book helps us to understand how climate change can effect a change in the fungal disease that is attacking western toads.

Gascon, C. and D. Planas. 1986. Spring pond water chemistry and the reproduction of the wood frog, *Rana sylvatica*. Canadian Journal of Zoology, vol. 64, pp. 543-550.

> Quebec WOOD FROG study. Sudden decreases in pH occur during spring snowmelt periods. Small ponds are not as buffered from this pulse by surrounding soils. Half of the study ponds (n=15) dried up completely. 11 of the 15 ponds (chosen mainly to give a wide range in pH) had WOOD FROG egg masses, ranging in number up to 336 in a 475m^2 pond Pond size ranged from 40 to 520m^2. pH from 3.4 to 6.7. DOC was highly variable. The study concluded that egg mass density was negatively correlated with acidity and total organic carbon. Hatching success was inversely correlated with pH. However, even the extremely acidic ponds had eggs, and hatching success was fairly high.

Gotthardt, T. 2003, Monitoring the distribution of amphibians in the Cook Inlet Watershed. Report for the Alaska Natural Heritage Program.

> Coordinated 90 volunteers in monitoring WOOD FROG populations by call and tadpole surveys on 118 sites, of which 62 held WOOD FROG. Tads detected at 6 of 20 sites surveyed.

Haslam, 1978, River Plants. Cambridge University Press

Good general reference on aquatic vegetation, especially on aquatic plants as indicators of water quality.

Heatwole, H. 1961. Habitat selection and activity of the wood frog, *Rana sylvatica* Le Conte. American Midland Naturalist. 66(2) pp. 301-313.

Early life history study of WOOD FROG in S. Michigan. Hardwood swamp habitat. Only one of hundreds observed was beyond the shade of trees. Found inactive frogs in pond bottom litter. "Active" frogs sit in ambush and only move for prey. Latest activity was in October.

Hecnar, S.J. and R.T. M'Closkey. 1996. Regional dynamics and the status of amphibians. Ecology, 77 (7) pp. 2091-2097.

SW Ontario metapopulation studies of 11 species in 97 ponds from 1992 to 94. One of three areas had significant species loss compared to historical records, due to land use patterns. Surprisingly high turnover of species at ponds. Cases of increased incidence ranged from .07 to .29 species per pond per year. Decreased incidence ranged from .16 to .30 sp/pond/yr. Leopard frog (*R pipiens*) declined and AMERICAN TOAD increased. Specific environmental factors may explain amphib loss in particular cases, but ultimate cause of large scale loss is reduced opportunities for colonization and increased frequency of extinction.

Hecnar, S.J. and R.T. M'Closkey. 1996. Amphibian species richness in relation to pond water chemistry in south-western Ontario, Canada. Freshwater Biology 36, pp. 7-15.

Study of 13 amphib spp. in relation to 15 chemical variables. Observed 180 ponds located from maps and aerials, from 1992 to 94. Most ponds visited at least 3 times, both day and night, by 3 to 7 people. Only 3 of the 180 ponds had no amphibs during any visit! Water was hard and alkaline. "Water chemistry was a poor predictor of amphibian species richness." Discriminant function analysis (DFA) gave barely better than random success in 5 of 8 species. Only in *Pseudacris spp.* was correct DFA classification moderately successful (~70%) and this may relate to their use of temporary spring ponds without predators, more than water quality *per se*.

Heinen, J.T. 1993. Aggregations of newly metamorphosed *Bufo americanus*: tests of two hypotheses. Canadian Journal of Zoology. vol. 71. pp. 334-338.

Aggregation study of AMERICAN TOAD in Michigan. Piling behavior investigated. Tested 2 hypotheses involving predation and desiccation. Concluded it was response to desiccation. At and shortly after metamorphosis, anurans face highest risk of their life cycle. Water loss highest. Smallest size. Predation is very high on both pre- and post metamorphic individuals. Synchrony (as opposed to mounding) may be a predator swamping strategy. Garter snake predation is highest at that stage. Eastern garter snakes can handle fairly high amounts of the toxins in toad skin secretions. Toads freeze in presence of active snakes.

Hermans, M. and R. Armstrong. 2000. Toads in Southeast Alaska. Alaskan Southeaster. September.

Includes speculation on local causes of declines

Herreid, C.F. and S. Kinney. 1967. Survival of Alaskan woodfrog (Rana sylvatica) larvae. Ecology, vol. 47 no. 6. pp. 1039-1040.

WOOD FROG larval survival study at College, AK. 52 egg masses studied averaged 778 eggs/mass. Average fertilization success 87%. Fungus killed 4%. Marked tads in 4 ponds allowed population estimates. In no pond did more than 10% of original population survive to metamorphosis in late July. Average survival was 3.7% Noted increased mortality in eggs laid at lower pond levels, maybe from lowered oxygen, temps or increased silt. Predation by *Dytiscus* was extensive in all ponds and lab tanks. Because many frogs survive to at least 3 years (necessary for breeding), survival after metamorphosis must be much higher – at least 0.25.

Heyer, W.R., M. A. Donnelly, R.W.McDiarmid, L.C. Hayek, and M.S. Foster, eds, 1994. Measuring and monitoring biological diversity: Standard methods for Amphibians. Smithsonian Institution Press.

Describes standard survey techniques in aquatic and terrestrial habitats.

Hicks, S., and W. Shofnos. 1965. Determination of land emergence from sea level observations in Southeast Alaska. Journal of Geophysical Research. 70(14): 3315-20.

Assessment of glacial rebound from tide gauge information.

Hodge, R. P. 1976. Amphibians and reptiles in Alaska, the Yukon, and Northwest Territories. Alaska Northwest Publishing, Anchorage.

The classic reference on Alaskan amphibians.

Hofrichter, R. (ed) 2000. Amphibians: the world of frogs, toads, salamanders, and newts. Firefly Books.

Authoritative state-of-our-knowledge text with the beauty of a coffee-table format. Superb photos.

Hopey, M.E. and J.W. Petranka. 1994. Restriction of wood frogs to fish-free habitats: How important is adult choice? Copeia, 1994(4), pp. 1023-1025.

WOOD FROG pond choice in N Carolina. Surveyed >20 natural ponds – vernal, spring-fed seepages, stream cutoffs, and found strong allopatry in fish and amphibs.

Study tested whether fish ponds were avoided by adults, or if larval survival was simply better in fishless. In experimental ponds with and without small sunfish, there was strong avoidance by adult WOOD FROG. They also observed individual WOOD FROG traveling widely among the ponds. The fish remained hidden in litter, so avoidance was probably chemical rather than visual.

Howard, R.D. 1980. Mating behavior and mating success in woodfrogs, *Rana sylvatica*. Animal Behavior. vol 28, pp. 705-716.

WOOD FROG mating behavior in Michigan. Males sexually mature 1 yr before females, and 5.6 times more abundant. Most eggs were deposited in only 1 m^2 of a 256 m^2 pond. Experimental introduction of eggs stimulated more laying. Interrupted chorusing usually resumed in <10 minutes. Spotlighting usually didn't discourage chorusing. WOOD FROG, like many ranids, change color to match background. Males would enter the darkwater pond and soon become almost black. Females entered the pond later and often were paler than males at time of amplexus. At temps below 7.5^oC there is significant embryo mortality, and no young develop below 3.4^oC. WOOD FROG tads don't begin feeding until at or near dispersal stages. (No source given for this statement; is this related to their choice of more sterile ponds than WESTERN TOAD and other amphibs?)

Howard, J.H. and R.L. Wallace. 1984. Life history characteristics of populations of the long-toed salamander (*Ambystoma macrodactylum*) from different altitudes. American Midland Naturalist. vol. 113, no. 2, pp. 361.

Life history of LONG-TOED SALAMANDER at different elevations in NE Oregon. Low elevation larvae metamorphosed in their first summer, while those from mid and high elevation metamorphosed in August of their 3rd or 4th summer. Breeding was in Feb in the low pond, and June or July in the high ones. Three size classes of larvae in the high ponds. Free water in soil is probably the stimulus for emergence (temperature varies too much).

Jones, M. (no date). Boreal Toad Research in Colorado. Colorado Division of Wildlife website: http://wildlife.state.co.us/aquatic/boreal/toadtext.asp

State and federal agencies in Colorado have probably done the most intensive work on boreal (= western) toad for anywhere in its range. This unpublished review of research is the most comprehensive summary we could find of factors relating to WESTERN TOAD decline.

Lane, S.J. and M.J. Mahony, 2002. Larval anurans with synchronous and asynchronous development periods: contrasting responses to water reduction and predator presence. Journal of Animal Ecology. 71, pp. 780-792.

Australian anurans with synchronous vs asynchronous larval development show contrasting responses to water reduction and predator presence. The synchronous species reached metamorphosis earlier in declining water, but metamorphs were smaller and had lower survival in terrestrial stages. Both synchronous and asynchronous sp responded to predator presence (restrained mosquitofish) by hanging out in the far end of the container, but they didn't alter development rate.

Licht, L.E. 2003. Shedding light on ultraviolet radiation and amphibian embryos. Bioscience. vol. 53. no. 6, pp. 551-561.

Evaluation of UVB as an agent in amphibian declines reveals study design weaknesses. Most studies show no effects. The few that do (eg Blaustein) give inadequate consideration to the natural biotic and abiotic factors that normally provide UV protection. DOC in water, jelly coatings of eggs, and melanin in the eggs themselves, all prevent UVB damage. Blaustein study used toxic materials in the UV filters. Cites Biek et al. 2002 who modeled decline factors and concluded that mortality in embryonic stages is less likely to cause declines than mortality in postmetamorphic stages.

Lindell, J. R. and E. M. Grossman. 1998. Columbia spotted frog (*Rana luteiventris*) distribution and local abundance in Southeast Alaska. USFWS, SEAK Ecological Services, Juneau AK (unpublished report).

COLUMBIA SPOTTED FROG survey of Southeast Alaska's major transboundary rivers. Provided baseline population estimates to which future surveys may be compared.

Lips, K.R., J.D. Reeve, and L.R. Witters. 2003. Ecological traits predicting amphibian population declines in Central America. Conservation Biology. vol. 17, no. 4, pp 1078-1088.

Ecological traits predicting amphib declines in Central America. Quantified the vulnerability of pops in 4 areas in central am. Compared taxon, geogr, elevation, adult and larval habitat, activity period, & body size. All 4 sites had similar decline pattern. Declining pops shared aquatic habitats, restricted elevational range, and large body size. Most significant factor was lifetime aquatic index (abstract doesn't say what that is)

MacDonald, S.O. and J.A. Cook. 1996. The Land Mammal Fauna of Southeast Alaska. Canadian Field Naturalist. vol 110(4) pp. 571-598.

Cited herein only in reference to the long tenure of beaver on Admiralty Island.

MacDonald, S.O. 2003. The amphibians and reptiles of Alaska; a field handbook. US Fish and Wildlife Service.

Available on the web at www.alaskaherps.info. Best current local reference. State of our knowledge of distributions, life history, etc.

Malakoff, D. 2000. Fungus among Australian Frogs. Science. vol 289. pp.1871.

Short note in Science: Skeptical researchers gathered in Cairns accepted strong evidence that *Batrachochytrium* fungus is the major killer of Australian amphibians. Government officials of the Northern Territory have banned import of amphibians to the so far chytrid-free state.

McDiarmid, R.W. and R. Altig. 1999. Tadpoles: The biology of anuran larvae. University of Chicago Press.

Considerable information on local species like WESTERN TOAD and WOOD FROG.

Muths, E., P.S. Corn, A.P. Pessier, and D.E. Green. 2003. Evidence for disease-related amphibian decline in Colorado. Biological Conservation 110 357-365.

WESTERN TOAD declines in Colorado. Fort Collins team monitored WESTERN TOAD metapopulation since 1991. Four sites using capture-recapture of adults and counts of egg masses. Males declined 78% from 1991 to 1994, 45% in 1995, and 3% between 1998 and 1999. Diagnosis of chytridiomycosis with infection of *Batrachochytrium* in 6 wild adults. Increase in female:male ratios is also consistent with chytrid fungus infections. 11 years of study indicate this population is in danger of extinction.

Norman, B. R. and T. J. Hassler. 1996. Field investigations of the herpetological taxa in Southeast Alaska. Nat. Biol. Serv., Calif. Coop. Fish. Res. Unit, Humboldt State Univ., Arcata CA (unpublished report).

Most wide-ranging recent survey of SE AK amphibians. Range extensions for many species. Visited islands in addition to the mainland transboundary rivers that were the primary search areas.

Olson, D. H., W. P. Leonard, R. P. Bury (eds.). 1997. Sampling amphibians in lentic habitats: methods and approaches for the Pacific Northwest. Soc. Northwestern Vertebrate Biology, Olympia WA.

Our primary reference for sampling methods. We relied especially on chapters 4 – Surveying and monitoring amphibians using aquatic funnel traps – and 6 – A habitat-based method for monitoring pond-breeding amphibians.

Orchard, S.A. 1992 Amphibian population declines in British Columbia. *in:* Bishop, C.A. and K.E. Pettit. 1992. Declines in Canadian amphibian populations: designing a national monitoring strategy. Occasional paper no 76. Canadian Wildlife Service.

Review of amphib declines in BC. Habitat specialists like Pacific giant, tiger, & Coeur d'alene salamanders, tailed frog and spadefoot toad are declining from habitat destruction. Spotted and leopard frogs are declining in pristine habitats, and may be affected by introduced fish and bullfrogs and managed waterfowl. Many of the former group are stream specialists that use upper reaches beyond fish. Ironically, these are the unprotected reaches.

Palen, W.J., D.E. Schindler, M.J Adams, C.A. Pearl, R.B. Bury, and S.A. Diamond. 2002. Optical characteristics of natural waters protect amphibians from UV-B in the US Pacific Northwest. Ecology. 83(11), pp. 2951-2957.

Optical characteristics of natural waters protect amphibians from UV-B in the Pacific NW. Quantified the UV-B transparency of 136 potential amphibian breeding sites in 2 montane regions. Found that 85% of sites are naturally protected by dissolved organic matter in pond water. Only in the clearest water could UV-B damage eggs. It is thus unlikely as a culprit in widespread amphibian declines.

Phillips, K. 1994. Tracking the vanishing frogs: an ecological mystery. St. Martin's Press, New York.

Especially good for the human side of the amphibian story. Chronicals the dawning realization by herpetologists that there is a global problem.

Relyea, R.A. 2002. The many faces of predation: how induction, selection, and thinning combine to alter prey phenotypes. Ecology. 83(7) pp. 1953-1964.

Hyla versicolor response to the dragonfly *Anax longipes*. Growth impact was mediated through thinning, but morphologic response was primarily through induction. Behavioral response was affected by both.

Relyea, R.A. 2002. Competitor-induced plasticity in tadpoles: consequences, cues and connections to predator-induced plasticity. Ecological Monographs. 72(4) pp. 523-540.

WOOD FROG response to predator vs competitor presence gives contrasting behavior and morphology. WOOD FROG distinguishes between inter and intraspecific competition.

Roberts, W. and V. Lewin. 1979. Habitat utilization and population densities of the amphibians of northeastern Alberta. Canadian Field Naturalist. vol 93 pp 145-154.

Good life history study. NE Alberta, 25 ponds with WOOD FROG, PACIFIC TREE FROG and CANADIAN TOAD 24 of 25 sites had WOOD FROG (spawned in 14), other 2 sp common but in <1/2 of sites. Spawning for all 3 sp probably doesn't occur until their 3rd summer. WOOD FROG postmetamorphs were 14-19mm, growing to 18-24mm by late aug. Yearlings 20-31mm in late june. Spawning males 29-50mm and females 34-56mm. Metamorphs mostly disperse away from the pond – few present in Aug. Egg stringers of CANADIAN TOAD are adaptive for a species using such a wide variety of pond types, as some will remain submerged if water recedes. Postmetamorphs 9-13mm grow to 19-28mm by late Aug. Yearlings >22m in June, thus readily distinguishable from young of year, which are abundant on pond margins thru early Sept, but gone by mid month. Across all 3 sp, 29% counted on cool mornings, 14% on cool afternoons, 35% on warm mornings, and 22% on warm afternoons.

Semlitsch, R. D. and J. R. Bodie. 2003. Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. Con. Bio. 17: 1219-1228.

Most amphibians breed in aquatic habitats but also use terrestrial habitats for seasonal migrations to and from wetlands and for foraging (this does not include juvenile dispersal from natal wetlands). The authors define the terrestrial area around a wetland that is used for migrations and foraging as a 'core terrestrial habitat.' Adult amphibians are usually philopatric to individual wetlands. From a review of the literature, the authors reported that the average minimum radius of the core terrestrial habitat for 19 species of frog was 205m from the edge of the wetland, and the average maximum was 368m. For salamanders (13 spp.), the corresponding values were 117m and 218m.

For *Bufo boreas* in CO and WY, the maximum core radius was 101m, but for other *Bufo*s it ranged up to 480m. For *Rana* spp., the maximum core radius ranged up to about 580m for most species, but>1000m for bullfrog. For *Taricha torosa granulosa* in OR the modal radius was 185m.

Skelly, D.K. K.L. Yurewicz, E.E. Werner, and R.A. Relyea. 2002. Estimating decline and distributional change in amphibians. Conservation Biology. vol. 17, no 3. pp. 744-751.

Evaluated former studies that used historical presence data to guide resurvey projects lasting one to several years. From 1996 to 2000, tested the validity of surveys of differing lengths, sampling 32 ponds in Michigan originally surveyed between 1967 and 74. By systematically degrading the 1996-2000 data, determined that a 1 year resurvey would estimate 45% decline, a 2-yr 28% decline, and a 5-yr only 3% decline. Also, if historical data listed only presences (not presence-absence), even a 5-yr resurvey would estimate 30% decline. Like Hecnar and M'Closkey 1996, found high yr-to-yr change in pond occupancy. Accumulation of presence records continued to rise even between year 4 and 5 of the study. Species on the study area are changing substantially in location, but there is little evidence for decline. Sampling was intensive and multipronged (chorusing, dipnetting, etc). Most presence determinations were based on numerous captures. One influence was drought in 1999 and 2000. In a Michigan study of AMERICAN TOAD, succession led to declines when ponds where overarched by tree canopy. Resurveys should extend for long enough to estimate the value of additional data. Geographic scale of the study should be based on amount and quality of the historical information. For example, in the Michigan study, the total # sp across the study area remained constant from 1996 through 2000, in spite of changes among ponds. With limited historical data, this larger scale would be the appropriate one for a resurvey attempt.

Skelly, D.K., L.K. Freidenburg, and J.M. Kiesecker. 2002. Forest canopy and the performance of larval amphibians. Ecology. 83(4) pp. 983-992.

Study of forest canopy and larval WOOD FROG & PACIFIC TREE FROG (peepers) at Yale-Myers Forest. Closing canopy with succession excludes PACIFIC TREE FROG but not WOOD FROG.

Slough, B. (no date). Frogs, Toads, and Salamanders: Amphibians of the Yukon and northern British Columbia. Canadian Wildlife Service, Environment Canada, Whitehorse YT.

Excellent brochure with range maps and collection sites for 5 Canadian species, most of whom colonized Alaska through these provinces. Good life history information.

Stebbins, R. C. and N. W. Cohen. 1995. A natural history of amphibians. Princeton Univ. Press.

Chapters on voice, skin, predators, reproduction, declines, etc. Delightful ink illustrations.

Taylor, M. S. 1983. The boreal toad (*Bufo boreas boreas*) as a successional animal in Glacier Bay, Alaska. MS thesis, Calif. State University, Hayward. 54 pp.

Documented survival of WESTERN TOAD in salt water. Explains dispersal to recently deglaciated regions of Glacier Bay.

Van Buskirk, J. and M. Arioli. 2002. Dosage response of an induced defense: how sensitive are tadpoles to predation risk? Ecology. 83(6). pp. 1580-1585.

Induced response to predators in *Rana lessonae*. Reared with differing numbers of *Aeschna* dragonfly larvae consuming differing numbers of tadpoles. Morphological response cued to naiad #s whereas behavioral response cued to # of tads eaten.

Waters, D. L. 1992. Habitat associations, phenology, and biogeography of amphibians in the Stikine River basin and Southeast Alaska. USFWS, Calif. Coop. Fish. Res. Unit, Humboldt State Univ., Arcata CA (unpublished report).

First of 3 surveys focusing on SE AK mainland rivers in the 1990s. Described use of several moving and still-water habitats. Possible range extension for northwestern salamander.

Appendix A
Pond assessment forms

(Copy double-sided and cut in half)

AMPHIBIAN HABITAT SURVEY

Discovery SE 463-1500 • Richard Carstensen 586-1272
richard@discoverysoutheast.org

date time observer(s)

pond name & #

lat/long **N**

W

site description

elev

air photo(s)

weather

air temp sky clear cloudy overcast precip dry showers rain snow wind none light med hard

precip last 2 days?

habitat

pond type *(circle any than apply)*
bedrock-controlled recent-glacial
uplift bog fen beaver (active inactive)
anthropogenic

length*(m)* width(ave)

depth*(dm)* max ave

surface area*(m²)*

connection? none inlet outlet both

conn. stream order 1 2 3 4

water level high average low

N
sketch map

water temp pH DO µS ppt site

water temp pH DO µS ppt site

temp logger (*notes from downloads*)

clarity clear stained turbidity clear cloudy iron floc absent present severe sheen none organic petro

depth org muck*(dm-probe)* over boulders cobbles gravel sand silt unknown

page 1

woody detritus *(twigs, bark chips)* absent some lots boards absent some lots

logs *(>10cm or large bark slabs)* # per 10m shore

stratum cover
use % shore on large or murky pond; use total % on small or linear pond **% cover**

vegetation *(circle & number, 1, 2, etc beneath for order of abundance)*

aquatic: emerg. CAsp EQFL HIVU HITR METR POPA CAPA other -

rooted floating NUPO SPEM POsp CAVE other -

submerged MYSP RAAQ *Chara* POsp other -

terrestrial: trees/shrubs: PISI TSHE POTR ALRU ALCR RUSP MYGA other -

herb/gram *(dominants only)*:

distance shore to nearest closed forest N S E W

successional status fairly stable (peatland or old-growth) slowly changing rapidly changing

describe *(eg tree growth rate)*

amphibian search entire site searched yes no % shore searched

disturbances? yes no fish? yes no species? other pred?

survey method visual hand ID boards traps net sweep

amphibian species seen where?

site A	*adults(SVL)*	*juv(SVL)*	*larvae(TL)*	*eggs*
number				
lengths				

site B	*adults(SVL)*	*juv(SVL)*	*larvae(TL)*	*eggs*
number				
lengths				

comments

page 2