Introduction to Amphibians

1. Amphibians: what are they, and what do they want with us?
2. Introduction to three major groups of amphibians
3. Riparian Forests: amphibian habitat, nutrient cycling, and effects of management

1. Amphibians: some basic facts

- Amphibian literally means "both lives" (*amphi*: both or all; *bios*: life)
- First colonized the land in the mid-Devonian, 350 mya.
- Transitional between fully aquatic lobe-finned fishes (Sarcopterygians) and terrestrial amniotes. As such, many (but not all) amphibians experience metamorphosis.
- Adaptive radiations in many groups of amphibians have resulted in more life history strategies than among any other group of tetrapods.

Amphibians have it hard

- Susceptible to pollutants and other drastic changes in both aquatic and terrestrial ecosystems
- Taste great (they are "the major conveyor belt that provides for transfer of invertebrate energy sources to predatory animals higher up the food chain")
- In 1758, Linneaus had this to say about amphibians: "These foul and loathsome animals are abhorrent because of their cold body, pale color, cartilaginous skeleton, filthy skin, fierce aspect, calculating eye, offensive smell, harsh voice, squalid habitation, and terrible venom; and so their Creator has not exerted his powers to make many of them." (Actually, There are upwards of 4,500 species of amphibians (more than mammals).

Some diagnostic characters of "modern amphibians"

- Glandular skin that contains both mucous and poison glands (but no epidermal structures--no scales, feathers, or fur)
- Three-chambered heart (two atria, one ventricle)
- Cutaneous respiration (most species also have lungs, but the three-chambered heart does not provide enough pressure to fully inflate the lungs on its own, so amphibian lungs are not as efficient as ours)
- Complex inner ear anatomy, including a membrane that allows amphibians to hear acoustic signals of less than 1,000 Hz (very low "bass" sounds).
- Highly variable chromosome number, genome size, and ploidy.

2a. Major groups: caecilians (Gymnophiona)

- Limbless, burrowing, tropical amphibians that nobody ever sees
- Circumtropical (except Madagascar)
- Adults are almost entirely subterranean (and therefore mostly blind)
- Internal fertilization
- Some very interesting parental care and reproductive modes exhibited, including viviparity, and egg and larval attendance

2b. The salamanders (Caudata)

- Caudata: salamanders (and newts, which are just a small group of often aquatic salamanders within the family Salamandridae)
- The only major group of amphibians with both tails and limbs
- Most diverse in SE U.S.—adaptive radiation spread them to most of North America and some of Central America, plus a few in Europe and east Asia.

Salamander life histories

- Most common life history: aquatic larvae, terrestrial adults, internal fertilization via spermataphore, eggs laid in water. (True amphibious lifestyle)
- Alternate life histories: ***paedomorphosis***. Reproductive adults retain larval characteristics, typically those associated with an aquatic lifestyle (these individuals live their entire lives in water). Adaptations include retention of external gills and dorsal fins. Species may have obligate or facultative paedomorphosis.
- *Notophthalmus viridescens* ("Eastern Newt"; eastern US). 3 part life history: Aquatic larvae metamorphose into terrestrial, non-reproductive efts, which stay on land for several years before metamorphosing again into aquatic, reproductive adults.

How do salamanders breathe? How does anything breathe? Or: What is respiration?

Now that we know what respiration is: how do salamanders do it? Put another way: What are the respiratory organs of salamanders?

Weird salamanders: One family is lungless: Plethodontidae, including *Ensatina* and *Plethodon* in W. Washington. What ramifications does lunglessness have?

Being lungless, plethodontids have evolved long, thin bodies, yielding high surface area:volume ratios for increased efficiency of cutaneous respiration. What is the downside of this body shape?

Rhyacotriton olympicus (Olympic torrent salamander)

- *Diagnostic features*: Up to 10cm total length. Large eyes. Bright yellow underbelly. Males have squared lobes of their cloacas. Lungs are reduced to reduce buoyancy in fast-moving streams.
- *Habitat*: In and around clear, headwater streams, especially where water is cool and clear, and substrate is gravelly.
- *Defense mechanism*: unken reflex (displaying bright underbelly)
- *Conservation status*: At risk from siltation and increasing water temp—results of logging.

Dicamptodon copei (Cope's giant salamander)

- *Diagnostic features*: Up to 20 cm total length. Most adults retain external gills.
- *Habitat*: Similar though not identical to that for torrent 'manders.
- *Development*: Most individuals are paedomorphic: they retain larval characters (e.g. gills, tail fin, toe-webbing) as reproductive adults. Rare individuals may undergo metamorphosis, however, so paedomorphosis is facultative, not obligate.
- *Importance*: Can comprise over 95 percent of the predator biomass in small streams

3c. Diagnostic features of Anura: *What makes a frog a frog?*

- Anurans are defined as the tailless amphibians (there is one apparent, although not actual, exception). Postsacral vertebrae are fused into a single element: the coccyx, or

"tailbone".
- Have elongated hind limbs (relative to their forelimbs) that are fused (ours our unfused), an adaptation for jumping.
- Most frogs have no ribs.
- More geographically widespread than Gymnophiona or Caudata, but still more prevalent in the tropics than elsewhere.
- Adaptations for jumping: Long hind limb bones; long feet bones; elongate pelvic girdle; shortened, but strong, spine.

Also:
- Most are nocturnal.
- Almost all anurans have external fertilization.
- Almost all are oviparous.
- Most anurans mate in a posture called ***amplexus***, in which the male grasps the female in the armpits or at the waist. In some species, amplexus can last for months.
- Length of breeding season is often limited by climate, or seasonal availability of breeding sites (such as ephemeral pools). Temporal patterns of reproduction can be roughly divided into two types: ***explosive breeding*** and ***prolonged breeding***. What generalities are likely to be true regarding which frogs breed explosively, and which have prolonged breeding seasons?

Frog life histories: the common mode

- An explosively breeding species in which an entire population convenes around a pond.
- During amplexus, large masses or strings of eggs are laid in the water, and afterwards both male and female disperse, never to encounter their offspring again.
- Those eggs that don't get eaten develop and hatch in the water. Tadpoles survive by eating muck or small aquatic insects, until they finally metamorphose, and only then come on land.
- This reproductive mode is the most common and phylogenetically widespread among anurans. But there are other ways to be a frog. Other strategies include:

Ascaphus truei: the tailed frog

- The most primitive of all living anurans, *Ascaphus* is endemic to the PNW, where it lives in fast-moving streams. Tadpoles have a ventral suction cup that they use to attach themselves to rocks in fast water.
- The "tail" is not actually a tail, but an extension of the cloaca used as an intromittent organ during copulation. *Ascaphus* is an exception to the rule of external fertilization in anurans.

Amphibian habitat

- Many amphibians live close to the border between land & water.
- Amphibians with "typical" life histories can be broadly separated into two types—those that live in lentic, or slow moving water (such as lakes and ponds), and those that live in lotic, or fast moving water (such as rivers and streams). What might some of the differences between these two broad types be?

Riparian zone

- **Definition**: terrestrial zone adjacent to the channel (river, stream) which strongly influences, and is strongly influenced by, the channel. A river and its riparian zone exchange material on the surface and below the surface. The riparian zone usually includes the floodplain plus some upslope / terrace land.
- Torrent salamanders, (*Rhyacotriton*) giant salamanders (*Dicamptodon*), and tailed frogs (*Ascaphus*) live for, and in, the riparian zone of semi-seasonal fast-moving streams.

Effects of forests on rivers

- Shading from solar radiation (temperature and light).
- Input of nutrients & sediments from upslope & from uptree (leaves, large woody debris)
- Habitat creation for aquatic communities along banks (roots, treefalls)

Effects of rivers on forests

- Streams, and therefore riparian forests, are quite different depending on what stream order they belong to.
- Amphibians move between rivers and forests, so nutrients move between them as well. Some stream nutrients ultimately come from the marine environment.

Amphibians and nutrient cycling

- It has been hypothesized that top-down effects of vertebrate predators (specifically frogs) will, in turn, affect nutrient cycling rates in terrestrial systems. How might you test this hypothesis in the field?

Why do *ratios* of available nutrients matter for ecosystem function?

Forest management and amphibians

- Through the world, but particularly in the PNW, forests are being managed in ways that impact amphibian (and other) inhabitants, but little research has been done to measure those impacts. Since the 1950s, application of Nitrogen-based fertilizers to managed forest lands, in order to accelerate tree growth and thus increase timber production, has been standard practice.
- In 2001, three forest-dwelling 'phib species were studied with respect to their response to Nitrogen addition in their habitat: *Plethodon vehiculum (*red-backed 'mander*)*, *Rhyacotriton variegatus* (Southern torrent 'mander), *Taricha granulosa* (rough-skinned newt)
- Methods: Two experiments: toxicity and avoidance.
- Results: All species avoided Nitrogen treatments when they had the option. Two of three species suffered an increase in mortality when exposed to Nitrogen fertilizer in the lab. Newts did not.
- Interpretation: Nitrogen fertilization is bad for amphibians. But these results beg a question: Why are two of these species more susceptible than the other?

Bonus material, if we have time: gladiator frogs!