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We thank the Of Pools and People team for contributing the science, photography, and figures for this presentation.....

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Wood frogs have a dark face mask above a white lip line. They are a small frog, often less then 2.5 inches long. In Maine, they are the first frogs to emerge from hibernation in upland forests where they have been frozen just below the leaf litter. Warm spring rains thaw the frogs, cueing them to make their way to breeding pools. Wood frogs live 3-5 years and are the most northerly ranging frog in North America.

Once they arrive at their breeding pool, male wood frogs float at the water surface and inflate vocal sacs on either side of their bodies (sounds like a flock of ducks quaking) hoping to entice females to the pool for the spring breeding frenzy (otherwise, it is a lonely party).

Sometimes there are competitions with multiple males vying for the same female…and even occasionally a drowning.

Wood frogs in amplexus (larger, salmon-colored female on bottom; smaller, darker male on top).

During amplexus the female wood frog deposits a single egg mass on a twig just below the water surface as the male fertilizes it.

Notice how small and tightly compact each egg is when first laid, then to the right of the frogs, compare these to the size of the individual eggs are of an older mass that has absorbed water and expanded in size. The eggs at the water surface to the right of the frogs were probably deposited the previous evening.

Newly laid wood frog egg masses are small and compact (about the size of a quarter), but quickly absorb water to reach their maximum size of approximately 5 inches **(roughly the size of a softball)**. Looking down at an egg mass, the embryos will look black or dark brown and blend in with the surrounding darkness of the bottom of the pool. The undersides of the egg masses are a contrasting white or cream color. From the perspective of a predator looking up at an egg mass, the light color blends in with the brightness of the sky above. Egg masses are attached to herbaceous vegetation persisting from the previous year (cattails, sedges, grasses) or to woody vegetation (winterberry shrubs are a common attachment site) including sticks and branches that have fallen into the pool.

Consisting of up to 1000 individual eggs, a wood frog egg mass appears lumpy like tapioca pudding or marbles. Note wood frog egg masses lack the thick outer jelly coating characteristic of spotted salamander egg masses.

Frequently attached to vegetation, wood frog egg masses often break the surface of the water and appear bubble-like. If we get an frost or ice after breeding season, the exposed part of the egg mass may die from exposure.

Rafts of wood frog eggs often contain many layers of masses on top of one another.

At a distance, this large communal raft of wood frog egg masses appears bubble-like at the water's surface. Communally laid rafts are thought to create better conditions for development by providing the eggs in the middle with protection from predators and solar warmth (to of eggs are black to absorb heat and be inconspicuous from predators above and are white below to fool predators below. Attached to winterberry shrubs in this photograph, egg masses are often laid in the deeper regions of a pool.

The majority of wood frog egg masses are attached to shrubs like winterberry or meadowsweet, but our researchers have found that it is not uncommon for egg masses to be found resting on the bottom of vernal pools. BOTTOM LINE: most egg mass counts underestimate egg mass numbers.

The best way to count wood frog egg masses is to enter a pool wearing waders or clothing that you don't mind getting wet. (It is important to make sure that you are not wearing any bug spray or sunscreen that may damage the eggs and developing embryos.) To begin you may wish to restrict yourself to a small area, count the number of masses that you can see at the surface, and then gently use your hands to identify and count the underlying masses by touch. Do not bring pets to the pool and limit the number of people in a pool.

Over a short time wood frog egg masses will deteriorate to the point where individual masses are no longer discernable from the rest of the large floating raft. For the most accurate results, wood frog egg mass counts should be completed within a few days to a week after all of the eggs have been laid. (Check with locals to figure out windows of opportunity as it may vary greatly based on region, forest cover type, exposure, etc.)

Summary of Egg Mass Identifying Characteristics

- Spherical masses with lumpy external appearance
- No outer jelly membrane
- Each mass contains close to 1000 eggs
- Masses often have the appearance of bubbles at the surface of the water
- Communal breeders – masses often deposited in large rafts attached to vegetation

During periods of drought, pools may dry too soon for successful hatching. Frogs will even lay on parking lots where a pool HAD been…most return to breed in the pool they hatched from regardless of degraded conditions. Ditches or skidder ruts on the way to the breeding pool will intercept the frog and may also result in laying in an inappropriate habitat. In this photo the arrow points to two spotted salamander egg masses within a larger raft of wood frog egg masses.

When egg masses, or in this case tadpoles, do end up on dry ground like this they still provide a readily available food source for many of our wildlife species that depend upon the concentration of food resources associated with vernal pools and vernal pool breeding species each spring.

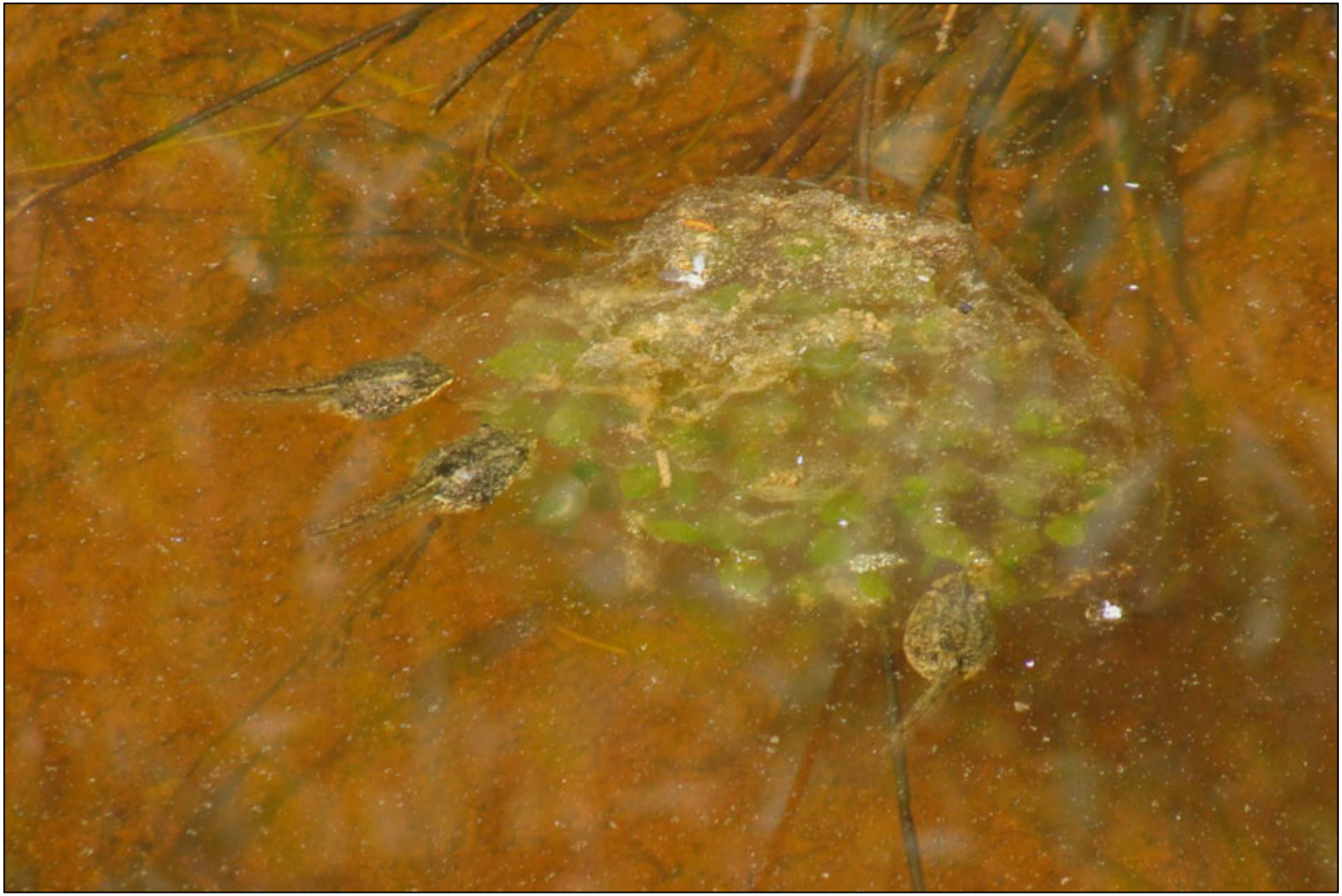
Depending up on the weather and water temperature in each pool, wood frogs begin to hatch roughly 20 days after deposition. Immediately after hatching wood frog tadpoles are very dark in color but as they grow, they become more mottled in appearance. In this photo their tiny external gills are visible.

After hatching wood frog tadpoles can often be seen near the raft of eggs grazing on algae associated with the egg masses.

Soon after hatching, thousands of wood frog tadpoles may be seen feeding in swarms on phytoplankton and algae near the water's surface. They may also feed on blue-spotted salamander embryos (they are not ~~dedicated~~ **hard-core** vegetarians).

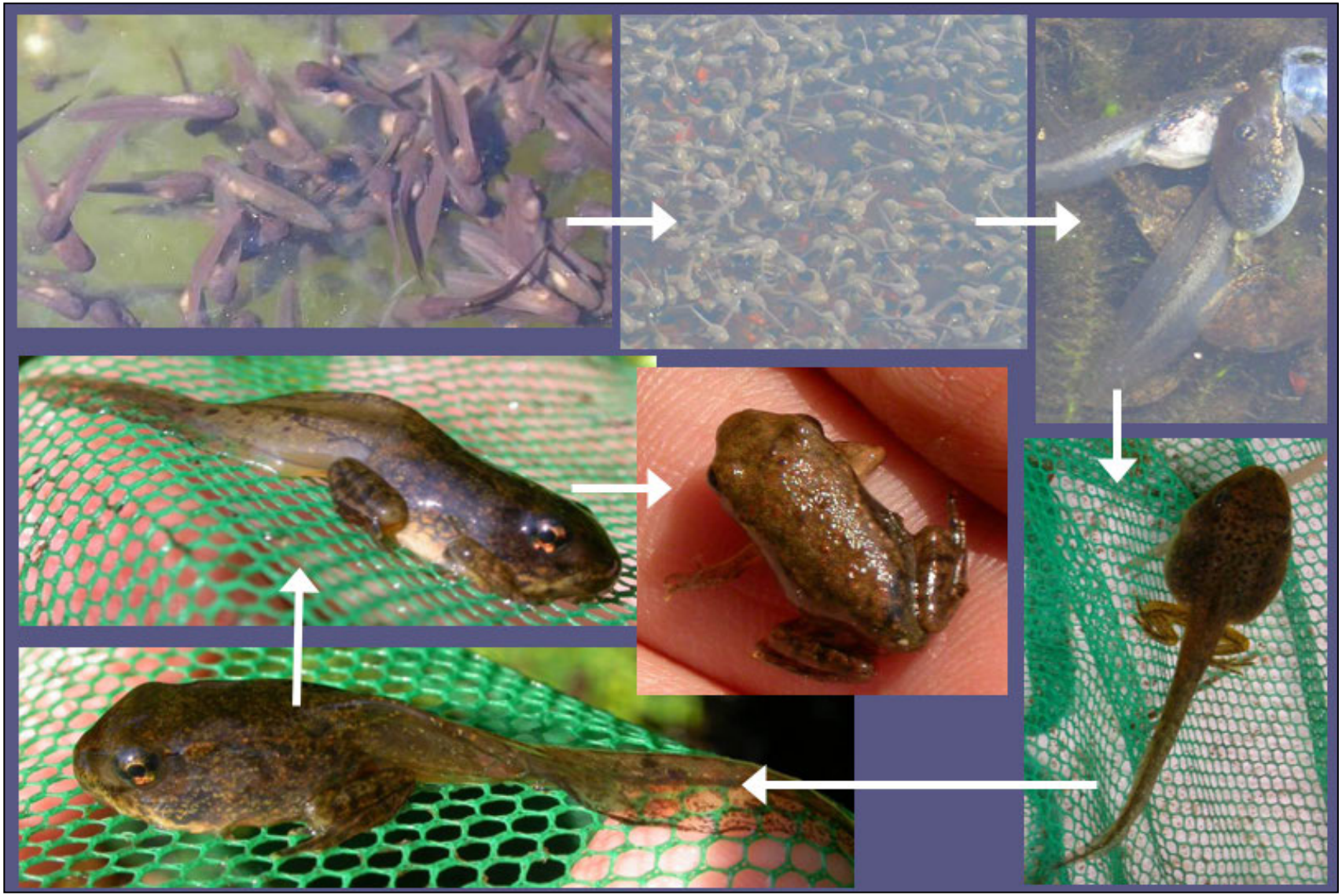
In the late spring and early summer, pools may contain large numbers of small, dark tadpoles with gold flecks along their sides. These are likely wood frog tadpoles: toad larvae are small and dark and green and bull frog tadpoles take two to three years to develop and hence do not breed in truly vernal pools.

American Toad tadpoles will be smaller and blacker than wood frog tadpoles. They hatch AFTER wood frogs from eggs that are deposited in long strings on the bottom of shallow water bodies. You can see that the wood frog tadpoles in this image are much larger than the toad tadpoles, more mottled in appearance, and as a result better camouflaged.



Recently hatched tadpoles are darkly colored and less than 0.5 inches long but as they grow and age, they appear more mottled and olive brown in color. It takes less than 70 days for the tadpoles to develop into metamorphs, or small frogs. In this image wood frog tadpoles feeding on remains of spotted salamander egg mass (note the outer jelly envelope).

Green frog and bull frog tadpoles overwinter in pools that are permanent or may be in former vernal pools where the hydrology has changed. These larger tadpoles prey on wood frog eggs and tadpoles and will be swimming around even before the wood frog egg masses are deposited.

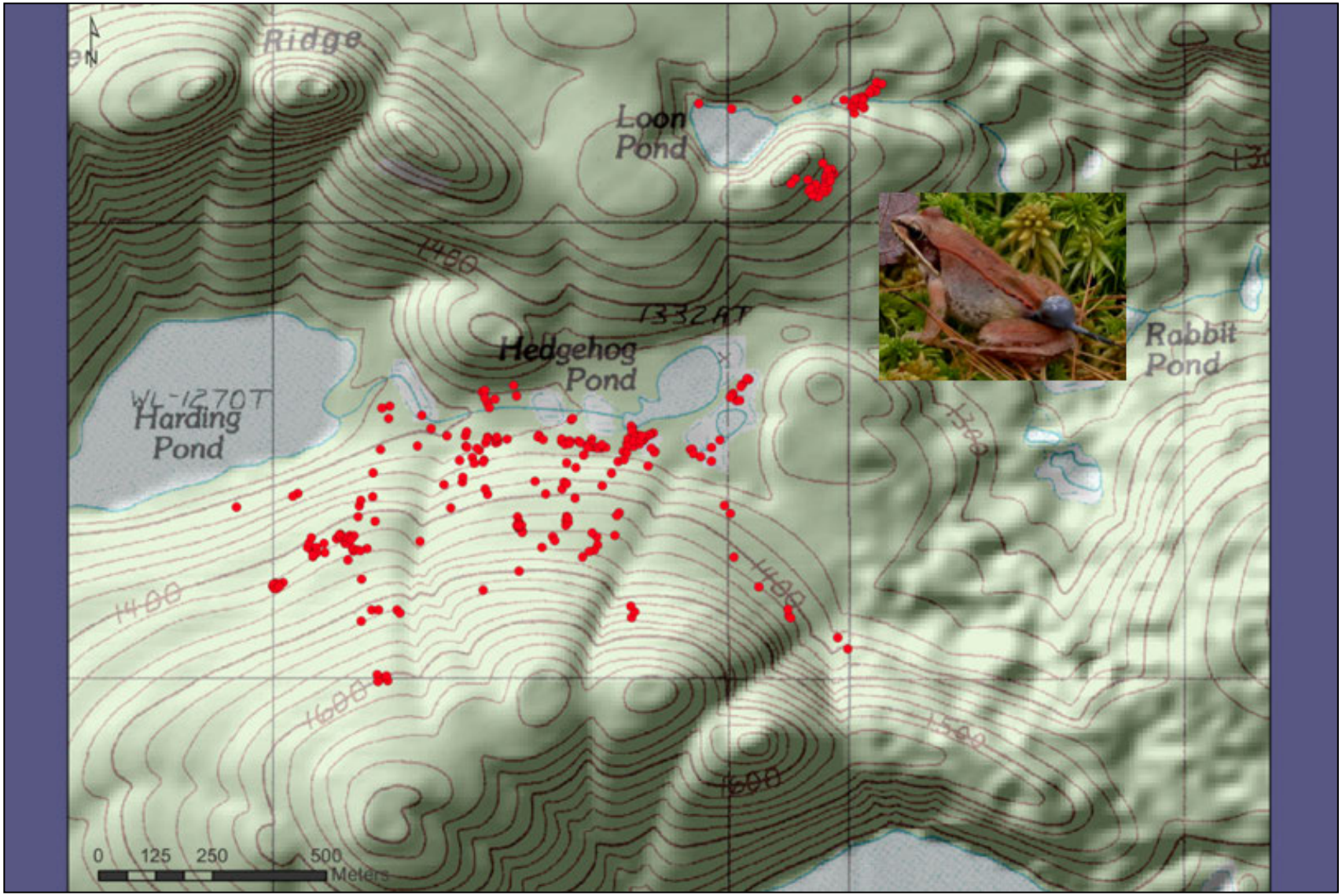


Development stages of wood frog tadpoles from larvae to just before emergence from the pool. Upon emerging they are called metamorphs and would easily fit on the thumbnail of a large male person.

Recently emerged juvenile wood frogs are about the size of your thumbnail. The young metamorphs leave their breeding pools all around the same time, as evidenced in this image of a submerged pitfall trap installed to capture dispersing juveniles. A small pool may produce as many as 10,000 metamorphs in one breeding season.

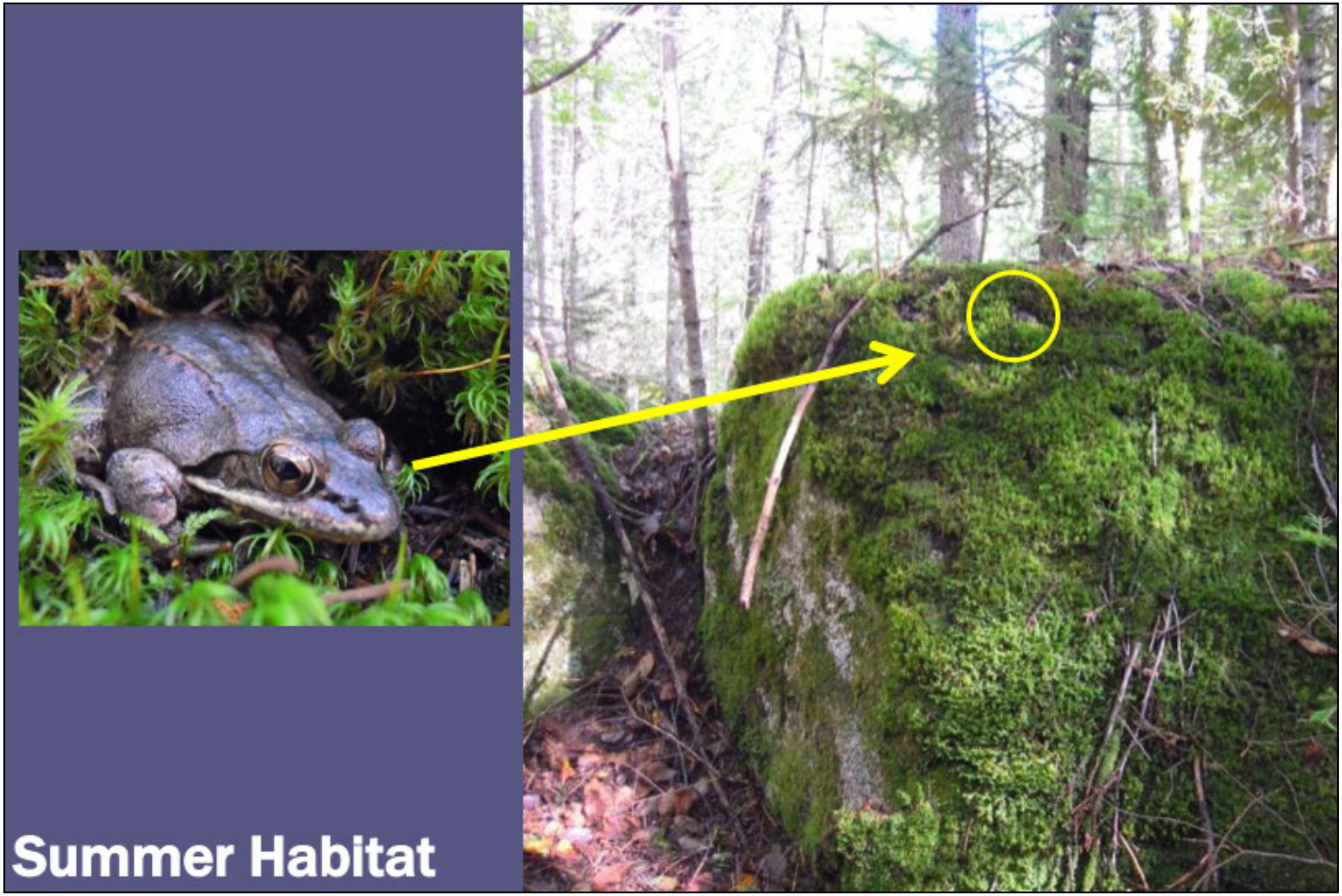
Juvenile wood frog in a forested wetland in the summer.

Tiny waist belt radio transmitters are fitted to adult frogs as they are leaving their breeding pool. Throughout the summer and fall researchers use radio telemetry to re-locate individual frogs to better understand post-breeding habitat preferences in Maine and to make sure the transmitters are not harming the frogs. We have learned that where they summer and hibernate varies depending on what region of the State they are in.



For example, in northern Maine, wood frogs often travel hundreds of meters to summer habitat (each dot represents a frog location).

For more information see: Groff, L.A., A.J.K. Calhoun, and C. Loftin. 2016. Hibernal ecology and habitat selection of wood frogs (*Lithobates sylvaticus*) in a northern New England montane landscape. *Journal of herpetology*.

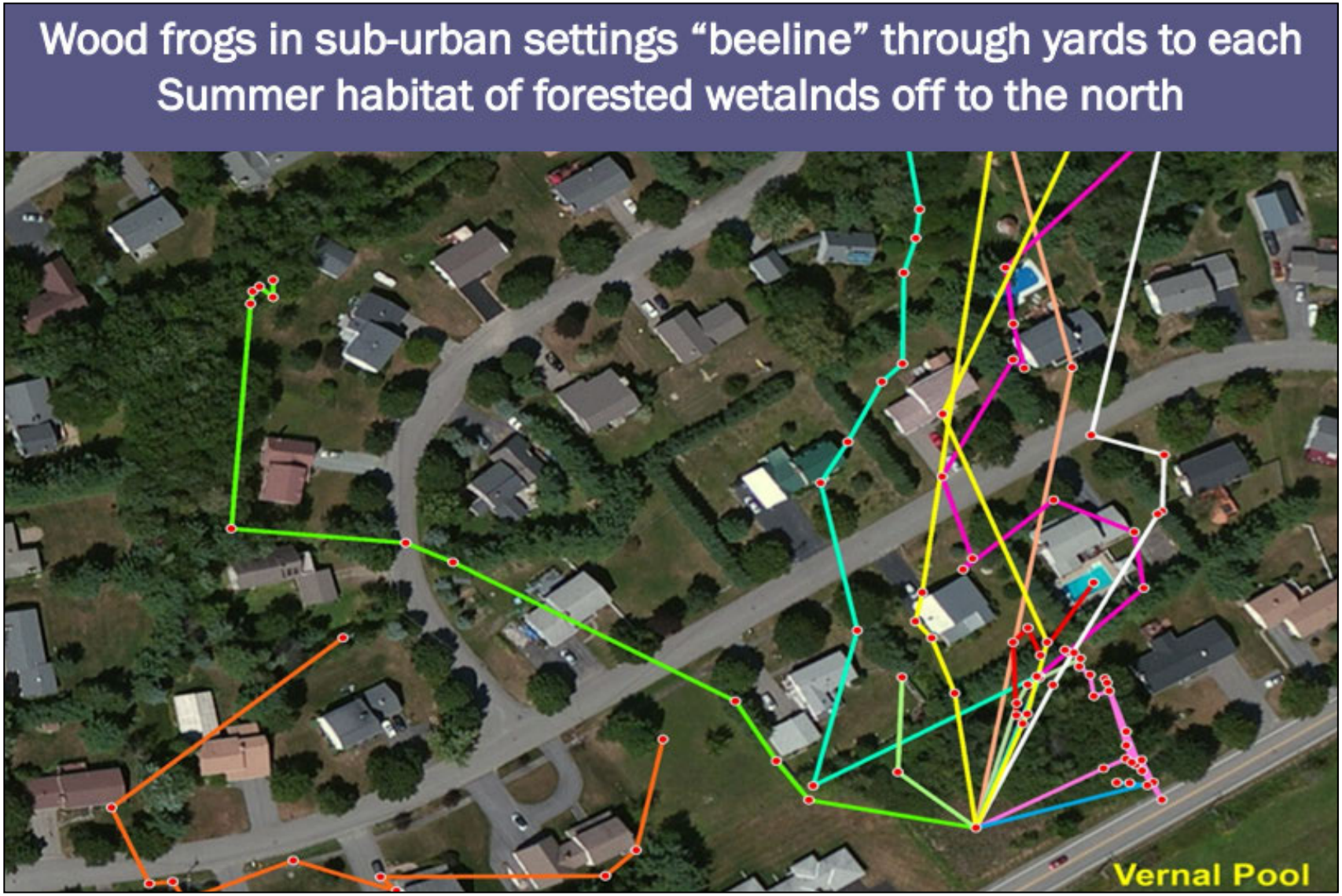


Luke Groff found that some frogs in the higher elevations in the mountainous region of Maine may summer in upland forests around large erratics…either in cool mosses on top of boulders or in damp, often wet soil at the bases of the erratics.

Wood frogs in Downest, central and mid-coast Maine, on the other hand, often summer in forested wetlands. Clearly, context matters when deciding what the best post-breeding habitat to conserve near pools would be.

For more information see: Baldwin, R., A.J.K. Calhoun, and P.G. deMaynadier. 2006. Conservation planning for amphibian species with complex habitat requirements: A case study using movements and habitat selection of the wood frog (*Rana sylvatica)*. *Journal of Herpetology* 40:443-454.

In the fall when temperatures begin to drop, wood frogs move to well drained upland forests where they nestle beneath the leaf litter for the winter. The transmitter was used to track the frog to this overwintering site.

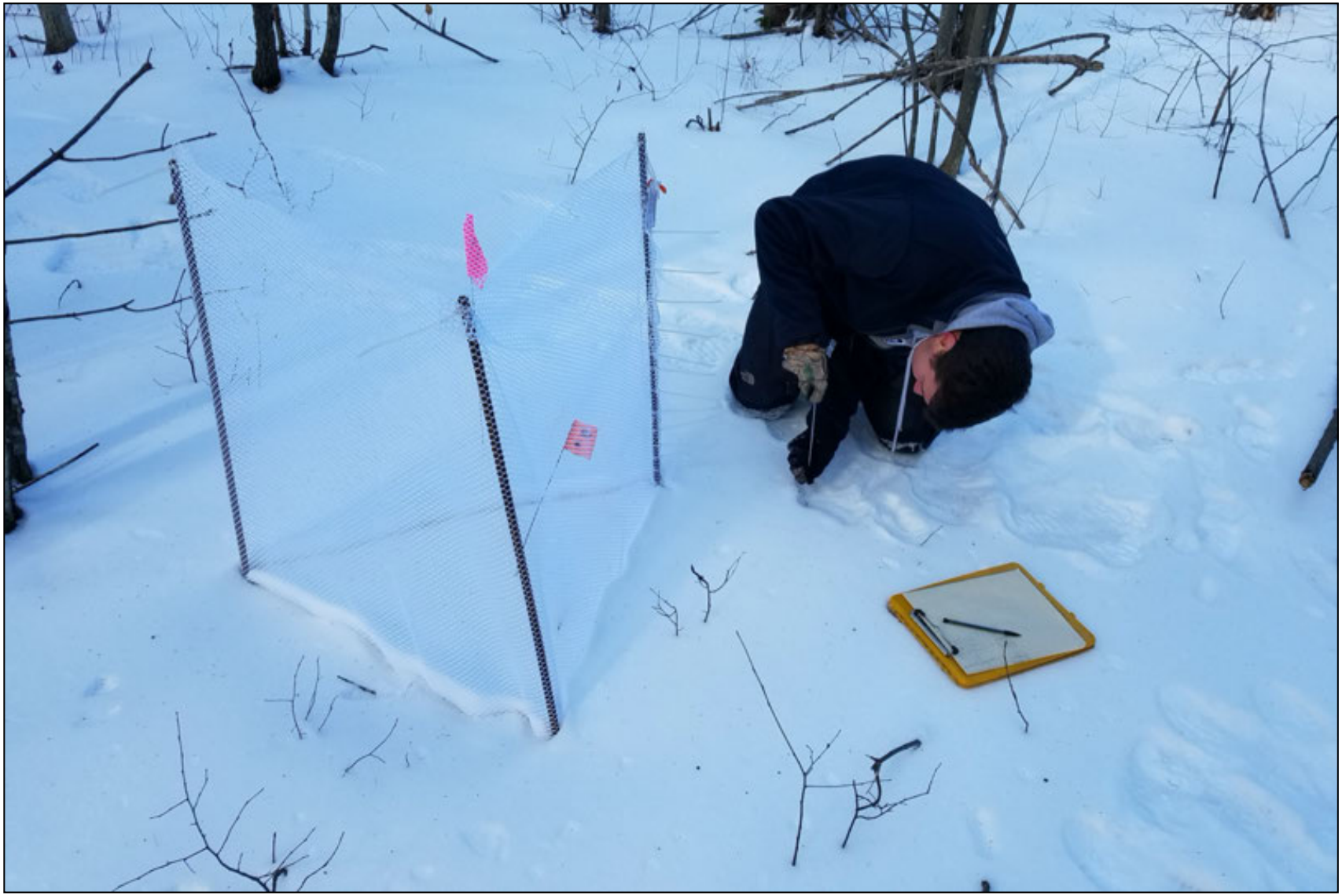


Catching the frogs among emergence allows us the opportunity to apply new transmitters to frogs as they emerge. Tracking in 2016 has shown us that the wood frogs do move through the neighborhood.

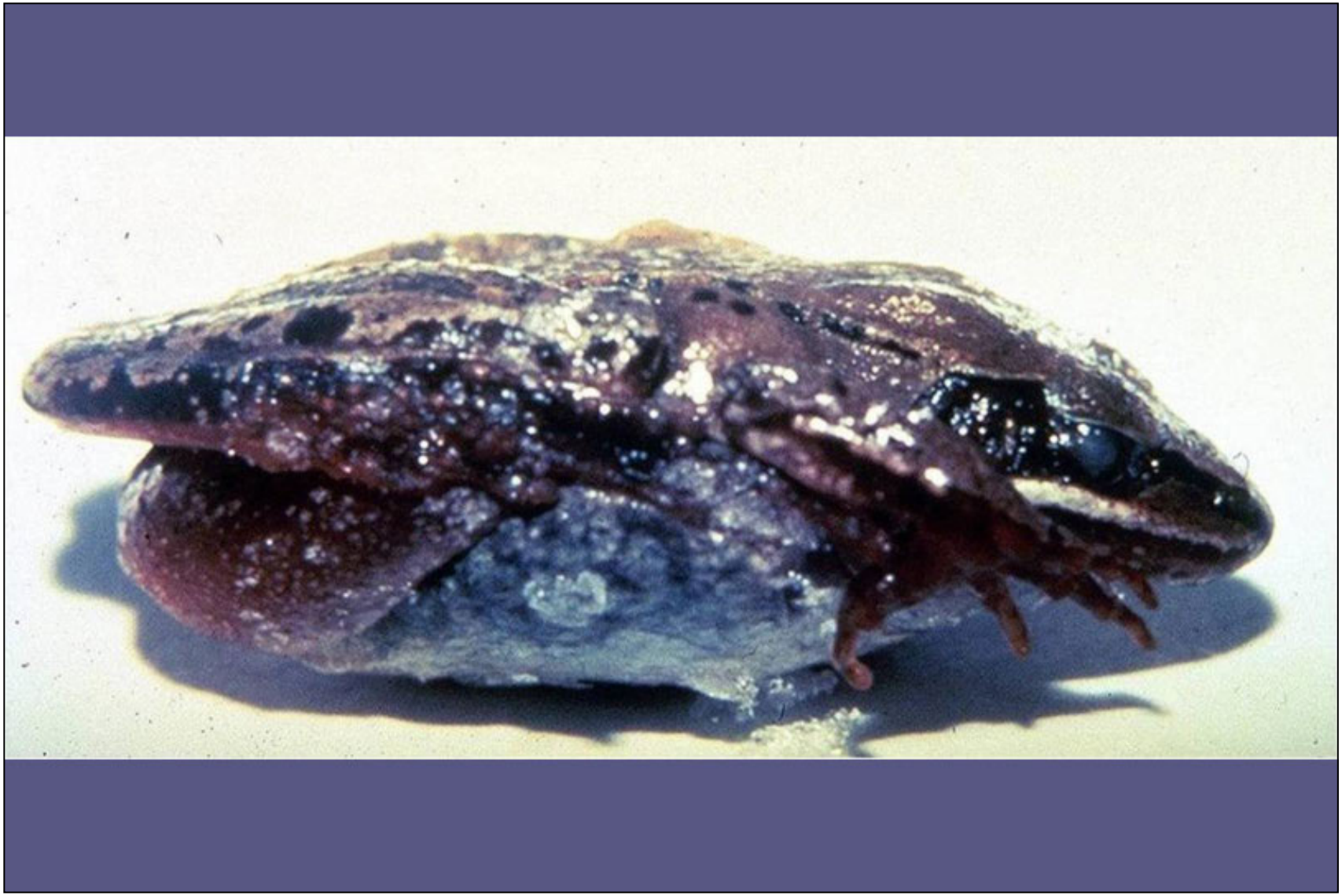
Manuscripts on this work are in progress (Hoffmann, K, T. Hastings, and AJK Calhoun).

Wood frogs hibernate in depressions under the leaf litter (deeper in the mountains than the lowlands) and may return to the same hibernaculum, or hibernating spot, each year.

For more information see: Groff, L.A., A.J.K. Calhoun, and C. Loftin. 2016. Hibernal ecology and habitat selection of wood frogs (*Lithobates sylvaticus*) in a northern New England montane landscape. *Journal of herpetology.*



Tom Hastings collecting snow depth and temperature data at a hibernaculum in the greater Bangor area to understand more about wood frog selection of hibernation sites. The wood frog is hibernating inside the inclosure.



In the winter if you were to uncover a wood frog it would likely look something like this….

Wood frogs have an amazing ability to partially freeze in order to survive the frigid temperatures of winter. In the early winter, their liver increases production of glucose, a natural anti-freeze which is distributed around its body preventing cell walls from bursting. A build up of urea that would normally be excreted in urine is also thought to help prevent freezing. Other fluids within their bodies freeze solid. You might notice in photographs of overwintering wood frogs that their eyes often look cloudy. That is because the lens of their eyes are frozen! In the spring wood frogs thaw from the inside out, regaining mobility and bodily functions just in time for the breeding season!

Not everybody makes it to an overwintering site. Wood frogs provide a concentrated source of food in vernal pools during the spring and summer months as well as once they have left breeding pools and have dispersed into adjacent forested habitats.