2014 Year of the Salamander

Salamander News

No. 6 June 2014

www.yearofthesalamander.org

Salamanders in a World of Pathogens

Plethodontid salamanders such as this Red-cheeked (Jordan's) Salamander (*Plethodon jordani*) appear to be relatively resistant to infection by the amphibian chytrid fungus (*Batrachochytrium dendrobatidis*) due to antimicrobial skin peptides. Photo: Nathan Haislip

Vanessa Wuerthner and Jason Hoverman, Department of Forestry and Natural Resources, Purdue University

Salamander populations around the world are in decline, with about 50% of species threatened globally. Habitat destruction and pollution are major contributors to these declines, but emerging infectious diseases are an increasing concern. Natural systems contain a diversity of pathogens including fungi, viruses, bacteria, and parasitic worms. While most pathogens pose minimal risk to salamander populations, a few have been linked to severe malformations, massive die-off events, or extinctions. Here, we focus on highly virulent pathogens that have been identified in salamander populations, to increase awareness of their effects on host pathology and mortality.

The amphibian chytrid fungus, *Batrachochytrium dendrobatidis*, is the best-known pathogen of salamanders. This fungal pathogen, which thrives in moist habitats, has been detected in amphibian populations across the globe and has been implicated in the decline and extinction of numerous species. Chytridiomycosis, the disease caused by the fungus, was first described in amphibian populations experiencing mass mortality in Australia and Panama in 1998. Recently, another chytrid species, *Batrachochytrium salamandrivorans*, was discovered in populations of the Fire Salamander (*Salamandra salamandra*) in the Netherlands. Extensive research efforts over the past decade have helped us understand this pathogen and its impact on amphibian hosts.

The fungus has a free-living zoospore stage that seeks out hosts in aquatic environments or during direct contact between infected individuals. When

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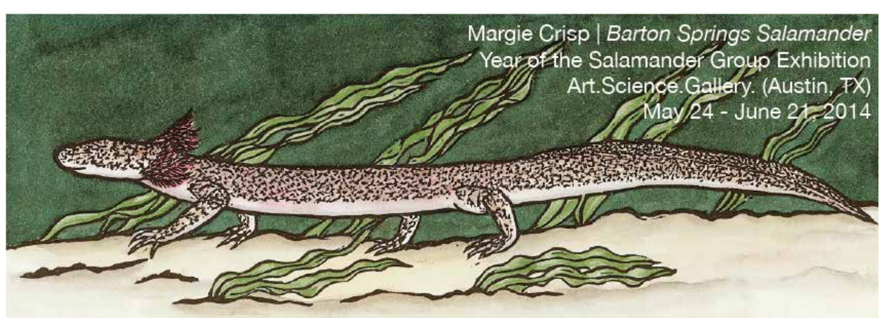

ArtScienceGallery of Austin, TX hosts salamander art exhibit this month. See p. 16 for details.

sponsored by PARC - Partners in Amphibian and Reptile Conservation

Get Your June Photo Contest Calendar - Free!

Fire Salamanders (*Salamandra salamandra*), like the one in this month's winning photo by **Stefano Rambaldi**, may be the most common salamanders in Europe, but they are now declining and increasingly at risk. To get the big picture and see our runner-up, an important functional cog in North American forests, go to **http://www.parcplace.org/images/stories/YOSal/YoSalCalendarJune.pdf.**

Call for Photos for the 2014 Year of the Salamander Calendar Photo Contest

We are seeking close-up, digital photos of salamanders, preferably in their natural habitats or within an educational or conservation context. One winner will be selected each month to be the featured photo as part of the Year of the Salamander online calendar. Runner-up photos will also be included in the calendar. In addition, all submitted images will be considered for use in the Year of the Salamander monthly newsletter and website as well as other Year of the Salamander-related conservation, outreach, and educational efforts. Give us your best shot! For more information and for entry details, please visit **http://www.parcplace.org/images/stories/YOSal/YOSphotocontest.pdf**.

Are Sirens calling you?

We especially need photos of some of our more elusive salamanders, the sirens, mudpuppies, amphiumas, and torrent salamanders, as well as species in the family Hynobiidae, and *Triturus* newts. If you have a good shot of any of these species that you're willing to enter in the photo contest, send them on in!

Get your Year of the Salamander 2014 Gear!

Go online to the PARCStore (**http://www.cafepress.com/parcstore**).

Ready to gear up for Year of the Salamander? We've got you covered!

At the Café Press PARCStore, you can find just about any style of t-shirt, sweatshirt, or hoodie, for men, women, or children. But don't stop there - you'll find a messenger bag, field bag, aluminum water bottle, even a beach towel (in case you want to join the salamanders crawling out of that primeval sea).

And take a look at the beautiful **Year of the Salamander Wall Calendar**, full of fantastic salamander photos for every month of your year!

Proceeds from sales go to the Year of the Salamander Conservation grant, managed by Amphibian and Reptile Conservancy, a not-for-profit organization that helps support PARC activities, such as public education, publications, and research.

June Newsletter Content Coordinator: Jacob Kubel, , MA Natural Heritage & Endangered Species Program
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Year of the Salamander Committee Chair: Mary Beth Kolozsvary, Siena College

Announcing a Year of the Salamander video contest!

Here's how you can participate!

Partners in Amphibian and Reptile Conservation and conservation groups from around the world have designated 2014 as the Year of the Salamander. Through this unprecedented partnership, organizations and individuals will work together to raise awareness of salamanders as well as scale up global salamander conservation, education and research efforts.

Here's your chance to get involved with the Year of the Salamander **by entering our video contest**:

Contest: "Salamanders Matter" video campaign! Make a video that will help raise awareness to the general public about salamanders around the world!

You may want to make a video on:

- Why salamanders are important to people and natural systems;
- What people can do to conserve salamanders;
- Why salamanders are important to you; or
- "Public service announcements" (e.g., watching out for salamanders on the roads during migration).

But you are not limited to just these ideas!

We're looking for videos that not only convey salamander conservation messages, but that also reflect your passion for these amazing species. They can be edited and polished videos, or rough cuts shot from your phone out in the field.

Salamanders Matter
...to aquatic, riparian, and terrestrial ecosystems, and the interconnections among them. Alpine Newt, *Icthyosaura (Mesotriton) alpestris*, by Tobias Eisenberg, Year of the Salamander Photo Contest.

Whether it is animation, live action, an original song, or something completely different, be sure to tell your story in a clear and creative way. Be sure to also come up with a unique and creative name for your video entry.

Deadline for the "Salamanders matter" contest is **July 31, 2014**.

Complete guidelines and contest details are posted on the Year of the Salamander webpage (**www.yearofthesalamander.org**). If you have any questions, please email us at: **yearofthesalamander@gmail.com**.

Salamanders are...dangerous?
They can be, if you eat them! The Rough-skinned Newt (*Taricha granulosa*, family Salamandridae) is one of the most poisonous animals in North America. More than just nasty-tasting to predators, *Taricha* newts produce tetrodotoxin, the same poison found in puffer fish, in quantities lethal to most mammals and birds, some fish, invasive Bullfrogs (*Lithobates catesbeianus*), and yes, humans. The only predator adapted to—more or less—safely consume adult *Taricha* newts is the Red-spotted Gartersnake (*Thamnophis sirtalis concinnus*), though raccoons, other gartersnakes, and some fish may occasionally eat them. Although mating Rough-skinned Newts are usually seen in pairs, they sometimes form impressive "mating balls" of multiple males with a single female, as shown in this photo by Dave Herasimtschuk, taken in a pond near Corvallis, OR.

Year of the Salamander Collaborating Partners

The Year of the Salamander Planning Team is pleased to welcome the following organizations to our growing list of collaborating partners:

Alpensalamander **http://alpensalamander.eu/blog/?page_id=663&lang=en-us**

Alpensalamander is a research group in Salzburg-Austria, founded in 2010, with the goal of mapping occurrence, population size, and development of Alpine and Fire Salamanders. First, we establish an oral history of Alpine Salamander observations in the past 50 years by conducting interviews in the local community, such as alpinists, farmers, National Park staff, mineral collectors, and hunters to preserve their well-versed local knowledge of the Salamander. Second, we field-check these regions ourselves to explore their habitat and their ecology. We also investigate the relationship among these species and other amphibians. The project is carried out at the University of Salzburg in collaboration with several national parks, schools and research institutions across Europe, and funded of the Ministry of Science and Research Austria. Our Sparkling Science project collaborates with 25 elementary, middle, and high schools in Austria, Spain, and Italy to clarify the distribution of Alpine and Fire Salamanders and encourage children to help protect these animals.

Save the Salamanders savethesalamanders.com

Save the Salamanders **www.savethesalamanders.com**

Save The Salamanders is a project created and run by Matt Ellerbeck (a.k.a. The Salamander Man), a salamander advocate & conservationist. Its mission is to help contribute to the conservation of these amphibians to ensure their continuing survival, the recovery and protection of threatened and endangered salamander species, their critical habitats, and their declining populations. The main objective of STS is to involve individuals of all ages and backgrounds in amphibian recovery via behavioral changes, informed decision making, stewardship actions, and habitat management efforts. STS's awareness and education programs, incuding media appearances, awareness campaigns, social networking, fact sheets, and educational presentations, help people develop a sense of empathy and concern for salamanders, to fuel their desire to become active in their preservation and advancement.

Serbian Herpetological Society **www.shdmr.org**

Serbian Herpetological society “Milutin Radovanović”

The Serbian Herpetological Society “Milutin Radovanović” is a non-profit professional organization dedicated to faunistic research and population studies of reptiles and amphibians in the Balkan Peninsula. In addition, we analyze patterns of behavioural and morphological variability among the populations of tortoises and other surveyed species. Another crucial mission of our society is education of various focal groups (e.g. schoolchildren, managers of protected areas). In previous years, we've established cooperation with colleagues from other ex-Yugoslav countries, and with researchers from France, Italy, Hungary, and Bulgaria. In the future we intend to widen and strengthen the network of people working on similar species and questions throughout the Balkan Peninsula.

We are still recruiting partners! If you are interested in contributing to the Year of the Salamander efforts, please send an email to **yearofthesalamander@gmail.com** with a brief description of your organization and its efforts. Our full list of partners can be found at **http://www.parcplace.org/news-a-events/2014-year-of-the-salamander/68-uncategorised/281-year-of-the-salamander-partners.html**

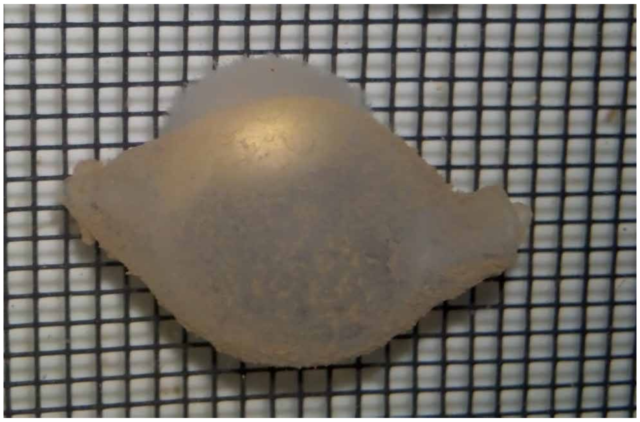
facebook

Follow all of the Year of the Salamander news and happenings on Facebook (https://www.facebook.com/YearOfTheSalamander2014) and Twitter (@YOSal2014).

Salamanders in a World of Pathogens, cont. from p. 1

the zoospores encounter a host, they embed in the skin and develop into zoosporangia, the reproductive stage. The fungus targets the keratinized skin tissue of amphibians. Chytrid infections result in thickening and sloughing of the skin. Because amphibians depend on their skin for respiration and osmoregulation, infection can have significant physiological effects on the host. For example, clinical signs may include dehydration, lethargy, loss of appetite, and skin shedding and reddening. Necrosis has also been seen in some cases. However, the extent of these effects can vary widely among individuals and species. It is important to note that many of these clinical signs can be seen from other infectious diseases. Thus, further tests, such as histological examinations and molecular analyses, are required to diagnose this disease. While the chytrid fungus has been shown to cause mass die-offs, not all amphibian species become infected or die when infected. For instance, many plethodontid salamanders appear to be resistant to infection. It has been hypothesized that antimicrobial skin peptides help to protect these species from infection. Generally, the susceptibility of salamanders to chytrid infection appears to be much lower than anurans.

Another pathogen that is found in salamander populations is *Saprolegnia ferax*, a water mold. *Saprolegnia* is a cosmopolitan pathogen that spreads through contact with the growing hyphae or zoospores. Infections, which are often "cotton-like" in appearance, have been reported in the eggs and larvae of aquatic salamanders. In larval salamanders, *Saprolegnia* appears to be a secondary invader that takes advantage of wounded individuals. If the infection is not cleared, mortality can result. Egg masses are particularly susceptible to infection because the mold can quickly



Hellbender (*Cryptobranchus alleganiensis)* egg infected with *Saprolegnia*. Photo: Renea Wilson.

Mass-mortality event of Spotted (*Ambystoma maculatum*) and Marbled Salamanders (*A. opacum*) caused by ranavirus infection. Photo: Matthew Niemiller.

spread between eggs within the mass. Species that lay eggs communally are at high risk of *Saprolegnia* oubreaks. For instance, *Saprolegnia* has caused mass-mortality events in the eggs of some species including Spotted Salamanders (*Ambystoma maculatum*). Additionally, *Saprolegnia* has been a common problem in captive breeding facilities. However, it remains unclear what impact *Saprolegnia* infection has on salamander populations given the highly variable nature of its occurrence.

In addition to fungal and water mold infections, salamanders are also susceptible to viral infections. Ranaviruses are a group of viral pathogens that were discovered in the 1960s, but their impacts on amphibians were not examined until 30 years later. These viruses have a global distribution and have been linked to mass-mortality events around the world. While the role of ranaviruses in the global decline of salamander populations is currently unknown, their high virulence is a growing concern among amphibian biologists. Ranaviruses are double-stranded DNA viruses of the family Iridoviridae. Three species are known to infect amphibians, Bohle iridovirus (BIV), frog virus 3 (FV3), and Ambystoma trigrinum virus (ATV). Both FV3 and ATV have been isolated from salamanders. Ranaviral infections can be transmitted in numerous ways including direct contact with infected individuals, ingestion of infected tissue, and contact with contaminated water and sediment. These viruses target the kidneys and liver of the host, where they replicate inside the cells, leading to cell death and necrosis. While larval and adult salamanders can be infected with the virus, larvae appear to have greater susceptibility due to their underdeveloped immune system and high densities. Signs of ranaviral disease include hemorrhaging, lethargy, edema, emaciation, and reddening of the skin. However, field surveillance studies have detected ranavirus infection in individuals that show no clinical signs of disease. Moreover, studies have documented substantial variation in the prevalence of ranavirus in wild salamander populations in the United States. In salamanders, mass die-offs linked to ranavirus have mainly been reported in ambystomatids (e.g., Eastern Tiger Salamanders [*Ambystoma tigrinum*], Marbled Salamanders [*A. opacum*], Spotted Salamanders). Because larval salamanders, especially ambystomatids, are known to be cannibalistic, ranavirus can spread rapidly within a population.

Eastern Tiger Salamander (*Ambystoma tigrinum*) with an extra forelimb malformation typical of infection by the fluke *Ribeiroia ondatrae*. Photo: Rod Williams.

Salamander larvae and adults are also infected by a diversity of helminth species. Helminths are a group of worm-like parasites that include flukes (trematodes), roundworms (nematodes), and tapeworms (cestodes). The flukes *Ribeiroia ondatrae* and *Echinostoma trivolvis* are two species that have received attention for their capacity to cause severe malformations or pathology in salamanders. These widespread flukes are complex life-cycle parasites that use salamanders as intermediate hosts. The first intermediate hosts of the parasites are freshwater snails. The parasites use the snails to generate thousands of free-living stages that seek out larval salamanders in ponds. Interestingly, the two parasite species target different regions of the salamander. *Ribeiroia ondatrae* targets the limbs of the salamander where they burrow into the tissue and encyst around the pectoral or pelvic girdle. By encysting in the tissue around the developing limbs, *R. ondatrae* infections can lead to severe malformations of the limbs and digits of the salamander. *Echinostoma trivolvis*, on the other hand, encysts within the kidneys of salamanders. The free-living stage of the parasite swims up the cloaca to gain access to the kidneys. For both parasites, pathology is dependent on the parasite burden; the more parasites that encyst within the individual the more severe the pathology. Signs of infection include hemorrhaging, lethargy, edema, and emaciation. Additionally, *R. ondatrae* is known to cause a diversity of malformations including extra limbs and digits, missing limbs and digits, and skin webbings.

Long-toed Salamander (*Ambystoma macrodactylum*) with severe limb malformations induced by infection with the fluke *Ribeiroia ondatrae*. Photo: Pieter Johnson.

Salamanders, like all wild species, are embedded in ecological communities containing a diverse assemblage of pathogens. Here, we have focused on well-studied pathogens that are known to negatively affect salamanders. Amphibian biologists working in the field should be cognizant of these pathogens and report disease outbreaks to state and federal agencies when encountered. Because our understanding of infectious diseases and their implications for salamander populations remains limited, there is an urgent need to gather more information about the prevalence and distribution of highly virulent pathogens.

Salamander Fact

The amphibian chytrid fungus (*Batracho-chytrium dendrobatidis*) attacks keratinized skin of amphibians. Anurans (frogs and toads) have keratin throughout their skin, but salamanders have keratin primarily in the skin of their feet. This makes it very important to include the feet when swabbing salamanders for *Bd*.

Chytrid in the Northeast: an Innocuous Infection?

Kathryn L Richards-Hrdlicka, School of Forestry and Environmental Studies, Yale University

This salamander is being "swabbed" for the amphibian chytrid fungus. Photo © Danté Fenolio.

The phrase "amphibian chytrid fungus" usually raises blood pressure and ignites catastrophic images in the minds of herpetologists, conservationists, and the public alike. But rest easy – at least for salamanders and other amphibians in the Northeast, the chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*), appears to be fairly innocuous.

For my dissertation research in the Yale School of Forestry and Environmental Studies, I led a team of investigators who swabbed and tested >1,900 amphibians from the field and >600 museum specimens for *Bd*. These samples included approximately 500 salamanders and spanned a geographic area consisting of six northeastern U.S. states (NY, CT, RI, MA, NH, ME) and the Canadian province of New Brunswick. Although the bulk of the samples originated in 2010 and 2011, some dated as far back as the 1960s.

To test a salamander (or other amphibian) for *Bd*, the field researcher swipes a toothpick along the animal's body and temporarily places the swab into a vial of alcohol; this sampling technique is fast, cheap, and noninvasive. Since *Bd* colonizes the skin, the toothpick swab picks up the fungus as well as the animal's DNA and anything else on the skin (e.g., dirt, bacteria). Back at the lab, all DNA is extracted from the swab and a very sensitive molecular test (quantitative polymerase chain reaction), specific only for *Bd*, is performed on the swab extract. Not only does this test tell us if the fungus is present, but it also provides a measure of the pathogen load.

From a few preserved plethodontids sampled during the study, we learned that *Bd* has been present in this part of the world since at least 1968. We also discovered from the swabs of live animals that 18 of 22 amphibian species examined in the Northeast tested positive for *Bd*, with 30-50% of individuals being infected. Frogs carry the fungus more often than salamanders, but both groups seem equally tolerant to infection – none of our live specimens exhibited clinical signs of disease, and no *Bd*-caused mass-mortality events have been confirmed in salamanders or frogs in the region to date. Moreover, according to the International Union for Conservation of Nature (IUCN), almost all salamanders in this region are of "Least Concern" regarding extinction risk, suggesting that even though they are exposed to and living with *Bd*, their population statuses remain largely unchanged.

Elsewhere in the world, amphibians have been known to carry massive loads of the fungus and fall victim to its suffocating, osmoregulatory-inhibiting symptoms, often within only a few weeks of exposure. Why salamanders and frogs in the Northeast can persist with infection, and at such low loads, is likely a combination of characteristics of the environment, the pathogen, and the host. The climate may be too cold and too volatile to allow *Bd* to really populate. This may be strictly tied to the climate, or the pathogen itself may be slow-growing. The host species here certainly play a major role – exciting research is now evaluating both the biotic and abiotic components of amphibian skin, with major attention paid to the Eastern Red-backed Salamander (*Plethodon cinereus*). This species, dominant across the northeastern landscape, has a special bacterium living on its skin, and presence of this bacterium often means *Bd* is largely absent. If this plethodontid has a support team of special bacteria warding off heavy loads of *Bd*, other salamander species in the region may, as well.

The Spotted Salamander is one of eighteen amphibians known to be living with chytrid infection in New England. Photo © Brian Bastarache.

Salamanders of the Northeast appear to be safe from *Bd* …for now. With climate change and the resulting shifts in species distributions and putative pathogen strains, it may not take much to tip the scales toward a disease outbreak. Furthermore, an apparent absence of clinically diseased salamanders does not mean that *Bd* is not having an impact. For instance, we know that the energy required to tolerate disease can erode the strength of an individual to forage properly. Such a tradeoff may be most damaging in populations of rare species – especially those at the limits of their geographic ranges or stressed for other reasons, such as habitat loss or degradation.

So, even though *Bd* isn't triggering massive die-offs in the Northeast, the possibility that it could be chipping away at the general health and viability of some amphibian populations cannot be ruled out. That's not to say *Bd* should keep us up at night worrying about the immediate fate of our salamanders, but we shouldn't be overly complacent, either.

Northeastern North American amphibian species tested. An * and **bold face** indicates that at least one individual from the field or museum tested positive for *Bd*.

Frogs and Toads		Salamanders	
American Toad*	*Anaxyrus americanus*	Blue-spotted Salamander	*Ambystoma laterale*
Fowler's Toad*	*Anaxyrus fowleri*	Jefferson's Salamander	*Ambystoma jeffersonianum*
Woodhouse's Toad	*Anaxyrus woodhousei*	Marbled Salamander	*Ambystoma opacum*
Eastern Gray Treefrog*	*Hyla versicolor*	**Spotted Salamander***	*Ambystoma maculatum*
Spring Peeper*	*Pseudacris crucifer*	**Hellbender***	*Cryptobranchus alleganiensis*
Bullfrog*	*Lithobates catesbeianus*	**Northern Dusky Salamander***	*Desmognathus fuscus*
Green Frog*	*Lithobates clamitan*	**Northern Two-lined Salamander***	*Eurycea bislineata*
Pickerel Frog*	*Lithobates palustris*	**Spring Salamander***	*Gyrinophilus porphyriticus*
Northern Leopard Frog*	*Lithobates pipiens*	**Four-toed Salamander***	*Hemidactylium scutatum*
Mink Frog*	*Lithobates septentrionalis*	**Eastern Red-backed Salamander***	*Plethodon cinereus*
Wood Frog*	*Lithobates sylvaticus*	**Eastern (Red-spotted) Newt***	*Notophthalmus viridescens*

Fire Salamanders under Threat from Deadly Skin-eating Fungus

A. Martel, F. Pasmans – Faculty of Veterinary Medicine, Ghent University, Belgium

A Fire Salamander suffering with *B. salamandrivorans*.

Fungi are increasingly recognised as important threats to biodiversity. *Batrachochytrium dendrobatidis* (*Bd*), has plagued amphibian populations across the globe and is thought to have wiped out more than 200 species worldwide. It causes the disease chytridiomycosis, which the International Union for the Conservation of Nature has called the single most devastating infectious disease in vertebrate animals. However, in several regions, including northern Europe, amphibians appeared to be able to co-exist with *Bd*. In one of these regions, a new species of fungus has ravaged the Fire Salamander (*Salamandra salamandra*) population in the Netherlands, bringing it close to regional extinction. Fire Salamanders, recognisable by their distinctive yellow and black skin patterns, have been found dead in the country's forests since 2010. The population has fallen to around ten individuals, less than four per cent of its original level. From the dead animals a new species of fungus was isolated and found that it can rapidly kill Fire Salamanders. This fungus was named *Batrachochytrium salamandrivorans*, the second part meaning "salamander-eating". The fungus can be passed between salamanders by direct contact, and possibly by indirect contact, although this hasn't yet been proven. It invades the animal's skin, eventually destroying it completely. In tests, the fungus was not able to infect Midwife Toads (*Alytes obstetricans*), which have been threatened by *Bd*, but whether other species might be vulnerable is still unknown.

Reference: A Martel et al. *Batrachochytrium salamandrivorans* sp. nov. causes lethal chytridiomycosis in amphibians. PNAS 2013.

Family of the Month: Salamandridae

The family Salamandridae includes all newts, as well as species named as salamanders. The Salamandridae are widespread throughout North America, Europe, and Asia. The Eastern Newt (*Notophthalmus viridescens*, also known as the Red-spotted Newt) occurs in North America from eastern Canada to Florida, and west to Texas, and the Fire Salamander (*Salamandra salamandra*) is common in many parts of Europe. Both of these species have aquatic and terrestrial life stages, with aquatic breeding and terrestrial juvenile and adult stages. The Eastern Newt secretes a toxin from its skin, making the salamander unpalatable to most predators. Juvenile Eastern Newts, known as efts, are bright orange and fully terrestrial. The eft is so distasteful that other salamander species may mimic its defenses by evolving bright coloration (instead of toxic skin secretions) to deter would-be predators. Fire Salamanders are cryptic when on land, and likely gave rise to the tales of salamander associations with fire, emerging from dead wood in campfires or fireplaces. A new species of amphibian chytrid fungus, *Batrachochytrium salamandrivorans*, has recently caused mass mortalities in Fire Salamanders in the Netherlands.

Brilliant orange and red-spotted Eastern Newt eft. Photo: Marty Silver, Year of the Salamander Photo Contest.

Fire Salamanders display great variation in color and pattern. Photo: Moises Cabirta, Year of the Salamander Photo Contest.

Family: Salamandridae

Also known as:	Newts & Salamanders
Number of Species:	61 species in 16 genera
Region / Habitat:	- widely distributed through most of the Northern Hemisphere; North America, Europe, and Asia
Physical Characteristics:	- great variation in size and shape within the family (lengths anywhere from 2 to 12 inches) - their limbs, lungs, and eyelids are all well-developed - terrestrial forms have rounded tails, while aquatic species or forms have tails that are flattened into a vertical keel shape
Behavior / Development	- there are both aquatic and terrestrial species within this family - for most genera, eggs are laid in flowing or stagnant water; the genus *Echinotriton* lays eggs on land but larvae develop in water; the genus *Lyciasalamandra* bears live, fully metamorphosed young - some species, like *N. viridescens*, can adapt to environmental conditions by an astonishing variation in life history: they may follow the typical sequence of aquatic larvae/terrestrial juvenile (eft)/terrestrial adult with lungs; partially metamorphose from larvae to aquatic juveniles, to adults with lungs; or mature as aquatic adults with gills
Fun Fact:	Though other salamanders may be referred to as newts, true newts are only found in the subfamily Pleurodelinae. True newts have three life phases (two metamorphoses): an aquatic larval stage, a terrestrial juvenile stage called an eft, and an adult stage that may be aquatic or terrestrial.

Salamanders in the Treetops

Sean M. Rovito, Museum of Vertebrate Zoology, University of California, Berkeley

While many people have seen salamanders under logs or in ponds, salamanders in the tropics have evolved to inhabit an environment we don't usually associate with these animals: the treetops. My collaborators and I have spent years searching for rare and unknown species of arboreal salamanders in the forests of Mesoamerica. Many of these species have been seen only a few times, and several are known from only a single specimen (often collected decades ago). Once you begin to look for them, the reason is quickly apparent: arboreal salamanders can be extremely hard to find.

Climbing a tree in the cloud forest to reach a large arboreal bromeliad in Quiché, Guatemala. Photo: Sean M. Rovito.

Most species of arboreal salamanders in the Neotropics take refuge in bromeliads by day, and come out to feed only at night. Bromeliads, which have a rosette of leaves surrounding a central tank with water, provide a cool, moist habitat for salamanders and many other kinds of animals. They can be very numerous, completely covering the limbs of large trees, and finding a tiny salamander amidst their leaves is challenging. Often, we search through bromeliads for an entire day and find only one or two individuals. The cloud forests where these salamanders occur exist only in a narrow elevational range on mountains, where rising air cools to form a near-constant bank of clouds. This dependence on cloud water makes these forests very fragmented across the landscape. Over time, this has led to very high levels of endemism (species unique to a particular area); most of these salamanders are found in only one or two patches of cloud forest. Rates of deforestation in the cloud forest are high, and some species have almost certainly gone extinct before they could be discovered.

Clouds cover the higher elevations on Montaña de Santa Barbara, Honduras, home to a species of *Dendrotriton* found nowhere else. Photo: Sean M. Rovito.

Many salamander species in Mesoamerica have declined severely over the past decades. At least some of these declines were caused by the fungal skin disease chytridiomycosis, which has heavily impacted Mesoamerican amphibians. At our study sites, however, terrestrial species have declined much more than arboreal species. We have detected the fungus that causes chytridiomycosis in arboreal salamanders, yet their populations appear to be more stable than those of terrestrial species. It is possible that something about an arboreal lifestyle, such as the microclimate in bromeliads, provides partial protection against this disease. Perhaps terrestrial species are more clumped under cover objects and transmit the disease more easily, while arboreal species are more spread out and encounter each other less commonly. The difficulty of finding arboreal salamanders makes it hard to answer these questions, yet their small range sizes mean that a disease that hits one population could threaten the survival of an entire species.

For many years, all the small arboreal Neotropical salamanders were placed in a single genus because they look outwardly similar. Using X-rays to look at their bones and DNA sequencing to determine relationships between species, scientists have discovered that there are actually multiple genera of small arboreal salamanders, which are not all each other's closest relatives. New species of arboreal salamanders are found each year as additional cloud forests are explored. While we now have a better understanding of the diversity of these groups, the difficulty of collecting

Dendrotriton rabbi, an arboreal salamander species found only in a single cloud forest in northwestern Guatemala. Photo: Sean M. Rovito.

them means that their ecology and natural history are still poorly understood. For most species, we have no knowledge of their diet, mating habits, or patterns of activity. Often, we can reach only the lower branches of trees to search for them, either by climbing or using tools on poles to collect bromeliads. This means that many aspects of the salamanders' lives in the treetops (especially in the higher parts of the canopy) remain a mystery to us.

Year of the Salamander Podcasts Coming Soon!

Podcasts will soon be posted on the Year of the Salamander webpage (**www.yearofthesalamander.org**). Check the site for details later in June.

Prevalence of Ranaviruses in Plethodontid Salamander Assemblages in the Great Smoky Mountains National Park

William B. Sutton, Matthew J. Gray, and Debra L. Miller

All photos by W.B. Sutton and M.J. Gray

Most people traveling to the Great Smoky Mountains National Park ("Smokies") are usually interested in the normal national park fare such as scenic hikes, motorcycle rides up to Newfound Gap, trout fishing, or viewing mega-fauna along the Cades Cove loop. Being people who enjoy the outdoors, the authors also partake in many of these activities (except the motorcycle part…too dangerous), but many of our trips to the Smokies are for an entirely different reason. In addition to being the most frequently visited national park in the eastern United States (over 1 million visitors annually), the Smokies are also known colloquially as the "Salamander Capital of the World". Nearly 30 salamander species, representing 5 separate families, call the Smokies home. The family Plethodontidae represents the most speciose family in the Smokies, with 24 species residing in the national park boundary. Plethodontid salamanders possess a unique physiological characteristic in that they lack lungs. Like all other vertebrates, they require oxygen, but they absorb it only through their skin and oral cavity. This physiological adaptation limits the distribution of plethodontid salamanders to habitats with relatively high moisture, and typically restricts surface activity to periods of cool ambient temperature and high humidity (e.g., during night hours and rainy periods).

Eurycea longicauda (Long-tailed Salamander), a plethodontid.

Any activity that affects environmental moisture could negatively affect plethodontid salamanders. For example, it has been shown that silviculture treatments, especially clear-cutting practices, have long-term negative impacts on lungless salamanders. Emerging pathogens represent an additional threat to amphibian populations, and changes in ambient moisture or temperature could affect their prevalence. The amphibian chytrid fungus (*Batrachochytrium dendrobatidis*; *Bd*), has wreaked havoc on countless amphibian species inhabiting high-elevation environments of Central and South America, Africa, western North America, and Australia. Climate change and pathogen

Desmognathus quadramaculatus (Black-bellied Salamander).

pollution (i.e., the translocation of a novel pathogen by humans) have been implicated in the emergence of many pathogens, including *Bd*. Ranaviruses are another pathogen that appears to be emerging, and possibly playing a role in species declines. Ranaviruses infect ectothermic vertebrates and cause disease in at least 70 amphibian, 20 reptile, and a dozen fish species worldwide. Amphibian species with explosive breeding habits and short time to metamorphosis are particularly susceptible to ranaviruses. There also is some evidence that small changes in atmospheric temperature and pathogen pollution may contribute to ranavirus emergence. However, these inferences are primarily based on laboratory experiments, and have generally been limited to pool-breeding amphibian species. The larger impacts of amphibian die-offs due to ranaviruses are poorly understood, because many ranavirus surveillance studies have been limited to one or two years. Long-term surveillance programs are essential to understand the role of pathogens in species declines.

Pseudotriton ruber (Red Salamander).

Since 2007, researchers in the Center for Wildlife Health at the University of Tennessee-Knoxville have been evaluating the prevalence of *Bd* and ranavirus in plethodontid salamander assemblages at multiple long-term monitoring sites in the Smokies. These sites are located at different elevations along first- and second-order streams that experience higher than normal public access, such as Abram's Creek near Cade's Cove, Ash Hopper Branch near the Sugarlands Visitor Center, and Indian Gap. During survey events, researchers turn logs, rocks, and leaf packs and capture salamanders opportunistically, with the goal of collecting non-lethal pathogen samples from up to 40 individual salamanders at each site. Salamanders are also sampled to maximize species richness, with up to 10 individuals sampled per species per site. Upon capture, each salamander is placed temporarily in a sealed plastic bag and identified to species. After standard measurements are obtained, skin swab and tail tissue samples are collected to test for *Bd* and ranavirus infections, respectively, via quantitative Polymerase Chain Reaction (qPCR) analysis.

University of Tennessee researchers working hard at the salamander processing station.

Over a six-year period (2007 – 2012), 566 individual plethodontid salamanders representing 14 species have been sampled for both *Bd* and ranavirus prevalence. We detected ranavirus positive individuals in 11 out of 14 (78.6%) species, with greatest prevalence in the *Desmognathus* and *Eurycea* salamander species (21.0% and 18.4% prevalence, respectively). In comparison, salamanders in the genus *Plethodon* have had comparatively lower prevalence (8.4%). Ranavirus prevalence has been greatest in the Seal Salamander (*Desmognathus monticola*; 41.2%), Spotted Dusky Salamander (*Desmognathus conanti*; 30.1%), and Black-bellied Salamander (*Desmognathus quadramaculatus*; 21.9%). The Pigmy Salamander (*Desmognathus wrighti*) and Blue-ridge Spring Salamander (*Gyrinophilus porphyriticus danielsi*) had the lowest infection prevalence (4.0%) among species with >10 captures. Overall, prevalence was greatest in 2007 and 2008 and tended to be highest in relatively low elevation (<800 m) sites. We detected the greatest number of infections in 2007 with 82.5% of sampled individuals testing positive for ranavirus. Prevalence of *Bd*, on the other hand, was low (<5%) at all sites and years, and we did not detect trends among species or elevations. Although some individuals tested positive for infection by these pathogens, we did not observe gross signs consistent with actual chytridiomycosis or ranaviral disease.

Our results illustrate that patterns of ranavirus infection in plethodontid salamander assemblages vary among years, and ecological and species-specific factors may play potential roles in these patterns. Overall, we identified that yearly fluctuations along with site elevation were important explanatory variables of ranavirus prevalence. We

Plethodon jordani (Red-cheeked Salamander).

postulate that environmental stressors in the form of record drought were responsible for high prevalence rates in 2007. Rainfall totals were 23.3 in (59.1 mm) below the annual average for the Smokies, making it one of the driest of the previous 50 years. Drought may have stressed individuals and reduced the availability of aquatic habitats, thereby increasing ranavirus shedding (essentially a process where animals excrete live virus from tissue and bodily fluids) and contact rates among individuals.

The trend of salamanders being infected more often at low elevations might be a consequence of greater virion concentration downstream as a result of viral shedding from upstream environments. Stream temperature at lower elevations also is greater, which could facilitate ranavirus infection – ranaviruses replicate faster in host cells at higher temperatures (up to 90°F). Lower-elevation sites in the Smokies tend to have more visitors, which may disturb aquatic environments and stress resident salamanders. Given that ranavirus can remain infectious outside a host for >2 weeks, recreationists also could unknowingly translocate novel ranaviruses on footwear and gear among streams, thereby causing pathogen pollution.

Although we detected ranavirus in 11 out of 14 plethodontid salamander species, the population-level effects of ranaviruses on salamander communities in the Smokies are unknown. If prevalence is any indication of mortality (as suggested by several controlled studies with amphibians), ranaviruses probably played a minor role in population dynamics of plethodontid salamanders in most years except for 2007 and 2008, when infection prevalence was greatest (range: 45 – 96%). Simulations on Wood Frogs (*Lithobates sylvaticus*) suggest that if ranavirus outbreaks occur once every five years, population declines could occur. These results emphasize the importance of long-term population monitoring associated with surveillance studies. Our initial findings in the Smokies indicate that infection prevalence varies among plethodontid salamander species, and although life history differences may play a role in ranavirus dynamics, site elevation and yearly fluctuations (probably due to environmental stressors) appear to play a larger role. Over the short-term, implementation of disease intervention strategies, such as establishing disinfecting stations with educational signage to inform the public of the risk of ranaviruses and other pathogens might help thwart outbreaks in "The Salamander Capital of the World." National Parks provide us with some of the wildest habitats remaining in the United States, and it is our duty to protect these resources for generations to come.

Gyrinophilus porphyriticus danielsi (Blue-Ridge Spring Salamander).

Dr. William B. Sutton is an Assistant Professor of Wildlife Ecology at Tennessee State University in Nashville, TN. Drs. Matthew J. Gray and Debra L. Miller conduct amphibian disease research in the Center for Wildlife Health in the Department of Forestry, Wildlife and Fisheries at the University of Tennessee in Knoxville, TN.

Outreach and Education Materials – NOW AVAILABLE!

For educators and naturalists, we now have outreach and education products that were created specifically for the Year of the Salamander on our website (**www.yearofthesalamander.org**)! We have ***face painting templates and notecards, a slide show and script, posters, and an educational packet*** for naturalists and teachers. We will continue to update the page with additional materials, as well as links to other educational resources. **Please check it out!**

If you have unit materials, educational program information, or PowerPoint presentations you are willing to share them, please send them to **yearofthesalamander@gmail.com**. We are also hoping to include videos! Please provide your name, the name of your school/nature center or organization, and location. If you did not create the materials, please be sure to tell us where you found them.

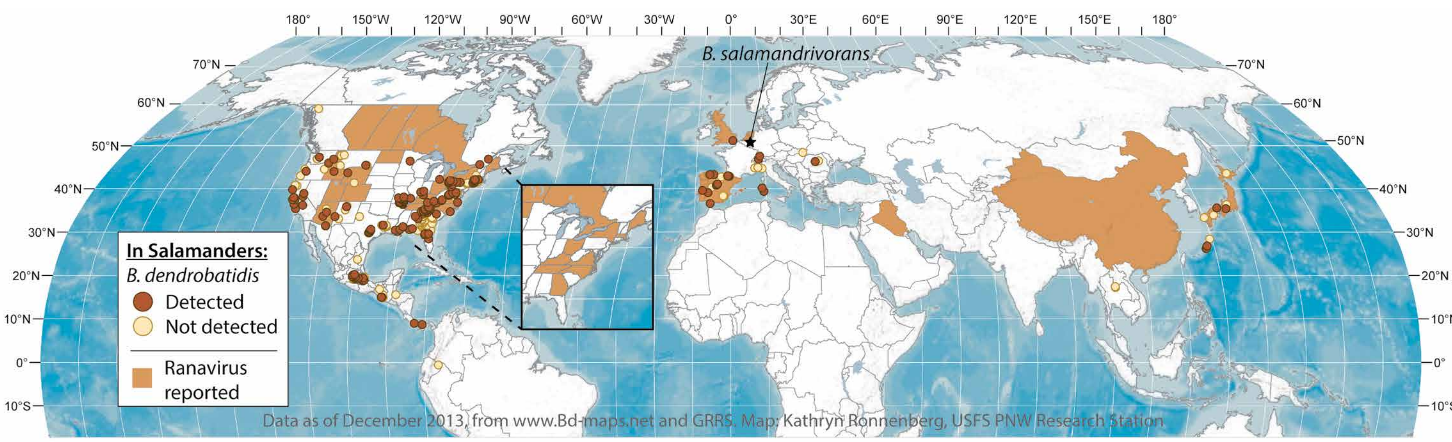
Salamander Disease Mapping: 2014 Update

Dede Olson and Kathryn Ronnenberg, US Forest Service, Pacific Northwest Research Station, Corvallis, OR

There is great concern for the implications of emerging infectious diseases in salamanders, and the community efforts to create and maintain online world mapping systems are aiding compilation and communication of recent developments, as well as bridging the science and management sectors. The web portal **www.Bd-maps.net** is an interactive database and mapping system of survey efforts for amphibian chytrid fungus, *Batrachochytrium dendrobatidis* (*Bd*), and will soon be mapping its new counterpart *B. salamandrivorans* (*Bs*). We continue to compile and manage the data, with Mat Fisher and David Aanensen maintaining the website at Imperial College, London, UK. We are now initiating the creation of the Global Ranavirus Reporting System (GRRS). For that effort, Amanda Duffus (Gordon College, GA, USA) has been taking the lead in designing the data structure and compiling data, and the Global Ranavirus Consortium (**http://fwf.ag.utk.edu/mgray/ranavirus/ranavirus.htm**) has been contributing results. We plan for GRRS will have a more comprehensive database of laboratory results, compared to the Bd-maps data set.

Table 1: *Bd* detection in wild salamanders, by family. Note that the two largest families, Plethodontidae and Salamandridae, are relatively lightly sampled, as a percentage of total species.

Family	Species tested for *Bd*	Species *Bd* detected	Total percent of species detected	Total species in family	Percent of spp. in family tested
Ambystomatidae	17	11	65	33	52
Amphiumidae	3	2	67	3	100
Cryptobranchidae	2	2	100	3	67
Dicamptodontidae	2	2	100	4	50
Hynobiidae	9	0	0	53	17
Plethodontidae	76	40	53	**444**	**17**
Proteidae	3	3	100	7	43
Rhyacotritonidae	0	0	0	4	0
Salamandridae	17	14	82	110	15
Sirenidae	4	3	75	4	100
Total	***133***	***77***	***58***	***665***	***20***



The map and tables shown here summarize our salamander infection knowledge from these data resources to date. Please note these data reflect only salamanders. We currently have 975 *Bd* data records for salamanders, as compared to 9300+ for anurans, a magnitude 10 difference. This difference may reflect: (a) the greater number and diversity of anuran species and families—over 6300 species of anurans vs. 670+ species of salamanders; (b) greater sampling intensity in anurans; (c) the fact that there are no salamanders in Africa (except for Morocco), Australia, or large parts of South America, where *Bd* sampling has been most intense outside North and Central America; (d) greater difficulty in finding and sampling many species and families of salamanders, particularly those that live primarily underground or in the mud of pond bottoms, or in tree canopies (see *Salamanders in the Treetops*, this issue). We have noticed that many *Bd* studies sampled only anurans, although salamanders were likely or known to be present at those sites. Also, where salamanders were tested among mixed anuran and caudate samples, they may not have been the target taxa, and may have been only incidentally sampled, potentially affecting findings shown here.

The tables reflect sampling needs for several taxa. Plethodontid patterns are shown separately due to their greater diversity, and limited sampling for several genera. Our ranavirus map shows known efforts to date for salamanders. Ranaviruses may infect other taxa such as fish and turtles, and the GRRS will be compiling those data as well. A much broader global distribution of ranaviruses is expected as knowledge accrues.

Table 2: *Bd* detection in salamanders by IUCN Red List conservation status. Categories: CR = critically endangered, EN = endangered, VU = vulnerable, NT = near threatened, LC = least concern, DD = data deficient, un = unevaluated. **Bold face** text indicates categories considered threatened.

	Number of salamander species sampled for *Bd*, by IUCN Red List category						
***Bd* detection**	**CR**	**EN**	**VU**	NT	LC	DD	un
Detected	**2***	**6**	**7**	8	49*	4	1
Not detected	**6**	**5**	**2**	5	35	1	1
Total	***9***	***11***	***9***	*13*	*84*	*5*	*2*

Table 3. Plethodontid salamanders tested for *Bd*, by genus. Even the numbers given do not completely reflect sampling effort, as in many cases sample sizes for even an apparently well-sampled genus may be quite small. Note that the three largest genera, *Bolitoglossa*, *Pseudoeurycea*, and *Plethodon*, are not particularly well-sampled.

	Genus	**Species tested**	**Species *Bd* detected**	**Total % species detected**	**Total species in genus**	**% of spp. in genus tested**
Subfamily Hemidactyliinae	*Batrachoseps*	5	5	100	21	23.8
	Bolitoglossa	8	5	62.5	128	6.25
	Bradytriton	0	-	-	1	0
	Chiropterotriton	3	0	0	12	25
	Cryptotriton	1	0	0	6	16.7
	Dendrotriton	1	1	100	8	12.5
	Eurycea	14	11	78.6	25	50
	Gyrinophilus	1	1	100	4	25
	Hemidactylium	1	1	100	1	100
	Nototriton	0	-	-	17	0
	Nyctanolis	0	-	-	1	0
	Oedipina	4	1	25	36	11
	Parvimolge	0	-	-	1	0
	Pseudoeurycea	6	3	50	52	11.5
	Pseudotriton	2	1	50	3	66.7
	Sterochilus	0	-	-	1	0
	Thorius	0	-	-	25	0
	Urspelerpes	0	-	-	1	0
Sf. Plethodontinae	*Aneides*	1	0	0	8	12.5
	Desmognathus	12	7	58	21	57.1
	Ensatina	1	0	0	1	100
	Hydromantes	1	0	0	11	9
	Karsenia	0	-	-	1	0
	Phaeognathus	0	-	-	1	0
	Plethodon	15	4	27	55	27

Year of the Salamander Group Exhibition

May 24 - June 22, 2014
Art.Science.Gallery, Austin, Texas
916 Springdale Rd., Building 2 #102
www.ArtScienceGallery.com 512-522.8278

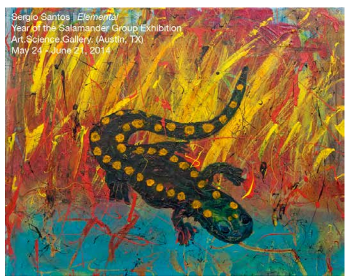
Viewing Tuesday - Saturday 12 - 6 pm and Thurs 12 - 5:45 pm through June 22nd (Sundays and Mondays by appt.).


Marjorie Moore | *Salamander Swing*
Year of the Salamander Group Exhibition
Art.Science.Gallery. (Austin, TX)
May 24 - June 21, 2014

An opening reception was held Saturday, May 24. The exhibition, a collaboration of Art.Science.Gallery, YOTS 2014, PARC, the E.O. Wilson Biodiversity Foundation, Austin Watershed Protection, and Treaty Oak Distilling Co., comprises 21 participating artists from the US, Canada, UK and Brazil!

Info: **http://www.artsciencegallery.com/2014/05/09/salamander/**

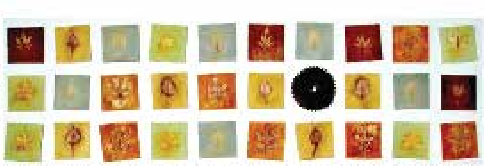

Victoria Harrell | *Red*
Year of the Salamander Group Exhibition
Art.Science.Gallery. (Austin, TX)
May 24 - June 21, 2014


Sergio Santos | *Elemental*
Year of the Salamander Group Exhibition
Art.Science.Gallery. (Austin, TX)
May 24 - June 21, 2014


Kira McEntire | *Diversity*
Year of the Salamander Group Exhibition
Art.Science.Gallery. (Austin, TX)
May 24 - June 21, 2014

Featuring works by: Kira McEntire (Athens, GA); Hayley Gillespie, Jessica Gordon, Roderick Hilliard, Lori Hollifield, Marjorie Moore, Adrienne Parker, (Austin, TX); Erik Wild (Belo-Horizonte, Minas Gerais, Brasil); William Hall (Cedar Hill, TX); Carrie Carlson (Chicago, IL); Victoria Herrell (Conroe, TX); Margie Crisp (Elgin, TX); Lisa Temple-Cox (Essex, England, UK); Sergio Santos (Houston, TX); John Self (Kerrville, TX); Joelle Geisler + J. Haley of Fierce and Furry Paintings (Lowell, MA); Tanya Chaley, Lauren Schneider (New York, NY); Drake Pillsbury (Phoenix, AZ); Sabra Booth (San Antonio, TX); Ele Willoughby (Toronto, ON, Canada).

ECOLOGY FOR EVERYONE
Tuesdays 6-8pm, July 1 – July 29, 2014
(no meeting July 15th)
4 meetings / 8 hours / registration required - $80
Registration Deadline: June 29, 2014



Just like our gallery, ecology is all about interactions! It is the study of the relationships between species and their environment. Learn how the world's ecosystems work, and become an empowered citizen scientist in this short course by ecologist Dr. Hayley Gillespie, featuring lectures, hands-on art activities and local field trips. Learn to keep a field journal, identify local plants and animals, and discover how art can help enhance ecological study. Students must provide their own transportation. A supply/book list will be provided.

Register online at: www.artscience.gallery.com/labs/calendar, or in person at the gallery, or by phone, 512-522-8278.

Upcoming Meetings & Events

Salamander Art Exhibit, May 24 – June 22, Art.Science.Gallery, Austin, TX.

Herpetology 101: Salamanders, May 31-June 21, Saturdays 9-noon. Register by May 29. Austin, TX. **www.artscience.gallery.com/labs/calendar**

Texas Salamander Extravaganza public lecture, June 7, Art.Science.Gallery, Austin, TX.

Biology of Plethodontid Salamanders course, June 9-21, Highlands Biological Station, Highlands, NC. More info at **www.highlandsbiological.org**

Sabino Canyon Lizard Walk, June 14, 8 am, Sabino Canyon Recreation Area, Tucson, AZ. Meet at the visitors' center.

"Fate of Salamanders in the Anthropocene", June 14, Discussion panel symposium, Association of Environmental Studies and Sciences (AESS) conference, New York, NY. See **http://aess.info/** for details.

Conservation Genetics of Salamanders course, July 7-19, Highlands Biological Station, Highlands, NC. More info at **www.highlandsbiological.org**

2014 Joint Meeting of Ichthyologists and Herpetologists (SSAR/ASIH), July 30 – August 3, Chattanooga, TN. More info at **www.dce.k-state.edu/conf/jointmeeting/**

NEPARC annual meeting, August 13 - 15, 2014, Allegany State Park, Salamanca, NY