Mt. Mansfield Amphibian Monitoring

Update

2017

(Covering 1993-2017)

February 2, 2018

For the Forest Ecosystem Monitoring Cooperative

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Amphibian Monitoring on Mt. Mansfield, Vermont
1993-2017

Background

After an initial amphibian survey and establishment of monitoring protocols, populations of amphibian species have been monitored almost annually on Mount Mansfield since 1993. The goals of the monitoring are to (1) establish a baseline data set of abundance indices for the amphibian species caught in the fences, (2) monitor year-to-year changes in their abundance indices, (3) monitor changes in the number and type of obvious external abnormalities, (4) gather inventory data for the Vermont Herp Atlas, and (5) gather basic natural history information on the species present. Amphibians are targeted for this kind of study because their multiple habitat usage and permeable skin make them especially sensitive to changes in environmental conditions. This is the longest-running set of amphibian monitoring data in the state.

Four drift fences were built at three elevations on the west slope of Mt. Mansfield: 1200 feet (2 fences), 2200 feet (1), and 3200 feet (1). With the exception of the fence at 3200 ft., each fence was made of two 50-foot sections of 20-inchwide metal flashing buried 4 inches below the surface of the ground. The two sections were placed at right angles to each other, resulting in 100 feet of flashing set upright as a 16-inch-high fence. Buckets were buried every 12.5 feet on both sides of the fence so that the top edges of the buckets were flush with the ground. The fence at 3200 feet was made of only one 50-foot section of flashing with buckets at 12.5-foot intervals. Amphibians that encounter a fence while moving through the forest must turn to one side and many eventually fall into a bucket. The lids are taken off the buckets in the late afternoon on rainy days, and the captured amphibians identified and counted the following morning. The locations of these four sites are indicated in Figure 1. The fence at 3200 feet was discontinued in 1996. The remaining three fences are opened and checked up to five times per month during rain events throughout the field season (April through October excluding August). The abundance indices are generated using the three most successful trap-nights per month.

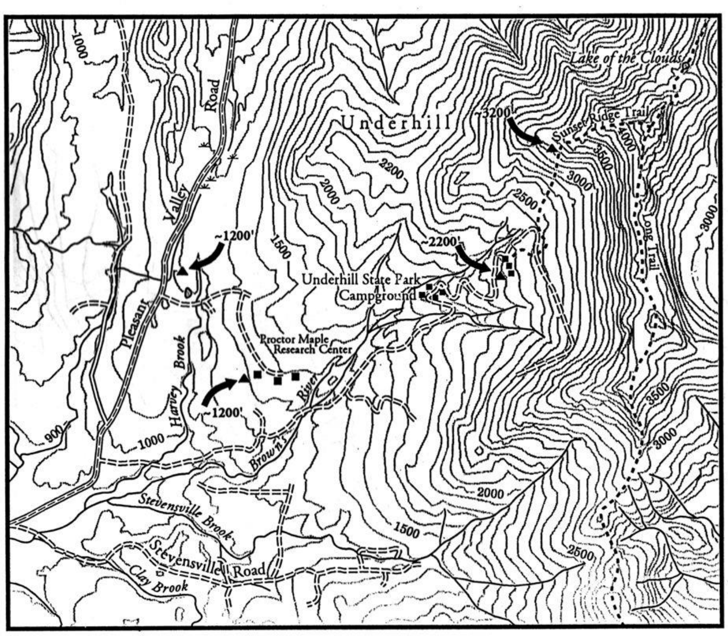

Figure 1.

Location of Drift Fences on Mount Mansfield Underhill, Vermont

We have drift-fence data from Mt. Mansfield from 1993 to the present, with the exceptions of 2004, 2009, 2015, and April and May of 2016. Due to an anticipated break in the funding the drift fences were removed from Mt. Mansfield during the summer of 2015. Luckily, funding was restored, the fences were reinstalled in May of 2016 and data collection began again in June of 2016.

Periodic monitoring at Lye Brook allows us to compare data at the two locations to see if there are corresponding patterns that may signal statewide changes. We collected data from fences near the Lye Brook Wilderness in southern Vermont annually from 1994 through 2002 when funding from the Green Mountain National Forest ended. During 2008 monitoring began again at Lye Brook Wilderness and continued at Mt. Mansfield as well. In 2009, only the Lye Brook Wilderness fences were monitored, and in 2010, only Mt. Mansfield fences were monitored. In the fall of 2011, Hurricane Irene washed out the road leading to the Lye Brook drift fences from the west, preventing data collection in the fall of 2011 and in 2012. A new road allowing access from Manchester has been completed. However, we would need to locate and train new staff and find additional funding before beginning monitoring again near Lye Brook.

In an effort to save money and time, we agreed in 2009 to begin an every-other-year schedule of generating indices, analyzing, and reporting on the data gathered. However, recent contracts have again required annual reports. The 2016 report included all data from 1993 through June of 2017 from Mt. Mansfield. Due to the re-installation of the fences in the summer of 2016, no data were collected in April and May 2016. In order to be able to continue comparing year-to-year results we needed to have a full year of results, including a spring migration in April and May. We chose to include the data collected during April and May 2017, as it was the closest chronologically to the 2016 field season and encompasses one full year. This report contains all data collected in the 2017 season, and the next report will follow the 2018 field season. Cleaned and updated sets of all the drift-fence data from Mt. Mansfield, including data not used in our indices have been sent to the FEMC.

Diversity of Adults and Young

In 2017, the usual five caudate (salamander) species were caught as adults. They are Spotted Salamander (*Ambystoma maculatum*), Northern Dusky Salamander (*Desmognathus fuscus*), Northern Two-lined Salamander (*Eurycea bislineata*), Eastern Newt (*Notophthalmus viridescens*), and Eastern Red-backed Salamander (*Plethodon cinereus*). We also caught adult Spring Salamanders (*Gyrinophilus porphyriticus*). This is a species we have only caught 11 of our 22 trapping seasons. We caught them only two of our first 11 trapping seasons and 9 of our last eleven seasons. Young of three of these species (Spotted Salamander, Eastern Newt, and Eastern Red-backed Salamander) were also caught (Table 1).

In 2017, adults of all six of or our normally trapped anurans (frogs) were caught. They are American Toad (*Anaxyrus americanus*), Gray Treefrog (*Hyla versicolor*), Spring Peeper (*Pseudacris crucifer*), Green Frog (*Lithobates clamitans*), Pickerel Frog (*Lithobates palustris*), and Wood Frog (*Lithobates sylvaticus*). Juvenile Wood Frogs were abundant (85). There were a few young Green Frogs (7) and Spring Peepers (4) but only one young American Toad and no young Pickerel Frogs or Gray Treefrogs (Table 1).

Overall, the total number of salamanders and frogs detected per trapping is higher than last year. Numbers were the highest ever detected for Spotted Salamander, Spring Salamander, Eastern Red-backed Salamander, and Wood Frog (Table 2).

Long-term Trends

Linear regressions most closely fit most of the data plots, so they are used to show potential trends in the abundance indices for all species caught from 1993-2017 (Figures 2-7). This year, in addition to using linear regressions to show potential trends in the abundance indices, we used the Monitor.exe freeware program to determine the reliability of the apparent trends.

Power

These results of the Power analysis are shown in Table 3. The likelihood that an apparent trend reflects a true trend in population numbers is referred to as power. Statistically it is defined as the likelihood of correctly rejecting the null hypothesis (no trend). Our goal is to achieve a power of 90% or greater. The powers of these data sets are dependent upon a number of variables: the length of the series of data-gathering units (at this point 22 years), the number of times each year data are gathered (3, see description below), the number of locations from which data are gathered (in this case one, because although three fences are used, the data are combined), the variability of the data collected (differs for each species, see below), the starting value of the abundance indices (differs for each species), how small a trend we hope to be able to detect (5% annually), and what statistical level of significance is acceptable: alpha = 0.10 (10% chance of incorrectly rejecting the null hypothesis). The variability (standard deviation) of the data collected for each species is an estimate of how much the index varies, not how much a species varies from year-to-year. Therefore, it was not reasonable to calculate standard deviation across years. It was also not reasonable to calculate across months, due to seasonal differences in amphibian movement. Because of this within-year variation, we stratify our data into six time-periods for each year. With those data, we generate one index per species per year. However, we needed to compare between indices for each species. Consequently, standard deviation was calculated using numbers from two successful trappings per month in 2014 (which was the most recent year with the maximum of 18 successful trappings per year). Different combinations of two trappings per month gave 3 different indices, from which standard deviation was calculated. Therefore, the number of counts per plot per survey (number of times each year data were gathered) was three, despite the fact that data were actually gathered between 12 and 18 times each year. Standard deviation was then divided by the mean to give a coefficient of variation, which was used in the Monitor program calculations. It is assumed that the standard deviation value I used is a very conservative estimate (higher than the actual standard deviation), since it is based on only two trappings per month instead of three, which is what the actual indices are based on. This method of determining the standard deviation value means that the power estimates included in Table 1 are likely conservative (lower than actual values) as well. In Table 3, trends that meet the 90% power criteria are bold faced in the column at the far right. The power figures shown were generated using the Monitor.exe program written by James P. Gibbs and Eduard Ene (2010).

Standard deviation and coefficient of variation

In Table 3, there are two sets of standard deviations, means, and coefficients of variation. The first (labeled 2014) were the values used in the calculation of power and were calculated using the three different indices described above. The second were taken from all 22 years of monitoring data and were calculated using the individual years' number per trapping values. The second set of values are useful for examining how much each species varies from year to year. Standard deviation (SD) values ranged from a low of 0.33 for Northern Two-lined Salamanders to a high of 3.76 for Eastern Red-backed Salamanders. However, some of this variation is due to differences in the mean number caught. Therefore, it is useful to use a statistic that takes the mean number caught into consideration. The coefficient of variation (CV) does this. It is defined as the standard deviation divided by the mean. The lowest CVs (and therefore the species that fluctuate the least from year-to-year) are the Eastern Newt (0.32) and Spotted Salamander (0.36). The most variable are Green Frog (1.65) and Spring Peeper (0.83). Other species that are not included in the table (Northern Dusky Salamander, Spring Salamander, Pickerel Frog, and Gray Treefrog) would more than likely show high CVs, because they are caught in low numbers, thereby making them hard to monitor with any accuracy at the fences.

Power to show a 5% annual decline

As shown in Table 3, if a 5% annual decline exists, we have the ability to detect it for six of eight species. Spotted Salamanders, Eastern Newts, Wood Frogs, and Spring Peepers show the best power (1.00), followed by American Toads and Northern Two-lined Salamanders (0.993 and 0.975, respectively). The other two species (Eastern Red-backed Salamander and Green Frog) likely do not show sufficient power to detect a 5% annual decline due to a large standard deviation in relation to the starting value (a high SD/starting value ratio). However, the actual increasing and decreasing trends for some species are enough larger than 5% that we do have the power to be confidant of the trends shown.

Increasing trends

Power analysis shows that three of the nine species abundant enough to monitor showed an average increase over this 22-year period, with statistical power to support the trend: Northern Two-lined Salamander, Eastern Red-backed Salamander, and American Toad (Table 3).

Looking at only linear regression lines, Spotted Salamander (Figure 3), Green Frog (Figure 7), and Wood Frog (Figure 6), show a positive trend line but we don't have the power we would like to reject the null hypotheses (no trend) based on a variety of factors. For Spotted Salamander and Green Frog, the slopes of their suggested increases are barely detectable.

Declining trends

Power analysis reveals that we have the power to state that Spring Peeper has had a declining trend over the 22-year period (-1.6% annually, 100% power, Table 3).

Looking at only linear regression lines, Eastern Newt (Figure 4) and Pickerel Frog (Figure 5) show a negative trend line but we don't have the power we would like to reject the null hypotheses (no trend) based on a variety of factors.

Young of the Year

Beginning with the 1995 report, we began documenting the number of young of the year, calculating the percentage of young of the year (YOY), and recording the date of the first metamorph caught by a drift fence. The cutoff lengths listed on Table 1 were calculated in 1995, based on data we had collected, and information gathered from the literature. As mentioned in the footnotes, in addition to using the total length as one cutoff for determining young of the year, we also use dates, as some larvae or tadpoles may overwinter in their aquatic phase and metamorphose in the early spring. In 2017, young of the year made up 17% of those caught (Table 1). Over the course of the entire study (1995 – 2017) the average percentage of young of the year of total catch was 27.5%. Since the study's inception the young of the year have varied from 11% (2014) to 74% (2002). Table 4 and Table 5 summarize the young of the year information for salamanders and frogs respectively.

All frogs monitored except for Green Frogs generally grow from egg to metamorph in one season. At this latitude and elevation, Green Frogs usually spend at least one winter as a tadpole and metamorphose a year or more after the eggs are laid. Other frogs metamorphose during the same year as egg laying but at a very small size. American Toads can be as small as 8-13 mm after metamorphosis. Gray Treefrogs can be as small as 15 mm. Wood Frogs can transform as small as 10-20 mm and Spring Peepers as small as 13 mm. It is possible that a froglet may have transformed in a previous year but still be under the cut-off size to be considered young of the year when found the following spring. Therefore, when determining young of the year we did not include small frogs or toads found in spring or very early summer if it was unlikely enough time had passed to allow for development through metamorphosis. Different species of salamanders show even more variability and for many the term *young of the year* is misleading. It would be more accurate for us to say *first year of their terrestrial phase*. The Eastern Newt and the Eastern Red-backed Salamander generally develop into a terrestrial form in the first year of their life; although like the frogs, they may still be very small and below our cutoff sizes the spring after they were deposited as eggs. Spotted Salamanders have a minimum larval phase of about 60 days but can remain in the water as larvae over their first winter. Small Spotted Salamanders found in the spring and early summers are not counted as young of the year in this report. Northern Dusky Salamanders can spend 7 to 11 months as larvae and transform the spring after emerging from eggs. Northern Two-lined Salamanders may remain in their aquatic stage for 2 – 3 years, and Spring Salamanders can remain in their larval form for up to 3-4 years (Harding 2000). What we refer to as young of the year for these species are individuals that had hatched in previous years but were spending their first year in the terrestrial form.

Individual Species' Trends

Northern Two-lined Salamander

We catch relatively few Northern Two-lined Salamanders. This was expected since we did not place the fences with their habitat in mind. This species prefers saturated soils and travels only a limited distance away from those areas in very wet conditions. The first decade of monitoring showed slight increasing trend in numbers caught. In 2005 we saw a large increase from 0.3 to 1.1 caught per trapping, followed in 2006 by a drop back to 0.2, then a slow increase until the population peaked again in 2010 with 1.1 per trapping. Since 2003, the indices have shown noticeably larger annual fluctuations and linear regression trend lines show an increase (Figure 2 and Table 3). Using power analysis, this species has been shown, with a power of 99%, to be increasing by 6.3% annually since 1993. Since the total numbers that are caught are still quite low, we are surprised to be able to detect this trend.

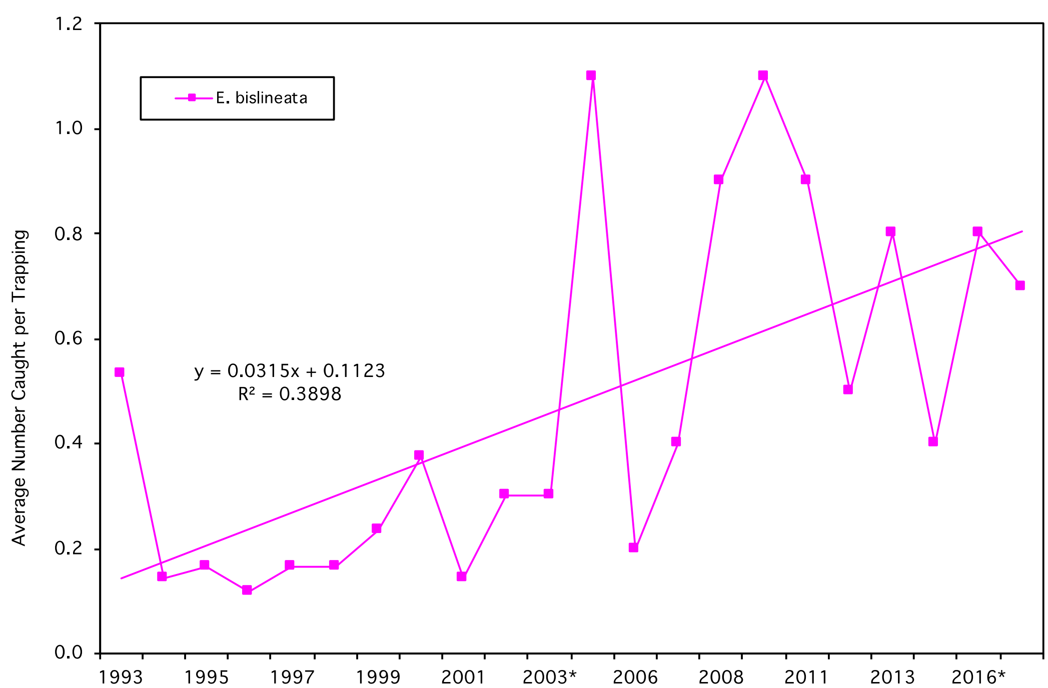

Figure 2. Northern Two-lined Salamander (*Eurycea bislineata*) population index from Mt. Mansfield, Underhill, Vermont, 1993-2017.

Spotted Salamander

The Spotted Salamander has a virtually flat regression trend line, with some annual variation (Figure 3) consequently, we do not have enough power to detect any long-term trends in this species. However, the trapping average for 2017 of 2.9 individuals was a record high for this species. This is a long-lived species with a life span of over 20 years. As a result, adult numbers are not expected to vary as much annually as a shorter-lived species such as a Spring Peeper or Wood Frog. At the same time the number of young of the year detected (10%) was well below the average of 30%.

Eastern Red-backed Salamander

This species shows a clear long-term increase. Like the other amphibian species found at this site, the Eastern Red-backed Salamander population occasionally shows large annual fluctuations; however, between 2001 and 2014 this species had been showing a steady, and on occasion, dramatic increase. In 2017, a record number were detected (Figure 3 and Table 2). Power analysis corroborated these results and found the species has a positive increase showing an annual change of 39.4% (Table 3). Our power to detect it is 100%.

This species is reported to do well in mature hardwood forests with abundant coarse woody debris and deep deciduous leaf litter. Unlike the Wood Frog and Spring Peeper it overwinters deep in the soil below the frost line, so it should be less subject to overwintering mortality. Also, unlike Wood Frogs and Spring Peepers, it does not require wetlands in any stage of its development, so hydroperiod or other conditions in breeding ponds would not have any direct impact on their numbers, although soil moisture could. The increase in this species could be a result of the leaf litter becoming deeper, the leaf litter holding moisture better, an increasing amount of course woody debris or some a combination of these factors. These could all be a result of a maturing hardwood forest.

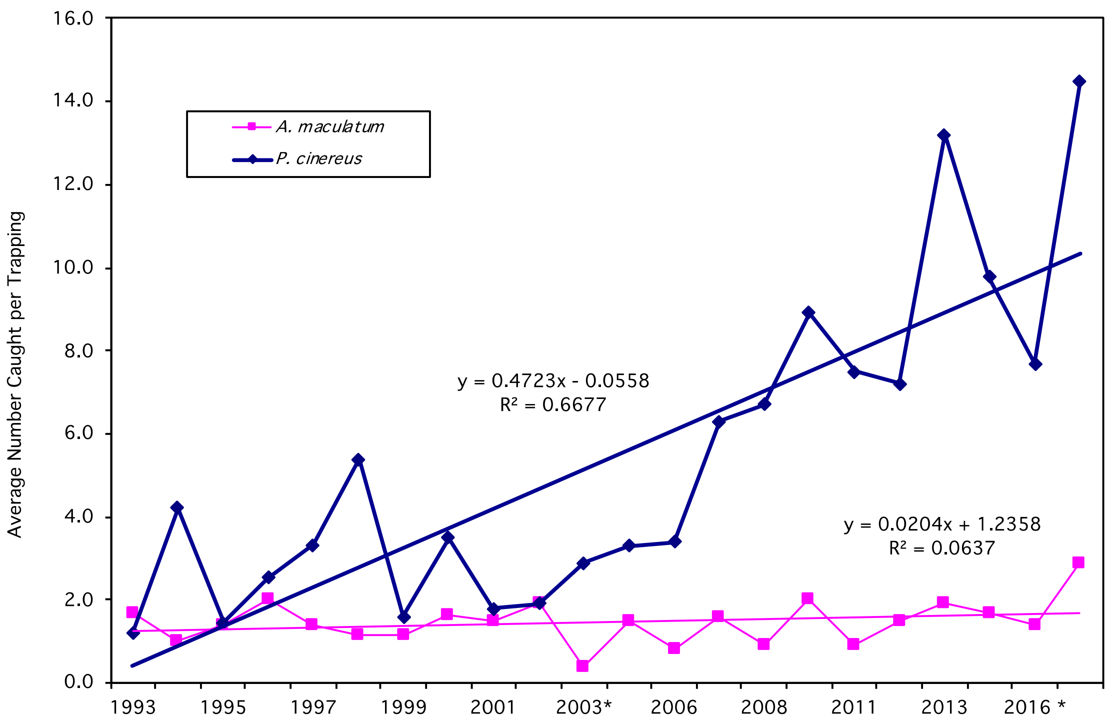

Figure 3. Spotted Salamander (*Ambystoma maculatum*) and Eastern Red-backed (*Plethodon cinereus*) Salamander population indices from Mt. Mansfield, Underhill, Vermont, 1993-2017.

Eastern Newt

The trapping rate for the Eastern Newt in 2017 was 1.4 animals per trapping. The long-term trend shows a downward regression line, but given the large annual variation, power analysis was not able to confirm a trend with any degree of certainty (Table 3). The number of young of the year detected for Eastern Newts was relatively low in 2017. Nineteen percent of total captures were young, the lowest percentage since 2008, and well below the average of 31%.

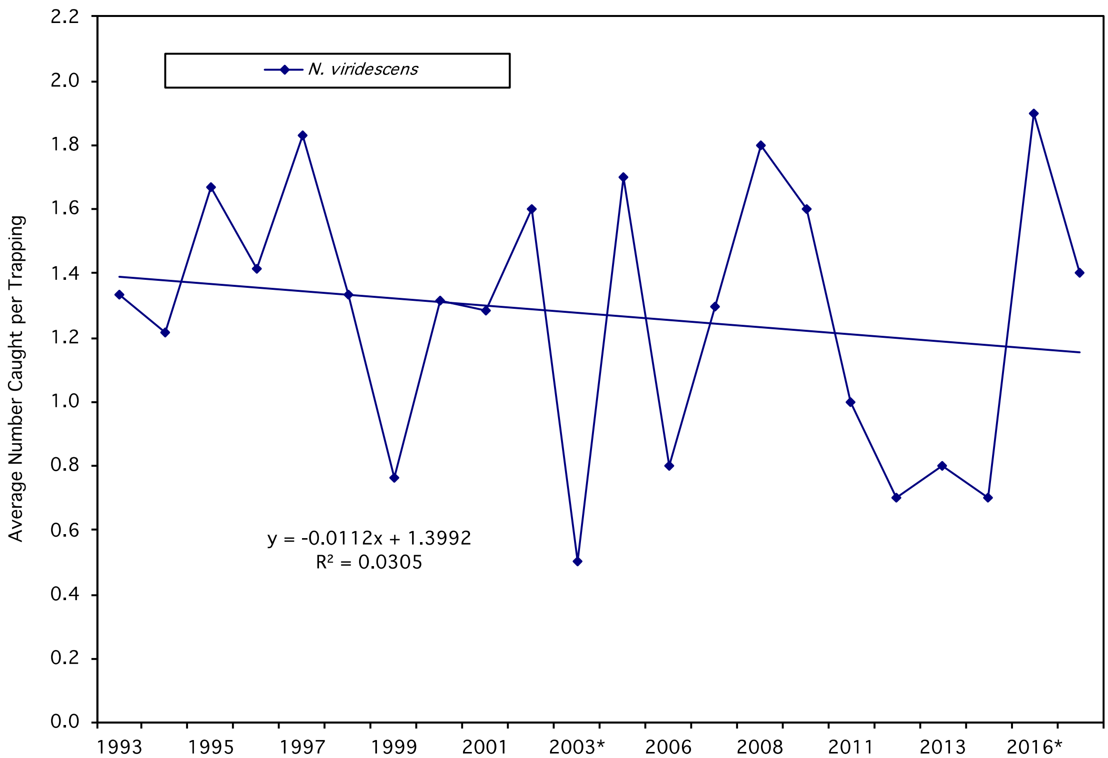

Figure 4. Eastern Newt (*Notophthalmus viridescens*) population indices from Mt. Mansfield, Underhill, Vermont, 1993-2017.

American Toad

American Toad captures have fluctuated with large annual variations (Figure 5). An all-time high of 5.4 American Toads per trapping was detected in 2013. After that year, our index dramatically fell back to 1.7, 1.9, and 1.2 over the last few trapping years. The regression line shows that the population appears to be increasing. Power analysis found that we could detect the annual increase of 7.3 % (Table 3) with a power of greater than 90%. However, a careful look at Figure 5 shows that we began monitoring this species at a low point in its numbers. A long-term regression line for the last twenty years would look fairly level for this species, despite the large annual variation.

Pickerel Frog

We catch so few Pickerel Frogs (fewer than 1.0 per trapping) that although it appears the population continues to decrease slightly; it is not possible to draw any meaningful conclusions (Figure 5 and Table 2). This is not surprising. Our fences were not located in the preferred foraging habitat (open annual vegetation near water) for this species.

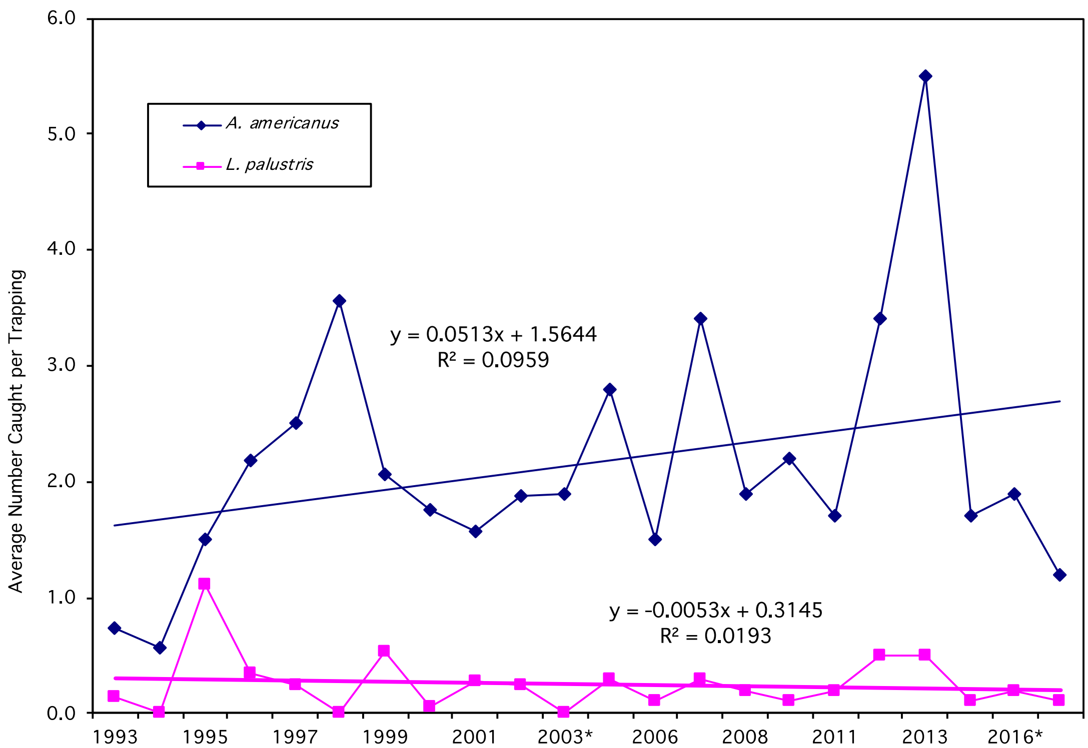

Figure 5. American Toad (*Anaxyrus americanus*) and Pickerel Frog (*Lithobates palustris*) population indices from Mt. Mansfield, Underhill, Vermont, 1993-2017. The numbers for the Pickerel Frog are too low to draw any meaningful conclusions.

Wood Frog

Wood Frogs continue to have large year-to-year fluctuations (Figure 6 and Table 2). The regression line appears to show a slight long-term increase, although that is largely the result of a record number of Wood Frogs per trapping (11.3) in 2017 (Table 1 and Figure 6). Power analysis tells us we do not have the power to safely confirm a trend of this size in this species. A relatively high percentage of Wood Frogs detected were young of the year (42%). This extra recruitment might result in a population increase next year if overwintering conditions are favorable.

Since this species grows from egg to metamorph in a matter of months, short-term droughts of only a couple weeks duration could have a large impact on a population. In addition, since this species overwinters in the leaf litter, depth of freeze could also have immediate and pronounced impacts on populations. At a privately funded research site in Lincoln (Colby Hill Ecological Preserve) where we are monitoring egg-mass numbers, we have not seen any significant trends for this species.

Spring Peeper

The 1.6% annual decline of Spring Peepers (Figure 6) is the only decline shown among the species we monitor on Mt. Mansfield that we confidently (100%) have the power to claim (Table 3 and Figure 6). After a long gradual decline for the first 14 years of our monitoring, this species disappeared entirely from our traps for two seasons (2008 & 2009). Although, the long-term trend is a decline, numbers have been increasing since 2009. This year resulted in the highest rate of catch (1.8 per trapping) since 1995.

Local changes in breeding habitat are one possible explanation for population variation, but we have no data to support a significant change in habitat. Spring Peepers breed primarily in open, shallow, and well-vegetated wetlands. If local breeding habitat were flooded by beaver and/or exposed to trout, populations would be expected to decline. The importance of nearby breeding habitat is supported by the fact that we have never caught a Spring Peeper at the drift-fence at Underhill State Park. As far as we can tell, there is no breeding habitat in that area. In our minds, changes in appropriate breeding habitat, perhaps as a result of forest succession, or changes in local beaver activity could potentially be driving population changes.

Spring Peeper is another species that overwinters in the leaf litter. Changes in the depth of frost during winter, or changes in the depth of the leaf litter could also bring about declines. Invasive worms and disease are other potentially significant variables.

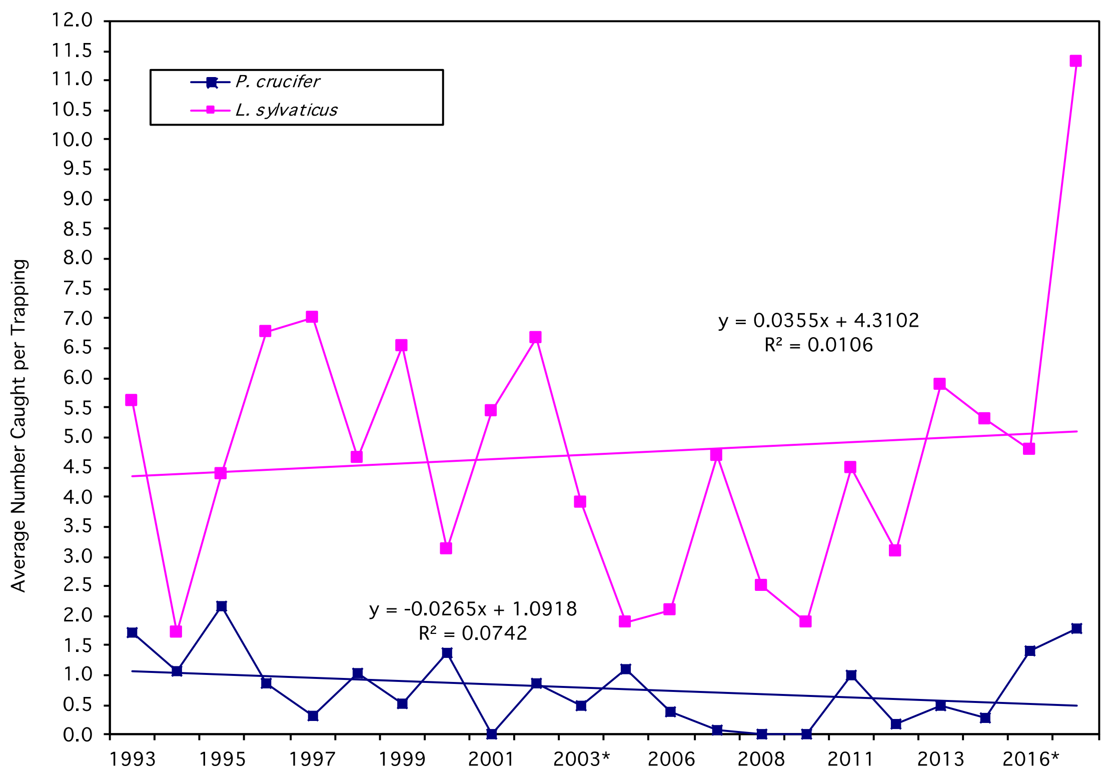

Figure 6. Wood Frog (*Lithobates sylvaticus*) and Spring Peeper (*Pseudacris crucifer*) indices from Mt. Mansfield, Underhill, Vermont, 1993-2017.

Green Frog

The number of Green Frogs increased slightly through 2002 when there was a dramatic increase from 1.9 per trapping to 22.1 per trapping, for a total of 350 Green Frogs captured (Figure 7). After that one dramatic year, there was a large drop back down to the historic trend line in 2003 and only relatively small annual variations since then. Although the long-term trend line implies a very slight increase overall, Green Frog numbers have decreased each year since 2012 with a near record low of 0.30 per trapping detected in 2016/17. A small increase to 0.6 per trapping was detected in 2017. So far, the take home message here is the ability of this species to show dramatic short-term population changes. Since this species overwinters as a tadpole, a winter that allowed high survival in a nearby breeding pond could generate a short spike like that of 2002, particularly if it was preceded and/or succeeded by wet conditions. Green Frogs are also largely aquatic and require standing pools of water to rehydrate and wet conditions in which to move. Seven of the 10 animals captured in 2017 were young of the year. This may be an indication that the population will start growing again (Table 5) provided these young overwinter successfully.

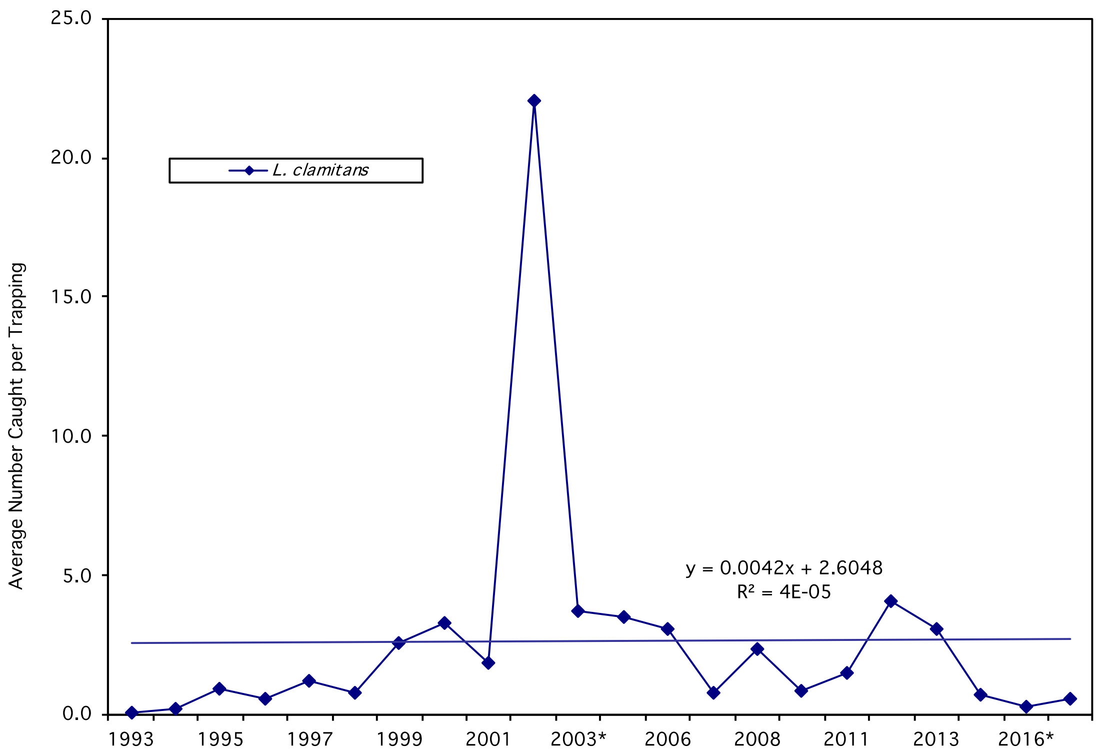

Figure 7. Green Frog (*Lithobates clamitans*) population indices from Mt. Mansfield, Underhill, Vermont, 1993-2017.

Abnormalities

The number of abnormalities continues to be low, with only one abnormality detected in 2017 out of 689 animals captured. The abnormality detected in 2017 was deemed by field technician Karl Reimer to be an injury of a Green Frog's back leg, and not a malformity.

There were also no abnormalities from 2007, 2008, 2009, 2010, 2013, 2014, or 2016/17. In 2011, one abnormality was detected in the 314 animals captured. It was a Wood Frog that had a left leg that bent back over the top of the frog. This could well have been the result of an injury. In 2012, two of the 384 animals were found with abnormalities. One Spring Salamander was missing toes and its lower leg, and a Green Frog was found with an atrophied right rear leg.

The numbers of abnormalities at this site have always been well below the level of concern. From 1998 through 2017, the total number of amphibians showing abnormalities from all captures has been 15 individuals.

Data

Data from these efforts are exported in Excel format and sent via E-mail to FEMC soon after reports are written.

Summary

The drift-fence array at Mt. Mansfield has generated the longest-running set of amphibian-monitoring data in the state. It is the only amphibian drift-fence location in Vermont that has been monitored almost continuously from 1993 through 2017.

Although we had not used power analysis to evaluate apparent trends in species populations since 2001, we used it again this year to see if we had the statistical power to detect the trends suggested by the regression lines. The power analyses confirm that:

- Populations of **Spring Peeper have decline**d over the long-term duration of this study; **however, the last six years of data have shown a rebound**.

- Populations of the **Eastern Red-backed Salamander have increased dramatically** over the length of the study.

- Populations of the **Northern Two-lined Salamander have increased** although we continue to catch relatively few.

- Populations of **American Toad have increased over the duration of the study**; however, we began gathering data at a very low-point in their populations. If we had begun monitoring five years later, the population trend line would appear fairly level.

Life history differences and similarities between species will help us rule out some potential causes of these changes and suggest others, but at this point, little is known about what is driving these changes.

Although always rare at this site, the **number of abnormalities remains very low**.

Acknowledgments

Long-term monitoring at Mt. Mansfield during 2017 was supported by a cost-sharing grant from the Vermont Department of Forests, Parks, and Recreation through the Forest Ecosystem Monitoring Cooperative (FEMC) and Vermont Family Forests. Field personnel at Mt. Mansfield were Warren Ellison, Karl Riemer, and Robert Robbins. Katherine Kelly performed the power analyses for us. Cynthia Brown entered all the data and Erin Talmage reviewed the data, generated the tables and figures, and drafted the report.

Table 1. Monitoring results from the two drift-fences at 1,200 ft. and one at 2,200 ft. on Mt. Mansfield, Underhill, Vermont during 2017. Traps were opened whenever conditions were appropriate for amphibian movement from April through November excluding August. Three successful trappings per month (± 10 days) were the goal, however due to periods of low rainfall, two trappings per month were sometimes used. **Data from 18 of 21 trap-efforts were used: April 12, 16, and 26; May 2, 14, and 26; June 6, 20, and 28, July 9, 15, and 25; September 28 and October 5 and 10; and October 25, 30, and Nov 6.** Abnormality, maximum size, and first metamorph data were taken from all **21** trappings.

Common name	Scientific name	# of all ages	# of young of the year [1]	% young of the year	date of first metamorph [2]	largest adult (total length in mm)	# per trapping[3]	% of group	% of total catch	# abnormal/ total [4]
Caudates (Salamanders)										
Spotted Salamander	*Ambystoma maculatum*	52	5	10%	Oct. 5	205	2.9	14%	8%	0/57
N. Dusky Salamander	*Desmognathus fuscus*	12	0	0%	N/A	120	0.7	3%	2%	0/158
N. Two-lined Salamander	*Eurycea bislineata*	13	0	0%	N/A	100	0.7	3%	2%	0/16
Spring Salamander	*Gyrinophilus porphyriticus*	10	N/A	N/A	N/A	183	0.6	3%	2%	0/10
Eastern Newt	*Notophthalmus viridescens*	26	5	19%	Oct. 5	81	1.4	7%	4%	0/29
E. Red-backed Salamander	*Plethodon cinereus*	261	3	1%	Nov. 6	104	14.5	70%	41%	0/278
Group totals	Group totals	374	13	3%	NA	NA	20.8	100%	58%	0/405
Anurans (Frogs)										
American Toad	*Anaxyrus americanus*	22	1	5%	June 20	86	1.2	8%	3%	0/22
Green Frog	*Lithobates clamitans*	10	7	70%	Sept. 28	90	0.6	4%	2%	1/13
Pickerel Frog	*Lithobates palustris*	1	0	0%	N/A	37	0.1	0%	0%	0/1
Wood Frog	*Lithobates sylvaticus*	203	85	42%	July 15	64	11.3	76%	32%	0/214
Spring Peeper	*Pseudacris crucifer*	32	4	13%	Oct. 5	36	1.8	12%	5%	0/34
Group totals	Group totals	268	97	36%	NA	NA	14.9	100%	42%	0/284
Amphibian totals	Amphibian totals	642	110	17%	NA	NA	35.7	100%	100%	0/689

[1] For each species, individuals under a given total length were considered potential young of the year. The chosen length was based on the timing of their appearance, gaps in their size continuum, and records in the literature. The cutoff sizes used were *A. maculatum* (70 mm), *D. fuscus* (30 mm), *E. bislineata* (60 mm), *N. viridescens* (45 mm), *P. cinereus* (32 mm), *A. americanus* (23 mm), *H. versicolor* (26 mm), *P. crucifer* (20 mm), L. *clamitans* (44 mm), *L. palustris* (34 mm), and *L. sylvaticus* (27 mm). Young of the year for *G. porphyriticus* have external gills and are aquatic for up to 4 years. In addition, it was necessary to examine the minimum possible development time for each species. Individuals shorter than the cutoff lengths clearly overwinter (possibly as larvae for *N. viridescens* and *A. maculatum*) and show up in very early spring. These are not counted as young of the year.

[2] No trapping took place in August.

[3] These figures are rounded to the nearest 0.1. All other figures are rounded to the nearest whole number. As a result of this, group totals may not be equivalent to the sum of the individual species' values.

[4] These may contain old deformities (traumatic) as well as malformities (developmental). Salamanders missing all or portions of their tails are not included. The total number checked may contain specimens that were caught more than once.

Table 2. A comparison of drift-fence data (numbers per trapping) from 1993 through 2017 (no data were collected in 2004, 2009, and 2015) field seasons at Mt. Mansfield, Underhill, Vermont. Data used are from two fences at 1,200 ft. and one fence at 2,200 ft. in elevation.

Common name	# per trapping [1]																					
	93	94	95	96	97	98	99	00	01	02[2]	03[2]	05[2]	06	07	08	10	11	12	13	14	16[4]	17
Caudates (Salamanders)																						
Spotted Salamander	1.7	1.0	1.4	2.0	1.4	1.2	1.2	1.6	1.5	1.9	0.4	1.5	0.8	1.6	0.9	2.0	0.9	1.5	1.9	1.7	1.4	2.9
N. Dusky Salamander	0.3	0.3	0.3	0.0	0.0	0.6	0.1	0.4	0.3	0.4	0.1	0.0	0.0	0.1	0.3	0.6	0.2	0.5	0.8	0.9	0.6	0.7
N. Two-lined Salamander	0.5	0.1	0.2	0.1	0.2	0.2	0.2	0.4	0.1	0.3	0.3	1.1	0.2	0.4	0.9	1.1	0.9	0.5	0.8	0.4	0.8	0.7
Spring Salamander	< 0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.2	0.1	0.1	0.1	0.2	0.1	0.2	0.6
Eastern Newt	1.3	1.2	1.7	1.4	1.8	1.3	0.8	1.3	1.3	1.6	0.5	1.7	0.8	1.3	1.8	1.6	1.0	0.7	0.8	0.7	1.9	1.4
E. Red-backed Salamander	1.2	4.2	1.3	2.5	3.3	5.4	1.6	3.5	1.8	1.9	2.9	3.3	3.4	6.3	6.7	8.9	7.5	7.2	13.2	9.8	7.7	14.5
Group totals	5.0	6.8	4.9	6.1	6.7	8.7	3.9	7.2	5.0	6.1	4.2	7.8	5.2	9.7	10.8	14.3	10.6	10.5	17.7	13.6	12.6	20.8
Anurans (Frogs)																						
American Toad	0.7	0.6	1.5	2.2	2.5	3.6	2.1	1.8	1.6	1.9	1.9	2.8	1.5	3.4	1.9	2.2	1.7	3.4	5.5	1.7	1.9	1.2
Gray Treefrog	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Green Frog	< 0.1	0.2	0.9	0.6	1.3	0.8	2.6	3.3	1.9	22.1	3.7	3.5	3.1	0.8	2.4	0.9	1.5	4.1	3.1	0.7	0.3	0.6
Pickerel Frog	0.1	0.0	1.1	0.3	0.3	0.0	0.5	0.1	0.3	0.3	0.0	0.3	0.1	0.3	0.2	0.1	0.2	0.5	0.5	0.1	0.2	0.1
Wood Frog	5.6	1.7	4.4	6.8	7.0	4.7	6.5	3.1	5.4	6.7	3.9	1.9	2.1	4.7	2.5	1.9	4.5	3.1	5.9	5.3	4.8	11.3
Spring Peeper	1.7	1.1	2.2	0.9	0.3	1.1	0.5	1.4	0.0	0.9	0.5	1.1	0.4	0.1	0.0	0.0	1.0	0.2	0.5	0.0	1.4	1.8
Group totals	8.1	3.6	10.1	10.8	11.4	10.3	12.2	9.8	9.2	31.9	10.0	9.5	7.2	9.3	7.0	5.1	8.9	11.3	15.5	7.9	8.7	15.0
Amphibian totals	13.1	10.4	15.0	16.9	18.1	19.0	16.1	17.0	14.2	38.0	14.2	17.4	12.4	19.0	17.8	19.4	19.5	21.8	33.2	21.5	21.3	35.8

[1] Numbers per trapping are rounded to the nearest 0.1. All other figures are rounded to the nearest whole number. As a result of this, group totals may not be equivalent to the sum of the individual species' values. There were a total of 15 trappings in 1993, 14 in 1994, 18 in 1995, 17 in 1996, 12 in 1997, 18 in 1998, 17 in 1999, 16 in 2000, 14 in 2001, 16 in 2002, 15 in 2003, 16 in 2005, 16 in 2006, 15 in 2007, 14 in 2008, 15 in 2010, 15 in 2011, 17 in 2012, 17 in 2013, 18 in 2014, 18 in 2016[4], and 18 in 2017. Trappings counted were on those nights when at least 2 of the three traps were opened under appropriate weather conditions for amphibian movement.

[2] For three years we used dowels in half of the traps to reduce small mammal mortality. In order to compare those year's with other year's data, we converted all numbers to approximate non-dowel values. Using the preselected data sets, this was done by excluding all dowel captures, doubling captures in unimproved traps and adding snake trap data.

[3] These figures are rounded to the nearest 0.1. All other figures are rounded to the nearest whole number. As a result of this, group totals may not be equivalent to the sum of the individual species' values.

[4] April and May data were gathered in the spring of 2017.

Table 3. Power analyses of the Mt. Mansfield drift-fence data from 1993 through 2017. Annual change percentages that are shown in bold type are those with a power greater than 90%. Not included in the table are Northern Dusky Salamander, Spring Salamander, Pickerel Frog, and Gray Treefrog, as they are caught in such low numbers that we don't have enough power to accurately detect a 5% annual population decline using Monitor.exe.

Common name	Statistics and trends [1]										
	Start Value [2] (1993)	SD 2014 [3]	Mean 2014 [3]	CV 2014 [3]	SD [4]	Mean [4]	CV [4]	Power 5% decline [5]	Power (x%) [6]	Annual Change	Annual % Change
Caudates (Salamanders)											
Spotted Salamander	1.7	0.22	1.67	0.13	0.52	1.47	0.36	1.000	0.60 (1%)	0.0204	1.2%
N. Two-lined Salamander	0.5	0.10	0.44	0.22	0.33	0.47	0.70	0.975	0.99 (5%)	0.0315	**6.3%**
Eastern Newt	1.3	0.17	0.67	0.25	0.41	1.27	0.32	1.000	0.39 (-1%)	-0.0112	-0.9%
E. Red-backed Salamander	1.2	1.99	9.72	0.20	3.76	5.37	0.70	0.596	1.00 (35%)	0.4723	**39.4%**
Anurans (Frogs)											
American Toad	0.7	0.42	1.72	0.24	1.08	2.16	0.50	0.993	0.949 (5%)	0.0513	**7.3%**
Green Frog	0.1	0.17	0.72	0.24	4.60	2.78	1.65	0.015	0.507 (4%)	0.0042	4.2%
Wood Frog	5.6	0.75	5.28	0.14	2.25	4.72	0.48	1.000	0.636 (0.6%)	0.0355	0.6%
Spring Peeper	1.7	0.08	0.33	0.25	0.65	0.78	0.83	1.000	1.000 (-2%)	-0.0265	**-1.6%**

[1] Trends are taken from a linear regression (see Figures 2-7). Annual change is shown in individuals per trapping and is the slope of the regression line. Percentage of change is based on the annual change's percent of the starting population.

[2] Start value is the number per trapping for each species from 1993. This value was used in the calculation of power using the Monitor.exe freeware program.

[3] The standard deviation (SD), mean, and coefficient of variation (CV) of indices within a year are taken from the 2014 data. The measures of variation are between three indices, each of which used different combinations of two dates from every month. The mean is an average of these three indices. The standard deviation value was used in the calculation of power using the Monitor.exe freeware program.

[4] The standard deviation (SD), mean, and coefficient of variation (CV) of indices between years are taken from all 22 years of monitoring data. The measures of variation are between the different years, and the mean is the average of the indices from all 22 years. These values were not used in the calculation of power, but can be used to show how much each species varies from year-to-year.

[5] This is the power to detect a 5% annual population decline after 22 years of monitoring, as determined using the Monitor.exe freeware program using linear regressions (with an alpha of 0.10).

[6] This is the power to detect the percent and direction of change indicated in the parentheses after 22 years of monitoring (see footnote 1). This percent change is equivalent to or as close as possible to the value in the column "Annual % Change" (rounded to the nearest whole number that the Monitor program would calculate).

Table 4. A comparison of young-of-the-year salamanders from drift-fence data from 1995 through 2017 (no data were collected in 2004, 2009, and 2015) field seasons at Mt. Mansfield, Underhill, Vermont. Data used are from two fences at 1,200 ft. and one fence at 2,200 ft. in elevation.

Common Name	# young of the year/ total amphibians captured (% young of the year) 1,2,3,4																			
	95	96	97	98	99	00	01	02[3]	03[3]	05[3]	06	07	08	10	11	12	13	14	16[4]	17
Caudates (Salamanders)																				
Spotted Salamander	3/25 (12%)	16/34 (47%)	0/17 (0%)	4/21 (19%)	0/20 (0%)	12/26 (46%)	6/21 (29%)	5/25 (20%)	5/10 (50%)	3/20 (15%)	6/12 (50%)	4/24 (17%)	4/12 (33%)	16/28 (57%)	5/13 (38%)	10/25 (40%)	8/32 (25%)	10/30 (33%)	11/16 (69%)	5/52 (10%)
N. Dusky Salamander	0/6 (0%)	0/0 (0%)	0/0 (0%)	0/10 (0%)	0/2 (0%)	0/7 (0%)	0/4 (0%)	0/7 (0%)	0/1 (0%)	0/1 (0%)	0/0 (0%)	0/1 (0%)	0/4 (0%)	0/9 (0%)	0/3 (0%)	0/9 (0%)	0/13 (0%)	0/17 (0%)	0/5 (0%)	0/12 (0%)
N. Two-lined Salamander	0/3 (0%)	0/2 (0%)	0/2 (0%)	0/3 (0%)	0/4 (0%)	0/6 (0%)	0/2 (0%)	1/2 (50%)	1/2 (50%)	1/8 (13%)	0/3 (0%)	0/7 (0%)	2/13 (15%)	3/15 (20%)	2/14 (14%)	1/9 (11%)	3/13 (23%)	1/8 (13%)	3/12 (25%)	0/13 (0%)
Spring Salamander	0/0 (0%)	0/1 (0%)	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/3 (0%)	0/0 (0%)	0/0 (0%)	0/3 (0%)	0/2 (0%)	0/2 (0%)	0/1 (0%)	0/4 (0%)	0/1 (0%)	0/2 (0%)	0/10 (0%)
Eastern Newt	13/30 (43%)	3/24 (13%)	1/22 (5%)	0/24 (0%)	0/13 (0%)	5/21 (24%)	6/18 (33%)	14/19 (74%)	0/5 (0%)	4/16 (25%)	4/13 (31%)	10/19 (53%)	4/25 (16%)	17/23 (74%)	9/15 (60%)	5/12 (42%)	5/14 (36%)	4/12 (33%)	11/26 (42%)	5/26 (19%)
E. Red-backed Salamander	0/24 (0%)	0/42 (0%)	2/40 (5%)	1/97 (1%)	0/27 (0%)	2/56 (4%)	0/25 (0%)	0/19 (0%)	0/24 (0%)	1/27 (4%)	1/55 (2%)	6/94 (6%)	1/94 (1%)	6/125 (5%)	0/113 (0%)	3/22 (2%)	9/224 (4%)	2/176 (1%)	2/97 (2%)	3/261 (1%)
Salamander group totals	16/88 (18%)	19/103 (18%)	3/81 (4%)	5/155 (3%)	0/66 (0%)	19/116 (16%)	12/70 (17%)	19/72 (26%)	6/42 (14%)	9/75 (12%)	11/83 (13%)	20/144 (14%)	11/151 (7%)	42/202 (21%)	16/160 (10%)	19/178 (11%)	25/300 (8%)	17/244 (7%)	27/158 (17%)	13/374 (3%)
Amphibian totals	108/270 (40%)	86/286 (30%)	55/217 (25%)	53/337 (16%)	67/274 (24%)	93/272 (34%)	57/198 (29%)	389/526 (74%)	68/155 (44%)	58/177 (33%)	80/197 (41%)	48/290 (17%)	41/249 (16%)	63/274 (23%)	50/295 (17%)	86/368 (23%)	103/562 (18%)	41/390 (11%)	40/226 (18%)	110/642 (17%)

[1] There were a total of 18 trappings in 1995, 17 in 1996, 12 in 1997, 18 in 1998, 17 in 1999, 16 in 2000, 14 in 2001, 16 in 2002, 15 in 2003, 16 in 2005, 16 in 2006, 15 in 2007, 14 in 2008, 15 in 2010, 15 in 2011, 17 in 2012, 17 in 2013, and 18 in 2014, 18 in 2016[4], 18 in 2017. Trappings counted were on those nights when at least 2 of the three traps were opened under appropriate weather conditions for amphibian movement. Data from 1993 and 1994 are not included in this chart as not all individuals were measured.

[2] For each species, individuals under a given total length were considered potential young of the year. The chosen length was based on the timing of their appearance, gaps in their size continuum, and records in the literature. The cutoff sizes used were *A. maculatum* (70 mm), *D. fuscus* (30 mm), *E. bislineata* (60 mm), *N. viridescens* (45 mm), *P. cinereus* (32 mm), *A. americanus* (23 mm), *H. versicolor* (26 mm), *P. crucifer* (20 mm), *L. clamitans* (44 mm), *L. palustris* (34 mm), and *L. sylvaticus* (27 mm). Young of the year for *G. porphyriticus* have external gills and are aquatic for up to 4 years. In addition, it was necessary to examine the minimum possible development time for each species. Individuals shorter than the cutoff lengths clearly overwinter (possibly as larvae for *N. viridescens* and *A. maculatum*) and show up in very early spring. These are not counted as young of the year.

[3] For three years we used dowels in half of the traps to reduce small mammal mortality. In order to compare those year's with other year's data, we converted all numbers to approximate non-dowel values. Using the preselected data sets, this was done by excluding all dowel captures, doubling captures in unimproved traps and adding snake trap data.

[4] April and May data were gathered in the spring of 2017.

Table 5. A comparison of young-of-the-year frogs from drift-fence data from 1995 through 2017 (no data were collected in 2004, 2009, and 2015) field seasons at Mt. Mansfield, Underhill, Vermont. Data used are from two fences at 1,200 ft. and one fence at 2,200 ft. in elevation.

Common Name	# young of the year/ total amphibians captured (% young of the year) 1,2,3,4																			
	95	96	97	98	99	00	01	02[3]	03[3]	05[3]	06	07	08	10	11	12	13	14	16[4]	17
Anurans (Frogs and Toads)																				
American Toad	25/27 (93%)	10/37 (27%)	6/30 (20%)	12/64 (19%)	2/35 (6%)	4/28 (14%)	6/22 (27%)	4/20 (20%)	3/19 (16%)	11/32 (34%)	12/24 (50%)	0/51 (0%)	0/26 (0%)	4/31 (13%)	1/26 (4%)	15/57 (26%)	1/93 (1%)	5/31 (16%)	0/27 (0%)	1/22 (5%)
Gray Treefrog	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/1 (0%)	0/0 (0%)	1/2 (50%)	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/7 (0%)	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/0 (0%)	0/0 (0%)	1/1 (100%)	0/0 (0%)	0/0 (0%)
Spring Peeper	3/39 (8%)	2/15 (13%)	2/4 (50%)	0/19 (0%)	0/9 (0%)	12/22 (0%)	0/0 (0%)	4/11 (36%)	2/6 (33%)	0/9 (0%)	0/7 (0%)	0/2 (0%)	0/0 (0%)	0/0 (0%)	0/15 (0%)	1/3 33%)	0/8 (0%)	0/6 (0%)	1/1 (100%)	4/32 (13%)
Green Frog	14/17 (82%)	4/10 (40%)	10/15 (67%)	9/14 (64%)	27/44 (61%)	42/53 (79%)	21/26 (81%)	340/350 (97%)	31/44 (70%)	28/36 (78%)	43/49 (88%)	6/12 (50%)	25/34 (74%)	11/12 (92%)	12/23 (52%)	46/70 (66%)	39/52 (75%)	3/13 (23%)	2/6 (33%)	7/10 (70%)
Pickerel Frog	19/20 (95%)	1/6 (17%)	0/3 (0%)	0/0 (0%)	0/9 (0%)	1/1 (100%)	4/4 (100%)	2/2 (100%)	0/0 (0%)	2/2 (100%)	1/1 (100%)	2/4 (50%)	1/3 (33%)	0/2 (0%)	0/3 (0%)	6/11 (55%)	0/8 (0%)	0/1 (0%)	0/3 (0%)	0/1 (0%)
Wood Frog	31/79 (39%)	50/115 (43%)	34/84 (40%)	27/84 (32%)	38/111 (34%)	14/50 (28%)	14/76 (18%)	19/76 (27%)	26/44 (59%)	8/23 (35%)	13/23 (39%)	20/70 (29%)	4/35 (11%)	6/27 (22%)	21/68 (31%)	02/52 (4%)	38/101 (38%)	16/95 (17%)	10/31 (32%)	85/203 (42%)
Frog group totals	92/182 (51%)	67/183 (37%)	52/136 (38%)	48/182 (26%)	67/208 (32%)	74/156 (47%)	45/128 (35%)	369/454 (81%)	62/113 (55%)	49/102 (48%)	69/114 (61%)	28/146 (20%)	30/98 (31%)	21/72 (29%)	34/135 (25%)	67/190 (35%)	78/262 (30%)	24/146 (16%)	13/68 (19%)	97/268 (36%)
Amphibian totals	108/270 (40%)	86/286 (30%)	55/217 (25%)	53/337 (16%)	67/274 (24%)	93/272 (34%)	57/198 (29%)	389/526 (74%)	68/155 (44%)	58/177 (33%)	80/197 (41%)	48/290 (17%)	41/249 (16%)	63/274 (23%)	50/295 (17%)	86/368 (23%)	103/562 (18%)	41/390 (11%)	40/226 (18%)	110/642 (17%)

[1] There were a total of 18 trappings in 1995, 17 in 1996, 12 in 1997, 18 in 1998, 17 in 1999, 16 in 2000, 14 in 2001, 16 in 2002, 15 in 2003, 16 in 2005, 16 in 2006, 15 in 2007, 14 in 2008, 15 in 2010, 15 in 2011, 17 in 2012, 17 in 2013, 18 in 2014, 18 in 2016[4], 18 in 2017. Trappings counted were on those nights when at least 2 of the three traps were opened under appropriate weather conditions for amphibian movement. Data from 1993 and 1994 are not included in this chart as not all individuals were measured.

[2] For each species, individuals under a given total length were considered potential young of the year. The chosen length was based on the timing of their appearance, gaps in their size continuum, and records in the literature. The cutoff sizes used were *A. maculatum* (70 mm), *D. fuscus* (30 mm), *E. bislineata* (60 mm), *N. viridescens* (45 mm), *P. cinereus* (32 mm), *A. americanus* (23 mm), *H. versicolor* (26 mm), *P. crucifer* (20 mm), *L. clamitans* (44 mm), *L. palustris* (34 mm), and *L. sylvaticus* (27 mm). Young of the year for *G. porphyriticus* have external gills and are aquatic for up to 4 years. In addition, it was necessary to examine the minimum possible development time for each species. Individuals shorter than the cutoff lengths clearly overwinter (possibly as larvae for *N. viridescens* and *A. maculatum*) and show up in very early spring. These are not counted as young of the year.

[3] For three years we used dowels in half of the traps to reduce small mammal mortality. In order to compare those year's with other year's data, we converted all numbers to approximate non-dowel values. Using the preselected data sets, this was done by excluding all dowel captures, doubling captures in unimproved traps and adding snake trap data.

[4]April and May data were gathered in the spring of 2017.