Amphibian & Reptile Monitoring

2000-2020

on the Lester and Monique Anderson Lands

in Lincoln, Vermont

Prepared for the

Colby Hill
Ecological Project

Prepared by

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Introduction

In the spring of 1999 Lester Anderson expressed an interest in establishing herpetological monitoring at selected sites on his property. Three types of monitoring were discussed: egg-mass counts of spring breeding amphibians, cover-board monitoring of woodland salamanders, and snake monitoring using artificial cover (slate). All these methods provide indices of different segments of the local herpetofaunal population. During the 1999 field season four ponds were selected for egg-mass monitoring and counts began. During the 2000 field season both the cover-board transects for salamanders and the snake-covers were put in place. Counts began along the cover-board transects in 2000. However, many of the snake-covers broke over the late fall and winter and needed to be replaced with thicker slates during the early fall of 2001 before counts began. The thicker slates have held up well with only two or three needing replacement each year since.

Beginning with the 2008 field season, egg-mass counts and salamander cover-board surveys were scheduled to alternate annually to reduce costs. Data updates are now produced every other year as well. During the 2008 season, cover-boards were not checked, egg-mass surveys took place, and a report was written. Despite our plans, due to funding limitations, only the snake-covers were checked during the 2009 field season and no report was written. In 2010 egg-masses were surveyed, salamander cover-boards were checked, and an update was written. In subsequent odd years we monitored only the snake-covers to keep them on an alternating-year-schedule. In even years, including 2020, we monitored egg-masses and salamander cover-boards. This report and the snake monitoring during the fall of 2021 will both be on the 2021 budget. The 2020 budget funded amphibian monitoring (egg-masses and salamander cover-boards) only. This alternation between amphibian monitoring and snake monitoring with a report is an effort to help minimize costs and keep the budget fairly stable from year to year. A day or two of maintenance is needed every year to replace rotten and broken covers, repaint marks, and trim vegetation. Our goal is to keep all artificial covers in use even on years when we are not checking them. Although annual monitoring would be ideal, we have fit our monitoring schedule to budget realities. Long-term monitoring is both rare and extremely valuable.

Egg-mass counts: Methods

Egg-mass counts take place at four ponds: Upper Fred Pierce (UFP), Lower Fred Pierce (LFP), Wells (WP), and Guthrie (GP). Upper Fred Pierce Pond is immediately across Colby Hill Road (east) from the Anderson residence. Lower Fred Pierce is roughly 100 m south of the residence across Colby Hill Road. Both of these ponds are found on the Fred Pierce tract. Guthrie Pond is immediately inside the gate off Guthrie Road on the Guthrie-Bancroft tract. Wells Pond is in a field roughly 50 m northwest of the Wells homestead on the Wells tract. Exact locations for these ponds are shown in the 2001 & 2002 reports.

Egg-mass counts at this site are designed to monitor egg-masses of two spring breeding species with very large and easily identified egg-masses: Wood Frogs (*Lithobates sylvaticus)* and Spotted Salamanders (*Ambystoma maculatum)*. The annual high count of egg-masses for each species is the index that over time can be used to show the relative size of the female breeding population at these sites (Corn and Livo, 1989). It is not intended to provide an estimate of the total population of either of these species only a convenient index of the number of breeding females. This is a variation of the breeding site survey recommended by Heyer et al. (1994). Adults and young of these and other species may be found during these counts and their presence and numbers are noted but these numbers are not intended to provide meaningful indices to those populations.

Since the egg-masses are visible for a few weeks after laying, the high count is very close to the total count in most years. These counts are not cumulative, nor do they have to be from the same day for different species. All surveys are performed under conditions that allow the viewer to see easily into the pond (limited wind, no rain, and adequate light from a high angle). Polarized glasses are sometimes helpful, and we wear them during most counts. The counts are designed to take place in habitats where Wood Frog and Spotted Salamander have been previously located and during or shortly after their breeding period. Egg-mass counts begin soon after the snow and ice melt and continue at weekly intervals until egg-laying activity ends or the total number of egg-masses is declining.

Egg-mass Counts: Basic species information

The Spotted Salamander is a large (~190 mm total length) heavy-bodied salamander that is widespread in Vermont in areas where mature hardwoods or mixed hardwoods and suitable breeding ponds occur, and migration is not obstructed. It is black with yellow spots and is largely fossorial (lives underground). It emerges from its woodland overwintering sites during the first warm rains of spring to migrate to its breeding pond. An adult female usually deposits from 2-4 egg masses within a few days and returns to its summer foraging territory. Larvae spend most of the summer in their natal ponds and usually metamorphose, leave their ponds, and return to the woods in the late summer. Spotted Salamander is a long-lived species with adults reaching over 20 years of age. Since the adults spend most of their lives underground, egg-masses are the most obvious evidence of its occurrence in an area.

The Wood Frog is a medium sized (60 mm) frog that is almost entirely terrestrial. It is easily recognized by its white upper lip and black mask on a mostly-solid brown background. It forages in the woodlands and only enters ponds in early spring to breed. Like Spotted Salamanders, Wood Frogs also deposit large and easily-identified egg-masses. It is referred to as an explosive breeder, in that most Wood Frogs using a given pond breed and lay eggs within the span of two weeks and then return to nearby woodlands. Tadpoles metamorphose and become terrestrial frogs by mid-to late summer in the same year they were laid. In contrast to the Spotted Salamander, Wood Frogs have a life expectancy of only 3-5 years. They are one of Vermont's freeze-tolerant anurans and overwinter in the leaf litter. A continuous layer of snow cover adds insulation and helps keep temperatures above the limits of its cellular antifreeze. It is widespread in Vermont as long as healthy woodlands and breeding ponds can be found and travel between the two is largely unobstructed.

Using data from the Vermont Reptile and Amphibian Atlas, Wood Frog egg masses have been seen as early as March 3 (2009) in Sunderland, in southwestern Vermont. The latest date recorded was June 21 (1995) when an egg mass was found in a small pond on Mt. Mansfield. The first egg masses of the season are usually reported from ponds and vernal pools in the lowlands of the Champlain Valley. They are generally found weeks later in the Green Mountain and Northern Vermont. The bulk of sightings in Vermont occur from the last week of March through May (Andrews 2021).

The earliest Spotted Salamander egg masses recorded and submitted to the Vermont Reptile and Amphibian Atlas was March 15 (2012) in Bridport, Vermont. Egg mass remnants have been found into the third week of July, and the latest egg mass with embryos still visible was photographed on July 21 (2016) in Glastonbury, Vermont (Andrews 2021).

Egg-mass Counts: Results and Discussion

In 2020, egg-mass counts were performed on eight dates at the four ponds that were selected for monitoring in 1999 (March 31, April 5, April 11, April 19, April 28, May 2, May 10, and May 16). All four ponds are man-made and fish-free with well-defined shorelines and within easy migration distance of hardwoods. Since all of these ponds are permanent or semi-permanent, they almost always hold some water even through dry years.

The results of counts performed in 2020 are shown in Tables 1-5 and Figures 1-7, additional details are in the Appendix. In 2020 the dates for the high counts of Wood Frogs were April 19 in all four ponds, with the first activity and masses seen on April 5 in all four ponds.

Table 1. Maximum counts of egg-masses in the Lower Fred Pierce Pond on the Lester and Monique Anderson lands in Lincoln from 1999 to 2020.

Lower Fred Pierce Pond	*Ambystoma maculatum*	*Lithobates sylvaticus*	Notes
1999 count dates: 5/5, 5/18	134	1	Early masses missed.
2000 count dates: 4/17, 4/29, 5/14	122	155	Timed well, early eggs of *L. sylvaticus* nonviable.
2001 count dates: 5/1, 5/7, 5/14, 5/21	178	101	Timed well, very dry spring.
2002 count dates: 4/23, 5/1, 5/10, 5/20	270	170	Timed well, irregular spring with late snow.
2003 count dates: 4/17, 4/25, 5/3, 5/9, 5/20	260	210	Timed well, cool spring, April drier than normal.
2004 count dates: 4/9, 4/15, 4/22, 4/29, 5/6, 5/12	166	228	Timed well.
2005 count dates: 4/13, 4/20, 4/26, 5/4, 5/11, 5/25	137	365	Timed well, went slightly later than normal.
2006 count dates: 4/14, 4/20, 4/27, 5/4, 5/11, 5/25	158	454	Timed well, went slightly later than normal.
2007 count dates: 4/4, 4/18, 4/25, 5/2, 5/17, 5/23, 5/30	181	554	Timed well – spring started late but went quickly.
2008 count dates: 4/9, 4/18, 4/23, 4/30, 5/7, 5/14, 5/21	251	392	Timed well.
2010 count dates: 4/2, 4/8, 4/15, 4/23, 4/30	216	237	Timed well – spring started early.
2012 count dates: 4/3,4/13, 4/18, 4/25, 5/2, 5/16	210	159	Two separate springs separated by a cold and dry spell.
2014 count dates: 4/9, 4/16, 4/23, 4/30, 5/7, 5/14	153	278	Timed well.
2016 count dates: 3/31, 4/7 4/14, 4/21, 4/27, 5/4, 5/11, 5/20	108	258	Longer than normal season.
2018 count dates: 4/11, 4/17, 4/24, 5/2, 5/10, 5/16, 5/24	176	286	Timed well
2020 count dates: 3/31,4/5,4/11, 4/19,4/28, 5/2, 5/10, 5/16	169	230	Timed well. *A. maculatum* high count May 16.

Table 2. Maximum counts of egg-masses in the Upper Fred Pierce Pond on the Lester and Monique Anderson lands in Lincoln from 1999 to 2020.

Upper Fred Pierce Pond	*Ambystoma maculatum*	*Lithobates sylvaticus*	Notes
1999 count dates: 5/5, 5/18	63	20	Early masses missed.
2000 count dates: 4/17, 4/29, 5/14	54	62	Timed well, early eggs of *L. sylvaticus* nonviable.
2001 count dates: 5/1, 5/7, 5/14, 5/21	72	66	Timed well, very dry spring.
2002 count dates: 4/23, 5/1, 5/10, 5/20	137	95	Timed well, cool spring, April drier than normal.
2003 count dates: 4/17, 4/25, 5/3, 5/9, 5/20	80	144	Timed well, cool spring, April drier than normal.
2004 count dates: 4/9, 4/15, 4/22, 4/29, 5/6, 5/12	92	71	Timed well.
2005 count dates: 4/13, 4/20, 4/26, 5/4, 5/11, 5/25	113	60	Timed well, went slightly later than normal.
2006 count dates: 4/14, 4/20, 4/27, 5/4, 5/11, 5/25	125	102	Timed well, went slightly later than normal.
2007 count dates: 4/4, 4/18, 4/25, 5/2, 5/17, 5/23, 5/30	115	107	Timed well – spring started late but went quickly.
2008 count dates: 4/9, 4/18, 4/23, 4/30, 5/7, 5/14, 5/21	77	63	Timed well.
2010 count date: 4/2, 4/8, 4/15, 4/23, 4/30	66	80	Timed well – spring started early.
2012 count dates: 4/2, 4/8, 4/15, 4/23, 4/30	52	91	Two separate springs separated by a cold and dry spell.
2014 count dates: 4/9, 4/16, 4/23, 4/30, 5/7, 5/14	75	114	Timed well.
2016 count dates: 3/31, 4/7 4/14, 4/21, 4/27, 5/4, 5/11, 5/20	60	61	Longer than normal season. *A. maculatum* high count May 20.
2018 count dates: 4/11, 4/17, 4/24, 5/2, 5/10, 5/16, 5/24	56	42	Timed well.
2020 count dates: 3/31,4/5,4/11, 4/19,4/28, 5/2, 5/10, 5/16	38	85	Timed well.

Table 3. Maximum counts of egg-masses at Guthrie Pond on the Lester and Monique Anderson lands in Lincoln from 1999 to 2020.

Guthrie Pond	*Ambystoma maculatum*	*Lithobates sylvaticus*	Notes
1999 count dates: 5/5, 5/18	50	5	Early masses missed.
2000 count dates: 4/17, 4/29, 5/14	138	538	Timed well, early eggs of *L. sylvaticus* nonviable.
2001 count dates: 5/1, 5/7, 5/14, 5/21	183	340	Timed well, very dry spring.
2002 count dates: 4/23, 5/1, 5/10, 5/20	121	133	Timed ok, may have missed high count for *L. sylvaticus* irregular spring late snow.
2003 count dates: 4/17, 4/25, 5/3, 5/9, 5/20	230	330	Timed well, cool spring, April drier than normal.
2004 count dates: 4/9, 4/15, 4/22, 4/29, 5/6, 5/12	96	450	Timed well.
2005 count dates: 4/13, 4/20, 4/26, 5/4, 5/11, 5/25	83	280	Timed well, went slightly later than normal.
2006 count dates: 4/14, 4/20, 4/27, 5/4, 5/11, 5/25	111	328	Timed well, went slightly later than normal.
2007 count dates: 4/4, 4/18, 4/25, 5/2, 5/17, 5/23, 5/30	118	427	Timed well – spring started late but went quickly.
2008 count dates: 4/9, 4/18, 4/23, 4/30, 5/7, 5/14, 5/21	128	221	Timed well.
2010 count dates: 4/2, 4/8, 4/15, 4/23, 4/30	225	270	Timed well – spring started early
2012 count dates: 4/2, 4/13, 4/18, 4/25, 5/2, 5/16	107	262	Two separate springs separated by a cold and dry spell.
2014 count dates: 4/9,4/16, 4/23, 4/30, 5/7, 5/14	220	625	Timed well, productive year.
2016 count dates: 3/31, 4/7 4/14, 4/21, 4/27, 5/4, 5/11, 5/20	149	465	Longer than normal season. *A. maculatum* high count May 20.
2018 count dates: 4/11, 4/17, 4/24, 5/2, 5/10, 5/16, 5/24	264	465	Timed well.
2020 count dates: 3/31,4/5,4/11, 4/19,4/28, 5/2, 5/10, 5/16	162	278	Timed well.

Table 4. Maximum counts of egg-masses in the Wells Pond on the Lester and Monique Anderson lands in Lincoln from 1999 to 2020.

Wells Pond	*Ambystoma maculatum*	*Lithobates sylvaticus*	Notes
1999 count dates: 5/5, 5/18	66	50	Early masses missed.
2000 count dates: 4/17, 4/29, 5/14	96	91	Timed well, early eggs of *L. sylvaticus* nonviable.
2001 count dates: 5/1, 5/7, 5/14, 5/21	111	80	Timed well, very dry spring.
2002 count dates: 4/23, 5/1, 5/10, 5/20	126	62	Timed well, irregular spring with late snow.
2003 count dates: 4/17, 4/25, 5/3, 5/9, 5/20	110	71	Timed well, cool spring, April drier than normal.
2004 count dates: 4/9, 4/15, 4/22, 4/29, 5/6, 5/12	110	59	Timed well.
2005 count dates: 4/13, 4/20, 4/26, 5/4, 5/11, 5/25	106	74	Timed well, went slightly later than normal.
2006 count dates: 4/14, 4/20, 4/27, 5/4, 5/11, 5/25	97	63	Timed well, went slightly later than normal.
2007 count dates: 4/4, 4/18, 4/25, 5/2, 5/17, 5/23, 5/30	120	53	Timed well – spring started late but went quickly.
2008 count dates: 4/9, 4/18, 4/23, 4/30, 5/7, 5/14, 5/21	114	36	Timed well.
2010 count dates: 4/2, 4/8, 4/15, 4/23, 4/30	153	76	Timed well – spring started early.
2012 count dates: 4/3, 4/13, 4/18, 4/25, 5/2, 5/16	101	61	Two separate springs separated by a cold and dry spell
2014 count dates: 4/9, 4/16, 4/23, 4/30, 5/7, 5/14	126	171	Timed well. Productive year.
2016 count dates: 3/31, 4/7 4/14, 4/21, 4/27, 5/4, 5/11, 5/20	172	100	Longer than normal season. *A. maculatum* high count May 20.
2018 count dates: 4/11, 4/17, 4/24, 5/2, 5/10, 5/16, 5/24	125	165	Timed well.
2020 count dates: 3/31,4/5,4/11, 4/19,4/28, 5/2, 5/10, 5/16	185	123	Timed well. *A. maculatum* high count May 16.

Table 5: Combined high counts of *Ambystoma maculatum* and *Lithobates sylvaticus* egg-masses for all ponds monitored on Lester Anderson lands in Lincoln, Vermont.

Lester Anderson Lands year and count dates	*Ambystoma maculatum* (combined)	*Ambystoma maculatum* (average)	*Lithobates sylvaticus* (combined)	*Lithobates sylvaticus* (average)
1999: 5/5, 5/18	313	78.3	Early	missed
2000: 4/17, 4/29, 5/14	410	102.5	846	211.5
2001: 5/1, 5/7, 5/14, 5/21	544	136.0	587	146.8
2002: 4/23, 5/1, 5/10, 5/20	654	163.5	460	115.0
2003: 4/17, 4/25, 5/3, 5/9, 5/20	680	170	755	188.8
2004: 4/9, 4/15, 4/22, 4/29, 5/6, 5/12	464	116.0	808	202.0
2005: 4/13, 4/20, 4/26, 5/4, 5/11, 5/25	439	109.8	779	194.8
2006: 4/14, 4/20, 4/25, 5/4, 5/11, 5/25	491	122.8	947	236.8
2007: 4/4, 4/18, 4/25, 5/2, 5/17, 5/23, 5/30	534	133.5	1141	285.3
2008: 4/9, 4/18, 4/23, 4/30, 5/7, 5/14, 5/21	570	142.5	723	180.8
2010: 4/2, 4/8, 4/15, 4/23, 4/30	660	165	663	165.8
2012: 4/3, 4/13, 4/18, 4/25, 5/2, 5/16	470	117.5	575	143.8
2014: 4/9, 4/16, 4/23, 4/30, 5/7, 5/14	574	143.5	1188	297
2016: 3/31, 4/7 4/14, 4/21, 4/27, 5/4, 5/11, 5/20	489	122.3	884	221
2018: 4/11, 4/17, 4/24, 5/2, 5/10, 5/16, 5/24	702	175.5	958	239.5
2020: 3/31,4/5,4/11, 4/19,4/28, 5/2, 5/10, 5/16	554	138.5	716	179
Average for all years	534	133.6	802	200.5

Figure 1. Egg-mass data from Lower Fred Pierce Pond on Lester Anderson lands in Lincoln, Vermont (2000-2020). In 2012, the Wood Frog egg-mass total was a combination of the high counts of both peaks (159).

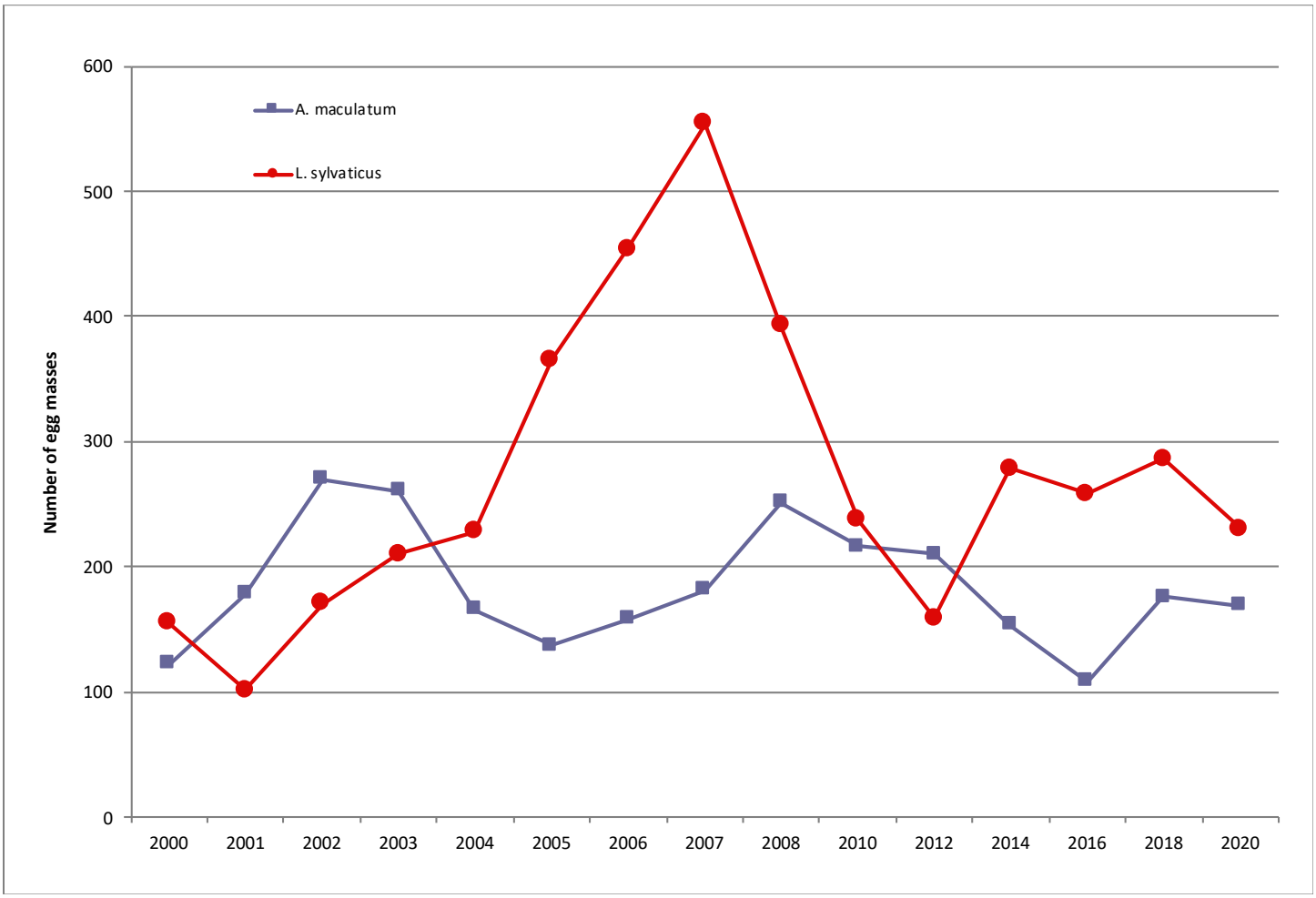


Figure 2. Egg-mass data from Upper Fred Pierce Pond on Lester Anderson lands in Lincoln, Vermont (2000-2020).

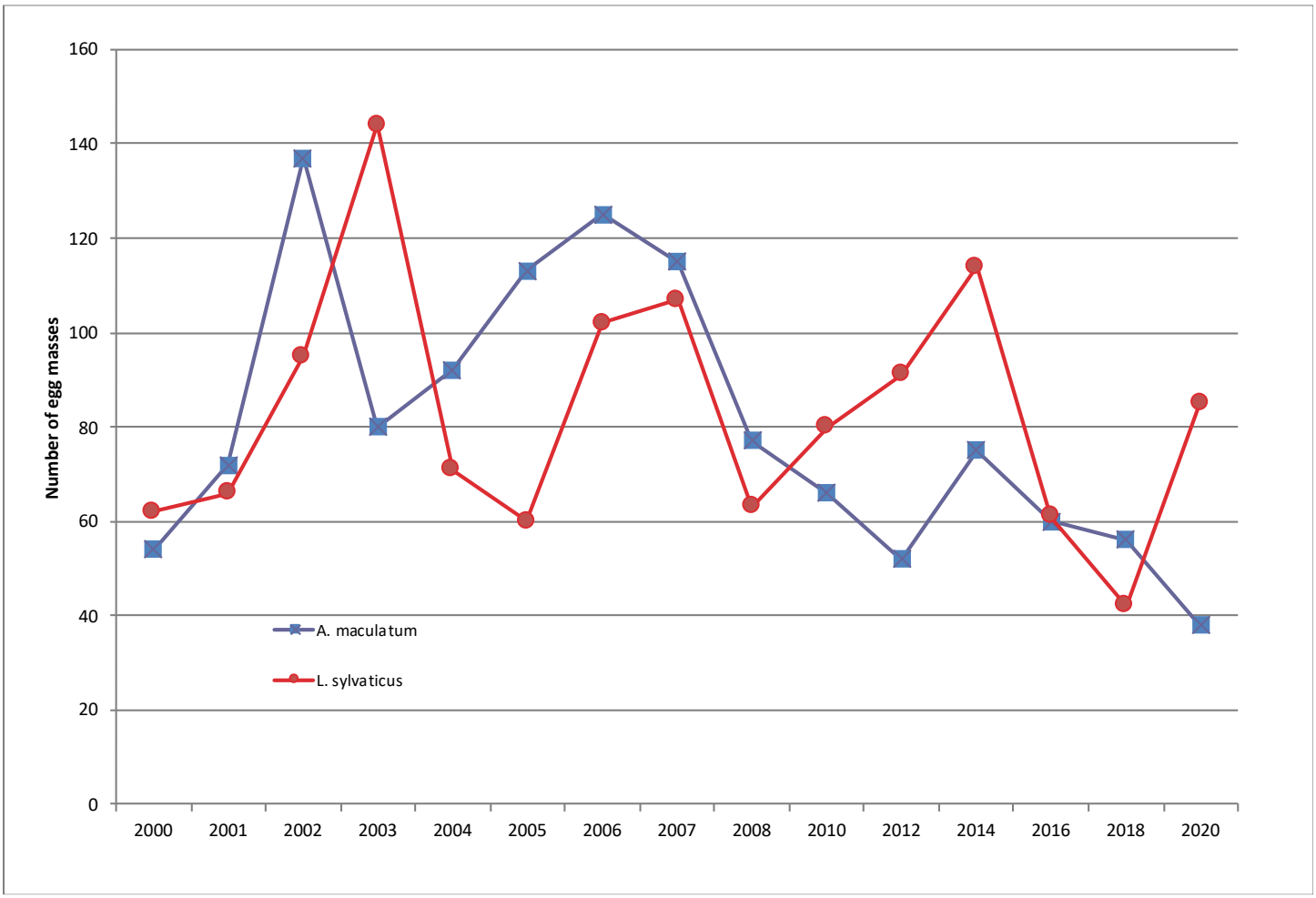


Figure 3. Egg-mass data from Guthrie Pond on Lester Anderson lands in Lincoln, Vermont (2000-2020). In 2012, the Wood Frog egg-mass total was a combination of the high counts of both peaks (262).

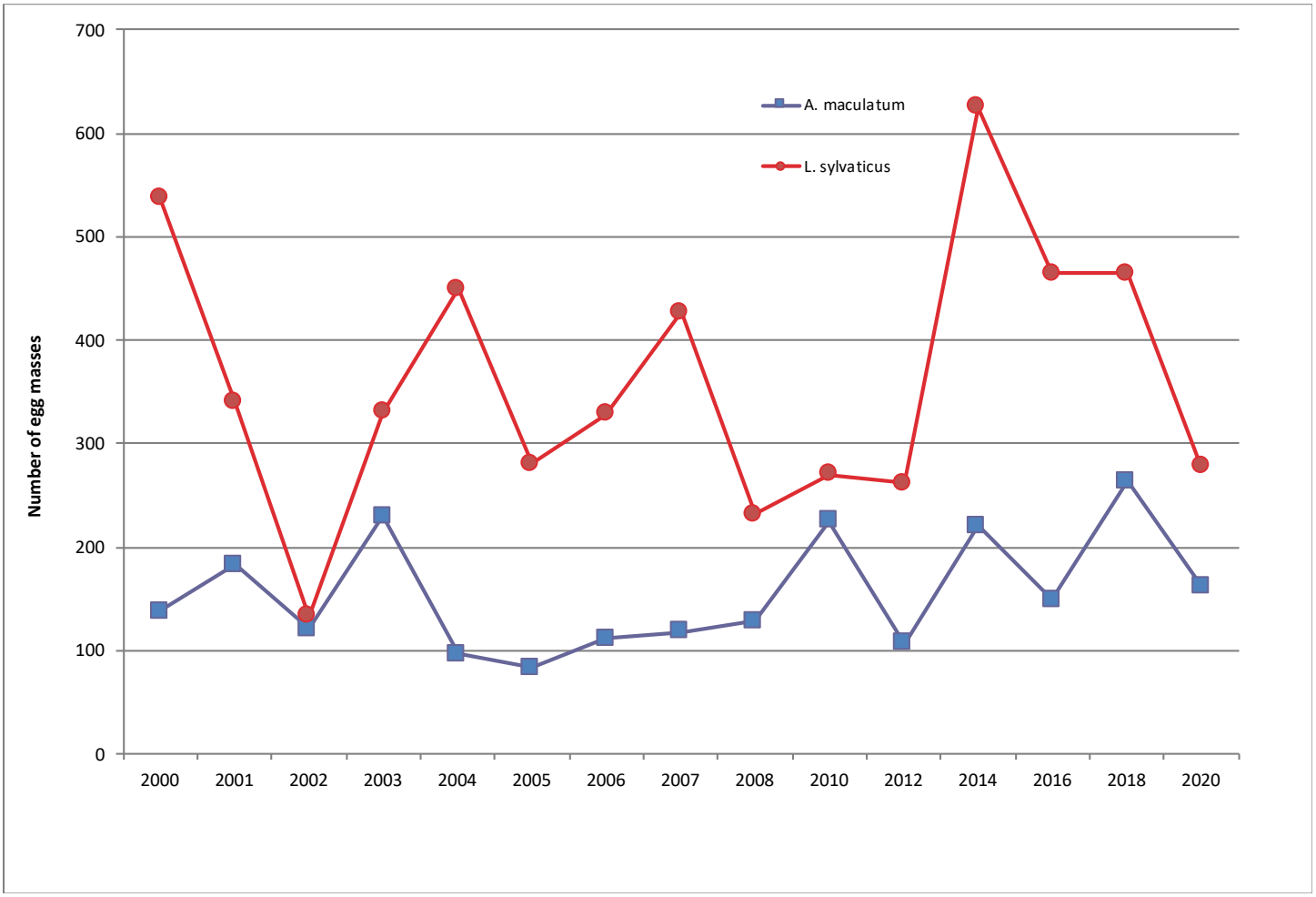


Figure 4. Egg-mass data from Wells Pond on Lester Anderson lands in Lincoln, Vermont (2000-2020). In 2012, the Wood Frog egg-mass total was a combination of the high counts of both peaks (63).

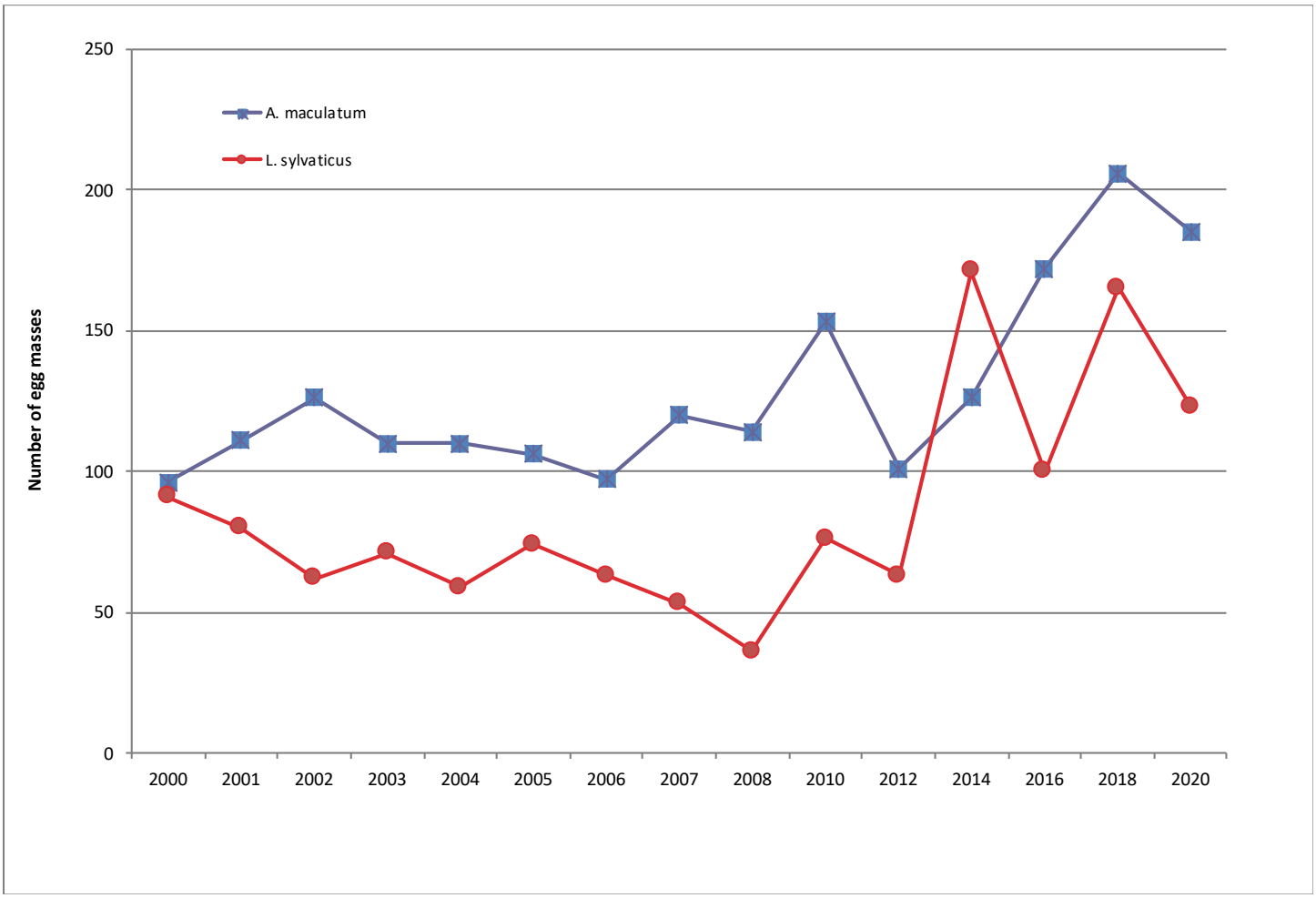
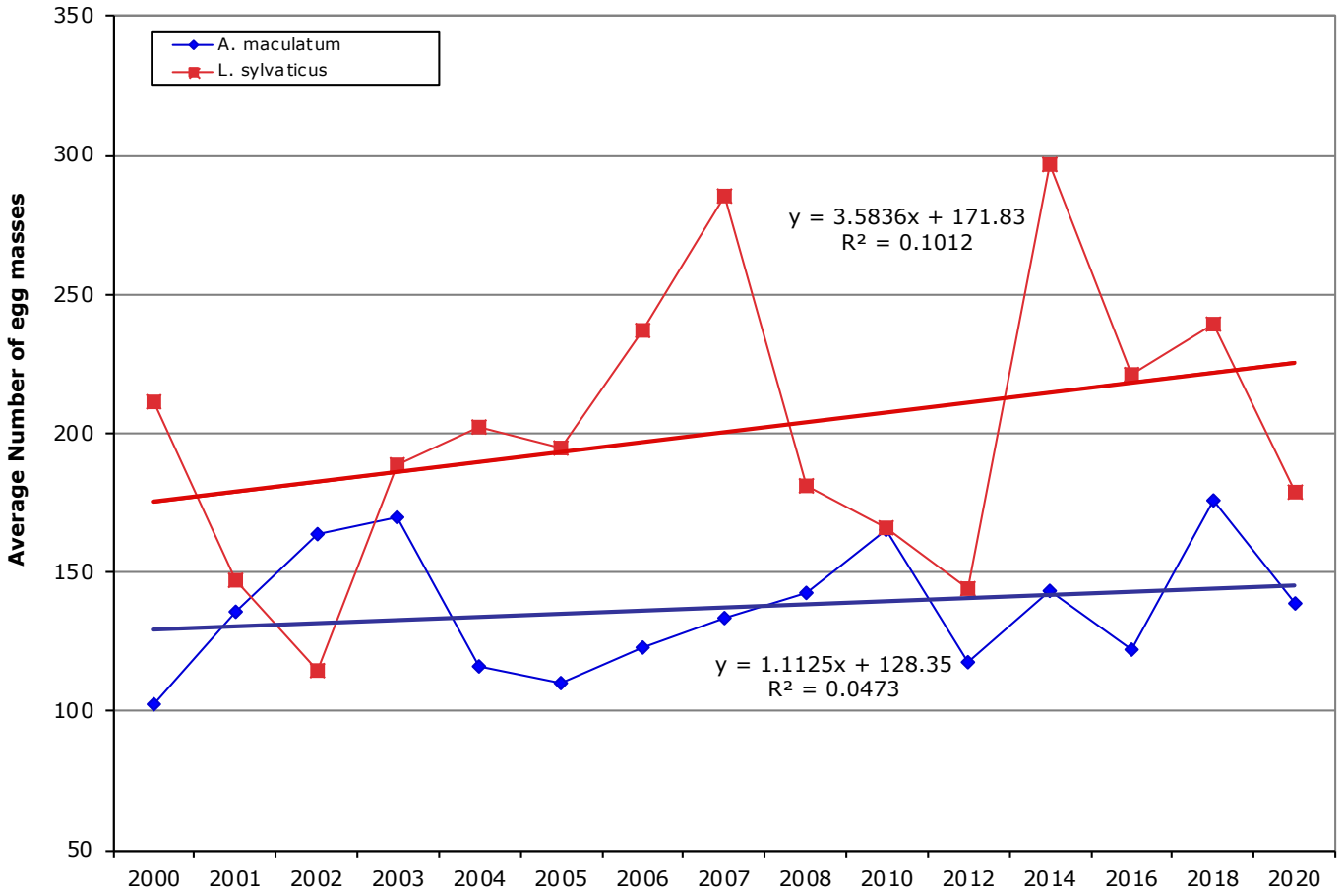


Figure 5: Average High Counts and trend lines for *A. maculatum* and *L. sylvaticus* egg-masses from all four ponds combined on the Lester Anderson Lands, Lincoln, Vermont (2000-2020).



Spotted Salamander

In 2020, the combined high counts of Spotted Salamander egg-masses from all ponds was 554 egg-masses, down from highest number we had recorded in 2018 of 702 (Table 5). At Lower Fred Pierce the number of egg-masses has fluctuated each year with a low detected in 2000 (122) and the high in 2002 with 270 (Figure 1, Table 1, and Appendix 1). At Upper Fred Pierce the numbers of egg-masses had been declining since 2006 to a low of 52 egg-masses found in 2012, the numbers remained fairly low in 2016 when 60 were detected and dropped even more in 2018 when 42 and this year when only 38 were detected. (Table 2, Figure 2, and Appendix Table 2. There was roadwork above the pond in early 2016 and David Brynn told us a fair amount of sediment went into the pond during that time. We have noticed, and reported on, the water looking murky and "dark", and a stick was often used to move vegetation to see farther into the water. At Guthrie we saw an increase in egg-masses between 2005 and 2010. In 2012 we saw a decrease from 225 to 107 egg-masses. Numbers of masses detected have gone up and down in recent years, a record high in 2018 of 264 while only 162 were detected this year (Figure 3, Table 3, and Appendix 3). There were a record number of Spotted Salamander egg-masses seen at Wells in 2016, when 172 masses were counted, fewer were seen in 2018 when 125 were detected, and this year we detected a new record number of 185 (Table 4, Figure 4, and Appendix 4). The combined high count and the average high count for all ponds can be seen in Table 5.

Annual variation in these numbers is to be expected and can be seen in Figures 1-5. Although there is year-to-year variation, it is not consistent from pond to pond. In Figure 5 egg-mass numbers for all ponds are combined and averaged. Throughout the entire duration of the study the number of egg-masses appears to cycle, increasing then decreasing every few years. Overall, the population of breeding females appears to show a gradual increase (Figure 5). We will be watching to see if the numbers cycle on a regular multi-year pattern. On average, Lower Fred Pierce Pond continues to be the most productive breeding location and Upper Fred Pierce the least productive.

According to Bishop (1941), breeding adult females lay from 2-4 egg-masses during their brief egg-laying period. Using an average of 3 masses per adult and the combined egg-mass numbers from Table 5, this suggests that in 1999 approximately 104 female Spotted Salamanders laid eggs in these ponds. These numbers increased to 227 females breeding in in 2003, dropped to a low of 146 in 2005 fluctuated each year, but have risen to a record high of 234 breeding females in 2018. Studies have shown that a small number of females breed every year, but most skip one or more years (Petranka 1998). Consequently, the group of females laying in any given year may well be entirely different from those laying the previous year. Unusual winter temperatures, droughts, predation, food availability, the number of foraging opportunities, energy storage, water levels, road work, and adjacent woodlot management are a few of the factors that either combined or individually could influence the number of females breeding in a given year.

Wood Frogs

The combined number of Wood Frog egg-masses fluctuates every year with our lowest count in 2002 (460) and our highest in 2014 (1188). We were slightly below average in 2020 with 716. As we have seen in the past, numbers of egg-masses per year fluctuate and therefore can potentially rebound or crash in a matter of just a couple years. The greatest numbers of Wood Frog egg-masses in 2020 were found in Guthrie with 278 masses detected (Figure 3, Table 3, and Appendix 3). Even with the relatively low numbers seen in 2020, trend lines for Wood Frog egg-masses show an increase for combined totals for all four ponds (Figure 5). In the past we have found Wood Frog egg masses at Upper Fred Pierce each year, but we rarely found many tadpoles. In 2018 we found more than 6500 tadpoles. We had been suspicious that the Eastern Newts were eating the tadpoles or the eggs, and/or that the Green Frogs were breaking up the egg masses. In 2018 large numbers of Green Frog tadpoles were not detected as they had been in recent years which could help explain the larger number of Wood Frog tadpoles. In 2020 we again found very few tadpoles at Upper Fred Pierce. A concerning note was that we also found no big clouds of tadpoles at either Guthrie or Lower Fred Pierce. On average, Guthrie is the most productive breeding location, and Upper Fred Pierce and Wells are the least productive for Wood Frogs.

Occasionally numerous male Wood frogs will attempt to mate with a single female. We found a drowned female, still with eggs, being clutched by four alive males in Guthrie on April 5 (see Appendix Photograph 2).

Weather and Climate

As we have now collected 15 years of data over a 21-year period we are able to look at long-term trends in timing for this site (Figures 6 and 7).

In Vermont, climate change has and will continue to affect the amount of precipitation, snow cover, length of winter, average temperatures, and intensity of storms (Gribkoff 2019). All of these will impact forest health, flooding and erosion, along with the distribution and abundance of native flora and fauna, pests, invasive species, and wildlife diseases (Dupigny-Giroux 2018, VT ANR Climate Change Adaptation Framework May 2013, Betts 2011).

Warmer late-winter and early-spring temperatures in the northeast have resulted in earlier leaf-out and blooming trends; it is predicted that the length of the freeze-free period will increase throughout the northeast (Dupigny-Giroux 2018). Less snowfall and fewer days with snow cover will have impacts on animals that spend winter underground especially in the subnivean layer (Dupigny-Giroux 2018). In Vermont, Spring has started 2-3 days earlier per decade, and the growing season has increased by 3.7 days per decade. Vermont's annual precipitation has increased by 1" per decade since 1941 (Galford 2014).

Specific changes, such as temperature, snowpack, and the amount and distribution of rainfall influence amphibians by altering the timing of breeding activities including seasonal migrations, calling, and egg laying (Arietta 2020, BeeBee 1995, Blaustein 2010, Todd 2010). Changes in reproductive timing and subsequent life-history events such as metamorphosis may alter ecological dynamics and community interactions.

The results we have seen in the four ponds on the Anderson Lands are not surprising based on some of these changes we are seeing on state and national levels. In the past 21 years, although the weather has varied from winter to winter (including two of the warmest winters and one of the coldest with large variations in snowfall) the overall effect of the changing climate appears when we look at the egg-mass trends over multiple years and decades.

During the 2020 season the first Wood Frog egg-masses were seen on April 5 (Guthrie, Upper Fred Pierce, and Lower Fred Pierce) and April 11 (Wells) (Appendix Tables 1-4). The high counts for Wood Frog egg-masses were on April 19 for all four ponds. The trend for first Wood Frog egg-masses over all is approximately 10-11 days earlier, or ½ day per year. It is possible that we missed some early egg-masses due to the timing of those first site visits. If we assume that to be the case, the peak egg-mass data are the safer and more conservative data. Those data show that peak numbers of egg masses have moved 2-3 days earlier over the last 17 years.

During the 2020 season the first Spotted Salamander egg-masses were seen on April 19 at all four ponds (Appendix Tables 1-4). The high counts for Spotted Salamander egg-masses were on May 2nd for Guthrie, May 10th at Upper Fred Pierce, and May 16th at Wells and Lower Fred Pierce. The trend for first Spotted Salamanders egg-masses over all is approximately 6-7 days earlier; although the peak egg-masses has remained virtually unchanged (Figure 7).

As mentioned above, the weather during the past few winters has varied a great deal and the last decade was the warmest in the historical record, with the greatest number of extreme precipitation events (Runkle et al. 2017). It is no surprise we are seeing annual fluctuations in the date we first see egg-masses. Still, as mentioned above, the long-term trends in timing are clear. Egg-masses are being deposited earlier (Figure 6). There are clear changes in the dates of first egg-masses deposited and average dates of high counts of egg-masses for both species. These show the earlier dates of spring arrival over the 21year study period (for Wood Frog). Since the Wood Frog responds most quickly to the arrival of spring breeding conditions and they move en masse to breeding sites, its response to the earlier spring conditions is most dramatic with the date of first-observed egg masses a full 10 days earlier and the dates of peak counts 2-3 days earlier. The Spotted Salamander timing reflects the same trend for the appearance of the first egg-masses, but more subtly.

These results are the first showing how climate change is affecting some of Vermont's amphibians.

Figure 6: First egg-masses detected and peak egg-masses (with trend lines) for *L. sylvaticus* across all four ponds on Lester Anderson Lands, Lincoln, Vermont (2000-2020).

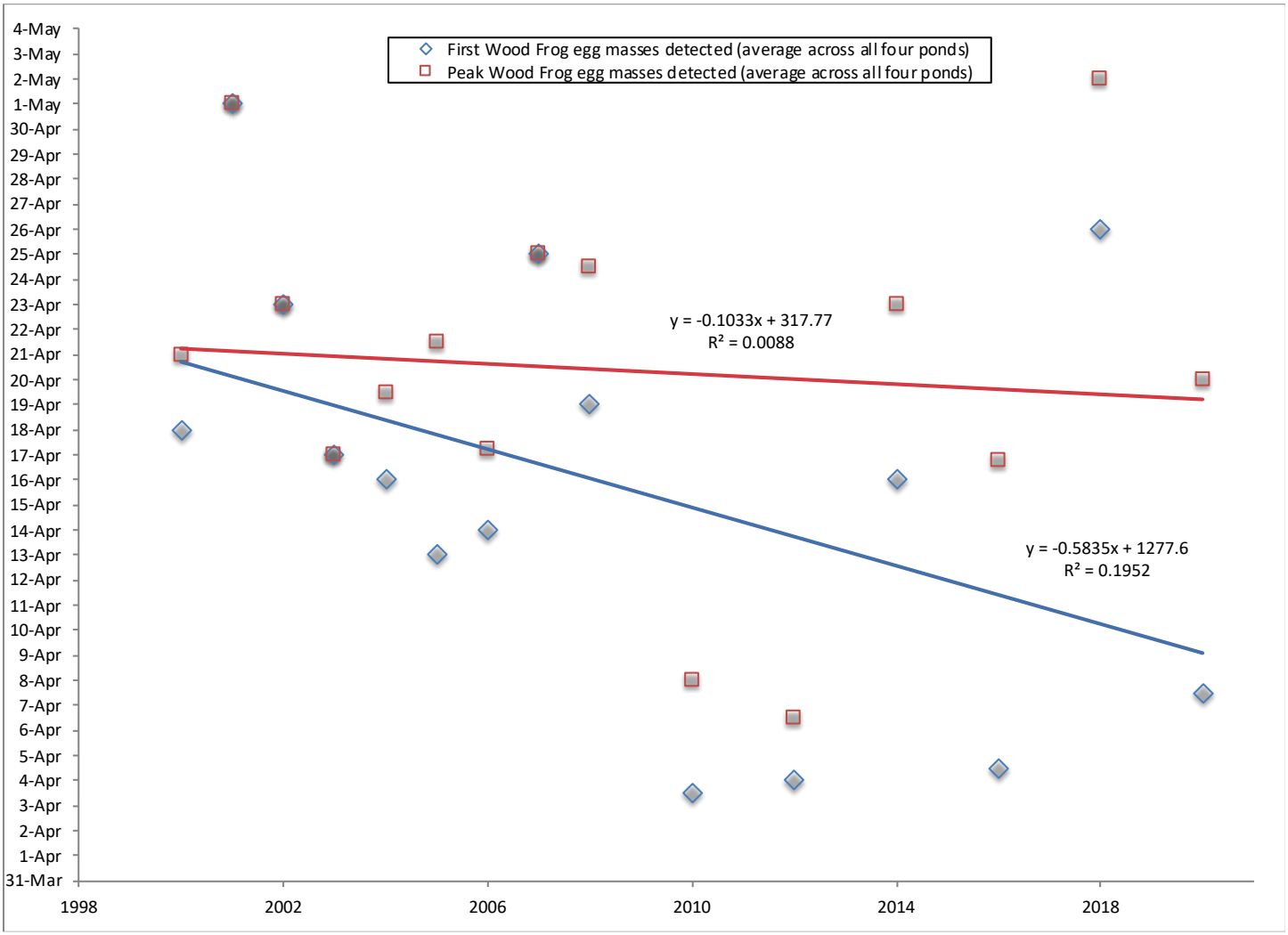
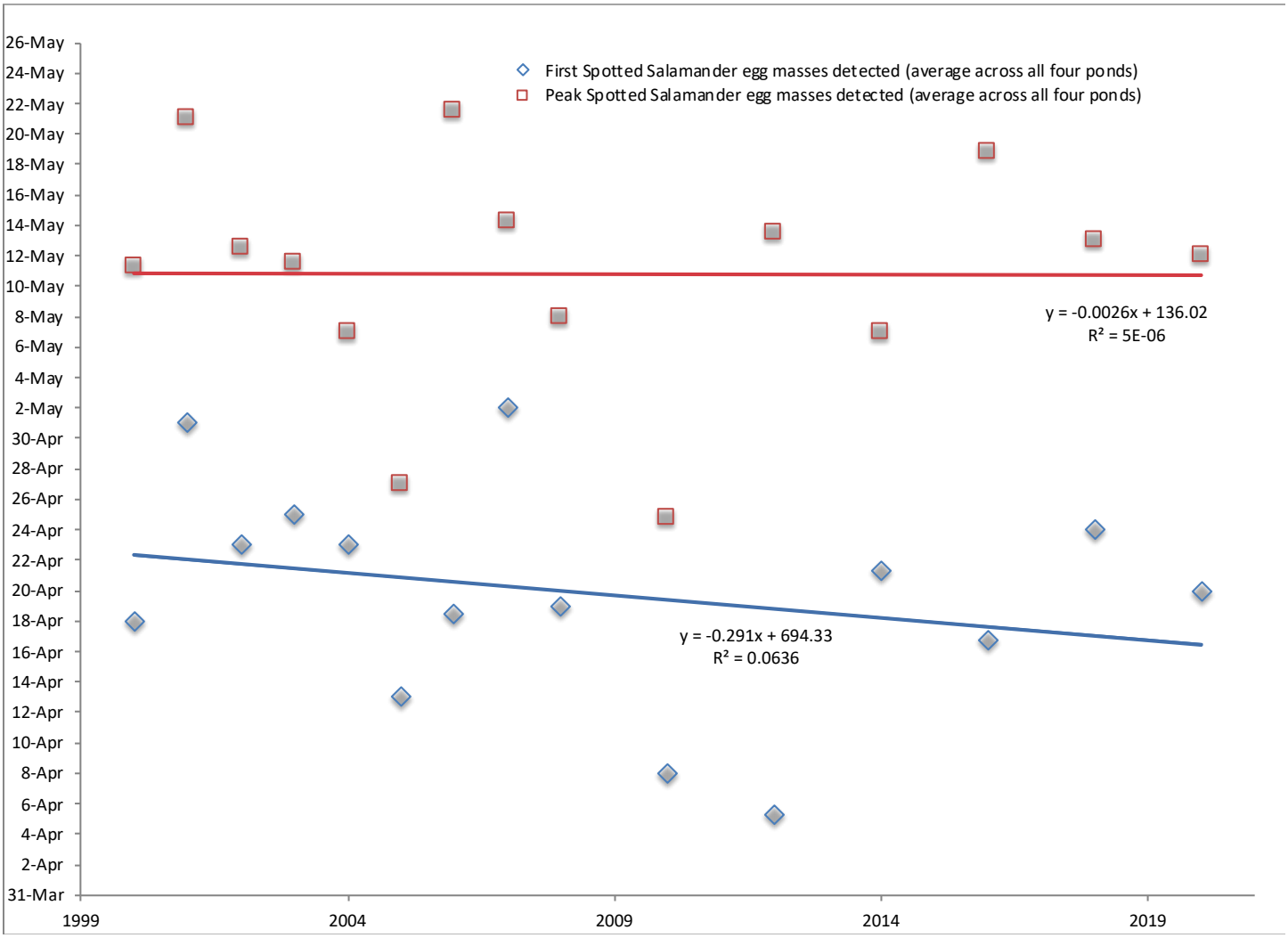


Figure 7: First egg-masses detected and peak egg-masses (with trend lines) for *A. maculatum* across all four ponds on Lester Anderson Lands, Lincoln, Vermont (1999-2020).



Egg-mass Counts: Summary

Our egg-mass indices taken from all sites combined suggest a slightly increasing number of female Wood Frogs over the course of our monitoring period; however, annual variation is great, and the trend could be reversed easily with a couple poor breeding years. Breeding female Spotted Salamander numbers appear fairly stable over the long term but may be increasing slightly.

These figures show the dates of first egg-mass counts and peak egg mass counts for both species are trending to an earlier date.

Notes on Other Species

During egg-mass counts we also found Eastern Newts (*Notophthalmus viridescens*) and Green Frogs (*Lithobates clamitans*) at all of the breeding ponds. Both of these common species spend their adult lives in or near permanent still water. Eastern Newts lay individual eggs attached to vegetation and Green Frogs lay egg-masses (surface films) during the summer, consequently they are not suitable for spring egg-mass monitoring. The Eastern Newts are voracious predators on the Wood Frog eggs. The Green Frog larvae scrape the algae off the Wood Frog eggs until the masses fall apart, and may even be eating the Wood Frog eggs (Montana 2019).

Birds seen or heard in the vicinity of the ponds during the 2020 egg-mass counts included; American Crow, American Goldfinch, American Kestrel, American Redstart, American Robin, Canada Geese (flying over), Baltimore Oriole, Barred Owl, Black-capped Chickadee, Black-throated Blue Warbler, Black-throated Green Warbler, Blue Jay, Broad-winged Hawk, Common Raven, Downy Woodpecker, Eastern Phoebe, Gray Catbird, Hermit Thrush, Least Flycatcher, Northern Flicker, Northern Parula, Ovenbird, Pileated Woodpecker, Purple Finch, Red-winged Blackbird, Red-breasted Nuthatch, Red-tailed Hawk, Ruffed Grouse, Song Sparrow, Yellow-bellied Sapsucker, and Yellow-rumped Warbler. We heard what sounded like a Fish Crow chasing a Raven on April 19 at Wells. Since we only occasionally recorded bird species we saw or heard near our survey sites, this is not a complete list of the birds on the property.

Other species recorded were bryozoans (in Wells), leeches (*Macrobdella decora)*, and a noticeable abundance of Black flies on May 16. We found blooming Marsh Marigold, and Horsetails were coming through the snow on May 10.

We had noticed Fairy Shrimp on April 14, 2016 at Guthrie (This was the first time we saw and/or recorded their presence at any of the survey ponds). We did not notice them in 2018 or in 2020, (nor did we focus a great deal of attention on looking for them).

Snake-covers: Methods

The snake-covers were initially an experiment, but they are working well. We are not aware of any other efforts to monitor snake populations using covers, though they are used as an inventory tool at other locations. We chose to use slate as a result of its ability to absorb the sun's rays and retain its heat as well as slate's permanence in ground contact. Through experience and informal communications with other herpetologists we have come to believe that the larger the piece of cover the better, but practical and aesthetic considerations led us to initially try old roofing slate. The largest used roofing slate that we could locate was 610 mm x 360 mm and 5 mm thick. With two of these slates we formed a sandwich with a small wooden spacer (~18 mm x ~22 mm x ~260 m) placed approximately ¼ of the way in from the outside edge to create a small space of varying height between the slates. We placed forty of these slate sandwiches along the upper margins of the Guthrie-Bancroft fields at a distance of roughly 2 m from the trees (see earlier reports for photos). We chose the upper margins of the fields to maximize the exposure to southern and western sun. The snake-covers were placed on the cut grass that already was in place. No additional cutting or clearing was done. During the late fall and winter of 2000-2001 most of the original snake-covers were broken. During the early fall of 2001, they were all replaced with thicker slate slabs that measured 560 x 360 mm and were 20-25 mm thick. Each year a few of these thicker covers are found to be broken and they are replaced, even if it is a year when monitoring does not occur. In addition, a few slates need to be remarked each year. We use white exterior latex paint for the numbers. Some of the new slates are slightly longer (610 mm x 360 x 20-25 mm thick) but otherwise identical. Five new sets of covers were added to the transect during the summer of 2008. These covers continue the transect on the north side of the stonewall and hedge row into the adjacent field to the north. This is an effort to determine if distance from the stonewall has an impact on the use of individual artificial covers. Data from the new covers (41-45) are not used for year-to-year monitoring comparisons.

Snakes often disperse widely during their foraging season; consequently, it was unknown whether forty pairs of artificial cover would attract enough snakes to provide useful data, however they seem to be working well. Conditions under the covers have changed from the first couple years as underlying vegetation dies, invertebrates colonize them, and small mammals begin to tunnel under them. In some places the woods began creeping into the field and/or branches reaching out and shading the covers. Initially the covers were approximately two meters from the woods. In 2007 we began an annual opening up of the cover array, including clearing brush that has moved into the field and cutting low branches that have shaded the covers. Sometimes ants completely fill the spaces between the covers with their nests. When this occurs, the spaces between the covers are cleaned out but the nests under the covers are left in place. If the ants persist in filling in the space between the covers, the pair of covers is moved slightly to one side of the ant nest.

We chose to monitor the slates in late summer and early fall, as it is after the young of the year have been produced and snake numbers are at their annual maximum. In addition, the cooler air temperatures of late summer and early fall should make the relative warmth of the slate more attractive. The snake-covers are checked once a week until the snakes den for the winter.

After a few years of monitoring we became aware that during the annual maintenance of the snake-covers in July, gravid female snakes (mostly Red-bellied Snakes, *Storeria occipitomaculata*) were using the covers. We believe they are using

the covers for incubation sites to help raise their body temperatures and speed development of their embryos. As a result, we have started to gather data while doing the summer maintenance. This provides data on clutch sizes, since the number of embryos within their bodies can be determined by palpation.

When a snake is found, we measure the snout to vent distance as well as the total body length. We record any unusual physical markings or injuries, and when we find Eastern Milksnakes (*Lampropeltis triangulum*) we record their patterns to allow us to distinguish individual snakes. In 2006 and 2007, in addition to length measurements we massed the majority of the snakes we found. We also keep records on where within the snake-cover the reptiles are found. Two locations are noted: between (between slate) and surface (between slate and ground).

We monitored the snake-covers during the fall of 2019, and we will monitor them again in the fall of 2021. We continue to follow our schedule such that in years when we monitor the snake-covers, the amphibians are not monitored. These are good years (to keep budgets even) to write summaries of our findings. The way the pattern has developed, the reports are written in the late winter/early spring of the year we monitor the snake-covers in the fall.

Snake-covers: Basic species information

When the **snake-covers** were placed, it was unknown which species of snake would be most attracted to them. During the fall of 2001 only Red-bellied Snake used the snake-covers. The Red-bellied Snake is a small, secretive, viviparous (giving live birth) snake of woodlands and woodland openings. Using data gathered in Vermont through 2006, an adult Red-bellied Snake has a median SVL of 195 mm and a median TBL of 240 mm (n=79). A neonate Red-bellied Snake in Vermont has a median SVL of 88 mm and a median TBL of 110.5 mm (n= 62) (Andrews, 2006). Using data gathered in Vermont through February 2013, the longest reported Red-bellied Snake was 330.2 mm (Andrews 2013). They are found throughout the state in small openings within forested areas (Andrews, 2013). They have a state rank of S5 and are the third most frequently reported species in the state. They have a brown, gray, or black dorsum (back) and a bright red venter (belly). Three light spots can be seen on the neck: one in the middle and one on each side. They are harmless to humans and quite docile. They feed primarily on slugs but will also eat other invertebrates (Mitchell, 1994). We have one record of a female Red-bellied Snake collected (legally) in Bridport, VT and brought into captivity. She then gave birth to 14 young on July 29. Determining the sexes of snakes can be difficult as there are no definitive external characteristics. Generally, the males have a longer tail relative to their total body length although there is often some overlap. Male Red-bellied Snakes generally have a tail length of 21-25% of their TBL while females generally have a tail length of 17-22% of their TBL (Ernst and Barbour 1989). The amount of taper in the tail in the first 8 caudal scale rows posterior to the vent is often a good indicator of gender with the female having a definite taper and males having almost no taper. However, even this indicator is not always clear. As we continue to collect more data and improve our techniques, we may be able to draw some conclusions regarding the sexual make-up of the snakes using the snake-covers.

Since 2001, three additional species have been located under the snake-covers: Common Gartersnake (*Thamnophis sirtalis*), Eastern Milksnake, and DeKay's Brownsnake (*Storeria dekayi*). As of 2020, Common Gartersnakes were the most frequently encountered snake during the fall season (490) using the covers with Red-bellied Snake second (290) and Eastern Milksnake a distant third (51). Dekay's Brownsnakes were only found during the summer maintenance period. However, relative numbers of each species vary from year to year.

The Common Gartersnake is the most common snake in the state (Andrews, 2021). They are widespread at all elevations and in a wide variety of habitats but are most abundant near a combination of water, small open areas, and exposed rock. Their primary food item is amphibians, but worms, insects, spiders, and other small invertebrates are also eaten. Male Common Gartersnakes mature in one to two years at an SVL of 360 mm – 390 mm, females usually mature in two to three years at an SVL of 420 mm to 550 mm. Litter sizes average 27 with a range from 1 to 101. Young Common Gartersnakes are born from mid-June to early November with most appearing in August and September. Neonates average 178 TBL (120mm – 278mm) and have a tendency to aggregate together (Ernst and Ernst, 2003).

The Eastern Milksnake is the second most frequently reported snake in Vermont, though this may in part be the result of its large size and its tendency to live near overgrown human dwellings, foundations, and barns. Eastern Milksnakes are oviparous (egg laying), smooth scaled, and eat a wide variety of prey including small mammals, birds, other snakes, and invertebrates. They often will shake their tails when irritated and are frequently confused with rattlesnakes as a result of

this behavior. The sex of the Eastern Milksnake is not possible to determine based on tail length because there is too much overlap between males and females (Ernst and Barbour 1989).

The DeKay's Brownsnake is a relatively common snake in the Lake Champlain Basin. it is often found in overgrown wet meadows and rocky forests. They are a relatively small snake, usually about a foot long. DeKay's Brownsnakes have keeled scales and give birth to live young in late summer (Andrews 2021).

Snake-covers: Results and Discussion

In 2019 snake-covers were checked ten times at weekly intervals starting on Sept. 4 with subsequent checks on Sept. 11, 18, and 25, Oct. 2, 9, 16, 23, and 30, and Nov 6 (Tables 6, 7, and 8). It is safe to assume that we have multiple captures of the same snakes over the course of the monitoring period. To evaluate population changes over time we generate an index of the annual population size for each species from a subset of our data. The index that we are using in Figures 8, 9, and 10 is simply the average number of snakes of each species seen on their three highest counts. If there were multiple days with the same number of captures the numbers of total captures and young of the year were averaged. No new species of snake were seen during the 2019 monitoring season; however, a DeKay's Brownsnake was seen in 2019 and 2020 while doing maintenance (see below).

In 2019 this index for Common Gartersnakes was 9.0, compared to previous year. In 2017 12 detected 12.34, the highest since 2006. In 2015 this index was 10.66 and in 2013 it was 2.67. Clearly, there is a great deal of fluctuation from year to year.

Red-bellied Snake had an index of 5.33 in 2009; by 2015 it had dropped to 0.66, the lowest during the span of this study, but rebounded slightly to 2.34 in 2017 and then 4.33 in 2019. There may be a multi-year cycle, that is starting to be seen as we collect more years of data. Anecdotally, we tend to see the high counts for Red-bellied Snakes later in the fall, late September and October. This may be because some overwinter in the ant colonies established below the covers and/or the result of an increased need for the heat provided by the slate as the temperature cools.

Similar to 2015 when we detected 7 distinct Eastern Milksnakes, in 2017 we again detected a relatively high number of Eastern Milksnakes (Table 8). The index calculated was 3.67, higher than Red-bellied for the second time in this study's history for that year. In 2019, the index calculated was 0.67, a drop from previous seasons. Three distinct individuals were seen, and one snake was seen twice (see Appendix Photograph 5 and 6).

We check our snake-covers in the fall so that we will be able to include the young of the year in our data. However, we have now discovered that young of the year numbers are the primary influence on our snake indices. Most of these young snakes will not survive their first year.

Fluctuations in snake numbers may be related to the amount or quality of incubating substrate (hay, compost, exposed rock), incubation temperatures, food availability, predators, overwintering mortality, disease or other factors. There may also be interactions between the species that we have not yet determined. Eastern Milksnakes have been known to eat both Red-bellied Snakes and Common Gartersnakes (Ernst and Ernst 2003).

Three Eastern Milksnakes were found using the covers during our 2019 maintenance visits on July 18 and August 1. For the first time a Dekay's Brownsnake was found, it was a female and 10 embryos were detected with palpitation. On Nov 6, 2019, our last day of weekly checks we found four young of the year Red-bellied Snake on the ground under 4 different coverboards. We wondered if they were going to over winter at that location. We went back on November 18, two were still visible, but very cold, under coverboard 23 (Table 9a). On Feb 3, 2020 we went back and checked Coverboard 23, but the snakes were not seen.

Seven Common Gartersnake, and eight Red-bellied Snakes were found using the covers during our 2020 maintenance visits on July 6, 2020. Snakes were measured and palpated, some of which had embryos (Table 9b). No Eastern Milksnakes were found at that time, but another Dekay's Brownsnake was found. The Dekay's Brownsnake was found under the same coverboard where it had been found in 2019 (#29), and had very similar measurements SV – 310 (TL – 381), and SV – 305 (TL – 380). Only two other Dekay's Brownsnakes have been reported from Lincoln, Vermont (Andrews 2021).

Three times during the fall of 2020 we randomly checked a few snake covers, while walking towards the salamander covers. During those incidental checking we found sixteen Common Gartersnakes, one Milksnake, and seven Red-bellied Snakes. Two Red-bellied Snakes found together showed the differing colors of their bellies and photos were taken. (See Table 9b and Appendix Photograph 3 and 4)

Since it appears that the snake covers are good thermal refugia for the Red-bellied Snakes in which the females can raise their body temperatures to optimal levels for internal incubation, the lack of gravid females in July could be a predictor for fewer captures in the fall.

Snake Fungal Disease

Snake fungal disease (SFD) caused by the fungus *Ophidiomyces* ophiodiicola in an emerging infectious disease with potentially serious implications for snakes in Vermont. SFD has been reported from Vermont and all surrounding states. Although it has the potential to impact numerous Vermont snake species, (Connelly and Fadden 2019), so far it has only been confirmed on Timber Rattlesnakes (*Crotalus horridus*) and Eastern Ratsnakes (*Pantherophis alleghaniensis*) in Vermont. During the 2019 maintenance, two Eastern Milksnakes were seen and photographed exhibiting possible SFD symptoms and an additional milksnake showing symptoms was seen during the regular season. See Appendix Photographs 7 and 8. This is cause for concern and may be worth taking samples, and extra precautions if SFD is found at this site.

Notes on Other Species

Some of the snake covers have small mammal tunnels under them. In addition, many invertebrates were found using the snake-covers. These are rarely identified to species and this is not a comprehensive list. However, in 2019 we noted red and black ants, slug eggs, Isabella Tiger moth caterpillars, Giant Leopard Moth caterpillars, black crickets, Harvestman, beetles, snails, millipedes, and a scorpion-like insect. We did see earthworms, including night crawlers, but did not notice any of the invasive jumping worms (*Amynthas agrestis, Amynthas tokioensis* and *Metaphire hilgendorfi*)

Additional invertebrates noted (not under the cover boards) were monarchs (July 18, 2019), and a black-legged tick found on a human.

We found a few additional amphibians and reptiles while cleaning and/or checking the snake covers in 2019 and 2020 including *L. clamitans* (heard), *P. crucifer* (heard), and *P. cinereus* (using covers 5 times).

It looks like a bear turned over a few covers on at least one occasion, and hunters stepped on some coverboards in November 2019.

We also detected multi-flora rose between cover boards 1 and 2, an invasive species like Buckthorn. Both European buckthorn and multi-flora rose should be carefully monitored and removed as resources allow.

Table 6. Fall 2019 snake-cover results from the Lester Anderson lands on the Bristol/Lincoln border in Vermont for the Common Gartersnake (*T. sirtalis*).

Date	*Species*	S-V length in mm	Total length in mm	Location Cover # - Cover Area	Physical Info
Sept. 4	*Thamnophis sirtalis*	155	195	#4 between	
Sept. 4	*Thamnophis sirtalis*	330	430	#16 between	
Sept. 4	*Thamnophis sirtalis*	155	190	#40 between	guessing female
Sept. 11	*Thamnophis sirtalis*	180	225	#2 between	young of year (YOY), eyes clear
Sept. 11	*Thamnophis sirtalis*	170	220	#1 ground,	young of year, cloudy eyes
Sept. 11	*Thamnophis sirtalis*	160	210	#6 ground,	young of year, cloudy eyes
Sept. 18	*Thamnophis sirtalis*	170	213	#1 ground	young of year
Sept. 18	*Thamnophis sirtalis*	180	228	#2 ground	young of year
Sept. 18	*Thamnophis sirtalis*	153	201	#3 ground	young of year
Sept. 18	*Thamnophis sirtalis*	385	513	#17 between	young of year
Sept. 18	*Thamnophis sirtalis*	140	182	#24 ground	young of year
Sept. 18	*Thamnophis sirtalis*	176	226	#24 ground	young of year?
Sept. 18	*Thamnophis sirtalis*	128	176	#25 ground	eyes a little cloudy
Sept. 18	*Thamnophis sirtalis*	140	179	#27 ground	eyes cloudy
Sept. 18	*Thamnophis sirtalis*	166	214	#36 ground	young of year?
Sept. 18	*Thamnophis sirtalis*	150	200	#36 ground	young of year
Sept. 18	*Thamnophis sirtalis*	152	192	#41 ground	young of year
Sept. 18	*Thamnophis sirtalis*	139	176	#43 ground	young of year
Sept. 18	*Thamnophis sirtalis*	161	206	#44 ground	young of year
Sept. 25	*Thamnophis sirtalis*	165	215	#3 ground	female, based on probe, YOY
Sept. 25	*Thamnophis sirtalis*	177	222	#3 ground	female, based on probe, YOY
Sept. 25	*Thamnophis sirtalis*	170	220	#3 ground	male, based on probe and palpation, YOY
Sept. 25	*Thamnophis sirtalis*	190	247	#24 ground	female, based on probe and palpation, YOY
Sept. 25	*Thamnophis sirtalis*	155	195	#36 ground	female, probed, YOY little scar on right side 2/3 of the way down
Sept. 25	*Thamnophis sirtalis*	157	203	#41 ground	female, based on probe and palpation, YOY
Sept. 25	*Thamnophis sirtalis*	170	215	#41 ground	male, based on probe and palpation, YOY
Oct. 2	*Thamnophis sirtalis*	175	222	#1 ground	
Oct. 2	*Thamnophis sirtalis*	175	225	#2 between	
Oct. 2	*Thamnophis sirtalis*	185	230	#40 between	
Oct. 2	*Thamnophis sirtalis*	160	205	#40 ground	
Oct. 2	*Thamnophis sirtalis*	195	250	#44 ground	
Oct. 9	*Thamnophis sirtalis*	180	230	#2 between	young of year
Oct. 9	*Thamnophis sirtalis*	175	223	#9 ground	young of year
Oct. 9	*Thamnophis sirtalis*	160	205	#26 between	young of year
Oct. 9	*Thamnophis sirtalis*	175	227	#28 between	young of year
Oct. 9	*Thamnophis sirtalis*	165	206	#35 ground	young of year
Oct. 9	*Thamnophis sirtalis*	165	205	#35 ground	young of year
Oct. 9	*Thamnophis sirtalis*	180	230	#6 between	young of year
Oct. 9	*Thamnophis sirtalis*	190	250	#12 between	young of year

Oct. 9	*Thamnophis sirtalis*	185	240	#20 between	young of year
Oct. 9	*Thamnophis sirtalis*	200	261	#37 between	young of year
Oct. 9	*Thamnophis sirtalis*	145	185	#40 ground	
Oct. 9	*Thamnophis sirtalis*	200	260	#44 ground	
Oct. 16	*Thamnophis sirtalis*	330	430	#23 between (in the crack right where the two slates meet)	female
Oct. 16	*Thamnophis sirtalis*	165	210	#23 ground	female, just ate, can feel food inside
Oct. 16	*Thamnophis sirtalis*	170	220	#24 ground	male, young of year
Oct. 16	*Thamnophis sirtalis*	160	210	#25 ground	male, young of year
Oct. 16	*Thamnophis sirtalis*	165	215	#29 ground	male, young of year
Oct. 16	*Thamnophis sirtalis*	195	255	#44 between	male
Oct. 23	*Thamnophis sirtalis*	190	245	#44 between	belly button still visible
Nov. 6	*Thamnophis sirtalis*	165	205	#9 ground	young of year, little injury on ventral side

Figure 8. Average *T. sirtalis* total captures and average *T. sirtalis* adult captures per highest three counts under snake-covers 1- 40 over entire season (2002-2019).

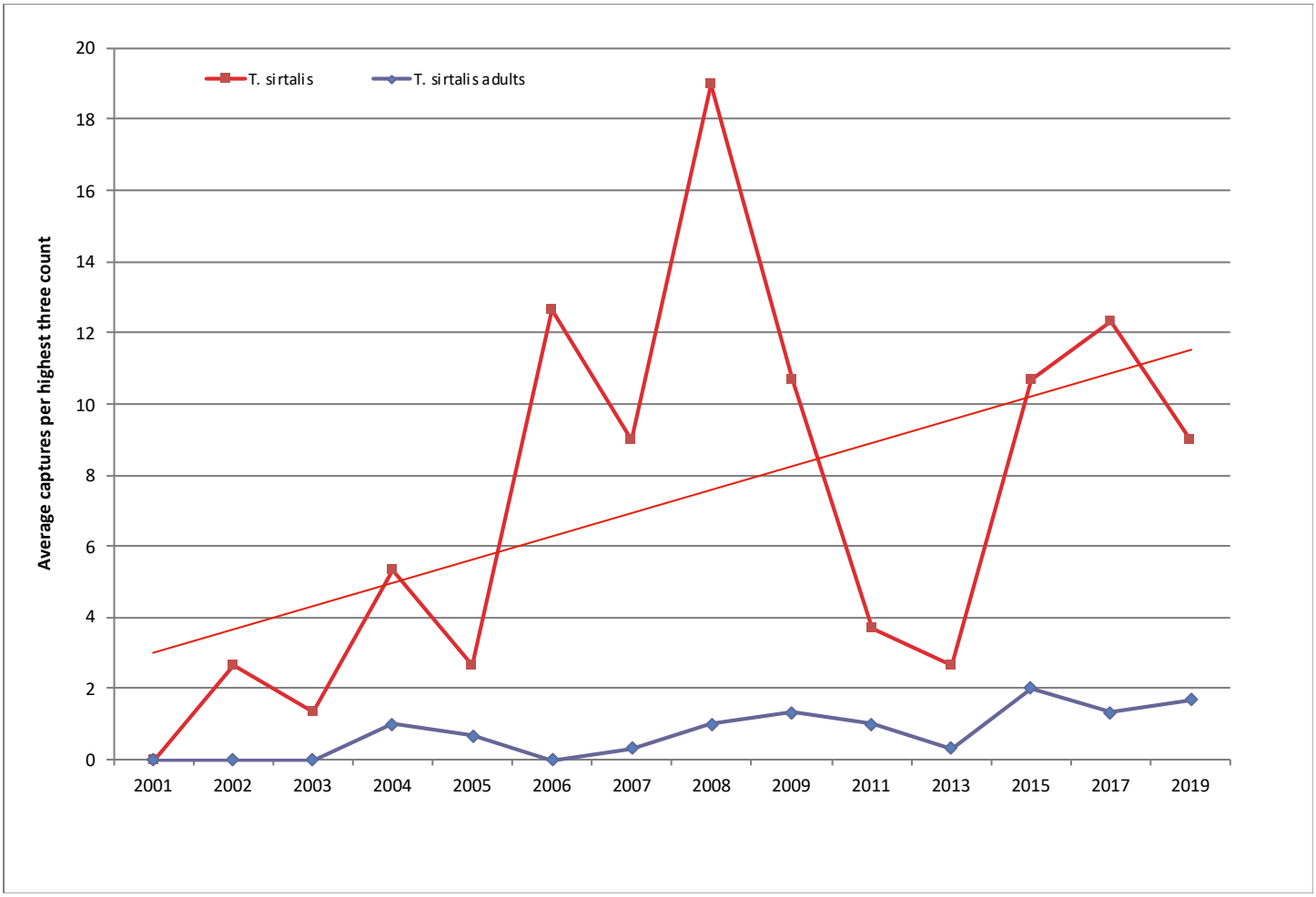


Table 7. Fall 2019 snake-cover results from the Lester Anderson lands on the Bristol/Lincoln border in Vermont for the Red-bellied Snake (*S. occipitomaculata*).

Date	Species	S-V length in mm	Total length in mm	Location Cover # - Cover Area	Mass and Physical Info
Sep. 4	*S. occipitomaculata*	205	255	#4 between	guessing female, felt food, but no babies
Oct. 9	*S. occipitomaculata*	230	285	#9 ground	adult
Oct. 9	*S. occipitomaculata*	85	108	#34 between	young of year
Oct. 9	*S. occipitomaculata*	225	281	#36 ground	
Oct. 9	*S. occipitomaculata*	75	95	#37 between	young of year
Oct. 16	*S. occipitomaculata*	73	98	#8, between	female, young of the year
Oct. 16	*S. occipitomaculata*	90	114	#21 ground	young of the year, unknown sex
Oct. 23	*S. occipitomaculata*	215	265	#8 between	female, adult
Oct. 23	*S. occipitomaculata*	75	95	#8 between	unknown sex, no hemi-penes detected, young of year
Oct. 23	*S. occipitomaculata*	75	92	#23 between	unknown sex, no hemi-penes detected, young of year
Oct. 23	*S. occipitomaculata*	68	90	#23 between, in crack between two slates	unknown sex, no hemi-penes detected, young of year
Oct. 23	*S. occipitomaculata*	75	95	#35 ground	unknown sex, no hemi-penes detected, young of year
Oct. 23	*S. occipitomaculata*			#44 ground	dead and being eaten by ants
Oct. 30	*S. occipitomaculata*	75	95	#23 between	young of year
Nov. 6	*S. occipitomaculata*	60	75	#9, ground	young of year
Nov. 6	*S. occipitomaculata*	70	95	#20, ground	young of year
Nov. 6	*S. occipitomaculata*	73	91	#23, ground	young of year
Nov. 6	*S. occipitomaculata*	70	90	#23, ground	young of year
Nov. 18	*S. occipitomaculata*	70	87	#23, ground	Temp of snakes 30.3 F before handling 29.9 ground under cover boards 29.1 F snake alive
Nov. 18	*S. occipitomaculata*	72	87	#23, ground	Temp of snakes 30.3 F before handling 29.9 ground under cover boards 29.1 F snake alive

Figure 9. Average *S. occipitomaculata* total captures and average *S. occipitomaculata* adult captures per highest three counts under snake-covers 1-40 over entire season (2001-2019).

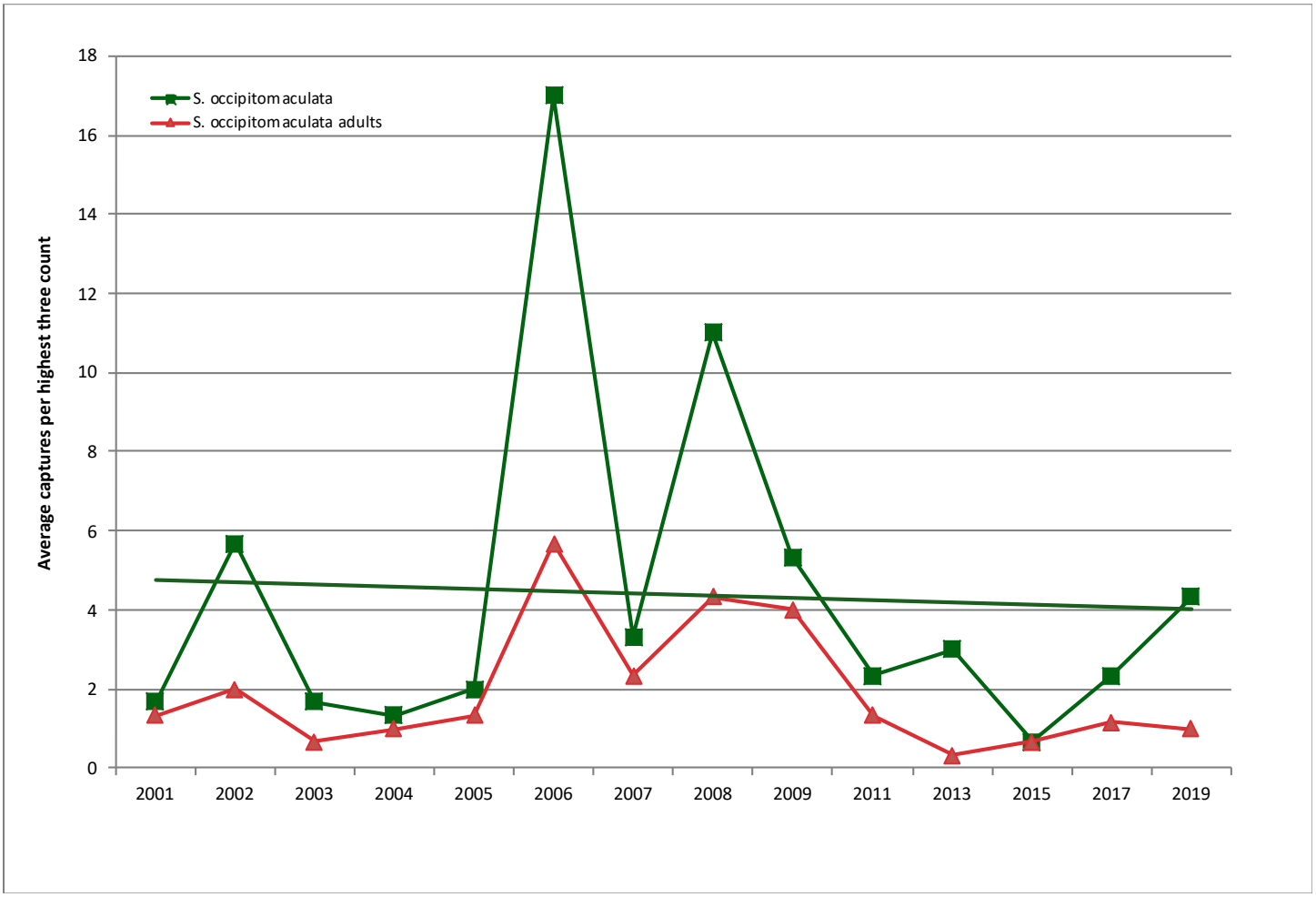


Table 8. Fall 2019 snake-cover results from the Lester Anderson lands on the Bristol/Lincoln border in Vermont for Milksnakes (*L. triangulum*).

Date	*Species*	S-V length in mm	Total length in mm	Location Cover # - Cover Area	Physical Info
Sep. 4	*L. triangulum*	435	590	#45 between	Guessing female, shedding a little necrosis on the underside (venter) U instead of Y, 2 is weird (sort of spot right connected to 4), 21 is Y right, 33 is a Y right, 37 is vent, 39 Y left, 40 Y right, 45 total
Sep. 11	*L. triangulum*	430	495	#23 between	The "Y" is chalice with an ice cube floating in, plus a white dot on right, 3 Y right, 5 Y left, 10 spot left, 16 Y right, 32 broken, 36 Y left, 37 vent, 42 Y left, 47 total Necrosis - tiny spot on bottom lip, scattered along ventral surface (Appendix Photograph 5 and 7)
Sep. 18	*L. triangulum*	840	960	Stone foundation	Complete Y, connects on left to little circle, 35 Y right, 36 vent (with injury) - 42 spot right, 48 total
Sep. 18	*L. triangulum*			Stone foundation	shed skin
Sep. 25	*L. triangulum*	425	495	#29 - between	Some necrosis along body and under lip. Chalice Y, broken on right top of Y, is U shaped. Dot in middle Y is "one-legged water boatman" and leg is on right side. Base of Y has a bulge. 3 is Y right, 5 Y left, 10 spot left, 36 Y left, 37 vent, 42 Y left, 47 total, eyes not cloudy (likely same one seen on Sept 11), (Appendix Photograph 6 and 8)

Figure 10. Average *L. triangulum* total captures and average *L. triangulum* adult captures per highest three counts under snake-covers 1-40 over entire season (2001-2019).

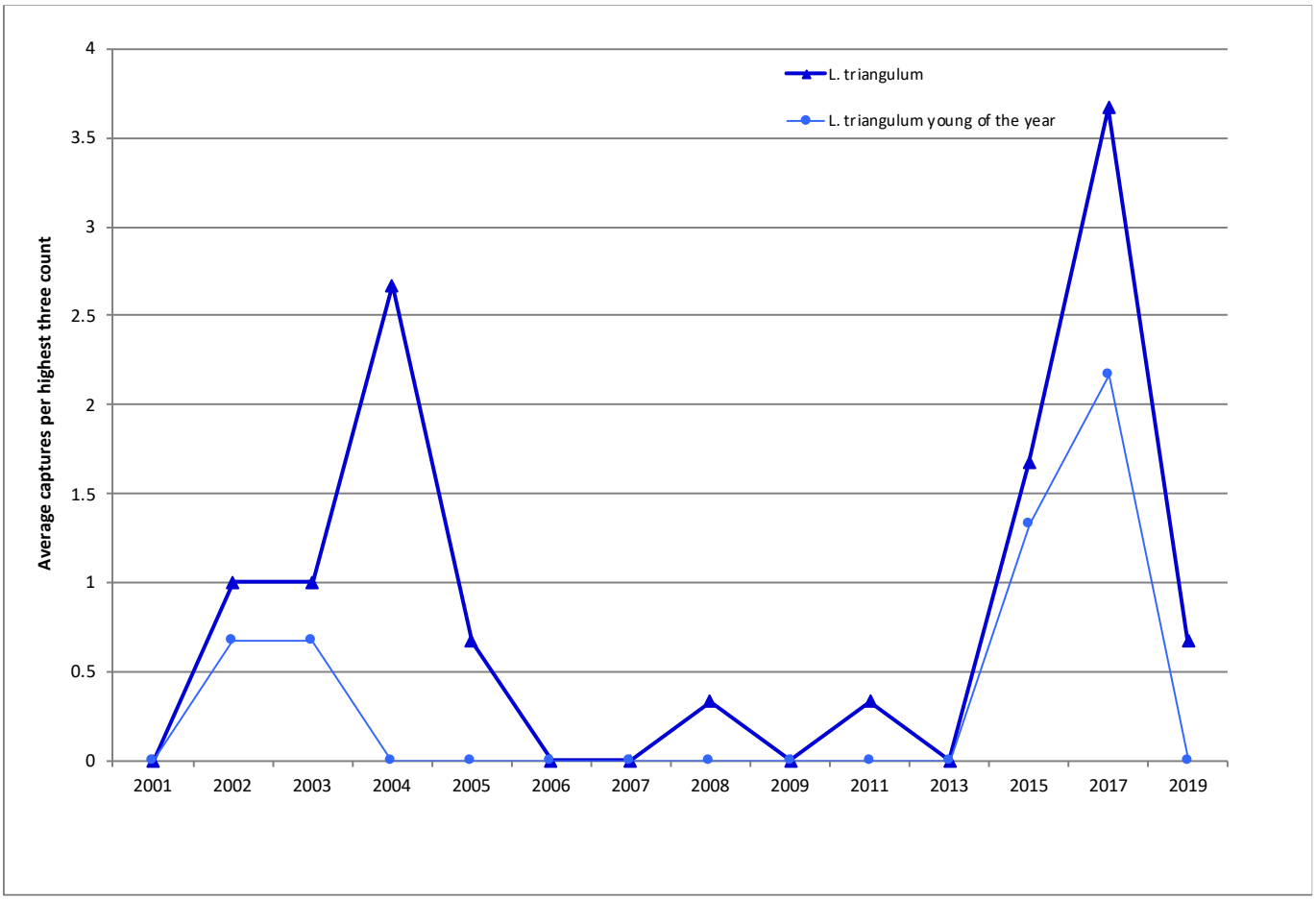


Table 9a. Accidental and unidentified snakes captured during the 2019 summer and fall in and around the snake-covers on the Lester Anderson lands on the Bristol/Lincoln border in Vermont.

Date	Species	S-V length in mm	Total length in mm	Location Cover # - Cover Area	Mass and Physical Info
Jul. 18	*L. triangulum*	270	310	#36	Cloudy eyes, Y on head connected to lighter color on head, 4 spot left, 8Y right, 23Y left, 25 Y right vent b/w 36 and 37, 41 Y left, 45 total, darker than usual Small spots of necrosis on lower job (possible SFD?)
Jul. 18	*L. triangulum*	430	496	#41	Cup shaped Y 5 spot right 19 spot right, 23 spot left and right, 28 spot left and right, 38 spot right, 44 spot right, 45 Y right, 42 left,, 43 vent, 48 spot left, 52 spot left, 53 spot right, about to shed. Small spots of necrosis on lower job (possible SFD?)
Aug. 1	*L. triangulum*			#38 ground	SFD? - looks worse on chin/bottom lip
Aug. 1	*S. dekayi*	310	381	#29 ground	10 embryos, pinkish on belly
Nov 18	*S. occipitomaculata*	72	87	#23 ground	Responded to touch but very slowly, young of year
Nov 18	*S. occipitomaculata*	70	87	#23 ground	Responded to touch but very slowly, young of year

Table 9b. Accidental and unidentified snakes captured during the 2020 summer and fall in and around the snake-cover from the Lester Anderson lands on the Bristol/Lincoln border in Vermont.

Date	Species	S-V length in mm	Total length in mm	Location Cover # - Cover Area	Mass and Physical Info
Feb 3	*Nothing found*			#23 coverboard	Checked to see if *S. occipitomaculata* was still there
July 6	*T. sirtalis*	250	328	#2 between	
July 6	*T. sirtalis*	240	308	#2 between	
July 6	*T. sirtalis*	250	330	#2 between	
July 6	*T. sirtalis*	235	295	#8 ground	
July 6	*T. sirtalis*	240	305	#23 between	5 embryos
July 6	*T. sirtalis*	280	345	#42 between	
July 6	*T. sirtalis*	385	520	#43 between	
July 6	*S. dekayi*	305	380	#29 ground	
July 6	*S. occipitomaculata*	140	170	#4 between	
July 6	*S. occipitomaculata*	190	135	#8 ground	3 embryos
July 6	*S. occipitomaculata*	195	245	#8 ground	5 embryos
July 6	*S. occipitomaculata*	200	250	#8 ground	6 embryos
July 6	*S. occipitomaculata*	185	230	#8 ground	9 embryos
July 6	*S. occipitomaculata*	110	135	#13 between	4 embryos
July 6	*S. occipitomaculata*	222	272	#23 between	8 embryos
July 6	*S. occipitomaculata*	250	300	#32 ground	4 embryos
Sept 9	*S. occipitomaculata*			unknown	2 snakes used in photo shoot
Sept. 16	*L. triangulum*			#22	YOY
Sept. 16	*T. sirtalis*			#22	YOY (4 snakes)
Sept. 16	*L. triangulum*			#22	YOY
Sept. 16	*L. triangulum*			#22	YOY
Sept 16	*T. sirtalis*			#42	YOY (4 snakes)
Sept 28	*T. sirtalis*			In either 1,2,3,4,5, or 6	2 snakes
Sept 28	*S. occipitomaculata*			#11 between	1 snake
Sept 28	*S. occipitomaculata*			#11 crack	4 snakes
Sept 28	*T. sirtalis*			#11 between	
Sept 28	*T. sirtalis*			#32 ground	
Sept 28	*T. sirtalis*			#43 between	
Sept 28	*T. sirtalis*			#43 ground	3 snakes
Sept 28	*S. occipitomaculata*			#42 between	

There are some cover boards along the transects that predictably have snakes, and others where we seem to rarely find snakes. To determine if this was indeed true, we plotted snakes by coverboards in two ways. Figure 11 is raw data of all snake captures/cover board. Figure 12 is total snake captures/years cover board has been part of transect.

Figure 11: Total Snakes detected per cover board for all covers (2001-2019). Coverboards 1 – 40 have been checked 14 times starting in 2001. Coverboards 41-45 have been checked 7 times starting in 2008.

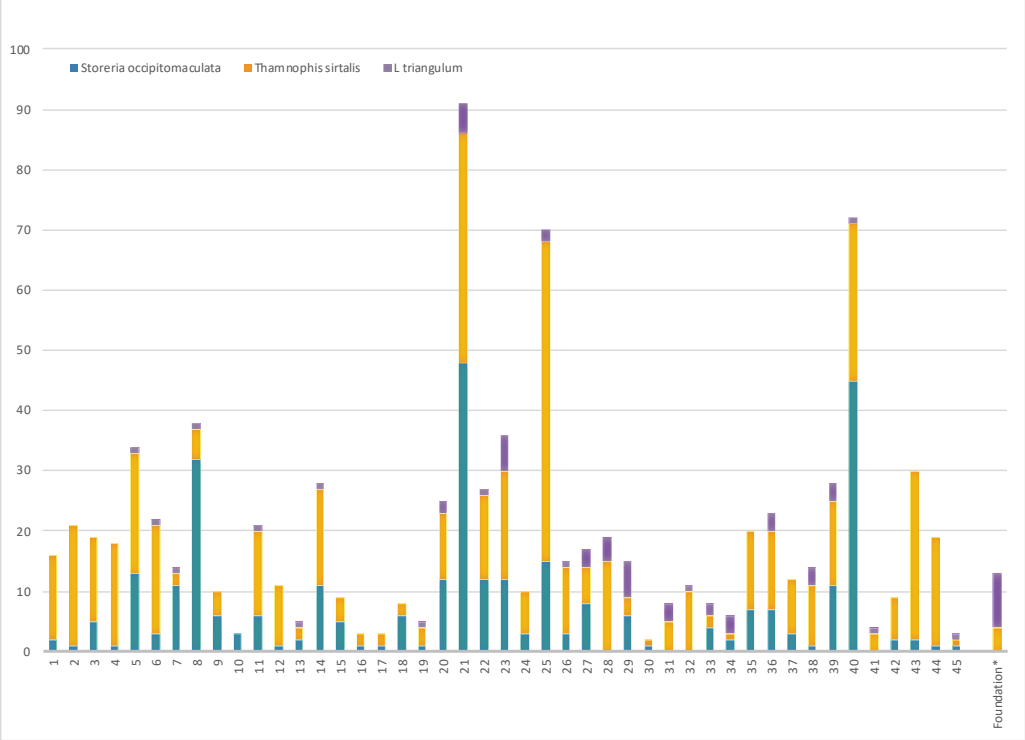
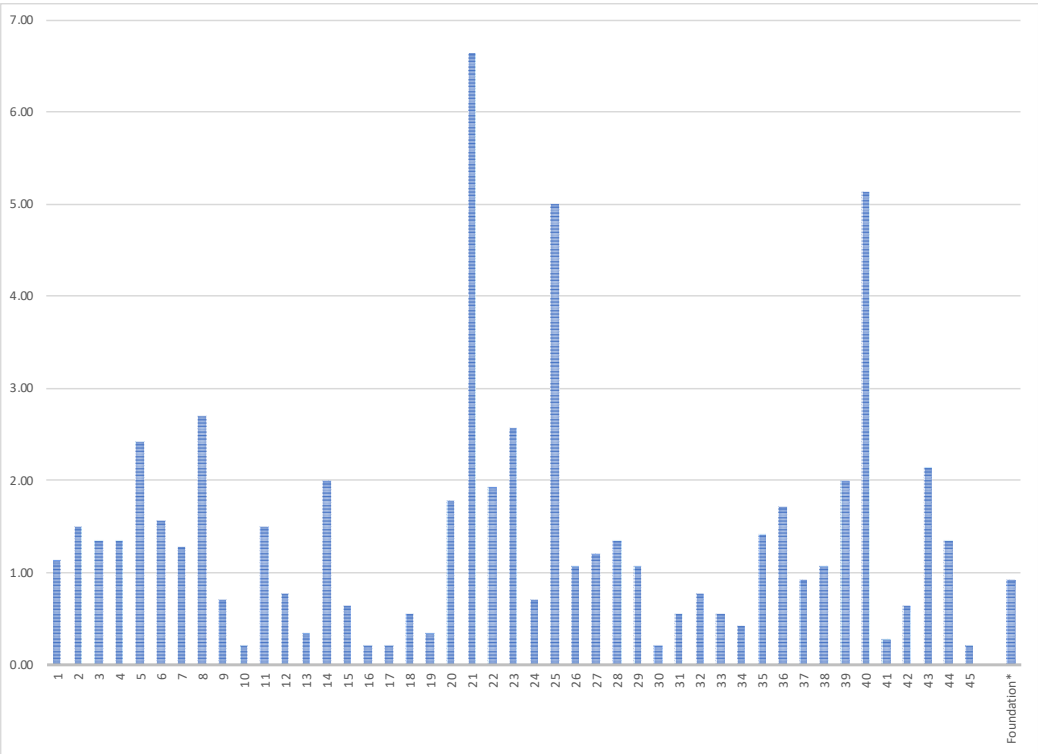


Figure 12: Total snakes divided by number of years coverboard has been checked. Coverboards 1 – 40 have been checked 14 times starting in 2001. Coverboards 41-45 have been checked 7 times starting in 2008.



Snake-covers: Summary

We have fourteen solid years of data from the snake-covers and we can begin to look at population trends for all three species. The number of average captures per highest three counts is trending downward for this species (Figure 9). Only two Red-bellied Snakes were detected during our survey period in 2015, but 11 were detected in 2017, and 18 were detected in 2019; although some may have been counted more than once (Table 7). On November 6, 2019, 4 individual young of the year were detected. Two of them were together under coverboard 23. We went back on Nov 18 and found both snakes still there (alive but cold). We returned again on Feb 3, 2020 and the snakes were no longer visible (Table 9b). They may have gone underground.

The numbers of young Common Gartersnakes had been overall increasing (with annual variation), although the numbers of surviving adults only showed very slight changes during the same time period (Figure 8). From 2008 through 2013 there was a period of steady decline of the total number of Common Gartersnakes. Then in 2015 and in 2017, a greater than average number of gartersnakes were captured, reversing the trend. In 2019, the numbers detected were lower than the previous two survey years, but considerably higher than the low seen in 2013, and the number of adults detected was the second highest since the study's inception.

Eastern Milksnakes continue to be very rare at the transect site at Guthrie; although more were found in 2015 and 2017 than had been seen during the previous decade. In 2019, we again detected very few, and no young of the year. Our snake indices are primarily influenced by young of the year numbers. Highly productive years result in very small increases in adult numbers. Most of these young snakes do not appear to survive their first year.

Cover-boards for salamanders: Methods

Three sets of cover-boards were constructed and put in place along the old wood road connecting the Guthrie-Bancroft fields with Rte. 17. This road starts near the Lincoln/Bristol border and continues into Bristol as you head northwest toward Route 17. It appears that all of the cover-boards; however, are within the town of Bristol. The first two sets each contain 15 pairs of cover-boards. Although it was our intention to have three sets of 15 pairs, the third set of cover-boards actually contained 16 pairs rather than the 15 that were intended. The extra set was left in place and the data are included. Exact locations of the three sets with UTM coordinates are shown in the 2001 report. These cover-boards were spaced based on North American Amphibian Monitoring Program (NAAMP) protocols with Canadian design covers (Craig et al., 1999) that have been shown to be highly successful in attracting salamanders. The structures (salamander condos) are built of four rough-cut white-oak boards that measure 305 mm x 152 mm (12" x 6") and two spacers. White oak was selected on the basis of its resistance to rot while in ground contact, however both boards and spacers have needed to be replaced at the rate of five or six per year as they gradually become saturated and rotten. Each condo consists of two boards side by side on the ground with a slight gap (~10 mm) left between them, so that they almost form a square 305 mm by 315 mm. The remaining two boards are placed on top of them and at right angles to them. In between the two layers of boards, along the outside edges, are two spacers (8 mm x 22 mm x 260 mm long), which are used to lift the outside edge of the upper two boards 8 mm and create a small gap of varying height for the salamanders. The pairs of structures were placed a minimum distance of 0.5 m apart based on NAAMP recommendations and each pair of condos was located a minimum distance of 6 m from the nearest pair. The three 15-pair transects are separated by distances of between 100 and 200 m. All organic matter was removed from under the condos so that they rested on the mineral layer. Herbaceous growth was removed from between the pairs and for a distance of ~50 cm in all directions and is kept free from the area. Forest litter is removed from the top of the condos but left between and around them. All condos are numbered with latex exterior paint (white). These numbers fade over the course of a year and are remarked as needed. The first set of 15 pairs consists of condos marked 1A and 1B through 15A and 15B. The second set consists of condos 16 A & B through 30 A & B, and the last set consists of condos 31 A & B through 46 A & B.

Records are kept on the specific condo in which amphibians are found. In addition, all amphibians found under the cover-boards are measured to provide information on age-class structure of the population using the boards. We measure both the snout to vent length (SVL) and the total body length (TBL) of the salamanders. However, the small salamander species that are being monitored using this method, sometimes lose all or a portion of their tails to predatory birds and small mammals. Consequently, the most reliable measure of size is their snout to vent length (SVL). Starting in 2006, in addition to taking length measurements we began measuring the mass of most of the salamanders as well. Kate Kelly has been part

of the data collection team since 2016. With her assistance we are able to look for the presence of eggs in a few of the salamanders (Appendix Photograph 9).

We also keep records on where within the salamander condos the amphibians are found. It is of interest to us in order to more effectively design future condos. Four locations have been noted: board (between boards), ground (between board and ground), crack (in the space between the boards) and adjacent (alongside the cover-boards). Salamanders found adjacent to the cover boards are not counted in our monitoring totals.

These counts are currently scheduled for every other year. Since the cover-boards have been very successful at attracting salamanders, we can obtain enough data and save time and money by only checking ½ of them during a given year. As described above, the covers are placed in pairs and both are labeled with the same numbers but different letters. During 2020 we checked only the A covers and left the B covers undisturbed.

Cover-boards for salamanders: Basic species information

Only one species of salamander is found often enough under the **cover-boards** to be monitored: Eastern Red-backed Salamander (*Plethodon cinereus)*. However, we have also found limited numbers of Northern Dusky Salamander, Spotted Salamander, Northern Two-lined Salamander, and Eastern Newt (*Notophthalmus viridescens*).

The Eastern Red-backed Salamander is a slender and small (40 mm) salamander that is Vermont's only fully terrestrial species of amphibian. Its most common color morph has a dark reddish-brown back with black sides and a salt and pepper (gray and white speckled) belly. Occasionally individuals are missing the red stripe on their backs and the entire salamander is a dark gray/brown color, this is referred to as a *lead* morph. Very occasionally the entire salamander is orange-red, this is called the *erythristic* morph. This species undergoes its larval stage and metamorphosis inside the egg. Eggs are laid in moist conditions inside a rotten log or in cavities in the soil as long as there is some solid object to suspend the egg-mass from. Consequently, it does not require open water at any life-stage and is dispersed widely in medium to mature hardwoods or mixed hardwoods regardless of the distance to the nearest water body. It is sensitive to soil pH, soil moisture, depth of leaf litter, and the structure and age of the woodlands in which it breeds. As a result, it is a good species to monitor as an indicator of forest health.

Cover-boards for salamanders: Results and Discussion

The cover-boards were not monitored during 2011, 2013, 2015, 2017, nor 2019 field seasons, but were checked in 2012, 2014, 2016, 2018, and 2020. Cover-boards are checked annually for maintenance purposes. At those times, the boards are renumbered and/or replaced as needed. In addition, brush and downed trees are cleared from around the cover-boards and along the access trail during the summer maintenance period, and if additional trees come down, during the fall.

Table 10. Summer 2013-2020 salamanders found during maintenance from the Lester Anderson lands on the Bristol/Lincoln border in Vermont.

Year	Day (s)	Eastern Red-backed Salamander	Northern Dusky Salamander	Eastern Newt
2013	July 31 and Aug 7	121	1	1
2014	July 10	158	1	2
2015	Aug 7 and Aug 27	88	3	
2016	Aug 2 and Aug 3	74	1	3
2017	July 19	63		3
2018	July 18 and July 27	83	1	6
2019	Aug 1	48		
2020	July 2	67		1

During summer maintenance the coverboards are not checked using our monitoring protocols, but even anecdotally the number of Eastern Red-backed Salamanders seen have been considerably lower since 2014.

In 2020 the cover-boards were checked on ten dates: Sept. 2, 8, 15, 22, and 29, Oct. 6, 14, 20, 22, and 27 (Table 11). As usual, we stopped the counts in the fall once we determined the number of salamanders seen each week was consistently

decreasing. As we have done previously, we only counted salamanders under one of each pair of cover-boards (the A cover-boards in 2020). This is the method we intend to continue since it produces plenty of salamanders for our purposes, saves both time and money, and reduces the stress on the animals.

The species found under the cover-boards are almost exclusively the Eastern Red-backed Salamander. However, Northern Dusky Salamanders were part of our count on one occasion in 2020. Overall, Northern Dusky Salamanders have been found under the cover-boards thirteen times during the regular monitoring and have been found eight times while performing maintenance. Over all monitoring years, they have been found on cover-board #10 (11 times), cover-board #11 (2 times), cover-board #12 (7 times), and cover-board #16 (one time).

This section of cover-boards (10-16) is in a particularly wet area and that is the habitat preferred by this species. Northern Dusky Salamanders are not known to travel more than a couple meters from their preferred habitat and that certainly appears to be shown here. Of course, individual Northern Dusky Salamanders may have been seen and counted on repeated visits.

In 2019 the high count for numbers of Eastern Red-backed Salamanders was 39 (Sept 2). For the last five years we have surveyed (2018, 2016, 2014, 2012, and 2010), the high counts have been: 41, 32, 50, 60, 63. To adjust for day-to-day variation caused by weather and seasonal differences we have developed an index to compare high counts from year to year. We have taken the highest three counts and averaged them. Results are shown in Figure 11. The high counts are often the first three counts in September, but occasionally include a count taken in October.

The highest count has been the first count in the fall on over 50% of the survey years. We had previously thought that since there is no obvious weather change of significance that corresponds with the drop-in numbers after the first check, the quick decline was possibly a result of disturbance. To check this, in 2003 and 2004 we checked all cover-boards on the first check, but only one half of the cover-boards on the following check, and every other subsequent check. Interestingly, the rate of decline was almost identical for those covers checked every two weeks and those checked every week. Apparently, checking at one- or two-week intervals did not have any impact on board use as a result of disturbance (Andrews and Talmage 2005). This is in accordance with the results published by Marsh and Goicochea (2003). They also found no difference between covers checked every week and covers checked every three weeks. It should be mentioned that although temperatures clearly drop as the fall progresses and these ectotherms need to descend to greater soil depths (or move to other locations) to keep from freezing, the decline in numbers under the boards begins before the decline in temperatures. Their original movement must be triggered by day length or some other factor other than temperature.

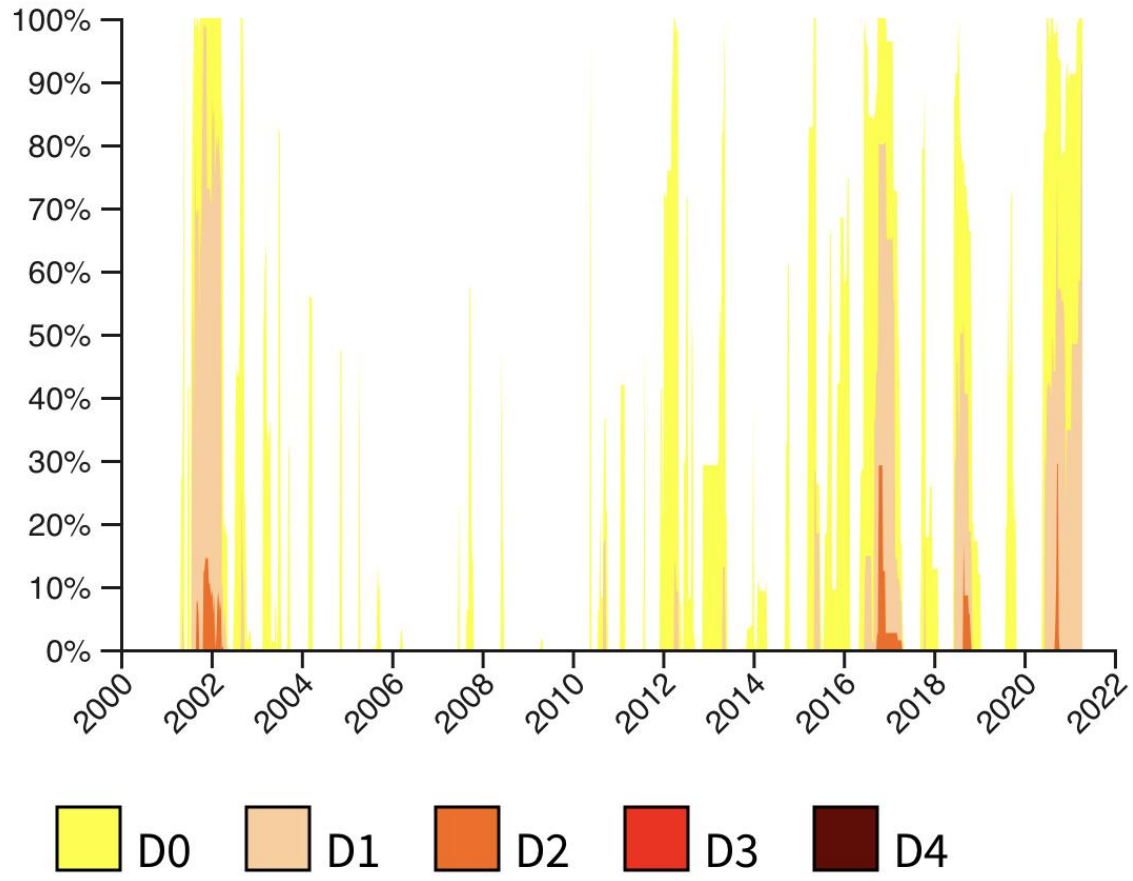
We have seen fall migrations of Eastern Red-backed Salamanders at other sites and this phenomenon was recently reported by Woolbright and Martin (2014). It appears this movement is from wetter substrates to upslope over wintering locations that are better drained. The better-drained locations probably allow the salamanders to descend below the depth of freeze without hitting the water table. This seasonal migration to more appropriate wintering locations may be part of the reason we see fewer salamanders as the fall progresses. Some of this movement may be almost entirely vertical as well, if the location already is sufficiently drained. Another possible explanation for declining numbers through the fall may be the result of the fact that Eastern Red-backed Salamanders start mating in the autumn and continue through the spring. One study found a population in NY started mating in the second week in October. Females have the ability to keep sperm in their cloacae through late April (Petranka 1998). Perhaps the high early-fall numbers are related to salamanders moving for mating purposes before disappearing underground for over wintering.

Based on Vermont data, juvenile Eastern Red-backed Salamanders are most often found from late July through November (Andrews 2021). This suggested to us, that the peak population size under the cover-boards should also be in the fall as opposed to the summer. In 2005 we tested this by doing additional counts in the summer. Counts were made on June 28 and August 3. As we had hypothesized, the high counts were in the early fall (Andrews and Talmage 2006). This may be something to look at again in the future as the numbers do appear to be consistently high when the cleaning is being done in the summer, and in 2014 and 2016 totals were higher than our high count (even when doubled) in the fall. It also would be interesting to do a count in mid-August when eggs, if in the vicinity, may have hatched. We did find four recently hatched young with an adult on September 3, 2014.

Cover-boards for salamanders: Population Indices

In 2014, although below average number of salamanders were detected, our index was still showing an increasing population. As shown in Figure 11, that no longer appears true. The fewest salamanders were detected in 2016, and although the numbers were slightly higher the last two years we surveyed, overall the trend is still showing a decrease in salamanders detected. Whether this is due to local forest management, other local factors, or is part of a larger regional trend due to weather or other conditions is not known. We would expect conditions to improve as hardwood forests age and produce increasing amounts of coarse woody debris. This debris provides moisture refugia, cover from predators, and egg-laying sites. The presence of the cover-boards themselves might bring about a temporary increase in population, but this would have to level off once the boards had been colonized. The record warm and dry winter of 2015-2016, followed by an extremely dry summer (about 10 inches below the mean precipitation) may have influenced the population. The drought may have influenced the population by reducing breeding opportunities, causing animals to move to wetter areas, or causing animals to move farther underground than our cover boards. Our most recent analysis of Eastern Red-backed Salamander numbers (through 2020) at our Mt. Mansfield monitoring site show that their population had also been increasing at that site, with considerable annual variation, including the lowest numbers detected in a decade in 2020 (Andrews and Talmage 2021). Monitoring at multiple sites allows us to make these comparisons. Long-term monitoring allows us to see if these changes are sustained or if multi-year cycles exist.

Figure 14: Percentage of Vermont experiencing drought from 2001-2021. (D0-abnormally dry, D1-moderate drought, D2 severe drought). Data from Drought.gov (accessed April 26, 2021)



It is important to note that individuals are not marked, and the total number of salamanders caught is not known. The same individuals may well have been counted on more than one date. However, for purposes of comparison from year to year we do not need to know the number of individuals. We can compare averages, high counts, and size-class information from the high-count days (Figures 11 and 12, and Tables 11, 12, and 13). As mentioned in earlier reports, Caitlin Corey's results

suggest that there is an upper limit to the number of adults that we can theoretically find under the boards, since adults using the cover-boards may exclude same-sex adults (Corey, 2002). Although we see annual variation, the average for the top three counts has shown variation since it peaked in 2006 (Figure 11), perhaps we have reached this upper limit. Corey's results also suggest that there is possible predation upon younger juveniles; therefore, the age-class data generated by the cover-boards may not be representative of those in the larger populations. It is still important data to collect. In theory, once we reach the upper limit, the age class distribution under the cover-boards would remain relatively stable. We are now able to begin to look at this question (Tables 11, 12, and 13 and Figure 12). It appears that the age class structure is fairly similar when comparing 2020 results with 2018 results (Figure 12). It will be interesting to see if this continues, and if Corey's hypotheses are correct.

As we continue to gather data, we are able to learn more about the Eastern Red-backed Salamander's population on this portion of the Anderson Lands and also its general natural history, including but not limited to, size and mass information (Figure 13 and 14). In 2016 Kate Kelly joined us in the field. She has experience determining the sex of salamanders and we were able to learn the technique and each year we sex a couple of the animals. We also were able to detect the existence of eggs. Due to the time involved, we do not sex all of the animals, but it is a piece of data we may want to consider collecting in the future.

Table 11. Fall 2020 cover-board results from the Lester Anderson lands on the Bristol/Lincoln border in Vermont. The species being monitored is Eastern Red-backed Salamander (*Plethodon cinereus*). Only the A cover-boards of each pair were checked in 2020.

	Snout to Vent Length						
Date	1-20 mm	21-30 mm	31-40 mm	41-50 mm	51-60 mm	Unk.[1]	Total
Sept. 2	0	5	24	10	0	0	39
Sept. 8	0	9	20	1	0	2	32
Sept 15	0	9	15	3	0	0	27
Sept. 22	0	9	11	6	1	0	27
Sept. 29	0	2	4	4	0	0	10
Oct. 6	0	0	12	5	0	0	17
Oct. 14	0	2	3	2	0	0	7
Oct. 20	0	1	3	4	0	0	8
Oct 27	0	2	2	2	0	0	6
Total	**0**[2]	**39**[2]	**94**[2]	**37**[2]	**1**[2]	**2**[2]	**173**[2]

[1] Salamanders escaped before measurements were taken.
[2] Salamanders may have been caught on more than one occasion throughout the field season.

Figure 11. Average number of Eastern Red-backed Salamanders (*Plethodon cinereus*) captured during the three highest counts[1] during cover-board monitoring on the Lester Anderson lands on the Bristol/Lincoln border in Vermont (2001-2020).

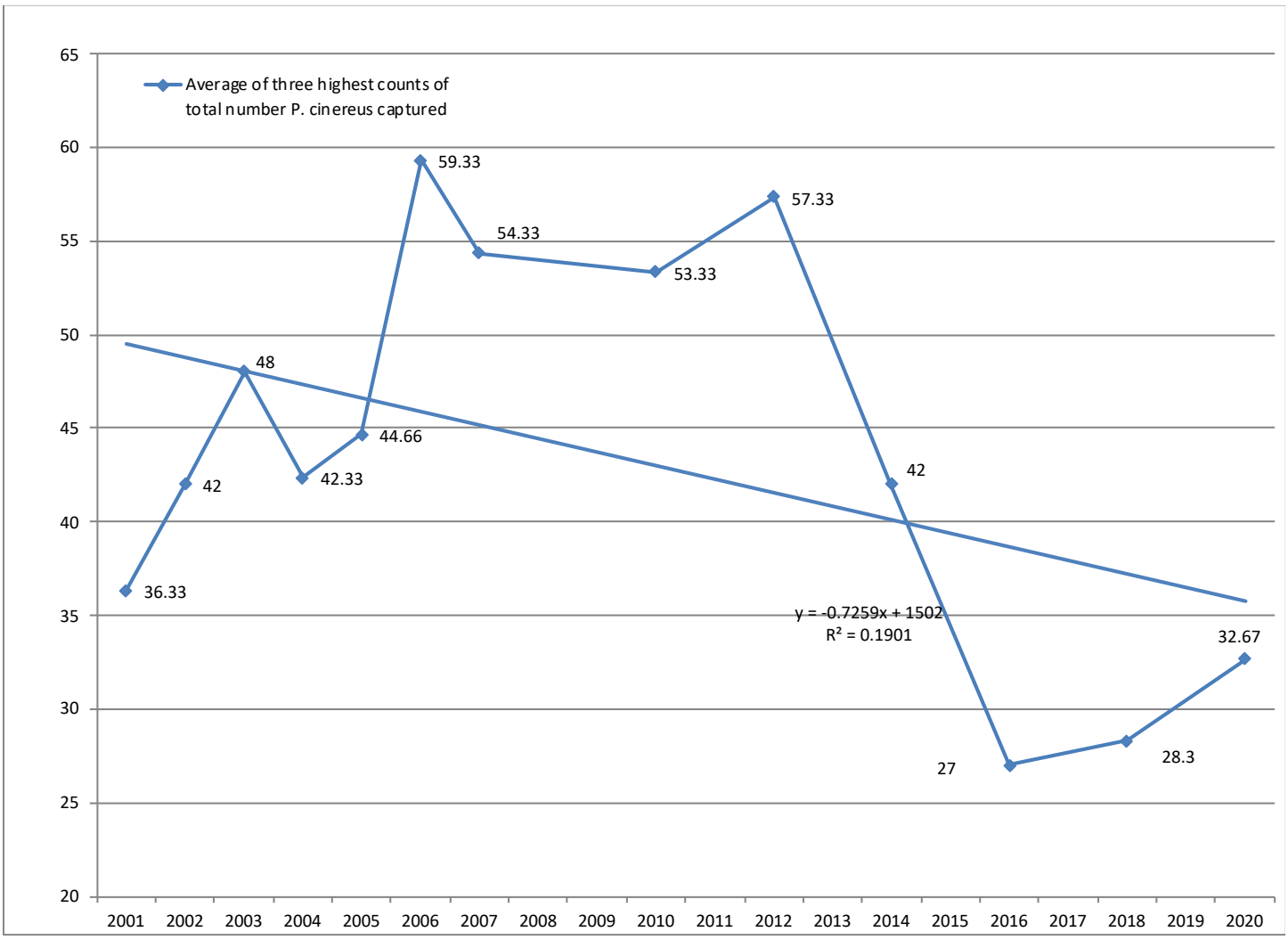


Table 12. Totals[2] for each cohort of Eastern Red-backed Salamanders (*Plethodon cinereus*) found on the three highest count days during cover-board monitoring on the Lester Anderson lands on the Bristol/Lincoln border in Vermont (2001-2020).

Snout to Vent Length						
Date	1-20 mm	21-30 mm	31-40 mm	41-50 mm	51-60 mm	Unk.[1]
2001	0	5	71	22	1	0
2002	0	7	91	25	0	0
2003	2	24	94	23	0	0
2004	2	40	64	19	0	0
2005	1	35	78	18	0	1
2006	10	40	93	34	0	0
2007	3	43	87	32	0	1
2010	0	15	98	46	0	1
2012	0	18	93	60	0	1
2014	6	16	67	44	2	0
2016	1	11	40	26	0	3
2018	0	11	60	12	0	2
2020	1	22	59	14	0	2
Average/Year	**2.00**	**22.08**	**76.54**	**28.85**	**0.46**	**0.62**

[1]Salamanders escaped before measurements were taken.
[2]Half of cover-boards checked (or data used), for each year. Cover-boards A in 2001, 2003, 2006, 2010, 2014, 2016, 2020. Cover-boards B in 2002, 2005, 2007, 2012, 2018, and odd numbered cover-boards in 2004.

Table 13. Percentage of totals for each cohort of Eastern Red-backed Salamanders (*Plethodon cinereus*) found on the three highest count days during cover-board monitoring on the Lester Anderson lands on the Bristol/Lincoln border in Vermont (2001-2020).

Snout to Vent Length			
Date	1-20 mm	21-40 mm	41-60 mm
2001	0.00%	76.77%	23.23%
2002	0.00%	79.67%	20.33%
2003	1.40%	82.51%	16.08%
2004	1.60%	83.20%	15.20%
2005	0.75%	85.17%	13.53%
2006	5.65%	75.14%	19.21%
2007	1.81%	78.31%	19.28%
2010	0.00%	70.63%	28.75%
2012	0.00%	64.54%	34.88%
2014	4.44%	61.48%	34.07%
2016	1.23%	62.96%	35.08%
2018	0.00%	83.53%	14.12%
2020	1.02%	82.65%	14.29%
Average/Year	**1.38%**	**75.88%**	**22.22%**

[1]Salamanders escaped before measurements were taken.

Figure 12: Percentage of totals for each cohort of Eastern Red-backed Salamanders (*Plethodon cinereus*) found on the three highest count days during cover-board monitoring on the Lester Anderson lands on the Bristol/Lincoln border in Vermont (2001-2020).

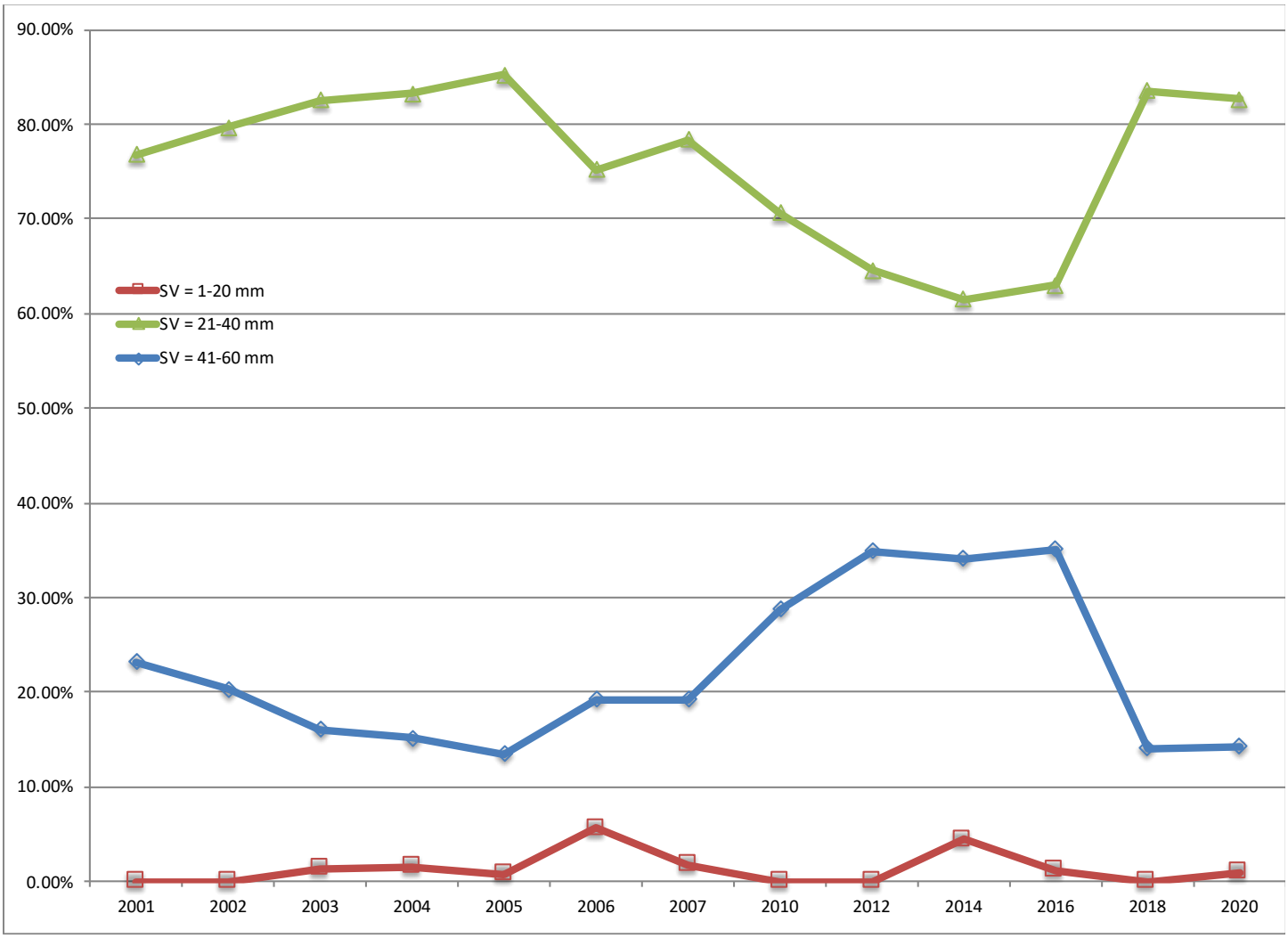


Figure 13: SV lengths for all *P. cinereus* found during cover-board monitoring on the Lester Anderson lands on the Bristol/Lincoln border in Vermont (2001-2020) n = 4519 captures.

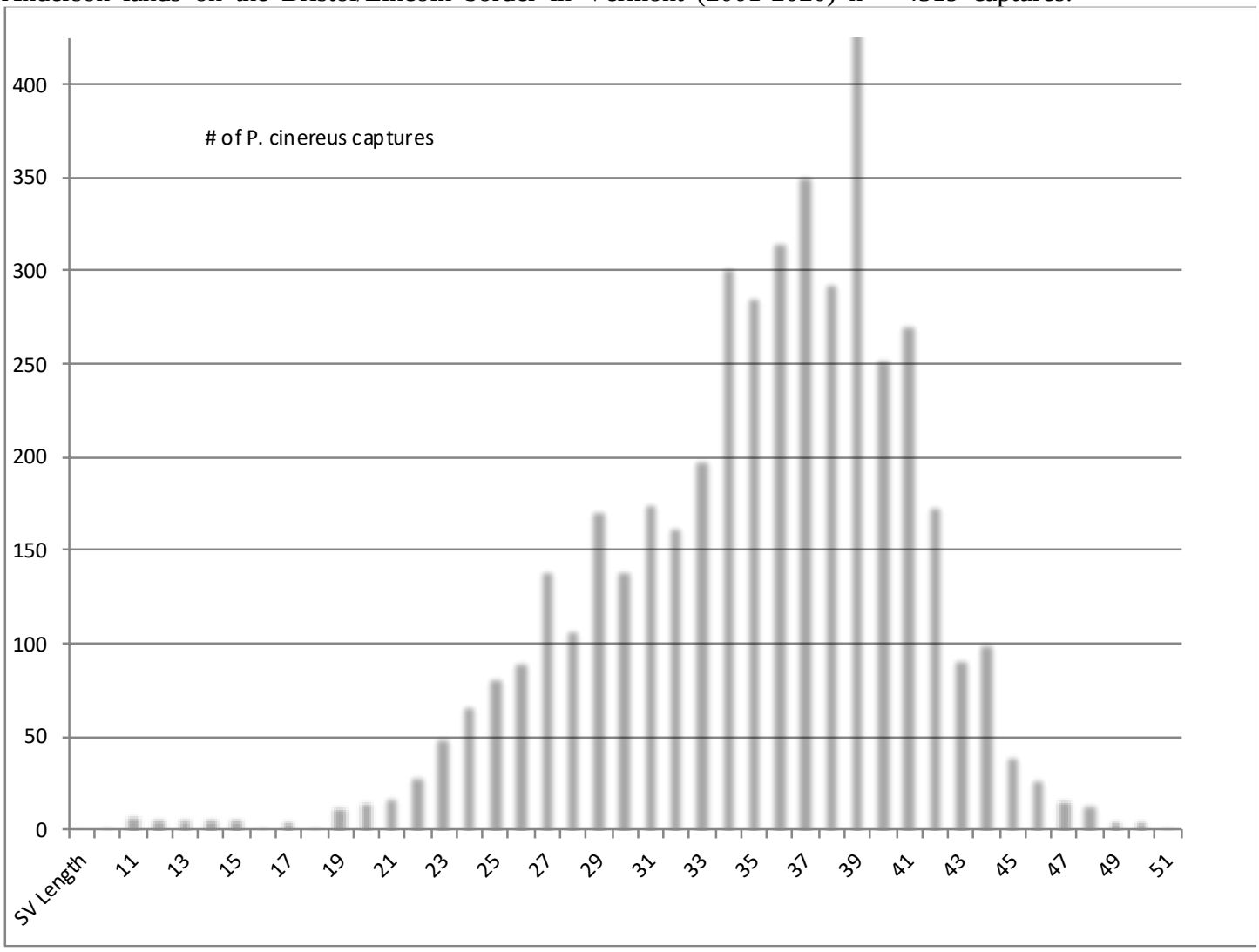
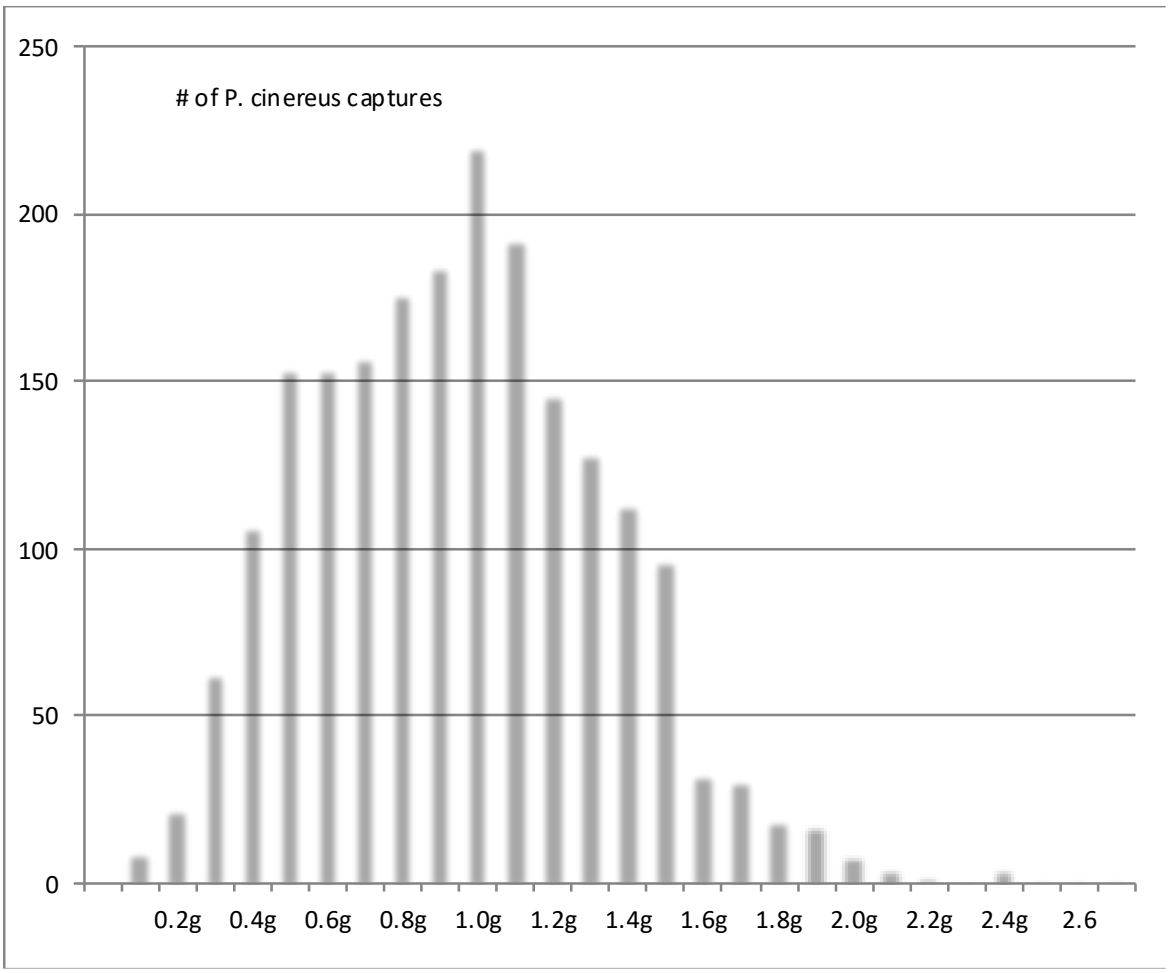
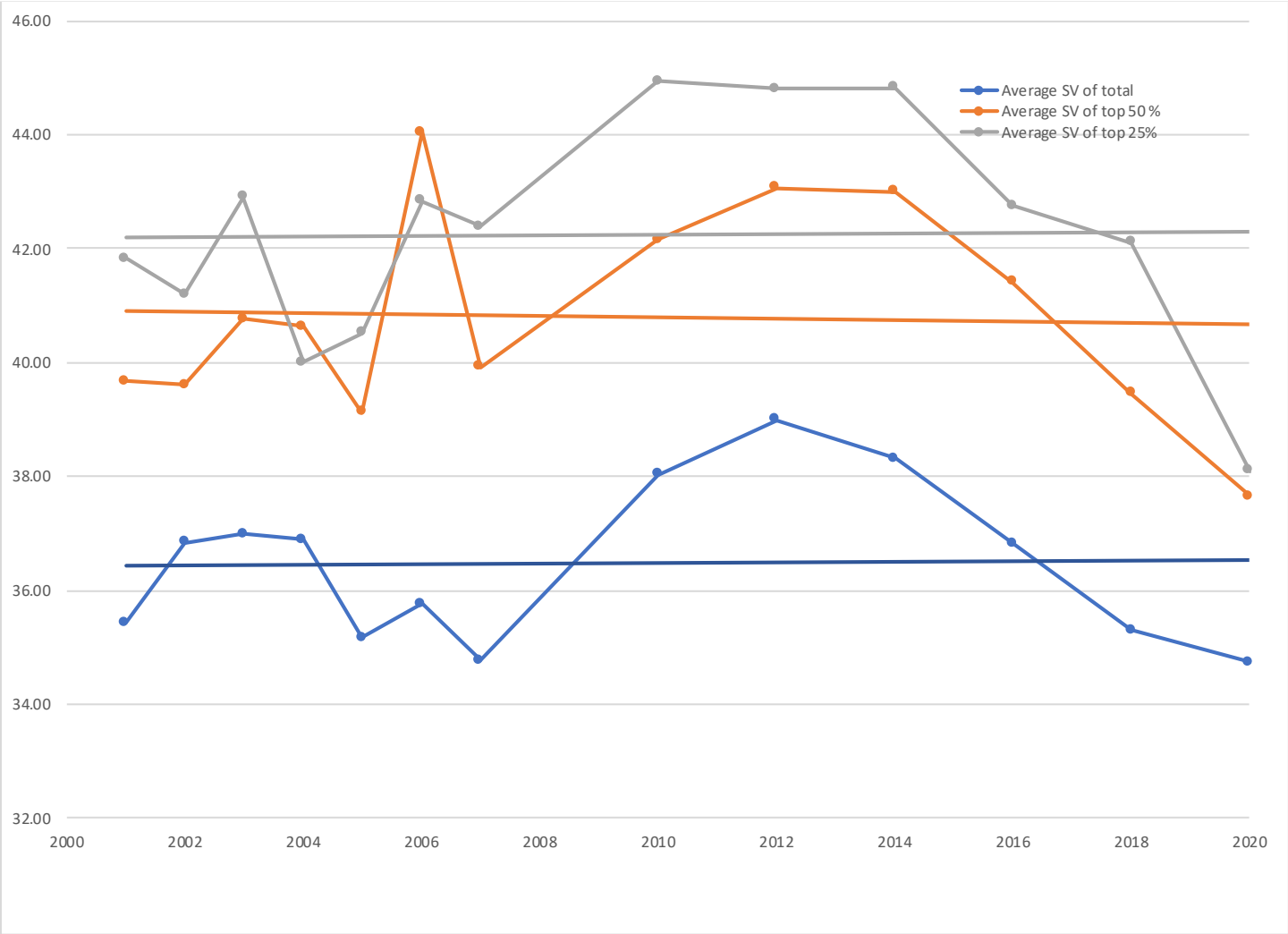


Figure 14: Mass in grams for all *P. cinereus* (for which mass was measured) found during cover-board monitoring on the Lester Anderson lands on the Bristol/Lincoln border in Vermont (2006-2020) n = 2041 captures.



A study was done in 2015 (Caruso et al.) showing a reduction in body sizes of adult salamanders in response to climate change. The authors compared historic and contemporary size measurements in 15 *Plethodon* species and found that six species, including Eastern Red-backed Salamanders showed significant reduction over 55 years. To see if the animals at our study site showed similar results, we compared average SV lengths of all salamanders greater than 20 mm captured on the top day by year (Figure 15). We did not find similar results, but our sample sizes were smaller, and we were looking over a shorter time span. It will be interesting to revisit this question in five or ten years.

Figure 15: Average SV of all *P. cinereus* greater than 20 mm captured on the top day of each year.



Cover-boards for salamanders: Summary

Eastern Red-backed Salamander numbers increased for a period of five years at the beginning of the study. They then plateaued for the next six years and have been declining precipitously for the last four years. For the last ten years there seems to be a shift occurring from the middle size-class to the larger size class with little change in the percentage of the small size class.

Notes on Other Species

Many invertebrates were found using the cover-boards. In 2020 we found: American cyanide millipede, flat-back millipede species, unidentified millipedes, unidentified centipedes, camel cricket, orange-headed beetle, ground beetles, winding mantle slug, western dusky slug, slug eggs, unidentified spiders, Ruffed Grouse, and American Woodcock. We noted a few earthworms but did not find any (that we knew of) invasive jumping worms.

Future Study

Our current schedule is as follows: we schedule an annual maintenance day or two in late July each year and take advantage of this day to check snake covers. This provides data on gravid females and might turn up additional Eastern Milksnakes. Data on gravid females are otherwise not available during fall checks. In spring 2019 we wrote a full report and monitored the snake covers in the fall. In 2020, we monitored egg-masses and one-half the cover boards but did not write a report. In early 2021 we wrote this report and plan to monitor the snake covers in the fall. In 2022 we plan to monitor the egg-masses

in spring and one-half the cover-boards (the Bs) in the fall. We might want to consider focusing on only one type of monitoring in each report. For example, one year it would be on snakes, two years later it would cover egg-mass counts, and two years later it would cover salamanders. This would leave a gap of six years (three data sets) between reports on any one monitoring protocol. However, it would allow for more in-depth reporting on each type of monitoring. In addition, it could allow for the addition of extra data collecting.

We have been asked to investigate areas on the Anderson Lands for potential Spring Salamander (*Gyrinophilus porphyriticu*s) monitoring. During the 2021 field season we will survey the most likely habitat to see if this is indeed feasible.

Thanks

Opportunities for long-term monitoring are both exceptionally rare and very valuable. Most funding for this type of project is short-term. This greatly limits the type of data that can be gathered and the reliability of the data. We continue to appreciate the opportunity that has been created for us through the Colby Hill Ecological Project. Data such as these are not being gathered anywhere else that we are aware of.

Acknowledgments

Jim Andrews, Kate Kelly, and Erin Talmage helped gather data with some regularity. Carol Adams, Amy Alfieri, Linda Andrews, Abi Barnes, Morgan Barnes, Matt Gorton, Abby Kelly, Molly Kelly, Bowen Lutz, Brittany Mosher, Levi Smith, and Jess Zulch also helped at least once with data collection. Matt Gorton, Kate Kelly, Nick Tepper, and Hannah Thorne helped with maintenance. Erin Talmage reviewed all the data and drafted this report. Unless otherwise noted, all photographs were taken by Erin Talmage.

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Appendix

Appendix Table 1. Spring 2020 egg-mass data from Lower Fred Pierce Pond on Lester Anderson lands in Lincoln, Vermont.

Date	*Ambystoma maculatum* egg-masses	*Lithobates sylvaticus* egg-masses	Notes
March 23	0	0	Visibility excellent, no ice on pond, polarizing glasses worn. Large aspen fell along edge, with branches in pond. Some movement in Champlain Valley on March 10, and March 20.
March 31	0	0	Visibility excellent. Polarizing lasses used. Did some site cleaning around pond, will do more next week.
April 5	0 One small clump and a few individuals one.	131 Saw two adults	Visibility pretty good to excellent, tree trimming was done, polarizing glasses worn.
April 11	0	172	Visibility good to excellent. Snowed last night, and sprits were low. Polarizing glasses worn. Duck weed growing and new cattails emerging above water.
April 19	12	230 Some are pretty fresh, new this week.	Visibility good, it is cloudy and getting dark, polarizing glasses used, there was one good migration night since last week.
April 28	26 A few clumps of spermatophore.	211 Some look new from last week, but top layer has dead eggs. Both Green Frog tadpoles and Eastern Newts within clouds of masses.	Visibility excellent.
May 3	133 Saw one adult	1 Most egg masses just full of lots and lots of dead eggs, a few tadpoles on masses, one is pretty fresh.	Polarizing glasses worn.
May 10	151	0 Only old ones with dead eggs, did not notice tadpoles.	Visibility poor to ok, water is dark, and sky is still cloudy, freezing temps and snow still on ground from snowfall on May 8.
May 16	169	0 Only a few old masses with dead eggs visible, >5 tadpoles (barely any compared to previous years).	Visibility good.

Appendix Table 2. Spring 2020 egg-mass data from Upper Fred Pierce Pond on Lester Anderson lands in Lincoln, Vermont.

Date	*Ambystoma maculatum* egg-masses	*Lithobates sylvaticus* egg-masses	Notes
March 23	0	0	Visibility good to excellent, polarizing glasses worn. Thin layer of ice over entire pond, lots of vegetation in pond. Some movement in Champlain Valley on March 10, and March 20.
March 31	0	0	Visibility good to excellent. Polarizing lasses used.
April 5	0	5 Very fresh, some have not expanded, and we can still see some white (where they have not turned over). Heard a chorus of adults, >40 adults.	Visibility pretty good water a bit murky, polarizing glasses worn.
April 11	0	79	Visibility good to excellent. Snowed last night, and sprits were low. Polarizing glasses worn. Duck weed growing and new cattails emerging above water.

April 19	3	85 Some are pretty fresh, new this week.	Visibility ok, very dark, and completely cloudy, polarizing glasses used, there was one good migration night since last week.
April 28	7 A few clumps of spermatophore.	76	Visibility good to excellent, water dark.
May 3	32	0 Eggs are old, can mostly only see dead ones.	Visibility good when sun comes out, water is very dark. Polarizing glasses worn.
May 10	38	0	Visibility poor to ok, water is dark, duckweed starting to show up, freezing temps, and snow still on ground from snowfall on May 8.
May 16	22	0 No tadpoles seen.	Visibility ok to good, still cloudy, occasional breeze.

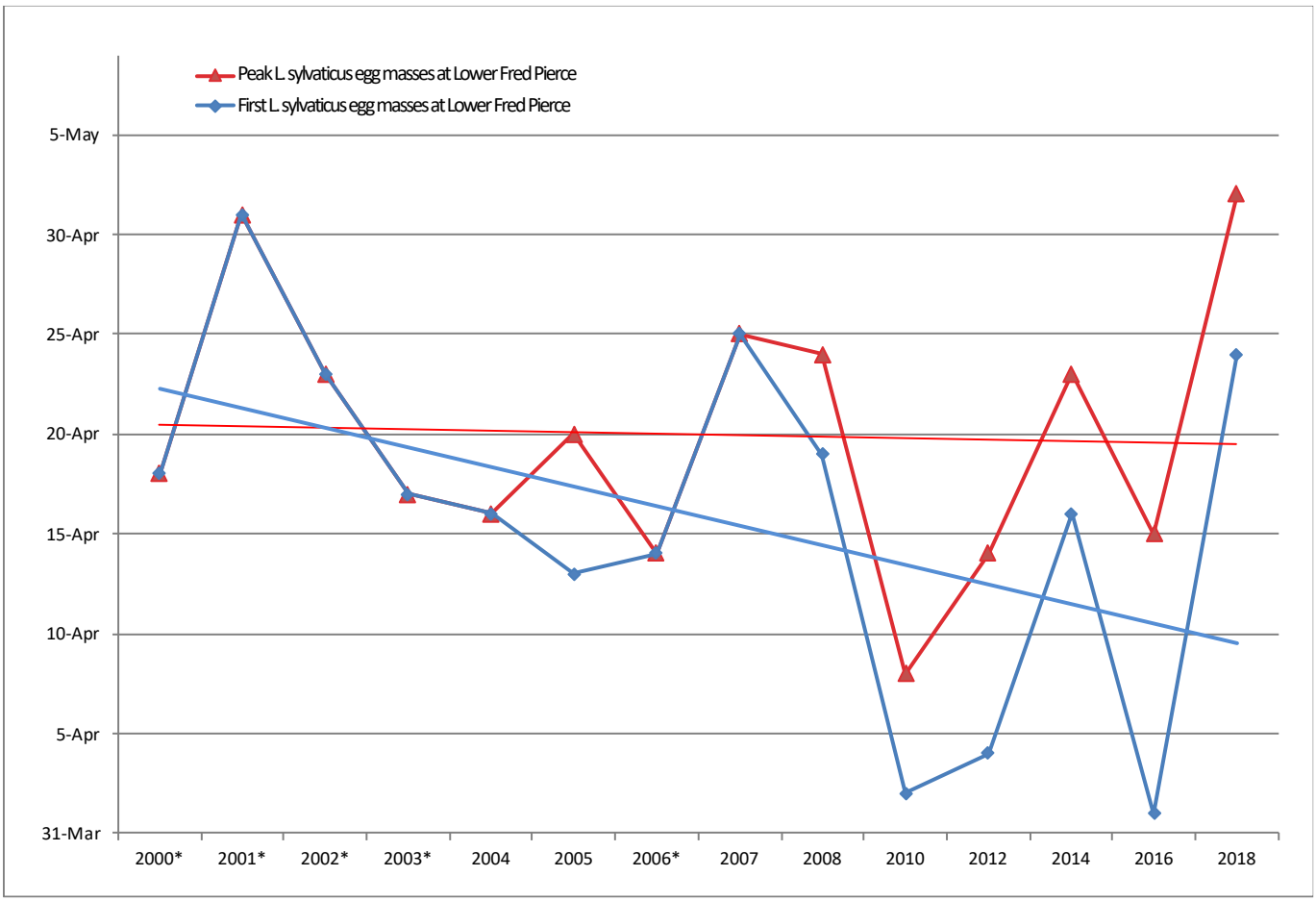
Appendix Table 3. Spring 2020 egg-mass data from Guthrie Pond on Lester Anderson lands in Lincoln, Vermont.

Date	*Ambystoma maculatum* egg-masses	*Lithobates sylvaticus* egg-masses	Notes
March 23	0	0	Visibility good, could see to bottom during breaks in wind, thinlayer of ice along edge. Some movement in Champlain Valley on March 10, and March 20.
March 31	0	0	Visibility good to excellent. Polarizing glasses used.
April 5	0	99 Eggs very fresh, most have not expanded. Greater than 30 adults, heard one calling, found four males on one drowned female (still with eggs).	Visibility pretty good - can see out about 7 feet, polarizing glasses worn.
April 11	0	178 Adult Newts and Green Frog tadpoles within masses.	Visibility excellent, except when wind blows. Snowed last night, and sprits were low. Polarizing glasses worn.
April 19	23	278 Some new from last week.	Visibility good, but not great, with moments of clarity. Polarizing glasses used; there was one good migration night since last week.
April 28	53 Saw adult wrapped around cattail laying eggs, also saw a clump of spermatophore.	271 Old and breaking up, some have hatched and can see little tadpoles, much of the top layer froze and many eggs are non-viable, the ones on the edge are fairly Fresh.	Visibility good to excellent, polarizing glasses worn.
May 3	162 Two opaque, one mostly non-viable, some pretty fresh from last week.	3 Eggs are either hatched or non-viable, one very fresh, only counted distinct masses. Lots of tadpole on or near masses. One adult seen.	Visibility excellent Polarizing glasses worn.
May 10	144 A few had non-viable eggs.	1 The rest of the masses have hatched and are dissolved. Can see small tadpoles swimming around and clinging to cattails.	Visibility good some of the time, a little breezy and cloudy, polarizing glasses worn freezing temps and snow still on ground from snowfall on May 8.
May 16	154 A couple have non-viable eggs.	0 All gone. No significant numbers of tadpoles were seen.	Visibility ok to good, still cloudy, occasional breeze.

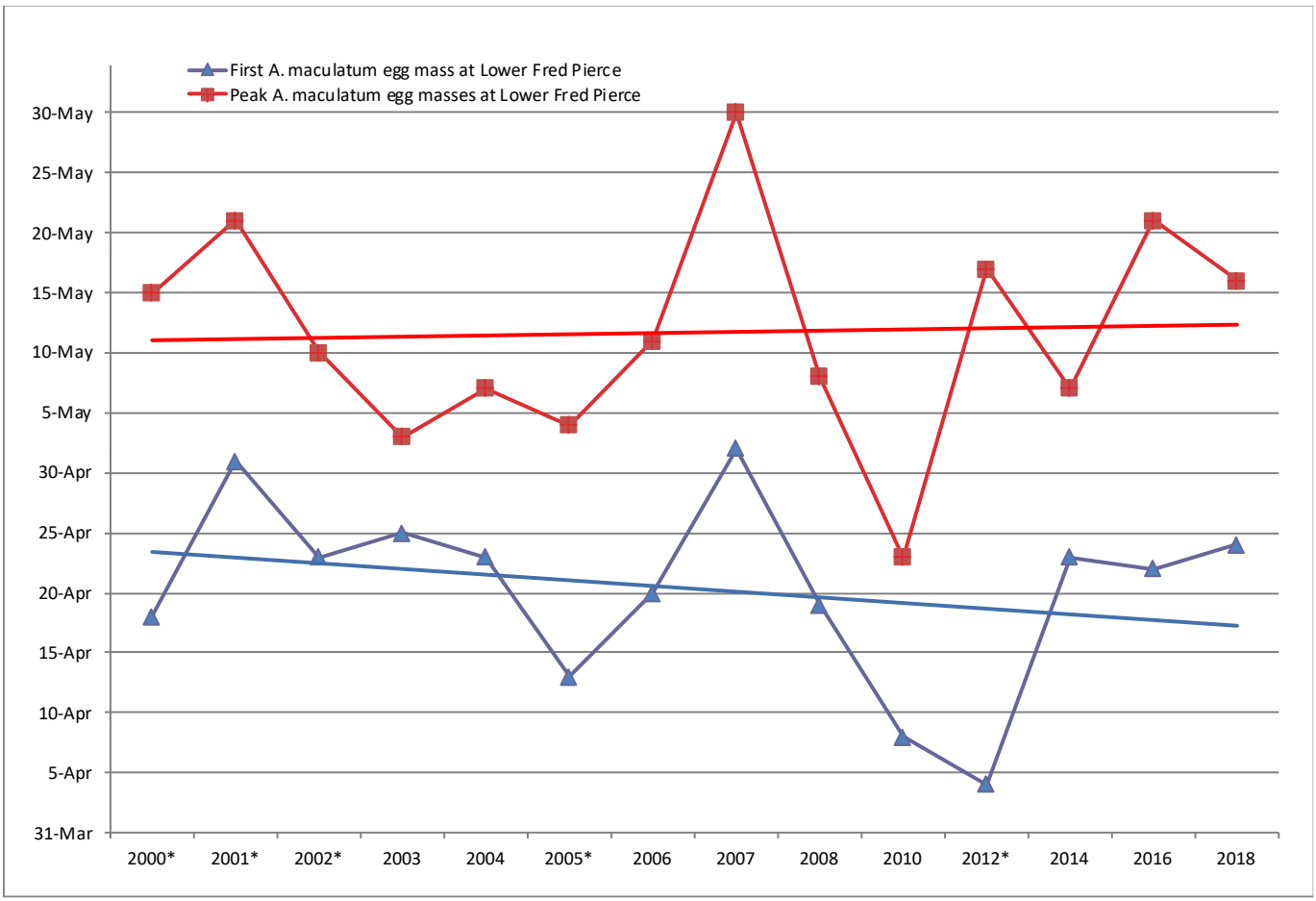
Appendix Table 4. Spring 2020 egg-mass data from Wells Pond on Lester Anderson lands in Lincoln, Vermont.

Date	*Ambystoma maculatum* egg-masses	*Lithobates sylvaticus* egg-masses	Notes
March 23	0	0	Visibility excellent, thin layer of ice over entire pond, but could still see the bottom of pond. Cattails growing into pond, as well as shrubs along edge that may make looking for masses more difficult. Bryozoans still visible on bottom of pond polarizing glasses worn. Some movement in Champlain Valley on March 10, and March 20
March 31	0	0	Visibility good to excellent. can see to bottom. polarizing glasses used.
April 5	0	0 Saw greater than 10 adults. No egg masses seen (probably 1-2 hours too early!).	Visibility pretty good to excellent, polarizing glasses worn.
April 11	0	55 One adult was seen.	Visibility good to excellent. Snowed last night, and sprits were low. Polarizing glasses worn.
April 19	28 Three were opaque.	123 Some new this week.	Visibility poor, breezy, needed to wait for moments of clarity, polarizing glasses used, there was one good migration night since last week.
April 28	60 At least three were opaque.	110 One is relatively fresh.	Visibility ok to good, water looks dark and murky.
May 3	137 Some very fresh, one adult seen.	4 Some have hatched, and a lot of non-viable eggs, 2 masses looked pretty fresh.	Visibility ok to good, a bit breezy. Polarizing glasses worn.
May 10	147	2 Mostly broken up, only dead eggs left.	Visibility ok still cloudy, water is dark and hard to see clearly, freezing temps and snow still on ground from snowfall on May 8.
May 16	185 Saw Spermatophore – seemed relatively fresh.	0 >250 tadpoles	Visibility ok to good, still cloudy, occasional breeze.

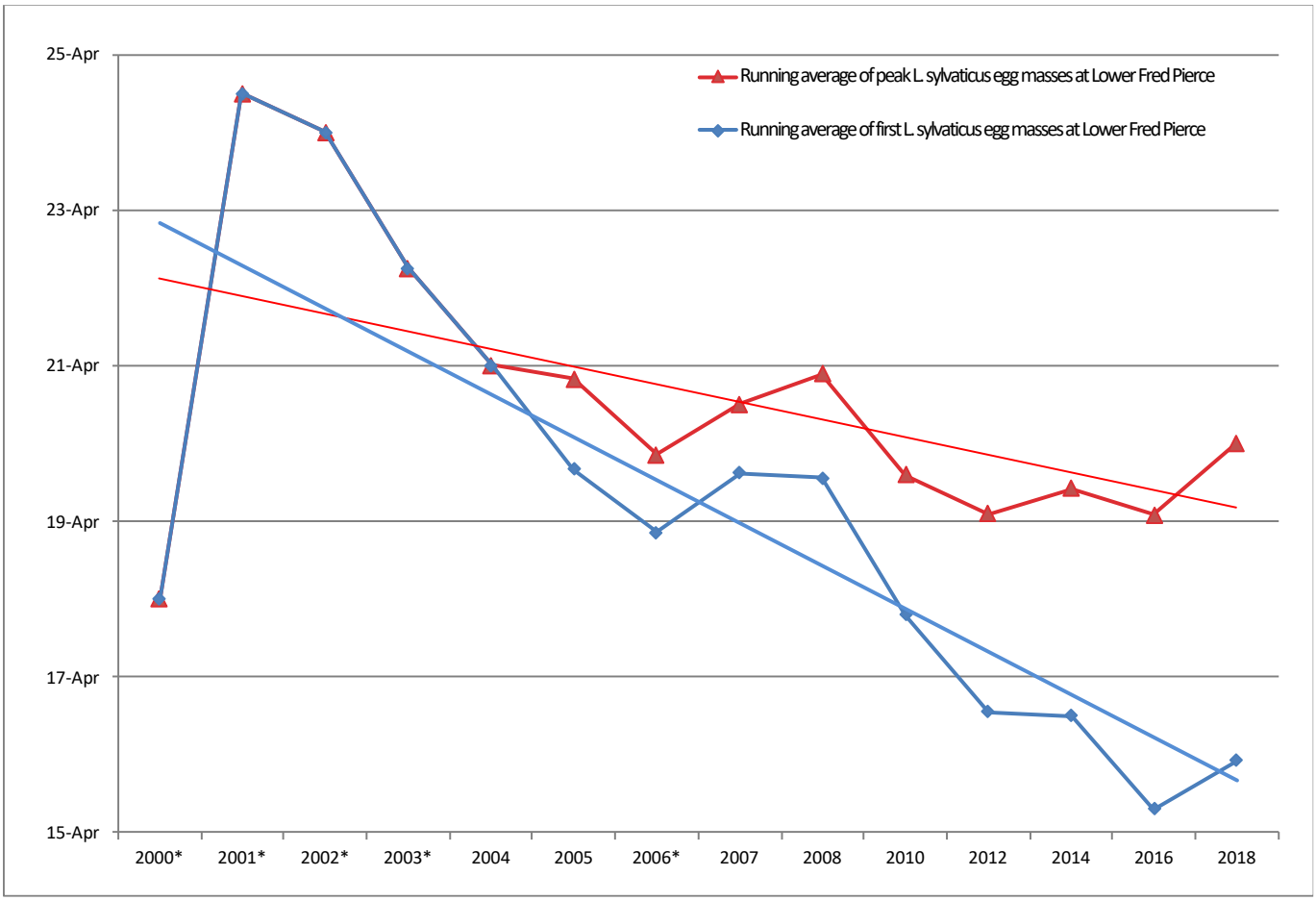
Appendix Figure 1: First egg-masses detected and peak egg-masses (with trend lines) for *L. sylvaticus* at Lower Fred Pierce on Lester Anderson Lands, Lincoln, Vermont (2000-2018).



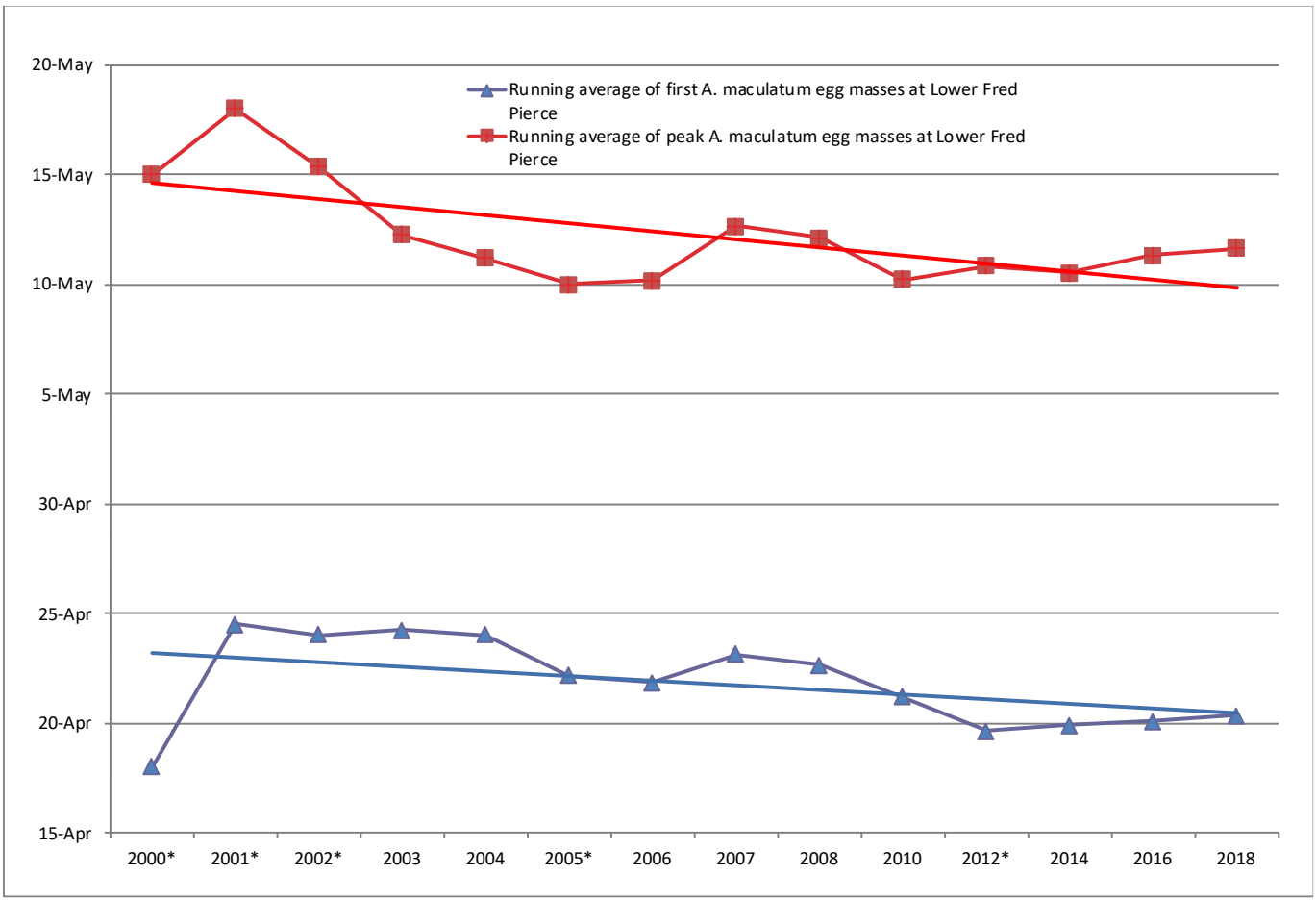
Appendix Figure 2: First egg-masses detected and peak egg-masses (with trend lines) for *A. maculatum* at Lower Fred Pierce on Lester Anderson Lands, Lincoln, Vermont (2000-2018).



Appendix Figure 3: Running average of first egg-masses detected and peak egg-masses (with trend lines) for *L. sylvaticus* at Lower Fred Pierce on Lester Anderson Lands, Lincoln, Vermont (2000-2018).



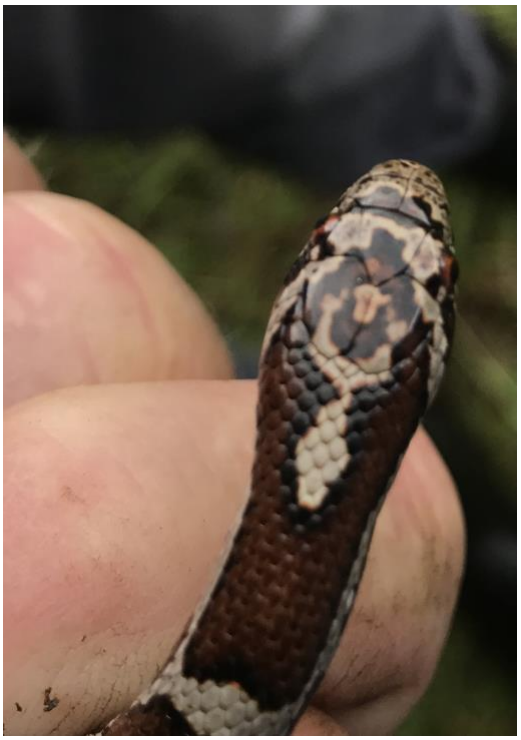
Appendix Figure 4: Running average of first egg-masses detected and peak egg-masses (with trend lines) for *A. maculatum* at Lower Fred Pierce on Lester Anderson Lands, Lincoln, Vermont (2000-2018).



Appendix Photographs 1 and 2: Dekay's Brownsnake on August 1, 2019 by Nick Tepper, and Wood Frogs (one dead female and four alive males, pulled from the water) on March 23, 2020.

Appendix Photograph 3 and 4: Ventral color variation of Red-bellied Snakes.

Appendix Photograph 5 and 6: Eastern Milksnake showing a “chalice with an ice cube” on September 11, 2019, and chalice with a dot in the middle that is a “one-legged water boatman” on September 25, 2019.



Appendix Photographs 7 and 8: Eastern Milksnakes showing necrosis typical of snake fungal disease on the ventral side and lower lip.

Appendix Photograph 9: Looking for eggs within a Red-backed Salamander.