Eastern Red-backed Salamander Monitoring

2000-2024

on the Lester and Monique Anderson Lands

in Lincoln, Vermont

Prepared for the

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Ecological Project

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Cover-boards for salamanders: Methods

Three cover-board transects were constructed and put in place along an old wood road connecting the Guthrie-Bancroft fields with Rte. 17. This road starts near the Lincoln/Bristol border and continues into Bristol, heading northwest toward Route 17. All the cover-boards are within the town of Bristol. The first two sets each contain 15 pairs of cover-boards. The third set contains 16 pairs of cover-boards. The exact locations of the three sets with center coordinates are shown in (Figure 1). 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 based on 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 (Figure 2), 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 between 0.5 m and 2 m apart based on NAAMP recommendations, and each pair of condos was located 6-10 m from the nearest pair. The three 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 this area is kept free from herbaceous vegetation with annual weeding. Leaves are 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 or peel 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 the 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 the salamanders as well. Kate Kelly has been part of the data collection team since 2016. With her assistance, we are also able to look for the presence of eggs in salamanders that appear gravid (Appendix Photographs 1 and 2).

In addition, we keep records of 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 layers of boards), ground (between board and ground), crack (in the space between the two boards on the ground surface), 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. In 2022 we checked only the B covers, and in 2024 we checked only the A covers.

The cover-boards are checked once per week 9 or 10 times per season (Table 2a, 2b, 2c). We stop the counts in the fall once we determine that the number of salamanders seen has been consistently decreasing.

Figure 1: Map of study site. Center coordinates for Transect A (15 coverboards) are 44.156659, -73.027143 +/- 75m. Center coordinates for Transect B (15 coverboards) are 44.158279, -73.030711 +/- 75m. Center coordinates for Transect C (16 coverboards) are 44.158808, -73.034679 +/- 75m.

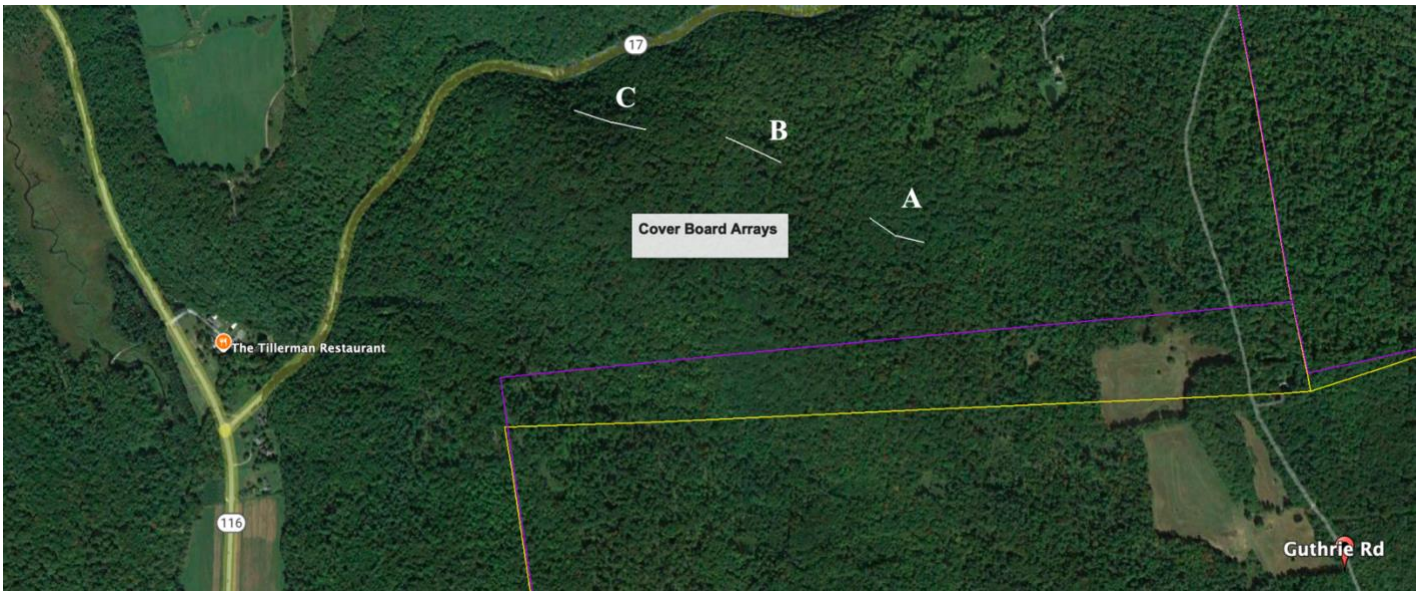


Figure 2: Close-up of single cover-board and a pair of cover-boards.

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 (*Desmognathus fuscus*), Spotted Salamander (*Ambystoma maculatum*), Northern Two-lined Salamander (*Eurycea bislineata*), 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. The eggs hatch in late summer. We occasionally find very small salamanders that presumably just hatched (Appendix, Photograph 2). Hatchlings typically measure between 19-25 mm, and although they look like adults, their tails are proportionally shorter to their total lengths compared to that of adults (Petranka 1998).

Cover-boards for salamanders: Results and Discussion

The cover-boards have been monitored for salamanders every other year beginning in 2008. Cover-boards are also 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 necessary, during fall monitoring.

Table 1. Salamanders found during maintenance from 2013 through 2024 on 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	0
2016	Aug 2 and Aug 3	74	1	3
2017	July 19	63	0	3
2018	July 18 and July 27	83	1	6
2019	Aug 1	48	0	0
2020	July 2	67	0	1
2021	July 14	80	0	0
2022	August 10	81	1	3
2023	August 1, August 3,	82	0	0
2024	August 15, August 22	62	5	0

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

Table 2a. Fall 2020 cover-board results for Eastern Red-backed Salamanders on the Lester Anderson lands on the Bristol/Lincoln border in Vermont. Only one of each cover-board pair (the A's) 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**	**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.

Table 2b. Fall 2022 cover-board results for Eastern Red-backed Salamanders on the Lester Anderson lands on the Bristol/Lincoln border in Vermont. Only one of each cover-board pair (the B's) were checked in 2022.

Snout to Vent Length							
Date	1-20 mm	21-30 mm	31-40 mm	41-50 mm	51-60 mm	Unk.[1]	Total
Sept. 1	0	7	18	15	0	1	41
Sept. 8	0	7	28	10	0	0	45
Sept. 15	0	8	23	9	0	0	40
Sept. 22	0	3	34	7	0	1	45
Sept. 29	0	10	23	10	0	0	43
Oct. 6	0	14	17	5	0	1	37
Oct. 13	1	10	18	3	0	1	32
Oct. 20	0	2	5	3	0	0	10
Oct. 27	0	2	4	2	0	0	8
Total	**1**	**63**[2]	**167**[2]	**64**[2]	**0**[2]	**4**[2]	**299**[2]

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

Table 2c. Fall 2024 cover-board results for Eastern Red-backed Salamander from the Lester Anderson lands on the Bristol/Lincoln border in Vermont. Only one of each cover-board pair (the A's) were checked in 2024.

Snout to Vent Length							
Date	1-20 mm	21-30 mm	31-40 mm	41-50 mm	51-60 mm	Unk.[1]	Total
Sept. 5	0	4	22	6	0	1	33
Sept. 12	0	4	19	4	0	0	27
Sept. 19	0	6	14	3	0	1	23
Sept. 26	0	2	18	2	0	0	22
Oct. 3	0	4	23	3	0	0	30
Oct. 10	0	3	12	4	0	0	19
Oct. 17	1	4	13	0	0	0	18
Oct. 24	0	1	2	3	0	0	6
Oct. 31	0	2	7	2	0	0	11
Nov 7	1	1	0	0	0	0	2
Total	**2**[2]	**32**[2]	**129**[2]	**27**[2]	**0**[2]	**2**[2]	**192**[2]

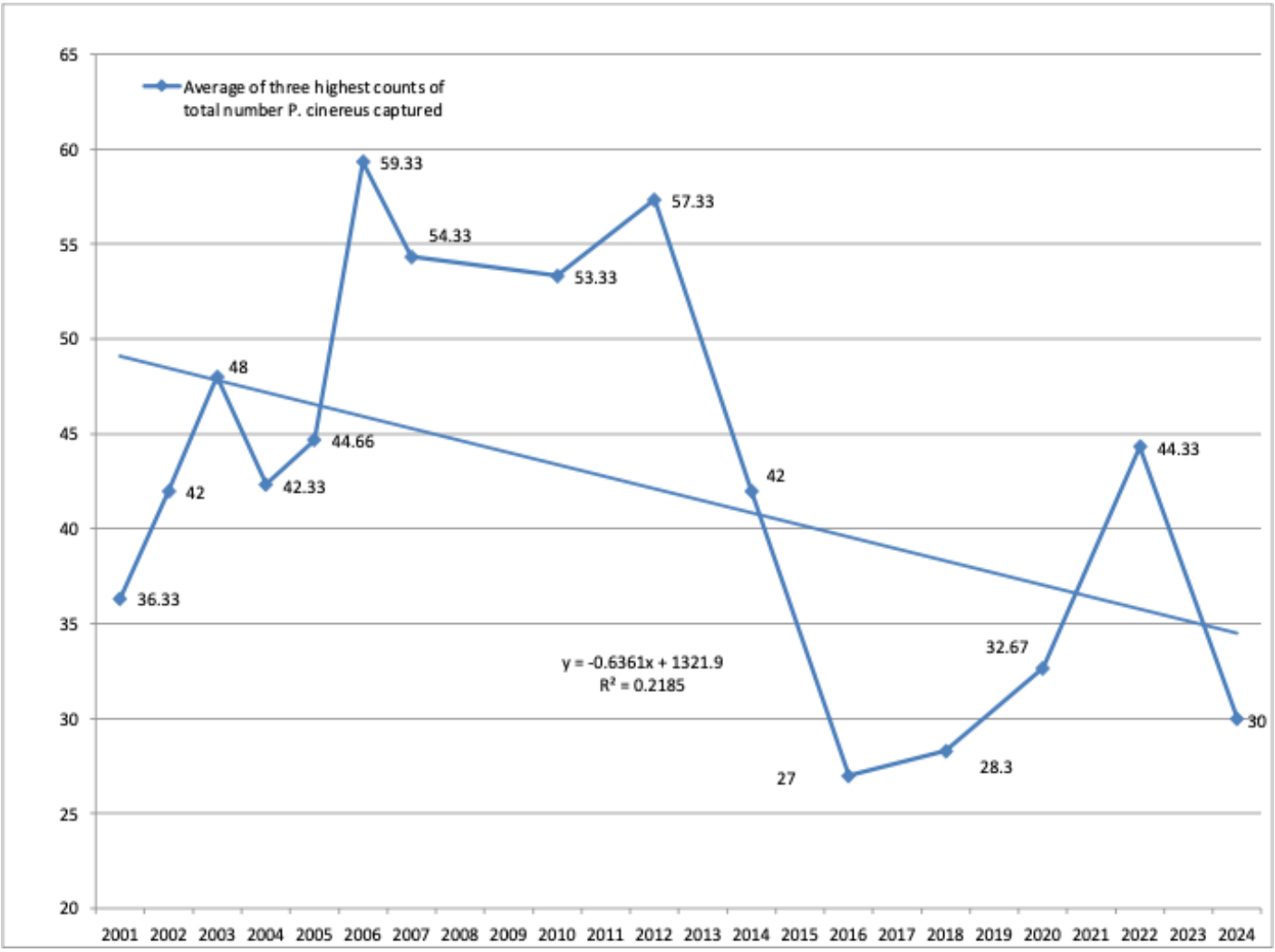
[1] Salamanders escaped before measurements were taken.
[2] Salamanders may have been caught on more than one occasion throughout the field season.

The species found under the cover-boards are almost exclusively the Eastern Red-backed Salamander. However, Northern Dusky Salamanders are occasionally found. Overall, Northern Dusky Salamanders have been found under the cover-boards twenty times during regular monitoring and fourteen times while performing maintenance. Throughout the monitoring years, they have been found on cover-board #10 (15 times), cover-board #11 (3 times), cover-board #12 (14 times), and cover-board #16 (one time), unknown (one time).

Cover-boards 10-16 are 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 few 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.

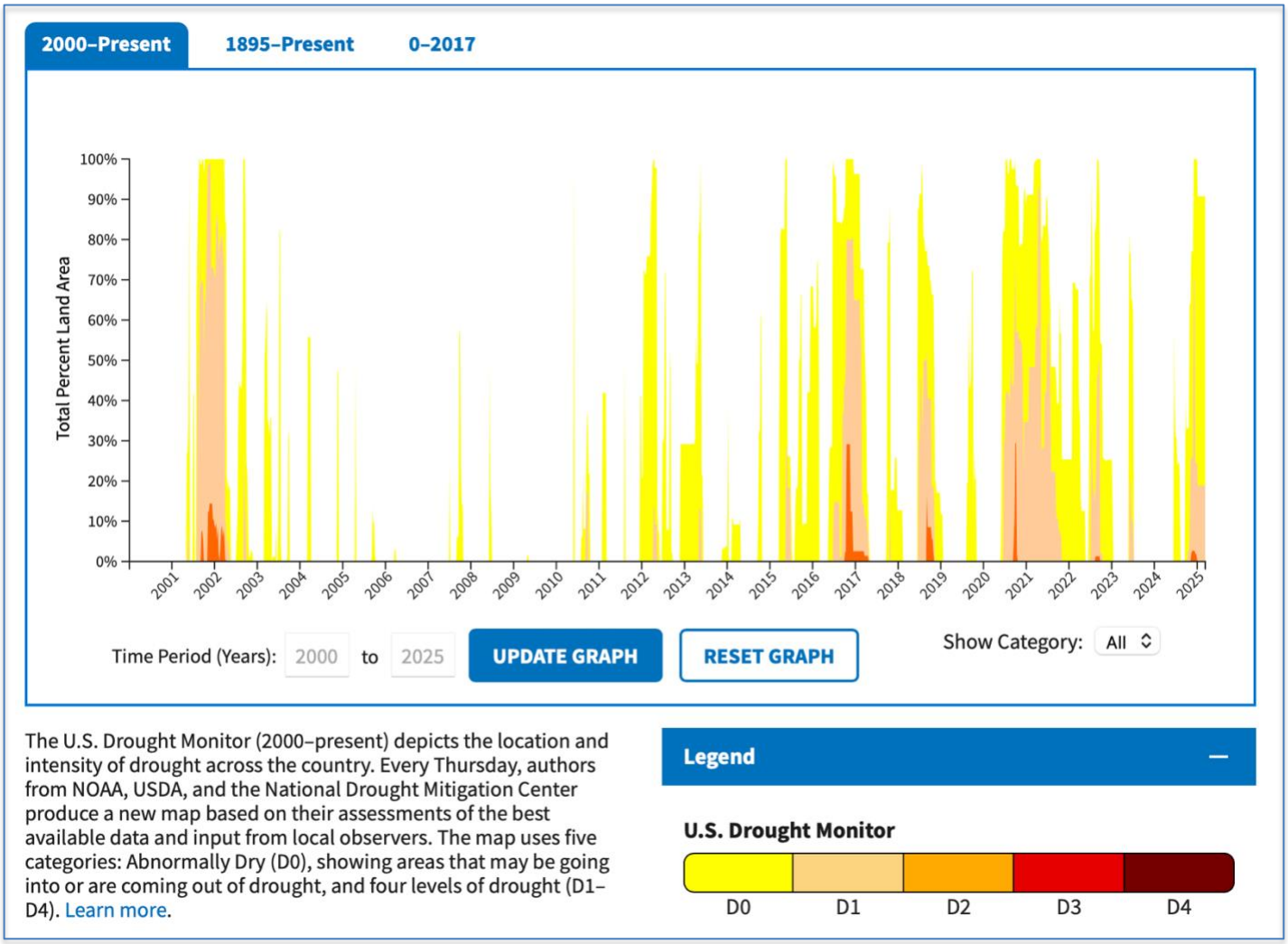
In 2020, 2022, and 2024, the high counts for numbers of Eastern Red-backed Salamanders were 39 (Sept 2, 2020), 45 (found on both Sept 8, 2022 and Sept 22, 2022, and 33 (Sept 5, 2024). For the five previous count years we had surveyed (2012, 2014, 2016, and 2018), the high counts were 63, 60, 50, 32, and 41. To adjust for day-to-day variation caused by weather and seasonal differences, we use an index to compare high counts from year to year. We take the highest three counts of a given year and average them. Results are shown in Figure 3. The high counts are often the first three counts in September but occasionally include a count taken in October.

Figure 3. The 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 (2001-2024).



In 2014, although a below-average number of salamanders were detected, our index was still showing an increasing population. As shown in Figure 3, that no longer appears true. The fewest salamanders were detected in 2016, and although the numbers have been slightly higher since then, the overall trend is still showing a decrease in the number of 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 the surrounding hardwood forests age and produce increasing amounts of leaf litter and coarse woody debris. This organic material provides moisture refugia, cover from predators, and egg-laying sites. The presence of the cover-boards themselves could have brought about a temporary increase in population, but this would have leveled 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 annual precipitation level), may have reduced the population. The drought may have reduced breeding opportunities, causing animals to move to wetter areas or causing animals to move farther underground than our cover boards. In 2023 and 2024, Vermont experienced record flooding, which may have impacted the population. Our most recent analysis of Eastern Red-backed Salamander numbers at our Mt. Mansfield monitoring site shows that their population had also been increasing at that site, with considerable annual variation (Andrews and Talmage 2024). 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 4: Percentage of Vermont experiencing drought from 2000-2025. (D0-abnormally dry, D1-moderate drought, D2 severe drought). Data from Drought.gov (screenshot accessed March 18, 2025)



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 5, and Tables 3 and 4). As mentioned in earlier reports, Middlebury College student Caitlin Corey's research results suggest that there is an upper limit to the number of adults that will share the same 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 3), perhaps we have reached this upper limit. Corey's results also suggest that there is possible predation upon younger juveniles by older adults sharing the same boards; 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 3 and 4 and Figure 5). It appears that the age-class structure has been fairly stable since 2018 (Figure 5). It will be interesting to see if this continues and if Corey's hypotheses are correct.

Table 3. Totals[2] for each cohort of Eastern Red-backed Salamanders found on the three highest count days during cover-board monitoring on the Lester Anderson lands on the Bristol/Lincoln border in Vermont (2001-2024).

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
2022	0	20	85	27	0	1
2024	0	13	63	13	0	1
Average/Year	**1.73**	**19.13**	**66.33**	**25.00**	**0.40**	**0.53**

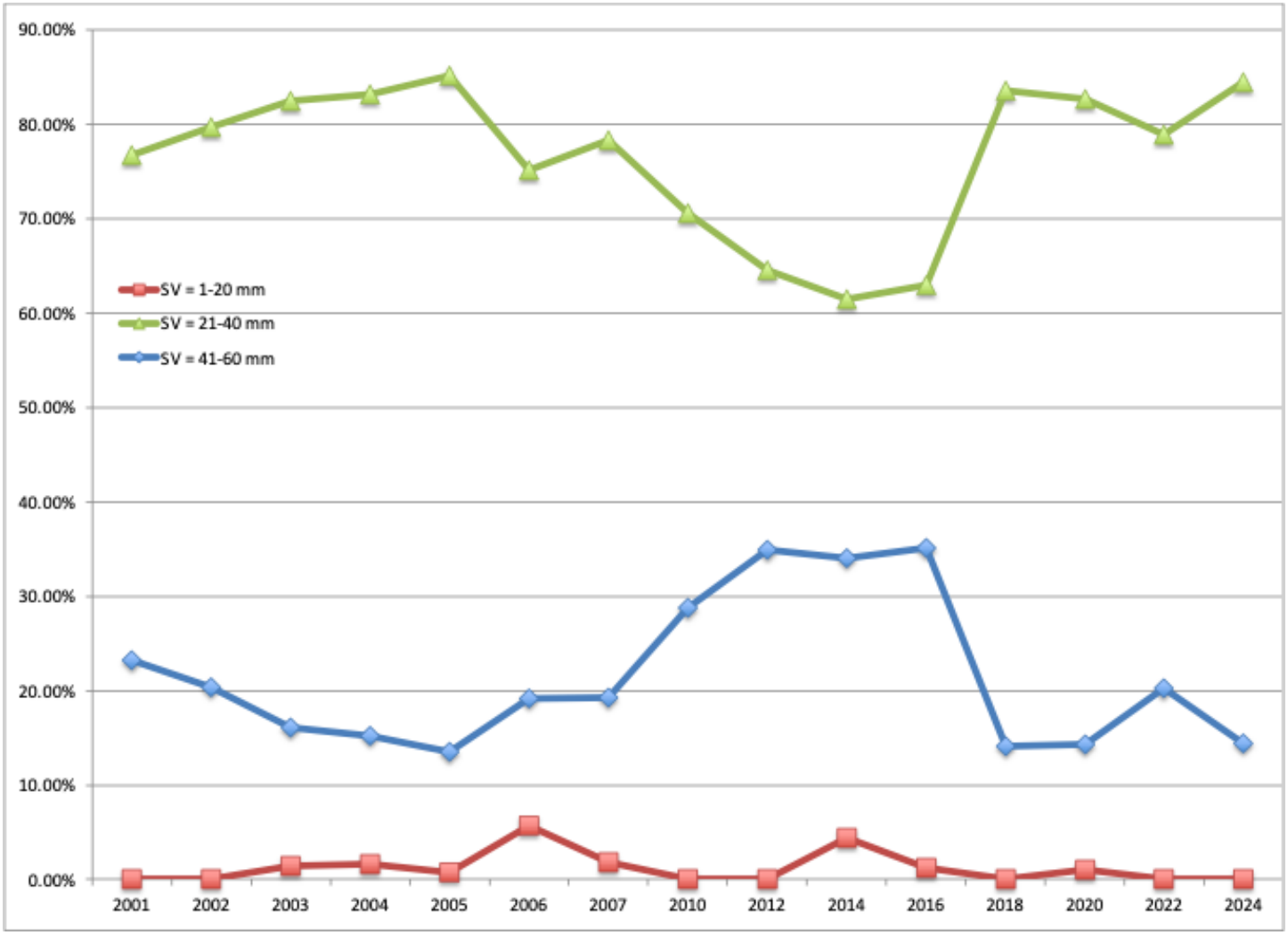
[1]Salamanders escaped before measurements were taken.
[2]Half of cover-boards checked (or data used), for each year. Cover-boards A in 2001, 2003, 2006, 2010, 2014, 2016, 2020, 2024. Cover-boards B in 2002, 2005, 2007, 2012, 2018, 2022 and odd numbered cover-boards in 2004.

Table 4. Percentage of totals for each cohort of Eastern Red-backed Salamanders found on the three highest count days during cover-board monitoring on the Lester Anderson lands on the Bristol/Lincoln border in Vermont (2001-2024).

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%
2022	0.00%	78.95%	20.3%
2024	0.00%	84.44%	14.44%
Average/Year	**1.38%**	**75.88%**	**22.22%**

[1]Salamanders escaped before measurements were taken.

Figure 5: Percentage of totals for each cohort of Eastern Red-backed Salamanders found on the three highest count days during cover-board monitoring on the Lester Anderson lands on the Bristol/Lincoln border in Vermont (2001-2024).



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 (Figures 6 and 7). 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. 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. In 2024, we identified three females with eggs (Appendix, photographs 1 and 2)

Figure 6: SV lengths for all Eastern Red-backed Salamanders found during cover-board monitoring on the Lester Anderson lands on the Bristol/Lincoln border in Vermont (2001-2024) n = 5004 captures.

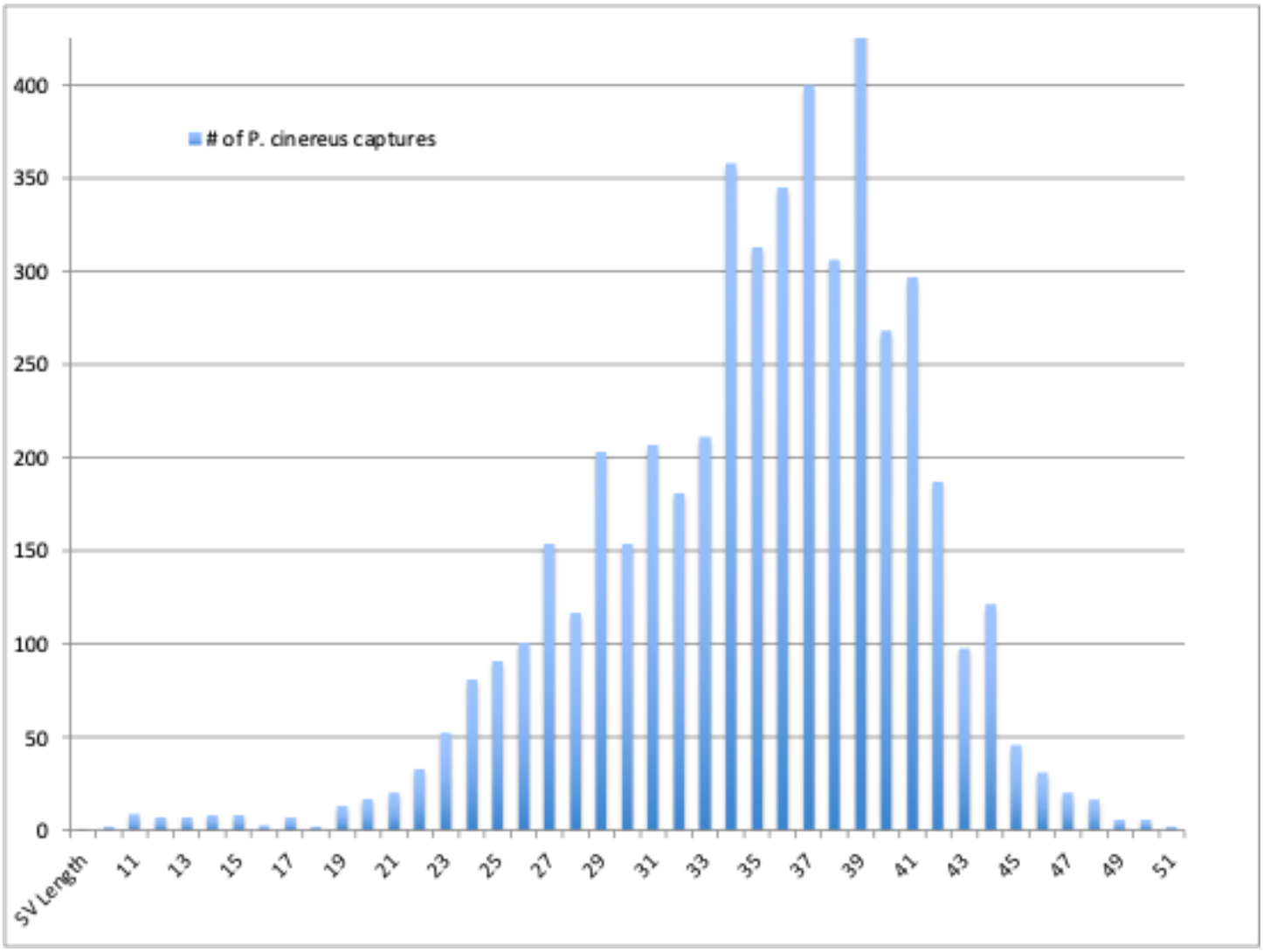
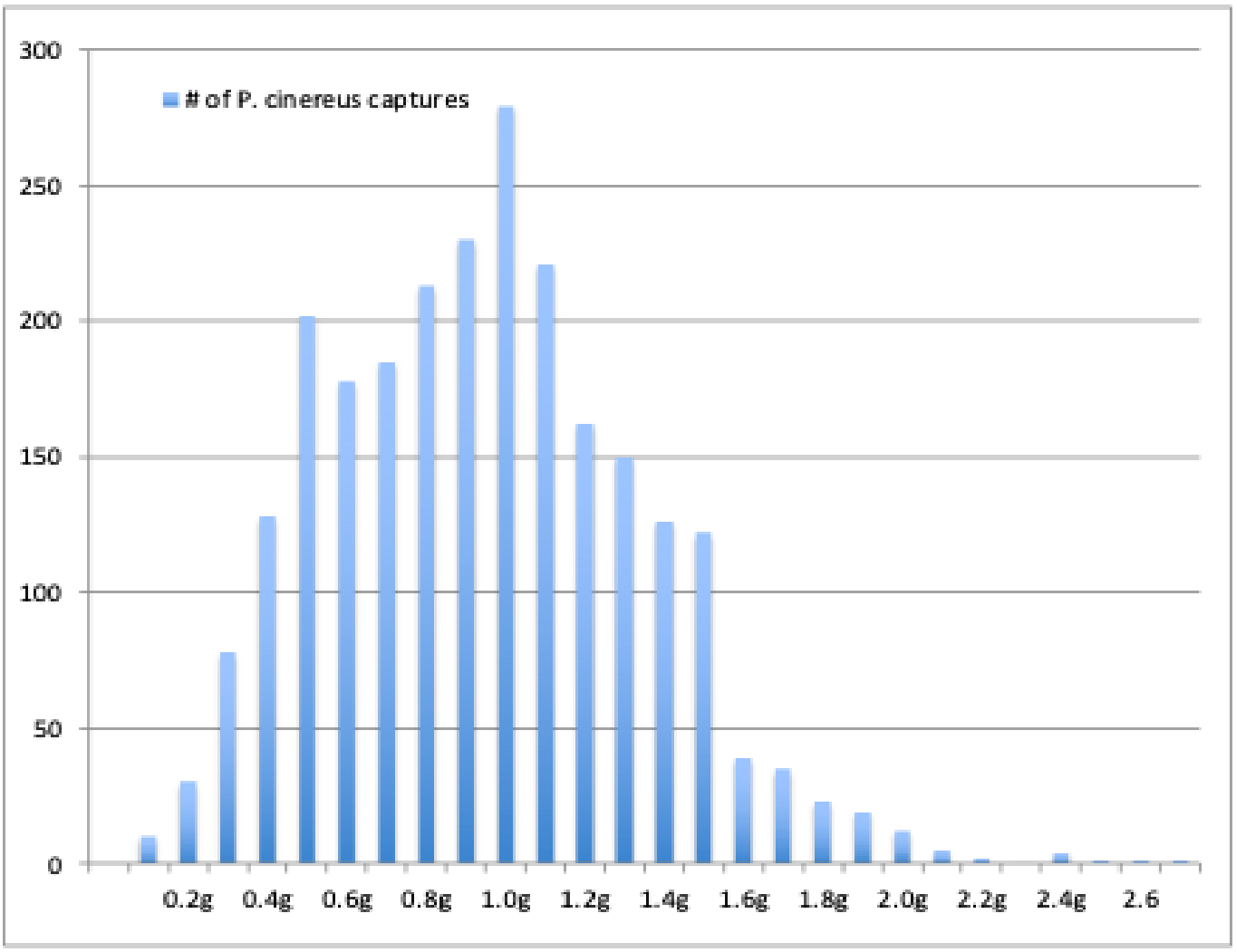
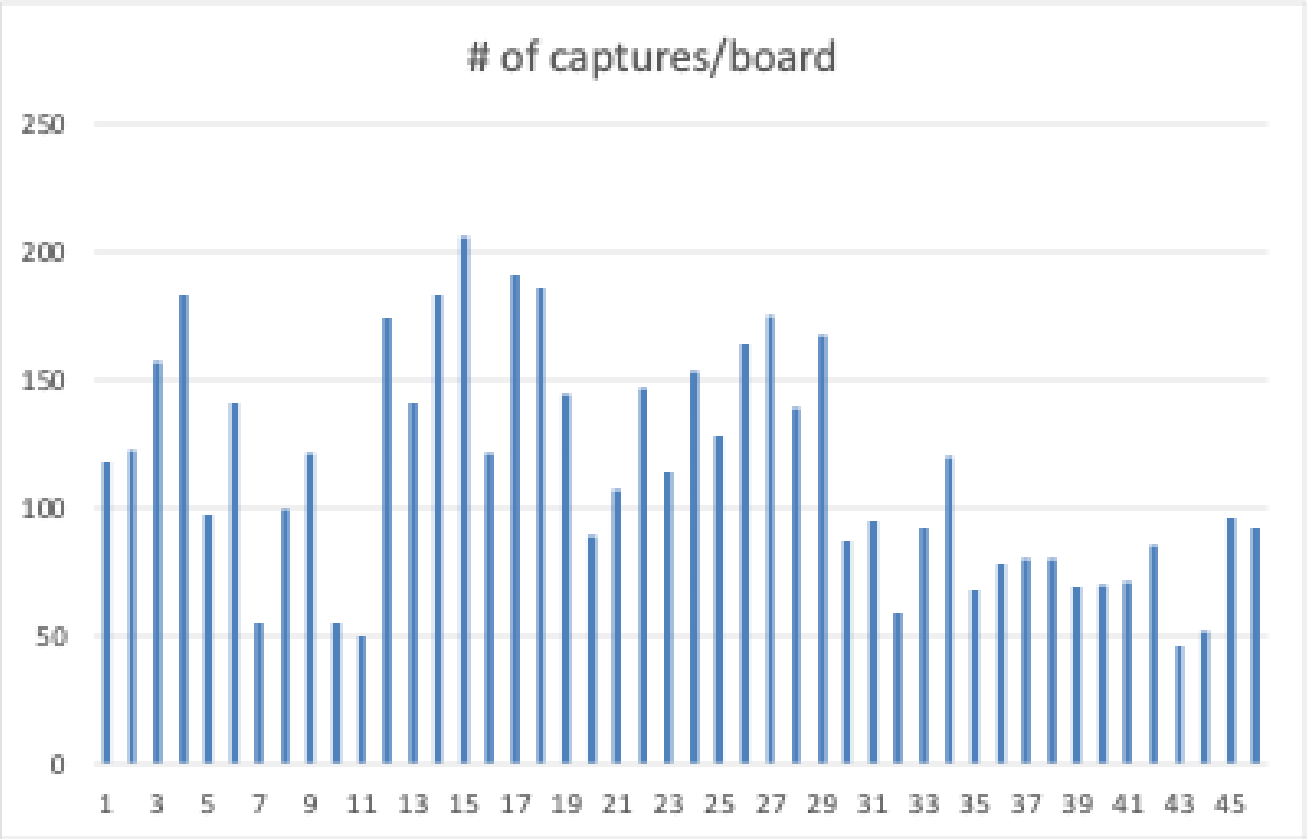


Figure 7: Mass in grams for all Eastern Red-backed Salamanders (for which mass was measured) found during cover-board monitoring on the Lester Anderson lands on the Bristol/Lincoln border in Vermont (2006-2024) n = 2456 captures.



We examined which boards are the most productive for capturing salamanders, and the number of captures varied throughout the transect (Figure 8). Future studies could look at soil moisture, soil composition, vegetation, the presence of invasive worms, and/or other factors that may influence the number of captures. We could also compare the numbers of captures by decade.

Figure 8: Number of captures Eastern Red-backed Salamanders found during cover-board monitoring on the Lester Anderson lands on the Bristol/Lincoln border in Vermont (2006-2024) by Board Number.



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 then declined precipitously until 2016. We then saw an increase again until 2022 followed by a drop in 2024. Overall, the number of Red-backed Salamanders at this site appears to be decreasing.

Notes on Other Species

Many invertebrates were found using the cover-boards. During the last few study years we have found: ant species, American cyanide millipedes, Black-legged Ticks, Bombardier Beetles, unidentified centipedes, camel crickets, orange-headed beetles, ground beetles, maple-leaf cutters, Canadian flat-backed Millipedes, other flat-back millipedes and unidentified millipede species, Monarch butterfly, bark larvae, Carolina Mantel Slugs, Winding Mantle Slugs, Western Dusky Slugs, slug eggs, unidentified spiders, and springtails. We noted a few earthworms but did not find invasive jumping worms.

We saw or heard: American Goldfinch, American Robin, American Woodcock, common raven, Common Crow, Black-billed cuckoo, Black-capped Chickadee, Black-throated Green Warbler, Black-throated Blue Warbler, Blue Jay, Broad-winged Hawk, Eastern Wood Peewee, Golden-Crowned Kinglet, Ovenbird, Pileated Woodpecker, Red-tailed hawk, Ruffed Grouse, Scarlet Tanager, White-breasted Nuthatch, Winter Wren, and Yellow-bellied sapsucker.

We also found signs of the following mammals: bear, coyote, fisher, human, and moose.

Future Study

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.

Our current schedule for all our monitoring on Anderson Lands is as follows: in the fall of 2025, we will monitor the snake covers. In 2026, we will monitor egg masses in the spring and salamander cover-boards in the fall. In early 2027, we will write a report on the egg-mass work and monitor the snake covers in the fall. In 2028, we plan to monitor the egg masses in the spring and the cover-boards in the fall. In early 2029, we will write a report on the snake cover data and monitor the snake covers in the fall.

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. Joel Andrews, Katy Arms, Chuck Clarke, Fabrice de Lacour, Matt Gorton, Matt Hallahan, Sarah Rackliff, Jeff Salisbury, Levi Smith, Cindy Sprague, and Jess Zulch, also helped at least once with data collection or on a maintenance day. 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 Photographs 1and 2: Candling for eggs within a Red-backed Salamander.

Appendix Photographs 3 and 4: Two recently hatched Red-backed Salamanders