Evidence for Arthropod Decline in Maine

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Executive Summary

This project assessed 17 historical collections of arthropod surveys (datasets) in Maine for evidence of decline in taxon richness (taxonomic groups such as species, genus, family, or order) and taxon abundance. Datasets were first investigated for their suitability to meet the objectives of assessing insect or arthropod decline over time in Maine. They incorporated surveys that ranged from 1-157 years in which specimens were collected and identified. The surveys also represented collections by 1 to several hundred surveyors in 1 to several hundred sites or locations. Eight datasets either did not encompass a long enough time series to provide evidence for statistical decline or the data was not in the correct format and needed major editing before analysis could be attempted. This left nine datasets that were used in an exploratory statistical analysis of faunal decline over time.

Overall, evidence of arthropod decline was found in Maine across several taxa ranging from moths and butterflies (Lepidoptera) and dragonflies (Odonata) to flower flies (Syrphidae in the order Diptera) and bees and ants in the order Hymenoptera. The taxa showing the least decline were cursorial spiders (class Arachnida) and aquatic benthic macro-invertebrates (several classes of arthropods and annelids). However, the decline in Maine does not appear to be as massive as that recorded by Hallmann et al. (2020) in Germany where a 60% decline in insect biomass has been documented. This report documents, in detail, the results of statistical analysis of the nine datasets of interest. A summary of findings are as follows.

1. The Maine Forest Service historical dataset contained the most diverse collection of arthropods. Twenty-two orders/subclasses of arthropods were represented by the long-term survey. Unfortunately, the time frame was from 1965-1998. Therefore, there were no recent records allowing an analysis of decline over the past two decades, a time when many scientists believe that major global insect declines started. However, the collection data did have accurate measures of sampling effort that could be used to adjust unequal effort between years. Therefore, the question posed in the analysis of this dataset was… did decline occur during the second half of the 20th century? Total arthropod abundance and species richness when all collected specimens were modeled, suggests that species richness during this time increased while total abundance showed evidence of decline over time (1967-1998). However, when only specimens collected in the adult stage were modeled, total adult arthropod abundance showed no evidence of decline or increase. Adult species richness, similar to when all records were modeled, showed evidence of an increase in species over time. A similar pattern was observed when each of 15 orders/subclasses (only 15 of 22 orders/subclasses had adequate sample sizes for modeling) were assessed for decline, 14 of 15 showed evidence of decline in abundance when all records (all life stages and unrecorded life stages) were used. None of the 15 orders/subclasses showed a decline in total adult abundance. This discrepancy in results depending upon the life stage modeled may be due to sample size,
being much smaller when only adults are modeled or it may have been due to several reasons as speculated in the discussion of the results for this dataset, such as a change in collecting protocols. Overall, widespread decline across all orders/subclasses is met with skepticism since the adult life stage modeling did not produce similar results. Therefore, it is not suspected that widespread declines occurred across all arthropod fauna in the later-half of the 20th century.

2. In forest moth species (n=191 species and morphospecies collected), 7 species showed evidence of decline in abundance while 6 were characterized by evidence of increase in abundance over time (1953-2020). All other species either were not sampled frequently enough to assess decline or provided no evidence of decline (n=26 species). Therefore, equal numbers of species appear to be in decline compared to those that are increasing in abundance throughout the state over time. This maybe a fairly typical situation of a taxa community in a steady state. A similar situation is common for the bee species community in northeastern North America (see Bartomeus et al. 2013).

3. Maine ants showed no decline in species richness between 1864 and 2011, but evidence was found for a decline in total abundance. In the last decade of the surveys between 1998 and 2011, evidence of a decline in species richness was also found, but not in total abundance. Four individual species showed a decline in abundance between 1998 and 2011 and four additional species were abundant and collected commonly between 1864 and 1953, but not between 1980 and 2011. Therefore, individual ant species appear to be suffering some decline in Maine.

4. Lowbush blueberry landscapes are common across Maine. Two herbivorous and one frugivorous native insect species were not found to have declined over 30 (1988-2017), 37 (1983-2019) and 53 (1961-2013) year sampling periods. However, two studies showed that native bees did show evidence of decline over time during 23 (1993-2015) and 27 (1989-2015) year sampling periods.

5. Flower fly (Family: Syrphidae) surveys showed decline in total abundance over the sampling period from 1882-2020, with the decline appearing to start in the 1970s. The number of species or species richness showed no evidence for decline from 1882-2020. When the most common species (n=24, relative abundance ≥ 1%) were investigated, 6 species showed evidence of decline and 1 showed evidence of increase.

6. Aquatic macro-invertebrates showed no evidence of decline in taxa richness (taxa are mostly genera) or total abundance over time with mixed models incorporating all sampling methods, water quality ranks, and stream reaches during the sampling period 1974-2019. Commonly abundant individual taxa (greater than 1% of total relative abundance) were also assessed when all sampling methods were used in modeling. Mixed linear models suggested that 3.6% of taxa were characterized by decline in abundance, whereas 8.1% of taxa increased in abundance over time. Data represented by standardized and replicated rock basket and rock bag sampling was considered the most reliable indicators of decline. Rock baskets showed increases in both overall total abundance and taxon richness. Investigation of individual taxa caught in rock baskets suggested 3.5% showed decline in abundance over time, but 4.8% of taxa increased in abundance over time. Rock bags showed no decrease in abundance over time, but a decrease in taxon richness over time. Of the common collected taxa in rock bags, 3.7% showed evidence of decline, but 2.9% appeared to increase in abundance over time. Therefore, the analyses suggest that the aquatic macro-invertebrate community showed minimal evidence of decline balanced by almost equal levels of increases in abundance.

7. Spiders showed no overall decline in total abundance and a marginal increase in species richness between 1975 and 2012. An analysis in four of the dominant habitats that were surveyed
was conducted. No evidence for declines in overall total abundance, species richness, or individual common species abundances were found in lowbush blueberry, pine, or salt marsh landscapes. Spruce forest understories were characterized by overall ground spider declines in total abundance and species richness. In addition, four commonly occurring species in the spruce forest understory were characterized by declines in abundance, only 1 species was observed to increase in abundance over time. Thus, spiders showed a minimal decline over time.

8. Dragonflies and Damselflies were sampled from 1881-2021 in Maine. A consensus of several analyses based upon differing proxies for sampling effort showed no overall long-term declines in total abundance or species richness of odonates (both dragonflies and damselflies). Dragonflies showed no evidence of decline in abundance, but some evidence of decline in species richness. A similar pattern was found in damselflies, no evidence of long-term decline in total abundance, but evidence of decline in species richness over time. Of 35 commonly occurring odonate species with relative abundances greater than 1% of the total abundance of the odonate community sampled, 25 species showed evidence of long-term decline. Assessment of more recent declines between 1995 and 2019 showed no evidence for decline in total abundance or species richness of odonates, but 8 of 34 commonly occurring species during this recent period showed evidence of decline. Several spatially rare species of dragonflies and damselflies (relative abundances much less than 1%) showed evidence of decline, but because of their infrequent detection over time and their occurrences at very low densities, these species are particularly difficult to assess.

9. Butterflies (121 species) were surveyed between 1864 and 2020. Overall total abundance showed no decline over time, but species richness did show a significant decline over time. Twenty percent (19 species) of species are listed as “of special concern” by the Maine Inland Fisheries and Wildlife Department. Three of the 19 species were only collected in 1 or 2 years between 1864 and 2020. These species are extremely rare in Maine. Ten (62.5%) of the 16 remaining species exhibited statistically supported evidence of decline and five species (31.3%) showed no evidence of decline. More recent butterfly surveys from 2007-2020 suggest that species richness has not declined, but total abundance has shown evidence of decline. Commonly abundant species (greater than 1% relative abundance) were also assessed over time for decline. Twenty-eight species were characterized by at least 1% relative abundance. Remarkable species congruence occurs between the abundant species over the entire historical survey period (1864-2020) and those from the more recent butterfly survey project period (2007-2020). Only 32.1% of the 28 species provided evidence of decline in abundance and only 2 of these species exhibited highly significant declines. It appears that decline did not occur strongly in recent survey periods, but more in the earlier survey years. This is probably why the list of common butterflies from 1864-2020 and the list from 2007-2020 are almost identical. One last conclusion that was arrived at, was when decline was assessed within individual towns, it was discovered that local dynamics between towns can be quite different. In one town a species may be in decline while in another town, the same species does not show evidence of decline. This is an important aspect of decline. What a statewide survey might reveal, averaging over all towns sampled might result in a different conclusion about insect decline than when analysis is conducted on a “town by town” basis, a more accurate assessment. The obstacle to such an analysis is that data is lacking on long-term repeated sampling over time in individual towns.