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OBSERVATIONS RELATIVE TO CLAIMS OF DISAPPEARANCE OF LILIACEAE AND ORCHIDACEAE IN CONCORD, MASSACHUSETTS, USA

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ABSTRACT

Historical evidence is reviewed in combination with field observations to evaluate the hypothesis that a disproportionate number of native species of Liliaceae and Orchidaceae have recently disappeared from Concord, Middlesex County, Massachusetts, and that this is attributable to climate change. The occurrence of the 16 native species of Liliaceae and 22 native species of Orchidaceae is reviewed. Only 3 of 16 Liliaceae species were formerly common and now possibly much less common or gone, while for Orchidaceae it is 6 of 22 species. Thus, the current study finds that evidence for any dramatic disappearance or decline in abundance in these families in Concord is weak. Further, a conclusion that only climate change has significantly affected the abundance of these 9 species is unwarranted, as many other causes in the Concord area are possible, e.g., reforestation, development associated with increasing population and suburbanization, degradation of water quality and air quality, predation associated with changes in animal populations, changes in land use, accidental burnings of woodlands, and spread of non-native plant species. In addition it is shown through historical examples, the author's observations, and comparison of floristic studies of the smaller Middlesex Fells Reservation, 10 miles distant from Concord, that determinations of what species are present in a local flora and of species abundances vary significantly.

In recent years dramatic claims have been made about mass extinction of native species in Concord, Massachusetts, particularly in certain families such as Liliaceae and Orchidaceae (Primack et al. 2009; Willis et al. 2008). The supposed disappearances have been attributed to climate change. This note reviews historical evidence and the varied experience of observers, present and past, to dispute those claims.

The most extensive floral explorations of Concord have been done by a long line of amateurs dating back to the early 19th century, even before the most prominent of these amateurs, Henry Thoreau (Eaton 1974). In the early 21st century a few professional botanists have undertaken surveys of parts of the town flora to evaluate a possible effect of climate change.

The following is a summary of historical sources for frequency of occurrence of plant species in Concord:

> Henry David Thoreau (1817-1862). Thoreau studied the flora of the town most intensely from 1850 through 1860. Although he did not record frequency of occurrence for all the species he found, he wrote copious botanical observations about Concord plants and their localities in his Journal. In addition he collected a sizable, well-organized herbarium of pressed plants of approximately 1000 specimens, including many from his trips outside of Concord. Unfortunately, other than for the difficult groups of Poaceae and Cyperaceae, data other than identity is absent for most of these. While the frequency of occurrence for species in Concord can be estimated to some extent from the number of references in his Journal (using, for example, my botanical index to his Journal (Angelo 1984)), this is problematical without examination of the context of such references. For example, the rare *Lygodium palmatum* (Climbing Fern) known then and now from only one locale in Concord is referred to approximately 20 times in his Journal, which is more than

the approximately 14 references in his Journal to *Comandra umbellata* (Bastard Toadflax), which Minot Pratt, Alfred Hosmer, and Richard Eaton all have agreed is common or very common.

Minot Pratt (1805-1878). Pratt was a Concord resident and friend of Thoreau, with whom he shared botanical information. Pratt lived in Concord from about 1845 until his death. He appears to have botanized throughout that time judging from references to him in Thoreau's Journal and the date of one of the only known herbarium specimens he collected in August 1872. He did not study all vascular plant groups in Concord as did Thoreau, but he did leave an impressive manuscript list of Concord plants (Pratt 1878) that includes most plant families with frequency of occurrence, habitat, and some specific locales for uncommon species. He did not maintain a herbarium, at least not one that has survived, so that the accuracy of his identifications cannot be assessed. However, some of his frequency information agrees with my personal experience more so than does Thoreau's, Hosmer's, or Eaton's for some distinctive species. Thus, it is likely he knew some parts of the flora better than his contemporaries and successors. Pratt is known to have introduced a number of species into Concord, mostly from Vermont and other parts of Massachusetts, and he noted most of them in his manuscript. None of the studies of species loss in Concord should include these introductions, as some have done, for example, in the preliminary list of missing Concord plants given to me by Primack and Miller-Rushing in 2007.

Alfred Winslow Hosmer (1851-1903). Hosmer was a life-long resident of Concord who apparently took up the study of botany about the time of Pratt's death in 1878 and pursued it primarily between 1888 and 1903, judging from the phenology data in his notebooks. Hosmer (like Pratt) did not study all plant families. Hosmer's notebooks (Hosmer 1903) extend to the year of his untimely death. Many more herbarium specimens collected by him survive than do Pratt's, but many fewer than Thoreau's and with little data other than identity and town of collection, typically Concord. Hosmer's manuscript notebooks provide flowering dates year-by-year (but unlike Thoreau, no record of locale for each date nor indication of whether at onset or peak or end of flowering), frequency of occurrence, and locales for some uncommon species. The problem with using Hosmer's notebooks for frequency of occurrence information is that they are not limited to Concord. The title of the notebooks says "Concord, Mass. and vicinity" and locales given for some species are in neighboring towns, such as Sudbury, Acton, and Lincoln. Frequency of occurrence is not necessarily the same for neighboring towns. For example, Thoreau, Pratt, and Eaton all agree that there was but one location in Concord for *Chamaecyparis thyoides* (Atlantic White Cedar). Yet Hosmer in his notebooks stated that this species was rather common. This discrepancy is understandable when one knows that extensive colonies of *Chamaecyparis* occur to this day in neighboring Sudbury and Bedford. Thus, use of Hosmer's frequency information must be approached with much caution when applying it strictly to Concord.

Richard Jefferson Eaton (1890-1976). Eaton was born and raised in Concord and botanized there from about 1920 until about 1970. He studied all vascular plant families. Through his long active membership in the New England Botanical Club, where he interacted with professional botanists, and through his 13 years as curator of the extensive NEBC vascular herbarium housed at Harvard University, he developed an expertise in plant identification that easily matched or surpassed all others who have studied or are studying Concord's flora, amateurs and professionals alike. His herbarium collections of Concord plants are the most extensive and contain the best information (habitat, locale, date of collection). Near the end of his life he published the most comprehensive account of the flora of the town to that date (Eaton 1974). His flora includes for each species: frequency of occurrence in Concord, habitat information, reference to a voucher specimen, and in some cases particular locales.

Recent studies of parts of the Concord flora and of another more limited area in eastern Massachusetts (Middlesex Fells Reservation) attempt to measure changes in species numbers in those floras. Two of these studies relate claimed changes in Concord to climate change:

(Drayton and Primack 1996). Drayton studied the flora of the Middlesex Fells Reservation, an area about 20% the size of Concord and located approximately 10 miles east of Concord. Drayton surveyed between 1990 and 1992, confining his study area to approximately 40% of the reservation and excluding ferns, graminoids, and aquatic plants. The findings, compared to results from an 1895 survey, resulted in a claim that 155 taxa were lost. Hamlin et al. (2012) noted that this paper has been cited widely for its conclusion that many taxa had been lost in the study area.

(Primack et al. 2009). In this study Primack and some of his students studied Concord's flora between 2003 and 2007. The study omitted about one third of the flora on the basis of difficulty in identifying the species in the field. It concluded that 27% of the species (native and introduced) seen by Thoreau could not be located and an additional 36% persist in only one or two populations where they are vulnerable to extinction. In addition, 20% of the 347 species seen by Edward Jarvis (1803-1889), as noted in his copy of Bigelow's (1824) "*Florula Bostoniensis*," are claimed as no longer occurring in Concord; 24% of 479 species seen by Hosmer similarly were no longer found; and 30% of 723 species seen by Eaton were no longer found in Concord. The study also asserted that in the past four decades (since Eaton's flora) that there has been a net loss of species (236 missing and 82 species gained). The authors assert that the losses appeared to be have been sustained mostly in the prior 30-40 years, with losses in certain groups, such as orchids, being particularly severe. The article noted that the manuscript of Pratt was not analyzed since his observations were claimed to overlap those of Thoreau and Hosmer. In fact, Pratt died only 16 years after Thoreau, and Hosmer's work concluded in 1903, 40 years after Thoreau's death, when changes in the Concord landscape due to reforestation were well underway.

(Willis et al. 2008). This study analyzed data for 473 Concord species (native and introduced) as noted by Thoreau, Hosmer, and Miller-Rushing, and Primack. Species were scored on such factors as changes in abundance, habitat, flowering time response to temperature (ability to track short-term seasonal temperature changes and shifts over long-term intervals), mean latitudinal range of the species, and native vs. introduced status. Among the results of the study was the observation that decrease in abundance was disproportionately high in certain families such as Asterales, Lentibulariaceae, Ranunculaceae (in part), Cornaceae, Liliaceales, Lamiaceae (in part), Orchidaceae, Saxifragaceales, and Malpighiales. The study further claimed that because the families particularly affected were the ones whose flowering times were not responsive to temperature change, that they were the ones whose abundance will be most affected by climate change.

(Hamlin et al. 2012). This work reported the results of a more intensive study of the entire Middlesex Fells Reservation over the period 2003 to 2011 by four principal investigators. In comparing the portion of the reservation studied by Drayton and Primack (1996), Hamlin et al. found 718 species of vascular plants (478 native), whereas Drayton and Primack found only 331 species (244) native, almost double the number of native species within the same study area. Equally striking was the comparison with the 1895 study of the reservation when the results of the Hamlin et al. (2012) study area were reduced to best fit the older study. Hamlin et al. found a total of 851 species (552 native, 299 introduced) while the 1895 study found a total of 680 species (570 native, 110 introduced). In summary, *there has been comparatively little change in the total number of native species* (only 18 fewer species), while the number of introduced species nearly tripled (189 more species).

In the late 1970s and early 1980s I lived in and explored the flora of the town almost daily during the growing season and found a number of native plants thought to have disappeared (3 of 12 native species listed by Eaton (1974) as "Extirpated"). Much as Thoreau in *Walden* (1854, p. 20) with his lost hound, bay-horse and turtle-dove, I was still on the trail of the other so-called extirpated species at the time I left Concord. In 2007 I checked on a small sample of species, determined by my physical ability to reach stations where I had seen them, claimed to be missing by Richard Primack of Boston University and his student, Abraham Miller-Rushing, who were studying the Concord flora. All but one of those species that I was able to revisit were still where they had been and in about the same abundance. These were not the only stations in town where I had seen them and not the stations with the most plentiful quantities (that I could no longer reach). Primack (pers. comm.) dismissed my findings of the continued presence of the given species, noting mainly that there were too few plants and thus they were practically extinct, as if these were the sole locales for the species in Concord. However, I found no compelling evidence for mass disappearance in Concord in the previous 30 years, contrary to the conclusion of Primack and his students (Primack et al. 2009).

I have intimate familiarity with the records of the key amateur botanists of Concord's past who left written information on their finds (Thoreau, Pratt, Hosmer, Eaton), and in late 2012 I set about compiling a detailed online flora of Concord that would summarize and compare their observations with my own from my notes and from my herbarium vouchers (see Angelo 2014). In the course of that work I noticed that the native Liliaceae and Orchidaceae of Concord are not disproportionately disappearing, even accepting for the sake of argument that particular species may no longer be present. As these two families are among those claimed to be experiencing loss of species, I did some simple counting to check on my sense of this.

The historical record (Angelo 2014) shows that 16 native species of Liliaceae *sensu lato* have been found in Concord (nomenclature for the two families is from Angelo and Boufford 2000):

**Allium canadense* var. *canadense* (Wild Garlic)
Clintonia borealis (Yellow Clintonia)
Hypoxis hirsuta (Common Stargrass)
Lilium canadense (Canada Lily)
Lilium philadelphicum (Wood Lily)
Maianthemum canadense (Canada Mayflower)
Maianthemum racemosum subsp. *racemosum* (False Solomon's-seal)
**Maianthemum stellatum* (Star-flowered False Solomon's-seal)
**Maianthemum trifolium* (Three-leaved False Solomon's-seal
Medeola virginiana (Indian Cucumber-root)
Polygonatum pubescens (Small Solomon's-seal)
Trillium cernuum (Nodding Trillium)
**Trillium undulatum* (Painted Trillium)
**Uvularia perfoliata* (Perfoliate Bellwort)
Uvularia sessilifolia (Wild-oats)
Veratrum viride (White Hellebore)

Five species in the list above (with asterisk) were rare or merely occasional in Thoreau's time, and the inability to relocate them now would not be a fair measure of disappearance. The list is thus reduced to only 11 species, a very small sample size. The following are still common and relatively easy to find: *Hypoxis hirsuta*, *Maianthemum canadense*, *Maianthemum racemosum* subsp. *racemosum*, *Medeola virginiana*, *Polygonatum pubescens*, *and Uvularia sessilifolia* (personal observation and Cherrie Corey, pers. comm. 2014). However, I did find *Clintonia borealis* and *Veratrum viride* in my physically limited visits in 2007, so that these are not truly gone and most likely occur at other Concord sites that I could not revisit. This is confirmed for *Veratrum* by Cherrie Corey,

a Concord resident and naturalist, who reports "*Veratrum* grows abundantly and with vigor throughout many of the wet seeps in Estabrook Woods … Last year I saw it somewhere else too," (pers. comm. 2014). Eaton (1974), who most extensively documented the flora of Concord, recorded *Veratrum* as common and *Clintonia* as frequent. This accords with my experience in the 1970s and 1980s. Thus, 7 of the 11 species are still common, and, if in fact *Clintonia* has significantly declined in frequency, it is a very precipitous decline within the period of only 20 years, unlikely due to climate change. This is because the northeastern USA increase in mean temperature per decade after 1970 was 0.5 degrees Fahrenheit (Northeast Climate Impacts Assessment 2007), while the geographical range of *Clintonia borealis* is from northern Georgia to Labrador, where a significantly greater difference in mean temperatures occurs. Far greater temperature fluctuations also occur in Concord year-to-year.

This leaves possibly 3 species formerly common that are either gone or much less common, *Lilium canadense*, *Lilium philadelphicum*, and *Trillium cernuum*. I was unable to verify the recent status of these three species, all of which I saw when I lived in Concord. Eaton stated in 1974 that *Lilium canadense* was common, *Lilium philadelphicum* was frequent but scarce, and *Trillium cernuum* was uncommon, which accords with my experience in the 1970s and 1980s except that I found *Lilium philadelphicum* to be occasional, and scarce where it did occur. *Lilium philadelphicum* requires dry, open habitats, habitats which have been vanishing in Concord. Hamlin et al (2012) also reported that *Lilium* populations are under strong impacts from herbivory by Scarlet Lily Beetles and White-tailed Deer, which could account for a reduction in their populations.

If in fact these 3 Liliaceae have disappeared, it has happened mostly in the period of 20 years which would suggest reasons other than climate change for the reasons noted above. The disappearance claim for Liliaceae disappearing in Concord thus revolves around the uncertain status of only 3 out of 11 native species that were common in Thoreau's time, which is an insignificant sample size to draw conclusions, and the likelihood of causes other than climate change is significant.

The historical record (Angelo 2014) shows that 22 species of native Orchidaceae have been found in Concord:

Arethusa bulbosa (Arethusa)
Calopogon pulchellus (Grass-pink)
**Corallorhiza maculata* (Spotted Coral-root)
Cypripedium acaule (Pink Lady's-slipper)
Goodyera pubescens (Downy Rattlesnake-plantain)
**Goodyera* x *tesselata* (Checkered Rattlesnake-plantain)
**Isotria verticillata* (Large Whorled Pogonia)
**Liparis liliifolia* (Large Twayblade)
**Liparis loeselii* (Loesel's Twayblade)
**Platanthera blephariglottis* var. *blephariglottis* (White Fringed Orchis)
Platanthera clavellata (Green Woodland Orchis)
**Platanthera dilatata* var. *dilatata* (Bog Candle)
**Platanthera flava* var. *herbiola* (Tubercled Orchis)
**Platanthera grandiflora* (Large Purple Fringed Orchis)
Platanthera lacera (Ragged Orchis)
**Platanthera orbiculata* var. *macrophylla* (Large Round-leaved Orchis)
Platanthera psycodes (Small Purple Fringed Orchis)
Pogonia ophioglossoides (Rose Pogonia)
Spiranthes cernua (Nodding Ladies'-tresses)
Spiranthes lacera var. *lacera* (Northern Slender Ladies'-tresses)
Spiranthes lacera var. *gracilis* (Northern Slender Ladies'-tresses)
**Spiranthes ochroleuca* (Yellow Ladies'-tresses)

Again, to meaningfully assess disappearance since Thoreau's time those species rare or occasional in his time should be recognized (with asterisk). This leaves 11 species formerly more or less common, a small sample size. Of these 11, *Cypripedium acaule* and *Goodyera pubescens*, both dryland species, are still common or frequent and easy to find (Cherrie Corey, pers. comm. 2014). Of the remaining 9, I observed in Concord in the early 1980s *Platanthera psycodes*, *Pogonia ophioglossoides*, and *Spiranthes cernua* but only at very few locations. Eaton (1974) noted *Platanthera lacera*, *Spiranthes cernua*, and *Spiranthes lacera* var. *lacera* as still common or frequent. Thus, of the 11 native species formerly common in Concord at least 5 were still common in 1974. Of the remaining 6 species, 3 (*Arethusa bulbosa*, *Platanthera psycodes*, and *Pogonia ophioglossoides*) were particularly common in Thoreau's time in river meadows that became seriously polluted in Concord in the 1930s according to Eaton (1974), resulting in significant changes to the river meadow flora after that time. Two others (*Calopogon pulchellus* and *Platanthera clavellata*) of the remaining 6 are primarily found in bogs and swamps where their decline might also be associated with water quality issues since Thoreau's time. In summary, while there is perhaps a better case for disappearance of native Orchidaceae formerly common in Concord than for Liliaceae, the sample size is small and the likelihood of causes other than climate change is significant.

Determining the presence, absence or frequency of occurrence of a given species in a sizable tract of land at a given time is not an easy or simple task. My study of what the historic Concord botanists were able to find or failed to find in Concord after their years of careful exploration reveals surprising differences from species to species. One of the most dramatic differences is for the relatively easily recognized fern, *Phegopteris connectilis* (Long Beech Fern). Pratt (1878) said that it was common, while Thoreau did not mention this species at all in his Journal and had no specimen of it in his herbarium. Hosmer (1903) noted its occurrence at only one swamp in Concord, while Eaton (1974) included it in his list of rare species for which the current status was unknown. Yet, in the late 1970s and early 1980s I found this fern plentiful in at least six localities that were clearly natural for this species.

This raises the issue of the ability of field biologists to find plants. Experienced botanists know that some people are more skillful at this than others. The ability depends on acuity and experience as well as on the search intensity and on being at the right place at the right time. A large, very showy population of *Castilleja coccinea* (Painted Cup) escaped the notice of the keen-eyed Thoreau until he happened upon it on May 8, 1853, at age nearly 36, prompting him to remark in his Journal that "It is wonderful what a variety of flowers may grow within the range of a walk, and how long some very conspicuous ones may escape the most diligent walker, if you do not chance to visit their localities in the right week or fortnight, when their signs are out." A more quantifiable, recent example of the variation among different investigators, arriving at significantly different results for plants in a given area is the case of the flora of the Middlesex Fells Reservation, as noted above. This flora was studied in 1993 leading Drayton and Primack (1996) to claim that 155 plant taxa had been lost. Yet Hamlin and his co-authors (Hamlin et al. 2012) who searched the same area of the Middlesex Fells Reservation over a longer period found that 105 (68%) of those putatively "lost" species were not missing. Equally important is that in the 15 month period following the impressive 2012 study, *new native species and additional locations for rare or uncommon species continue to be found* in the Middlesex Fells Reservation. Hamlin and Kittredge (2013) reported that 22 new plant taxa were found, of which 9 are native, and that new locations for 67 less common taxa were found. Different results will ensue depending on the investigator and intensity of investigation. Based upon all that has been pointed out above it is a contention of this article that no person or small group of persons can accurately measure in a limited span of time the entire extent of a flora the size of a town such as Concord or even of a much smaller area such as the Middlesex Fells Reservation, where such a diversity of habitats exists.

Finally, as noted in more detail in the introduction of my online Concord Flora, changes undoubtedly have occurred in the flora and vegetation of Concord since Thoreau's time, since it is part of a huge, extremely complex, integrated, dynamic ecological system constantly evolving in time. Enormous changes have clearly occurred in the landscape of Concord from Thoreau's time to the present, including areas currently under protection, due primarily to reforestation (a regional phenomenon), development associated with increasing population and suburbanization, and spread of non-native plant species. Key botanical hot spots have been ruined since Thoreau's time by construction or landowner "improvements" (e.g., Clamshell Hill by Route 2, a four-lane highway, and the fabulous *Ledum* Swamp by drainage and cutting by a succession of owners). In addition there surely are a myriad of other changes that are less visually apparent — degradation of water quality and air quality, predation associated with changes in animal populations (not just deer, but both vertebrate and invertebrate and microbial), disappearance of pollinators, changes in land use (such as, using woodlands for firewood, decline of and change in types of farming), radiation changes associated with changes in the atmosphere, climate change, significant accidental burnings of woodlands (such as the one of more than 300 acres beside Fairhaven Bay caused by Thoreau and Edward Hoar in 1844, for which many townsfolk remembered Thoreau for decades rather for than any of his writings, and the one in Walden Woods in the 1930s that destroyed one of the last, or the very last, colony of *Linnaea borealis* (Twinflower) in Concord according to Eaton (1974)), and factors not even thought of. Simply documenting and measuring changes in native plant populations in Concord is problematic in itself, but assigning a cause or causes to purported changes would require multidisciplinary studies of the numerous complex ecological processes at play in order to determine their effects on plant population dynamics.

The world's climate undoubtedly is changing, and the local climate of Concord is changing with it, indicated by earlier flowering and leaf-out times in the area (Ellwood et al. 2013). The study by Willis et al. (2008), however, does not appear to document the effect of climate change on the Concord flora. Their conclusion is directly predicated on the premise that species presence and abundance in certain plant groups is significantly declining, which is challenged here for Liliaceae and Orchidaceae, two of the groups for which they found decline but for which better sampling shows the continued presence and abundance of the species. The assumption, essential for the recent mass disappearance studies of Concord, that it is possible to gauge with sufficient accuracy the degree of presence of particular vascular plants species at certain points in time, is seriously questioned by a review of historical records of the most experienced Concord botanists.

"Absence of evidence is *not* evidence of absence." -- Carl Sagan (1997, p. 213).

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