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NEW ENGLAND BOTANICAL CLUB 120TH ANNIVERSARY RESEARCH CONFERENCE PRESENTATIONS

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More than 160 botanists, ecologists, and plant enthusiasts from the eastern US and Canada came together to showcase their research and enjoy camaraderie at Smith College (Northampton, MA), June 5–7, 2015. They also convened to celebrate the 120th anniversary of the founding of the New England Botanical Club, one of the country's oldest such organizations. Eight botanical organizations and publishers staffed display tables with a wealth of information on their activities and research initiatives. Several members and officers of other botanical organizations also met at Smith College's Ada and Archibald MacLeish Field Station to share ideas about how to keep their organizations vibrant and relevant in a world increasingly alienated from nature. Six field trips were made to botanically rich sites around the Connecticut River Valley. It was a very lively gathering!

Here, we reprint the abstracts of the 21 oral and 16 poster presentations given at the conference (these are also available online, along with videos of talks, at www.rhodora.org/conference2015). Presenters included a diversity of researchers: graduate and undergraduate students, professors, conservation biologists with non-profits and government agencies, and many others. Topics were similarly diverse, spanning the wide range of disciplines that the rich field of "botany" *sensu lato* encompasses. Speakers discussed exciting new projects to develop and compare floras of particular regions or habitats such as lakes, ponds, and rivers; regional-scale analyses of species affinities and rarity status; the ecology, demography, and life history of vascular plants and fungi; the capacity for native and invasive plants to respond and adapt to stressors such as climate change, serpentine soils, and the advent of invasive herbivores; the roles of herbaria and paleoecological studies in reconstructing how the flora has changed over time; and exciting

new initiatives to digitize plant collections and use them for teaching a new generation of botanists. New observations and insights into plants were reported from field studies, monitoring programs, and laboratory experiments.

The featured keynote speaker was renowned plant biologist, Dr. Pamela Diggle, Editor-in-Chief of the *American Journal of Botany*, Past President of the Botanical Society of America, and professor at the University of Connecticut. Working from genes to the whole organism, she studies the evolution of morphological diversity among plants, with particular emphasis on understanding how features of development shape the dynamics of evolutionary change. She also delves into the history of botanical societies, and this was the focus of her talk, which ranged from the mid-1700s to today and beyond: "Learned Societies—Past, Present, and Future?" She asked, why are physical gatherings of scientists still so important, in an age of skype, twitter, and Facebook?

Clearly, the June conference demonstrated how significant and enlivening such gatherings can be. They allow everyone, but especially people outside of—or just entering—academe to display their discoveries, network with others, see new and fascinating hotspots of plant diversity, and move the field forward.

ORAL PRESENTATIONS SUMMARIES

For each paper, the name of the oral presenter is underlined.

Not out of the woods yet: Wild blueberry illustrates that flower removal studies have a ways to go to get mechanical

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Abstract: The consequences of initial variability in reproductive effort on later pollination and fruit development have frequently been investigated with flower removal experiments. Often, plants produce many fewer fruits than flowers, so flower removal might not be expected to alter subsequent growth or development patterns all that much. Yet, many studies have demonstrated such changes even for species with low average fruit set, which begs for an explanation. Many (at least seven, by our count) such explanations have been reported in the literature, but experimental support for

most is limited. In summer 2014, we conducted a field experiment on a lowbush blueberry (*Vaccinium angustifolium*) farm in Maine. In this experiment, we coupled flower removal with three other treatments, each designed to assess the validity of one of three often-cited hypotheses invoked to explain why growth and development changes occur following flower removal: 1) "Short-term nutrient shortages;" 2) "spatiotemporal limitations;" and 3) "the compound interest effect." The three respective treatments—foliar nitrogen fertilization, positionally biased flower removal, and defoliation—were designed to either intensify or weaken the apparent effects of flower removal if the corresponding hypothesis had merit. As in a 2013 preliminary experiment, flower removal elicited several statistically significant growth and development changes in blueberry, including increases in final leaf area, ripe fruit weight, fruit ripening rate, and relative fruit production. The additional treatments also elicited several significant plant responses, though not always with concomitant flower removal effects as well. For example, fertilization generally increased fruit cluster mass by harvest, but flower removal itself had no such effect on cluster mass. Most observed interactive effects between flower removal and the additional treatments either ran counter to expectations, were limited in scope, or couldn't be unambiguously interpreted. For at least a few observed changes, none of the additional treatments significantly altered the effects of flower removal. We conclude that current hypotheses for the mechanistic basis for changes induced by flower removal are inadequate, at least for blueberry, a species with frequently low fruit set even when managed commercially. However, strong intellectual and economic imperatives exist to encourage further investigation into this open question.

Horticultural escape and naturalization of *Magnolia tripetala* (L.) L. north of its native range will give tree species a 'head start' on climate change

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Abstract: Plants grown in horticulture or occurring as adventives outside their native range can provide insight into species' fundamental niche requirements that might not be evident from the native range, or realized niche, alone. Such occurrences can also identify conditions that support individual survival, but do not currently sustain positive population growth (i.e., a species' 'tolerance niche'). Further, in the context of rapid climate change, horticultural and adventive occurrences beyond current range edges might circumvent natural dispersal limitations and facilitate species range shifts. To explore these concepts in the field, we investigated the history and structure of five newly discovered populations of naturalized *Magnolia tripetala* near horticultural sites in western Massachusetts, USA. This tree species is native to the southeastern US, but has been grown horticulturally in the Northeast since the 1800s. However, naturalized populations had not been well documented in the region previously, raising the possibility that the species' escape has been triggered by recent climate change. With tree coring and life stage surveys, we asked whether the naturalized populations exhibited synchronous patterns of establishment and expansion, suggestive of climatic release and a shift from tolerance niche to fundamental niche conditions in the region. Across the five sites, we documented 660 individuals, with populations ranging in size from 46 to 396 individuals, including seedlings, saplings, and reproductive trees. Although horticultural specimens of *M. tripetala* have been present near the sites for many decades, the adventive populations showed clear evidence of recent, synchronized escape and naturalization. Dated tree cores from the 10 largest adventive *M. tripetala* at each site showed the average age of establishment was 22.8 years (~1991), with the individual population means falling in a narrow range from 20.6 to 25.3 years (~1989–1993). Three older trees (35–45 years) in 3 of the 5 populations suggested rare establishment of individuals prior to 1980s, but most individuals (88–96%) were seedlings and smaller saplings that have established since the 1990s. Recent escape from old horticultural plantings is allowing *M. tripetala* to rapidly colonize newly-suitable habitat in the northeastern US, ~300 km beyond its native range. Recent climate change appears to have released the reproductive potential of horticultural trees that had existed under 'tolerance niche' conditions for many decades, resulting in vigorous new naturalized populations. It is unlikely that natural dispersal from the south would have allowed *M. tripetala* to reach this region anytime soon.

Patterns and changes in the flora of Franklin County, Massachusetts

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Abstract: We initiated a systematic examination of the flora of Franklin County, Massachusetts, in 2010. This geologically and topographically diverse county is home to many rare species, yet no floristic treatment has ever been published. Knowledge of the historical flora came from examination of all Franklin County specimens in herbaria at several institutions, especially the University of Massachusetts and Harvard University, along with several sources in the published and unpublished literature. Thus far, we have compiled 17,400 herbarium records and 8,300 literature records. Knowledge of the current flora comes from 500 field visits occupying a total of 1,500 hours, broadly distributed over seasons and habitats, and including an average of 19 visits to each of the county's 26 towns. The 33,500 field records include an average of 680 species per town, with several of the towns in the Connecticut River Valley having the greatest species richness. Three regions (the Connecticut River Valley and the uplands to the east and west) show distinct floristic profiles. Towns in the western uplands are more likely to contain taxa of rich mesic forest, such as *Asarum canadense*, *Dicentra cucullaria*, and *Carex plantaginea*. Connecticut River Valley towns are more likely to support floodplain species (e.g., *Acer saccharinum*, *Quercus bicolor*), species with southern affinities (e.g., *Q. palustris*, *Benthamidia florida*) and certain nonnative taxa. The eastern uplands are more likely to support several species of peatlands and ponds, reflecting the greater frequency of such habitats east of the Connecticut River Valley. Although the greater sampling intensity of our recent surveys has resulted in greater recent than historical species lists for most towns, certain taxa show fewer town records today than in the past, especially members of the Orchidaceae and Ophioglossaceae. The percentage of non-native species ranges from 20-27% in different towns and, in part, reflects patterns of recent land use. Mean flowering times of spring-flowering species have advanced by an average of about a week between the historical (pre-1980) and recent

periods, with greater increases among species flowering earlier. In species that have been adequately sampled, the magnitude of the flowering advance in different species is correlated with the amount of advance found in a recent study in neighboring Worcester County.

Examination of pollen profiles and frequency distribution of diatom species, found in 8500 years of peat at Poutwater Pond, Holden, Massachusetts

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Abstract: Poutwater Pond is a "National Natural Landmark." We have listed plants and animals found there and we have collected a core from the peat bog. This core has been radiocarbon dated and pollen, diatoms, other microfossils, and some bacteria have been isolated from the core. The frequency of pollen grains at different depths of the bog (i.e., different ages) tells what trees grew nearby during the past 8,500 years. Differences in diatom species present at different depths may indicate changes in acidity. Microfossils were examined in detail with a scanning electron microscope. Pollen and diatom frequency diagrams have been constructed to show the distribution of common taxa since the last retreat of the ice age. These data were used to deduce fluctuations in climatic conditions that may have occurred at this site during the Holocene, as well as to infer changes in pH.

Keynote Address: "Learned Societies" – Past, Present, and Future?

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The formation of "learned societies" began in the mid-17th century and played a central role in the establishment and practice of modern science. I will explore the history and evolution of

learned societies from the establishment of the Royal Society for the Improvement of Natural Knowledge in London in 1663 and the American Philosophical Society in pre-revolutionary Philadelphia, to the emergence of the diverse "professional and regional societies" of today. From their very inception as venues for conversation and presentation of new ideas, learned societies have played, and continue to play, essential roles in fostering scholarly interactions and communication, and in disseminating research. I will conclude by considering the future relevance of learned societies in our increasingly digital age. Given that we can all upload our talks to YouTube, download publications instantaneously, and be in constant contact via multiple electronic means, why have we come to this meeting? And what does the future hold for learned societies, such as those invited to this conference.

State of the Plants: Challenges and opportunities for conservation of the New England flora

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Abstract: New England Wild Flower Society recently released a comprehensive, peer-reviewed report that, for the first time, gathers together the most up-to-date data on the status of plants on the New England landscape. From these data, we can discern increases and declines in both rare and common species across all six states. We identify hotspots of rare plant diversity, and discuss factors that foster this diversity. We document the primary ecological and anthropogenic threats to both rare and common species. We discuss activities and initiatives by New England Wild Flower Society and its partner organizations in the New England Plant Conservation Program to conserve and manage rare plants and habitats throughout the region. We articulate a research agenda to bridge gaps in our knowledge of plant species and ecological communities and develop a framework for protecting the viability of thousands of species that together comprise our diverse and vibrant flora.

Local adaptation to environment is observed from genome-wide SNP data in *Populus balsamifera*

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Abstract: *Populus balsamifera* has a large geographic range, and local populations occupy distinct locations along strong environmental gradients of climate and photoperiod. Range-edge populations, particularly southern populations, may contain high levels of standing genetic diversity and harbor unique alleles adapted to longer, warmer, and drier growing seasons—environments that may become more widespread in the future. At the same time, southern populations are likely to be at greater risk of extirpation from climate change. In this study, we characterize the population structure and diversity of southern range-edge versus range-core populations, and identify genomic regions associated with local adaptation. We analyzed 534 individuals collected from 63 core and range-edge populations, and obtained genome-wide SNP data from >150K loci using genotype-by-sequencing at 48-plex. Population structure was estimated using Bayesian clustering (fastSTRUCTURE) and discriminant analysis of principal components (DAPC). Tests for local adaptation manifest as F_{ST} outliers and SNP-environmental associations were estimated with Bayescan, BAYENV, and LFMM. We find genomic regions suggesting novel, locally adapted loci in range-edge populations that likely contribute to their fitness in warmer, drier environments. Loci adapted to longer growing seasons and warm, dry environments may be useful for integrating into poplar breeding programs under future climates.

Adaptation, performance, and host-resistance: *Tsuga* spp. research in the Northeast

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Abstract: Exotic insect pests of importance, including Hemlock Woolly Adelgid and Elongate Hemlock Scale, have taken their toll

on *Tsuga canadensis* populations, causing widespread decline and mortality of the species throughout southern New England and the mid-Atlantic. In addition to its value as a forest tree, *T. canadensis* is also treasured as a landscape planting—both as a hedge and a specimen tree. For more than 10 years, local researchers have been exploring host resistance to invasive insects using *Tsuga* specimens from other parts of North America and around the world; this research has also included the study of human perceptions and attitudes regarding the acceptance of non-native *Tsuga* in the landscape.

Potential effects of Eastern Hemlock decline on the hemlock-associated liverwort, *Bazzania trilobata*

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Abstract: *Bazzania trilobata* is a leafy liverwort species that often occurs in association with *Tsuga canadensis* (Eastern Hemlock) in New England. The impending loss of hemlock due to the invasive insects *Adelges tsugae* (Hemlock Woolly Adelgid) and *Fiorinia externa* (Elongate Hemlock Scale) raises concerns about the future of this ecosystem and species that might be dependent on its unique conditions, such as *B. trilobata*. Ecological changes already observed in this system include the replacement of evergreen Hemlock with deciduous *Betula lenta* (Black birch) canopies, shifts that are known to increase light exposure and raise temperatures, possibly putting light- and moisture-sensitive understory species at risk of decline. Similar environmental impacts might also be occurring in this system through the forest management technique of salvage logging hemlocks prior to their death due to exotic insects. To test the likely response of *B. trilobata* to these environmental changes, and the species' reliance on hemlock forests, we initiated a multi-year transplant experiment testing survival and growth across a range of physiographic settings and under forest canopies of varying hemlock vs. deciduous tree species composition at Smith College's MacLeish Field Station in western Massachusetts. By exposing *B. trilobata* to a range of novel conditions relative to its natural habitat, we can begin to consider the importance of hemlock to this liverwort. We also executed

a second transplant into a recently logged site to consider the potential impacts of salvage logging. Results from the initial transplant suggest that *B. trilobata* can generally survive in areas with modest hemlock canopy decline and mesic forest floor conditions, but declines at both the drier and wetter ends of the soil moisture gradient should be examined. More strikingly, solar radiation levels, as determined by local slope and aspect, emerged as a significant predictor of plant decline, raising the possibility that hemlock canopy thinning and death might eventually expose *B. trilobata* to unsuitable, higher light conditions on sites other than north-facing slopes. Nevertheless, preliminary findings from the salvage logging experiment suggest that the vigorous growth of early successional herbs and shrubs might protect *B. trilobata* from excess light and bleaching.

Transatlantic connections: Marsh floras and vegetation along the gradient from freshwater to ocean salinities along the Elbe (northern Europe) and Connecticut (northeastern North America) Rivers

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Abstract: Relationships between the flora and vegetation of northern Europe and the northeastern United States have been long noted but little studied. Here, quantitative sampling of high, low, and mid-marsh zones was carried out in 20 marshes along a gradient from non-tidal freshwater, via tidal freshwater and brackish to salt marshes in each of two large river systems, the Elbe in Europe (Germany) and the Connecticut in North America (southern New England, USA). Overall, species richness was higher in the Connecticut marshes, where the number of species was more than 22% higher than along the Elbe. Species richness declined in both streams along the gradient from non-tidal freshwater to tidal freshwater, brackish and then salt marshes. Only European salt marshes had a slightly higher species richness than their Connecticut equivalents. Twenty-four species occurred in both stream systems, nearly 10% of the total marsh flora. Shared species were

found in all four marsh types and occasionally in more than one marsh type. Introduced taxa are not prominent in either river system except for *Spartina anglica* in the salt marshes and *Acorus calamus* in the non-tidal freshwater marshes of the Elbe and *Typha angustifolia* and *Phragmites australis* in the brackish marshes along the Connecticut. Overall, Asteraceae and Poaceae were the largest (most species rich) families in the marshes of both streams. The vegetation of each marsh type in each stream system is briefly described and possible reasons for differences in species richness, non-native species occurrences and the origin of marsh floras are discussed.

Pigeon peas and pawpaw: Frederick Pursh's plants of Onondaga

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Abstract: For this project, I drew from Frederick Pursh's northern journal of 1807 to create a list of plants observed by the botanist during his four-month stay in the Onondaga Lake area, central New York State. This research is part of a larger initiative to inform the recovery of Onondaga Lake, a major Superfund site, and surrounding lands. Pursh's notes provide insight about plant communities around the lake and the physical setting supporting those plants before the ravages of major industrialization. The objectives of this project are: to list plants Pursh found in the Onondaga and Oswego area; to assign each plant a confidence index indicating likelihood that I have listed the same species Pursh actually saw; to use the plant list thus compiled to make inferences about early Onondaga Lake habitats; and to extract from the journal data regarding the physical and biocultural setting in the Onondaga Lake area during this time. I listed plant names in a spreadsheet, updating nomenclature based on the International Plant Names Index and The Plant List. To reflect the uncertainty inherent in field identification, I assigned each species a confidence rank (from 1–5) based on nomenclature recognition, voucher presence, habitat aptness, and other criteria. The final list of about 280 species includes rare plants, weeds, wetland and aquatic plants, timber, medicines, and more. The

plants recorded tell us not only about the land, but also reflect changes in land stewardship (from indigenous to Euro-American) in central New York following the American Revolution.

Shifting conservation focus from species occurrence to habitat forming process: The importance of lateral channel migration to persistence of floodplain forest plant populations

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Abstract: Much of the regulations and activities for the conservation of rare or threatened species or communities have traditionally focused on the protection of known occurrences. This approach has led to positive conservation outcomes as far as past occurrence is a reliable indicator of habitat suitability into the future, which is often the case. A notable exception to the long-term success of this paradigm is when species rely on ephemeral habitats. We argue that in such cases, conservation focus should shift toward conserving the processes that create the ephemeral habitats. We will illustrate the need for a process-focused approach to conservation with research from the Connecticut River on floodplain forests, a community type that is ranked as imperiled by many state natural heritage programs in the region. In particular, we show how floodplain forest succession is initiated by lateral channel migration and associated formation of bars and oxbows. Subsequent sediment deposition and erosion creates topographically heterogeneous floodplains with diverse successional habitats, where differences in flood regime act as an ecological filter on species composition. We will draw on results from recent research at over 100 floodplain forest research sites located throughout the Connecticut River basin to support our case. This research includes analyses of historical aerial photos, hydraulic models, dendrochronology, vegetation transects, and other field research.

The impact of invasive Honeysuckle removal on Black-legged Tick density in an exurban residential setting

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Abstract: *Ixodes scapularis* (Black-legged Tick) is the vector for *Borrelia burgdorferi*, the bacteria that causes Lyme Disease. Elucidating the ecological dynamics of the Black-legged Tick will clarify geographical patterns in Lyme Disease and aid in its management and control. Black-legged Ticks have expanded their range in recent decades, bringing *B. burgdorferi* with them. Our study examined the relationship between *Lonicera tatarica* (Tatarian Honeysuckle) and the Black-legged Tick. Tatarian Honeysuckle is a non-native shrub that invades open forests and fields and crowds out native species. Our study adds to a growing body of research regarding the relationship between ticks and invasive shrubs. We surveyed ticks in two plots, a treatment plot in which Tatarian Honeysuckle was removed and a paired control plot. The density of Black-legged Tick larvae was significantly lower in treatment vs. control plots. Adult and nymphal densities were similar in both plots. Factors that may explain the large reduction of larvae numbers, but not adult numbers, are microclimate, animal transport, and the timeline of the study. The long-term effectiveness of the treatment will depend on whether adult ticks re-establish larval densities in future years, or whether fewer larvae leads to fewer adults. Our results have implications for the extent and duration of invasive species control that might be required by homeowners wishing to limit exposure to tick-borne pathogens.

Combining incidence and demographic modeling approaches to evaluate metapopulation parameters for Furbish's lousewort (*Pedicularus furbishiae*)

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Abstract: Furbish's lousewort (*Pedicularis furbishiae*) is a rare plant endemic to the St. John River that has been continuously monitored since 1976. Metapopulation dynamics are thought to be important for the persistence of *P. furbishiae*; however, estimating key parameters such as colonization rates presents a substantial obstacle to modeling metapopulations in any species. We develop a model that combines incidence-based and demographic-based approaches to build a relationship between

observed patch occupancy, habitat turnover rates, and colonization rates. Applying this model to *P. furbishiae*, we predict that observed habitat patches averaging 550m in length receive colonizing seedlings with a yearly probability of 0.4 (95%; CI = 0.2 – 0.6). Although the predicted colonization rate rests on several simplifying assumptions, the overall model allows us to understand the impact that increasing rates of habitat turnover would have on the future survival of this species.

The historic flora of Franklin County MA, 1811–1990: Major collectors and collection patterns

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Abstract: To develop a historical flora of Franklin County, Massachusetts, we searched herbaria at the University of Massachusetts (MASS), Harvard University (HUH), Smith College, Michigan State University (MSC), and the Henry M. Flynt Library of Historic Deerfield. We found at least 14,893 specimens collected between 1811 and 1990 by 512 individuals or collecting teams, with 25 individuals or teams collecting at least 150 specimens. The collection effort started early, with a third of the 26 towns in the county represented by 1830. Major peaks of collection activity occurred from 1900 to 1939, and from 1950 to 1989. There were two smaller peaks between 1817 and 1821 and in the 1870s. The earliest collectors were physicians. Dr. Dennis Cooley and Dr. Stephen West Williams of Deerfield account for the peak in collection prior to 1820, with 515 specimens. Other early physician collectors include Dr. George Peirce from New Salem, whose 271-specimen herbarium was collected between 1839 and 1850. It was obtained by C. A. Weatherby, remounted and deposited in the New England Botanical Club (NEBC) Herbarium. In the 1870s, the largest collectors were H. G. Jesup (325 specimens), subsequently Professor of Natural History at Dartmouth, and Elizabeth H. Perry (137 specimens), a teacher in Conway who received botanical training at Mount Holyoke College. Other collectors in this period were at

Amherst College or the Massachusetts Agricultural College. About 53% of all Franklin County historic specimens were collected between 1900 and 1939. From 1900 to 1909, major collectors included W. D. Forbes of Buckland, students or faculty at the Massachusetts Agricultural College, and members of NEBC, most notably F. F. Forbes, R. A. Ware, and E. F. Williams. Between 1910 and the early 1920s, the field days of the NEBC organized by M. L. Fernald, C. H. Knowlton, and F. G. Floyd made impressive contributions to the historical flora. Participants on these trips in May of 1912, 1913, 1915, and 1921 were organized into teams and sent out to collect everything identifiable. From the late 1920s and into the 1930s, most of the collecting efforts were headed by A. S. Pease and A. S. Goodale of Amherst College. The latter was working on a flora of the Connecticut River watershed and also collected from areas to be flooded by the Quabbin Reservoir. In addition, W. E. Manning, then at Smith College, contributed 257 specimens. Collecting increased again after WWII (1950-1989) due largely to the faculty and students of the University of Massachusetts (particularly H. E. Ahles), Smith College, and Bruce Sorrie of the Massachusetts Natural Heritage and Endangered Species Program. However, the largest single collection of this, or any period, was by Roberta G. Poland, physics instructor at Deerfield Academy. Between 1945 and her death in 1989, Poland collected 3,069 specimens, mostly from Deerfield. These collectors—amateurs, professionals, and students—shared a passion for collecting and for placing their specimens in herbaria. They created a rich historical record that now may be used for research.

Changes in the vascular plant diversity of the Monomoy Islands, Massachusetts

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Abstract: The objective of the present study was to determine changes in species diversity at Monomoy National Wildlife Refuge, Massachusetts, and to compile an inventory of the island's vascular flora. Collecting trips were made to the two islands during the

growing seasons of 2010 to 2012 for the purpose of collecting and preparing voucher specimens. The vascular flora of the Monomoy Islands comprises 73 families, 199 genera, and 284 species, of which 225 species (79%) are native and 59 species (21%) are non-native. Flowering plants (Division Magnoliophyta) comprise the majority of the flora and account for 65 families, 172 genera, and 271 species (dicots: 50 families, 142 genera, and 178 species; monocots: 15 families, 30 genera, and 93 species). There are five conifer (Division Pinophyta) species in two genera and two families, and six fern (Division Polypodiophyta) species in five families and six genera. Club-mosses (Division Lycopodiophyta) are represented by *Lycopodiella appressa* and horsetails by *Equisetum arvense*. The largest families are Asteraceae (27 genera, 40 species), Cyperaceae (8 genera, 32 species.), and Poaceae (19 genera, 31 species). The largest genera are *Carex* (13 species), *Juncus* (11 species), and *Eleocharis* (6 species). The islands' active geological history and human habitation in the 19th and 20th centuries have had an impact on the flora here.

Herbarium treasure hunt: Botanical consortium portals as teaching tools for undergraduate research

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Abstract: The increasing availability of herbarium specimen data and images on-line through botanical consortium portals (e.g., Consortium of Northeastern Herbaria, Macroalgal Herbarium Consortium, Consortium of Bryophyte Herbaria) has obvious applications for research in systematics, floristics, and ecology. The ability to rapidly search collections from one or more herbaria allows for broader and quicker access to specimen data, and the ability to define search parameters by factors such as geography, habitat, and time period provides a powerful tool for addressing questions about floristic diversity and biogeography in light of climate change and human impacts. By introducing students to these herbarium consortium portals new interest is generated in herbaria, and in the traditional lab exercise of the herbarium

treasure hunt—searching the collections for specimens in order to answer questions about plant morphology, habitat, distribution, and phenology. Once students understand the kinds of information available from specimens, and the capabilities of the portals, they will be able to participate in more extensive class projects that utilize and possibly add to existing portals. Examples include: compiling a flora of College Woods, a 250 acre University of New Hampshire property used for research, instruction, and recreation; tracking changes in the macroalgal flora along Maine's indented coastline; assessing the threat of invasive species in select habitats; refining georeference coordinates for plant specimens from targeted sites. Ultimately, the students may incorporate these resources in research of their own design.

Digitization of the New York Botanical Garden Herbarium

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Abstract: The William and Lynda Steere Herbarium of the New York Botanical Garden contains about 7.5 million specimens. We began to database specimens in the late 1980's, with the result that today we have information and/or images available through our Virtual Herbarium website for approximately 2.5 million specimens. Due to the availability of funding through the National Science Foundation's Advancing Digitization of Biodiversity Collections program, we are now digitizing specimens at the rate of about 30,000 per month. Sensing that we have nearly maximized the rates we can achieve using manual methods, we are currently considering adopting an industrial approach that will allow us to complete the digitization of the rest of the herbarium within a reasonable timeline. Freed from the need to focus solely on the digitization process, we could begin to think about the wide range of uses to which these data could be deployed for biodiversity studies and conservation. Outreach to potential stakeholders for these data is not just a New York Botanical Garden issue, but is one that the nationwide digitization effort is grappling with as well, and we are hoping that synergy from this effort will help all collections to find the users who most need their data.

Herpomyces chaetophilus, a new record of Laboulbeniales for North America

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Abstract: The Laboulbeniales are an order of microscopic fungi (phylum Ascomycota, class Laboulbeniomycetes) that obligately parasitize arthropod hosts. They are ectoparasites; they occur externally, on the cuticle of the host. Study of Laboulbeniales can give insight into the life history of their arthropod hosts and the community dynamics of host-parasite interactions. Since insects disperse with their parasites, there is potential for infection of local hosts by infected introduced insect species. *Herpomyces chaetophilus*, found on the American cockroach (*Periplaneta americana*), is a new record of Laboulbeniales for North America. Cockroaches were collected around the Harvard University campus through sticky traps and hand collections. Parasite prevalence was greater than 95%. Sometimes a double infection was reported, with both *H. chaetophilus* and *H. periplanetae* on the same host specimen. Molecular analysis of the rDNA region confirms that these are two separate species. The behavior of *P. americana* may be a key factor to the high infection prevalence with *Herpomyces* spp. The American cockroach prefers moist, dark, and enclosed locations especially during aggregation. Since cockroaches are living together in large numbers, two conditions are fulfilled for continuous infections with Laboulbeniales fungi: (1) Laboulbeniales tend to thrive in moist to damp places and (2) heaviest infections are usually found in densely-populated, older colonies.

The highly invasive grass _Brachypodium sylvaticum_ – a candidate for early detection/rapid response in eastern North America?

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Abstract: *Brachypodium sylvaticum* is a grass native to Eurasia that is known to be highly invasive in parts of North America (NA).

Land managers in the Pacific Northwest where it has been established since the 1960s, are actively researching and controlling this species. In eastern NA, it is less well known and has yet to become a high priority for invasive control programs. This is the case even though it is naturalized in New York (since ~1998), Michigan (since 1984), Ontario (since 2011), and Virginia (since 1992). At one known high quality botanical area in western New York it is has become widespread and dominant. At that site it appears to be degrading the habitat and may be causing a decline in the rare plants that occur there. The main purpose of this presentation is to raise awareness and knowledge about this species in eastern NA, and to encourage invasive plant managers to implement an "early detection and rapid response" protocol. We discuss the history of the species in eastern NA, including details regarding the known populations in New York. We suspect that it may be more widespread than is known. We researched the climate and habitat preferences of *B. sylvaticum* in its native range and it appears that much of eastern NA may be suitable for it. In eastern NA, *B. sylvaticum* has demonstrated great ecological amplitude, growing in deep shade to full sun, in wet to mesic soils, in successional to mature forests, and even in old fields. We provide evidence that this species has been in cultivation from as early as 1933 (1949 in NA) although primarily in botanical gardens. In 2011, at least one eastern NA company offered seeds for sale. We present information on identification of the species and note earlier misidentifications, which have included *Elymus* and *Festuca*. In gross appearance, it superficially resembles a species of *Bromus*. Distinguishing characteristics include its generally pendulous spike-like inflorescence which has 3–12 very short-stalked ($\leq$2 mm long) spikelets each with $\geq$5 florets; lemma awns 7–15 mm long; pubescent culm nodes; and leaf blades mostly 5–12 mm wide.

Plants of Maine's lakes and rivers

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Abstract: Maine has over 6000 lakes and ponds, and hundreds of miles of rivers and streams. There are 137 species in 50 genera in 31

families of submerged, floating, and open-water emergent, vascular plants (not including ferns and mosses) that have been found in them. Rooted below water surface, at the edge, fringe, 78 species in 47 genera in 27 families, have been found. Three trees and shrubs, 11 ferns, 21 mosses, 3 non-vascular genera, and 29 plants that might be seen in the waters, add to the listing. Five plants are tagged as invasive, and 14 are rare. Based on the surveys of more than 200 entire lakes over 20 years by dozens of state and federal government botanists, professional consultants, and volunteers, species lists average a little over 20 (alpha diversity) per lake (maximum nearly 100) and are influenced by the size of the lake (or perimeter). There is little influence due to elevation (not statistically significant), and no statistically significant correlation with ecoregion, climate, water chemistry, or latitude. However, the local prevalence of several species is influenced by elevation and latitude (presumably climate) and water chemistry, especially alkalinity (and closely related conductivity and pH). We propose a hierarchical botanical classification system of the lake plants, starting at the whole lake (northern and southern types, with northern types further divided into calcareous and mountain), each lake type having specific indicator species. Drilling down the hierarchy, coves (in large lakes, bays then coves within them) and "sectors" or "sections" between coves usually hundreds of meters long in the littoral zone, classified by the name of the dominant plant(s) within the respective cove (as may be observed by a quick pass-by in a canoe or kayak); down to communities (assemblages) usually no more than a few hundred meters' extent of a contiguous collection of plants; down to individual "patch", "stand", or "colony", mostly a monoculture of one or at most a few species. Communities usually have several stands within them immediately adjacent to each other, with a nearly sterile strip separating communities. The Maine Natural Areas Program classification has six lake communities, and we propose expanding that to include a "deep littoral" or "deep-water bed" community of water depth usually two meters and more, absent of floating and emergent plants, dominated by *Potamogeton robbinsii*, *Nitella* spp., *Chara* spp., and *Elodea* spp. Data analysis methods include logistic regression, ordination (canonical correspondence analysis, de-trended correspondence analysis, non-metric multidimensional scaling), cluster analysis using dendrograms, and "heat maps." We propose a new metric for aquatic plant density, species

richness divided by lake size, a simplified SPAR (species-area relationship). We have noticed that lakes with a denser littoral zone have more species, but this proposal needs to be validated. Obstacles to the study of botany on Maine's lakes and rivers include missed species, light shimmer on the water surface interfering with the ability to see the plants, need for more professionals to survey more entire lakes, need for more well-trained volunteers, and more plant records in herbaria.

Bud set in temperate woody species: Variation in dormant bud size across species and range, with implications for springtime phenology

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Abstract: Investing in developing a bud before the winter cold may provide competitive or other fitness benefits to temperate woody species during spring leaf-out. However, increased investment in bud development also constitutes increased risk of resource loss to cold damage. Despite this interesting potential trade-off, there is relatively little known about the contents of dormant buds, especially in regard to the inter- and intra- specific variation in bud resource investment. This study presents multiple metrics to assess the resources that woody species invest in their buds via size, mass and developmental phase of leaves and flowers. We then examine the variation in this investment across 27 species (from genera including *Acer*, *Betula*, *Corylus*, *Fagus*, *Ilex*, *Populus*, *Prunus*, *Quercus*, and *Viburnum*, among others) and range (sampling from Harvard Forest, MA, USA and Saint Hippolyte, QC, Canada). Finally, using phenological data from growth chamber clipping experiments, we compare bud investment with relative time of bud burst to evaluate whether the level of investment is related to springtime phenology. Our results suggest there is dramatic variation across species in their investment in overwintering buds, which may influence how species balance risk and reward in cold climates.

POSTER PRESENTATIONS

It's all in the timing: Answering short term research questions while establishing a long-term phenology study

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Abstract: Phenology offers insights into species' response to climate change. Shifts in phenology can disrupt ecological processes including: exposure to spring frost, availability of leaves for herbivorous insects, increase risk of seed predation, plant-pollinator interactions and seed production. Nantucket Island, Massachusetts is host to unique species assemblages including coastal shrubland, heathland, and the globally rare sandplain grassland communities. Species-specific responses to climate changes could result in alterations to these rare habitats. In establishing a long-term phenological research program at the Linda Loring Nature Foundation, we focus on native shrubs characteristic of these plant communities. Whereas we recognize the benefits of a long-term data-set, we begin by asking short-term research questions to 1) justify the expense and labor to our funding agencies, board of directors, and constituents, 2) offer educational opportunities to our community, and 3) provide a base for student research projects. To accomplish these goals, we established eight plots across our study site with multiple individuals of each of our 10 study species present. In addition to recording phenological observations 2–3 times per week, loggers record hourly temperature at each plot location. Initial questions include: What are the main phenophases of the common, woody shrubs of the coastal heathland community? How do small differences in temperature (imposed by topography) affect the timing of these phenophases among plots and years? How do these differences vary among species? At the early stages of this phenology program, we have been able to identify the main phenophases of 10 of our common, native shrubs characteristic of the Nantucket coastal heathland communities. Among our plots, even slight variations in topography have resulted in temperature differences of up to 10°C. These temperature differences have had species-specific effects; some shrubs show more synchronous annual bud burst regardless of within-season temperature variation

(*Morella caroliniensis*, for example). Other species, such as *Gaylusaccia baccata*, show asynchronous bud burst spanning a 10-day period with leaf-out highly correlated with minimum spring temperatures. These preliminary results provide a base for a long-term research program. Additional years of data will help illustrate potential plant species' responses to changing temperatures. Differential climate sensitivities have implications for the assemblages of shrub communities in these threatened systems with predicted warmer temperatures. If future communities leaf out and/or flower in novel assemblages, pollinator-mediated interactions may be altered and plant reproductive performance could be impacted.

The Conservator—A modern flora for Martha's Vineyard

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Abstract: In 2002 the Polly Hill Arboretum in West Tisbury, MA received their first herbarium collections and set out to document the flora of Martha's Vineyard. Today, working with Island land conservationists, the Arboretum houses nearly 3000 specimens with plans to build a new education center and botany lab in September, 2015.

Nietzsche was right: Multiple cycles of drought training strengthens *Phaseolus vulgaris* L. tolerance to drought stress

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Abstract: Common beans (*Phaseolus vulgaris*), including kidney beans, are a major crop in Africa. However, drought is a large threat to bean crops, especially in developing countries. Greater than sixty percent of bean crops will be negatively affected by drought at some point in their development. An important question is: Can a novel approach to drought: training plants using multiple controlled cycles of dehydration and recovery, result in plants that

have greater tolerance to extreme drought stress? In this study, it was hypothesized that multiple training cycles (ranging from 1 to 4 cycles) of moderate drought (soil moisture 20%) followed by rehydration recovery (soil moisture 50–60%) and maintenance (soil moisture 40–50%) will improve the red kidney bean (*Phaseolus vulgaris* L.) plant's ability to withstand subsequent extreme drought stress (soil moisture 10%). Four experimental groups of bean plants (groups B, C, D, and E) were subjected to varying numbers of drought training cycles (1, 2, 3, and 4 cycles, respectively) followed by extreme drought stress, and then four dependent variables (height, leaf area, bean pod yield, and stomatal density) were compared to those of a control group (group A). Each additional cycle of drought training was associated with increasingly greater values in all four variables. Average height for groups A, B, C, D, and E were as follows: 37.2 cm, 41 cm, 43.2 cm, 43.6 cm, and 47.8 cm, respectively. Average total leaf area was: 390 cm^2, 450 cm^2, 511 cm^2, 525 cm^2 and 541 cm^2, respectively. Total bean pod yield was: 8, 10, 13, 13, and 17, respectively. Average stomatal density was: 433/cm^2, 661/cm^2, 689/cm^2, 1023/cm^2, and 1093/cm^2, respectively. A one-way analysis of variance (ANOVA) test comparing stomatal density among the five plant groups found $p < 0.0001$ and $F = 62.38$. Drought-trained bean plants showed substantial evidence of increased tolerance to drought stress. Plant height, leaf area, bean pod yield, and stomatal density improved with each additional drought training cycle. These results may have potential implications for increasing crop yield in drought-stricken countries.

A new population of *Triphora trianthophora* (Orchidaceae) in western Massachusetts

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Abstract: In August 2014, I discovered a new population of approximately 1200 flowering stems of the rare and endangered three-birds orchid, *Triphora trianthophora*, in Williamstown, MA. Plants were found in deep litter trapped in the pits of old tip-up mounds and an abandoned woods road running cross-slope through the population. The present forest composition and

inferred land-use history suggest a novel suite of disturbances which created the requisite habitat, and even possibly through which the orchid persevered. The poster describes the novel stand composition, including important discrepancies with other known occurrences and the strong evidence of repeated and intensive natural and anthropogenic disturbances, namely wind-throw and timber harvest.

Are *Achillea millefolium* and *Hypercium perforatum* locally adapted to serpentine and granite outcrops on Deer Isle, Maine? A greenhouse study on ecotypic differentiation of two common herbaceous plants

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Abstract: Changing environmental conditions influence the survival and reproductive fitness of locally adapted species because their site-specific adaptations can lead to habitat specialization. Long-term selection on certain morphological and physiological traits associated with local habitat conditions can give rise to the evolution of ecotypes. This study explores the relative effects of lithology and genetic differences on reproductive fitness and timing of fall and spring phenology for *Achillea millefolium* (yarrow) and *Hypericum perforatum* (St. John's wort) populations found on serpentine and granite outcrops on Deer Isle, Maine. Seeds were collected from ten mother plants of similar age and health from comparable microhabitats at both sites. To test effects of substrate on reproductive fitness and ecotypic differentiation, a reciprocal transplant experiment is currently being conducted in a Conviron growth chamber using field-collected soils. Data on individual plant attributes such as germination, growth rates, above- and below-ground biomass, survival, phenology, and reproductive fitness are being collected. The experiment also investigates the edaphic-climatic influences on plant phenology (leaf drop in the fall, leaf-out and flowering in the spring-summer) of these populations at the two sites. Researchers and six citizen scientists tagged and monitored leaf drop and leaf color change in Fall 2014 and monitored leaf-out and flowering times in Spring 2015. Microchip temperature loggers (iButtons) were installed to record differences in temperature between the serpentine and granite outcrops. Outcomes of this

study include evidence for possible local adaptation of *A. millefolium* and *H. perforatum* to granite and serpentine soils in a greenhouse setting and possible evidence of flowering time differences between these species at the serpentine and granite sites. Our findings are important to better understand the mechanisms that promote evolutionary change and assess how special edaphic floras may respond to future changes in climate.

Effects of multiple interactive global change factors on the introduced common reed, *Phragmites australis*

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Abstract: Multiple interacting global change factors such as elevated CO_2, nitrogen, and sea level rise modify the growth of plant species in different ways and, consequently, alter ecosystem function. These global change factors can induce species shifts and enhance the productivity of native or introduced species. An introduced lineage of the common reed, *Phragmites australis*, was introduced from Eurasia and has invaded wetland habitats spanning the North American Atlantic Coast. Both nitrogen pollution and elevated CO_2 are known to facilitate the spread of the invasive reed, however, little information exists on how these global change factors will interact with sea level rise. Our objective was to determine how nitrogen pollution, elevated atmospheric CO_2, and relative sea level interact to affect *P. australis* productivity in the current and near future environments. To evaluate this, a mesocosm experiment was conducted in a brackish estuary on the Rhode River of Chesapeake Bay, at the Smithsonian Environmental Research Center's Global Change Environmental Research Wetland. Six marsh elevation platforms (used as a method for manipulating sea level relative to marsh elevation), each consisting of six different sea level treatments were distributed across six open

top chambers with either ambient or elevated levels of CO_2. Half of the replicates received nitrogen treatments and half did not. Aboveground productivity was estimated each month between June 2010 and September 2010, with a destructive harvest in October. We report a differential response among a multitude of these interacting global change factors, including significant treatment effects in the sea level rise by nitrogen by elevated CO_2 plots. Nitrogen pollution by ambient atmospheric CO_2 treatments increased aboveground productivity the greatest under high levels of inundation. The data supports a hierarchical response to global change factors, with sea level, nitrogen, and CO_2, and suggests that steady increases in global change factors may aid *P. australis*' survival.

Research in progress: Documenting the serpentine biota of Massachusetts

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Abstract: During the summer of 2015 we will conduct floristic and ecological surveys on several outcrops of serpentinite bedrock in western Massachusetts. Serpentinite outcrops and the soils weathered from them (both of which are commonly called "serpentine") present a number of unique edaphic challenges to the plants and other organisms that live on them, due to a low Ca:Mg ratio, deficits in other essential nutrients, high heavy metals, and poor soil development relative to neighboring lithologies. Although the biota of serpentine outcrops has been studied extensively in the western US, and some research has been conducted on serpentine sites in Maine, Vermont, Newfoundland, and Quebec, we can find published data on only one serpentine outcrop in Massachusetts, in the northeastern portion of the state. Such research is urgently needed; because serpentinite bedrock is rare in the state and has not been studied floristically, it is currently considered to host a critically imperiled (S1) plant community. The research we are conducting will help to close this gap in our knowledge of the geoecology of northeastern North America by addressing the following major questions: (a) do individual Massachusetts serpentine outcrops support a biota distinct from that of nearby non-serpentine areas; (b) is there a recognizable "serpentine biota"

in Massachusetts across multiple serpentine sites; (c) can changes in the diversity and density of species along a serpentine to non-serpentine gradient be correlated to features of soil chemistry; (d) do any plants on Massachusetts serpentine outcrops accumulate elevated quantities of nickel; and (e) does serpentine bedrock exert any influence on lichen secondary metabolites? In this poster, we present the progress we have made thus far in selecting field sites using bedrock geologic maps, aerial photography, and GIS. We also outline the methods that we will use to assess the diversity and rock/soil preferences of plants and lichens at these sites. We hope that presenting these methods at this early stage will encourage critiques that can improve the project before the intensive field season begins.

Do pollinators care about petal number? Comparing petal number variation in outcrossing and selfing species of *Phlox*

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Abstract: Many angiosperm lineages, especially in the eudicots, have become mostly fixed on pentamerism (five petals). Botanical field guides organized by petal number highlight this fact by devoting a large portion of the book to five-petaled flowers. Historically, the notion was that the reduction and fixation of petal number during the evolution of angiosperms was a result of adaptation to selection by pollinators. However, this has been poorly tested and it is unclear whether there is strong selection on petal number or whether pollinators have an innate preference for five-petaled flowers. Species in the genus *Phlox* (Polemoniaceae), although primarily pentamerous, have low levels of natural variation in petal number. We quantified this variation in natural populations of *Phlox drummondii*—an outcrosser, and a close relative, *Phlox cuspidata*, which is primarily self-pollinated, setting fruits autogamously. We found no difference in the amount of variation for petal number between the two species. Given that the autogamous species did not appear to have more natural variation in petal number, despite a presumed release from selective forces enacted by pollinators, this suggests that selection by pollinators

does not play a role in maintaining petal number constancy in *Phlox*. However, natural populations varied in the amount and direction of petal number variation. Here, we present results of a common-environment greenhouse experiment to elucidate whether those differences between natural populations are maintained in a second generation, indicating a genetic basis and divergence between populations. We also present the results of several generations of selection in *Phlox drummondii* on increased petal number, decreased petal number, and constancy in petal number, in which we find that there is considerable heritable and selectable variation for increased and decreased petal number, but that selection for constancy in petal number seems to be difficult. Our work is the first in many years to attempt to address whether or not the ubiquitous nature of pentamery throughout the eudicot clade is maintained via selection by pollinators. In an era of declining pollinators and burgeoning research on the evolution of angiosperms, it is crucial to understand the link between pollinator preference and selection on floral form and function.

Patterns and changes in the nonnative flora of Worcester County, Massachusetts

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Abstract: The influence of non-native species on the integrity of local ecosystems is a major concern. Non-native species often impose high costs for management or eradication, and their introduction and establishment may cause major ecosystem disruption through increased competition with native species, altered nutrient cycles, and facilitation of pests and disease. Better data on the patterns and extent of establishment of non-native species will allow better assessment of the threats they pose to local ecosystems. Because many biological processes and effects of non-native species are site-specific, examination of patterns of invasion in different regions is important. Few comprehensive studies have been conducted on the changes in regional abundance of non-native plants in North America. The availability and reliability of historical and current data for the flora of Worcester County, Massachusetts, allowed a detailed investigation into the trends of

non-native vascular plants in this region. Using data from floristic surveys conducted from 1930–1950 and 1980–2000, we found that non-native species richness was most strongly correlated with the percentage of land in residential use, and was also positively associated with human population density and extent of commercial and urban open land. Non-native species richness was negatively correlated with elevation and extent of natural vegetation (mostly forest). Established, non-native species comprised 21–36% of all species present in the county's 60 townships. Most non-native species increased in frequency between the two sampling periods, although a few declined or disappeared. Increasing and decreasing species differed in several characteristics. Decreasing species were recorded earlier in the region, were more likely to be of European origin, and included more agricultural weeds and species of herbal and culinary use. Increasing species were more likely to be recent introductions, of Asian or North American origin, and associated with ornamental use. This research documents the influence of anthropogenic landscape modification in favoring the proliferation of non-native species. The data suggest that minimizing the residential footprint and increasing scrutiny of the invasive potential of ornamental plants are critical steps in combating the spread of non-native plants.

Vascular plants observed since 2006 during botany club investigations at retired cranberry bogs, Coonamessett River, Falmouth, Massachusetts

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Abstract: Successional changes in the vegetative community on recently retired cranberry bogs are being investigated by Botanical Club of Cape Cod and the Islands (BCCCI) members. Site visits were initiated in 2006 and have continued on a regular basis through spring 2015. Our searches have been carried out on Town of Falmouth conservation land prior to the planned restoration of the stream channel and adjacent cranberry beds on the lower Coonamessett River. Species diversity on the retired beds is being managed through the removal of invasive species, primarily an

aggressive introduced exotic gray willow (*Salix atrocinerea*). We expect that specimens of native shrubs including leatherleaf, inkberry, winterberry, northern arrowwood, black elderberry, and chokeberry, with American holly, tupelo, and selected red maple trees, will be salvaged and relocated within the site and serve as planting sources for the restoration. Seeds in the seed bank will reestablish the herbaceous cover. Our investigations provide a baseline inventory for directing the restoration efforts. To date, we have observed about 170 higher vascular plant taxa in the river channel and reservoir pond, on banks and the cranberry platform, and in the immediate surrounding upland. Approximately 80% are native to Barnstable County, 75% are herbaceous, and 20% are woody shrubs and trees. Four permanent photo stations were established in 2013 to photo-document changes in the vegetation.

Comparison of several relocation techniques and success rates for Wild Lupine (*Lupinus perennis*) and Birds Foot Violet (*Viola pedata*) in Nashua, NH.

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Abstract: Sandplain habitats in New Hampshire are a relatively uncommon natural community and, as such, several plant species associated with these environs are listed as rare species in the State. Extensive populations of two of these species, wild lupine (*Lupinus perennis*; ±5000 plants) and bird's foot violet (*Viola pedata*; ±10,000 plants), were located partially within an area of proposed impact associated with the reconstruction of the runway at Boire Field, a small airport in Nashua, NH. Little has been published on the success rates of various transplantation methods for either species; therefore, as part of our ecological surveys and permitting for this project, we implemented several relocation techniques of these species, part of a comprehensive mitigation package. Our primary means of relocation was direct transplantation, relocating 3562 violet ramets and 957 lupine genets to suitable habitat outside of the construction zones. These transplants were monitored for three growing seasons with a combined success

rate for these two species of 76.2% (62.7–103.4%) for the violet and 108.4% for the lupine. In addition to direct transplantation of individual plants, we also saved and re-used topsoil from impacted populations of bird's foot violet as top cover and evaluated the degree of successful regrowth in these areas from latent root and seed stock.

Mycoremediation in the face of anthropogenic environmental damage

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Abstract: Mine tailings, a major source of concern in conservation biology, produce chemical imbalances and generate toxic edaphic and hydrologic conditions, disrupting the establishment and survival of local organisms. Ecologically and economically sound mycoremediation offers unique prospects for addressing widespread ecological damage in mine settings. Mushrooms are bioremediators: they break down recalcitrant chemical contaminants, sequester heavy metals, bind toxic metals in the soil, and stimulate microbial metabolism and decomposition, thus promoting vital ecosystem processes in degraded ecosystems. By investigating the potential benefits of *Pleurotus ostreatus* (oyster mushroom) for modifying contaminated soil from the Callahan Mine, a superfund site in Brooksville, Maine, we are exploring the unique intersection of fungi and conservation biology. We propose amending Callahan Mine soil with mycelium and organic matter to observe the impact of these additions on plant survivability and vigor as a measure of ecosystem health.

The New England Vascular Plants Project: 200,000 specimens digitized and counting

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Abstract: The New England Vascular Plants Project is a multi-institutional collaborative project seeking to digitize all New England herbarium records and specimens. The Harvard University Herbaria (HUH) houses the largest collection of New England specimens in the region, with an estimated 500,000 specimens, and has spearheaded digitization efforts with a unique workflow and methodology. Efforts at the HUH have been divided into three stages. During the pre-capture phase, completed in 2013 by a two-person team, specimen folders were outfitted with customized QR codes to maximize data input efficiency. During the primary digitization phase, specimens are being imaged and data are being captured for essential fields including collector, collection date, and locality. Secondary digitization will focus on further data capture using the images and focusing on habitat, phenology, and enhanced georeferencing. Two conveyor belt imaging stations have been installed at the HUH, and have been in continuous use since November of 2013. Currently, the databasing team is comprised of four full-time and one part-time staff member. To date, nearly 200,000 herbarium specimens and collection records have been imaged and databased, nearly 80% of which belong to the New England Botanical Club. The preliminary data have already been used to develop lines of research dealing with a number of botanical and ecological topics, including changes in range and distribution of New England flora, georeferenced non-native plant invasions, and shifts in phenological timing.

Digitizing the Brown University Herbarium collections

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Abstract: The Brown University Herbarium dates to 1869 when local businessman Stephen Thayer Olney donated his plant collection to the University. The herbarium includes Olney's extensive collection of *Carex*, in addition to a survey of Rhode Island flora from the 19th century. It is also rich in plants from the western and southern parts of North America from the golden age of natural history exploration. There are also specimens from Mexico, Cuba, Colombia, South Africa, India, New Zealand, Australia, and various countries in Europe. The collection now

includes around 100,000 specimens of plants, fungi, mosses, lichens, and algae. Funding from the National Science Foundation has made it possible to start digitizing the herbarium, and a team of Brown undergraduate students has recorded data from around 26,000 specimens over the past year and half. This dataset will be combined with records from other herbaria in New England and can be used to track the effects of climate change on plant phenology and other physiological processes. Herbarium specimens also provide data for studies related to plant evolutionary history, plant distributions, and the spread of invasive species.

Bud development: Comparing pentamerous to hexamerous flowers in *Phlox drummondii*

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Abstract: The stage of maturation and development of flower buds determines the orientation of petals, sepals, stamens, and carpels. Although flowers of species *Phlox drummondii* are pentamerous (five-petaled), there are occasional cases of hexamerous (six-petaled) flowers. These flowers are moderately rare, but they are not random; they have a partial genetic basis. We studied how the development of six-petaled flowers differs from five-petaled flowers to gain a better understanding of the nature of these anomalies. We aimed to compare the sizes and diameters of five and six-petaled flower buds early in development, and we also wanted to compare the floral meristem size within plants that produce many six-petaled flowers, to plants that are strictly (or mostly) pentamerous. After two rounds of selection for higher petal number, most plants had a 20–40% relative frequency for six-petaled flowers. However, of the buds we collected, only a few were six-petaled, and we did not gather sufficient evidence to fully understand whether meristem size contributed to the development of six-petaled flowers. Although no conclusions can be made, the few hexamerous buds provide valuable information. There are no notable differences in sizes of these buds when compared to pentamerous buds. Bud position and age seem to have a greater impact on size than merism. For example, terminal buds are always larger than other buds in the

inflorescence regardless of the number of petals. We also looked at buds of many sizes to determine the stages in which flower organs emerge and how these flower organs develop. Our observations show that sepals emerge with spiral phyllotaxy in *Phlox drummondii*; each sepal develops at a different time, which causes asymmetry in the early bud stages. In addition, we learned that within developing buds of *Phlox drummondii*, the stamens and sepals emerge first from the meristem cells, and petals and carpels form after. Sepals can be clearly identified under the microscope, but petals appear as small stubs until later in development. Our work has led to a better understanding of bud development and meristem differentiation in *Phlox drummondii*. Further research on hexamerous buds may support or reject our original hypothesis regarding six-petaled flowers, but we know that meristem differentiation for six petals occurs at a very early stage. These findings are critical to the understanding of how buds emerge in both normal and abnormal flowers.

Morphological and molecular identification of a new species of *Truncospora* (Polyporales, Basidiomycota) in North America

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Abstract: A new polypore, *Truncospora microspora*, is described based on a combination of molecular and morphological data. The phylogenetic analysis shows that four specimens from Wisconsin, USA, form a monophyletic group based on molecular data of nuclear internal transcribed spacer regions (nucITS). The translation elongation factor 1-α coding gene (tef1-α) sequence data further confirmed that the new taxon forms a monophyletic lineage (100% BS, 96% BP, 1.00 BPP) and groups with *T. ohiensis* and *T. arizonica*. *Truncospora microspora* is characterized by an annual habit, pileate basidiocarps with a white pileus and pore surface, a dimitic hyphal system with slightly dextrinoid to non-dextrinoid, strongly cyanophilous skeletal hyphae and ellipsoid, truncate, slightly thick-walled, strongly dextrinoid basidiospores (9–11 × 6–7.5 μm).