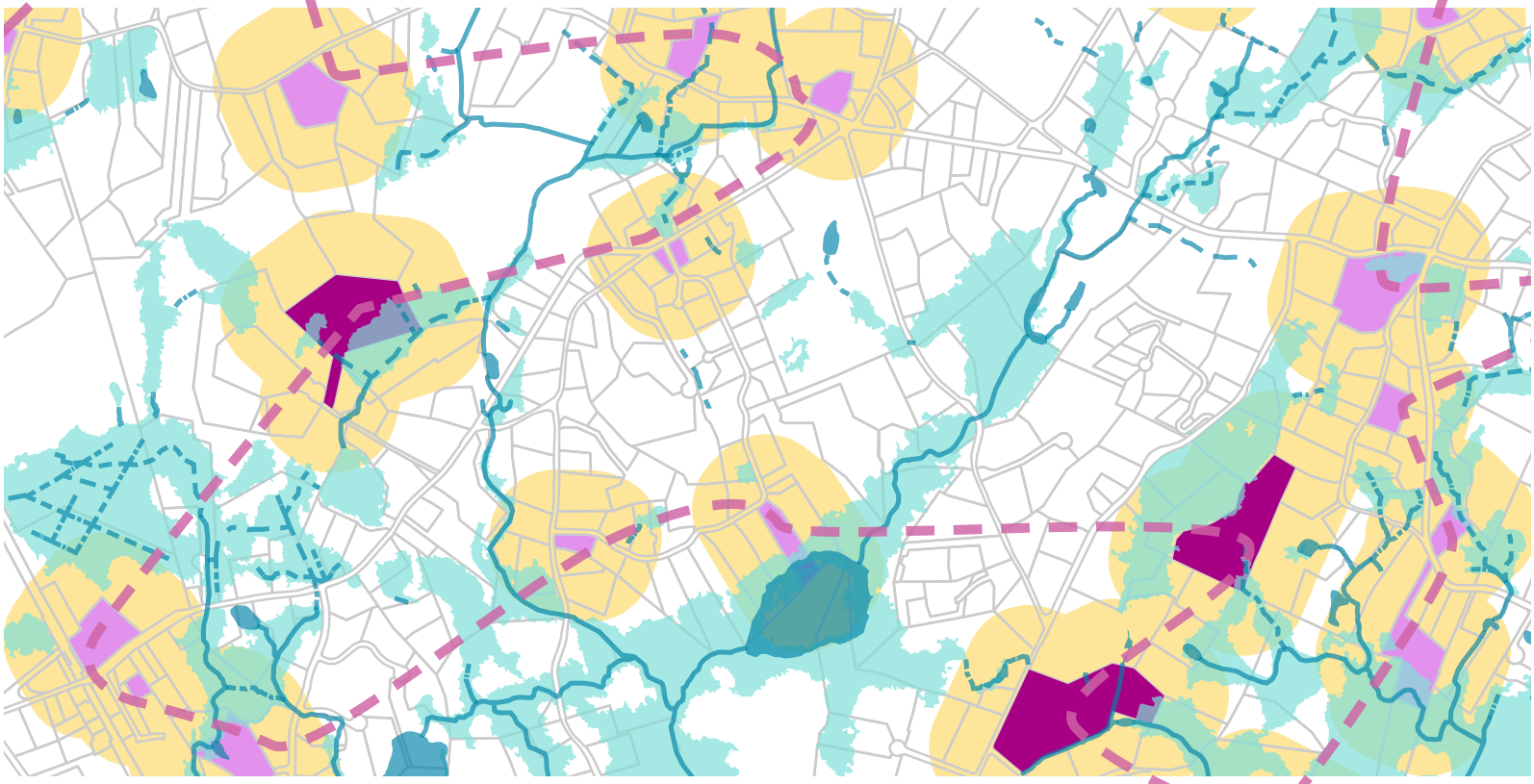
Lincoln Pollinator Action Plan

PLANTING FOR BIODIVERSITY AND CLIMATE RESILIENCE

Evan Abramson



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Commissioned by the Lincoln Land Conservation Trust

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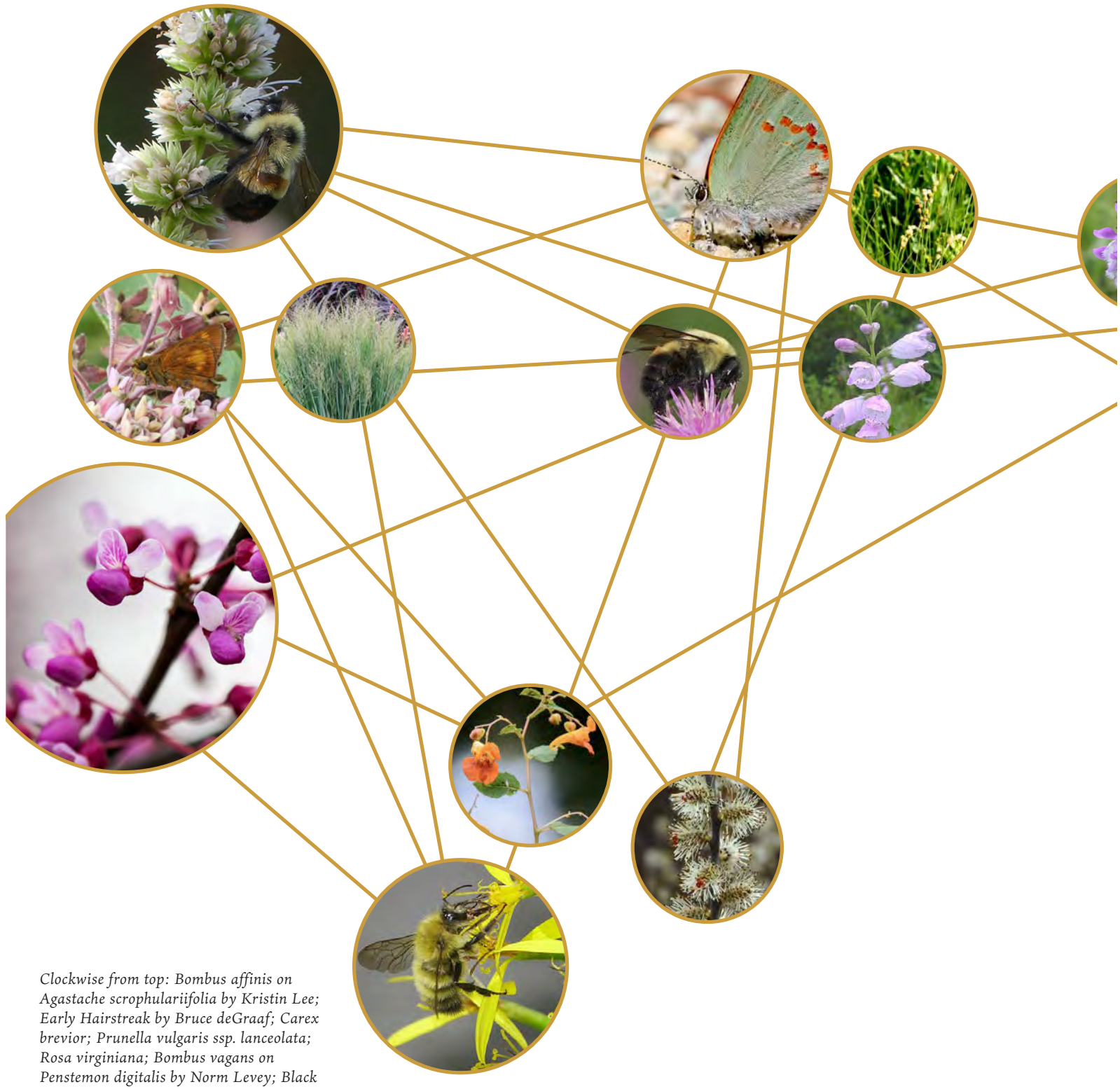

Clockwise from top: Bombus affinis on Agastache scrophulariifolia by Kristin Lee; Early Hairstreak by Bruce deGraaf; Carex brevior; Prunella vulgaris ssp. lanceolata; Rosa virginiana; Bombus vagans on Penstemon digitalis by Norm Levey; Black Dash; Salix humilis; Impatiens capensis; Bombus perplexus by Norm Levey; Cercis canadensis; Mulberry Wing on Asclepias syriaca. Center from left: Panicum virgatum; Bombus griseocollis; Physostegia virginiana.

Table of Contents

Written and Designed by Evan Abramson
Principal, Landscape Interactions

Scientific Consultant: Dr. Robert Gegear
Professor of Biology, UMass-Dartmouth
Founder and Director, New England Beecology Project

GIS Specialist and Associate Designer: Bo Carpen

Field Botanist: Adam Kohl

For more information contact:
Landscape Interactions
16 Center Street #426
Northampton, Massachusetts 01060
landscapeinteractions.com

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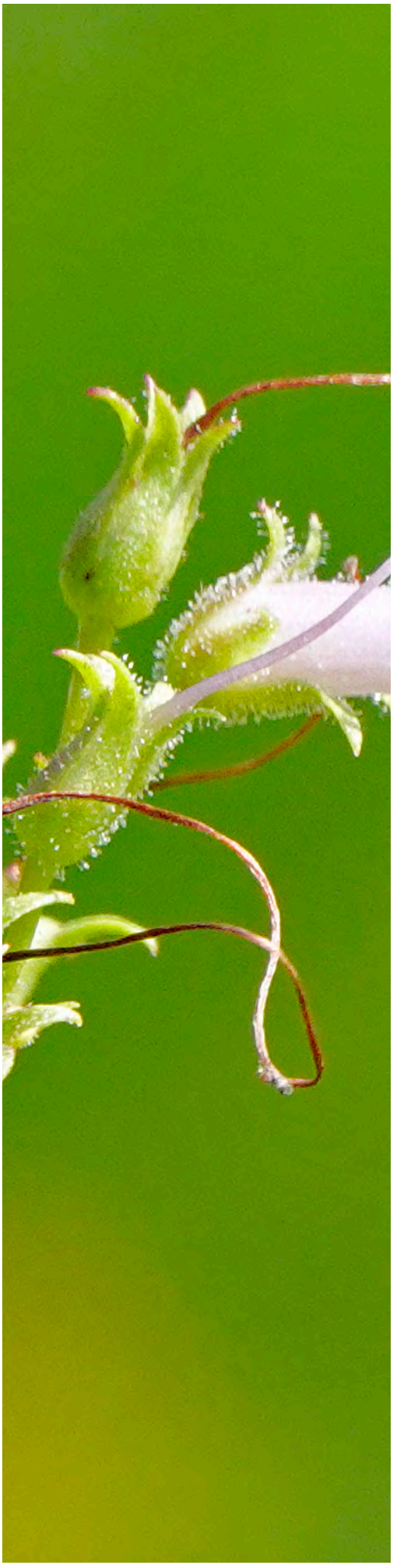
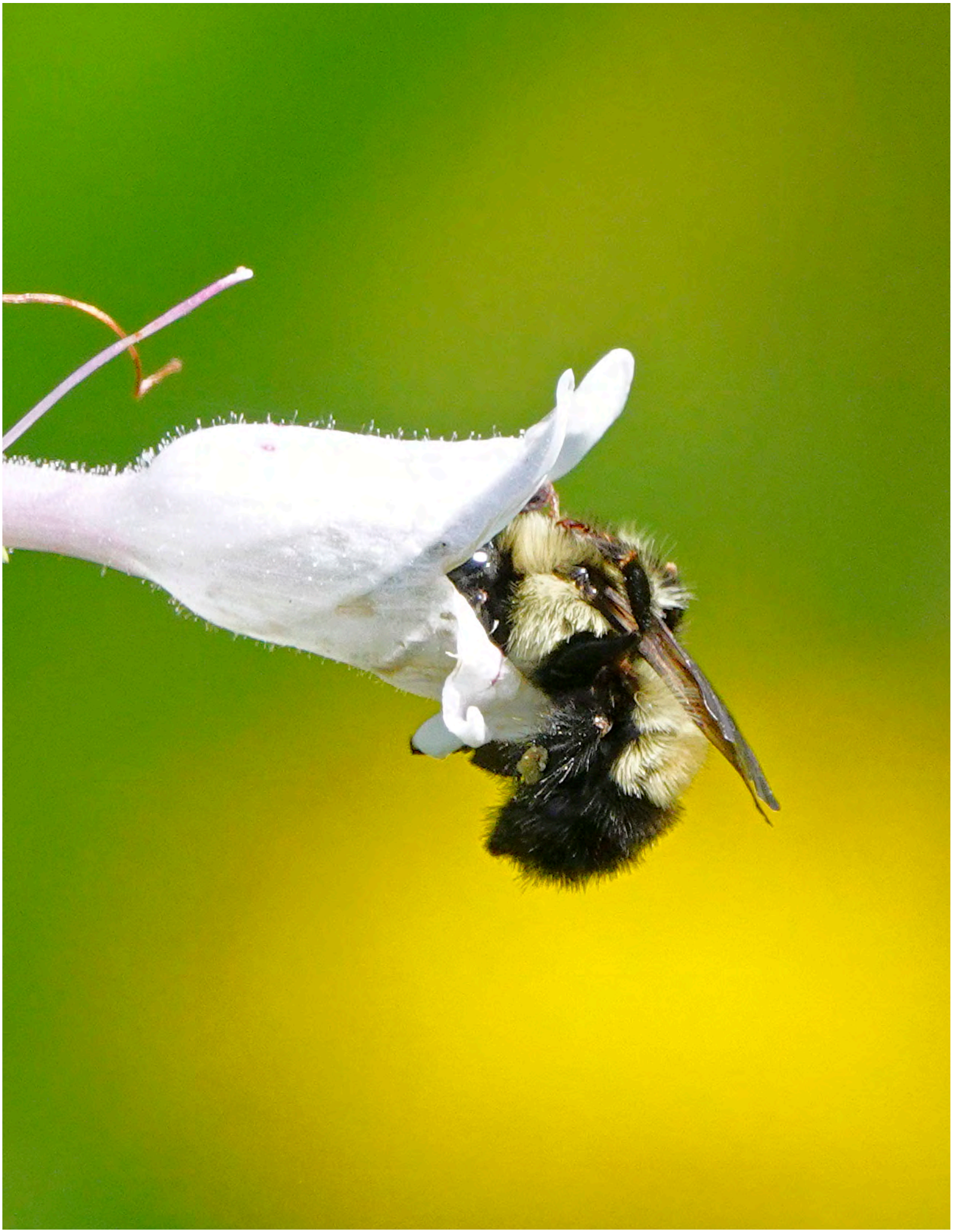


Bombus vagans on Penstemon digitalis.
Photograph by Norm Levey.



"THE ESSENTIAL, INTERCONNECTED WEB OF LIFE ON EARTH IS GETTING SMALLER AND INCREASINGLY FRAYED. THIS LOSS IS A DIRECT RESULT OF HUMAN ACTIVITY."

Professor Josef Settele, Co-Chair, 2019 IPBES Global Assessment on Biodiversity and Ecosystem Services

Above: photographer unknown. Opposite top: photograph by Lou Gold; bottom: photograph by Chris Jordan from the Midway *series.*

Playing with Fire

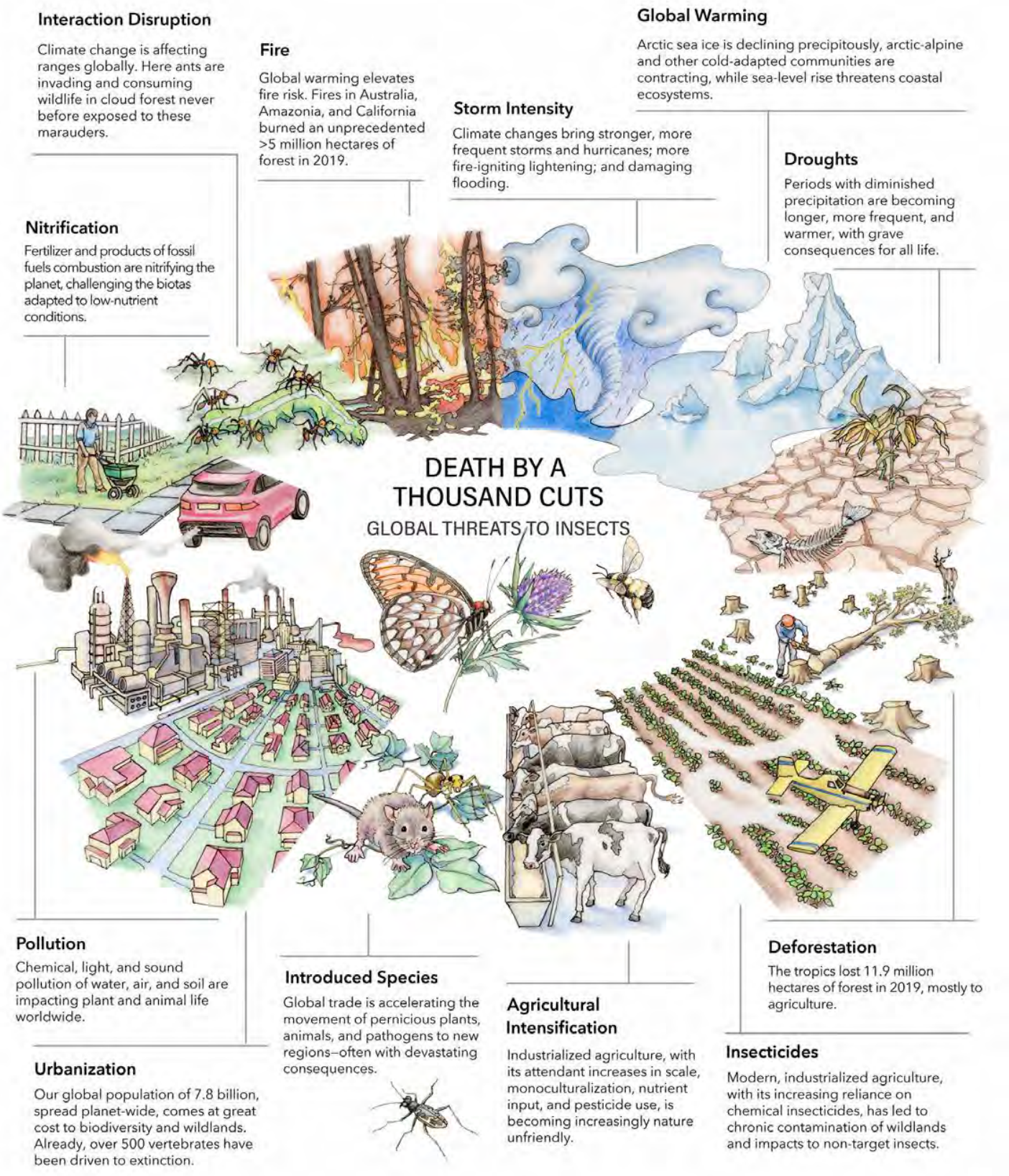
We live in unprecedented times. Humanity's impact on the Earth is now so profound that a new geological epoch has been declared. The Age of the Anthropocene is defined by a striking acceleration since the mid-20th century of carbon dioxide emissions and sea level rise, the global mass extinction of species, and the transformation of land by deforestation and development. Climates are erratically and steadily changing from pole to pole, triggering unprecedented droughts, fires and floods across continents. According to the panel of scientific experts comprising the Anthropocene Working Group, many of these changes will persist for millennia or longer, altering the trajectory of the Earth System, some with permanent effect (Working Group on the Anthropocene). Professor Chris Rapley, a climate scientist at University College London and former director of the Science Museum in London put it starkly: "The planet is our life support system...we are playing with fire, a potentially reckless mode of behavior which we are likely to come to regret."

Nature is declining globally at proportions unmatched in human history. Species across the planet are dying off at rates unseen since the loss of dinosaurs 66 million years ago, and most biologists agree that the world has entered its sixth mass extinction event (Wagner et al). By the middle of this century, as many as 30 to 50 percent of all species on Earth may be extinct (Ibid. and Thomas, et al.; D'Angelo; UN News). Helen Spafford at the University of Hawaii urges the importance of **"A coordinated, international effort to protect the living systems on Earth that produce the air, water and food we need."** (Hance). Sir Robert Watson, Chair of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) stresses **"It is not too late...if we start now at every level from local to global."** He is also clear that this will not be easy: "By its very nature, transformative change can expect opposition from those with interests vested in the status quo." (IPBES).

Collapse of Nature

Insects are the cornerstone of all terrestrial ecosystems — as pollinators, food for other creatures, and recyclers of nutrients. Without them, a bottom-up trophic cascade occurs: in essence, a domino effect that surges up through the food chain, wiping out higher animals (Carrington 2019a). Forty percent of the 1 million known species of insect are presently facing extinction. (Carrington 2019b). At the current rate of decline, insects could vanish within less than a century. (Sánchez-Bayo, et al.; Carrington 2019c). Habitat loss and widespread pesticide use — in particular through industrial agriculture — are commonly understood to be the main drivers of the declines, in addition to climate change. New classes of insecticides introduced in the last 30 years, including neonicotinoids, have been particularly damaging. Half-lives of neonicotinoids can be up to 1,000 days in soils and more than a year in woody plants, and their water-solubility allows the pesticide to move into and accumulate in soil and lakes, creeks, and other water bodies (Bonmatin et al.).

By some measures, the biodiversity crisis is even more serious than that of climate change. Since the dawn of civilization, humanity has caused the loss of 83% of all wild mammals. In the last 50 years alone, the populations of all mammals, birds, reptiles and fish on the planet have fallen by an average of 60%. In a study published in late 2019, it was reported that over 1 in 4 birds in North America have disappeared since 1970, or 3 billion birds (Rosenberg et al.). Habitat loss was again cited as the most direct cause.



Above: Art by Virginia R. Wagner. From Insect decline in the Anthropocene: Death by a thousand cuts. *Proc Natl Acad Sci USA 118, e2023989118 (2021). Opposite: Photo illustration by Matt Dorfman. Source photographs: Bridgeman Images.*

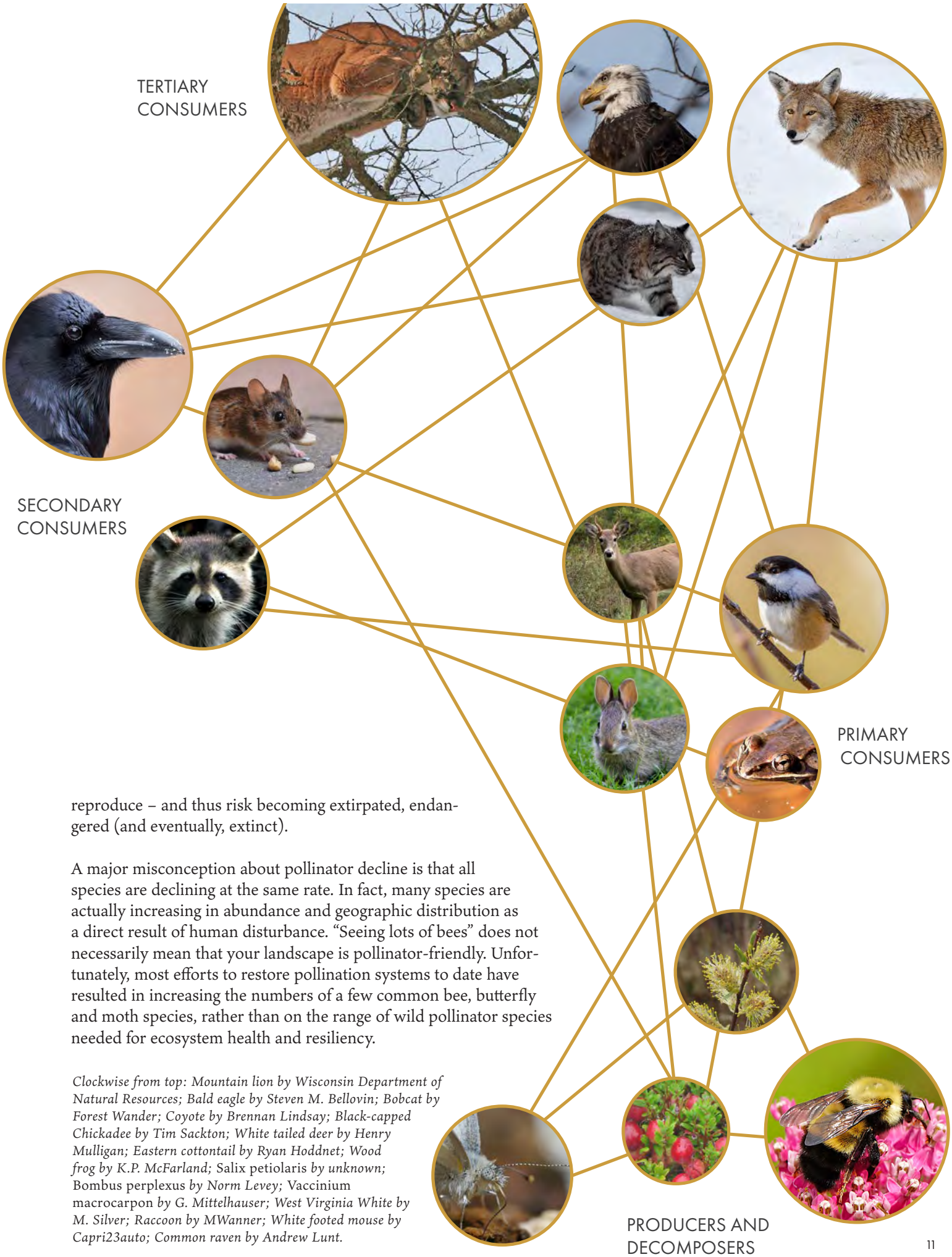
Bombus fervidus foraging on Monarda didyma (Scarlet bee balm). One of the most abundant bumblebee species in Massachusetts a few decades ago, it is now the second rarest bumblebee species in the state. Photograph by Norm Levey.

Why Pollinators?

Native pollinators are vital to creating and maintaining the habitats and ecosystems that most animals rely on for food and shelter — including humans. What happens (or doesn't happen) at the pollination scale has repercussions all the way up the food chain. Over 80% of the flowering plants on Earth depend upon insect-mediated pollination; bees alone pollinate 45% of the food crops grown in Massachusetts, and one-third of the food grown in the United States. In a global study of more than 40 crops in 600 fields across every populated continent, scientists found that wild pollinators were twice as effective as honeybees in producing seeds and fruit (Garibaldi et al.). In the United States, wild bee pollination services were estimated to be worth $3.07 billion in 2006 (Losey & Vaughan). This estimate is a conservative approximation of wild bee pollination's contemporary value, considering the increase in pollinator-dependent crop plants over the past decade (Russo et al.; Mathiasson & Rehan).

As **keystone species**, wild pollinators provide food, shelter and nest sites to wildlife at other trophic levels through their interactions with native flowering plants. Protecting diversity of native pollinator-plant interactions, or "pollination systems" is therefore critical for maintaining healthy and diverse ecosystems. Pollination systems include bees, butterflies and moths, birds, beetles and flies, and represent over 80% of plant species worldwide.

Just like humans, pollinators need nutrient-dense food, shelter, and successful reproduction to thrive. But not all species require the same thing. A delicate balance exists between native plants and their pollinators, relationships that evolved over millions of years. Some plants have a small guild of species which coevolved with them to ensure their pollination. Similarly, approximately 15% of northeastern native bees are considered pollen specialists (Fowler). For many specialists, once their "partner" is missing from the landscape, they cannot

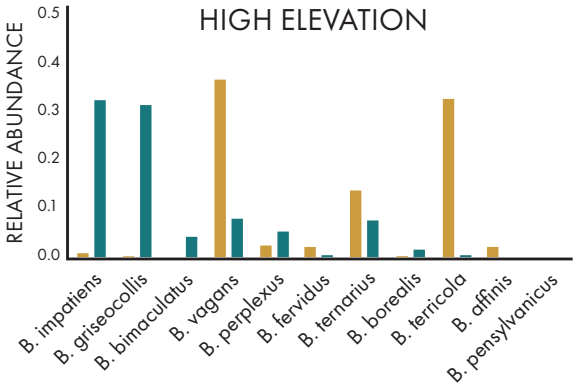


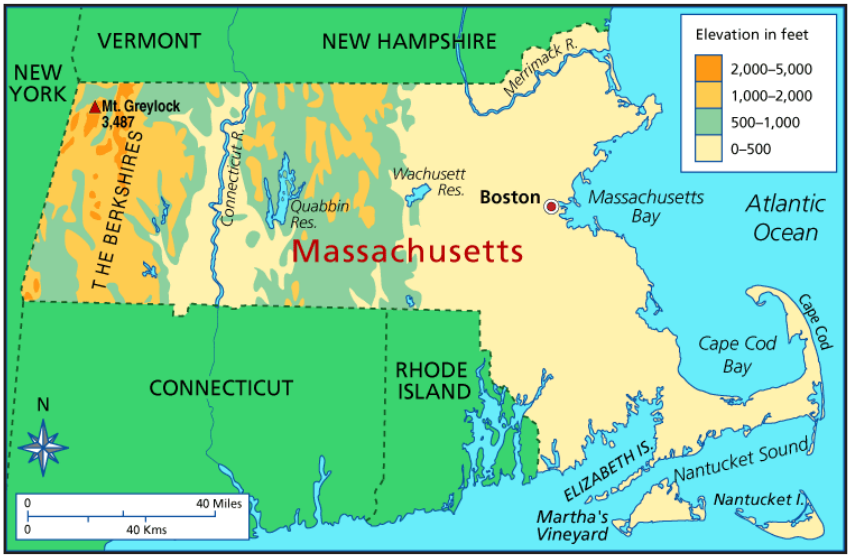
reproduce – and thus risk becoming extirpated, endangered (and eventually, extinct).

A major misconception about pollinator decline is that all species are declining at the same rate. In fact, many species are actually increasing in abundance and geographic distribution as a direct result of human disturbance. "Seeing lots of bees" does not necessarily mean that your landscape is pollinator-friendly. Unfortunately, most efforts to restore pollination systems to date have resulted in increasing the numbers of a few common bee, butterfly and moth species, rather than on the range of wild pollinator species needed for ecosystem health and resiliency.

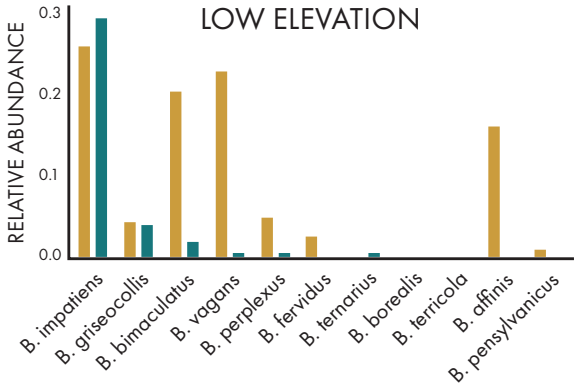
Clockwise from top: Mountain lion by Wisconsin Department of Natural Resources; Bald eagle by Steven M. Bellovin; Bobcat by Forest Wander; Coyote by Brennan Lindsay; Black-capped Chickadee by Tim Sackton; White tailed deer by Henry Mulligan; Eastern cottontail by Ryan Hoddnet; Wood frog by K.P. McFarland; Salix petiolaris *by unknown;* Bombus perplexus *by Norm Levey;* Vaccinium macrocarpon *by G. Mittelhauser; West Virginia White by M. Silver; Raccoon by MWanner; White footed mouse by Capri23auto; Common raven by Andrew Lunt.*

STATUS OF BUMBLEBEE SPECIES IN MASSACHUSETTS (1960-2020)





BOMBUS FERVIDUS



BOMBUS IMPATIENS

Data and graphs courtesy Dr. Robert Gegear. Historical records from Yale Peabody Museum of Natural History. Photographs by Norm Levey.

Pollinator Decline in Massachusetts

By tracking bee, butterfly and moth observations over the past 150+ years, we get an accurate picture of pollinator health in the state. The situation isn't so great: the number of bumblebee species has dropped from 11 to nine, with three more species (*Bombus fervidus, Bombus terricola* and *Bombus vagans*) in danger of being extirpated within the next decade. MassWildlife lists five more bees and 44 butterflies and moths as Species of Greatest Conservation Need (Massachusetts Division of Fisheries and Wildlife). These losses risk cascading impacts across ecosystems. If trends continue, human actions will remove too many species and natural systems will begin to collapse.

Native Plant Community Loss

The flora of New England also shows some disturbing trends. At present, 22 percent of the region's native plant taxa are globally, regionally or locally imperiled or extirpated (Farnsworth). In a study of the native flora of Concord, Massachusetts which compared observations recorded primarily by Henry David Thoreau and Alfred Hosmer from the mid-1800s through 1902, with observations recorded between 2003 and 2009, 27% of the species that Thoreau and other botanists had recorded from Concord were no longer present, and a further 36% of formerly common species were now rare (Primack & Miller-Rushing). Many of these rare species existed only in small populations — in some cases, only a few individuals, or even just one plant.

Penstemon hirsutus, historically more common, is presently ranked as extremely rare (S1) and endangered (E) in Massachusetts. Tubular flowers like these are key nectar sources for long-tongued bumblebees, many of which are also at risk. Photograph by Andi Wolfe/Ohio State University. Illustration by Mary E. Eaton from Addisonia: colored illustrations and popular descriptions of plants. *New York: New York Botanical Garden, 1916-[1964].*

Old Field early succession in Franklin County, Massachusetts by Evan Abramson.

Diversity is Resilience

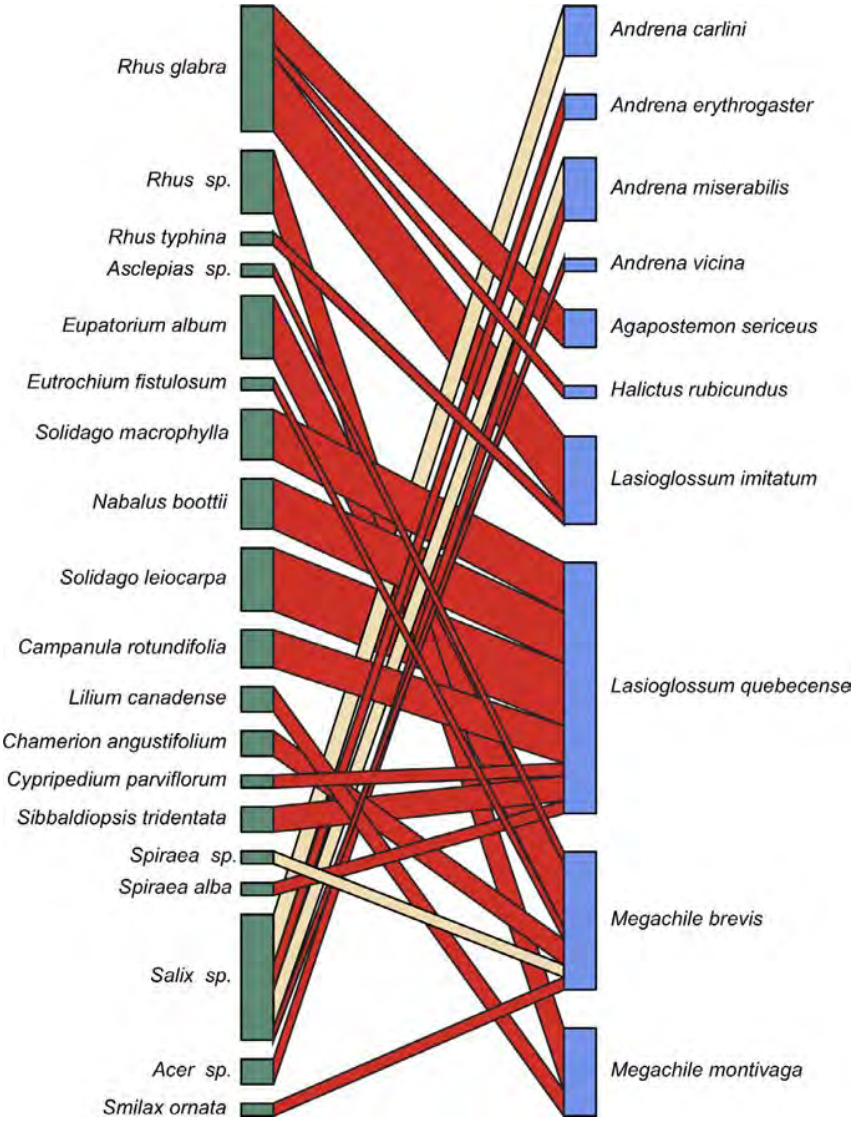
One of the most important components of any healthy and viable ecosystem is diversity. Diversity is strongly linked to the resilience of natural communities (Helzer 2009). A diverse combination of plant and animal species in a community increases the likelihood that the loss of one species can be somewhat compensated by other species that might play a similar role in the ecosystem. The greater the number and diversity of pollinator-plant interactions, the greater the reproduction of both plants and insects (producers), resulting in a greater availability of food, shelter and nest sites for primary consumers (herbivores) and secondary consumers (omnivores); this in turn results in greater availability of food, shelter and nest sites for tertiary and quaternary consumers (carnivores and predators). The cycle continues with decomposers, who turn dead material into soil, sequestering carbon and recycling nutrients so that they can be reused by producers to create more food.

Each species has a unique set of traits that determine where and when it can live, how it interacts with other species and how it contributes to ecosystem function, referred to as its niche. **Functional diversity** refers to the range of niches represented by all species in a given geographic area. The single most important criteria for establishing and maintaining functionally diverse pollinator habitat is plant selection. Unfortunately, most pollinator conservation efforts are biased toward increasing populations of common species (abundance) at the expense of species at risk (functional diversity). What one bee wants or needs — be it for pollen, nectar or nesting — is not the same for every other bee species.

Every species of plant and animal plays a certain role within a natural community. High species richness provides redundancy of function and helps ensure that if one species disappears or can't fill its role, others can cover for it. That contributes to ecological resilience – the ability of an ecological community to respond to stress without losing its integrity. **Ecological resilience may be the most important attribute for any natural system, especially in the face of rapid climate change, continuing loss and degradation of habitat, encroaching invasive species and other threats** (Helzer 2017).

Plant diversity helps support healthy populations of pollinators and herbivores by ensuring a consistent supply of food throughout the year. In addition, managing for a variety of vegetation structure types (including a wide range of both plant stature and density) can help support more animal diversity, including birds, mammals, reptiles, and insects (Helzer 2017). Animal and plant species diversity means ecological resiliency — crucial in an era of unpredictable climate and more frequent, intense and longer weather extremes. Diversity of native pollination systems also provides ecosystem services, defined as the contributions of ecological processes to the well-being of humans and other species, including decomposition, water purification, carbon sequestration and pollination. It is particularly important to maintain a diversity of wild pollination systems in areas with high levels of disturbance, such as farmland and regions of urban-suburban development.

ANIMAL AND PLANT SPECIES DIVERSITY MEANS ECOLOGICAL RESILIENCY — CRUCIAL IN AN ERA OF UNPREDICTABLE CLIMATE AND MORE FREQUENT, INTENSE AND LONGER WEATHER EXTREMES.



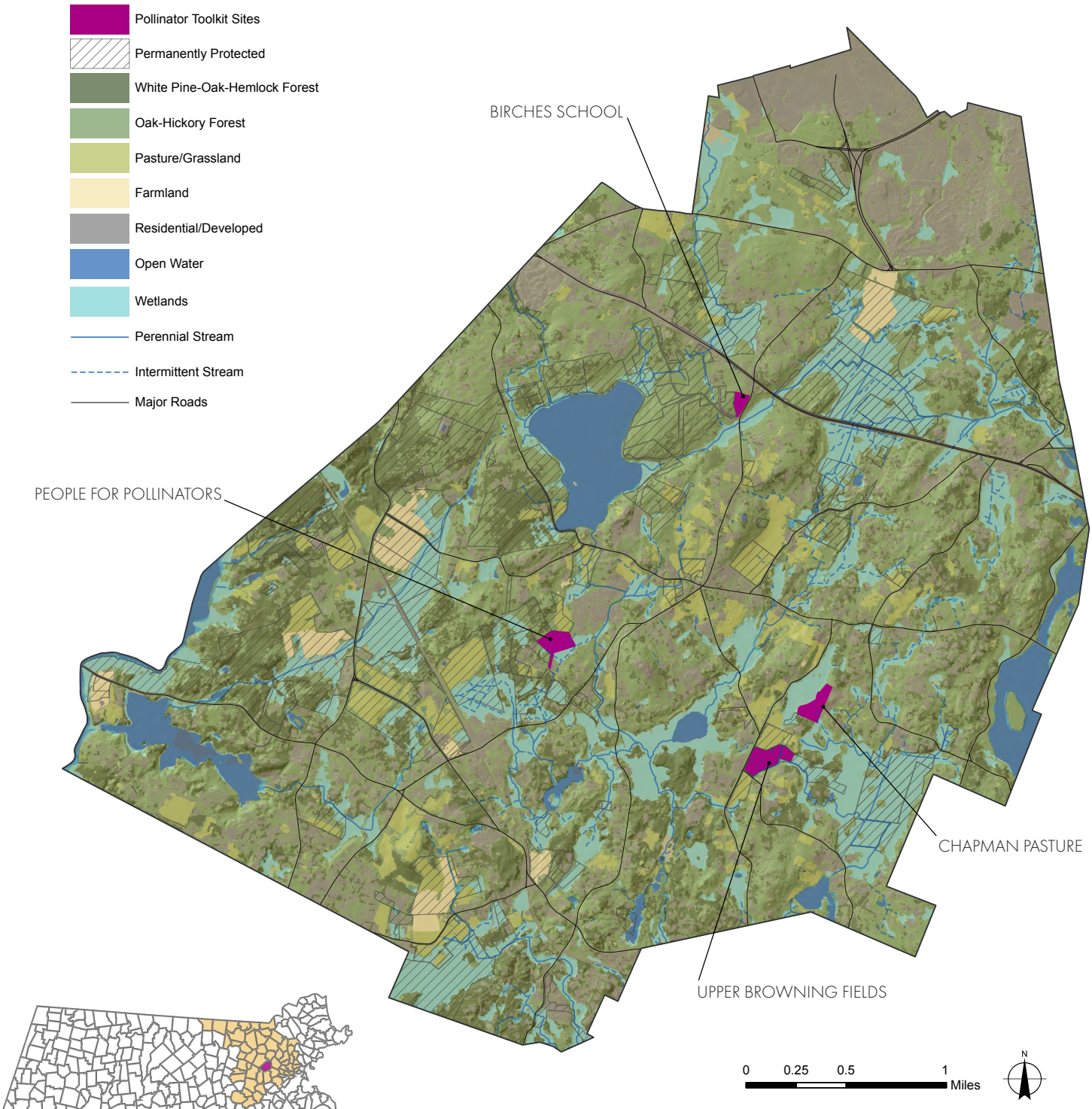
Historical (1891–1987) plant-pollinator interaction network for declining wild bee species and contemporary (1988–2016) presence or absence of these interactions. Yellow lines represent interactions that were maintained from the historical period through the present and red lines represent interactions that were lost. Courtesy Mathiasson and Rehan.

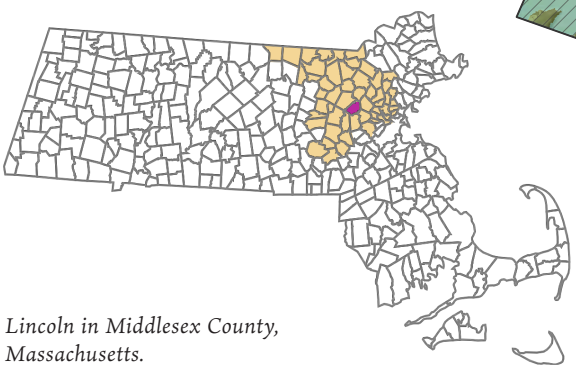
Responding to Regional Trends

In a study that was published in June 2020, researchers determined that habitat loss from expanding agriculture and development as well as climate change were the primary drivers for a **94% loss of plant-pollinator networks** across northern New England over the past 125 years (Mathiasson & Rehan). Their findings provide a rare insight into the fragile nature of plant-pollinator interactions. Multiple wild bee species presently in decline were found to have historic ties to plant species which are presently threatened or endangered. Because many of these plant species are no longer found in most of their historic range, the scientists concluded that **conservation efforts focused specifically on habitat restoration for declining wild bee and plant species are fundamental to the preservation of regional biodiversity**.

What was particularly sobering about the findings is the impact that non-native and invasive plants are having: in many cases, plant-pollinator relationships have been disrupted directly as a result of invasive plants replacing native taxa in their historic range. This disproportionately effects specialist bees and bee species with a smaller diet breadth, as opposed to generalist species or species which are able to consume pollen and nectar from a wider range of flowers, including non-native and invasive plants (Mathiasson & Rehan).

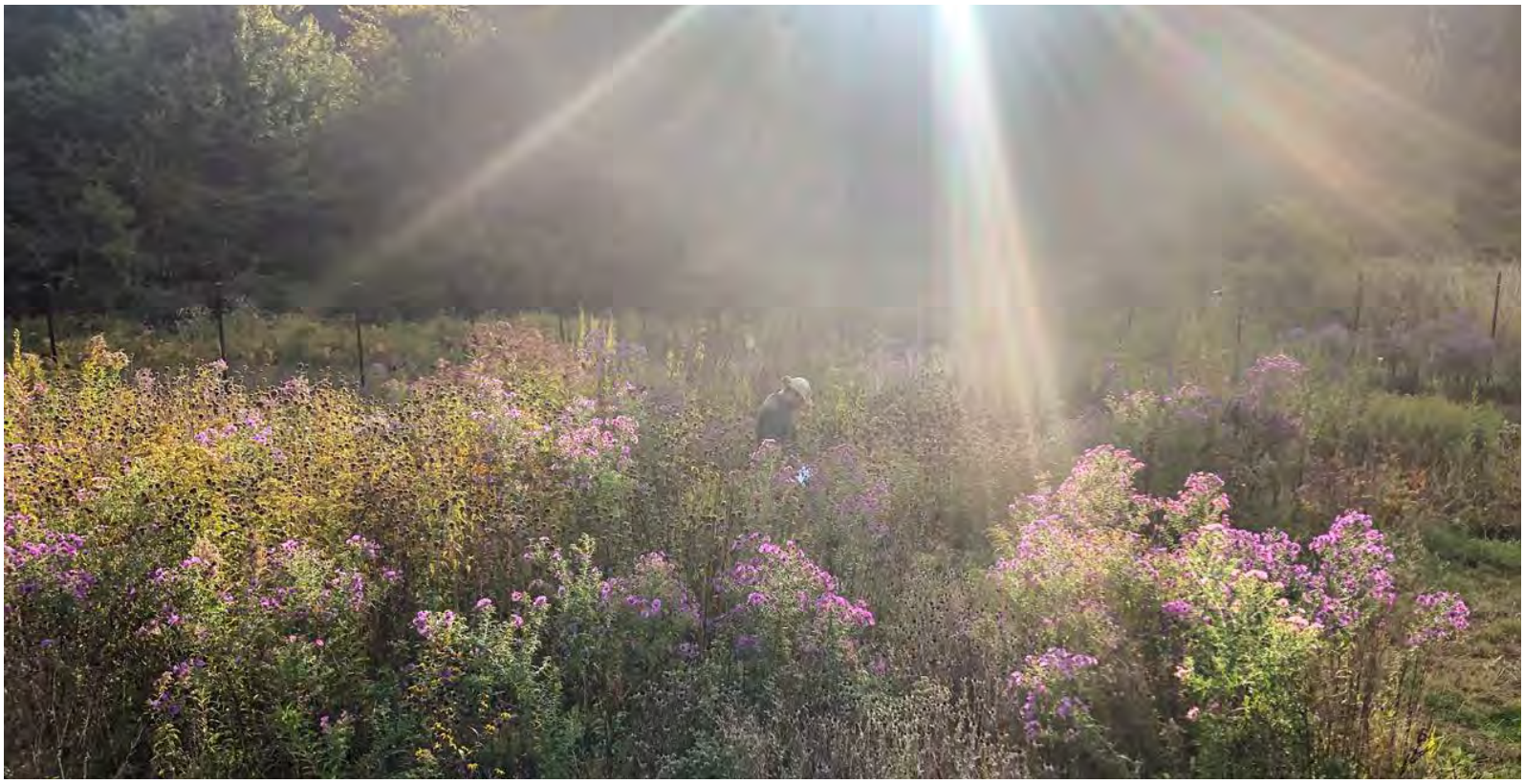
LAND USE AND NATURAL COMMUNITIES IN LINCOLN





Lincoln in Middlesex County, Massachusetts.

Lincoln is "a hill town, a wet town and a forest town" (Brooks) comprising 15 square miles, located 30 minutes west of Boston. 38% of the town is permanently protected and approximately 30% of the town is wetland. All residents rely on local drinking water. Virtually deforested in the 19th Century, pine-oak woodlands dominate the upland forests of the town, and red maple swamps fill the lowlands (OSRP). A high level of connectivity exists within the landscape: both wildlife and trail users move throughout the town with minimal road crossings and exposure to development (OSRP), although increased residential development in recent years has resulted in extensive vegetation clearing, as large lawns and formal gardens replace native plant communities and wildlife habitat, further degrading the resilience of the greater landscape.



Field Botanist Adam Kohl surveys the People for Pollinators site in September 2019. Photograph by Evan Abramson.

Taking Action in Lincoln

Since September 2019, the Lincoln Land Conservation Trust (LLCT) has worked closely with Dr. Robert Gegear and Evan Abramson of Landscape Interactions to collect data on threatened pollinator species in Lincoln, and to prioritize sites for habitat design and restoration in order to expand the populations and range of those at-risk species. The planning process began with a survey of 14 properties which LLCT wished to consider for the project, ranging from open fields and woodlands owned and managed by LLCT to private residential properties and working farms and wetlands owned by the Town of Lincoln and managed by the Conservation Department. After assessing the 14 sites based on a range of ecological and land use conditions, including floral diversity, connectivity, access, overall habitat quality and ownership, recommendations were presented to LLCT staff and Board members. Four Case Study sites representing a wide range of landscape typologies were selected, in order to create model design and habitat management guideline Toolkits for each site that would be scalable and replicable on other similar sites across Lincoln and surrounding communities.

The Toolkits are presented on the following pages of this report:

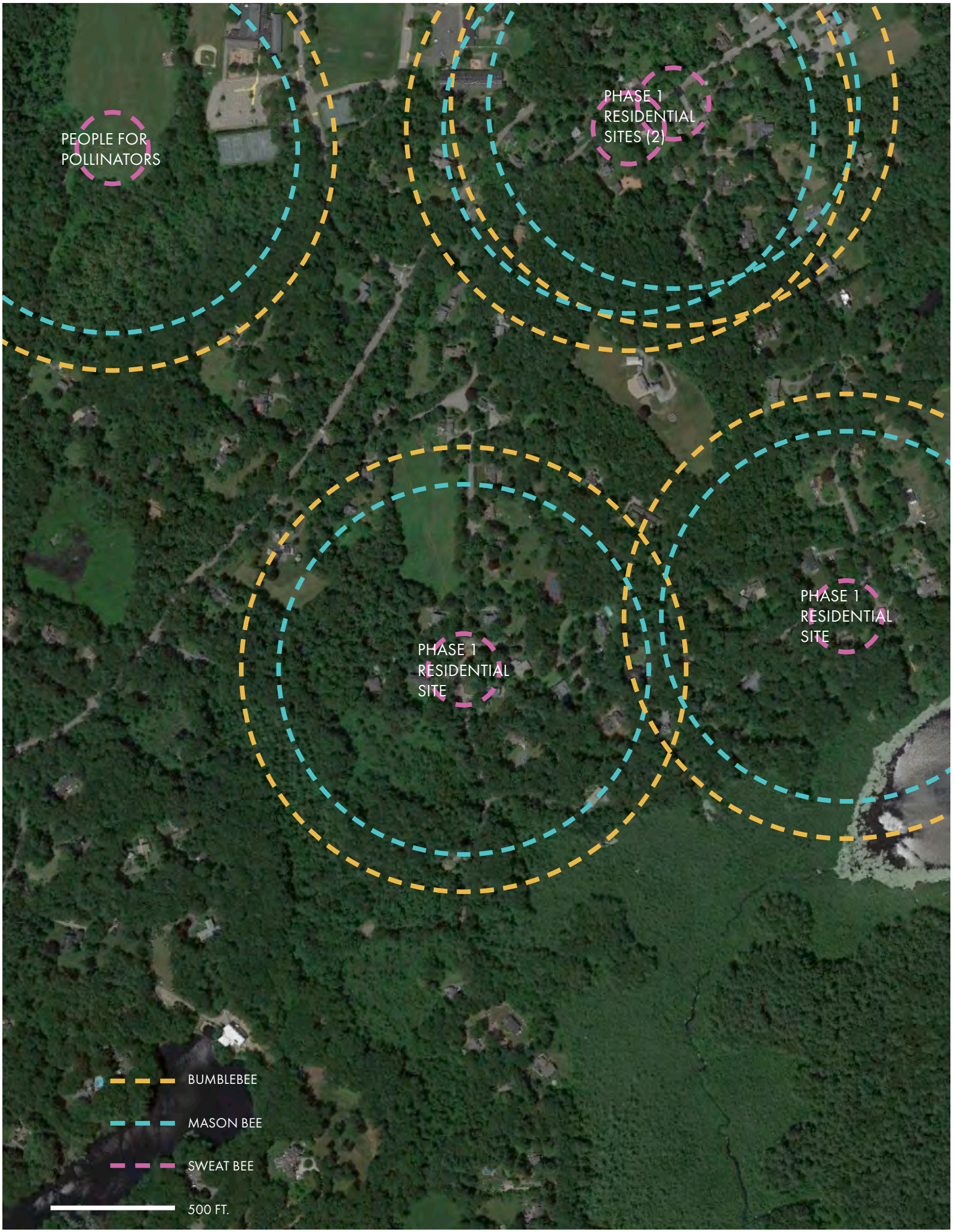
MEADOW & WOODLAND TOOLKIT
PEOPLE FOR POLLINATORS *page 38*

OLD FIELD TOOLKIT
CHAPMAN PASTURE *page 46*

WET MEADOW TOOLKIT
UPPER BROWNING FIELDS *page 54*

GARDEN & LAWN TOOLKIT
BIRCHES SCHOOL *page 62*

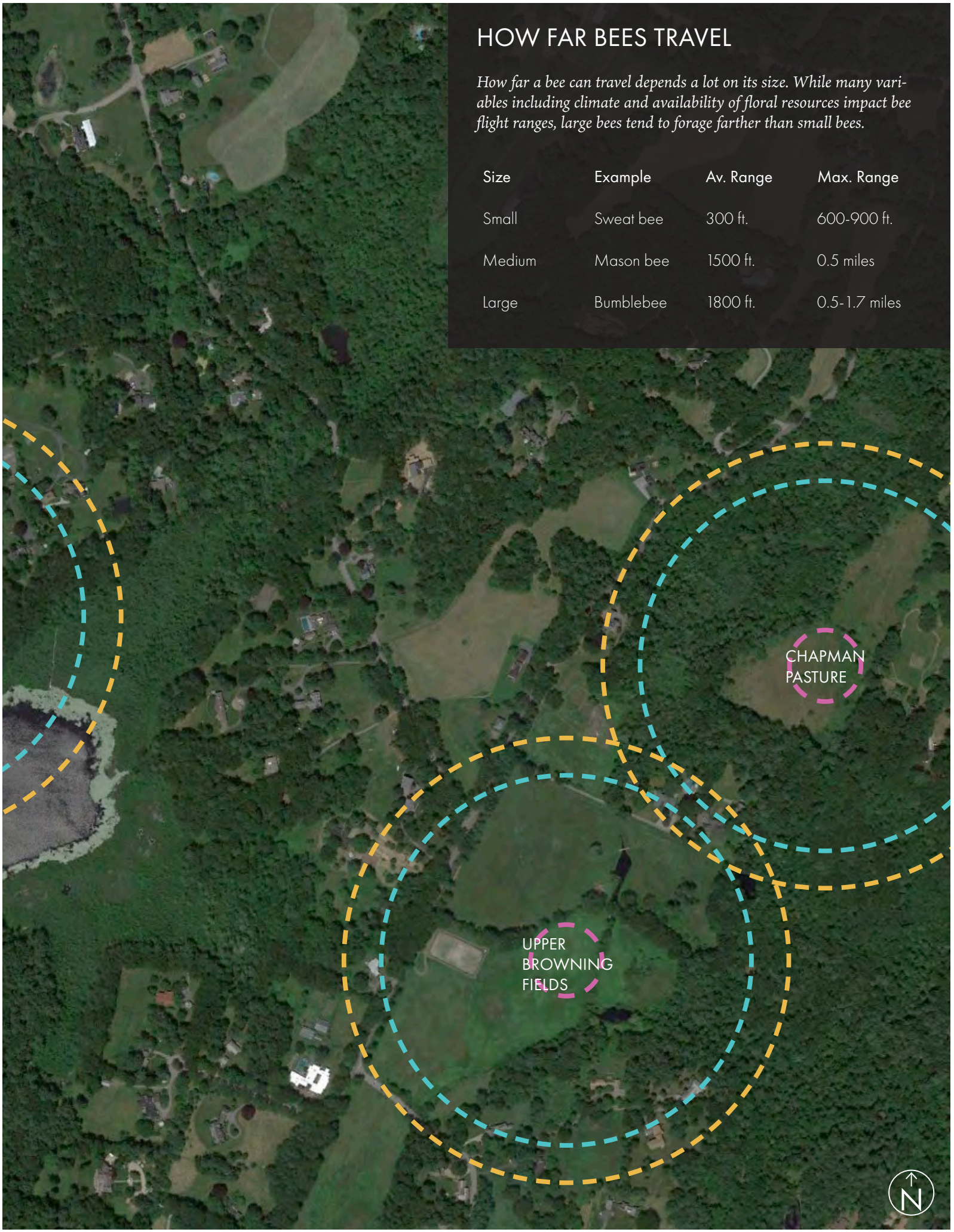
By applying the landscape designs, plant lists, implementation guidelines and maintenance strategies from each Toolkit to ecologically similar sites, the building blocks for a town-wide pollinator corridor will be created. To that end, 43 households in Lincoln have already installed plants from the Garden & Lawn Toolkit on their own properties, representing a successful "Phase 1" of this Plan's implementation — six months before its publication.


PEOPLE FOR POLLINATORS
PHASE 1 RESIDENTIAL SITES (2)
PHASE 1 RESIDENTIAL SITE
PHASE 1 RESIDENTIAL SITE
BUMBLEBEE
MASON BEE
SWEAT BEE
500 FT.

HOW FAR BEES TRAVEL

How far a bee can travel depends a lot on its size. While many variables including climate and availability of floral resources impact bee flight ranges, large bees tend to forage farther than small bees.

Size	Example	Av. Range	Max. Range
Small	Sweat bee	300 ft.	600-900 ft.
Medium	Mason bee	1500 ft.	0.5 miles
Large	Bumblebee	1800 ft.	0.5-1.7 miles



Science informs Design

Pollination Ecologist and Conservation Biologist Robert Gegear, Ph.D. has been studying the ecology, evolution and conservation of pollination systems native to eastern North America for over 25 years. An Assistant Professor of Biology at the University of Massachusetts-Dartmouth as well as Founder and Director of the New England Beecology Project, Dr. Gegear is a Scientific Consultant at Landscape Interactions whose research informs the plant selection and pollinator species targeted for each Toolkit in this plan. Dr. Gegear's research approach spans many boundaries, combining concepts and experimental techniques from behavioral ecology, neurobiology, experimental psychology, molecular biology, population and community ecology, evolutionary biology and computer science.

People for Pollinators, Chapman Pasture and Upper Browning Fields are being surveyed for pollinator species diversity and change over a three-year period by Dr. Robert Gegear. A classic "before and after" experiment, Year One (2020) involved observing and documenting pollinator and plant species interactions on the sites before any planting or landscape modifications took place. Years Two and Three (2021 and 2022) will document changes in species presence and interactions after the recommended plants, designs and management guidelines from the Toolkits have been implemented. **The Toolkits have been created to specifically target and support bee and butterfly species which are threatened or at risk in Northeastern Massachusetts.** The study format is based upon years of intensive field and lab observations by Dr. Gegear, which correlate at-risk bee and butterfly species with particular pollen, nectar and host plants, as well as nesting preferences. It is expected that populations of the at-risk bee and butterfly species targeted in this Plan will not only be observed, but sustained on each site in Years Two, Three and beyond.

After kicking off Lincoln's Pollinator Action Plan programming with a public presentation in January 2020, Dr. Gegear offered workshops in Lincoln during the spring and summer, as well as an online tutorial, in order to recruit citizens to collect data on bumblebee species distributions in Lincoln using the **Beecology** app he created (https://beecology.wpi.edu). Videos and photographs of bumblebees on plants are taken on a smartphone or tablet and uploaded through the app. Dr. Gegear and members of his lab verify every bumblebee and plant ID before they are added to the database.

Another highly valuable visual resource for aspiring citizen scientists emerged in the summer of 2020,

when renowned photographer, wildlife observer and Lincoln resident Norm Levey released **Bombus: The Bumblebees of Lincoln**, a bee ID video published in collaboration with Beecology and the Lincoln Land Conservation Trust. Billed as "a virtual walk in the People for Pollinators meadow and other locations in the town to meet the local bumblebees," the 13 minute video is an excellent tool for learning how to differentiate between seven different species of bumblebee presently abiding in Lincoln.

To become a Beecologist you can get started at: https://beecology.wpi.edu/website/participate#apps

This page: video stills from Bombus: The Bumblebees of Lincoln *filmed and produced by Norm Levey/The Natural World in Lincoln. https://theindwellingspider.wordpress.com/video/bombus-the-bumblebees-of-lincoln/ Opposite: Beecology workshop hosted by Dr. Gegear. Photographs by Bryn Gingrich, Outreach Director, Lincoln Land Conservation Trust.*

Clockwise from top left: Bombus ternarius and Bombus vagans by Norm Levey, Oak Hairstreak by Pete Gumaskas, Pedicularis Canadensis by Eric Hunt. Background image of Upper Browning Fields by Evan Abramson.

Measuring Success

While the subject of pollinator decline is understood by many people to be highly significant, few pollinator habitat projects target the range of species at risk in a given geographic area. This is ironic since it is due to the decline of so many pollinator species that we are aware of the pollinator crisis in the first place. Shouldn't pollinator habitat projects therefore target the species that require conservation and protection, rather than common or abundant species whose populations are stable?

Many of the species whose numbers have fallen so sharply in recent decades possess more specialized habitat requirements. With respect to pollinators, this usually involves foraging and/or nesting preferences among particular groups of plants. As discussed earlier, the same can be said among certain plant taxa, with many of the species experiencing steep declines associated with a limited group of insects for their reproductive needs. Yet **few pollinator habitat design or restoration projects collect data before, during or after recommended plantings and strategies have been implemented.** Limited research based on first-hand field observations exists, in order to demonstrate the efficacy (or inefficacy) of particular plant species or landscape management regimes in promoting the abundance and diversity of those species that are the most in need of conservation.

For the People for Pollinators, Chapman Pasture and Upper Browning Fields sites, field observations of bumblebee and butterfly species at risk in Eastern Massachusetts have been collected by Dr. Gegear throughout the 2020 growing season. To measure the success (or failure) of the Toolkits in attracting and sustaining at-risk pollinator species on these sites, the following criteria will be measured over a three-year period (2020-2022):

NATIVE BUMBLEBEE AND BUTTERFLY SPECIES DIVERSITY SUSTAINED *(ie, not just one sighting of a particular species)*

PLANT SELECTION SUPPORTS SPECIES RICHNESS ACROSS FUNCTIONAL TRAITS, TROPHIC LEVELS AND ANIMAL GROUPS *(bee, butterfly, moth, bird)*

FUNCTIONAL DIVERSITY IMPROVED OVER TIME

In other words, which bumblebee and butterfly species were on the site before and after the design and habitat modifications were implemented? Which plant species were added? What management changes worked? And how were animals further up the food web affected?

The results will be published and shared widely in order to promote the best possible outcomes for habitat restoration in Lincoln and in ecologically similar communities across the Northeast.

Students installing the Garden & Lawn Toolkit design. Photo by Bryn Gingrich. Below: slide from a PowerPoint presentation about the Pollinator Action Plan courtesy of Jane Gruba-Chevalier, former Special Projects Coordinator at LLCT and Birches School parent.

Building Regional Impact

Since launching the Pollinator Action Plan in early 2020, the Lincoln Land Conservation Trust has broadened its reach through a range of public programming; expanded its membership; engaged participants from over a dozen towns and cities; and installed or distributed thousands of native plants specifically recommended by Landscape Interactions to support at-risk pollinator species. The foundation for a regional pollinator corridor is already being laid.

In September 2020, the Garden & Lawn Toolkit design (pages 64-65) was installed by more than 160 volunteers from the Birches School community, Lincoln and statewide pollinator networks, including the Native Pollinator Task Force of the MetroWest Conservation Alliance. Approximately 6,000 sq.ft of habitat was installed, comprising over 600 shrubs, forbs and graminoids. Additionally, over 300 plants were sold on site based on enthusiasm for the design, raising over $1,500 to support the project.

Perhaps most noteworthy, as a result of the 98 planting kits which were sold to LLCT members and area residents based upon the Garden & Lawn Toolkit design, 43 households in Lincoln have already implemented a suite of recommended plants to support at-risk pollinators, thereby expanding the corridor beyond the initial Case Study sites before the Pollinator Action Plan was even complete. See the following page for maps showing these Phase 1 residential properties and their proximity to the Toolkit sites.

250
Program Participants

30
New LLCT Members

13
New LLCT Volunteers

98
Plant Kits Sold

1,944
Plants Distributed

12+
Towns Represented

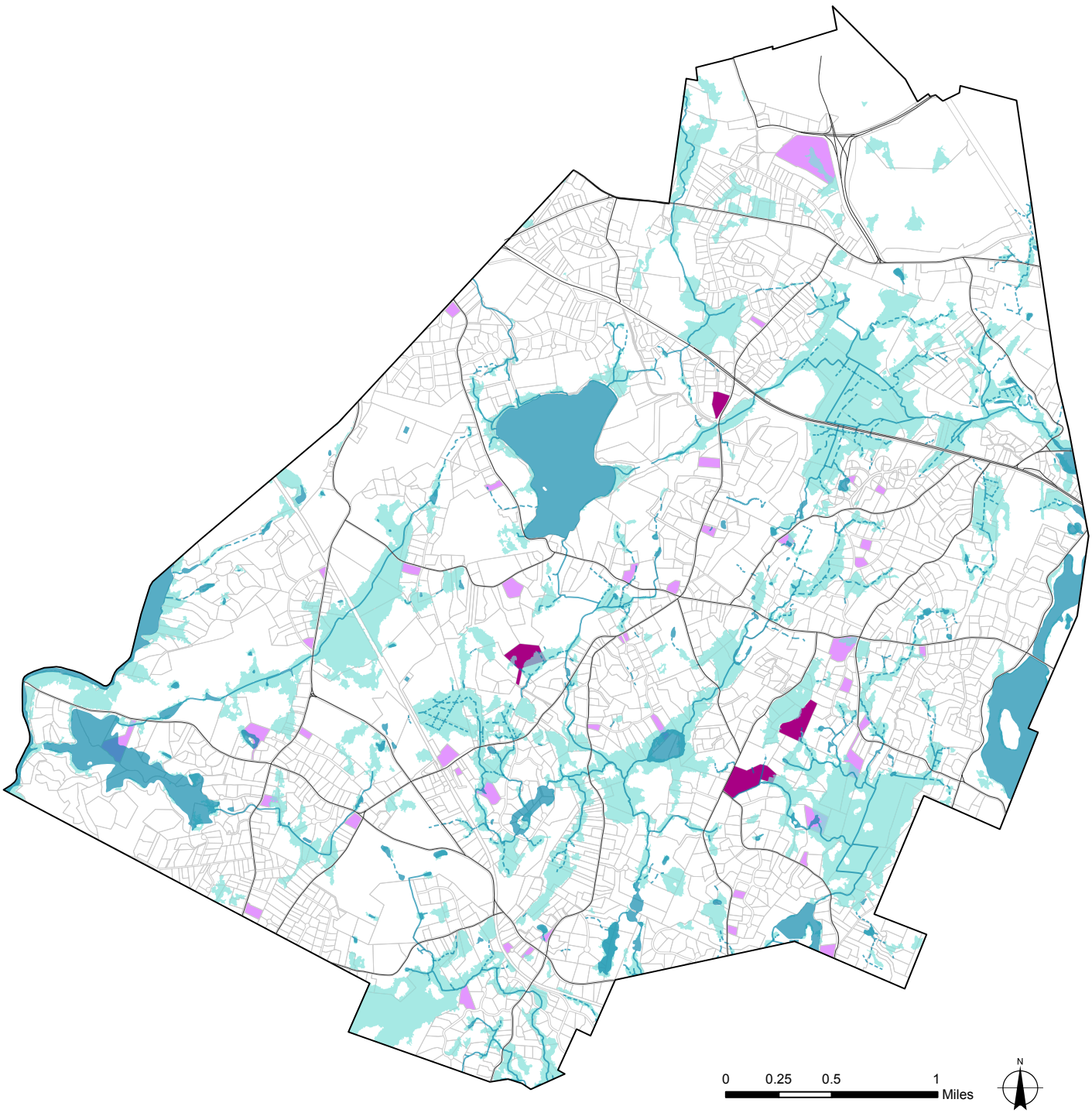
Bombus fervidus by Norm Levey

2
At-Risk Bumblebees Helped

Frosted elfin photo by Tom Whelan

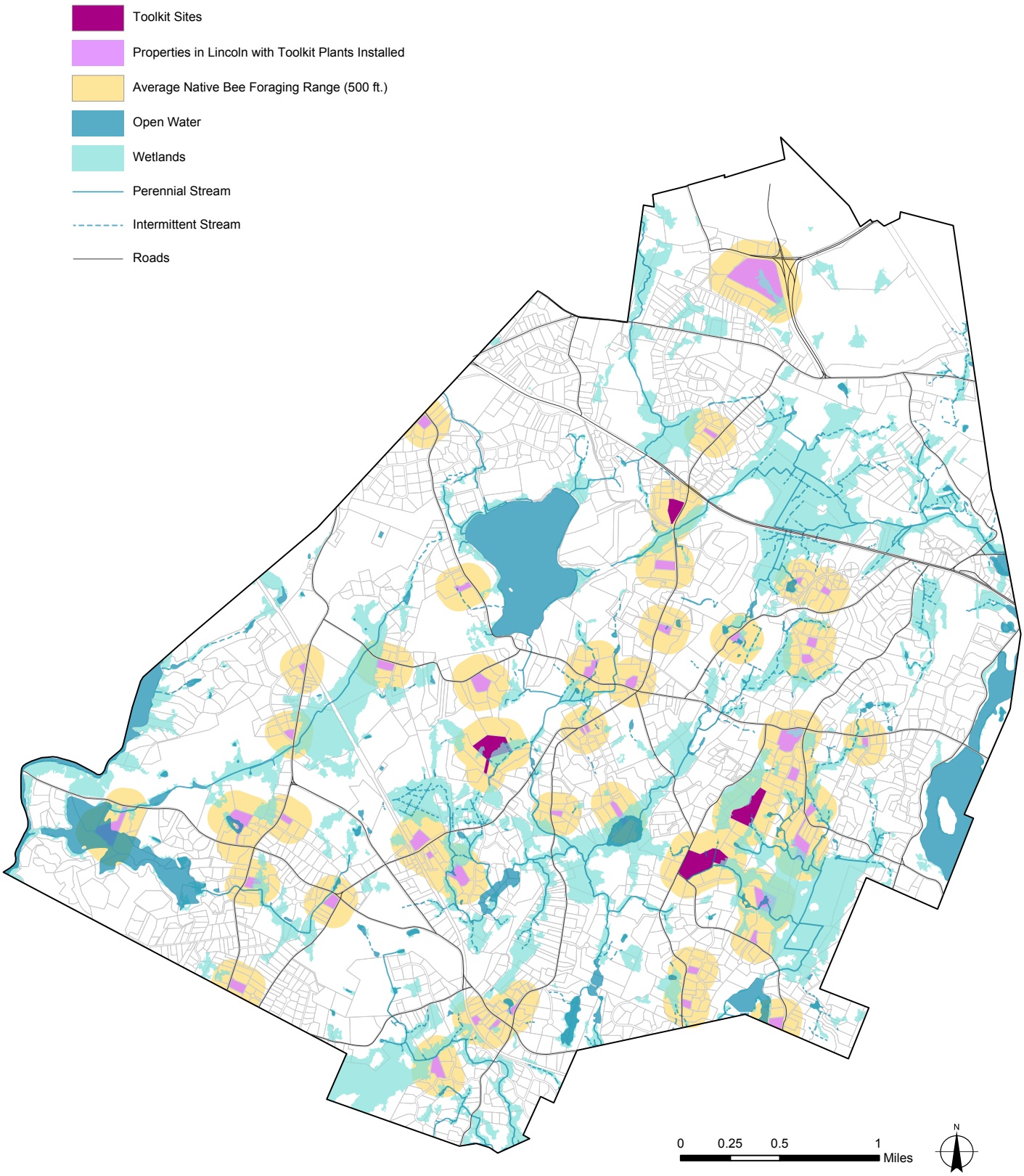
10
At-Risk Lepidoptera Helped

Toolkit sites seen in correlation to the 43 properties in Lincoln that installed plant kits based on the Birches School landscape design, which were sold through a plant sale by LLCT. The plants were selected to support at-risk bumblebee and butterfly species in Eastern Massachusetts specifically, rather than species whose populations are stable. A buffer of 500 feet was added to each property, representing the average foraging range of a native bee, in an attempt to depict opportunities for habitat connectivity across the town-wide landscape. While many solitary bee species forage limited distances from their nests, bumblebee species are known to forage much farther than 500 feet, as are many butterfly species.



POLLINATOR CORRIDOR PHASE 1 SITES

Toolkit sites and properties in Lincoln with pollinator habitat installed



Baseline Survey Results

Across the Year One (2020) growing season, Dr. Gegear surveyed three of the Toolkit sites in Lincoln (People for Pollinators, Upper Browning Fields and Chapman Pasture) for bumblebee and butterfly species at risk in Northeastern Massachusetts. His observations were compared to historical data for pollinator species in the area, and inform the plant selection and habitat establishment recommendations for each site, outlined on the following pages.

This baseline data will be compared to subsequent surveys in 2021 and 2022 (Years Two and Three) after the planting designs and landscape management guidelines outlined in each site's Toolkit have been implemented. This will demonstrate the significance of species-level plant selection and in particular, of combining specific groups of plant species together on a site, to not only attract but sustain populations of pollinator species that are of the highest conservation priority. This science-based approach to landscape biodiversity design is at the core of the work that Landscape Interactions does.

INITIAL SURVEY REPORTS FOR BUMBLEBEE AND BUTTERFLY SPECIES AT RISK

(Year 1, 2020 season)

Robert J. Gegear

Historical records of bumblebee species relative abundance and distribution data were obtained from the Yale Peabody Museum for areas close to the study sites in Lincoln. Surveys of bumblebees and at-risk butterflies were taken in spring, summer and fall (one survey per time period). Bumblebee surveys included all species historically present in the area whereas butterfly surveys focused only on species at risk.

The following common bumblebee species were recorded at both People for Pollinators and Upper Browning Fields: *Bombus impatiens, B. griseocollis, B. perplexus* and *B. bimaculatus.* The at-risk *B. fervidus* and *B. vagans* were also observed at People for Pollinators and Upper Browning Fields. Chapman Pasture only had *B. impatiens* and one *B. fervidus* worker. *B. sandersoni,* which is a rare species with stable numbers, was not observed at any site.

It must be noted that Chapman Pasture had unusually low bee activity due to the lack of diverse floral resources (nesting habitat, however, seemed good for all species at Chapman Pasture).

A list of the target species expected to be at each site based on historical records is provided on the following page. I also provide an assessment below of the overall abundance and diversity of flower visitors (low, moderate, high) given site size.

Note: only at-risk butterflies were surveyed. None were found on any site.

SUMMARY FINDINGS:

People for Pollinators: High abundance, high diversity;
Upper Browning Fields: High abundance, moderate diversity;
Chapman Pasture: Low abundance, low diversity.

Left: Dr. Gegear surveying bumblebees in Lincoln. Photograph by Bryn Gingrich.

Photographs (clockwise from top): Aphrodite Fritillary by Andrea Janda; Bombus pensylvanicus by Matthew Beziat; Bog Coppers by Jim Brighton; Bombus affinis by Serina Jepsen (opposite page).

At-Risk Pollinators Supported by this Plan

BEES:

- *Bombus affinis* Rusty patched bumblebee
- *Bombus fervidus* Golden northern bumblebee
- *Bombus pensylvanicus* American bumblebee
- *Bombus vagans* Half-black bumblebee

BUTTERFLIES:

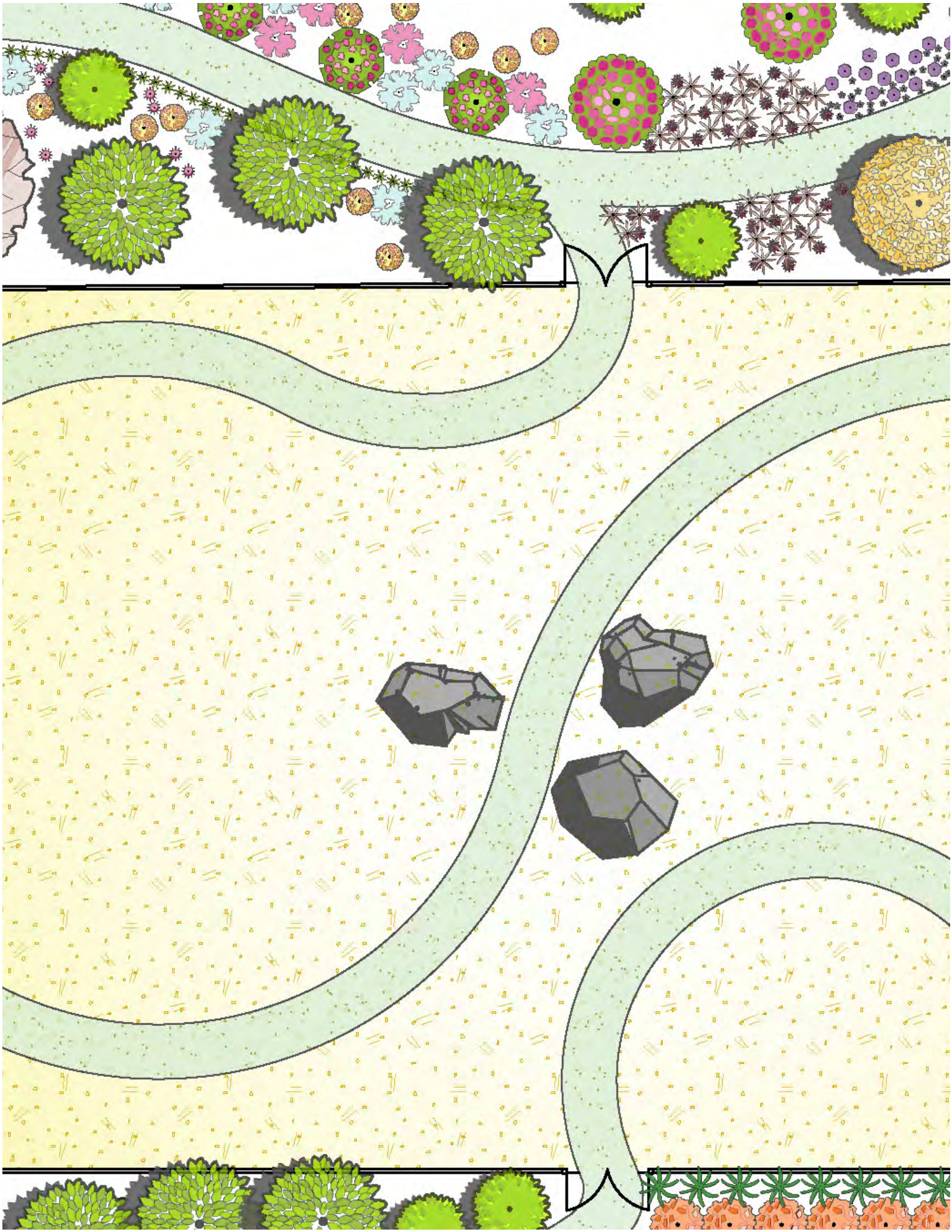
- *Amblyscirtes hegon* Pepper and Salt Skipper
- *Callophrys gryneus* Juniper Hairstreak
- *Callophrys hesseli* Hessel's Hairstreak
- *Callophrys irus* Frosted Elfin
- *Carterocephalus palaemon* Arctic Skipper
- *Chlosyne harrisii* Harris' Checkerspot
- *Euphyes conspicua* Black Dash
- *Hesperia leonardus* Leonard's Skipper
- *Hesperia metea* Cobweb Skipper
- *Hesperia sassacus* Indian Skipper
- *Lycaena epixanthe* Bog Copper
- *Lycaena hyllus* Bronze Copper
- *Poanes massasoit* Mulberry Wing
- *Satyrium acadica* Acadian Hairstreak
- *Satyrium favonius* Oak Hairstreak
- *Speyeria aphrodite* Aphrodite Fritillary

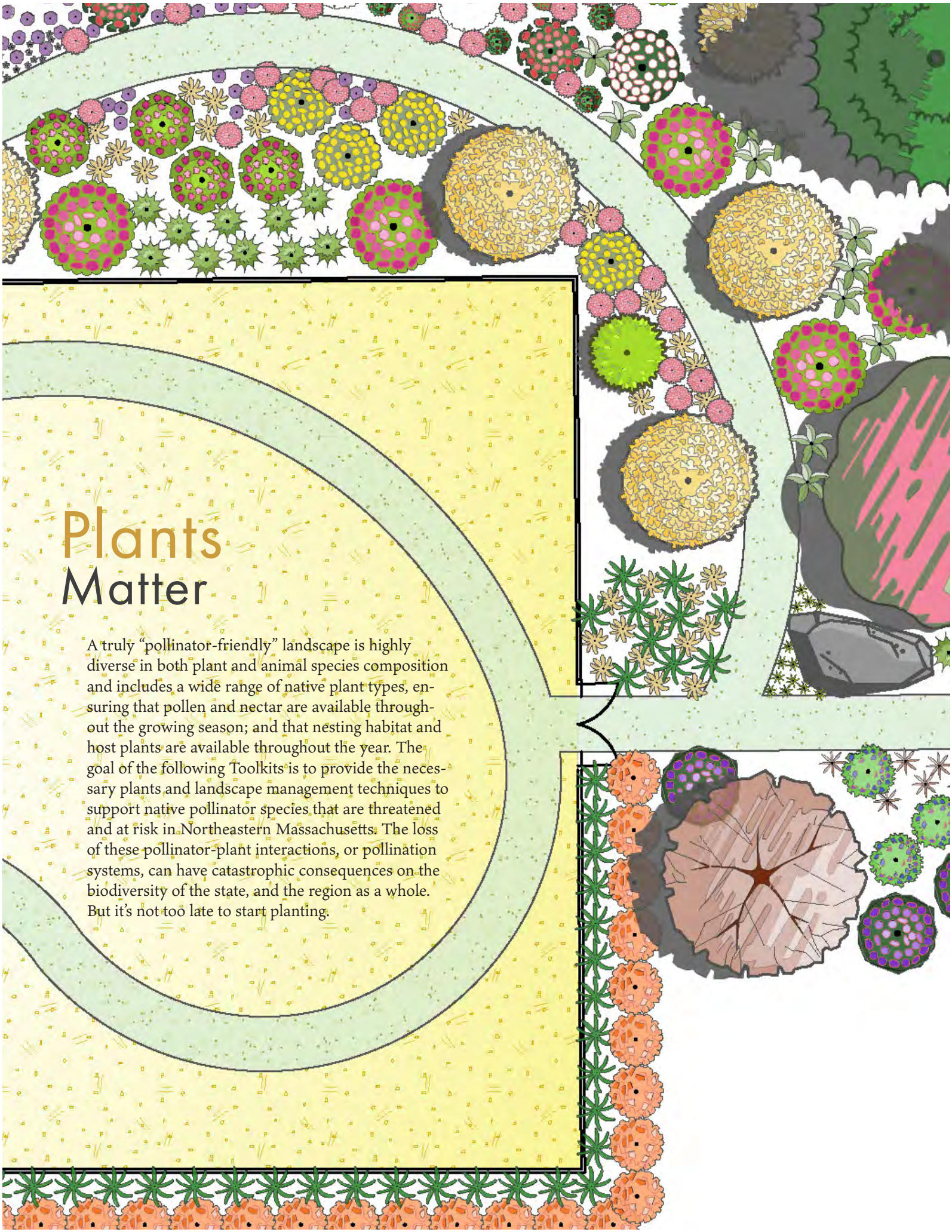
BIGGEST THREATS FACING POLLINATORS

- Habitat Loss *(agriculture + human development)*
- Pesticides
- Climate Change

Toolkits for Replication

The designs, plant lists and management guidelines on the following pages are based on the most prevalent landscape conditions in the Town of Lincoln. But their relevance stretches far beyond town boundaries. By providing detailed information regarding site preparation; seeding and planting; and maintenance over time for a wide range of natural communities and land use types, this Plan endeavors to make pollinator habitat creation easy, exciting and aesthetically pleasing — and inspire landowners to view their properties as part of a network of ecosystems that stretches throughout Lincoln and beyond, into surrounding communities and across the wider region.





Plants Matter

A truly "pollinator-friendly" landscape is highly diverse in both plant and animal species composition and includes a wide range of native plant types, ensuring that pollen and nectar are available throughout the growing season; and that nesting habitat and host plants are available throughout the year. The goal of the following Toolkits is to provide the necessary plants and landscape management techniques to support native pollinator species that are threatened and at risk in Northeastern Massachusetts. The loss of these pollinator-plant interactions, or pollination systems, can have catastrophic consequences on the biodiversity of the state, and the region as a whole. But it's not too late to start planting.



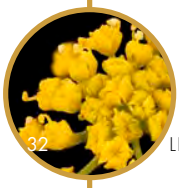



Recommended Plants for Northeastern Massachusetts*

Latin Name	Common Name
Agastache scrophulariifolia	Purple giant hyssop
Andropogon gerardii	Big bluestem
Asclepias incarnata	Swamp milkweed
Asclepias syriaca	Common milkweed
Asclepias tuberosa	Butterfly milkweed
Baptisia tinctoria	Yellow wild indigo
Carex spp.	Sedges
Cephalanthus occidentalis	Buttonbush
Cercis canadensis	Redbud
Chamaecyparis thyoides	Atlantic white cedar
Cirsium discolor	Field thistle
Cirsium pumilum	Pasture thistle
Desmodium canadense	Showy tick-trefoil
Diervilla lonicera	Northern bush honeysuckle
Doellingeria umbellata	Tall white aster
Eutrochium dubium	Coastal plain Joe-Pye weed
Eutrochium fistulosum	Hollow Joe-Pye weed
Eutrochium maculatum	Spotted Joe-Pye weed
Eutrochium purpureum	Purple Joe-Pye weed
Geranium maculatum	Spotted crane's-bill
Hypericum ascyron	Great St. John's-wort
Hypericum prolificum	Shrubby St. John's-wort
Hypericum punctatum	Spotted St. John's-wort
Impatiens capensis	Spotted touch-me-not
Juniperus virginiana	Eastern red cedar
Lupinus perennis	Wild lupine
Mimulus alatus	Winged monkey flower
Mimulus ringens	Allegheny monkey flower

Latin Name	Common Name
Monarda didyma	Scarlet bee balm
Monarda fistulosa	Wild bergamot
Panicum virgatum	Switchgrass
Pedicularis canadensis	Canadian lousewort
Penstemon digitalis	Foxglove beardtongue
Penstemon hirsutus	Northeastern beardtongue
Prunella vulgaris ssp. lanceolata	Common selfheal
Prunus maritima	Beach plum
Quercus ilicifolia	Scrub oak
Quercus spp.	Oaks
Rosa carolina	Carolina rose
Rosa palustris	Swamp rose
Rosa virginiana	Virginia rose
Rubus allegheniensis	Common blackberry
Rubus odoratus	Purple-flowering raspberry
Rubus pensilvanicus	Pennsylvania blackberry
Rubus vermontanus	Vermont blackberry
Rumex altissimus	Pale dock
Rumex spp.	Water dock (native)
Salix bebbiana	Bebb's willow (male)
Salix discolor	Pussy willow (male)
Salix humilis	Prairie willow (male)
Salix lucida	Shining willow (male)
Salix petiolaris	Meadow willow (male)
Schizachyrium scoparium	Little bluestem
Scutellaria galericulata	Hooded skullcap
Scutellaria lateriflora	Mad dog skullcap
Solidago caesia	Axillary goldenrod

**Plant recommendations are site-specific and based on landscape conditions at the Toolkit sites, however, the sites chosen represent a wide range of habitat types, land use, soils and hydrological conditions.*



Opposite page, clockwise from bottom: Zizia aurea; Vaccinium angustifolium; Rubus odoratus; Ribes rubrum; Penstemon hirsutus; Bombus ternarius on Salix discolor; Spirea alba. This page, from top: Baptisia tinctoria; Carex stricta; Prunus maritima; Vaccinium macrocarpon; Schizachyrium scoparium; Scutellaria galericulata; Lupinus perennis.

Latin Name	Common Name
Solidago flexicaulis	Zig-zag goldenrod
Solidago juncea	Early goldenrod
Solidago odora	Sweet goldenrod
Solidago puberola	Downy goldenrod
Solidago sempervirens	Seaside goldenrod
Solidago speciosa	Showy goldenrod
Spiraea alba	White meadowsweet
Spiraea tomentosa	Steeplebush
Symphyotrichum laterifolium	Calico American-aster

Latin Name	Common Name
Vaccinium angustifolium	Lowbush blueberry
Vaccinium corymbosum	Highbush blueberry
Vaccinium macrocarpon	Large cranberry
Vaccinium oxycoccos	Small cranberry
Vaccinium pallidum	Hillside blueberry
Viola spp.	Violets (native)
Zizia aptera	Heart-leaved golden Alexanders
Zizia aurea	Common golden Alexanders

Latin Name	Common Name	Bloom Time	Function	At-Risk Pollinators Supported*
Agastache scrophulariifolia	Purple giant hyssop	July-Sept	Nectar	Bumblebees, Butterflies, Other bees
Andropogon gerardii	Big bluestem	Aug	Host	Butterflies
Asclepias incarnata	Swamp milkweed	July-Aug	Nectar, Host	Butterflies, Other bees
Asclepias syriaca	Common milkweed	June-Aug	Nectar, Host	Butterflies, Other bees
Asclepias tuberosa	Butterfly milkweed	June-July	Nectar, Host	Butterflies, Other bees
Baptisia tinctoria	Yellow wild indigo	June-Aug	Nectar, Host	Bumblebees, Butterflies
Carex spp.	Sedges	Apr-June	Host	Butterflies
Cephalanthus occidentalis	Buttonbush	June-Aug	Nectar	Bumblebees, Butterflies, Other bees
Cercis canadensis	Redbud	Mar-May	Pollen, Nectar, Host	Bumblebees, Butterflies, Other bees
Chamaecyparis thyoides	Atlantic white cedar	Mar-May	Host	Butterflies
Cirsium discolor	Field thistle	Aug-Oct	Nectar	Bumblebees, Butterflies, Other bees
Cirsium pumilum	Pasture thistle	Aug-Oct	Nectar	Bumblebees, Butterflies, Other bees
Desmodium canadense	Showy tick-trefoil	July-Aug	Nectar	Bumblebees, Other bees
Diervilla lonicera	Northern bush honeysuckle	June-Aug	Nectar	Bumblebees, Butterflies, Other bees
Doellingeria umbellata	Tall white aster	July-Sept	Host	Butterflies, Other bees
Eutrochium dubium	Coastal plain Joe-Pye weed	July-Sept	Nectar	Bumblebees, Butterflies, Other bees
Eutrochium fistulosum	Hollow Joe-Pye weed	July-Sept	Nectar	Bumblebees, Butterflies, Other bees
Eutrochium maculatum	Spotted Joe-Pye weed	July-Sept	Nectar	Bumblebees, Butterflies, Other bees
Eutrochium purpureum	Purple Joe-Pye weed	July-Sept	Nectar	Bumblebees, Butterflies, Other bees
Geranium maculatum	Spotted crane's-bill	Apr-May	Nectar, Pollen	Butterflies, Other bees
Hypericum ascyron	Great St. John's-wort	July	Pollen	Bumblebees, Other bees
Hypericum prolificum	Shrubby St. John's-wort	June-Aug	Pollen	Bumblebees, Other bees
Hypericum punctatum	Spotted St. John's-wort	July-Sept	Pollen	Bumblebees, Other bees
Impatiens capensis	Spotted touch-me-not	July-Sept	Nectar	Bumblebees, Other bees
Juniperus virginiana	Eastern red cedar	Mar-May	Host	Butterflies
Lupinus perennis	Wild lupine	May-July	Nectar	Bumblebees, Butterflies
Mimulus alatus	Winged monkey flower	July-Sept	Nectar	Bumblebees, Butterflies, Other bees
Mimulus ringens	Allegheny monkey flower	June-Sept	Nectar	Bumblebees, Butterflies, Other bees
Monarda didyma	Scarlet bee balm	June-Aug	Nectar	Bumblebees, Butterflies, Other bees
Monarda fistulosa	Wild bergamot	July-Sept	Nectar	Bumblebees, Butterflies, Other bees
Panicum virgatum	Switchgrass	July-Sept	Host	Butterflies
Pedicularis canadensis	Canadian lousewort	Apr-May	Nectar	Bumblebees, Butterflies, Other bees
Penstemon digitalis	Foxglove beardtongue	May-July	Nectar	Bumblebees, Butterflies, Other bees
Penstemon hirsutus	Northeastern beardtongue	May-June	Nectar	Bumblebees, Butterflies, Other bees
Prunella vulgaris ssp. lanceolata	Common selfheal	May-Sept	Nectar	Bumblebees, Butterflies, Other bees
Prunus maritima	Beach plum	Apr-June	Pollen, Nectar, Host	Bumblebees, Butterflies, Other bees
Quercus ilicifolia	Scrub oak	Mar-June	Host	Butterflies

Latin Name	Common Name	Bloom Time	Function	At-Risk Pollinators Supported*
Quercus spp.	Oaks	Mar-June	Host	Butterflies
Rosa carolina	Carolina rose	June-Aug	Pollen	Bumblebees, Other bees
Rosa palustris	Swamp rose	June-July	Pollen	Bumblebees, Other bees
Rosa virginiana	Virginia rose	June-Aug	Pollen	Bumblebees, Other bees
Rubus allegheniensis	Common blackberry	June-July	Pollen, Nectar	Butterflies, Other bees
Rubus odoratus	Purple-flowering raspberry	June-July	Pollen	Bumblebees, Other bees
Rubus pensilvanicus	Pennsylvania blackberry	May-June	Pollen, Nectar	Butterflies, Other bees
Rubus vermontanus	Vermont blackberry	June	Pollen	Other bees
Rumex altissimus	Pale dock	June-Aug	Host	Butterflies, Other Bees
Rumex spp.	Water dock (native)	Apr-Aug	Host	Butterflies, Other Bees
Salix bebbiana	Bebb's willow (male)	Apr-May	Pollen, Nectar	Bumblebees, Butterflies, Other bees
Salix discolor	Pussy willow (male)	Mar-Apr	Pollen, Nectar	Bumblebees, Butterflies, Other bees
Salix humilis	Prairie willow (male)	Apr-May	Pollen, Nectar	Bumblebees, Butterflies, Other bees
Salix lucida	Shining willow (male)	Apr-May	Pollen, Nectar	Bumblebees, Butterflies, Other bees
Salix petiolaris	Meadow willow (male)	Apr-May	Pollen, Nectar	Bumblebees, Butterflies, Other bees
Schizachyrium scoparium	Little bluestem	September	Host	Butterflies
Scutellaria galericulata	Hooded skullcap	July-Sept	Nectar	Bumblebees, Butterflies, Other bees
Scutellaria lateriflora	Mad dog skullcap	July-Sept	Nectar	Bumblebees, Butterflies, Other bees
Solidago caesia	Axillary goldenrod	Aug-Oct	Pollen, Nectar	Butterflies, Other bees
Solidago flexicaulis	Zig-zag goldenrod	Aug-Oct	Pollen, Nectar	Butterflies, Other bees
Solidago juncea	Early goldenrod	July-Sept	Pollen, Nectar	Butterflies, Other bees
Solidago odora	Sweet goldenrod	Aug-Sept	Pollen, Nectar	Butterflies, Other bees
Solidago puberola	Downy goldenrod	Aug-Oct	Pollen, Nectar	Butterflies, Other bees
Solidago sempervirens	Seaside goldenrod	Aug-Oct	Pollen, Nectar	Butterflies, Other bees
Solidago speciosa	Showy goldenrod	Aug-Oct	Pollen, Nectar	Bumblebees, Butterflies, Other bees
Spiraea alba	White meadowsweet	June-Sept	Pollen	Bumblebees, Other bees
Spiraea tomentosa	Steeplebush	Aug-Sept	Pollen	Bumblebees, Other bees
Symphyotrichum laterifolium	Calico American-aster	Aug-Oct	Nectar	Butterflies, Other bees
Vaccinium angustifolium	Lowbush blueberry	May-June	Nectar	Bumblebees, Butterflies, Other bees
Vaccinium corymbosum	Highbush blueberry	May-June	Nectar	Bumblebees, Butterflies, Other bees
Vaccinium macrocarpon	Large cranberry	June-Aug	Host	Bumblebees, Butterflies, Other bees
Vaccinium oxycoccos	Small cranberry	June	Nectar	Bumblebees, Other bees
Vaccinium pallidum	Hillside blueberry	May-June	Nectar	Bumblebees, Butterflies, Other bees
Viola spp.	Violets (native)	May-June	Host	Butterflies, Other bees
Zizia aptera	Heart-leaved golden Alexanders	May-June	Pollen, Nectar	Butterflies, Other bees
Zizia aurea	Common golden Alexanders	May-June	Pollen, Nectar	Butterflies, Other bees

**A plant's function supports specific pollinator species. For example, where "bumblebees" are listed as collecting nectar from Cephalanthus occidentalis, specifically B. vagans has been observed; one should not presume Buttonbush helps all at-risk bumblebees. Similarly, host plants support specific at-risk butterflies, not all at-risk species. To match the plants on this list with their at-risk pollinators, visit the Gegear Lab website's Native Plant Finder: https://gegearlab.weebly.com/plant-list.html.*

Toolkit Sites

1. MEADOW & WOODLAND
   PEOPLE FOR POLLINATORS
2. OLD FIELD
   CHAPMAN PASTURE
3. WET MEADOW
   UPPER BROWNING FIELDS
4. GARDEN & LAWN
   BIRCHES SCHOOL

Conceptual rendering of the Chapman Pasture landscape design by Evan Abramson.

Meadow & Woodland Toolkit

PEOPLE FOR POLLINATORS

EXISTING CONDITIONS

People for Pollinators is a 8,700 sq.ft planted meadow surrounded by fencing, with a planted shrub layer on the south side of the fence, adjacent to woodland edges and open fields abutting the Lincoln Public Schools property. The site is situated on the northernmost portion of a 10.2-acre site owned and protected by LLCT. The soils are mesic and nearly all of the site is in full sun.

Since 2016, LLCT has managed the site for native pollinators by direct seeding and planting a variety of forbs, graminoids and shrubs. Approximately 25-35% of the fenced in meadow remains as non-native grasses and common weeds.

After an initial survey of plant species diversity on the site by Evan Abramson and Adam Kohl of Landscape Interactions in 2019, Dr. Gegear surveyed the site for bumblebees and at-risk butterflies multiple times in 2020. While pollinator populations at the site were categorized as "high abundance, high diversity" by Dr. Gegear, a lot of room remains for improvement, not only in native plant species diversity (early season pollen sources and host plants in particular) but also with regards to aesthetics and the visitor experience.

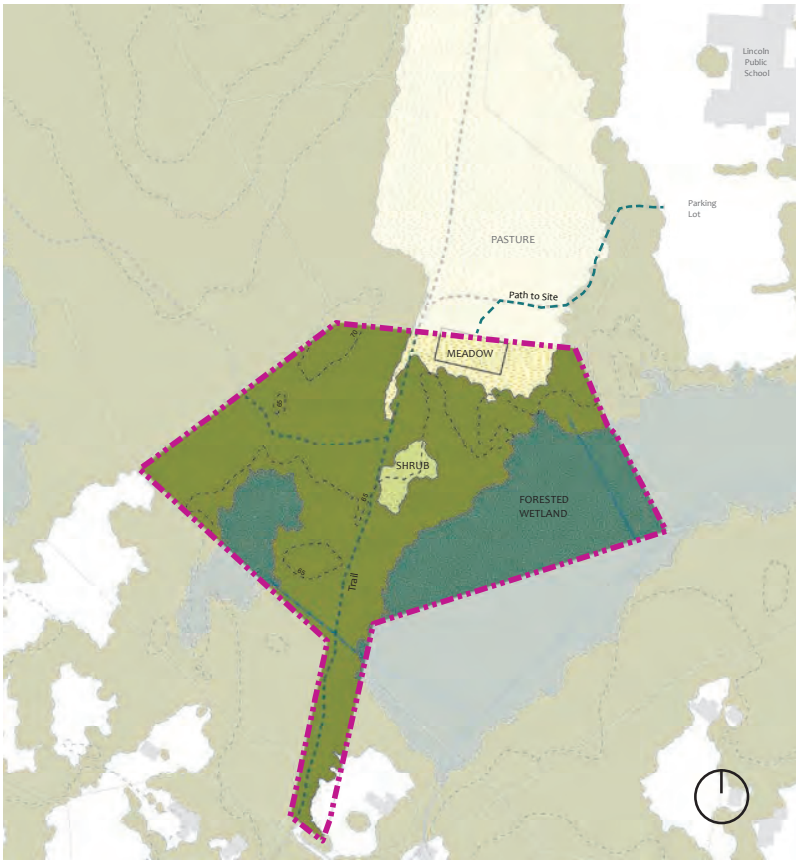
LLCT's goals for the site include expanding public education and programming; access to the location, therefore, needs to be more clear and welcoming. The meadow is currently surrounded by an 8 ft. tall chain link fence, with only one gate for entry, situated on the northern side. The fence was initially installed to prevent deer browse and to deter dog

walkers from allowing their dogs off leash. The location is somewhat hard to find, although it is marked by a sign at the edge of the Lincoln Public Schools parking lot. A narrow path through woods and a field leads visitors to the site, with a mowed section of path branching off to the south and leading up to the fence.

While LLCT has been actively stewarding People for Pollinators for several years, no permanent water source exists and establishing new plantings remains a challenge. Additionally, the shrubs planted between the fence and the surrounding woods are being pressured by invasive oriental bittersweet and weeds.

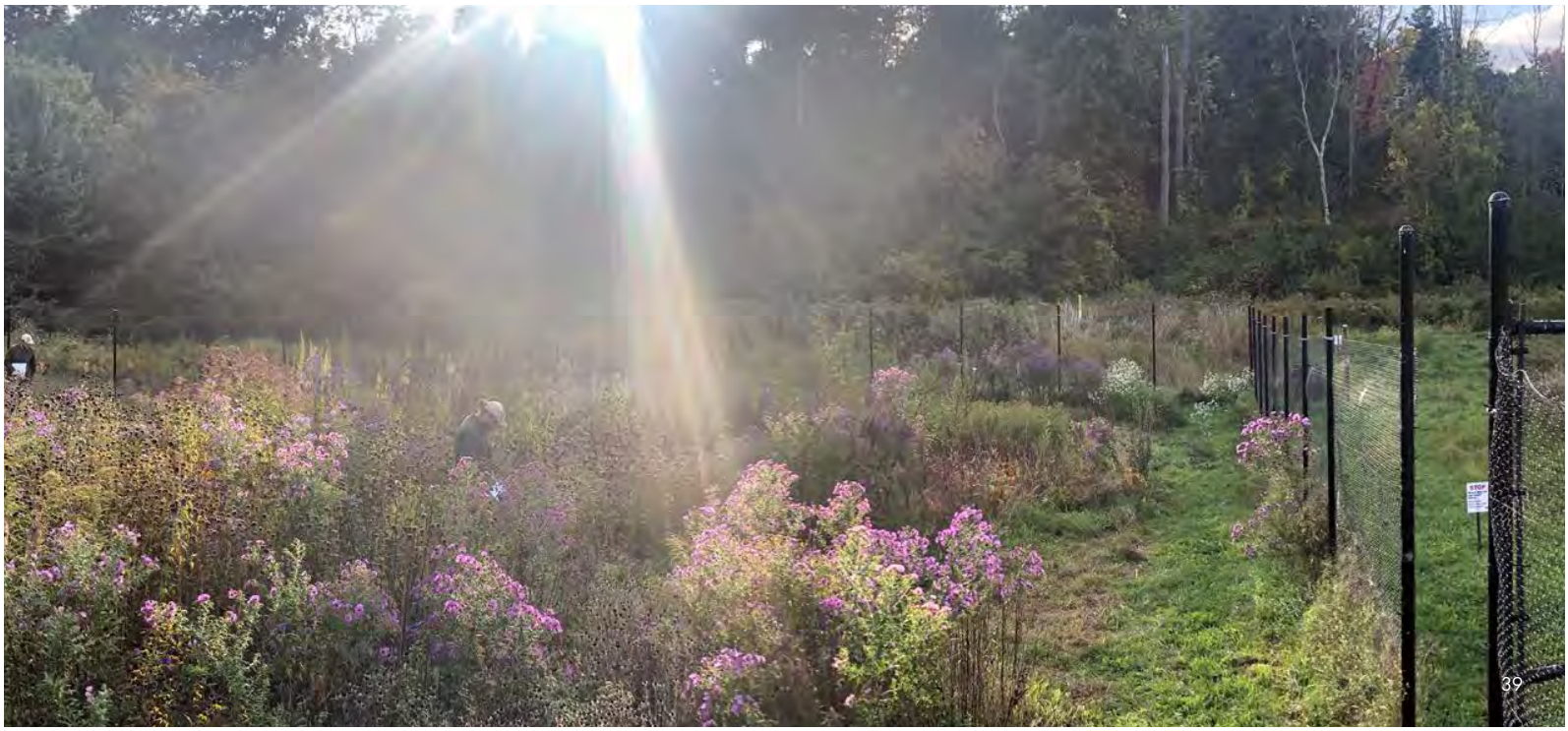
Paths within the meadow and shrub areas are not clearly defined or do not exist, and in order to access the shrubs visitors have to exit the meadow through the gate on the opposite side and walk around the fence. No seating or shade areas exist at the site, nor is there a gathering space for workshops.

After a number of site visits and conversations between designer Evan Abramson and LLCT staff, it was determined that a small gathering space should be added, with a slanted roof to allow for rainwater catchment. The fence will be reduced to a 2' height to deter dogs, with winding paths and gates connecting



the various areas to each other. Plant species diversity on the site will be vastly widened per Dr. Gegear's recommendations in order to attract and sustain a long list of threatened and at risk species from early spring to late fall. Sitting areas will offer visitors the opportunity to take in the site's abundance and diversity at their own pace.

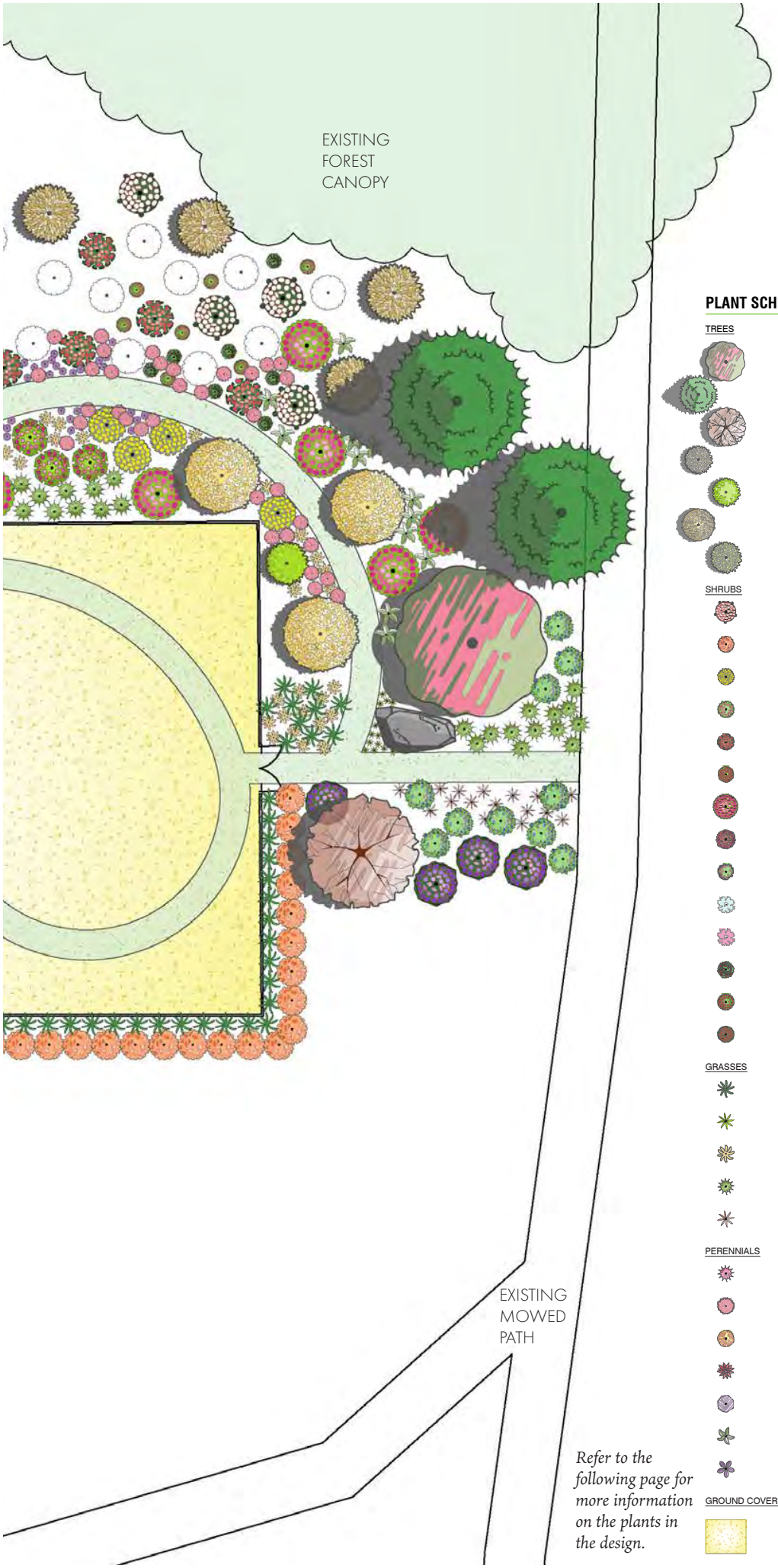
Composite panorama of field botanist Adam Kohl at People for Pollinators in 2019. Pollinator-supporting plants well established on the site include Asclepias incarnata, Eutrochium fistulosum, Monarda fistulosa, Penstemon digitalis, Salix lucida, S. petiolaris, Symphyotrichum novae-angliae, Vaccinium corymbosum and Zizia aurea. Opposite: sign at site entrance. Photographs by Evan Abramson.



Meadow & Woodland Toolkit

PEOPLE FOR POLLINATORS

LANDSCAPE|NTERACTIONS
16 Center Street #426
Northampton, MA 01060
landscapeinteractions.com



SITE CONDITIONS

MEDIUM TO MOIST SOILS
FULL SUN TO PART-SHADE
MODERATE FOOT TRAFFIC
FORMER HAY FIELD

PLANT SCHEDULE

TREES	BOTANICAL NAME	COMMON NAME	QTY	REMARKS
	Cercis canadensis	Eastern Redbud	2	20` wide spacing
	Chamaecyparis thyoides	Atlantic White Cedar	2	20` wide spacing
	Quercus ilicifolia	Scrub Oak	3	15` wide spacing
	Salix discolor	Pussy Willow	5	8` wide spacing
	Salix humilis	Prairie Willow	10	6` wide spacing
	Salix lucida	Shining Willow	5	10` wide spacing
	Salix petiolaris	Meadow Willow	10	10` wide spacing

SHRUBS	BOTANICAL NAME	COMMON NAME	QTY	REMARKS
	Cephalanthus occidentalis	Buttonbush	4	6` wide spacing
	Diervilla lonicera	Northern Bush-honeysuckle	36	4` wide spacing
	Hypericum prolificum	Shrubby St. John`s-wort	10	5` wide spacing
	Rosa carolina	Carolina Rose	7	4` wide spacing
	Rosa palustris	Swamp Rose	5	5` wide spacing
	Rosa virginiana	Virginia Rose	9	5` wide spacing
	Rubus odoratus	Purple-flowering Raspberry	8	7` wide spacing
	Rubus pensilvanicus	Pennsylvania Blackberry	4	6` wide spacing
	Rubus vermontanus	Vermont Blackberry	10	4` wide spacing
	Spiraea alba	Meadowsweet	10	3` wide spacing
	Spiraea tomentosa	Steeplebush	10	3` wide spacing
	Vaccinium macrocarpon	American Cranberry	7	2` wide spacing
	Vaccinium oxycoccos	Small Cranberry	7	2` wide spacing
	Vaccinium pallidum	Hillside Blueberry	30	2` wide spacing

GRASSES	BOTANICAL NAME	COMMON NAME	QTY	REMARKS
	Andropogon gerardii	Big Bluestem	75	3` wide spacing
	Carex pensylvanica	Pennsylvania Sedge	125	1` wide spacing
	Chasmanthium latifolium	River Oats	40	2` wide spacing
	Panicum virgatum	Switchgrass	70	3` wide spacing
	Schizachyrium scoparium	Little Bluestem	100	2` wide spacing

PERENNIALS	BOTANICAL NAME	COMMON NAME	QTY	REMARKS
	Cirsium pumilum	Pasture Thistle	50	1` wide spacing
	Eutrochium dubium	Coastal Plain Joe-Pye Weed	36	2` wide spacing
	Hypericum ascyron	Giant St. John`s-wort	26	2` wide spacing
	Pedicularis canadensis	Canadian Wood Betony	80	1` wide spacing
	Prunella vulgaris	Selfheal	116	1` wide spacing
	Rumex altissimus	Pale Dock	12	2` wide spacing
	Viola pedata	Bird`s-foot Violet	40	.5` wide spacing

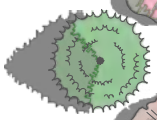
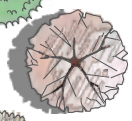
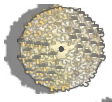
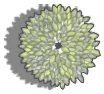
GROUND COVERS	BOTANICAL NAME	COMMON NAME	QTY	REMARKS
	Dry Mix	Upland Meadow Seed Mix	8,714 sf	Seed 35% of total area

Refer to the following page for more information on the plants in the design.

KEY TO DESIGN AREAS

full sun, medium soil | full sun, moist soil | full sun, moist to medium soil | full sun to part-shade, medium soil | part-shade, medium soil

PLANT SCHEDULE

TREES	BOTANICAL NAME	COMMON NAME	QTY	REMARKS
	Cercis canadensis	Eastern Redbud	2	20` wide spacing
	Chamaecyparis thyoides	Atlantic White Cedar	2	20` wide spacing
	Quercus ilicifolia	Scrub Oak	3	15` wide spacing
	Salix discolor	Pussy Willow	5	8` wide spacing
	Salix humilis	Prairie Willow	10	6` wide spacing
	Salix lucida	Shining Willow	5	10` wide spacing
	Salix petiolaris	Meadow Willow	10	10` wide spacing

SHRUBS	BOTANICAL NAME	COMMON NAME	QTY	REMARKS
	Cephalanthus occidentalis	Buttonbush	4	6` wide spacing
	Diervilla lonicera	Northern Bush-honeysuckle	36	4` wide spacing
	Hypericum prolificum	Shrubby St. John`s-wort	10	5` wide spacing
	Rosa carolina	Carolina Rose	7	4` wide spacing
	Rosa palustris	Swamp Rose	5	5` wide spacing
	Rosa virginiana	Virginia Rose	9	5` wide spacing
	Rubus odoratus	Purple-flowering Raspberry	8	7` wide spacing
	Rubus pensilvanicus	Pennsylvania Blackberry	4	6` wide spacing
	Rubus vermontanus	Vermont Blackberry	10	4` wide spacing
	Spiraea alba	Meadowsweet	10	3` wide spacing
	Spiraea tomentosa	Steeplebush	10	3` wide spacing

Meadow & Woodland Toolkit

PEOPLE FOR POLLINATORS

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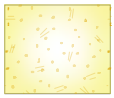
	Vaccinium macrocarpon	American Cranberry	7	2` wide spacing	
	Vaccinium oxycoccos	Small Cranberry	7	2` wide spacing	
	Vaccinium pallidum	Hillside Blueberry	30	2` wide spacing	
GRASSES	BOTANICAL NAME	COMMON NAME	QTY	REMARKS	
	Andropogon gerardii	Big Bluestem	75	3` wide spacing	
	Carex pensylvanica	Pennsylvania Sedge	125	1` wide spacing	
	Chasmanthium latifolium	River Oats	40	2` wide spacing	
	Panicum virgatum	Switchgrass	70	3` wide spacing	
	Schizachyrium scoparium	Little Bluestem	100	2` wide spacing	
PERENNIALS	BOTANICAL NAME	COMMON NAME	QTY	REMARKS	
	Cirsium pumilum	Pasture Thistle	50	1` wide spacing	
	Eutrochium dubium	Coastal Plain Joe-Pye Weed	36	2` wide spacing	
	Hypericum ascyron	Giant St. John`s-wort	26	2` wide spacing	
	Pedicularis canadensis	Canadian Wood Betony	80	1` wide spacing	
	Prunella vulgaris	Selfheal	116	1` wide spacing	
	Rumex altissimus	Pale Dock	12	2` wide spacing	
	Viola pedata	Bird`s-foot Violet	40	.5` wide spacing	
GROUND COVERS	BOTANICAL NAME	COMMON NAME	QTY	REMARKS	
	Dry Mix	Upland Meadow Seed Mix	8,714 sf	Seed 35% of total area	

Meadow & Woodland Toolkit

PEOPLE FOR POLLINATORS

MANAGEMENT GUIDELINES

SITE ESTABLISHMENT

As previously mentioned, significant portions of the People for Pollinators site had been direct seeded and planted as far back as 2016. Because of this, only about 35% of the fenced in area requires seeding, due in large part to the presence of non-native grasses and weeds. A custom seed mix has been created for the site (see opposite page) and LLCT staff and volunteers will remove the undesired vegetation.

To create the Beecology research garden, LLCT staff rented a push behind sod cutter and, after mowing as low as possible, cut 1-2" deep, removing the well established turf grasses from the site. Some areas were also smothered using black landscape fabric (refer to photographs on opposite page).

If smothering, black plastic or tarp must be well secured on all sides using ground staples, cinder blocks, large rocks or other weighted objects, so that the material does not flap over in the wind. It should be left in place for an entire growing season (May to September) in order to kill off unwanted vegetation.

Direct seeding is best suited for the late fall or early winter, as many, if not most of the native forbs, shrubs and graminoids selected require at least 30-60 days of cold stratification in order to germinate. An additional benefit of fall seeding is that watering is not required. When hand seeding small areas, it is recommended to mix the seeds with a medium such as sand or sawdust (use 4:1 ratio of medium to seeds) in order to help distribute the seeds more evenly and to provide some cover without burying the seeds too deeply. For seeding larger areas, refer to the Old Field Toolkit on the following pages.

Shrubs, plugs and other plants can be installed at any time during the growing season, but it is recommended to plant either in the early spring or the fall, in order to avoid plants drying out. Late spring or mid summer plantings should be avoided unless adequate watering systems or schedules are in place.

Mulching around new plantings can help suppress weeds and retain moisture. If mulching, use natural, dye-free materials such as shredded leaves, wood chips or straw and leave 2" of bare soil around the crown of the plant. To the extent possible, only mulch around new plantings. Ground nesting bees, which constitute approximately 70% of native bee species in the Northeast, require bare, exposed areas of soil to excavate their nests, which are often found at the base of bunching grasses. Landscaping which includes total coverage of areas in between plants with mulch prevents ground nesting bees from finding suitable nesting locations.

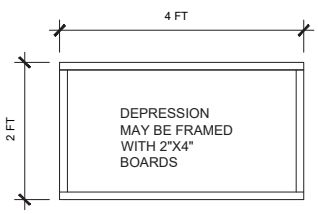
For additional information regarding landscape practices to support native pollinators, refer to the **Best Management Practices** section of this report.

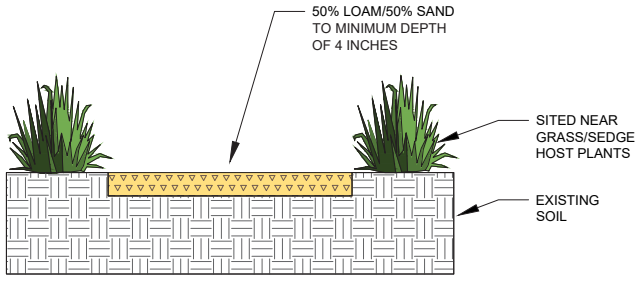
MOWING REGIMES

For meadow areas which have been recently seeded,

BEE NESTING STRIP DETAIL

Ground nesting bee habitat can be created by creating a 2'x4' or larger area and removing all vegetation and at least 4 inches of soil. 50% of the soil can be added back in mixed with 50% sand. The area should be well draining, in full sun and kept clear of weeds, grasses or other vegetation. Do not mulch.





it is generally recommended to keep all new vegetation in these areas at a height of 8-12 inches consistently, for the first 1-2 growing seasons. When the average height of plants in these newly seeded areas reaches approximately 12 inches, all vegetation in these areas should be cut back to no less than 8 inches. This practice should continue through the entire first growing season, and possibly the second. During the second or third growing season, vegetation should be assessed as to whether it is comprised predominantly of the species that were seeded. If it is, and if turf grass and invasive species pressure is low, the 8-12 inch mowing schedule can be replaced by selective hand pulling (on a small scale) or by a once-a-year weed whack or brush hog (on a large scale). If weed whacking or brush hogging, vegetation should be cut no lower than 4-6 inches, and always during the dormant season after plants have gone to seed. Ideally, the area would be divided into 2 or 3 sections. One section would be cut per year on a rotational basis for the life of the project, in either early spring (before April 1) or late fall (after November 15).

PEOPLE FOR POLLINATORS MEADOW SEED MIX

Shrubs		% Count	% Weight
Spiraea alba	Meadowsweet	4.05	0.83
Spiraea tomentosa	Steeplebush	4.05	0.83
Forbs			
Agastache scrophulariifolia	Purple giant hyssop	2.51	1.67
Asclepias incarnata	Swamp milkweed	0.61	7.83
Asclepias syriaca	Common milkweed	0.11	1.67
Asclepias tuberosa	Butterfly weed	0.23	3.34
Baptisia tinctoria	Yellow wild indigo	0.20	2.51
Cirsium discolor	Field thistle	0.17	1.67
Doellingeria umbellata	Tall white aster	1.81	1.67
Eutrochium fistulosum	Hollow Joe-Pye weed	0.99	0.78
Eutrochium maculatum	Spotted Joe-Pye weed	1.20	0.78
Eutrochium purpureum	Purple Joe-Pye weed	1.70	2.51
Geranium maculatum	Spotted crane's-bill	0.20	2.51
Hypericum punctatum	Spotted St. John's-wort	7.82	0.83
Hypericum pyramidatum	Great St. John's-wort	5.12	1.67
Impatiens capensis	Spotted touch-me-not	0.22	3.34
Lupinus perennis	Wild lupine	0.07	4.18
Mimulus ringens	Allegheny monkey flower	29.12	0.78
Monarda punctata	Spotted bee balm	3.42	2.35
Pedicularis canadensis	Canadian lousewort	1.25	2.35
Penstemon hirsutus	Northeastern beardtongue	6.70	1.67
Solidago juncea	Early goldenrod	7.83	1.67
Solidago odora	Sweet goldenrod	3.37	0.83
Solidago speciosa	Showy goldenrod	2.41	1.57
Zizia aptera	Heart-leaf golden Alexanders	0.49	2.51
Zizia aurea	Golden Alexanders	0.45	2.51
Graminoids			
Andropogon gerardii	Big bluestem	0.14	0.83
Carex brevior	Plains oval sedge	3.67	7.83
Carex molesta	Field oval sedge	3.17	7.83
Panicum virgatum	Switchgrass	0.19	0.83
Schizachyrium scoparium	Little bluestem	6.75	27.83

Portions of the People for Pollinators site were prepared for planting by smothering with black plastic (left) and sod cutting (right) in 2020. Photographs by Bryn Gingrich.

Old Field Toolkit

CHAPMAN PASTURE

EXISTING CONDITIONS

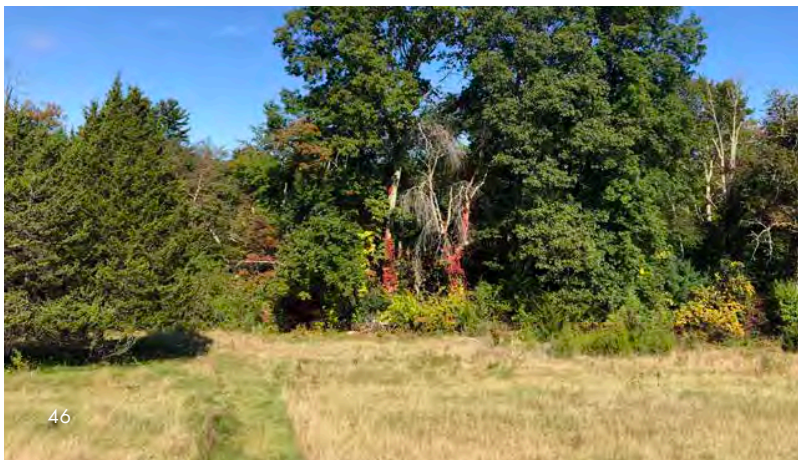
Chapman Pasture is a rolling 8-acre grassland that was grazed with sheep for over forty years. The property is unique in that its vegetation is relatively consistent: upland areas of the site are almost all non-native grasses that reach a mature height of less than 3 feet. The property forms part of a contiguous 95-acre corridor of protected land owned and managed by LLCT.

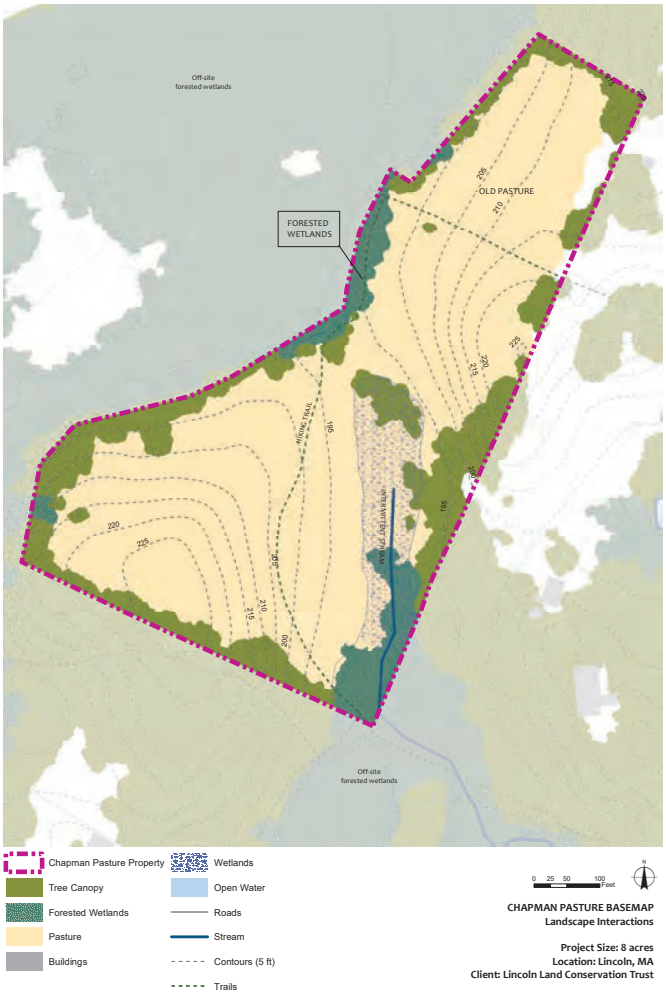
Forested wetlands border the site on both northwest and southeast sides, with an intermittent stream running northward through the center of the field from the southeast corner of the property. This stream, combined with the topography of the site, creates a low point in the center of the field, a wet swale which is comprised predominantly of native vegetation.

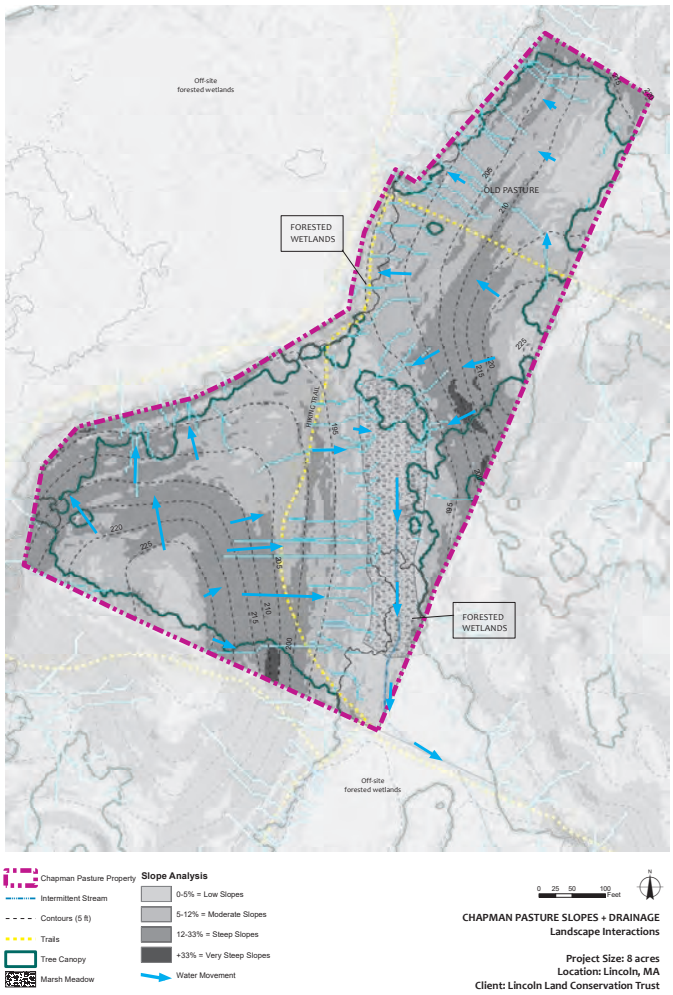
Whereas the upland two-thirds of the site are dominated by non-native grasses with small patches of early successional *Pinus strobus* (White pine) and *Juniperus virginiana* (Eastern red cedar), this wet swale contains a somewhat limited range of plants that support threatened pollinator species, including *Carex vulpinoidea* (Common fox sedge), *Asclepias incarnata* (Swamp milkweed), *Symphyotrichum nove-belgii* (New York American-aster) and *Solidago gigantea* (Smooth goldenrod). Field borders and forest edges contain significant portions of invasive *Celastrus orbiculatus* (Oriental bittersweet) as well as *Rosa multiflora* (Multiflora rose).

While Chapman Pasture is somewhat secluded, the site is open to the public and one point of access originates from another Toolkit site, Upper Browning Fields. LLCT is committed to converting the low habitat value of the grasses at Chapman Pasture to a diverse pollinator meadow with shrub areas. Seven bird boxes at Chapman Pasture are monitored for Eastern Bluebirds and Tree Swallows by a dedicated LLCT volunteer. Enhancements to the site will benefit these birds and wildlife at other trophic levels.

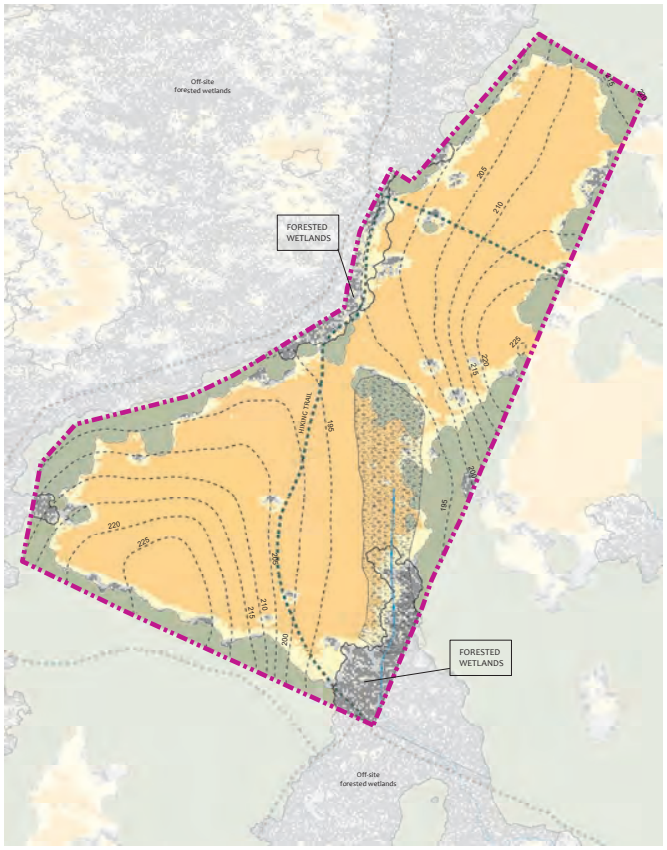
Due in large part to the dominance of the non-native grasses on the site, as well as the large scale of the property, Landscape Interactions proposed that prescribed fire be used to clear the site of existing vegetation and expose the soil for seeding. A proposal was prepared by LLCT and Landscape Interactions and sent to U.S. Fish & Wildlife Service. After visiting the site and learning more about LLCT's town-wide effort to target threatened pollinator species, USFWS agreed to fund a burn plan for the site, and to help find a team to execute the burn. USFWS will clear approximately one acre of field edges in preparation for the burn, which is scheduled for early spring 2021.

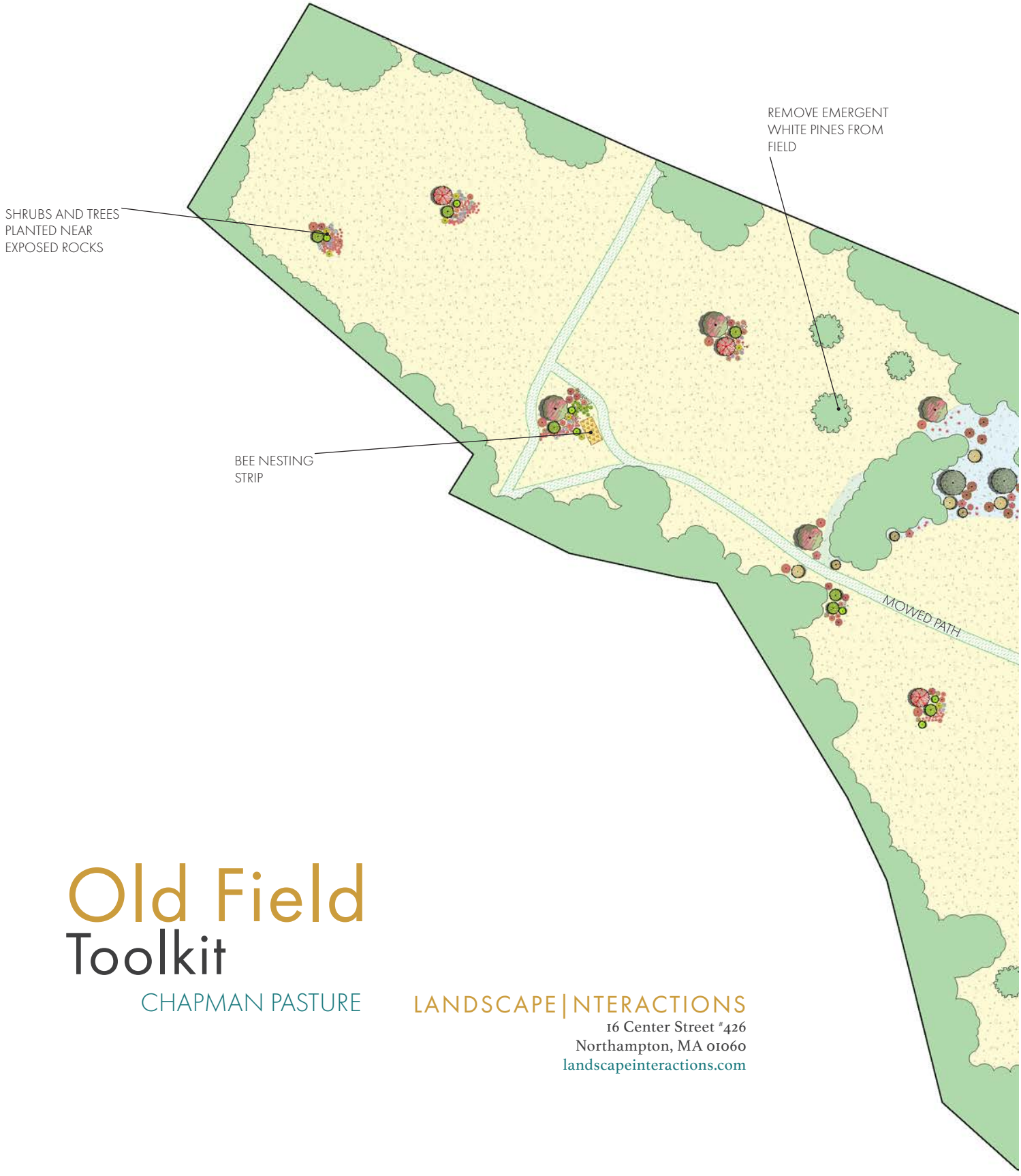






Above and right: some of the site analyses created to interpret the Chapman Pasture site and develop recommendations for habitat conversion and design. Clockwise from top left: Basemap, Slopes and Drainage, Sun and Shade. Below: existing conditions at the Chapman Pasture site in September, 2019. Opposite: Oriental bittersweet climbing a tree at the field edges.





Old Field Toolkit

CHAPMAN PASTURE

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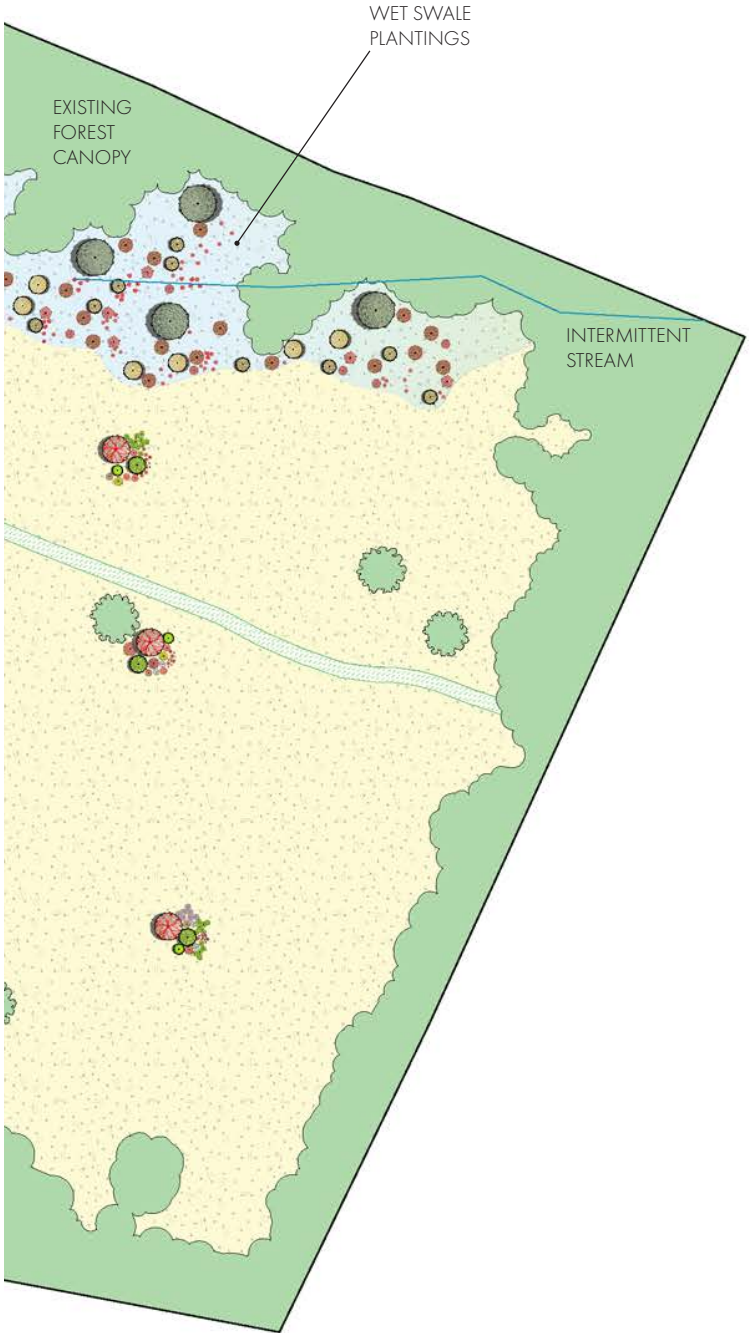
SITE CONDITIONS

DRY SOILS & MOIST TO WET SOILS
FULL SUN & PART SHADE
NATURALIZED LANDSCAPE
OLD FIELD GRASSLAND



PLANT SCHEDULE

TREES	BOTANICAL NAME	COMMON NAME	QTY	REMARKS
	Cercis canadensis	Eastern Redbud	4	20` wide spacing
	Quercus ilicifolia	Scrub Oak	6	15` wide spacing
	Salix bebbiana	Beaked Willow	6	20` wide spacing
	Salix discolor	Pussy Willow	12	8` wide spacing
	Salix humilis	Prairie Willow	10	6` wide spacing
	Salix lucida	Shining Willow	10	10` wide spacing
	Salix petiolaris	Meadow Willow	10	10` wide spacing

SHRUBS	BOTANICAL NAME	COMMON NAME	QTY	REMARKS
	Cephalanthus occidentalis	Buttonbush	10	6` wide spacing
	Diervilla lonicera	Northern Bush-honeysuckle	12	4` wide spacing
	Hypericum prolificum	Shrubby St. John`s-wort	10	5` wide spacing
	Rosa carolina	Carolina Rose	8	4` wide spacing
	Rosa palustris	Swamp Rose	8	5` wide spacing
	Rosa virginiana	Virginia Rose	8	5` wide spacing
	Rubus odoratus	Purple-flowering Raspberry	8	7` wide spacing
	Rubus pensilvanicus	Pennsylvania Blackberry	10	6` wide spacing
	Rubus vermontanus	Vermont Blackberry	10	4` wide spacing
	Spiraea alba	Meadowsweet	22	3` wide spacing
	Spiraea tomentosa	Steeplebush	22	3` wide spacing
	Vaccinium angustifolium	Lowbush Blueberry	36	3` wide spacing
	Vaccinium corymbosum	Highbush Blueberry	24	8` wide spacing
	Vaccinium macrocarpon	American Cranberry	24	2` wide spacing
	Vaccinium oxycoccos	Small Cranberry	24	2` wide spacing
	Vaccinium pallidum	Hillside Blueberry	100	2` wide spacing

PERENNIALS	BOTANICAL NAME	COMMON NAME	QTY	REMARKS
	Cirsium pumilum	Pasture Thistle	20	1` wide spacing
	Eutrochium dubium	Coastal Plain Joe-Pye Weed	30	2` wide spacing
	Hypericum ascyron	Giant St. John`s-wort	20	2` wide spacing
	Pedicularis canadensis	Canadian Wood Betony	40	1` wide spacing
	Viola pedata	Bird`s-foot Violet	40	.5` wide spacing

GROUND COVERS	BOTANICAL NAME	COMMON NAME	QTY	REMARKS
	Dry Mix	Upland Meadow Seed Mix	265,186 sf	Min. 110 PLS/sq.ft
	Wet Mix	Wet Meadow Seed Mix	23,789 sf	Min. 110 PLS/sq.ft

100 FT.

Refer to the following page for more information regarding plants in the design.

KEY TO DESIGN AREAS

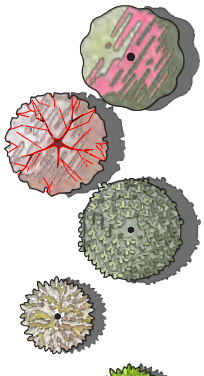
rock outcrop, full sun

rock outcrop, full sun to part-shade

wet swale, full sun

wet swale, full sun to part-shade

PLANT SCHEDULE

TREES	BOTANICAL NAME	COMMON NAME	QTY	REMARKS
	Cercis canadensis	Eastern Redbud	4	20` wide spacing
	Quercus ilicifolia	Scrub Oak	6	15` wide spacing
	Salix bebbiana	Beaked Willow	6	20` wide spacing
	Salix discolor	Pussy Willow	12	8` wide spacing
	Salix humilis	Prairie Willow	10	6` wide spacing
	Salix lucida	Shining Willow	10	10` wide spacing
	Salix petiolaris	Meadow Willow	10	10` wide spacing

SHRUBS	BOTANICAL NAME	COMMON NAME	QTY	REMARKS
	Cephalanthus occidentalis	Buttonbush	10	6` wide spacing
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	Rosa palustris	Swamp Rose	8	5` wide spacing
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CHAPMAN PASTURE

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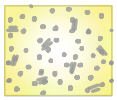
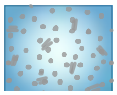
	Spiraea alba	Meadowsweet	22	3` wide spacing	
	Spiraea tomentosa	Steeplebush	22	3` wide spacing	
	Vaccinium angustifolium	Lowbush Blueberry	36	3` wide spacing	
	Vaccinium corymbosum	Highbush Blueberry	24	8` wide spacing	
	Vaccinium macrocarpon	American Cranberry	24	2` wide spacing	
	Vaccinium oxycoccos	Small Cranberry	24	2` wide spacing	
	Vaccinium pallidum	Hillside Blueberry	100	2` wide spacing	

PERENNIALS	BOTANICAL NAME	COMMON NAME	QTY	REMARKS	
	Cirsium pumilum	Pasture Thistle	20	1` wide spacing	
	Eutrochium dubium	Coastal Plain Joe-Pye Weed	30	2` wide spacing	
	Hypericum ascyron	Giant St. John`s-wort	20	2` wide spacing	
	Pedicularis canadensis	Canadian Wood Betony	40	1` wide spacing	
	Viola pedata	Bird`s-foot Violet	40	.5` wide spacing	

GROUND COVERS	BOTANICAL NAME	COMMON NAME	QTY	REMARKS
	Dry Mix	Upland Meadow Seed Mix	265,186 sf	Min. 110 PLS/sq.ft
	Wet Mix	Wet Meadow Seed Mix	23,789 sf	Min. 110 PLS/sq.ft

Old Field Toolkit

CHAPMAN PASTURE

MANAGEMENT GUIDELINES

SITE ESTABLISHMENT

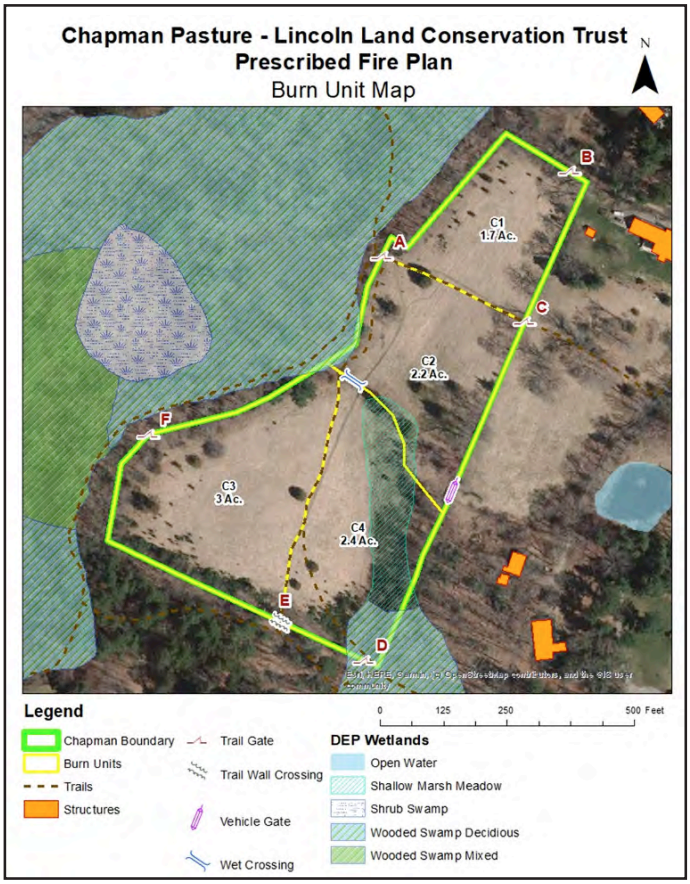
As mentioned, Chapman Pasture will be subject to prescribed fire in April 2021 as the initial method of site preparation for seeding. The burn will knock back non-native cool season grasses which dominate the site, expose the soil and encourage remnant native plant communities. As soon as 1 week following the burn, the wet swale can be planted with the recommended species depicted in the design. Additionally, exposed rocks and boulders on the site will be planted with the recommended arrangements of plants. Prescribed burns should continue on the site every 3-5 years as a primary method of vegetation management.

In late October or November 2021, the entire site should be mowed as close to the ground as possible, with the exception of those areas planted in the wet swale and in/around boulders in the field. If any emergent trees or invasives are found in the meadow during the 2021 growing season, they should be grubbed or pulled.

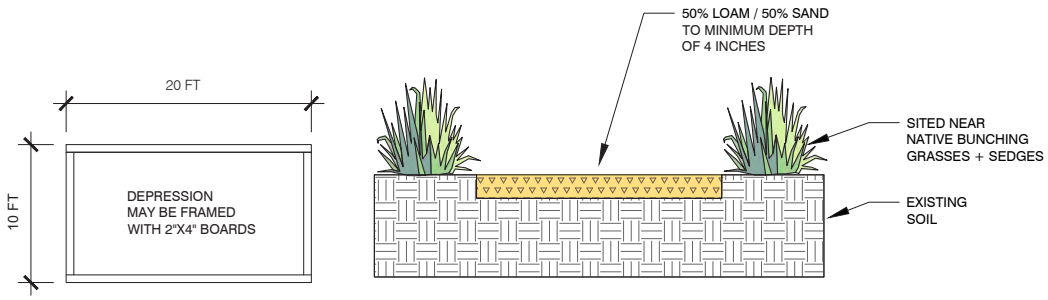
In November or December 2021, the wet and dry mixes should be seed drilled across the site, according to the areas outlined on the preceding page. If a seed drill is not available, the seed mixes may be broadcast; a harrow raking across the site may be required beforehand to ensure sufficient seed to soil contact (if drilling, no harrow raking is required). 100 lbs./acre of winter wheat cover crop should be added when fall seeding (if spring seeding, wild oats should be used instead). The plant lists for each seed mix are on the opposite page.

MOWING REGIMES

For the first growing season following seeding (2022), the entire site should be closely monitored for growth of vegetation. When the average height



BEE NESTING STRIP DETAIL



Above: Map of burn unit areas from Chapman Pasture Prescribed Fire Plan courtesy Alex Entrup of Entrup Consulting. Left: Due in part to the scale and accessibility of the Chapman Pasture site, rather than having multiple 2'x4' nesting strips, it is recommended to create a single 10'x20' nesting location. Remove all vegetation and at least 4 inches of soil. 50% of the soil can be added back in mixed with 50% sand. The area should be well draining, in full sun and kept clear of weeds, grasses or other vegetation. Do not mulch.

CHAPMAN PASTURE UPLAND MEADOW SEED MIX

Shrubs	
Spiraea alba	Meadowsweet
Spiraea tomentosa	Steeplebush
Forbs	
Agastache scrophulariifolia	Purple giant hyssop
Asclepias syriaca	Common milkweed
Asclepias tuberosa	Butterfly weed
Baptisia tinctoria	Yellow wild indigo
Cirsium discolor	Field thistle
Geranium maculatum	Spotted crane's-bill
Hypericum punctatum	Spotted St. John's-wort
Lupinus perennis	Wild lupine
Monarda fistulosa	Wild bergamot
Pedicularis canadensis	Canadian lousewort
Penstemon digitalis	Foxglove beardtongue
Penstemon hirsutus	Northeastern beardtongue
Prunella vulgaris ssp. lanceolata	Common selfheal
Solidago odora	Sweet goldenrod
Solidago speciosa	Showy goldenrod
Symphyotrichum lateriflorum	Calico American-aster
Zizia aptera	Heart-leaf golden Alexanders
Zizia aurea	Golden Alexanders
Graminoids	
Andropogon gerardii	Big bluestem
Carex blanda	Common wood sedge
Carex brevior	Plains oval sedge
Panicum virgatum	Switchgrass
Schizachyrium scoparium	Little bluestem

of vegetation in a given area is approximately 12 inches, the area should be brush hogged to a height of no less than 8 inches. This schedule should be continued throughout the first, and possibly second growing season.

In the second growing season (2023), the site should be periodically assessed by a botanist or other individual with vetted plant identification skills. If the majority of vegetation on the site or in a given area is native species from the mixes which were seeded, then the mowing schedule for the site or that area may be transitioned to a once-a-year mow. This should always occur during the dormant season (after November 15 or before April 1), after plants have gone to seed or before they begin next season's growth. Ideally, the site would be broken up into 2 or 3 sections, with each section being mowed once a year on a rotational basis. During this annual mow, vegetation should be cut to a height of 4-6 inches.

If during the second growing season, the majority of vegetation on the site or in a given area appears to remain non-native grasses, then continue mowing to keep the overall height of plants between 8-12 inches. This regime should be followed until the third growing season.

CHAPMAN PASTURE WET MEADOW SEED MIX

Forbs	
Asclepias incarnata	Swamp milkweed
Doellingeria umbellata	Tall white aster
Eutrochium fistulosum	Hollow Joe-Pye weed
Eutrochium maculatum	Spotted Joe-Pye weed
Eutrochium purpureum	Purple Joe-Pye weed
Impatiens capensis	Spotted touch-me-not
Mimulus alatus	Winged monkey flower
Mimulus ringens	Allegheny monkey flower
Rumex orbiculatus	Great Water Dock
Scutellaria galericulata	Hooded skullcap
Scutellaria lateriflora	Mad dog skullcap
Graminoids	
Andropogon gerardii	Big bluestem
Carex blanda	Common wood sedge
Carex brevior	Plains oval sedge
Panicum virgatum	Switchgrass

No-till seed drills such as the Flex by Truax pictured above are ideally suited for largescale native seeding without the need for raking. ***Sites should never be tilled before seeding native species, as doing so brings dormant weed seeds to the surface, increasing competition.***

By the end of the third growing season (2024), the site should be ready for transition to an annual mow on a rotational basis. Invasive species and early successional trees in the open portions of the site should be closely monitored throughout, and either manually grubbed using a weed wrench ("Pullerbear" brand) or mechanically grubbed using a brush grubber ("Brush Grubber" brand) mounted on a tractor, ATV or pickup truck.

Wet Meadow Toolkit

UPPER BROWNING FIELDS

EXISTING CONDITIONS

Upper Browning Fields is a 13.5-acre conservation property owned by the Town of Lincoln, and managed by the Lincoln Conservation Department. The site is highly diverse in native plant species composition, and includes a mix of wet meadow and transitional wet-to-dry meadow habitat. A perennial stream bisects the site running north to south, and an intermittent stream seeps into the center of the site from the north, creating a wet meadow complex that dominates the majority of the property. A second wet meadow/shrubland exists in the eastern portion of the site. The entire property is MassWildlife Natural Heritage and Endangered Species Program (NHESP) Priority Habitat of Rare Species. A horse ring in the northwest corner of the property is used by the public a few times a year and contributes to overflow parking in the old pasture portion of the site which is south of the entrance.

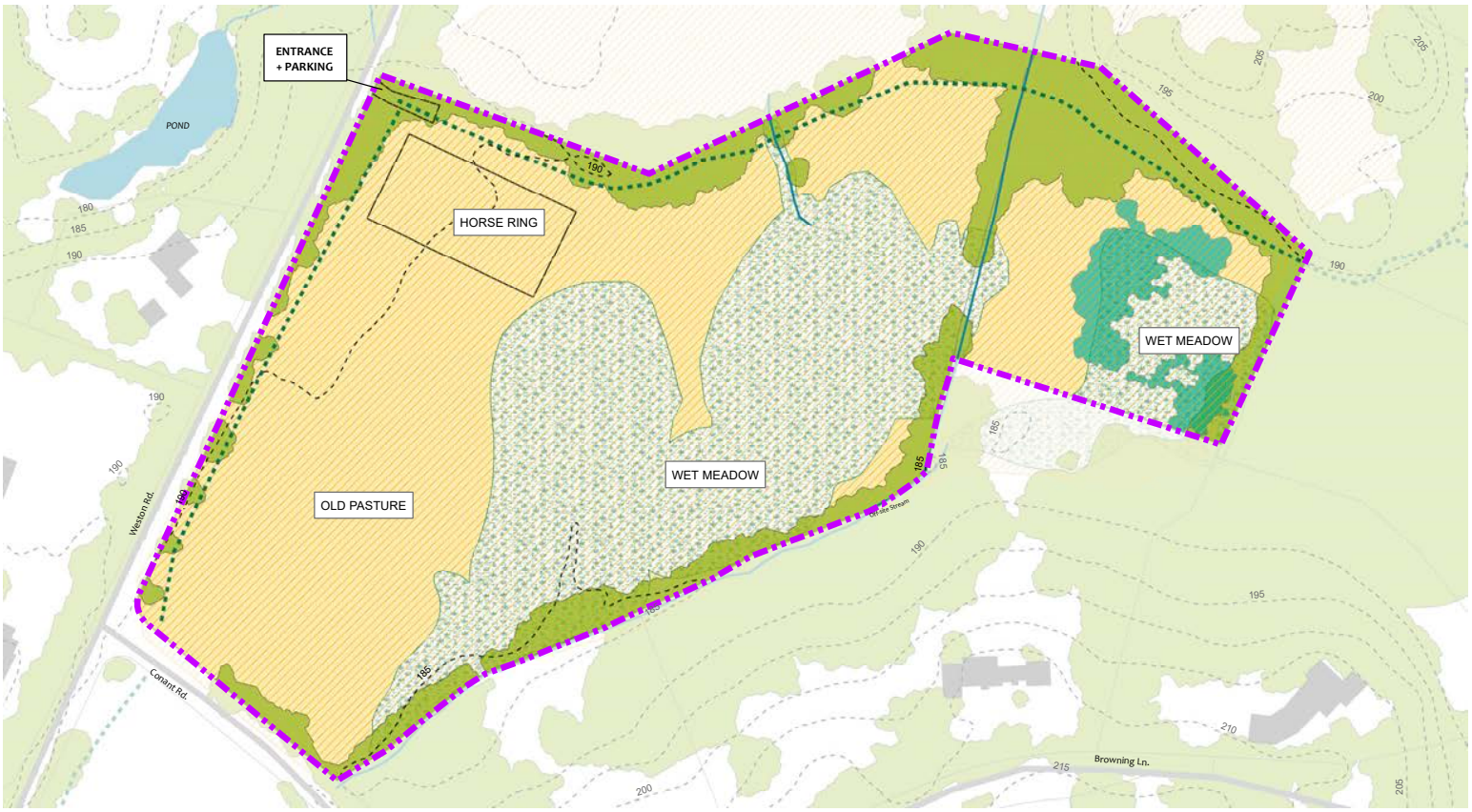
Native plant species dominate Upper Browning Fields in both wet and dry areas as well as in full sun and shaded portions of the site, contributing to its overall diversity. "Old Pasture" portions of the site (refer to map on opposite page) closest to Weston Road and Conant Road are somewhat less diverse in terms of plant species, and include significant quantities of non-native agricultural grasses. Still, *B. fervidus*, a threatened bumblebee species and one of the target species for this Plan, was found nesting adjacent to the southwest corner of the horse ring by Dr. Gegear, in one of the most highly disturbed portions of the site due to its proximity to overflow parking during events. Similarly, numerous native plant species of high value to threatened and at-risk pollinators were found in marginal areas of the site, alongside the trail and in the shade along the forest edges, oftentimes at risk of competition from more well established plant communities. Refer to the Ecological Communities map on pages 56-57 for a more detailed examination of the plant communities found at Upper Browning Fields.

Invasive *Frangula alnus* (Glossy buckthorn) as well as *Lythrum salicaria* (Purple loosestrife) pose the biggest management challenges, as the buckthorn in particular is well established in both wet and dry meadow areas. Glossy buckthorn, responds favorably to mowing, and mature plants that are cut near the base sprout vigorously (CABI). Cutting alone is usually not an effective method for glossy buckthorn removal. If herbicides are not an option, as is the case on most, if not all of Lincoln's conservation properties, it is recommended to topkill Glossy buckthorn by fire in late spring just after it has leafed out. **Spot burning using a backpack torch is a highly effective method for removing Glossy buckthorn, followed closely by the replanting of desired native species** (Nature Conservancy). A qualified technician should be hired to conduct spot burning. Girdling and buckthorn bags have also been demonstrated to be effective removal methods (CABI). Younger buckthorn plants can be removed by handpulling or grubbing, as can Purple loosestrife. Galeruccella beetles have been an effective biocontrol for Purple loosestrife; unfortunately, these European beetles are no longer being bred for release.

Large conservation sites are complex and the Conservation Department's management practices reflect this complexity. The maps on pages 58-59 present strategies for stewarding the varied plant communities, habitat types and ecological conditions for threatened and at-risk pollinator species at Upper Browning Fields. Replication of these strategies can be scaled for private landowners as well.

While much in the way of nectar, pollen, host plants and nesting sites is already present at Upper Browning Fields, there are a whole suite of plants which can be added to the site in order to strengthen its ecosystems and expand its biodiversity. This will also help wet meadow portions to regenerate following removal of glossy buckthorn and purple loosestrife.

Opposite top: landscape conditions at Upper Browning Fields include significant areas of highly diverse wet meadow and upland meadow habitat. Numerous native plants which support at-risk pollinator species are found on the site, including Eutrochium maculatum (Spotted Joe-Pye weed). Bottom: basemap used for initial site analysis at Upper Browning Fields. Wet Meadow areas were much larger than state-level data, and were tracked on site using GPS.



Upper Browning Property
Buildings
Tree Canopy
Roads
Contours (5 ft)
Streams
Trails
Pasture
Wetland Shrubs
Wet Meadow
NHESP Priority Habitat of Rare Species

UPPER BROWNING FIELDS BASEMAP
Landscape Interactions

0 25 50 100 Feet

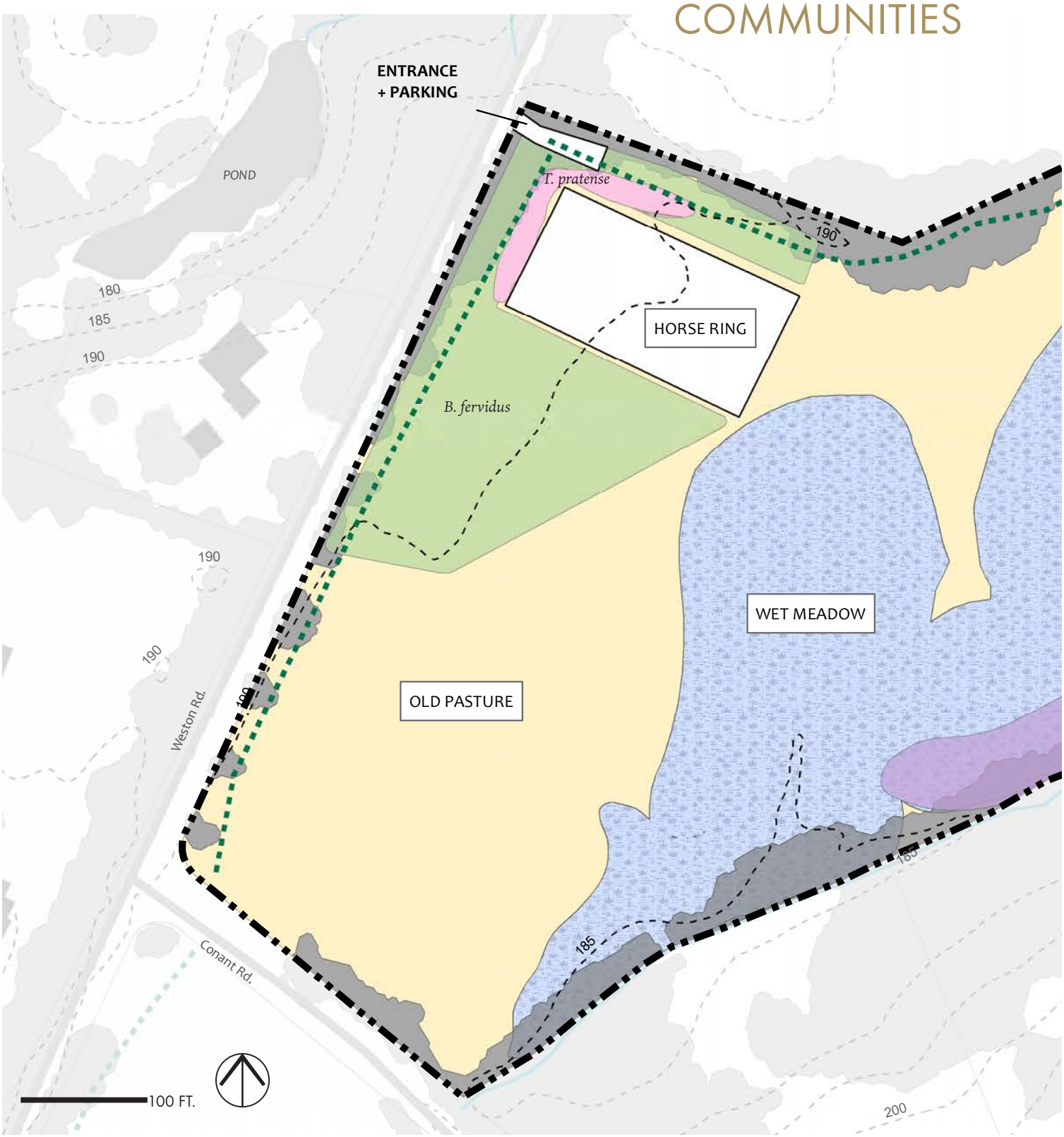
N

Property Size: 13.5 acres
Location: Lincoln, MA
Client: Lincoln Land Conservation Trust

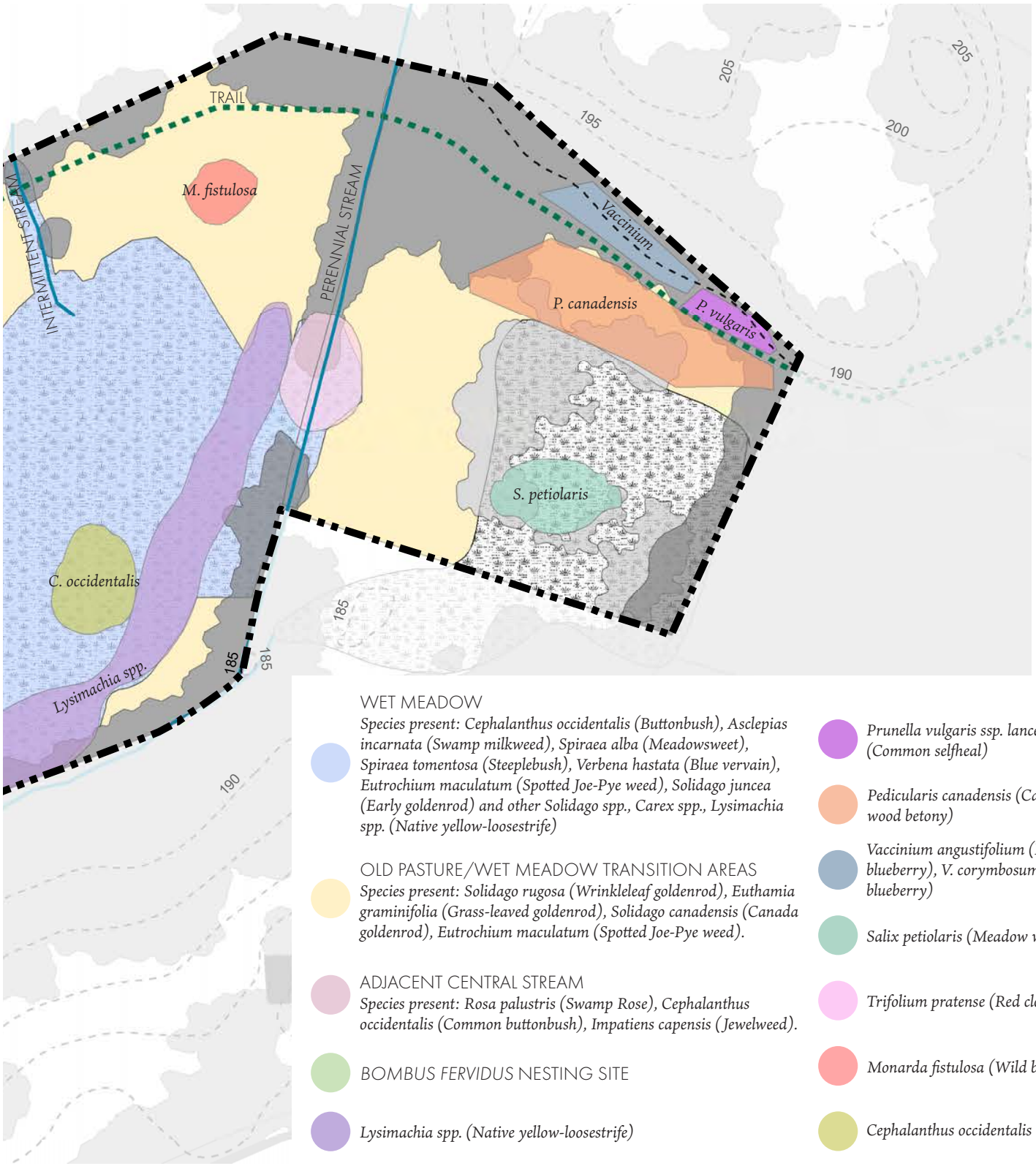
Wet Meadow Toolkit

UPPER BROWNING FIELDS

ECOLOGICAL COMMUNITIES



This map of plant species locations on Upper Browning Fields and the mowing/management guidelines presented in the map on the following pages were provided to Lincoln Conservation Department staff and LLCT in the early fall of 2020, to help interpret the varying ecosystems and plant communities present on the site, and understand the diverse management methods each unique area requires in order to better steward the landscape for at-risk pollinators.



WET MEADOW
Species present: Cephalanthus occidentalis (Buttonbush), Asclepias incarnata (Swamp milkweed), Spiraea alba (Meadowsweet), Spiraea tomentosa (Steeplebush), Verbena hastata (Blue vervain), Eutrochium maculatum (Spotted Joe-Pye weed), Solidago juncea (Early goldenrod) and other Solidago spp., Carex spp., Lysimachia spp. (Native yellow-loosestrife)

OLD PASTURE/WET MEADOW TRANSITION AREAS
Species present: Solidago rugosa (Wrinkleleaf goldenrod), Euthamia graminifolia (Grass-leaved goldenrod), Solidago canadensis (Canada goldenrod), Eutrochium maculatum (Spotted Joe-Pye weed).

ADJACENT CENTRAL STREAM
Species present: Rosa palustris (Swamp Rose), Cephalanthus occidentalis (Common buttonbush), Impatiens capensis (Jewelweed).

BOMBUS FERVIDUS NESTING SITE

Lysimachia spp. (Native yellow-loosestrife)

Prunella vulgaris ssp. lanceolata (Common selfheal)

Pedicularis canadensis (Canadian wood betony)

Vaccinium angustifolium (Lowbush blueberry), V. corymbosum (Highbush blueberry)

Salix petiolaris (Meadow willow)

Trifolium pratense (Red clover)

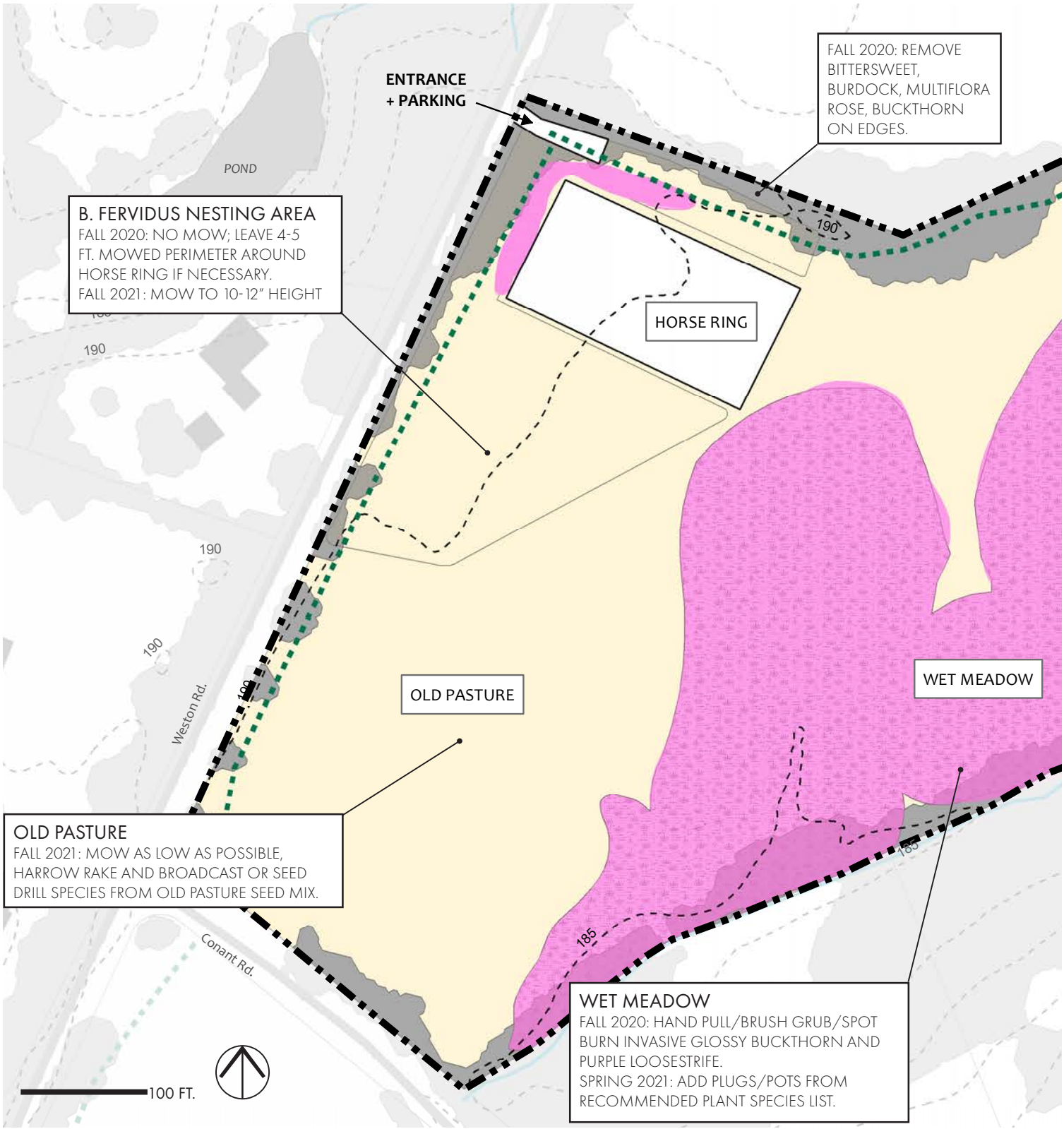
Monarda fistulosa (Wild bergamot)

Cephalanthus occidentalis (Buttonbush)

Wet Meadow Toolkit

UPPER BROWNING FIELDS

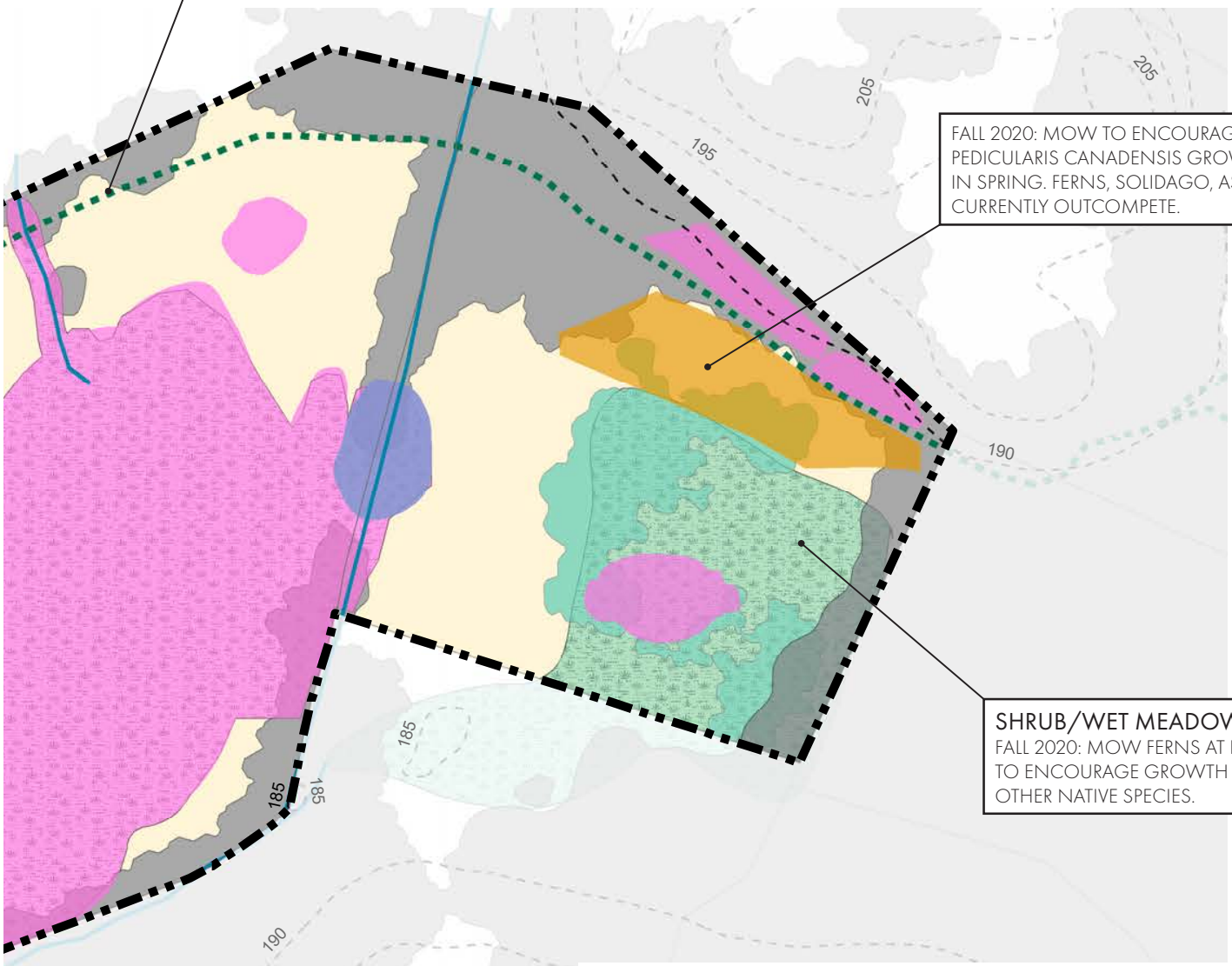
LANDSCAPE | NTERACTIONS
16 Center Street #426
Northampton, MA 01060
landscapeinteractions.com



SITE CONDITIONS

MEDIUM SOILS & WET SOILS
FULL SUN & PART SHADE
CONSERVATION HABITAT
WET MEADOW

TRAILSIDE
SPRING 2021: SOD CUT ALONG MOWED PATH EDGES, 2-4 FT WIDE ON ONE OR BOTH SIDES; PLANT PENSTEMON, MONARDA, BAPTISIA, PRUNELLA, EUTROCHIUM, SOLIDAGO, ASTERS, NATIVE GRASSES AND OTHERS FROM LIST.



FALL 2020: MOW TO ENCOURAGE PEDICULARIS CANADENSIS GROWTH IN SPRING. FERNS, SOLIDAGO, ASTERS CURRENTLY OUTCOMPETE.

SHRUB/WET MEADOW
FALL 2020: MOW FERNS AT EDGES TO ENCOURAGE GROWTH OF OTHER NATIVE SPECIES.

- NO MOW AND SPOT REMOVE INVASIVES (AREA OF ESTABLISHED NATIVE PLANTS AND WET MEADOW)
- MOW FALL 2020 (SEE NOTES)
- MOW FALL 2021 (SEE NOTES)
- MOW EDGES FALL 2020 (SEE NOTES)
- REMOVE TREE CANOPY TO PREVENT SHADING

Wet Meadow Toolkit

UPPER BROWNING FIELDS

MANAGEMENT GUIDELINES

SITE ESTABLISHMENT

As mentioned, the majority of Upper Browning Fields is intact wet meadow and transitional wet-to-dry meadow habitat. The dominant management challenges are how to deal with invasive Glossy buckthorn and Purple loosestrife, as well as to what extent to dedicate staff time and resources towards invasive species removal along the trailside at the entrance to the property near the horse ring.

Because the site contains well established, diverse native plant communities in so many places, it is recommended to discontinue brush hogging the majority of the site, and in the late spring of 2021, all areas containing Glossy buckthorn in Upper Browning Fields be spot burned using backpack torches, and replanted using species from the Wet Meadow Plant List on the opposite page. Manual weed wrenches ("Pullerbear") or brush grubbers mounted to a tractor ("Brush Grubber") can also be utilized to remove not only buckthorn, but also Purple loosestrife, as both methods remove significant portions of a plant's root mass.

For Trailside locations, in spring of 2021 it is recommended to mow 2-4 ft. alongside one or both sides of the existing foot path as low to the ground as possible, followed by sod cutting to remove existing vegetation. These areas can then be planted using the Trailside Plant List on the opposite page. It is also possible to smother these areas using black tarp or plastic following mowing in lieu of sod cutting, although this would require securing the material alongside all edges for the length of the trail, which is somewhat cumbersome given the scale of the site.

For Old Pasture areas, as described on the preceding page, in the fall of 2021 these upland portions of the site can be mowed low, followed by a harrow raking and then direct broadcast of seeds from the mix on the opposite page; alternatively, in lieu of raking and broadcasting, these areas could be drilled if a seed drill was available.

For areas where *Bombus fervidus* nesting sites have been located, it is recommended to consult with Dr. Gegear throughout the 2021 and 2022 growing seasons, as he gathers more data in his field surveys.

Bee nesting strips should also be created in Upper Browning Fields for ground nesting species. Refer to page 52 of this Plan for a diagram as well as instructions.

MAINTENANCE

Hand pulling of weeds, non-native grasses and other undesired vegetation in all recently planted areas will be necessary for numerous years following installation. For areas that are direct seeded, refer to the Mowing Regimes section in the **Old Field Toolkit Management Guidelines** on page 52.

Follow up spot burns for areas containing Glossy buckthorn will likely be necessary for several years. Girdling and buckthorn bags are also highly effective removal methods (CABI).

Spot burning Glossy buckthorn is considered one of the most effective non-chemical management methods. Image courtesy Woody Invasives of the Great Lake Collaborative.

UPPER BROWNING FIELDS WET MEADOW PLANT LIST

Trees	
Chamaecyparis thyoides	Atlantic white cedar
Shrubs	
Cephalanthus occidentalis	Common buttonbush
Rosa palustris	Swamp rose
Salix bebbiana	Bebb's willow (male)
Salix discolor	Pussy willow (male
Salix lucida	Shining willow (male)
Vaccinium corymbosum	Highbush blueberry
Vaccinium macrocarpon	Large cranberry
Vaccinium oxycoccos	Small cranberry
Forbs	
Asclepias incarnata	Swamp milkweed
Doellingeria umbellata	Tall white aster
Eutrochium fistulosum	Hollow Joe-Pye weed
Eutrochium maculatum	Spotted Joe-Pye weed
Eutrochium purpureum	Purple Joe-Pye weed
Impatiens capensis	Spotted touch-me-not
Mimulus alatus	Winged monkey flower
Mimulus ringens	Allegheny monkey flower
Rumex orbiculatus	Great Water Dock
Scutellaria galericulata	Hooded skullcap
Scutellaria lateriflora	Mad dog skullcap
Symphyotrichum lateriflorum	Calico American-aster
Graminoids	
Andropogon gerardii	Big bluestem
Carex lacustris	Lakeside sedge
Carex stricta	Tussock sedge
Panicum virgatum	Switchgrass

UPPER BROWNING FIELDS TRAILSIDE PLANT LIST

Trees	
Cercis canadensis	Redbud
Quercus spp.	Oaks
Shrubs	
Diervilla lonicera	Northern bush-honeysuckle
Hypericum prolificum	Shrubby St. John's-wort
Rosa carolina	Carolina rose
Rosa virginiana	Virginia rose
Rubus allegheniensis	Common blackberry
Rubus odoratus	Purple-flowering raspberry
Rubus pensilvanicus	Pennsylvania blackberry
Salix humilis	Prairie willow (male)
Salix petiolaris	Meadow willow (male)
Spiraea alba	Meadowsweet
Spiraea tomentosa	Steeplebush
Vaccinium angustifolium	Lowbush blueberry
Vaccinium pallidum	Hillside blueberry
Forbs	
Agastache scrophulariifolia	Purple giant hyssop
Asclepias syriaca	Common milkweed
Asclepias tuberosa	Butterfly weed
Baptisia tinctoria	Yellow wild indigo
Cirsium pumilum	Pasture thistle
Eutrochium dubium	Coastal plain Joe-Pye weed
Hypericum ascyron	Great St. John's-wort
Lupinus perennis	Wild lupine
Monarda didyma	Scarlet bee balm
Monarda fistulosa	Wild bergamot
Pedicularis canadensis	Canadian lousewort
Penstemon digitalis	Foxglove beardtongue
Penstemon hirsutus	Northeastern beardtongue
Prunella vulgaris ssp. lanceolata	Common selfheal
Solidago odora	Sweet goldenrod
Solidago speciosa	Showy goldenrod
Symphyotrichum lateriflorum	Calico American-aster
Viola spp.	Violets
Zizia aptera	Heart-leaf golden Alexanders
Zizia aurea	Golden Alexanders
Graminoids	
Andropogon gerardii	Big bluestem
Carex blanda	Common wood sedge
Carex brevior	Plains oval sedge
Panicum virgatum	Switchgrass
Schizachyrium scoparium	Little bluestem

UPPER BROWNING FIELDS OLD PASTURE SEED MIX

Shrubs	
Spiraea alba	Meadowsweet
Spiraea tomentosa	Steeplebush
Forbs	
Agastache scrophulariifolia	Purple giant hyssop
Asclepias syriaca	Common milkweed
Asclepias tuberosa	Butterfly weed
Baptisia tinctoria	Yellow wild indigo
Cirsium discolor	Pasture thistle
Geranium maculatum	Spotted crane's-bill
Hypericum punctatum	Spotted St. John's-wort
Lupinus perennis	Wild lupine
Monarda fistulosa	Wild bergamot
Pedicularis canadensis	Canadian lousewort
Penstemon digitalis	Foxglove beardtongue
Penstemon hirsutus	Northeastern beardtongue
Prunella vulgaris ssp. lanceolata	Common selfheal
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Zizia aurea	Golden Alexanders
Graminoids	
Andropogon gerardii	Big bluestem
Carex blanda	Common wood sedge
Carex brevior	Plains oval sedge
Panicum virgatum	Switchgrass
Schizachyrium scoparium	Little bluestem

Garden & Lawn Toolkit

BIRCHES SCHOOL

EXISTING CONDITIONS

THE SITE

The Birches School is situated on a privately owned 3.9-acre parcel near Route 2 in Lincoln. The property is part of the former Wang Family estate and the original colonial home remains an important part of the school's compound. As such, the property still retains a residential quality despite functioning as a modern school. The school is adjacent to several protected properties and abuts a town ball field. It is within close proximity to ecologically significant habitat on several sites, including a large wetland complex that extends from Ricci Farm to a portion of the Cambridge Reservoir Watershed.

Birches is an independent, co-educational Pre-K through 8th grade school with an emphasis on nature-based education. As such, use of the landscape surrounding the school building is an important part of the daily learning activities of students. A relatively new construction which completed renovation in 2018, the school's landscape at the start of the project was still evolving and consisted of turf grass, mulch and cultivars of native plant varieties. A large parking lot envelops the school to the north and northeast; to the southwest there exists a mixed oak and pine-dominated forest with an open understory, which serves as a natural playground for students.

THE PROJECT

The LLCT and Birches have a long-standing relationship and have worked together on past conservation projects. For the Lincoln Pollinator Action Plan, Birches enthusiastically agreed to develop gardens for at-risk pollinators that could serve as demonstration sites and an outdoor learning space for the school community. After several meetings, it was determined that the areas immediately outside the front of the school, between the school entrance, the side entrance and the parking lot, as well as two large parking lot islands would be ideally suited for such landscape conversion.

Soils on site were compacted and constituted predominantly of fill, with several inches of densely packed mulch in most locations where grass was not planted. Parents, administration and faculty were highly motivated to fund-raise for plants and landscaping materials, in addition to installing the plants.

After sharing the Birches School design during a public presentation by Evan Abramson in early March, Lincoln Land Conservation Trust members and members of the public were invited to purchase planting kits from LLCT which were based on the plants used in the design and recommended by Dr. Gegear. These efforts resulted in nearly 2,000 plants being distributed to 43 households in Lincoln as well as in 55 more households in a dozen other communities. A final version of the design was provided to Birches School parents, LLCT members and members of the public who purchased planting kits in May.

Above: conceptual rendering of the Birches School landscape design seen from the northwest side of the school facing south by Evan Abramson. Below left: the same location one year prior to planting; below right: location during installation of the final design. The School now contains nearly 6,000 sq.ft of planted space dedicated to at-risk pollinators, as well as a vegetable garden constructed and installed by the Grade 2-3 class. Opposite: volunteers review the design and procedures before planting begins. Photographs by Bryn Gingrich.

BRINGING THE DESIGN TO LIFE

In September 2020 nearly 160 volunteers gathered at the school to install several portions of the campus-wide design. Both parking lot islands were planted, as well as a large area on the northwest side of the school. Other areas in the initial design, including large areas of lawn conversion to bee lawn, were postponed due to COVID, as outdoor classrooms had been constructed on those sites.

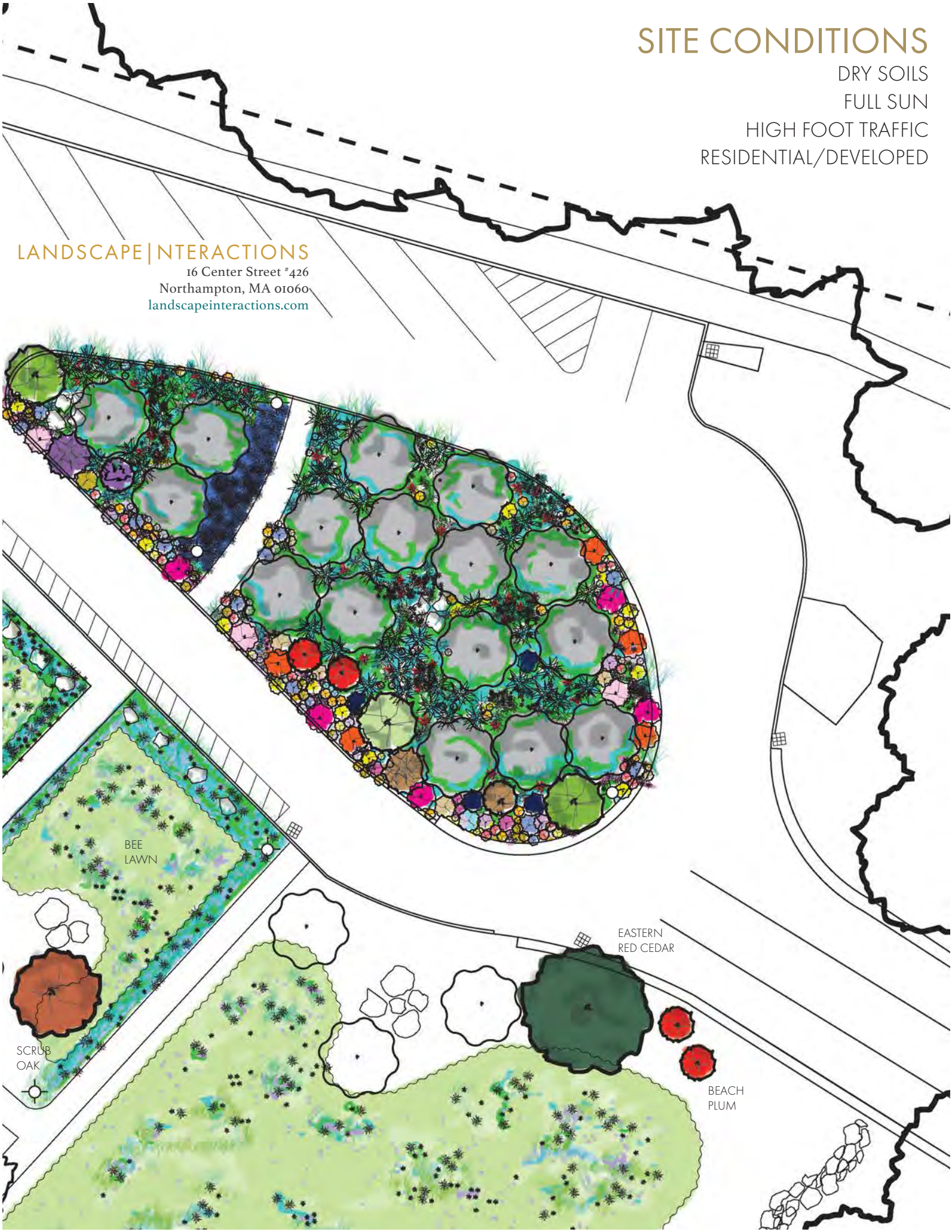
Garden & Lawn Toolkit

BIRCHES SCHOOL

SITE CONDITIONS

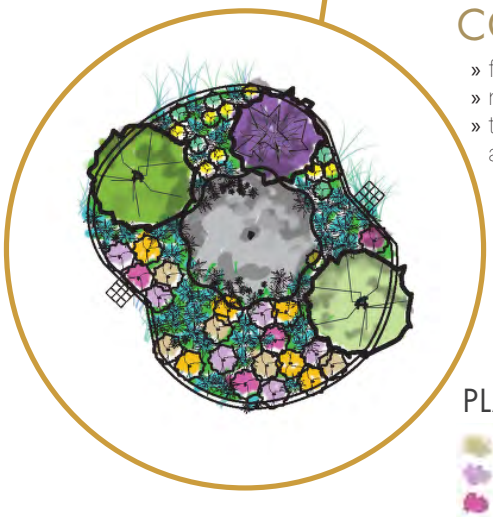
DRY SOILS
FULL SUN
HIGH FOOT TRAFFIC
RESIDENTIAL/DEVELOPED

LANDSCAPE|NTERACTIONS
16 Center Street #426
Northampton, MA 01060
landscapeinteractions.com



60 FT.

Area 1



HABITAT CONDITIONS

» full sun to part shade
» medium to wet soils
» tolerant of snow plowing and harsh environment

PLANT LIST

- TALL WHITE-ASTER
- COASTAL PLAIN JOE-PYE WEED
- SPOTTED JOE-PYE WEED
- GREAT ST. JOHN'S-WORT
- PURPLE-FLOWERING RASPBERRY
- LITTLE BLUESTEM
- SHINING WILLOW
- MEADOW WILLOW
- AXILLARY GOLDENROD
- ZIG-ZAG GOLDENROD
- (EXISTING RED MAPLE)

Area 2

HABITAT CONDITIONS

» full to part shade
» dry to medium soils
» tolerant of snow plowing and harsh environment

PLANT LIST

- PENNSYLVANIA SEDGE
- CANADIAN LOUSEWORT
- SWITCHGRASS
- COMMON SELFHEAL*
- LITTLE BLUESTEM
- VIOLET

**to be sown directly as seed*

Garden & Lawn Toolkit

BIRCHES SCHOOL

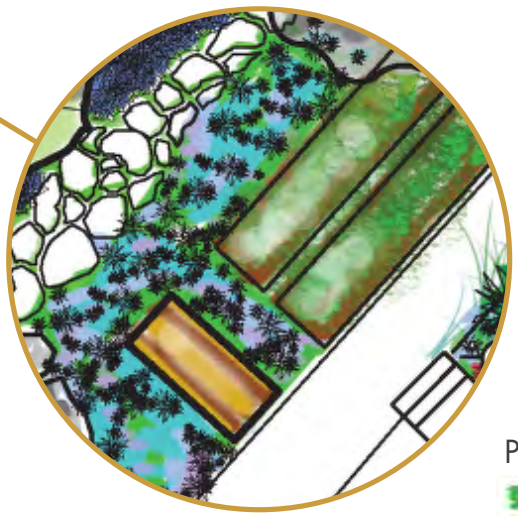
Area 3a

HABITAT CONDITIONS

- » full sun to part shade
- » dry to medium soils
- » tolerant of snow plowing and harsh environment on exterior edges
- » acidic soils (low pH)

PLANT LIST

- COMMON MILKWEED
- YELLOW WILD INDIGO
- PASTURE THISTLE
- SHOWY TICK-TREFOIL
- NORTHERN BUSH-HONEYSUCKLE
- SPOTTED ST. JOHN'S-WORT
- NORTHEASTERN BEARDTONGUE
- CAROLINA ROSE
- PRAIRIE WILLOW
- SHINING WILLOW
- MEADOW WILLOW
- LITTLE BLUESTEM
- AXILLARY GOLDENROD
- ZIG-ZAG GOLDENROD
- EARLY GOLDENROD
- WHITE MEADOWSWEET
- HILLSIDE BLUEBERRY
- (EXISTING BIRCH)



Area 3b

HABITAT CONDITIONS

- » full sun to part shade
- » dry to medium soils
- » tolerant of heavy foot traffic and mowing

PLANT LIST

- PENNSYLVANIA SEDGE
- COMMON SELFHEAL*
- LITTLE BLUESTEM*
- VIOLET

**to be sown directly as seed*

Area 4

HABITAT CONDITIONS

- full to part shade
- dry to medium soils
- tolerant of foot traffic and occasional mowing

PLANT LIST

- PENNSYLVANIA SEDGE
- CANADIAN LOUSEWORT*
- COMMON SELFHEAL*
- AXILLARY GOLDENROD
- ZIG-ZAG GOLDENROD

**to be sown directly as seed*

Area 5

HABITAT CONDITIONS

- full to part shade
- dry to medium soils
- high growing (visual screen)

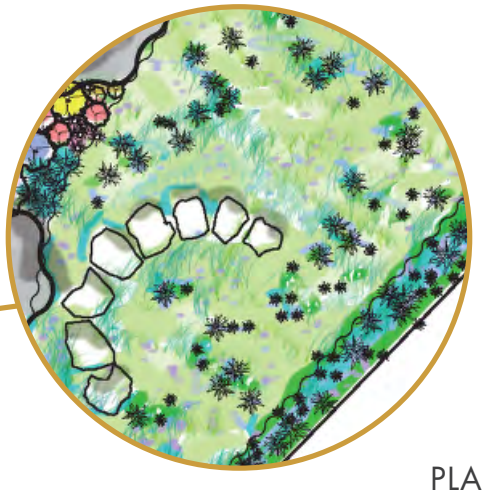
PLANT LIST

- BIG BLUESTEM
- PENNSYLVANIA SEDGE
- CANADIAN LOUSEWORT*
- COMMON SELFHEAL*
- LITTLE BLUESTEM
- AXILLARY GOLDENROD
- ZIG-ZAG GOLDENROD
- (EXISTING BIRCH)

**to be sown directly as seed*

Garden & Lawn Toolkit

BIRCHES SCHOOL



HABITAT CONDITIONS

» full sun to part shade
» dry to medium soils
» tolerant of heavy foot traffic and mowing

Area 6

PLANT LIST

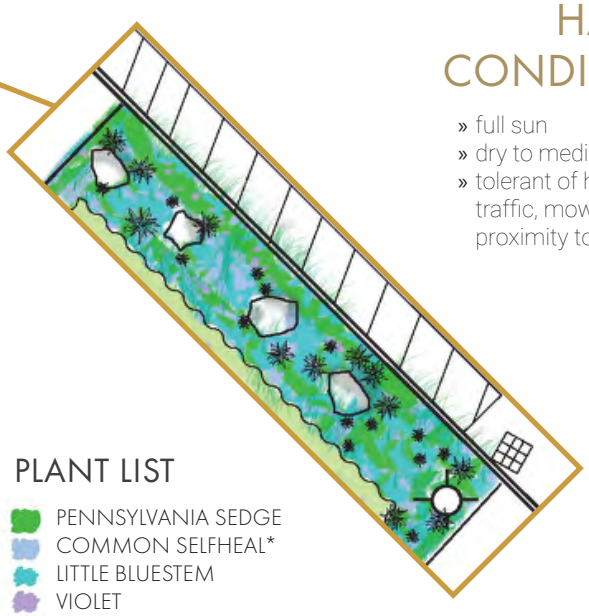
- PENNSYLVANIA SEDGE
- COMMON SELFHEAL*
- LITTLE BLUESTEM*
- VIOLET
- (EXISTING TURF)

**to be sown directly as seed*

HABITAT CONDITIONS

» full sun
» dry to medium soils
» tolerant of heavy foot traffic, mowing and proximity to snow plowing

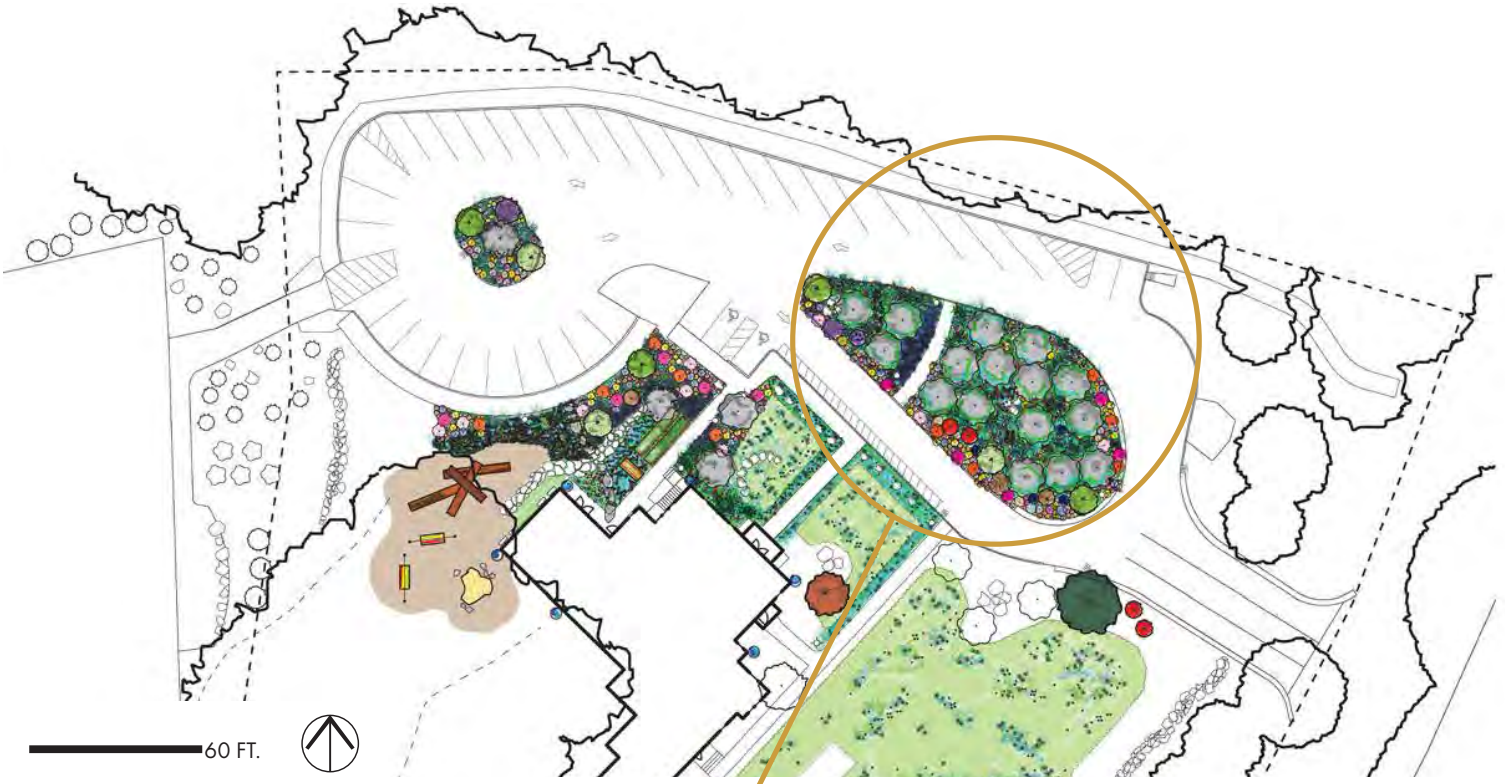
Area 7



PLANT LIST

- PENNSYLVANIA SEDGE
- COMMON SELFHEAL*
- LITTLE BLUESTEM
- VIOLET

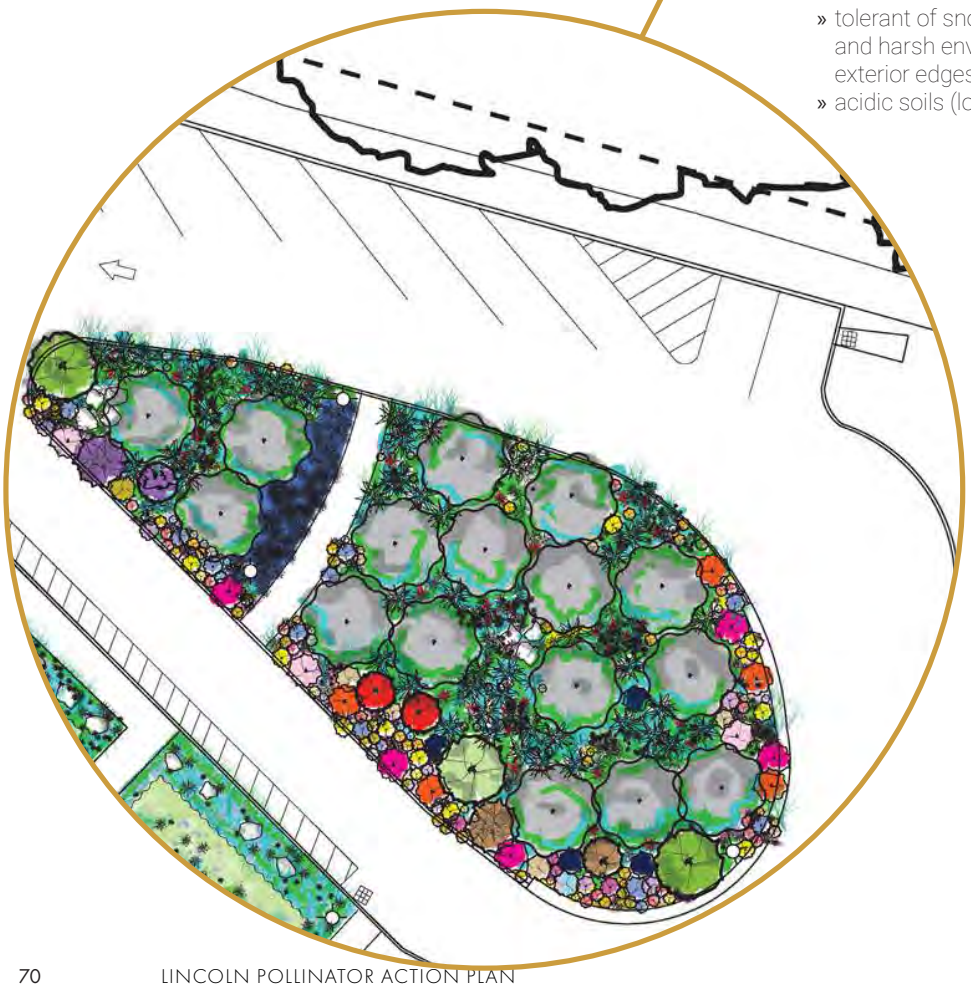
**to be sown directly as seed*



Area 8

HABITAT CONDITIONS

- full sun to part shade
- medium to wet soils
- tolerant of snow plowing and harsh environment on exterior edges
- acidic soils (low pH)



PLANT LIST

- BIG BLUESTEM
- COMMON MILKWEED
- YELLOW WILD INDIGO
- PENNSYLVANIA SEDGE
- PASTURE THISTLE
- SHOWY TICK-TREFOIL
- NORTHERN BUSH HONEYSUCKLE
- TALL WHITE-ASTER
- COASTAL PLAIN JOE-PYE WEED
- SPOTTED JOE-PYE WEED
- GREAT ST. JOHN'S-WORT
- SPOTTED ST. JOHN'S-WORT
- CANADIAN LOUSEWORT
- SWITCHGRASS
- NORTHEASTERN BEARDTONGUE
- BEACH PLUM
- CAROLINA ROSE
- NORTHERN BLACKBERRY
- PURPLE-FLOWERING RASPBERRY
- LITTLE BLUESTEM
- PRAIRIE WILLOW
- SHINING WILLOW
- MEADOW WILLOW
- EARLY GOLDENROD
- DOWNY GOLDENROD
- SEASIDE GOLDENROD
- WHITE MEADOWSWEET
- HILLSIDE BLUEBERRY
- (EXISTING BIRCH)

Garden & Lawn Toolkit

BIRCHES SCHOOL

Birches School student planting parking lot island Design Area 8. Photograph by Bryn Gingrich.

BEST MANAGEMENT PRACTICES

1. NO CHEMICALS

Eliminate pesticide use, particularly those containing neonicotinoids. Herbicides and chemical lawn treatments can also be highly damaging to pollinators.

Avoid planting in areas previously contaminated by pesticides or without a spatial buffer from areas where pesticides are applied (at least 100 ft. wide forested buffer is recommended).

Ensure plants and seeds come from a clean, pesticide-free source. Many commercial nurseries treat their plants and seeds, oftentimes before retailers receive them. Some pesticides and most neonicotinoids persist in plants and soil for months to years.

2. DIVERSE NATIVE PLANTS

Plant straight native plant species. Cultivars and exotic plants largely do not support the pollen and nectar preferences of threatened and at-risk pollinators, and tend to be visited by common pollinator species whose populations are stable.

Include a range of plant types (trees, shrubs, forbs, grasses, sedges) with varying bloom times, to ensure pollen, nectar and host plants are available across the entire growing season. Remove and manage invasive species to ensure that native plant communities have adequate space and opportunities to flourish.

3. CREATE NESTING OPPORTUNITIES

Seventy percent of native bee species are ground nesting. Mulch using compost or natural materials (e.g. chopped leaves, seed-free straw, composted wood chips) and leave bare areas of well-drained soil in sunny locations. Thirty percent of native bees are cavity nesting. Allow dead trees, snags and pithy stemmed plants such as raspberries to remain standing.

To benefit bumblebees, maintain small brush piles. This will provide cover for rodents that will in turn create nesting habitat for bumblebees. Where possible, leave leaf litter in gardens and allow it to build up over time. This provides cover for overwintering queens. Barns with unbaled hay or a dry, protected cavity containing hay, straw, clumps of moss or grass located above or below ground are also ideal. As with other ground nesting bees, limiting or eliminating tillage practices will limit the potential of harming bumblebees.

4. BE MESSY

Skip the fall clean up, allowing dead stems, leaves and seed heads to stand over winter for overwintering pollinators. Wait until evening temperatures consistently reach 50 degrees before raking in the spring, so as not to disturb species who have not emerged yet.

Don't be overzealous when it comes to tidying up. Some weeds act as host plants for caterpillars, such as lambsquarters *(Chenopodium album)* for Common Sootywing *(Pholisora catullus)* and Queen Anne's lace *(Daucus carota)* for Black Swallowtail *(Papilio polyxenes)*.

5. IT DOESN'T STOP WITH PLANTING

That being said, with new plantings, water and weed regularly for the first two years.

To deter deer and rodents until plants fully establish, it may be helpful to construct temporary fencing or set up netting. Natural repellent sprays such as *Plantskydd* can be effective when applied regularly. Thorny plants such as roses can also deter deer browse and function as natural fences for more vulnerable plants.

6. LAST BUT NOT LEAST

Put something in place to catch rainwater, with a shallow dirt base to simulate a puddle and small rocks to perch on to avoid drowning. This provides pollinators necessary minerals. Make it last between rainy days.

Keep night skies dark for moths and other nocturnal insects: motion-detecting lights or lamps facing down instead of spotlights on all night.

Some plant species establish best by direct seeding: while late fall or early winter is the best time to sow, early spring seeding is also possible, although some species may not germinate until the following year.

TURN YOUR LAWN INTO HABITAT

Maintaining a manicured lawn can not only be expensive, it also oftentimes requires high water and chemical usage. Many turf lawns are habitat dead zones, as they are comprised primarily of non-native sod-forming grasses that spread by rhizome, outcompeting native vegetation and offering little opportunities for ground-nesting bees by carpeting the soil.

Lawns can be converted into habitat in a number of ways:

METHOD 1: OVERSEED A TRADITIONAL LAWN

STEP 1: Mow your lawn at one inch or less to improve seed to soil contact. Remove grass clippings to expose as much soil as possible.

STEP 2: Rake, scrape, score or use a spading fork to break up the lawn surface. This helps create good conditions for seed germination and healthy growth through seed to soil contact.

STEP 3: Spread native seed and plant plugs. Here are the recommended rates for overseeding lawn as depicted in Area 6 of the Birches School Toolkit (page 69):

» *Prunella vulgaris ssp. lanceolata* (Common selfheal) at 5 ounces per 1000 sq.ft
» *Schizachyrium scoparium* (Little bluestem) at 7 ounces per 1,000 sq.ft
» *Carex pensylvanica* (Pennsylvania sedge) at 1 plug per sq.ft of exposed ground
» *Pedicularis canadensis* (Canadian lousewort) at 1 plug per sq.ft of exposed ground
» *Viola spp.* (Violets) at 1 plug per sq.ft of exposed ground

Thoroughly mix the seed into a filler material such as sand or sawdust before applying. Use 4 gallons of filler per 1,000 sq.ft and hand broadcast the seed mix, leaving it on soil or snow surface.

WHEN TO DO IT

Late fall or winter are the best times to seed most native plant species, as many require cold stratification to germinate. Early spring is also possible, although some species will not germinate until the following year. If there is not adequate rainfall, areas recently seeded should be watered.

Lawn containing Prunella vulgaris (Common selfheal). Photograph by Matt Lavin.

METHOD 2: CREATE A BLANK SLATE

STEP 1: To start you must first remove existing grass. Plan accordingly: large areas of bare soil are easily eroded by runoff and provide fertile ground for weeds to establish. Chemical herbicides are not recommended because of their negative impacts to pollinators and ecosystems as a whole. Below are several alternatives to chemical removal.

- SOD CUTTING is the quickest way to remove grass. Equipment rental companies and hardware stores rent walk behind sod cutters for $100-$150/day. In a few hours several thousand square feet of grass can be cut, rolled up and carted away. A lot of topsoil is lost in the process, but can be added back in with screened loam if necessary.
- SHEET MULCHING uses cardboard or newspaper to smother grass. It is best started several months before you want to use the planting area. Fall is an excellent time to sheet mulch as the material breaks down slowly over the winter and is ready for planting in the spring. The basic technique involves smothering grass and building organic matter in place by placing alternate layers of carbon materials and nitrogen materials directly on top of each other. Layers should be fairly equal to allow for even decomposition, approximately 1" thick.
- SMOTHERING/SOLARIZIATION is a method of site preparation that involves covering the planting area with black or clear plastic and allowing the sun and lack of water to kill unwanted vegetation. This takes a full growing season at a minimum, requires that the plastic is firmly secured in place all along the edges at all times, and may be best performed in sections rather than on a large scale.

STEP 2: Follow the previous directions to direct seed and plant plugs (seeding rates will be higher if starting with a blank slate).

MAINTENANCE

If you mow, keep your blades at least four inches off the ground; allow newly seeded and planted vegetation to fully establish before cutting. Once vegetation is established, mow no more than every two to four weeks. Taller lawns are beneficial in that they shade the ground, preventing moisture from evaporating while also discouraging weed seeds from sprouting. Refrain from mowing while flowers are blooming to increase the amount of forage available for pollinators and to allow plants to more fully establish by setting seed.

SITE SELECTION

There are numerous factors to consider before selecting a site for pollinator habitat implementation, deciding which plants to establish, and by what method. These pages present a process for making these decisions, listing relevant questions. As each site and situation are unique, different questions may arise which are not found here.

Once a site is selected, the following considerations can help define which Toolkit may be most suitable to implement.

EXISTING CONDITIONS

What are the physical and cultural characteristics of the site(s)?

PLANTING REQUIREMENTS

What is needed to establish the desired vegetation?

MAINTENANCE REQUIREMENTS

What management criteria may be required following installation?

Diagram by Elan Bills.

EXISTING CONDITIONS are the ecological and cultural components that may influence a site. Assessing the following can help ensure that appropriate landscaping decisions are made, that the plants chosen are suitable for the site conditions present, and that the aesthetics of the design features are suitable for the location.

- What habitat and vegetation currently exists, and what life do they support?
  What's doing well where? Are there any invasive species present?
- Soil type, light conditions, and moisture levels.
  Hours of sunlight, soil type and the water-holding capacity of the soil will determine which native plant species can grow where. A soil sample may be useful to send to a lab for analysis. A USGS Web Soil Survey can also be incredibly informative.
- Parcel size and location.
  Knowing the scale of the site to be planted, and its proximity to disturbed areas or protected habitat, can help guide site establishment and management methods, as well as the plant selection process. For example, establishing a 5-acre meadow entirely with plugs may prove to be too expensive; similarly, a wildflower meadow may not be possible in a sidewalk strip.
- Land use history.
  Is there a history of pesticide use, or environmental contamination on the site? Does anything show up in the lab soil test? Environmental remediation may be necessary, or choosing a different site for pollinator habitat restoration.
- Current land use (and that of adjacent properties, if applicable).
  You may not want to put those lowbush blueberries along a parking lot that gets salted in the winter.

PLANTING REQUIREMENTS are guidelines for establishing or enhancing native vegetation to support pollinators. This may be accomplished through multiple phases and at varying scales, in order to meet both short and long-term goals.

- What is needed to establish native vegetation to create or enhance pollinator habitat?
  Is there lawn or are there invasive plants to be removed? Are soil amendments required? Is direct seeding possible? Should plugs be used instead?
- If particular pollinator species are to be targeted, what are their preferred pollen sources or host plants?
- To attract and sustain a wide range of pollinator species, it is generally recommended to provide a variety of flowering plants that bloom from early spring to late fall, and therefore to include native shrubs, trees, bunching grasses and sedges.
- Increase floral abundance with at least three species of flowering plants for each portion of the season (early spring, late spring, early summer, late summer, early fall, late fall).
- Consider structural arrangements of plantings based on public use.
  Formal or wild? Lower growth closer to sidewalks and foot paths?
- Use mulch sparingly.
  Ground nesting bees require bare, exposed pieces of ground to nest and overwinter, preferably in sunny, well-drained sites.

MAINTENANCE REQUIREMENTS are steps to follow for successful habitat establishment and long-term management.

- What kind of management is required following installation, and how often?
  Mowing, brush hogging, watering, weeding.
- Who will install it?
- Who will maintain it?
- Will staff education and training resources be provided?
- What is the short-term and long-term budget for maintenance of the site?

CREATING A MEADOW

To support functionally diverse pollinator populations, a highly effective course of action is to establish a native meadow. This process consists of five steps:

1. SITE ANALYSIS
2. SITE PREPARATION
3. PLANT SELECTION
4. PLANTING TECHNIQUES
5. ONGOING MANAGEMENT

SITE ANALYSIS

There are four main aspects to consider in analysis of a site. Item number one is light exposure. Full sun is a necessary requirement for meadow planting. Insufficient sunlight will favor woody species over herbaceous wildflowers and grasses causing an increase in maintenance requirements. Soil type will be your next consideration. It is imperative to understand and identify which soil you are working with (sand, loam, clay, etc.) in order to select plants that will adapt successfully to the site. If poor soils exist, a decision can be made to either amend the soil or narrow the plant list to those that will tolerate that specific condition. In some cases "bad" soil conditions, either poorly drained or very dry, can provide a competitive advantage to the meadow species. Fertilization should in most cases be avoided, as it will most likely favor weeds and invasives more than the desirable species.
Grade and topography can affect a number of decisions. A north slope may not be favorable to meadow plants, as they will receive less direct sunlight. If the meadow is in a low lying area and remains wet during spring thaw and rains, plants adaptable to these conditions should be selected. Micro variations within the site can be noted and considered.

Analyzing existing growth on and adjacent to the site can yield extremely valuable information relating to which plants will grow well on the site which what specific weedy species are likely to be a problem. If a problematic weed or invasive plant is existing on or near the site, it is highly recommended to eradicate it beforehand in order to avoid future infestations. Sod removal is relatively easy if the existing vegetation is predominantly low-growing turf grasses. On small patches of land, smothering or solarizing the existing vegetation with black or clear plastic is very effective.

SITE PREPARATION

Site preparation begins with the elimination of existing growth. Sod cutting, smothering/solarizing or grubbing are the most common non-chemical methods. Tillage will bring to the surface dormant weed seeds which must be allowed to germinate and then repeatedly shallow cultivated for the extent of the growing season before planting. A no-till seeding is ideal for larger sites.
Creating a finely graded seed bed, incorporating the seed into the soil, tamping or rolling for good seed to soil contact and mulching with salt marsh hay or seed-free straw if on a slope. Sowing in the fall is preferable as many native species require a period of cold stratification to germinate.

PLANT SELECTION

Based on your analysis of the site, you can now select the plant species that will form your seed mix. Several seed mixes have been created for the various Toolkit sites in this project, suitable for a range of environmental conditions.

In general, the plants that will afford the best long-term results will invariably be those that are found in conditions similar to your site and are native to your particular region. As in most naturally occurring meadows and prairies, graminoids should be a component of the plant mix, but for the benefit of pollinators, grasses and sedges should not comprise more than 25-35 percent of the mix by seed per square foot. Many grasses and sedges are larval host plants for butterflies, and provide nesting sites for certain bumblebee species and other bee and insect species. Clump-forming grasses are incredibly beneficial, including Big and Little Bluestem. A cover crop composed of Winter Wheat (fall seeding) or Wild Oats (spring seeding) should also be included at 100 lbs/acre to help secure the site from weed invasion and erosion during the first season.

OCCUPY EVERY NICHE

An important concept to understand when combining plant species is the idea of *niche*. A study of a mature Midwestern prairie will reveal an

incredibly dense tapestry where every possible space is occupied. If all of these elements are present the meadow will have a strong capability to resist weeds. There is no place left for them to grow.

You also need to fill the niches in time. Some plants are active in warm weather while other plants are most vigorous during the cool seasons, particularly spring. By including both types there will be no seasonal opening for weed invasion. Some plants establish a cover during the first year, some during the first few years and some long-lived plants may not have a serious presence for many years.

PLANTING TECHNIQUES

For forbs, particularly perennial species in New England, fall planting is often best. Many perennial plant seeds require exposure to cold temperatures and damp conditions before germination can occur. Winter precipitation also helps the seeds settle into the soil and will stimulate germination. Spring planting is possible, but typically favors grasses over flowers.

Due to the small size of many native seeds, it will be necessary to mix the seed with an inert material such as sawdust or sand before spreading. To achieve good seed to soil contact, the seed can be compacted into the ground with a standard lawn roller or the wheels of a tractor, or walked on.

ONGOING MANAGEMENT

An understanding of ecological succession is important for the maintenance of a meadow. Ecological succession is the process by which a disturbed area progresses naturally from herbaceous vegetation (first annuals, then perennials) to woody shrubs and pioneer trees and finally to a mature forest. In establishing a permanent meadow in the northeast, where woods naturally predominate, we are arresting the process of ecological development at the herbaceous perennial stage.

Although a meadow, once established, will require substantially less maintenance than a mowed lawn, the first one to two years will require guidance in order to achieve success. A maintenance plan should be in place before starting, to insure that this crucial portion of the project is not later neglected.

For the first year or two after planting, it will be necessary to carry out a weed control program. As the process of ecological succession would suggest, the first year will bring a rapid cover of annual weeds while the perennial wildflowers and grasses are slowly developing underneath. This is to be expected, and if managed properly, is not a problem.

By mowing the meadow down to a height of 8 inches every time the vegetation reaches a height of 12 inches, you will not only prevent many annual weeds from seeding, but ensure that the young perennial plants growing below your mow height receive enough light for strong establishment. These perennials will emerge the following year far stronger than if they had been buried under 4 feet of annual foliage. This is why the inclusion of annual wildflowers in your seed mix can be detrimental to the long-term health of the planting.

During the second year the faster growing perennials will begin to provide color, and the entire planting should be well enough established to allow a decrease in weed control. You will need to monitor the planting for those weeds that can cause problems for the meadow. If needed, control can be obtained through spot herbicide or horticultural vinegar application, or manual weeding. If weeds and non-native grasses continue to dominate in the second growing season, continue with the above mowing regime. If not, transition to below schedule.

By the third year the native plants should be fairly dominant on the site and able to resist weed/invasive invasion with minimal management. Once the meadow is mature, you should only mow or burn part of the planting in a single season — ideally one-third or one-half of the overall area at one time, always between November 15 and April 1. No single area should be burned or mowed more frequently than every 1-2 years, to protect dormant insects such as butterfly pupae or stem-nesting bee larvae. For aggressive species, you may wish to remove seed heads in order to slow their expansion.

Adapted from Wildflower Meadows: Let's Get Real *by Larry Weaner and* Establishing Pollinator Meadows From Seed *by Mader et al.*

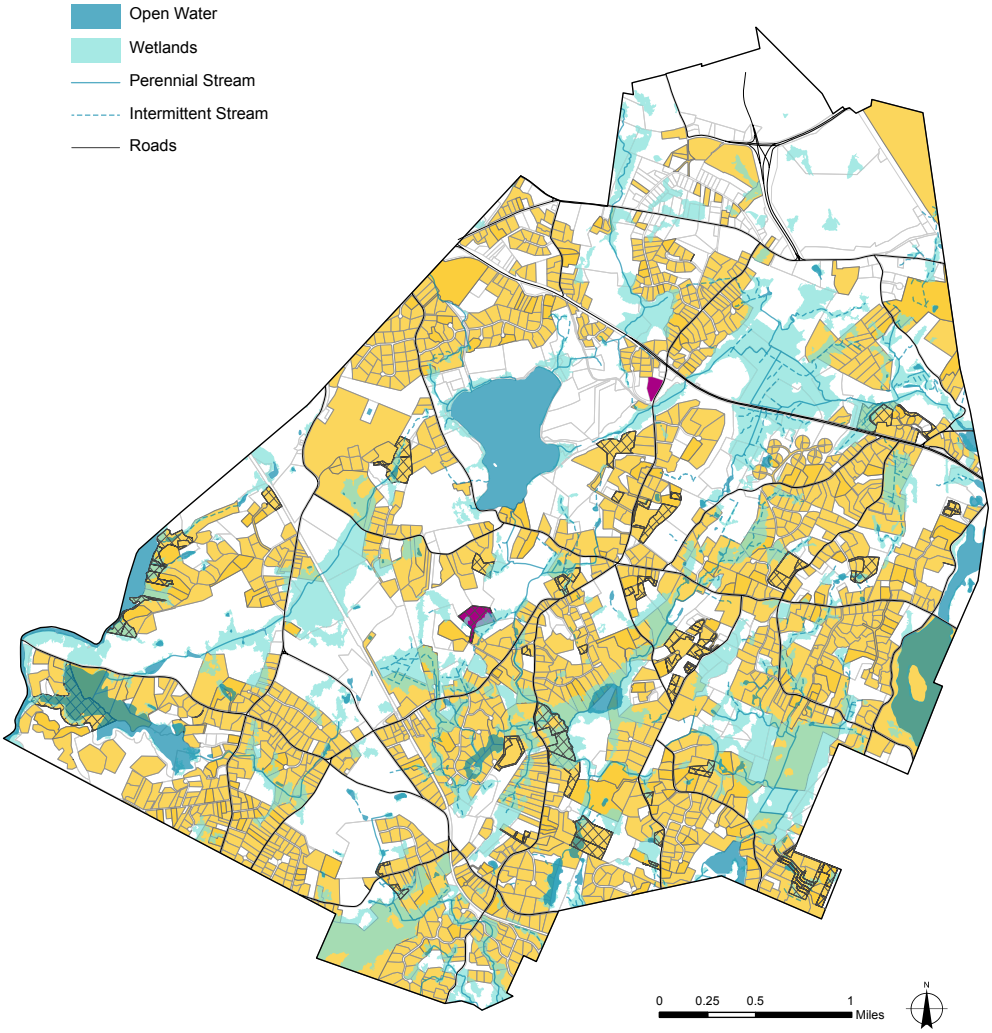
Opportunities

for Connectivity

OPPORTUNITIES FOR PEOPLE FOR POLLINATORS AND BIRCHES SCHOOL TOOLKIT REPLICATION

Residential and developed properties in Lincoln and parcels with less than 5000 sq.ft of open field habitat

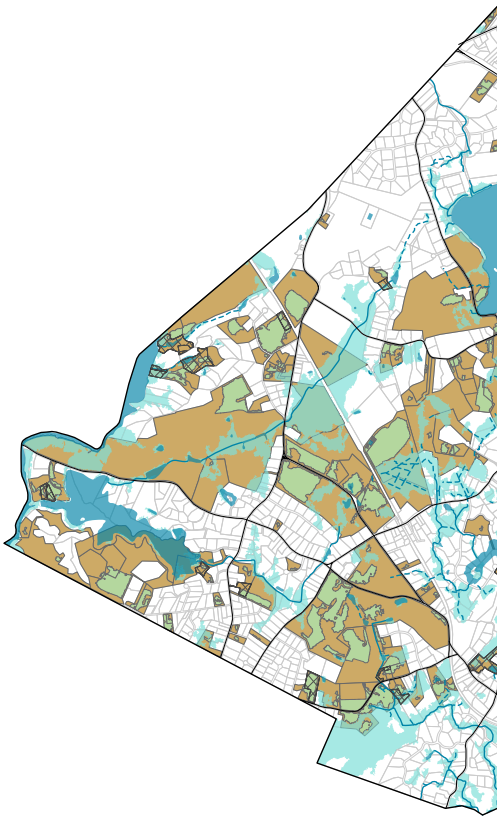
- Birches School and People for Pollinators
- Residential/Developed Sites and Parcels with <5000 sq.ft Open Field
- Properties Owned/Protected by LLCT
- Open Water
- Wetlands
- Perennial Stream
- Intermittent Stream
- Roads



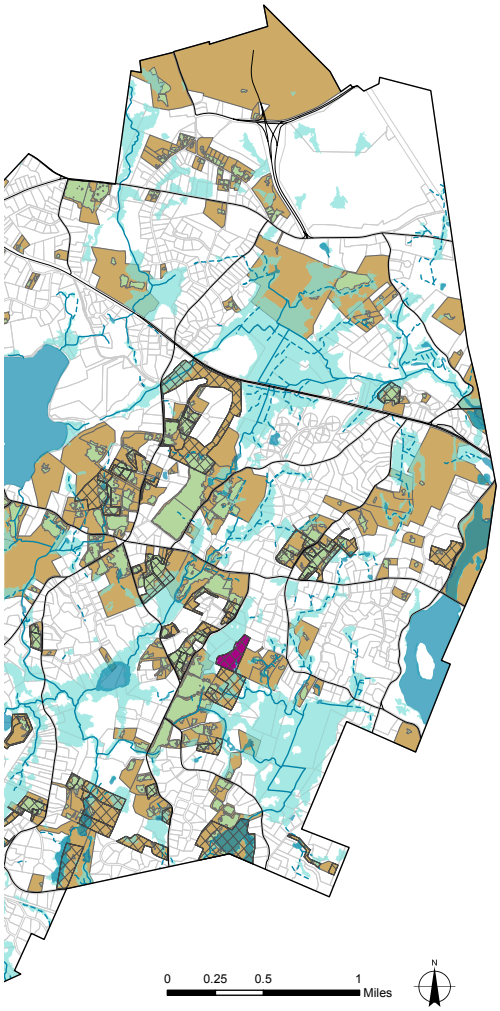
OPPORTUNITIES FOR CHAPMAN PASTURE TOOLKIT REPLICATION

Properties in Lincoln containing greater than 5000 sq.ft of open field habitat

- Chapman Pasture
- Open Field Habitat (>5000 sq.ft)
- Parcels with >5000 sq.ft Open Field
- Properties Owned/Protected by LLCT
- Open Water
- Wetlands
- Perennial Stream
- Intermittent Stream
- Roads

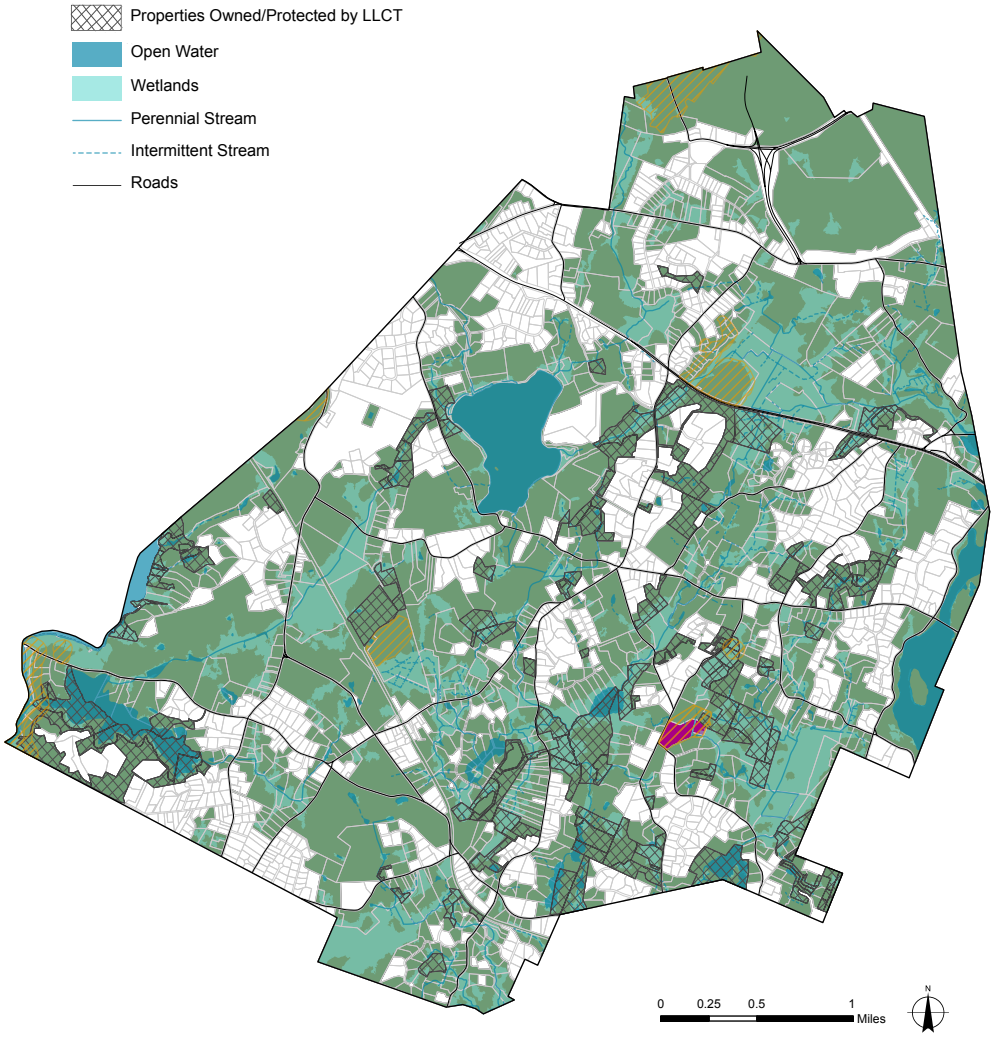


Opportunities for replication of the Toolkit designs in Lincoln. Left: properties in yellow are zoned as residential or developed, or contain open field areas measuring less than 5000 sq.ft, similar conditions to the context in which the People for Pollinators and Birches School designs were created; center: properties in brown contain large areas of open grassland habitat, comparable to the Chapman Pasture site; right: properties in dark green contain wetlands, wet meadows or priority/estimated habitat of rare species, conditions which are analogous to the Upper Browning Fields site.



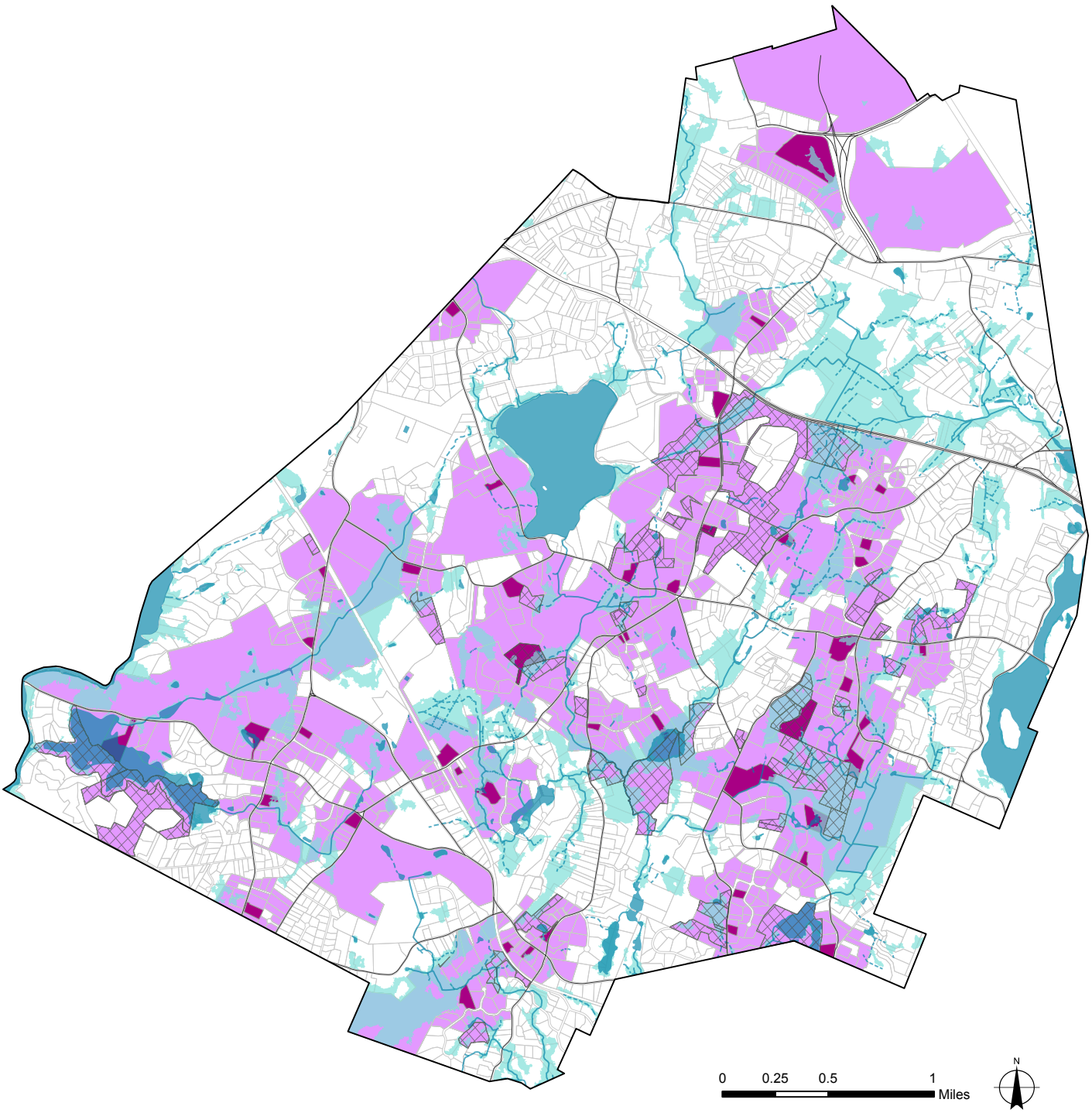
OPPORTUNITIES FOR UPPER BROWNING FIELDS TOOLKIT REPLICATION

Properties in Lincoln containing wetlands, open water or Priority/Estimated Habitat



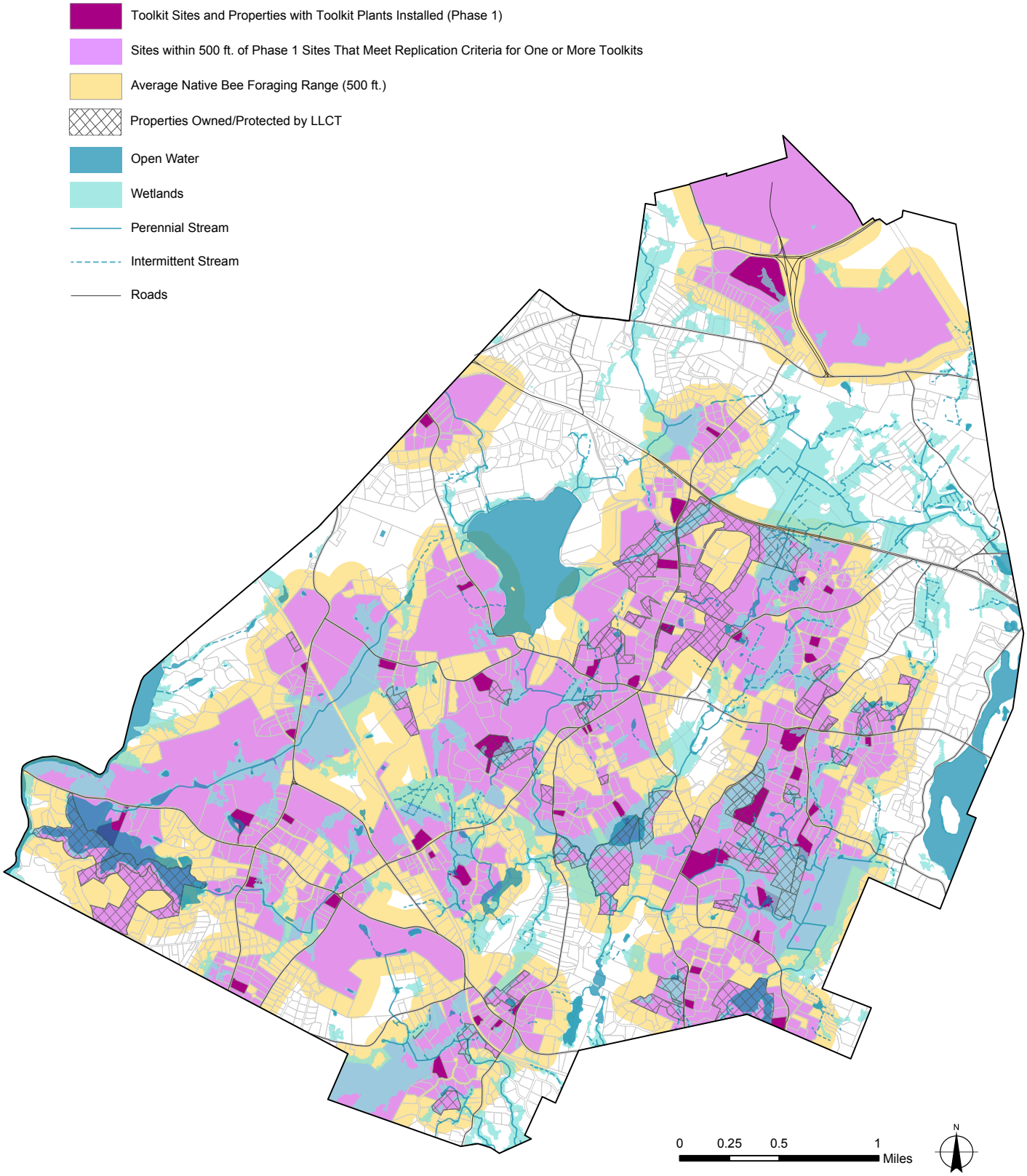
Note: Town-wide analyses are at a coarse scale, based on state GIS data which is sometimes inaccurate at the ground level. Wetland demarcations are based on aerial surveys, not site-specific visits, and in many cases wetlands as depicted have not been delineated or may be inaccurate. All wetlands in Massachusetts are subject to regulatory permitting under the Wetlands Protection Act. Wetlands in Linoln cannot be planted or modified without prior approval from the Lincoln Conservation Commission.

Properties that meet the replication criteria for one or more of the Toolkit designs based on their existing landscape typologies are seen in correlation to the Phase 1 Toolkit sites and properties with planting kits installed. All properties in lavender are within 500 feet of one or more of the Pollinator Corridor Phase 1 sites, and contain land use conditions or habitat features which are similar to one or more of the Toolkit sites. Right: with a 500 ft. buffer on every potential Phase 2 property, representing the average foraging range of a native bee species, a town-wide pollinator corridor in Lincoln is demonstrated, with overlapping flight ranges allowing for redundancy and further strengthening of the life stages of the target threatened and at-risk species.



POLLINATOR CORRIDOR PHASE 2 SITES

Properties in Lincoln suitable for replication of Toolkit designs with maximum connectivity



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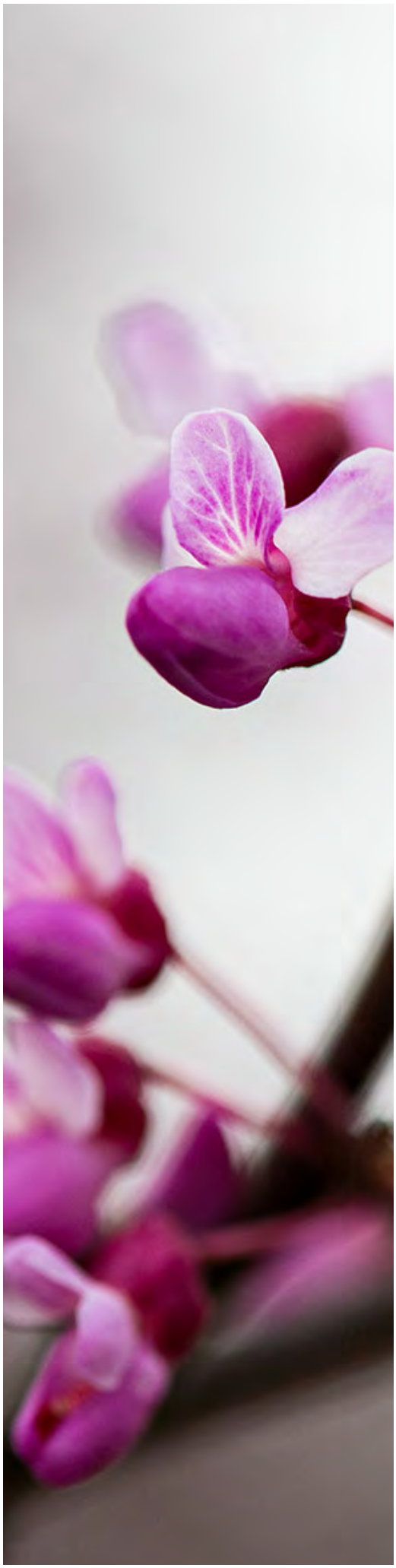
OPPORTUNITIES FOR CONNECTIVITY

Data layers: MassGIS.



Left to right: Cercis canadensis; Salix petiolaris by Peter Dziuk; Impatiens capensis.

The Lincoln Pollinator Action Plan is a comprehensive field guide for creating and maintaining habitat on a wide range of landscapes, to support threatened and at-risk pollinator species in the Northeast. While the designs, plant lists and management recommendations contained herein are based on the prevalent landscape conditions in Lincoln, Massachusetts, their applicability stretches far beyond town boundaries. The product of a year-and-a-half-long collaboration between scientists, designers, planners, conservation professionals and citizens, this Plan endeavors to make pollinator habitat conversion easy, exciting and aesthetically pleasing — and inspire landowners to view their properties as integral parts of a network of ecosystems that stretches into surrounding communities and across the wider region.

Commissioned by
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LANDSCAPE | NTERACTIONS
16 Center Street #426
Northampton, MA 01060
landscapeinteractions.com