Generative Landscapes:

Successional and Equitable Plant
Propagation on Rhode Island's Public Lands

Elizabeth Hunt

Thesis Book was written and designed by Elizabeth Hunt.

Typeface: Public Sans

Generative Landscapes :
Successional and Equitable Plant
Propagation on Rhode Island's Public Lands

Elizabeth Hunt
MLA Landscape Architecture, RISD

A thesis submitted in partial fulfillment of the requirements for the Master of Landscape Architecture Degree in the Department of Landscape Architecture of the Rhode Island School of Design, Providence, Rhode Island.

By: Elizabeth Hunt
05/23/2020

Approved by Masters Examination Committee:

Johanna Barthmaier-Payne, Department Head, Landscape Architecture

Colgate Searle, Primary Thesis Advisor

Ann Kearsley, Thesis committee

CONTENTS

Ash Roots on Alverson Ave Sidewalk,
Providence, RI

HOPES

Caretaking has taken on a new meaning for the world during the writing of this thesis. The way we take care of each other, the importance of our nursing system, and our priorities have been laid bare. Caretaking is an integral part of life. It is the daily maintenance of living things and the emergency care for vulnerable things. Although the nonhuman world has not historically needed humans to "nurse" and maintain biodiversity, it now does. Landscapes today are vulnerable in climate change. They need the extra care that we understand that vulnerable humans need. Because landscapes are living places, we need to reconsider our role, our timelines, and our processes as architects.

While we often talk about participating in community we seldom mention participating in nature. In order to take care of the more than human world, we also need to see it's agency and life. We need to propagate a culture of seeing and caring for plant cycles through education, play, and beauty. We need to embody the knowledge that our wellbeing is dependent on the resilience of the plant world. And act accordingly.

Nurseries are places for spreading plants. From nurseries plants are multiplied and driven across neighborhoods or thousands of miles. While this system is currently capitalistic, seed banks and other programs spread plants without money. Landscapes should be places from which plants are shared and multiplied. While the squirrels, birds, and bees are constantly engaged in this practice, we can be too. We should be collecting seeds from our landscapes and planting them, we should be taking cuttings, multiplying and encouraging the growth that helps the vulnerable.

Nurseries are also sites for sharing information and expertise. Market nurseries educate people about how to help their plants prosper. They often organize the plants in particular ways like, shade versus sun, tree versus shrub, annual versus perennial, and therefore influence the way people plant. They help beginners with the basics, and often teach people how to care for their plants. Our landscapes can also be places for education. They can teach people names, cycles, beneficial practices. This can be taught by people but also by didactic design.

Nurseries are sites for local experimentation. Citizen science will be a crucial way of moving through climate and habitat changes in the gentlest way. How can we use our landscapes as places where we can test and monitor new relationships in a very local condition? In this way the goal of the research should be how we can make the best decisions for each place.

Landscapes are already nurseries. But it is time we began thinking of them as such. They are places for plant birth, change, displacement, healing, multiplying, sharing, learning, and experimentation. By focusing on these qualities, and the words and associations we have with nursing, and nurturing, we might be able to more gently move through climate change.

GLOSSARY OF TERMS

PRODUCTION: How plants are born and raised for their life. This includes both nursery markets and natural reproduction.

PROPAGATION: How plants are intentionally reproduced.

NURSERY: A place where plants are propagated, people learn about plants, and local experimentation is done.

SUCCESSION: The process whereby ecological communities change and are sometimes replaced by new communities over time.

GENERATIVE: Creative, innovative, unconventional, envisioning, sensitive, causal, conceiving, fertile, inspiring, productive, resourceful.

PROBLEMS

CLIMATE CHANGE PROBLEMS:

Plants are not adapted to the changing environmental conditions and cannot migrate in time.

Planting conditions will become much more unpredictable in the next 50-100 years.

Increased disturbances may cause ecological collapse, increased extinctions, and increased environmental inequality.

SOCIAL PROBLEMS:

There is a dramatically unequal distribution of urban canopy, which causes unjust health differences.

There is a common lack of understanding of natural cycles.

There is a common lack of resources to buy plants for places that need them.

PROBLEMS

CONDITIONS CHANGES IN THE NEXT 50-100 YEARS

WHITE PINE CURRENT DISTRIBUTION

WHITE PINE FUTURE DISTRIBUTION

IMPORTANCE VALUE

- 0
- 1-3
- 4-6
- 7-10
- 11-20
- 21-30
- 31-50
- >50

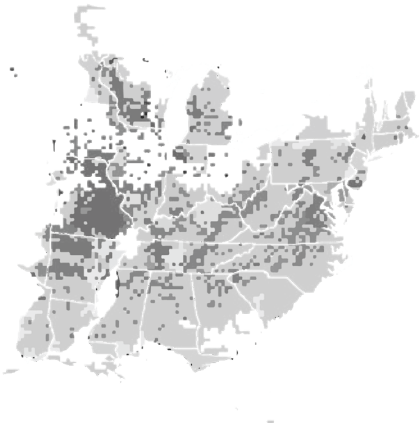
PERSIMMON CURRENT DISTRIBUTION

PERSIMMON FUTURE

IMPORTANCE VALUE

- 0
- 1-3
- 4-6
- 7-10
- 11-20
- 21-30
- 31-50
- >50

WHITE OAK CURRENT DISTRIBUTION



WHITE OAK FUTURE DISTRIBUTION

PROBLEMS

UNEQUAL DISTRIBUTION OF CANOPY

iTree

These maps were produced using i Tree
a program that allows anyone to overlay tree cover information with health, environmental and census data.

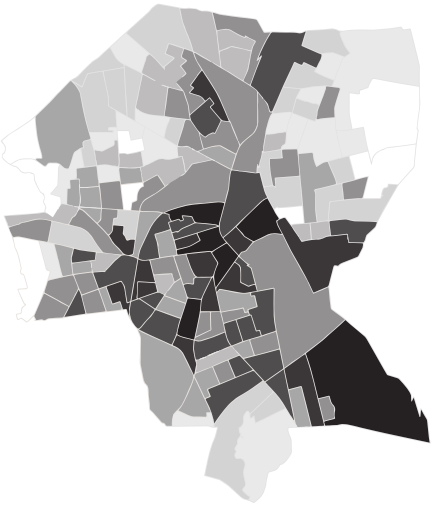
People and the Environment

Environmental and social issues are deeply intertwined. Without equality of health, safety, and welfare, there will never be an equality of environmental quality.

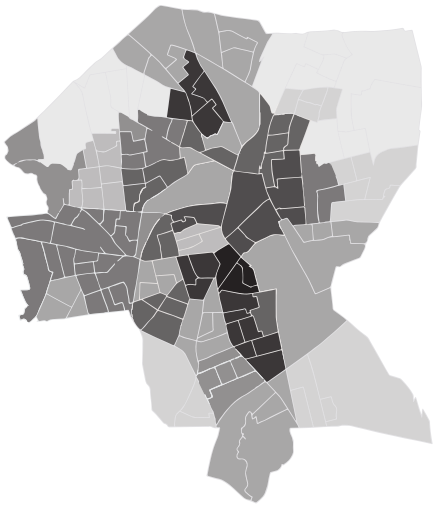
Scale Lowest To Highest

Tree Stocking Level

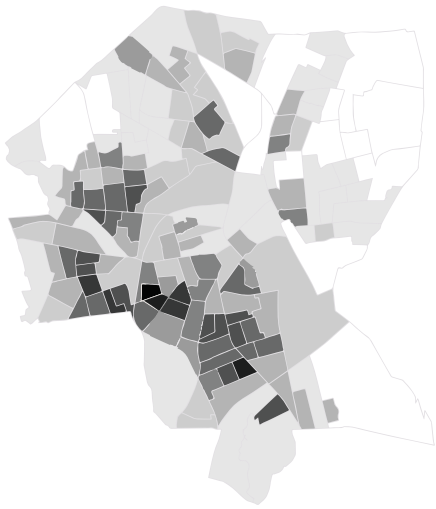
The number of trees per area



Population Below The Poverty Line



Minority Population Density



PROBLEMS:

VOICES FROM THE INDUSTRY

DOUG STILL
Providence City Forester

"All the trees for Providence public plantings come from Oregon." (Interview with Author)

NOEL KINGSBURY
Garden Designer, Author

"Planting today is harmed by the way plants are being produced, nurseries are not focused on long term suitability, or sustainability."*

MATT URBANSKI
Landscape Architect, Principal at MVVA

"Planting in the future should consider the full life cycle of the plant, change, death and succession."*

STEVEN HANDEL
Ecologist, Professor at Harvard GSD

"Plant production today is scaled and focused on horticulture not larger landscapes." *

*Harvard University
Graduate School of Design Lecture. March 7, 2017.
"Planting in the Public Realm: Projects and Projections."

Opposite: Dead vincas on site for DHM Design, photo taken by author.

HISTORY

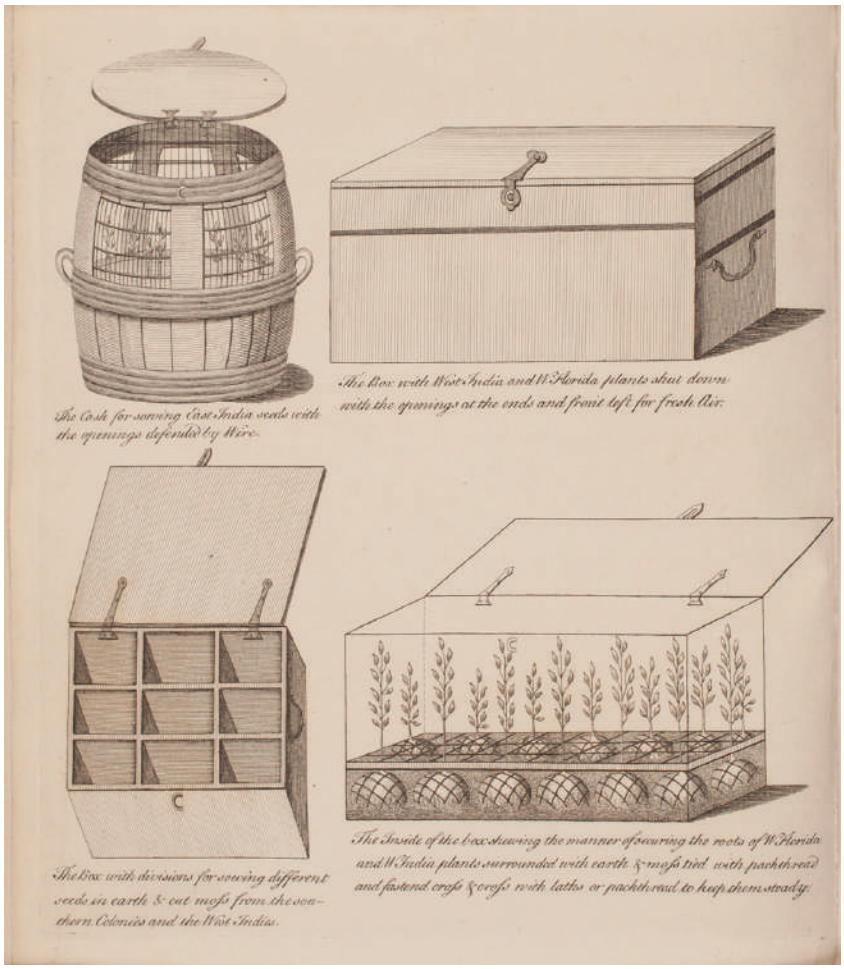
WHAT CREATED MODERN IDEAS OF PLANT PRODUCTION?

1. COMPETITION TO PLANT FORESTS AMONG THE 18TH C ENGLISH GENTRY.

“One of the most important branches of the trade became the production of forest trees in great numbers. At first this was for planting avenues and parks as showpieces, but in the course of the 18th century a wave of ‘improvement’ swept over the country. Many of the landed nobility and gentry vied with one another in planting large expanses of wasteland and mountain slopes with thousands of trees, deciduous and coniferous....There had been planting for a century and more before that, but on a smaller scale whose demands could be met mainly by the creation of private nurseries and sowing of seed.” (Harvey, John. Early nurserymen: With reprints of documents and lists. Phillimore, 1974.)

2. COLONIALISM, GLOBAL TRADE

“Following on the heels of the trade in forest trees came the era of exotics. Ever since the 16th century there had been important introductions of plants from distant lands, in an ever increasing flood. A few of the plants such as the Lilac and ‘Syringa’ (Philadelphus) soon became common and more or less naturalized.” (Harvey)



Directions for bringing over seeds and plants, from the East Indies and other distant countries, in a state of vegetation.
Ellis, John, 1710?-1776.
London: Printed and sold by L. Davis, 1770
Dumbarton Oaks

HISTORY

SEEDS AND NURSERIES

1. SEPARATE INDUSTRIES

“The seedsman proper, was usually a merchant pure and simple, centralizing supplies bought from individual raisers at home and abroad, and selling both to local firms and to the public direct. Until quite modern times practically the whole of the seedman’s trade was concentrated in London, and particularly in the City and Liberties. Provincial firms of ‘seedsmen’ bought all or most of their stock from these great firms of seed merchants, and this applied even in Scotland.” (Harvey)

2. CLONES, CUTTINGS, STERILITY

Today in order to meet expectations for flowering, fruit sweetness and any other quality, many plants are produced as identical to their parent plant through cloning. Because the life cycle of plants could compete with commercial production, some companies produce sterile varieties so that farmers need to buy seed each year without being able to reproduce their crop.

Telford’s Seed Catalogue: Pompions, English Tobacco, Horn-Poppies and Willow Leav’d Beans

North Yorkshire County Record Office

A CATALOGUE of SEEDS, &c.

Sold by JOHN and GEORGE TELFORD,

NURSERYMEN and SEEDSMEN in *Tanner-Row, YORK.*

Seeds of Roots.

STRASBURG Onion
Spaniſh Onion
Portugal Onion
Blood-red Onion
Silver-ſkin'd Onion
Welch Onion
London Leek
London Orange Carrot
Early Horn ditto
Swelling Parſnep
Scorzonera
Salſafy
Skirret
Early Dutch Turnep
Early Stone Turnep
White Norfolk Turnep
Red Norfolk Turnep
Long French Turnep
Yellow Turnep
Rocambole
Shallots
Garlick Heads

Sallad Seeds, &c.

EArly Short-top'd Radiſh
London Radiſh
Salmon Radiſh
White Spaniſh Radiſh
Black Spaniſh Radiſh
Cabbage Lettuce
Brown Dutch Lettuce
Royal Brown Dutch ditto
Green Dutch Lettuce
Tennis-Ball Lettuce
Early-frame Cabbage ditto
Sileſia Lettuce
Imperial Lettuce
White Coſs Lettuce
Green Coſs Lettuce
Red Coſs Lettuce
Aleppo, or Spotted Coſs ditto
Capuchin Lettuce
Round Spinage
Bourdeaux Spinage
Common White Beet
Swiſs Beet
Red Beet
Green-top'd Red Beet
Turnep-rooted Red ditto
Green Curled Endive
White Curled Endive
Batavian Endive
Red Orach
White Orach
Italian Finochia
Common Parſley
Spaniſh Cardoon
French Sorrel
Sweet Chervil
Green Purſlain
Golden Purſlain
Corn Sallad
White Muſtard
Brown Muſtard
Garden Creſſes
Curled Creſſes
Large Naſturtium
Dwarf Naſturtium
Dutch Aſparagus
Batterſea Aſparagus
Beſt Cauliflower, Early
Late Cauliflower
Beſt Early Cabbage
Early Dutch Cabbage
Early Batterſea Cabbage
Sugar-loaf Cabbage
Ruſſia Cabbage
Red Cabbage
Green Savoy Cabbage
Yellow Savoy Cabbage
Turnep Cabbage
Reynolds's Turnep Cabbage
Italian Purple Brocoly
Cauliflower Brocoly
Chou de Milan
Green Curled Thick-leav'd Cole
Hamburgh Cole
Jeruſalem Cole
Variegated Cole
Jagg-leav'd Cole
Early Cluſter Cucumber
Early Prickly Cucumber
Long Prickly Cucumber
Short Prickly-Cucumber
Green Turkey Cucumber
White Turkey Cucumber
Roman Long Cucumber
Fine Cantalupe Melon, Sorts
Romana Melon
Italian Melon, and ſeveral others
Pompions
Gourds, of Sorts

Pot and Sweet Herb-Seeds

THyme
Hyſop
Winter-Savory
Summer-Savory
Sweet Marjoram
Pot-Marjoram

Phyſical Seeds.

CArdus
Scurvy-Graſs
Angelica
Engliſh Tobacco
Dill
Common Fennel
Sweet Fennel
Carraway

Perennial Flower Seeds.

SCarlet Lychnis
Roſe Campion, Red
Painted Lady ditto
Red Valerian
Greek Valerian
Polyanthus
Everlaſting Peas
Double Hollyhock
Carnation
Pheaſe-ey'd Pink
Matted, or Dwarf Pink
Double Columbine
Globe-Thiſtle
Purple Linaria
Indian Reed

Biennial Flower Seeds.

BRrompton Stock
Queen's Stock
Twittenham Stock
White Stock
Painted Lady Sweet William
Dark-red
Snap-Dragon
French Honeyſuckle
Bloody Wall-Flower
White Wall-Flower
Canterbury Bells
Honeſty, or Sattin Flower
Broad-leav'd Indian Pink
Small-leav'd ditto
Horn-Poppy
Xeranthemum

Annual Flower Seeds.

SCarlet ten Weeks Stock
Purple ten Weeks Stock
Purple Pruſſian ditto
White Pruſſian ditto
Purple Candy Tuft
Venus Navelwort
Venus Looking-Glaſs
Belvidere
Tall Double Sun-Flower
Dwarf Double ditto
Flos Adonis
Large Dutch Poppy
Small Dutch Poppy
Scarlet Zinia
Red Hawkweed
Yellow Hawkweed
Annual Snap-Dragon
Lavatera
Bladder Ketmia
Curled Mallow
Purple Mallow
Lobel's Catch Fly
Double Purple China After
Double Red ditto
Double White ditto
Double-ſtrip'd ditto
White Cryſanthemum
Yellow ditto
Prince's Feather
Love lies bleeding
Yellow Lupines
White Lupines
Roſe Lupines
Large Blue Lupines
Small Blue Lupines
Purple Sweet Peas
Painted Lady Sweet Peas
White Sweet Peas
Tangier Peas, or Scarlet Lupines
Spaniſh Painted Lady Peas
Perſicaria
Bottles of Sorts
Nigella Romana
Spaniſh or Dwarf Nigella
Snails
Caterpillars
Hedgehogs
Convolvulus Major
Small Scarlet Convolvulus
Strip'd Convolvulus Minor
African Marygold
French Marygold
Dwarf French ditto
Double-ſtrip'd French ditto
Cateſby's Marygold
Cape Marygold
Capſicums, of Sorts
Marvel of Peru
Sweet Sultan
Yellow Sweet Sultan
Portugal Buſh Baſil
Minionet
Upright Reſeda
Humble Plant
Melongena, or Egg Plant
Double Stramonium
Scarlet Apocynum
Cerinthe, or Honeywort
Palma Chriſti Major
Palma Chriſti Minor
Diamond Ficoides
With ſeveral others

Tree Seeds.

CYpreſs
Silver Fir
Spruce ditto
Larch
Scotch Fir
Acorns
Evergreen Oak
Weymouth Pine
Cluſter Pine
Pineaſter
Stone Pine
Beech Maſt

Seeds to improve Land.

RED Clover
White Dutch Clover
Trefoil
Rib Graſs
Rye Graſs
Natural Graſs
Bird Graſs
Timothy Graſs
La Lucerne
Burnet Graſs
Buck Wheat
Tare Vetch
Bird Seeds, of Sorts
French Furze

Peas and Beans.

EArly Golden Hotſpur Peas
Early Charlton ditto
Ormerods, or Forty Days ditto
Maſter's Hotſpur Peas
Long Hotſpur Peas
Dwarf Marrow Peas
Large Marrow Peas
Imperial Green Marrow ditto
Large Egg ditto
Smyrna Black-ey'd ditto
White Rouncival ditto
Blue Rouncival ditto
Early Dwarf Peas
Split Peas
Early Mazagan Beans
Early Spaniſh Beans
Long-podded Beans
Nonpareil Beans
Toker Beans
Windſor Beans
White-bloſſom'd ditto
Purple-bloſſom'd Beans
Green Venetian Beans
Dwarf Pruſſian Bog Beans
Willow-leav'd Beans
Early Yellow Kidney Beans
Early Dwarf White ditto
Large-ſeeded Dwarf White ditto
Negro Kidney Beans
Black ſpeckled ditto
Red ſpeckled ditto
Large White Dutch ditto
Scarlet Kidney ditto
Batterſea ditto
Party-coloured ditto

Flower Roots.

RAnunculus
Anemone
Tulip
Crocus
Hyacinth
Narciſſus
Martagon
Tuberoſe
Guernſey Lily
Crown Imperial
Iris, of Sorts
Frittillaria
Orange Lily
With moſt Sorts of fibrous-rooted Perennial Flowers

Fruit Trees.

PEaches
Nectarines
Plumbs
Apricots
Cherries
Pears
Quinces
Apples
Medlars
Vines
Mulberries
Figs
Gooſeberries
Currans

HISTORY

PLANT PRODUCTION THEN AND NOW

NURSERY KNOWLEDGE

"The fact is, and it is a fact not hitherto adequately recognized, that a great deal of botanical knowledge is owed directly to nurserymen. It is a fiction largely based on modern social and academic attitudes that draws a hard-and-fast line between the 'scientist' on the one hand and the 'tradesman' on the other." (Harvey)

NURSERY EXPERIMENTATION

"Conditions of light or darkness, heat or cold, as affecting the germination of seeds or the season of flowering, now begin to be fully understood as they apply to one species after another. Long and patient experiment in each field of enquiry is essential. Even though not upon the basis of scientific predictability, such experimentation has provided the basis of all successful gardening through the centuries." (Harvey)

HISTORY

MODERN CONTEXT

1. RAPID ECOLOGICAL CHANGE ON A BROAD SCALE

The rate and scale of conditions changes in climate scenerios is unprecedented. How can we shift nurseries to meet the extreme scale of climate change? Nurseries were first designed in order to meet a larger scale, how can we design them again?

2. GLOBALISM

The world is more connected then it ever has been. How can we rethink our boundaries? What is necessary to keep separate and what is not? What can we move and what should we isolate?

3. URBAN HEALTH

Most people now live in cities and it is clear that plants have a significant effect on both human, water and soil heath in urban areas. How can we meet these particular needs with changing practices?

HISTORY

URBAN FORESTRY IN THE USA

THE INVENTION OF ARBOR DAY

"When the rays of a burning sun poured down all day long, the thought of cooling shades, of rustling leaves, or winds gently murmuring among trees, came unbidden, as dreams of springs haunt the mind of a fever patient."' (J Sterling Morton 22)

The first arbor day idea was conceived of by J Sterling Morton as a way to bring economic prosperity to the frontier as well as return some of the nostalgic beauty of the more familiar east coast.

The idea floated around the midwest but was not widely followed until Cincinnati's Arbor Day in 1882.

STUDENTS AND ARBOR DAY CINCINNATI

"I will take the public-school children into the Park on that day," he declared to the forestry organizers, 'and have them plant and dedicate trees to American authors." (19) John Bradley Peaslee, Superintendent of schools in Cincinnati, Ohio.)

Peaslee's idea was to bring every single public school student out for a day to plant.

By the 1970's Arbor Day dragged on but other event like Earth Day had begun to supercede it. It became quaint though still with significant branding power, as it is probably conceived as today.

“Air conditioning and cars had obviated those compelling reasons to plant and nurture city trees, just as the elms began to die. If trees were no longer saving children and helping families survive hot summers, what were they doing to justify their presence in the cityscape? Why bother replacing the elms?”

Jonnes, Jill. Urban forests: A natural history of trees and people in the American cityscape. Penguin, 2017. 168

THE REACTION TO DUTCH ELM DISEASE

"In the wake of the continuing loss of the American elm, the American Forestry Association was launching a new twentieth century crusade to rebuild the nation's urban forests" (164)

1. Dayton Climate Control Study
Quantified tree services in cities for pollution, heat, etc.

2. Tree City USA
Set up a program for cities to have an urban forester dollar amount towards urban forestry.

3. National Arbor Day Foundation
The Foundation sent people free tree seedlings in the mail and membership skyrocketed.

4. Tree People
The massive volunteer group that began the million trees movement in LA. Their publicity during the 1980 torrential rains allowed them to become visible to the public.

QUESTION AND PRINCIPLES

HOW CAN PLANT PRODUCTION MEET THE SCALE AND UNCERTAINTY OF CLIMATE CHANGE? BY BEING MORE:

EXPERIMENTAL

DIVERSE

MUTABLE

LOCALLY ADAPTED

AND EQUITABLE

WITH:

SPECIES EXPERIMENTATION

GENETIC, SPECIES AND HABITAT DIVERSITY

SUCCESSIONAL DESIGN

LOCAL PROPAGATION

COMMUNITY EDUCATION AND ENGAGEMENT

Goal	Place	People
Strategy	**Careful Plant MULTIPLICATION in the Age of Climate Change** With climate change predicted to create large-scale disturbance and plant loss, how can we rethink our methods of nursery propagation and landscape planting to meet the scale of the crisis?	**Resilient MULTIPLICATION** Plants can be multiplied in many ways, from ecological systems that involve wind and other animals, to people propagating them by seed and cutting. With the urgency of climate change forcing strategic thinking, how can we make this necessary work scalable by making it public and ecology-driven?
Method	**Natural Systems PROPAGATION** How can we respect the sophistication and complexity of natural systems by working with succession, seasonal cycles, and natural reproduction? Can we plant seed immediately when harvesting to respect the winter cycle, allow plants to adapt to urban environments in their own way and then propagate them, etc.?	**Experimental PROPAGATION** There is so much we still need to know about local plant and conditions changes. What if our landscape became that large experiment? Sections of school fields could be used for local, urban adaptation propagation. Kids could plant “their” tree in a neighborhood and monitor and nurture it in a citizen science project.
	Seasonal ACTIVITIES How can we create strategies that are specific to time and place and general enough to be replicated? Each place and season would need’s it’s own directions but the method and structure can remain the same.	**Playful ACTIVITIES** Propagating can’t be costly, protected, or perfect to scale but it can be careful. What if we created the structure and support for playfully scattering goldenrod seeds, scavenging for and pulling Japanese stilt grass, creating kid-focused games with flower bombs, etc?

TENSIONS

SCALE-EXPERIMENTATION

It is difficult to both experiment with what we need to be planting in climate change at the same time as scaling our solution large enough to make an impact.

EASE-COMMUNITY ENGAGEMENT

It is difficult to create something easy for a wide variety of people to do. But it is necessary that the work be public to meet the scale of the problem

SPECIFICITY-GENERALIZATION

It is difficult to create a replicable model that can have an impact and a model that is specific to place and situation.

SOLUTIONS

THOUGHTFUL EXPANSION

It is difficult to both experiment with what we need to be planting in climate change at the same time as scaling our solution large enough to make an impact.

FUN, PLAYFUL

It is difficult to create something easy for a wide variety of people to do. But it is necessary that the work be public to meet the scale of the problem

GENERAL RULES, SPECIFIC EXAMPLES.

It is difficult to create a replicable model that can have an impact and a model that is specific to place and situation.

CASE STUDIES

ASSISTED MIGRATION ADAPTATION TRIAL IN BRITISH COLUMBIA

Beginning in 2009, and continuing today, the British Columbia Ministry of Forests is doing an experiment for assisted migration of trees to prepare for climate change.

They are taking 16 species from 40 locations in British Columbia, Washington, Oregon and Idaho and planting them in 48 sites.

Some are moving north, to test how they do in places that historically had conditions out of their range, and some are moving south, to mimic impending warming and see how species will do in climate change conditions.

It makes sense that British Columbia is the first to do trials like this. The poles are and will be experiencing more warming than the rest of the planet. They are already seeing the effects as pine beetles and other insects that would normally be killed off by cold winters are proliferating and decimating their forests.

Beetle Kill and Drought galvanized public opinion, and those tragedies convinced people to try this trial and change government policies about how far the timber industry could move plantations.

In British Columbia, it is expected that trees need to move 100k in 100 years in order to be in conditions that they favor, but many complexities hinder that migration and there is still so much we can't predict about how they will move and adapt.

The project is very controversial. Dov Sax, an ecologist at Brown, says that he sees how a place with such a commercial dependence would move quickly toward such actions. Marris comments on how ecologists focus on the connections between species and this is just a tree move. I think this project inspires us to think about how we might migrate specific plants to preserve their connections, rather than just commercial trees.

SOURCE:
Emma Marris, Nature.com, 2009. https://www.nature.com/news/2009/090617/pdf/459906a.pdf

Assisted Migration Adaption Trial, British Columbia, website, articles and updates. https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/tree-seed/forest-genetics/seed-transfer-climate-change/assisted-migration-adaptation-trial

AMAT PHOTOS AND MAPS

Some of the tree species being moved in the assisted migration trial.

SOURCE: Emma Marris, Nature.com, 2009. https://www.nature.com/news/2009/090617/pdf/459906a.pdf

PROVIDENCE WATER EXPERIMENT

“Mr. Riely helps manage 20 square miles of woodland for Rhode Island’s largest water utility, Providence Water. Inside the five-acre enclosure, among the native oaks and pines, he had planted southern trees including persimmon and shortleaf pine — species better adapted to hotter, drier conditions. And they were thriving.

Mr. Riely is particularly delighted by the Virginia pine, brought in from a nursery nearly 400 miles away in Maryland. “For New England, this is quite incredible growth,” he said, pointing to a young tree now taller than he is. It suggests that climate has already changed enough in Southern New England for some mid-Atlantic species to survive.

Bringing in southern trees may be one solution. But it won’t help, he has discovered, without first dealing with the deer. They ate many of the young trees he planted outside the fence, and are a major reason the hardwood forest has difficulty regenerating.

As a cautionary tale, Mr. Riely looks to the forest collapse that struck near Denver some years back. Conditions in the Rockies differ substantially from those in Rhode Island; still, he calls it “a water supplier’s nightmare.”

In the 1990’s, dry spells, insects and disease began killing trees there. In 1996 and 2002, ferocious fires tore through. Then the rains came. Flash floods carried dark, ash-filled silt and debris into Denver’s reservoirs, clogging them.

So in 2010, Denver Water began replanting the mountainsides, making the forest more drought-resistant by spacing trees farther apart and reducing competition for water. Opening the forest canopy allowed other kinds of plants, which also prevent erosion, to grow as well.

Failing to plan for the changing environment was a costly lesson, said Christina Burri, Denver Water’s watershed scientist. A big part of what she does today, she added, is “convincing people about the benefits of being proactive.” Planning ahead, she said, is much cheaper than reacting to catastrophes.”

SOURCE:
Moises Velasquez-Manoff. “Can Humans Help Trees Outrun Climate Change?”

PROVIDENCE WATER EXPERIMENT
STUDENT PARTICIPATION

SOURCE:
https://www.nytimes.com/2019/04/25/climate/trees-climate-change.html

GREEN THUMBS, ONTARIO

Green thumbs is schoolyard community garden nonprofit program begun in 1999 in that builds learning gardens in underserved communities in Toronto. Using after-school and school-hour programming, students learn how to grow in an environmentally sustainable manner.

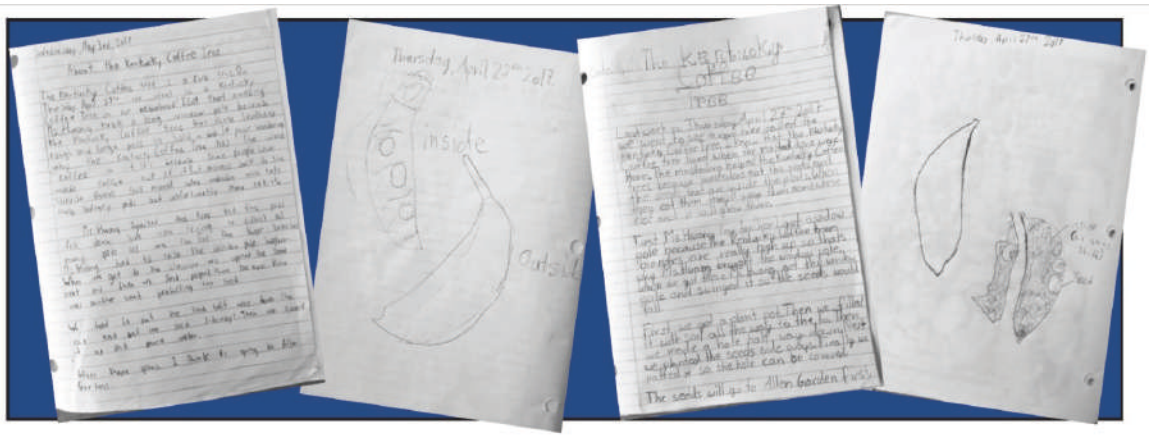
In 2017 they began a program to grow urban street trees from seed on the school grounds. Students learn about the importance of native trees to Indigenous people and cultures.

From their website:

“Native trees grown from seed will be better adapted to the microclimatic conditions of the city. Growing from seed protects biodiversity within the species, allowing future arborists toselect for desired characteristics such as disease or pest resistance. We cannot know all of the effects of climate change, and biodiversity is the best insurance for native species’ survival. We do know that some trees planted in Toronto are sourced from elsewhere and are not adapted to our region, thus failing.”

URBAN TREES FROM SEED

SOURCE:
https://greenthumbsto.org/2017/11/02/urban-trees-from-seed/



1. "To engage elementary students in growing native trees from seed on their school grounds, connected to science curriculum and other subject areas."

2. "To develop a community of practice within school communities sharing knowledge and resources on native tree establishment and care."

3. "To disseminate locally grown native tree seedlings from local seed sources back into the community."

4. "To include and enhance student awareness of the importance of native trees to Indigenous people and cultures."

PRINCIPLES

1. SELECT CLIMATE-MINDFUL SPECIES

Seed propagating plants
Low Pollution Trees
5 year suitability

2. GENERATE INCLUSIVE DESIGN

Games
Education
Awareness

3. EXPERIMENT WHEN WE DON'T KNOW

New Species
Tough Areas
Habitat Value

4. INTERCEDE ON THE CYCLES

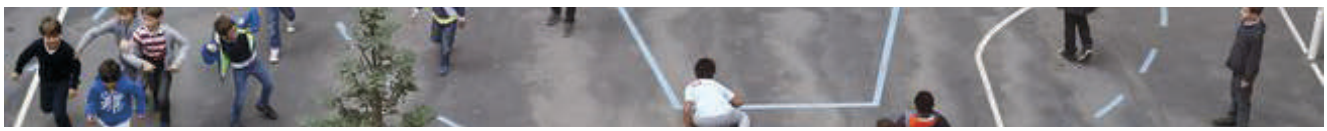
Life Cycle
Carbon Cycle
Succession

TYPOLOGIES

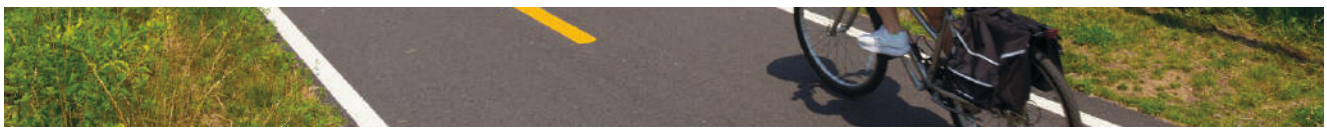
FOREST

RESIDENTIAL STREET

SCHOOLYARD

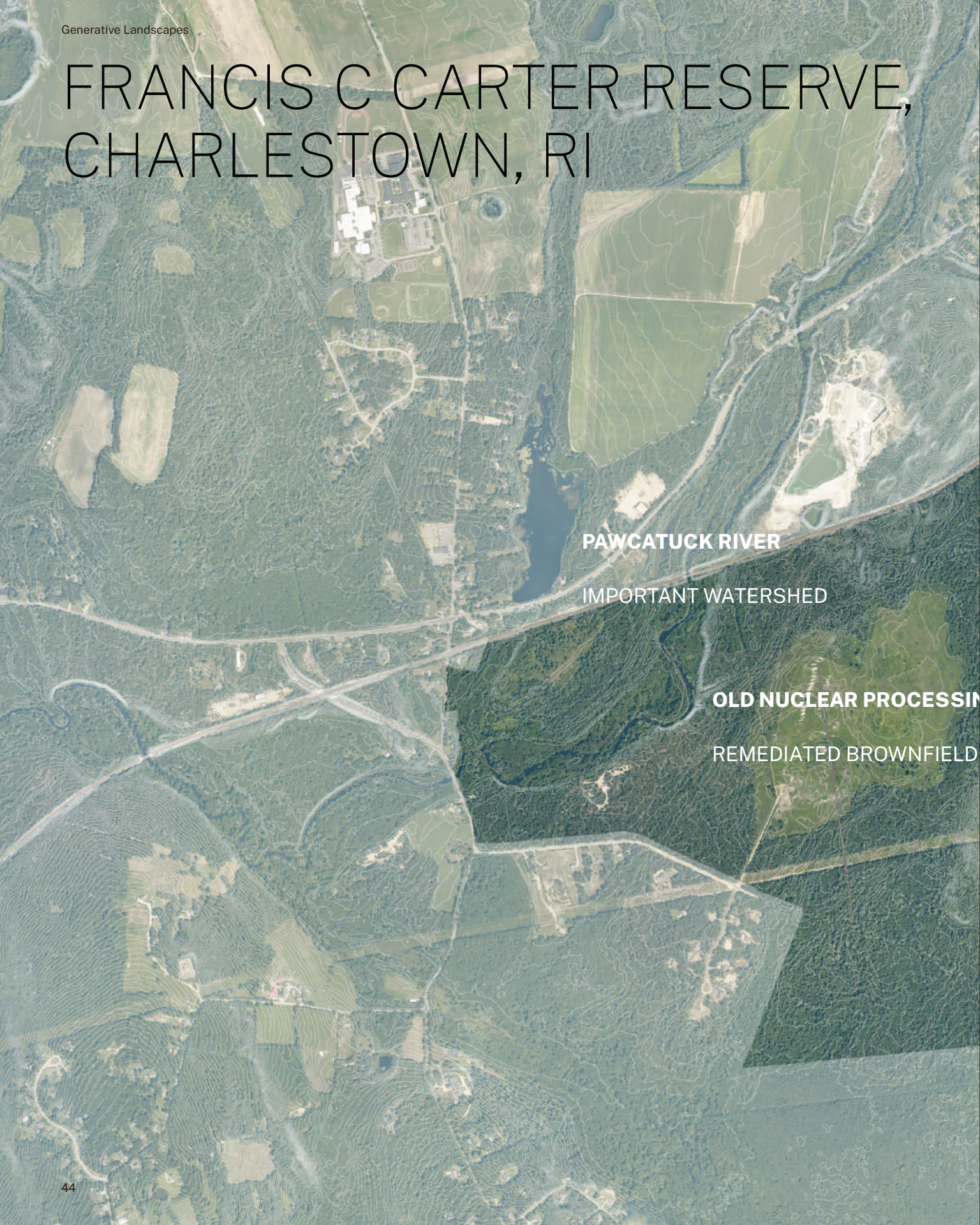


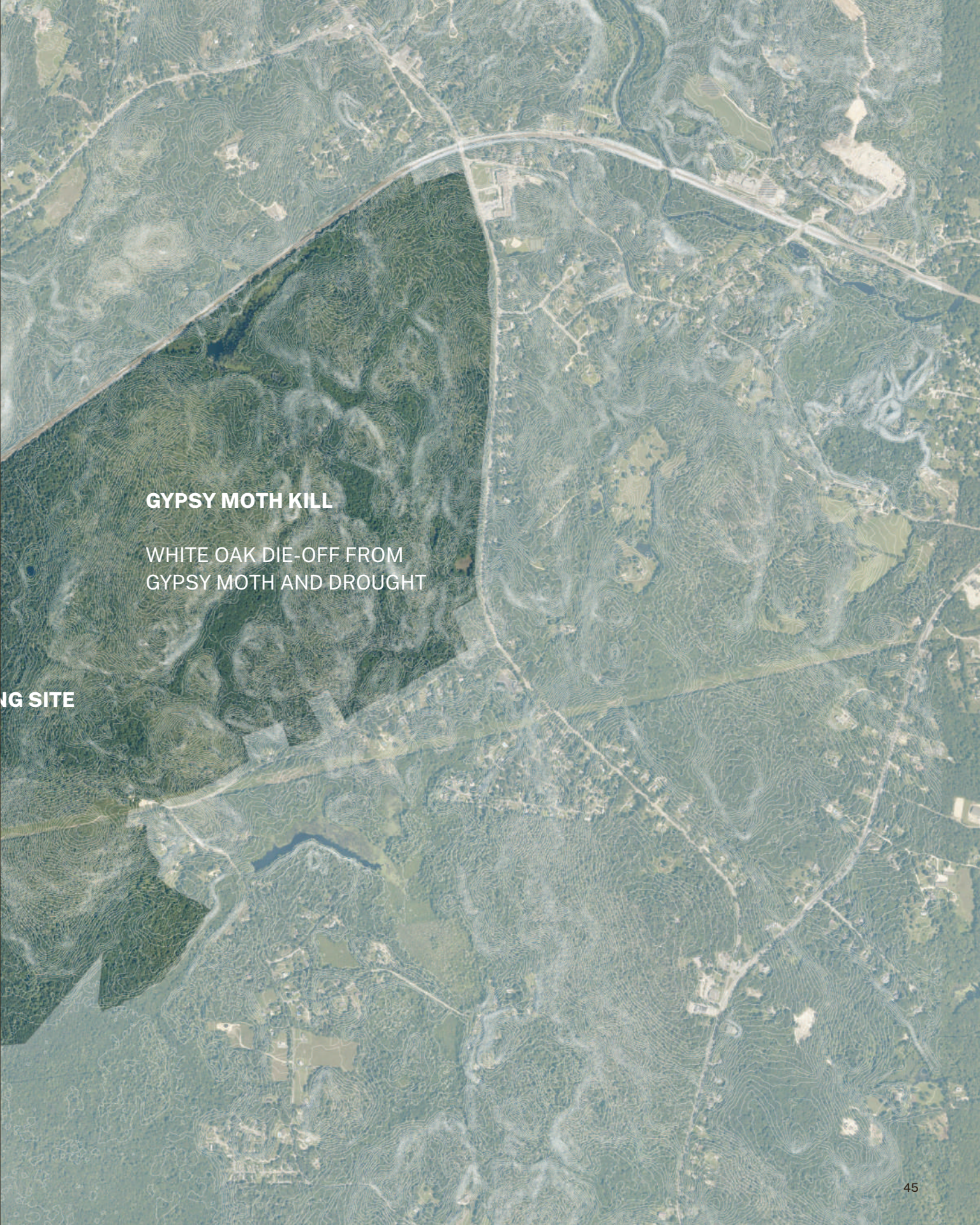
5. RIVERSIDE PARK



forest

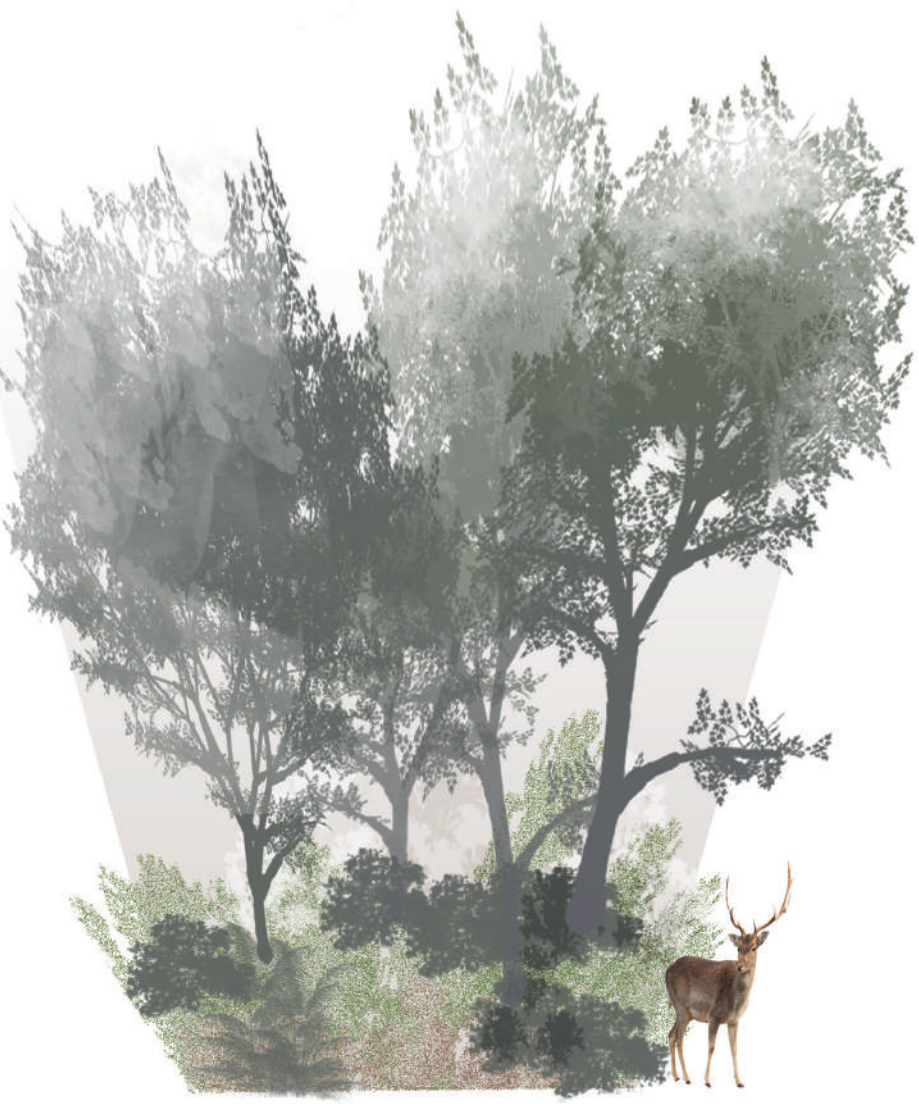
FRANCIS C CARTER RESERVE, CHARLESTOWN, RI




GYPSY MOTH KILL
WHITE OAK DIE-OFF FROM
GYPSY MOTH AND DROUGHT
NG SITE

SUCCESSION AT CARTER RESERVE

An open oak forest with a low growth of blueberry huckleberry and sheep laurel.

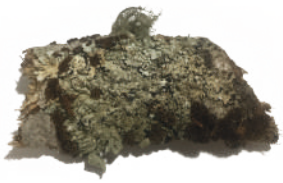


After drought and gypsy moth infestation, most of the trees are dead and lichens, fungi, bacteria and white pine are the new plant community.

The white pines will create a dappled shade for other trees to grow but the only seeds in the seedbank are those that will continue to be susceptible to drought and gypsy moth.

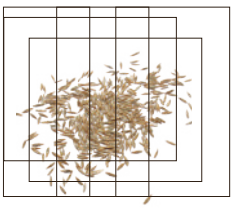
FOREST STRATEGIES

1. GYPSY MOTH PLANTING EXPERIMENT



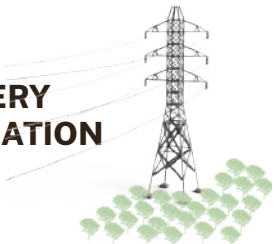
1. Experiment in planting composition:
Plant bitternut hickory, shagbark hickory, tulip tree, southern oaks and persimmons. Propagate carbon storing fungi to mitigate the carbon output of the dead forest

2. MEADOW SEED BANK AND REMEDIATION



2. The Site is still polluted with nitrites and heavy metals. The site should be remediated as possible. And public weeded.

3. POWER LINE NURSERY FOR HABITAT PROPAGATION



3. Propagate plants unique to the site under the powerlines like pitch pine, oak/hickory, and sheep laurel

4. PITCH PINE TREE REHAB

4. Thin Young white pine forest and plant pitch pine. Fire is possible for pitch pine restoration.

CARTER RESERVE PROPOSED PLAN

TRAIL HEAD SCAVENGER HUNT

An addition to the trail head sign with seed boxes and a weed box encourage and allow people to collect favorable seeds and unfavorable weeds.

Someone else can take the seeds from the boxes and spread them along their walk, or take them home and spread them in their garden. Probably the seeds won't be spread in the right place, and the action of collecting might be mixed and unskillful, but the very practice of looking, practicing and participating with nature, will help people to learn to become stewards of the place. Then, as they learn more, these measure could make marked and important positive changes at scale.


Carter Preserve Trail System
The Nature Conservancy
Seeds
Seeds
Seeds
Seeds
Seeds
Seeds
Seeds
Seeds
Seeds
Seeds
Seeds
Japanese Stiltgrass

JAPANESE STILTGRASS HUNT

Japanese Stiltgrass was accidentally introduced into the U.S. state of Tennessee around 1919 as a result of being used as a packing material in shipments of porcelain from China. Invasion of Stiltgrass can reduce growth and flowering of native species, suppress native plant communities, alter and suppress insect communities, slow plant succession, and alter nutrient cycling. However, removal can lead to recovery of native plant communities.

It is very easy to pull and can identified with a handout. People can pull them on their walks through the preserve and not only support more biodiverse growth but encourage close observation of the natural world. By looking at the leaves they will see other plants, and may grow more observant of the diverse and beautiful plants around them.

Plant propagation is not always an additive process. Sometimes plants can be subtracted and edited in order to encourage more growth.

street

SOUTHWEST PROVIDENCE POTENTIAL PARTNERS AND LEADERS

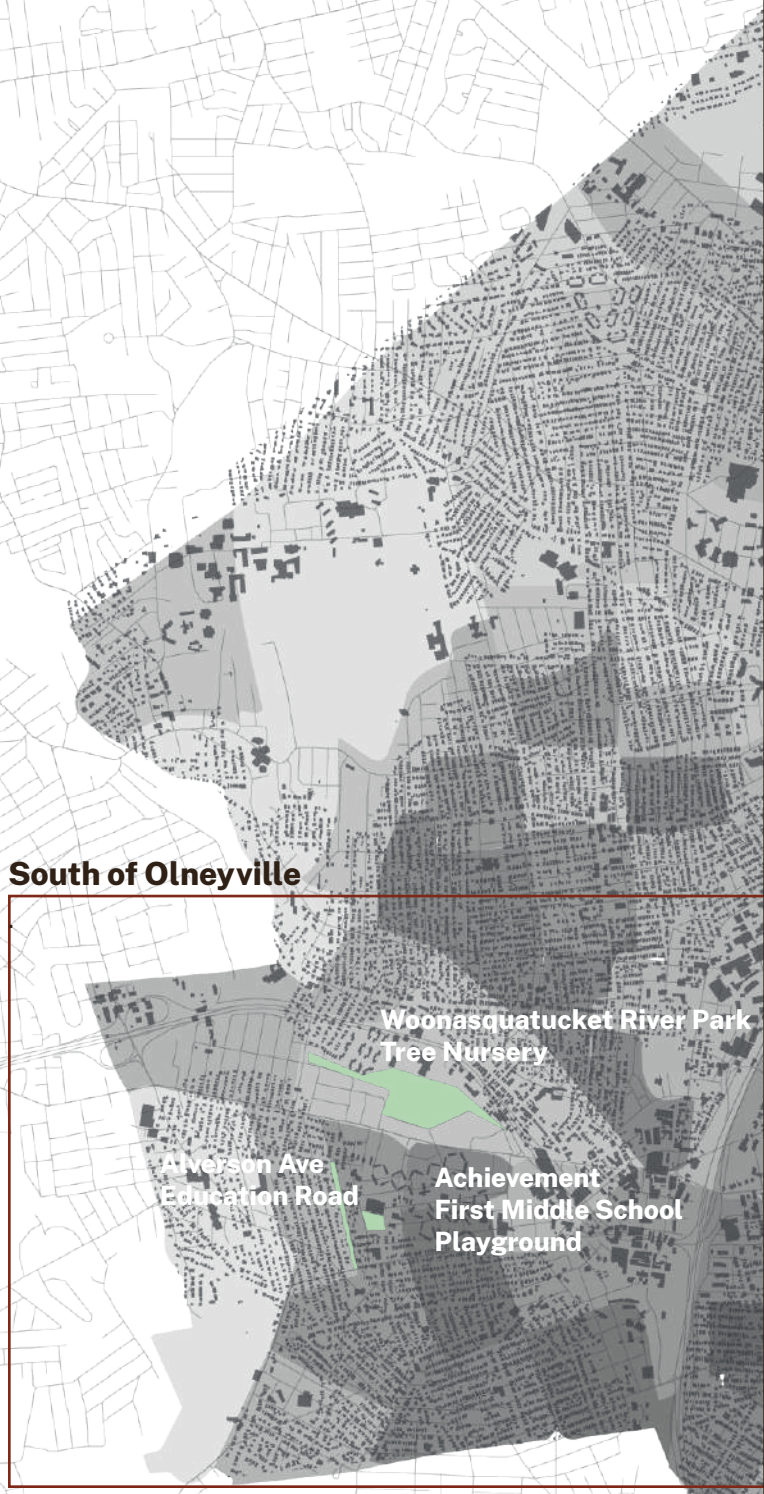
From the iTree Map, this is an overlay of canopy coverage, poverty rates, and population diversity, that prioritizes areas for planting.

South Providence shows the strongest correlation of need. Just south of Olneyville, a new greenway for the bikepath along the Woonasquatucket River has large open grassy fields. Nearby, a charter school has a large empty lawn, and two streets over, a street is planted only with Ash trees.

SOUTHWEST PROVIDENCE

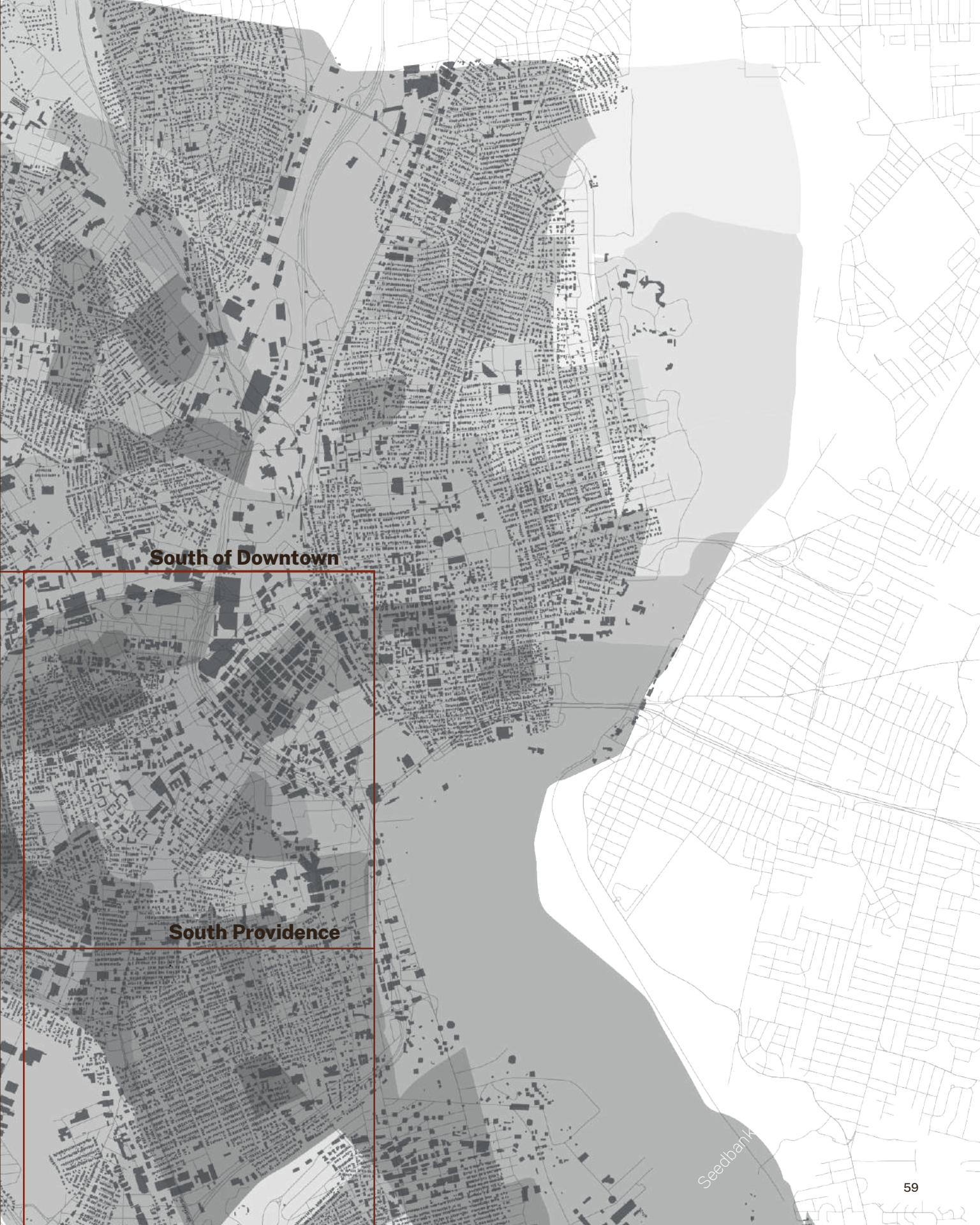
From the iTree Map, this is an overlay of canopy coverage, poverty rates, and population diversity, that prioritizes areas for planting.

South Providence shows the strongest correlation of need. Just south of Olneyville, a new greenway for the bikepath along the Woonasquatucket River has large open grassy fields. Nearby, a charter school has a large empty lawn, and two streets over, a street is planted only with Ash trees.



Priority areas

Priority areas by canopy, poverty, and diversity


South of Downtown
South Providence
Seedbank

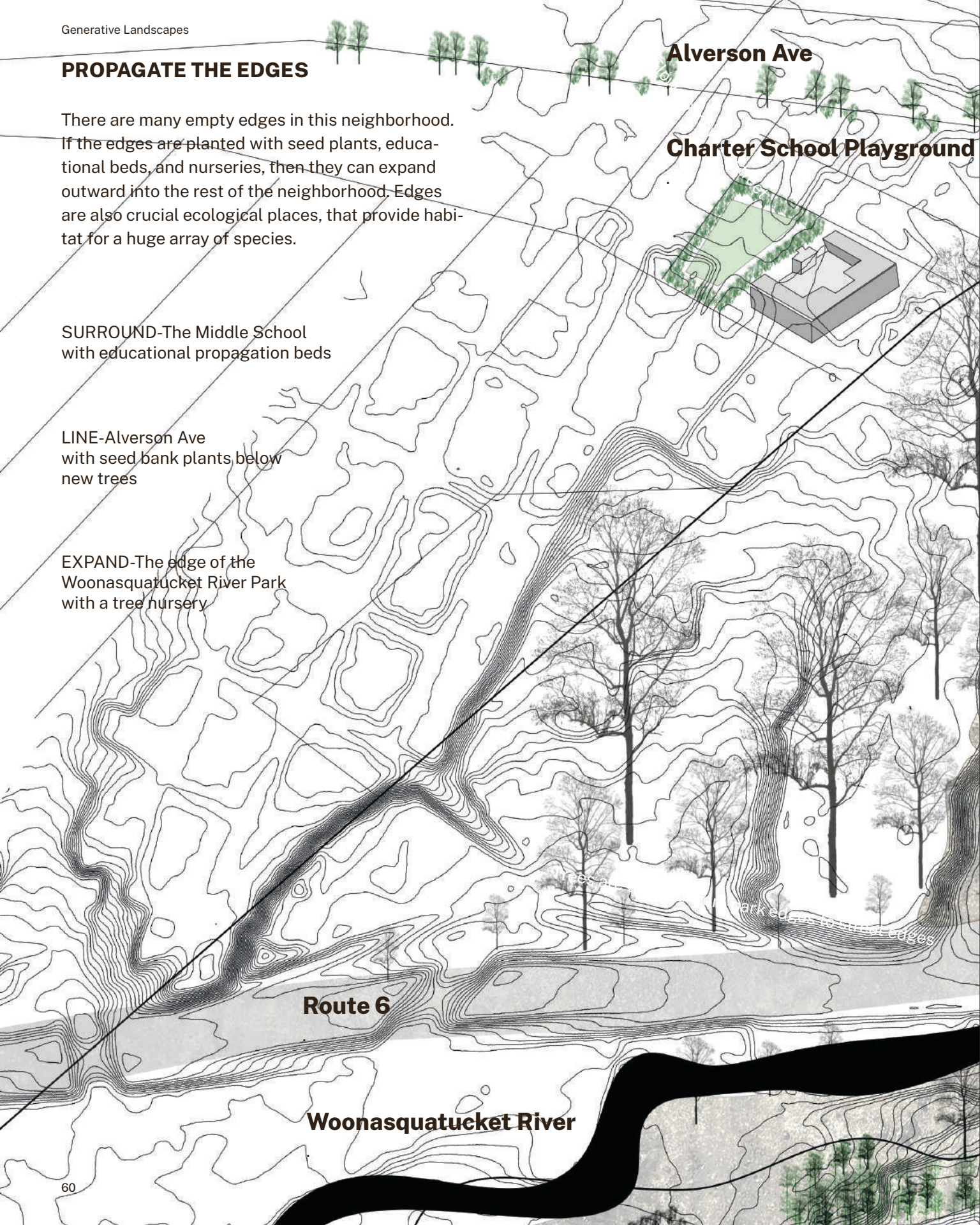
PROPAGATE THE EDGES

There are many empty edges in this neighborhood. If the edges are planted with seed plants, educational beds, and nurseries, then they can expand outward into the rest of the neighborhood. Edges are also crucial ecological places, that provide habitat for a huge array of species.

SURROUND-The Middle School
with educational propagation beds

LINE-Alverson Ave
with seed bank plants below
new trees

EXPAND-The edge of the
Woonasquatucket River Park
with a tree nursery

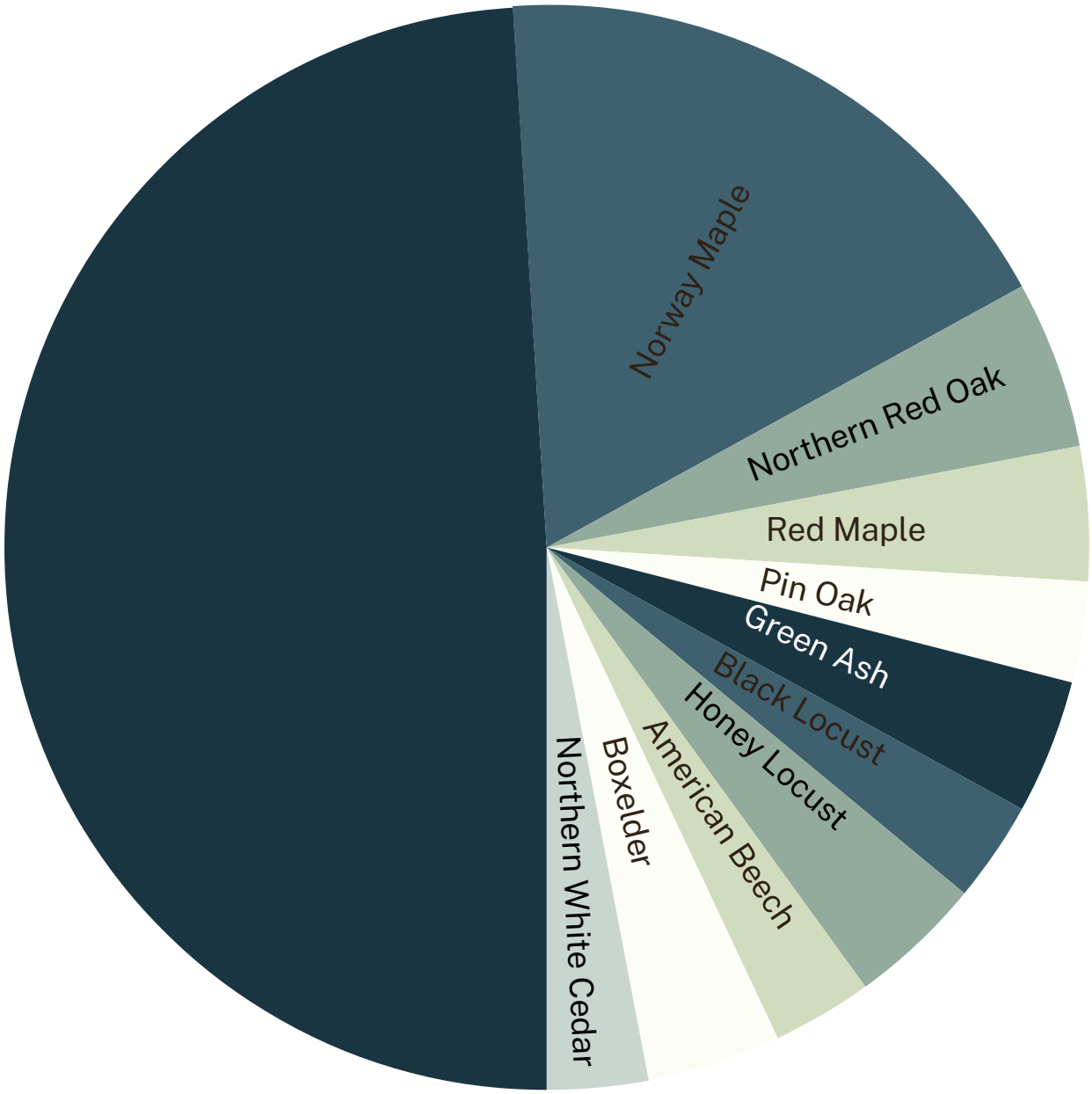



Woonasquatucket
River Park

PROVIDENCE TREE CANOPY

FACTS:
Number of trees: 415,000, or 34.4 trees per acre
Tree cover: 23.9%
Structural values: $582 million
Most common species: Norway maple, Northern red oak, Honeylocust
Percentage of trees less than 6” (15.2 cm) diameter: 49.6%
Ground Cover: 59% impermeable vs. 41% permeable

TREE SPECIES IN PROVIDENCE



INTERVIEW WITH CITY FORESTER
Doug Still

What are you most concerned about?
Emerald Ash Borer

Where do Providence's trees come from?
Northborough Bigelow Trees, all their whips come from Oregon, are potted and grown for a year at Bigelow and then we buy them.

Why potted?
It's easier for volunteers.

Why doesn't Providence have it's own nursery?
They tried, not enough staff, expertise, or money. Plus the liability of having so much money exposed to the weather.

How far apart do you plant trees?
25' for shade trees.

How large are the tree pits?
4x6' minimum preferably 5 x 10' but PNPP can't afford to cut to 10.'

Why are there some places with strips and some with pits in providence?
Seemingly, Public Works has been mostly switching to strips in the last 10 years.

What are you doing to increase the equitable distribution of canopy in Providence?
The "Opt-Out program" People get a tree unless they opt out.

What other challenges are there to increasing the canopy?
College student vandalism around Providence College, lack of watering.

“THE PROBLEM IS NOT GETTING ENOUGH TREES PLANTED, IT’S GETTING THEM TO SURVIVE.”

PROVIDENCE NEIGHBORHOOD PLANTING PROGRAM

PNPP is the city's main way of planting trees. It is a public/private partnership with an endowment from the Mary Elizabeth Sharpe Foundation. They usually plant around 500 street trees a year through neighborhood applications. Five people in the neighborhood have to agree to plant and take care of the trees and they get the trees for free. They usually plant on Saturdays and PNPP staff do a demonstration.


AXTERS
TRUCK & AUTO
REPAIR

EMERALD ASH BORER

The emerald ash borer is projected to kill most if not all of the 15,909 ash trees in Providence very soon. This is an apt analogy for how the city will deal with climate change induced condition changes and loss in the future.

One particular street, Alverson Ave, has only Ash trees and the sidewalks are due for replacement. I propose that this street act as an experiment and typology for a new way of planting.

The dead ash is difficult to dispose of because it cannot be spread out of the area for fear of increasing the spread of the infestation.

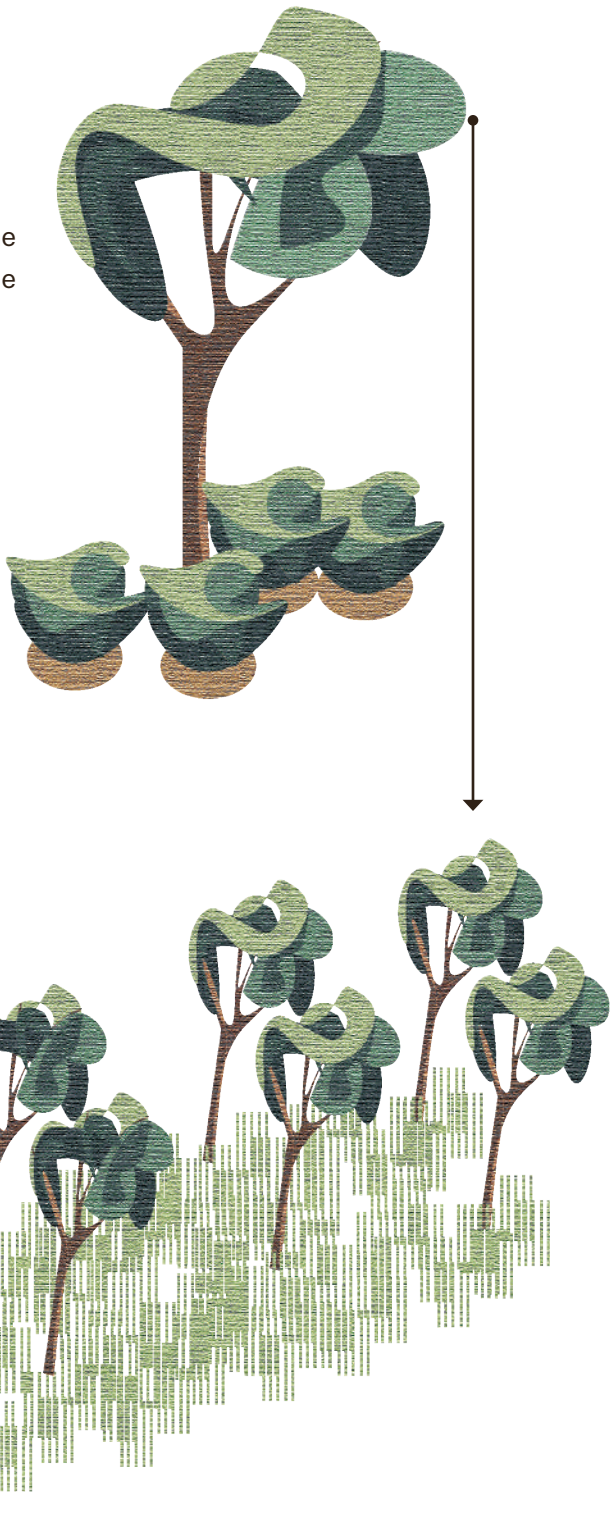
Doug Still mentioned that not only will the city have to deal with replanting the streets but there are other problems:

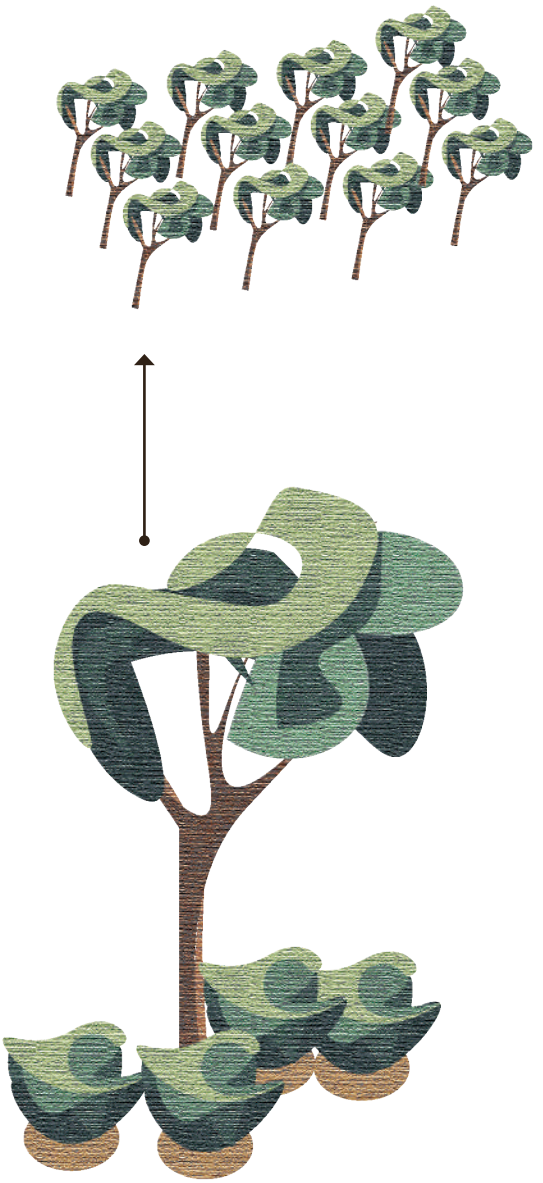
1. The city cannot afford to take out all the trees immediately.
2. Many of the sidewalks are too narrow to allow for replanting, (They need 7'.)
3. They only have a very small amount of inoculant to treat some of the trees.

STRATEGY 2: SUCCESSIVE PRODUCTION

Street tree beds can be used as seed banks in successional systems. Grass and perennial seeds can be collected and spread into another bed in the fall. Tree seeds can be collected and brought to the nursery. In this way people can participate in the successional cycle of plants and trees in order to help them adapt to the place and the changing climate.

With each generation, the plants may be more resilient. And with each planting, people will learn more about how to plant in their place, therefore growing both plants and education.





HOW SHOULD WE PLANT OUR STREETS IN RESPONSE TO CLIMATE CHANGE?

1. While the canopy is crucially important to the result of an urban forest, we actually need to focus from the bottom.

2. While a tree only performs it's typically cited functions when growing, we also need to consider it's death and reproduction

3. We need to be far more specific about what we plant and why as we learn more about habitats, pollution, water management and hardiness in climate change.

WE ARE RAPIDLY LOSING OUR URBAN FORESTS

In a 2018 USFS study almost all states have reported forest decline and the most significant loss was in urban areas. In the past five years, urban areas have lost an average of 1% of their canopy. Rhode Island reported the third most severe loss, with .4% per year or about double the average.[1]

The problem lies less in planting than in maintenance. Mark Buscaino of Casey Trees says there were 90,000 street trees in Washington D.C. in 2000 making up a 35% canopy. They have been planting 13,000 trees each year since then, and the canopy has remained at 35%, a rare net eveness when most cities are in sharp decline.[2]

Political campaigns to plant trees like Boston's then-Mayor Thomas Menin's ambition to plan 100,000 new trees by 2020 may not take into consideration the maintenance and especially watering of those trees. [3]

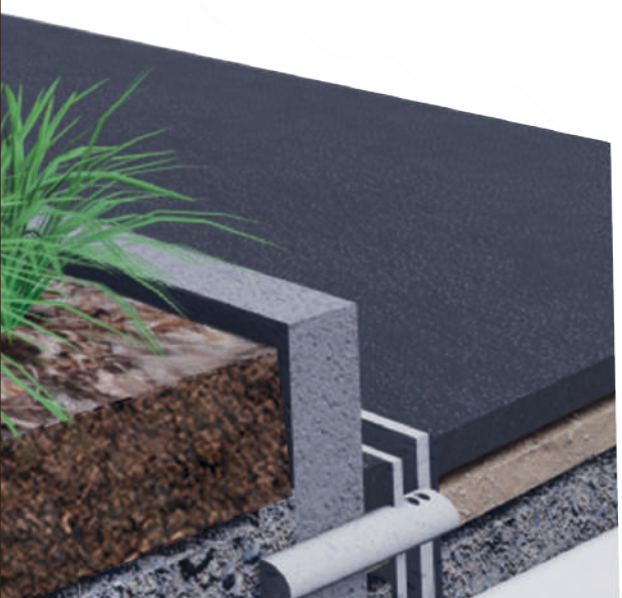
Trees behave differently in urban stress. In general, street trees grow up to 4 times faster than rural trees because of the carbon dioxide and nitrogen in the air.[4] And there is evidence that street trees are reacting to the stress of urban life by releasing more VOC's into the air. [5]

1 Nowak, David J., and Eric J. Greenfield. "Declining urban and community tree cover in the United States." Urban forestry & urban greening 32 (2018): 32-55.
2 Jonnes, Jill. Urban forests: A natural history of trees and people in the American cityscape. Penguin, 2017. Page 344.
3 https://www.bostonglobe.com/ideas/2019/08/16/urban-forests-are-crucial-for-combating-climate-change-but-planting-more-trees-easier-said-than-done/Tu48O-ZUMQnjy0RR8CBma4K/story.html
4https://www.bostonglobe.com/ideas/2019/08/16/urban-forests-are-crucial-for-combating-climate-change-but-planting-more-trees-easier-said-than-done/Tu48O-ZUMQnjy0RR8CBma4K/story.html
5 https://www.irishtimes.com/news/science/the-city-trees-that-pose-a-threat-to-human-health-1.2548050


Gather
Weed
Germinate
Water

ACCESSIBLE GARDEN BEDS

Garden beds with pressed seeds, weeds, and starts will help people to participate in gardening without any experience. The frame of the bed will focus attention on where to look and the instructions will encourage seasonal propagation techniques for communities to grow their canopy, biodiversity, and climate resilience.



INHABITABLE

Depending on the width of the sidewalk the space can be inhabitable to encourage observation. Even those participants who do not actively weed or water can be observers and learners of the cycles of plant life and successions.

ALL AGES

Lower bars allow people who have trouble bending down to kneel and access the beds. Seats allow people to participate without having to move or stand, and therefore older residents can participate with students who are doing plant projects and seed bombs.

PLANTING GROUPS

SOIL BUILDING

The soil in cities is compacted and nutrient deprived and therefore does not hold water well or feed the plants. Soil builders, borrowed from agriculture and hardy, urban species, could help!

Choose 1 of each

Legume ———

Composite ———————

Grass ———————————

Nitrogen Fixing ———

Soil Loosening ———————

Carbon Adding ———————————

Achillea milefolium

Festuca rubra

Trifolium incarnatum

BEAUTY

Choose 1 of each

Spring _____

Summer _____

Fall _____

People are more likely to take care of plants if they are beautiful. Therefore the beautiful plants are not just there for themselves but for all the trees, the soil builders and the habitat builders.

Low Water _____

Easily Re-seedable _____

Stress-tolerant _____

Grape Hyacinth _____

Rudbeckia hirta _____

Cosmos _____

HABITAT VALUE

Plants do not live in isolation from the rest of the natural world. Therefore pollinator and habitat building plants are essential for the adaptation and resilience of the community.

Butterflies

Birds

Pollinaters


Asclepias tuberosa
Schizachyrium scoparium
Solidago nemoralis

schoolyard

EDUCATION-SEEING PLANTS AS LIVING BEINGS

Educational programming at the school can correlate with the life cycles of plants. Beginning in Pre-K and continuing through middle school, science curriculum can line up with experiential propagation. Then as adults, people can continue to learn and contribute in the community.

SEED KIDS

MAKING SEED BOMBS
TOSSING GAME
MAKING SEED INTO BREAD

STARTS

MEASURING
THINNING
DESIGNING

BLOOMS

COUNTING POLLINATORS
LEARNING ABOUT REPRODUCTION
GIVING FLOWER PRESENTS

FRUITS

COLLECTING FRUITS
CLEANING SEED
TEACHING THE SEED KIDS

SEED BOMBS
Seed bomb materials tests made from pulped paper, mycelium, peat, soil and seeds.

SEED BOMBS

INGREDIENTS:
Paper, peat, soil, mycelium, and seeds.

INSTRUCTIONS:
Pulp the paper, then combine half paper with half soil and roll together with seeds in palms. Squeezing out water and adding more soil as necessary. Then lay out in the sun to dry.

PAPER

PAPER AND SOIL

PAPER, SOIL, PEAT

PAPER, PEAT

SOIL,

PLAYGROUND

Markers help to divide counting and measure in seed tossing game.

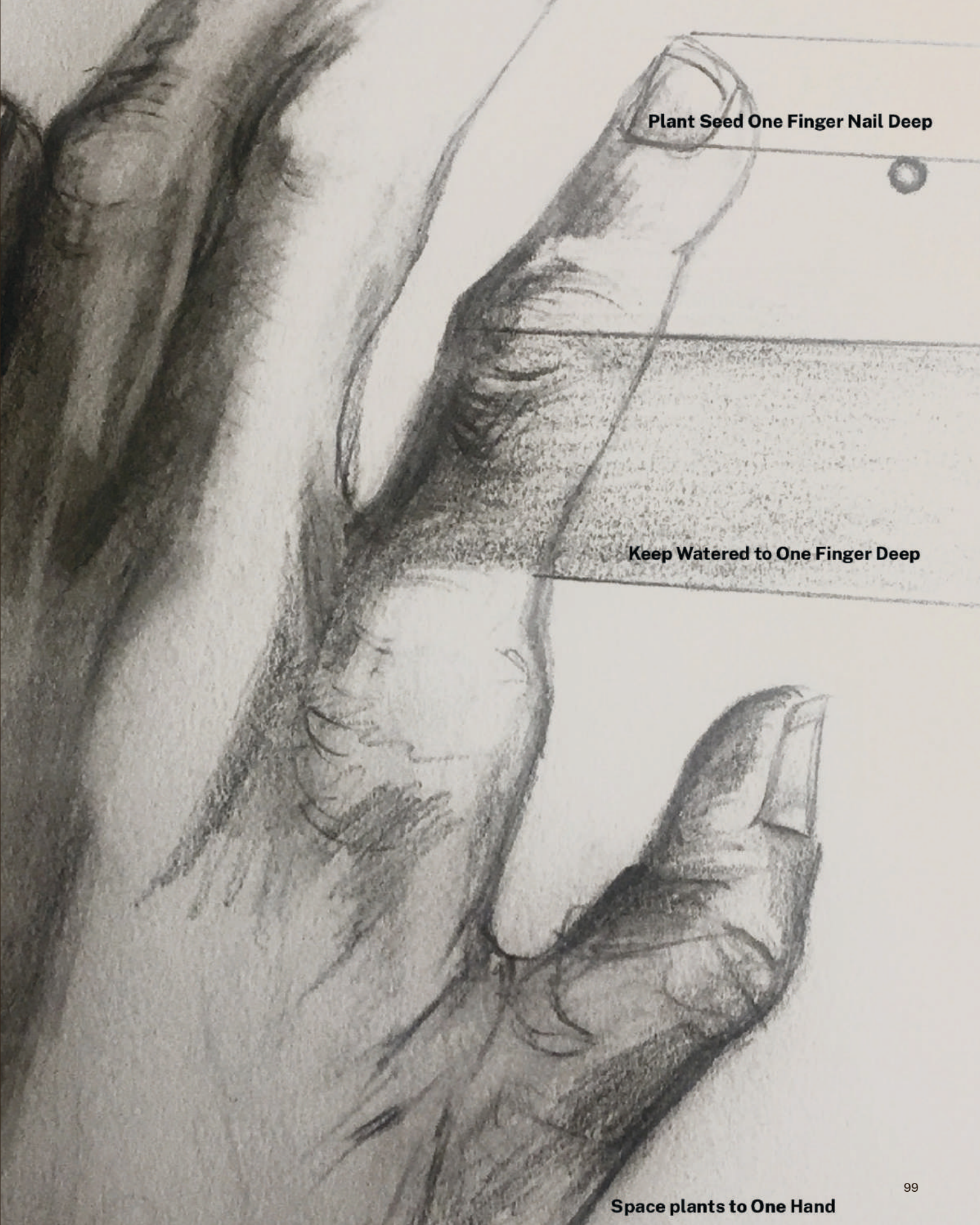

Seed Bomb Tossing
Plants are thinned and grow up to have pollinators counted and seeds collected.


Markers help connect schoolyard technique to tree nursery

riverside park

THE BODY AS MEASURING TOOL AND METAPHOR

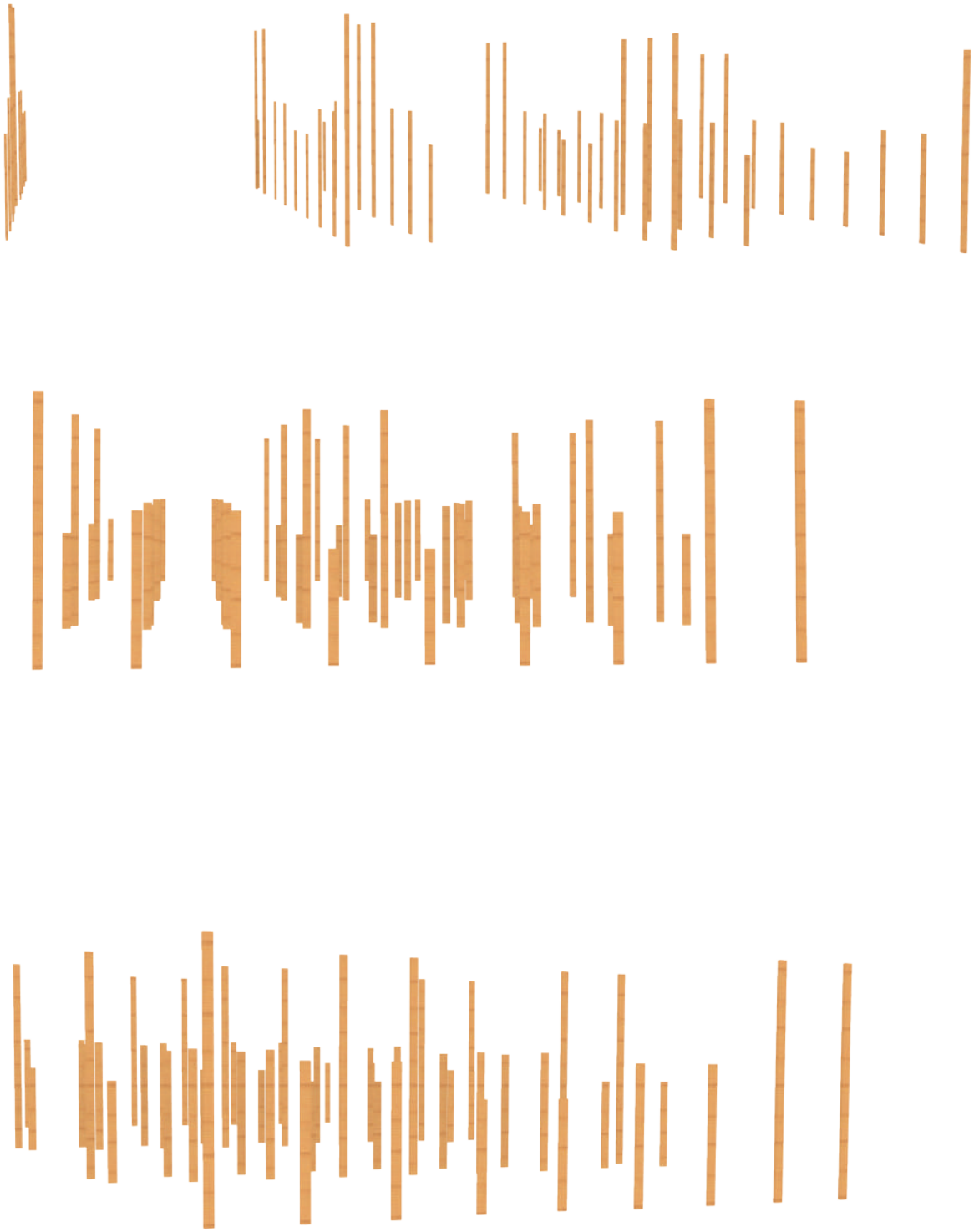
Our bodies are our best metaphor for understanding life and natural processes. From an easy way to teach gardening to a way to see ourselves in relation to the growing, cycling and changing world.


Plant Seed One Finger Nail Deep
Keep Watered to One Finger Deep
Space plants to One Hand

MARKERS

Marking posts next to the seedling trees in the nursery can both support the trees and mark the perspective of the participant. Set up to correspond with the thinning process, the tallest posts will have the tallest trees.

Upon each post the child who planted the tree will inscribe their name and height and the height of the tree. The post will then follow the tree wherever it goes, forever showing the change in human-natural growth and life.



LEARNING EMBODIED

By seeing the changes in the tree, and growing up themselves, young people will see the trees not just as objects but as living, breathing, lives.


Emily W
Cole

MOVEMENT

The nursery will be a moving place but it is perfectly located in a place where people typically move through it quickly on bi-cycles. This makes it more likely that the trees won't be harmed, and the markers can be experienced in quick time while the nursery grows in slow time.

CLIMATE-MINDFUL TREE SPECIES

While planting to improve soil, pollination, and watering, we must also propagate trees specific to climate change.

Plants are the primary source of VOC's that combine with NO2 to create Ozone. But they release them to different degrees. Species selection could make an enormous difference in our ozone pollution.

PLANT LOW POLLUTION TREES

Tree species rating high for reducing air pollution

Source: Nowak 2000.

English elm (Ulmus procera)

American basswood (Tilia americana)

Lime/linden* (Tilia europea, T. euchlora, T. cordata, T. platyphylios, T. tomentosa)

Tulip tree+ (Liriodendron tulipifera)

Dawn redwood (Metasequoia glyptostroboides)

Maidenhair tree * (Ginkgo biloba)

American sycamore + (Platanus occidentalis)

Sugarberry/Mississippi hackberry (Celtis larvigata)

Common ash/European ash (Fraxinus excelsior)

Black birch/river birch (Betula nigra)

Species that do not emit the VOC isoprene

Source: Russel Monson, pers. comm.

Pines+ (Pinus spp.)

Firs (Abies spp.)

Hickory (Carya spp.)

Maple* (Acer spp.)

Most grasses

Most herbaceous crops & natives

*Species (or genus with species) with a tolerance to ozone, as identified by Appleton et al. (2000)

+Species (or genus with species) that show a sensitivity to ozone, as identified by Appleton et al. (2000).

AVOID HIGH POLLUTION TREES

Species prone to emitting the VOC isoprene

Source: Russell Monson, pers. comm.

Eucalyptus (Eucalyptus spp.)

Oaks*+ (Quercus spp.)

Poplars (Populus spp.)

Sycamore (Platanus spp.)

Sweetgum (Liquidambar spp.)

Spruce (Picea spp.)

Most tropical trees

Bamboo, a tropical grass

THE DOING

"We must cultivate our garden" (Candide, 74)

This project began with an interest in plant nurseries. In the way plants are produced to build and transition landscapes, especially in the context of climate change. But climate change is tremendously uncertain. It became obvious that the scale of the issue could not be solved with a market that is so focused on profit, without confidence in which plants to grow. We need to begin experimenting with and adapting plants to help us hedge against species loss. It became clear in the forest context that through successional planting and other strategies, these experiments and adaptations could be done rather simply. But it had to be done by many more people than foresters and scientists in order to meet the scale of the problem and specificities of microclimates. So the design problem became how to create accessible, fun, educational ways for anyone to participate in the process of future landscape propagation?

Once communities became an essential force in the propagation plan, the thesis further expanded when looking at priority places. It is impossible to separate urban climate change issues from social equity. While looking for a place to test the thesis I found the widespread correlation between poverty, diversity, canopy coverage, pollution and health that exists in most US cities. In Providence Rhode Island, South Providence has a strong correlation between underserved neighborhoods and poor canopy coverage, so the issues became intertwined.

Designers can create ways so that anyone can participate in the life cycles and reproduction of our environment. Depending on the time and resources people have, everyone can help. While participating in this practice culture will change. We learn differently when we are actively doing something. We value differently when we are caretaking, and we notice differently when we are looking.

Finally, in designing ways for the community to participate, the process raised the question of how we can design care and curiosity so that people will want to take care of plants? The designs seek to empathetically connect the most basic symbol of life, our own bodies, with the life cycles and bodies of plants. For us to take care of the plant world, we need to see the life in it. The historian Michel Foucault wrote about how early modern Europeans stripped plants of their living associations. Plants became parts that could be taken apart and measured. But in our desire to understand and categorize things, we can lose all the qualities that can't be easily measured. Moving into climate change we will need to work with uncertainty and all the moving, changing qualities of life.

Voltaire, who wrote extensively on optimism, social equity, and education, ended his famous book *Candide* with the advise to cultivate our garden. Voltaire believed that we shouldn't accept the world we are given as the best possible of all worlds. With a modern move towards individual agency and humanism, that critique might seem anachronistic, but in writing this thesis I found it everywhere. People often use optimal thinking and assume that nature knows best, and that humans should not intercede. Many assume that capitalist solutions have the best chance of success or that because we have not recently experienced a culture of environmental stewardship that communities can't do it. These do not fit into the contemporary definition of optimism but they fit into Voltaire's definition. We need to shift our culture and thinking away from optimal optimism and into a practice of caretaking, participation, and action in order to move healthfully, diversely, and safely through the coming changes.

ACKNOWLEDGEMENTS

I am so grateful for the people who made writing this a joyful and fun experience. To my classmates, for being the biggest source of inspiration, support and fun, these past three years. To my advisor Colgate Searle, for encouraging me to think more deeply, carefully, and radically and allowing me to find my way to what I believe in. To Ann Kearsley, for understanding and sharing my passions and ethics from the very beginning and giving such exciting feedback. To my friend and classmate, Cornelia Overton, for talking me through many ideas and encouraging me to stand by my beliefs and interests. To my family, for sharing food, encouragement, and patience for three years of grad school.

BIBLIOGRAPHY

"Assisted Migration Adaptation Trial." *https://www2.gov.bc.ca/gov/content/industry/forestry/managing-our-forest-resources/tree-seed/forest-genetics/seed-transfer-climate-change/assisted-migration-adaptation-trial.* Web. 27 April, 2020.

Crawford, Amy. "Urban forests are crucial for combating climate change, but planting more trees is easier said than done." *https://www.bostonglobe.com/ideas/2019/08/16/urban-forests-are-crucial-for-combating-climate-change-but-planting-more-trees-easier-said-than-done/Tu48OZUMQnjy0RR8CBma4K/story.html.* August 16, 2019. Web.

Del Tredici, Peter, and Steward TA Pickett. *Wild urban plants of the northeast: a field guide.* Cornell University Press, 2020.

Ellis, John, 1710?-1776. "Directions for bringing over seeds and plants, from the East Indies and other distant countries, in a state of vegetation." London: Printed and sold by L. Davis, 1770. Dumbarton Oaks.

Foucault, Michel. *The Order Of Things.* Routledge, 2005.

Green Thumbs Nonprofit. "Urban Trees From Seed." Web. https://greenthumbsto.org/2017/11/02/urban-trees-from-seed/ May 1, 2020.

Harvard GSD. "Planting in the Public Realm: Projects and Projections," with Steven Handel, Noel Kingsbury, Norbert Kühn, Doug Reed, and Matthew Urbanski." Lecture: March 7th, 2017. https://www.gsd.harvard.edu/event/planting-in-the-public-realm-projects-and-projections/

Harvey, John. *Early nurserymen: With reprints of documents and lists.* Phillimore, 1974.

Jonnes, Jill. *Urban forests: A natural history of trees and people in the American cityscape.* Penguin, 2017.

Lenart, Melanie. "Urban Forests and Pollution." May 16, 2019. By Climate Woodlands. https://climate-woodlands.extension.org/urban-forests-and-pollution/

Marris, Emma. "Planting the forest of the future: while conservation biologists debate whether to move organisms threatened by the warming climate, one forester in British Columbia is already doing it." Nature 459.7249 (2009): 906-909.

McCargo, Heather. "Hellstrip Plantings: Creating Habitat in the Space Between the Sidewalk and the Curb." Ecological Landscape Alliance: May 15, 2018. Landscape Design, Native Plants. https://www.ecolandscaping.org/05/designing-ecological-landscapes/native-plants/hellstrip-plantings-creating-habitat-in-the-space-between-the-sidewalk-and-the-curb/

Nowak, David J., and Eric J. Greenfield. "Declining urban and community tree cover in the United States."

Urban forestry & urban greening 32 (2018): 32-55.

Telford's Seed Catalogue. "Pompions, English Tobacco, Horn-Poppies and Willow Leav'd Beans." North Yorkshire County Record Office.

Velasquez-Manoff, Moises. "Can Humans Help Trees Outrun Climate Change?" NYTimes. 2019. https://www.nytimes.com/2019/04/25/climate/trees-climate-change.html

Voltaire, Francois. *Candide: Or Optimism*. Penguin Classics Deluxe Edition. Penguin, 2005.

Wilson, Kendra. "DIY: Make Your Own Wildflower Seed Bombs." Gardenista Issue 19 — Spring Makeover. May 16, 2019. https://www.gardenista.com/posts/diy-wildflower-seed-bombs/. Web. May 3, 2020.