WHY YOU SHOULD PARTNER WITH A UNIVERSITY GIS PROGRAM

Greenbelt
Essex County's Land Trust

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Outline

- Program Descriptions
- Example Projects
- Questions
- Student Considerations
- Conclusions & Lessons Learned
- Questions

Clark University Internship Program

Human-Environment Regional Observatory

Engaging Clark Undergraduate Students in Applied Research Projects during Summer and Fall/Spring

Urban Tree Inventory in Pittsfield, MA

Stakeholder Stewardship Assessment in Fall River, MA

Human Environment Regional Observatory

Deborah Martin and John Rogan

1999 Year one (David Angel and BL Turner)

24 Years in operation

185 Undergraduate students mentored

https://www.clarku.edu/departments/hero-program/

Human Environment Regional Observatory HERO Program

HERO students discuss their research with DCR Foresters 2018

HERO students with DCR Forester in Chicopee, MA 2018

Student Engagement

HERO students with DCR Forester in Chicopee, MA
2018

HERO student interviews resident in Worcester, MA
2015

Who we have partnered with

OPACUM LAND TRUST

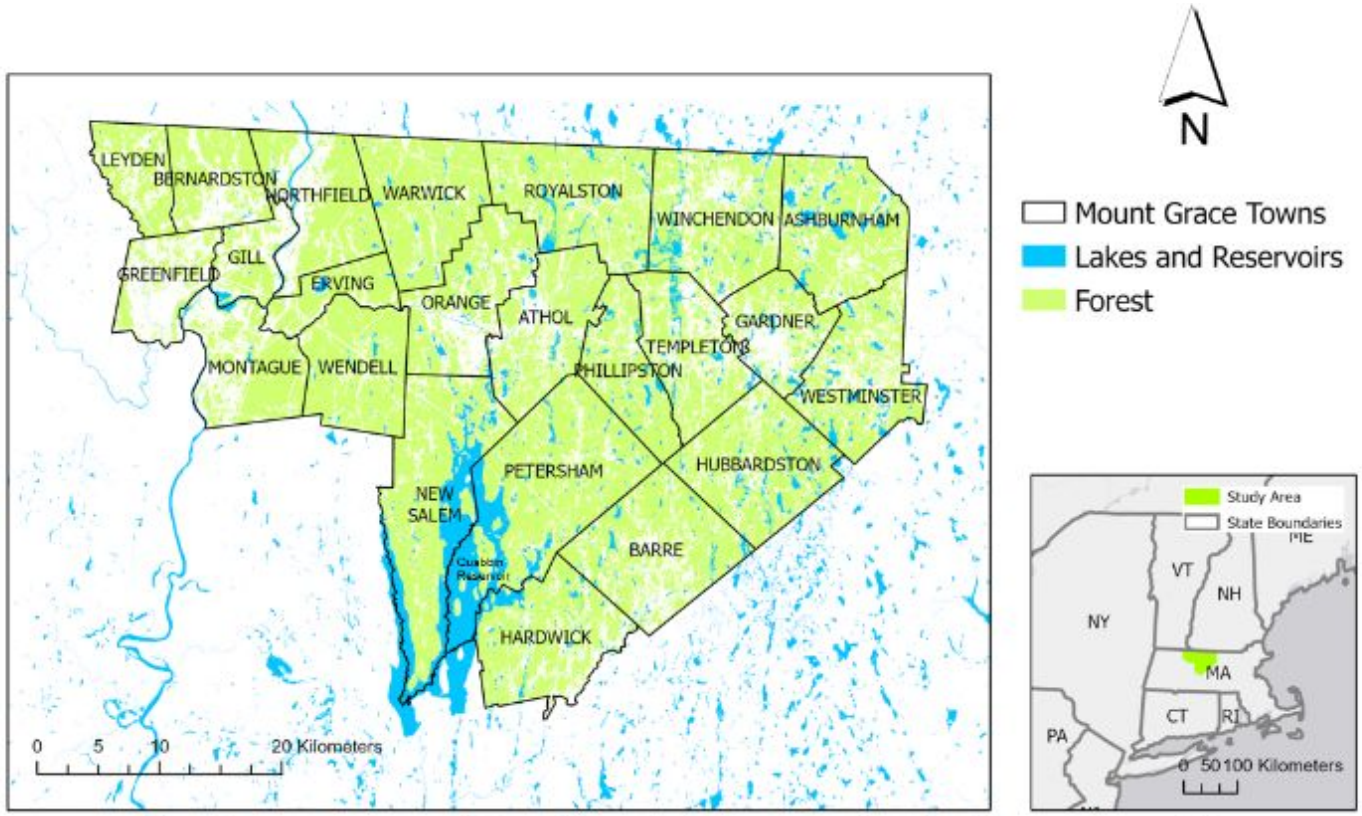
Mount Grace Land Conservation Trust

GWLT

DEPARTMENT OF CONSERVATION AND RECREATION
dcr
Massachusetts

GROUNDWORK
CHANGING PLACES CHANGING LIVES
GROUNDWORK Providence

Characterizing past and future land-use dynamics in the Mount Grace Conservation Area from 1976 to 2020



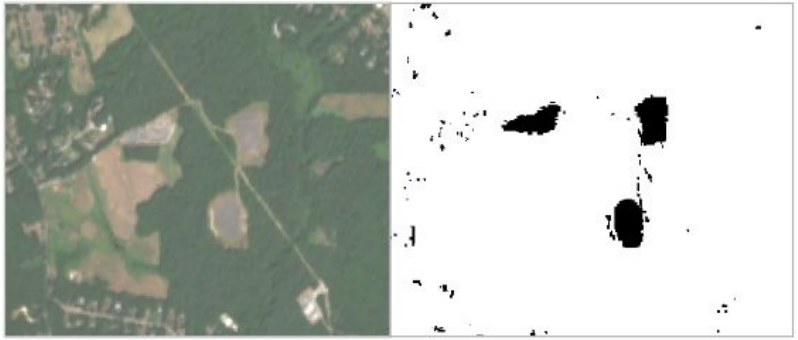
Study area map of the Mount Grace region in Massachusetts

Land area: 510,640 Acres (7.6% of Massachusetts)

Number of Towns: 23

Forest loss to ground solar installations

- Solar panels are detected using Sentinel-2 imagery from the summer of 2022
- Used a Random Forest model to determine solar and non-solar in the landscape
- Polygons for each solar field (a) and the solar field with the surrounding cleared area (b)



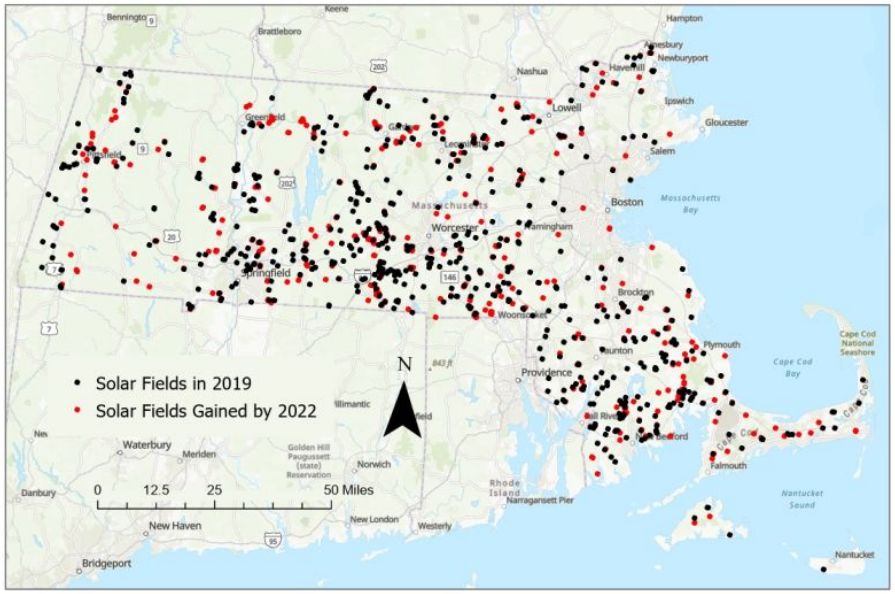
Satellite image of solar panels (left) and the random forest classification (right)

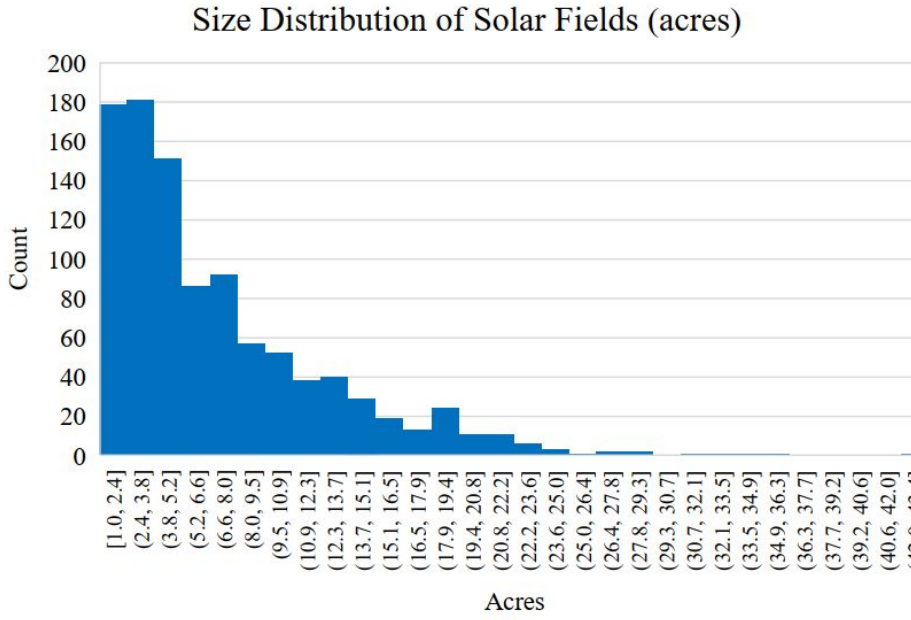
(a) Solar field polygon

(b) Cleared area polygon

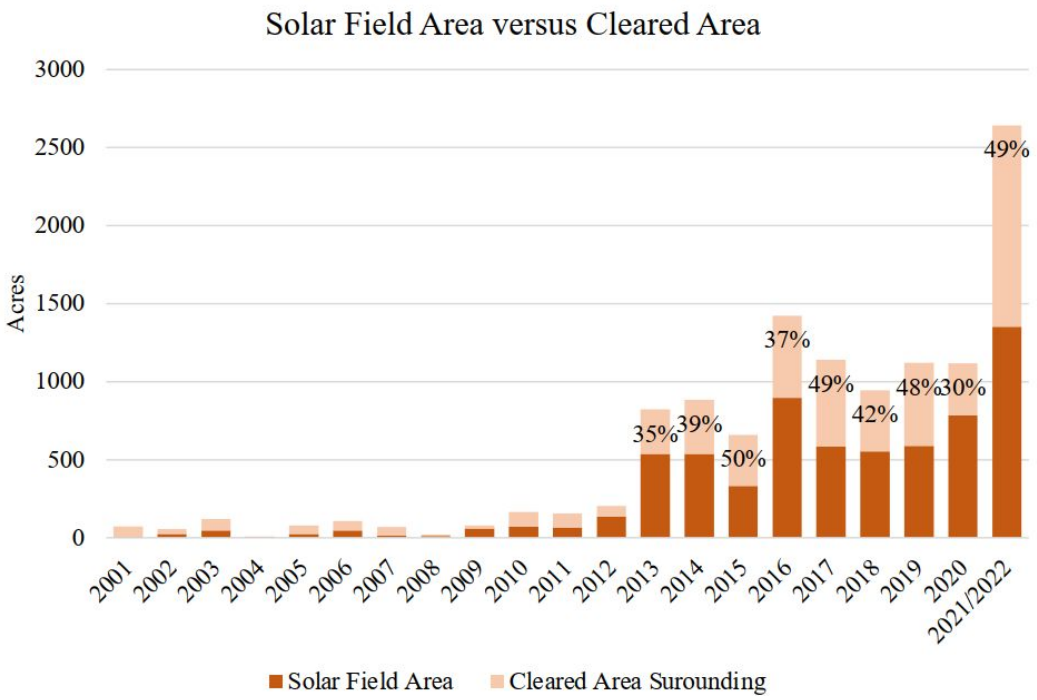
2

- There are approximately **1000** solar installations as of summer 2022 in Massachusetts.
- Between 2019 and 2022, approximately **250** new solar fields were built.



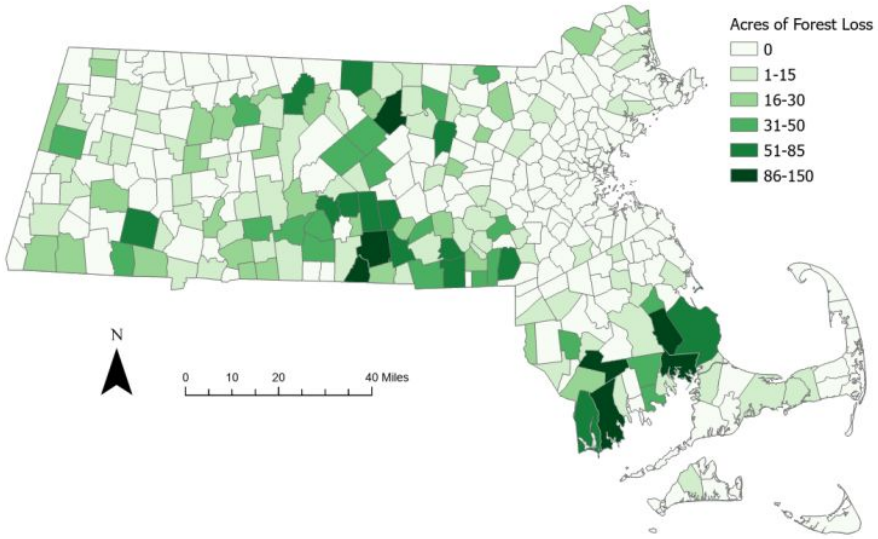


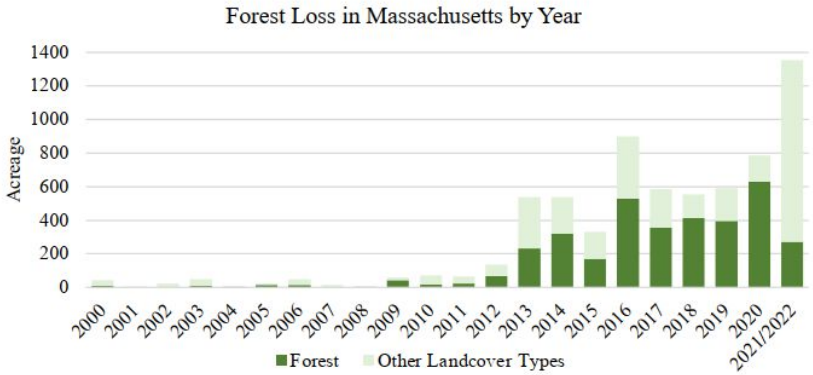
- The solar fields total to **7,000 acres** as of 2022 with a gain of **1,850 acres** since 2019.
- The mean size for solar fields is **5.27 acres** and the median is **5.1 acres**.

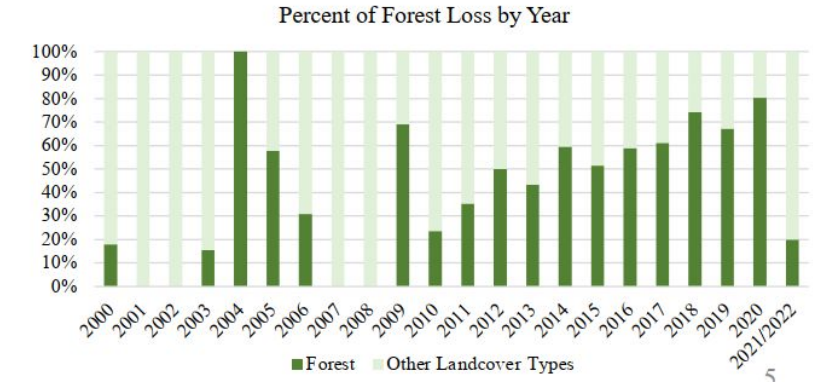


- Solar field installations have been increasing in total acreage since 2013.
- The cleared area surrounding is defined as the mowed area around the panels themselves.
- As seen in the figure to the left, **the cleared area takes up a large portion of the total area covered.**
- Since 2013, the area surrounding solar panels has been **approximately 40%** of the total area taken over by the solar installation.

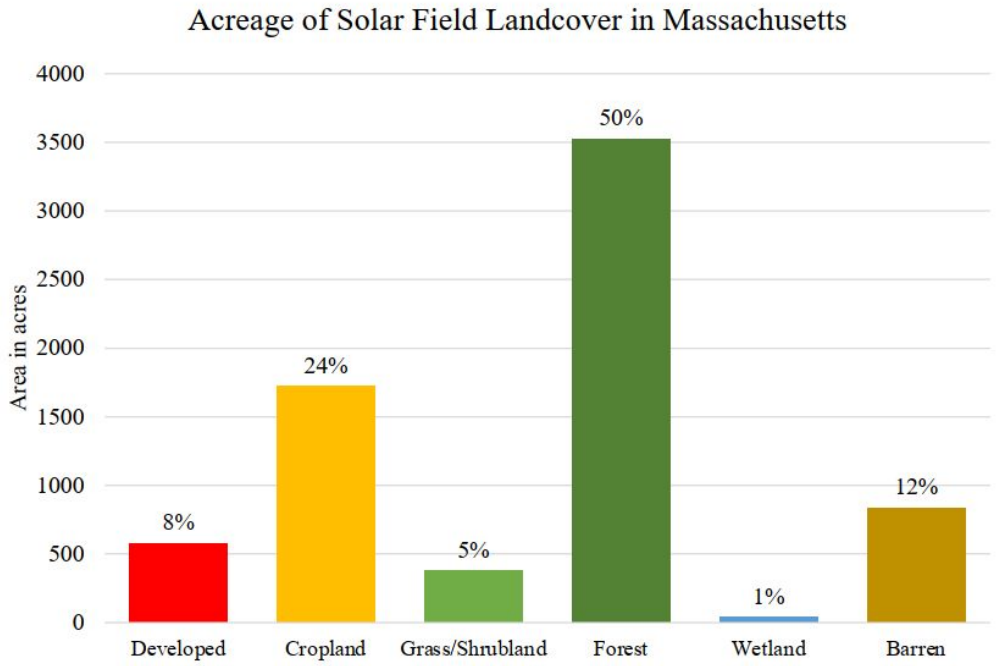
- The charts (right) compare the acreage and percentage of forest loss due to solar compared to the other landcovers each year.
- The map (below) displays the total acreage of forest loss due to solar in each town.



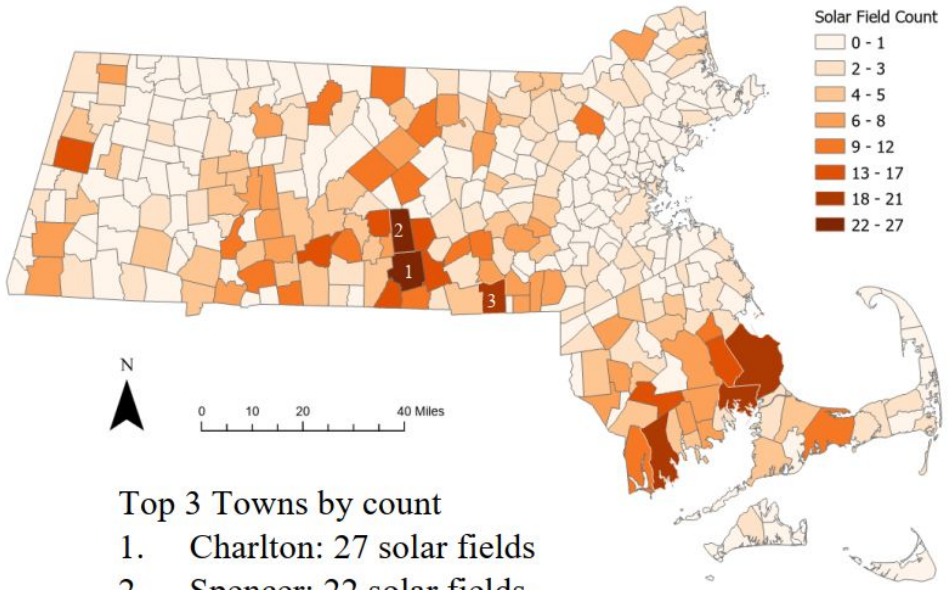




- Baseline landcover maps were used to establish the land cover type prior to the solar installation.
- Solar fields have predominately taken over forested regions of the state at approximately **50% of the total landcover and 3500 acres**.
- Cropland and pastures are the second most abundant land cover class at **24% and 1700 acres**.
- Finally, barren or dirt ground is the third most abundant land cover class at **11% and 830 acres**.



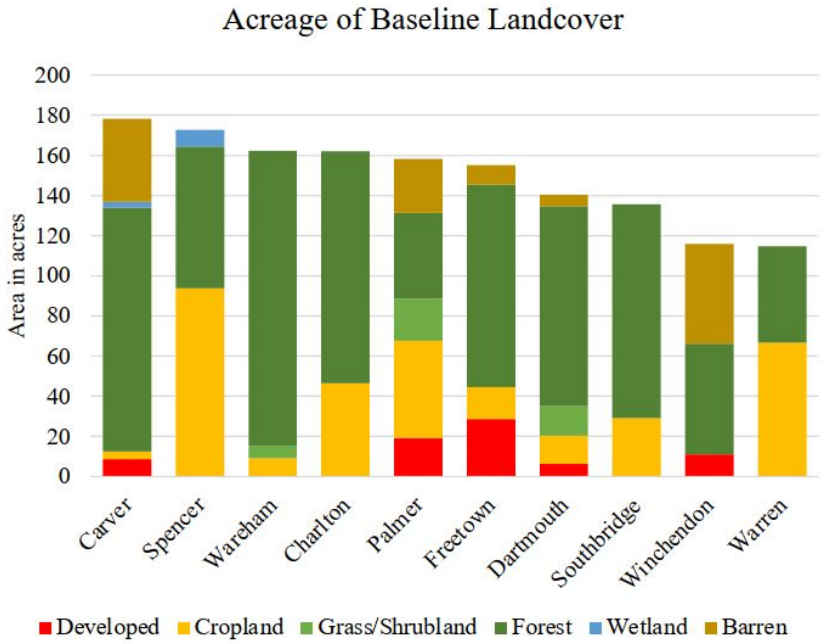
Distribution of solar fields by town



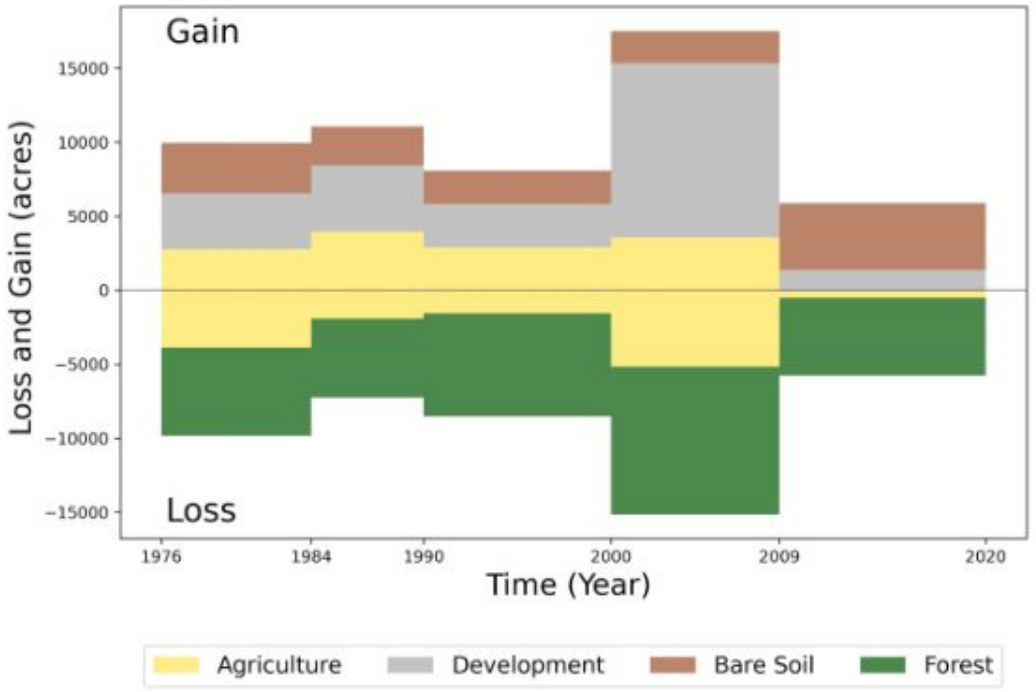
Top 3 Towns by count

1. Charlton: 27 solar fields
2. Spencer: 22 solar fields
3. Uxbridge: 21 solar fields

Top 10 Towns



Land cover change gains and losses (1976-2020)



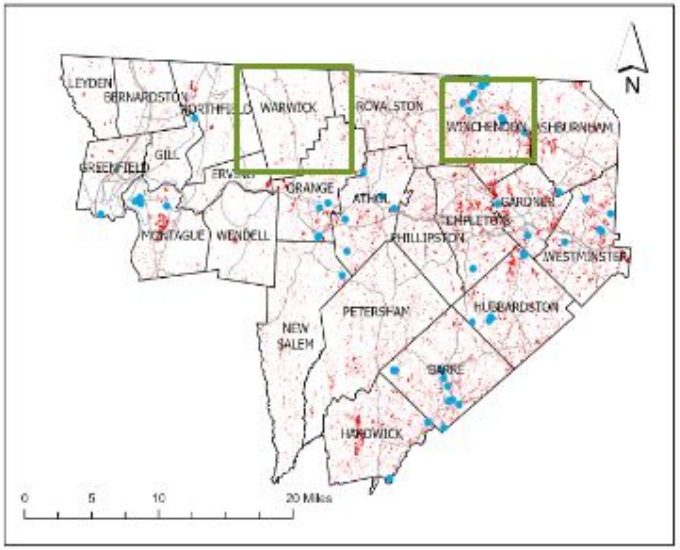
Total area of development gain: 24339 acres

Total proportion of development gain: 75.7%

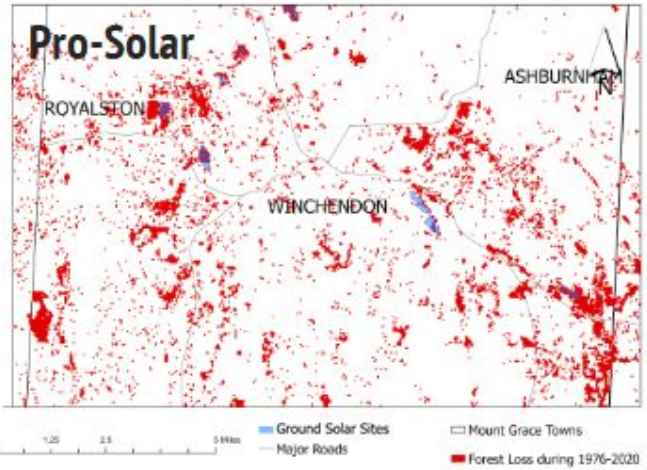
Annual area of development gain: 553.2 acres (419 football fields per year)

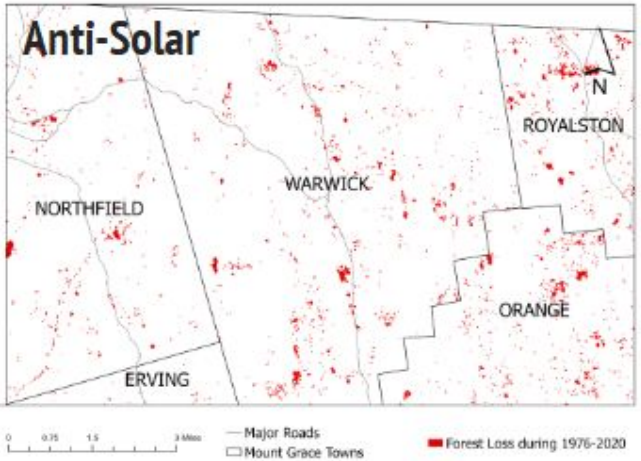
[6]

Forest loss to ground solar installation



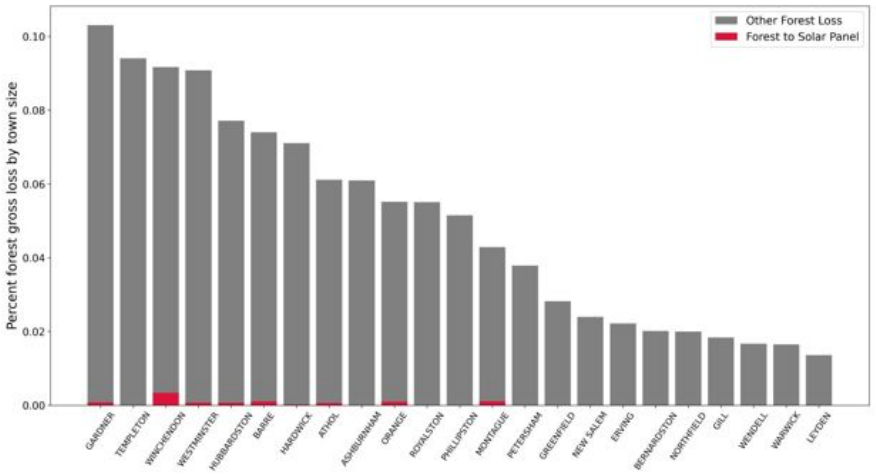
Forest Loss during 1976-2020
Major Roads
Ground Solar Sites





Forest loss to ground solar installations

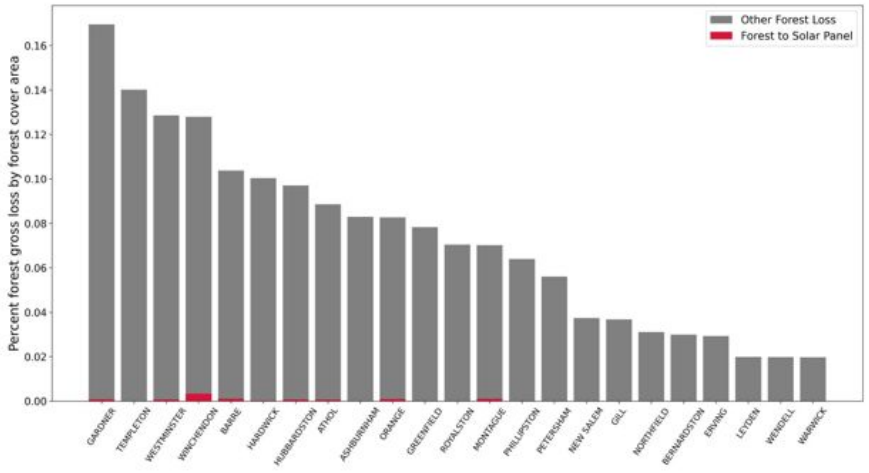
Percent forest loss by town



Top four towns with forest loss to solar:

1. Winchendon
2. Barre
3. Montague
4. Orange

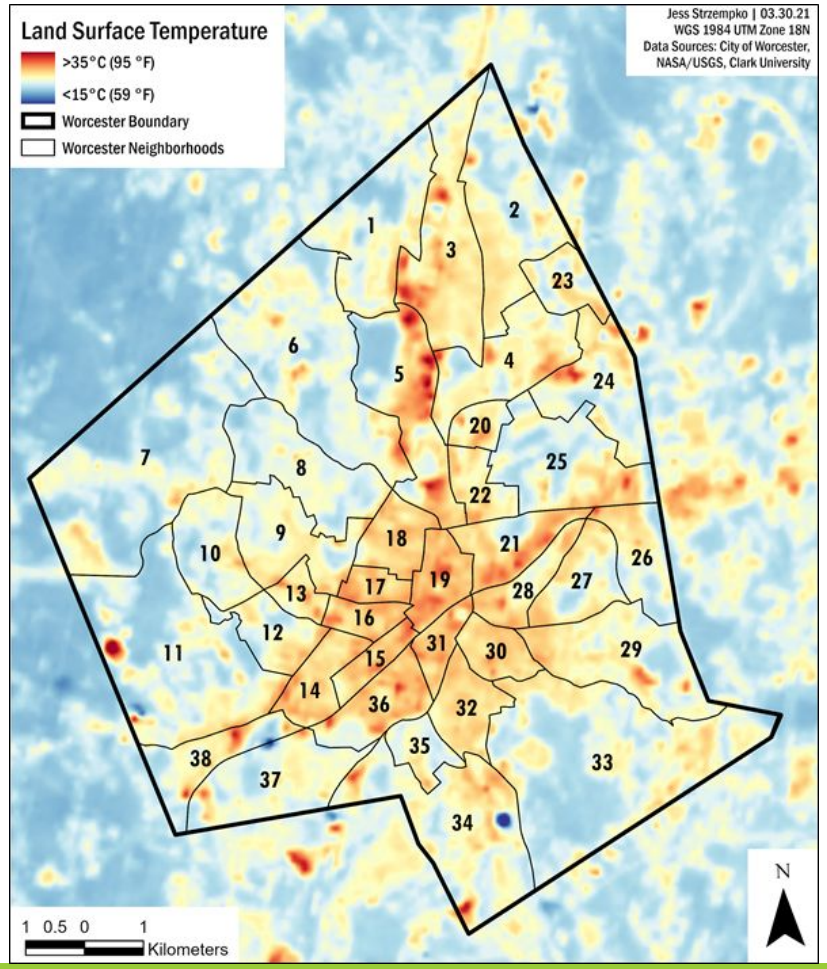
Percent forest loss by forest area in a town



Lowest four towns with forest loss to solar:

1. Leyden
2. Warwick
3. Wendell
4. Gill

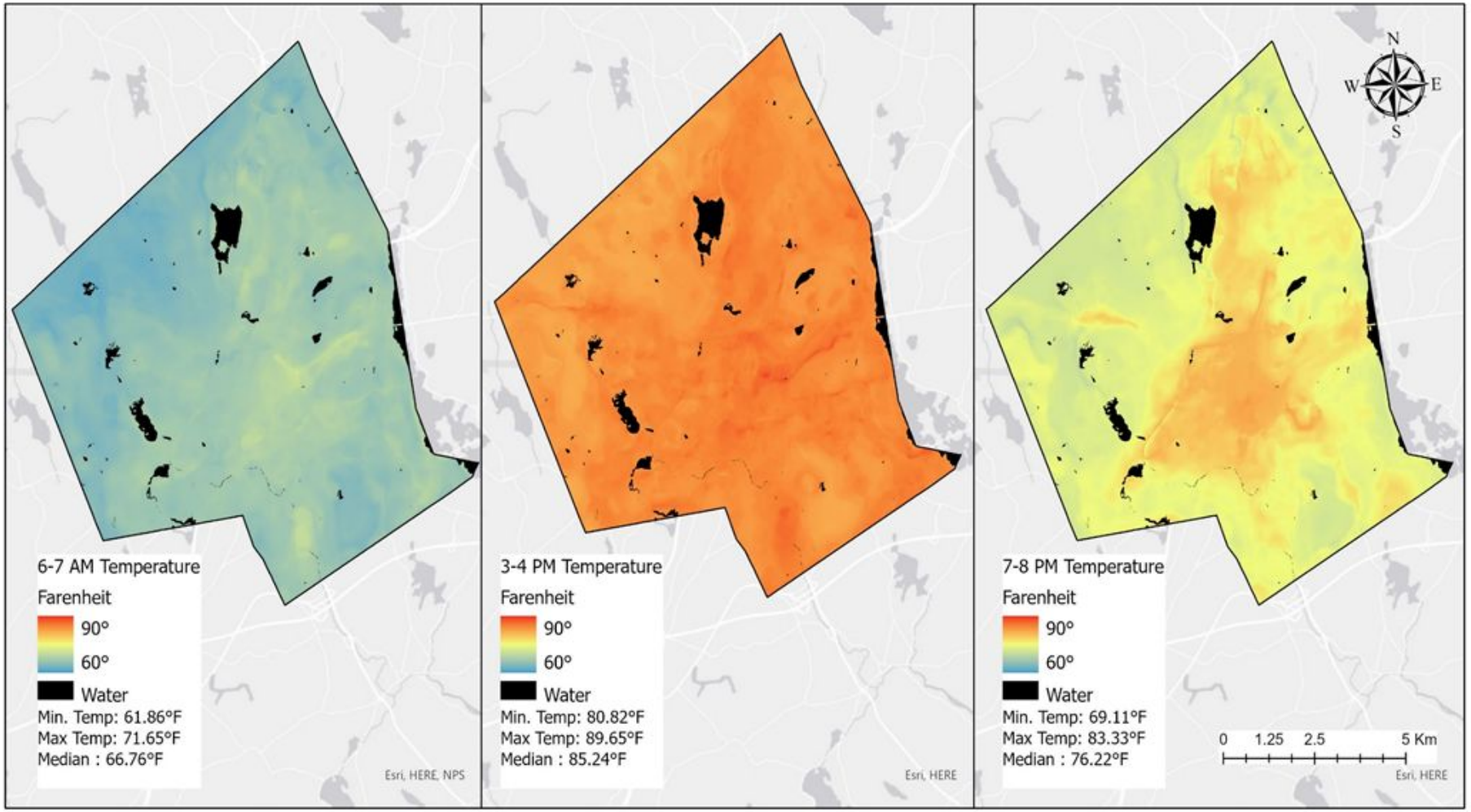
Examining urban tree planting efforts to mitigate heat island impacts and foster more resilient and equitable cities in Massachusetts



Temperature Distribution
6-7 AM during August 20th, 2019

Temperature Distribution
3-4 PM during August 20th, 2019

Temperature Distribution
7-8 PM during August 20th, 2019

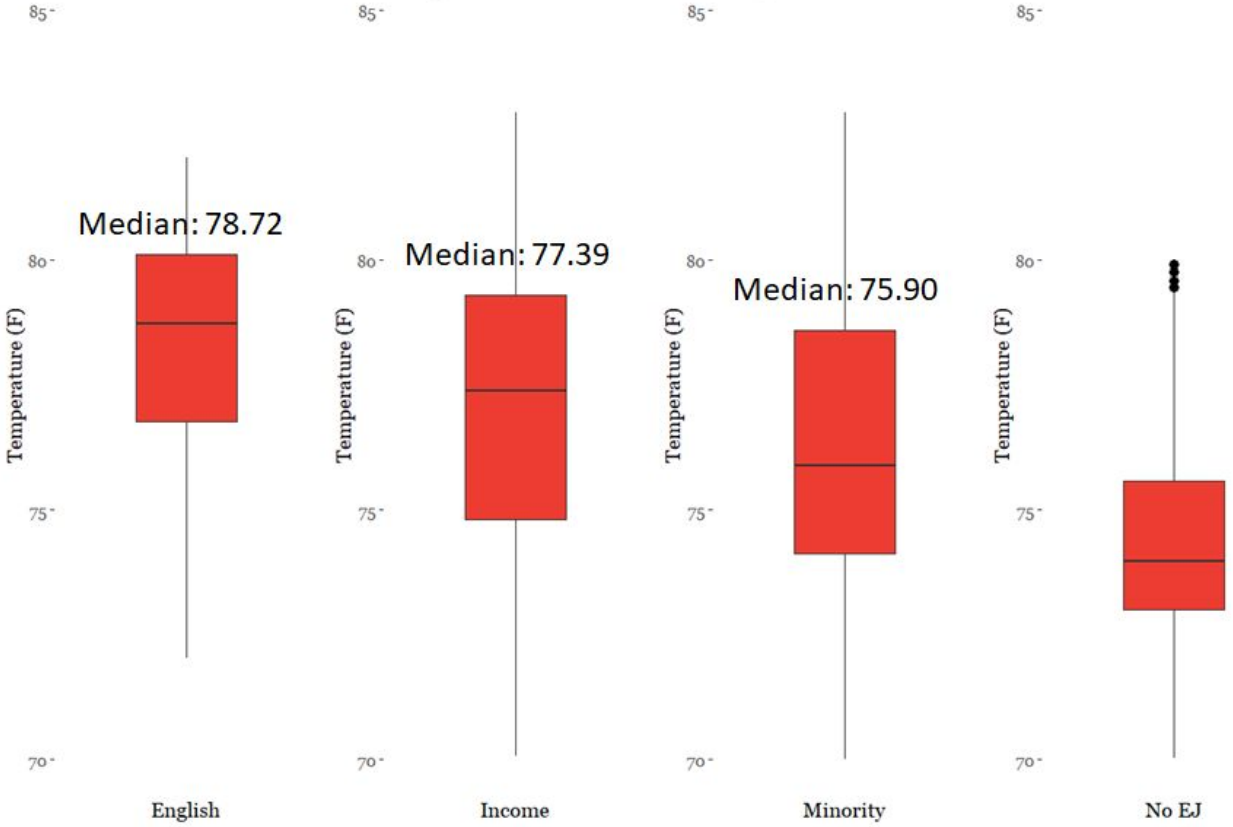


EJ Risk Factors and Air Temp (Evening)

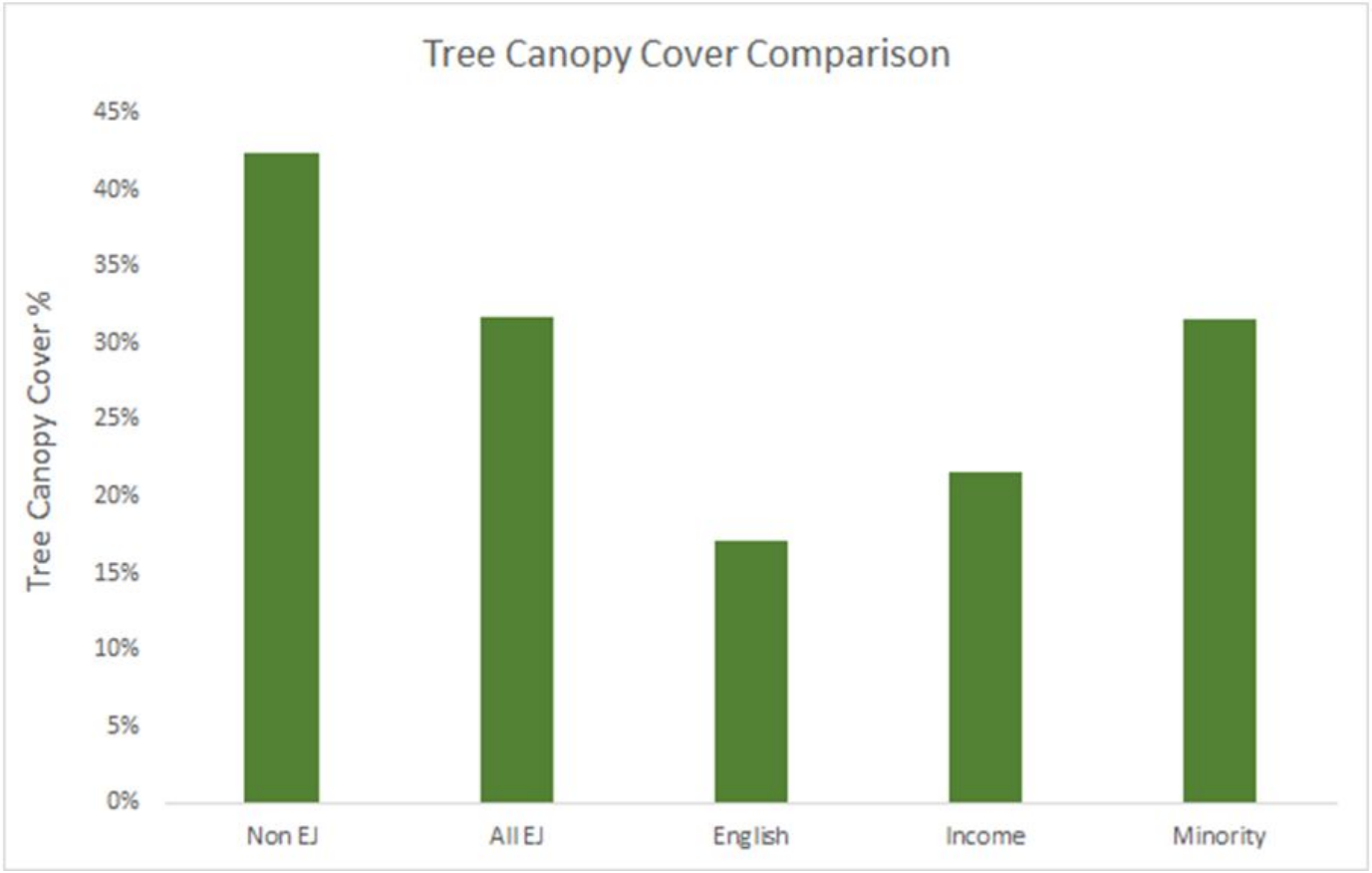
Median Temperature : 76.22 (F)

Almost 5 degree (F) difference between the No EJ Risk and English isolated communities

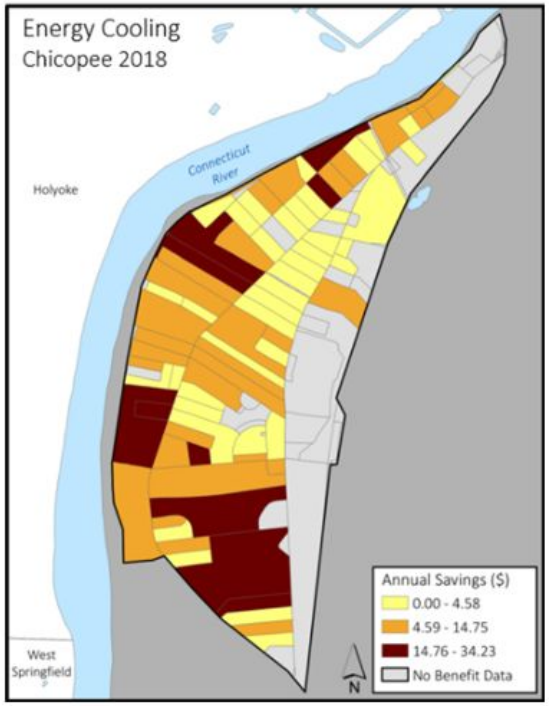
Temperatures are hottest for the English isolated communities (recent immigrants).

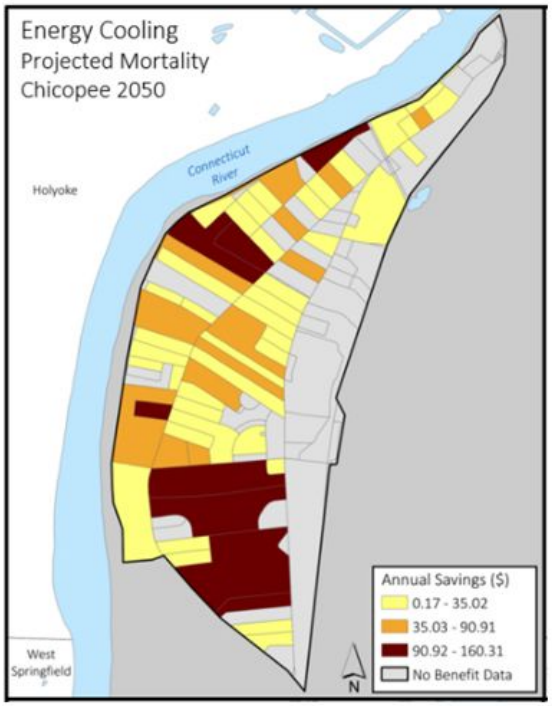


EJ Risk Factors and Tree Canopy



Energy Savings from Trees (planting to 30 years)





Services were maximized in neighborhoods where large numbers of trees were planted, right tree right place planting practices were followed, and **tree density was two to three trees per acre.**

Thirty year cumulative benefits = $157,546 (951 trees planted)

i-Tree®

What we have learned – Tree Planting Initiatives

Tree Cooling Benefits

Elmes et al. 2020:

- Canopy cover of 40-45% results in significant mitigation of the heat island effect
- Benefit of planting amplified when pre-existing tree canopy exceeds 20%.
- Pre-existing tree canopy below 5% results in negligible temperature reduction….

Moody et al. 2021:

- Juvenile trees provided $1520 (year 2018) in total annual energy savings per town
- Modeled to 2050 conditions- show increased total annual savings of $5840 per town (cumulative = $157,546 -951 trees planted)
- A tree planting density of three trees per acre achieved the largest energy savings

Program Governance and Stewardship

Breger et al. 2019:

- State funding and coordination of tree stewardship can enhance survivorship
- Municipalities need plans for funding and staffing to maximize tree planting success

Healy et al. 2022:

- Success of urban tree planting depends on how well the new trees fit into existing municipal structures and capacities

Geron et al. in review:

- Residents are an under-tapped resource for communication about tree planting, and higher survivorship may result

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Greenbelt

- Serve 34 Cities & Towns of Essex County
- Protected over 19,000 acres since 1961
- Conserve land for habitat, agriculture, recreation, scenic value, and climate resilience

Greenbelt Internship Program

- Started with a simple goal – increase productivity of GIS program
- 10 years, 13 students
- Undergraduate & Graduate Students from Salem State University's Geography & Sustainability Program

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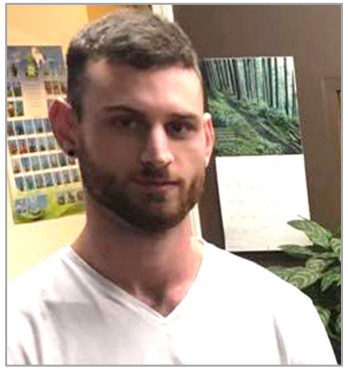












Greenbelt Internship Program

Funding

- Funding Strategy: foundation grants
- Have had unpaid internships, stipends, and now paid hourly
- Stand alone grants haven't been very successful
- Apply for the project the student will be working on, not just the internship
- Build into larger proposal

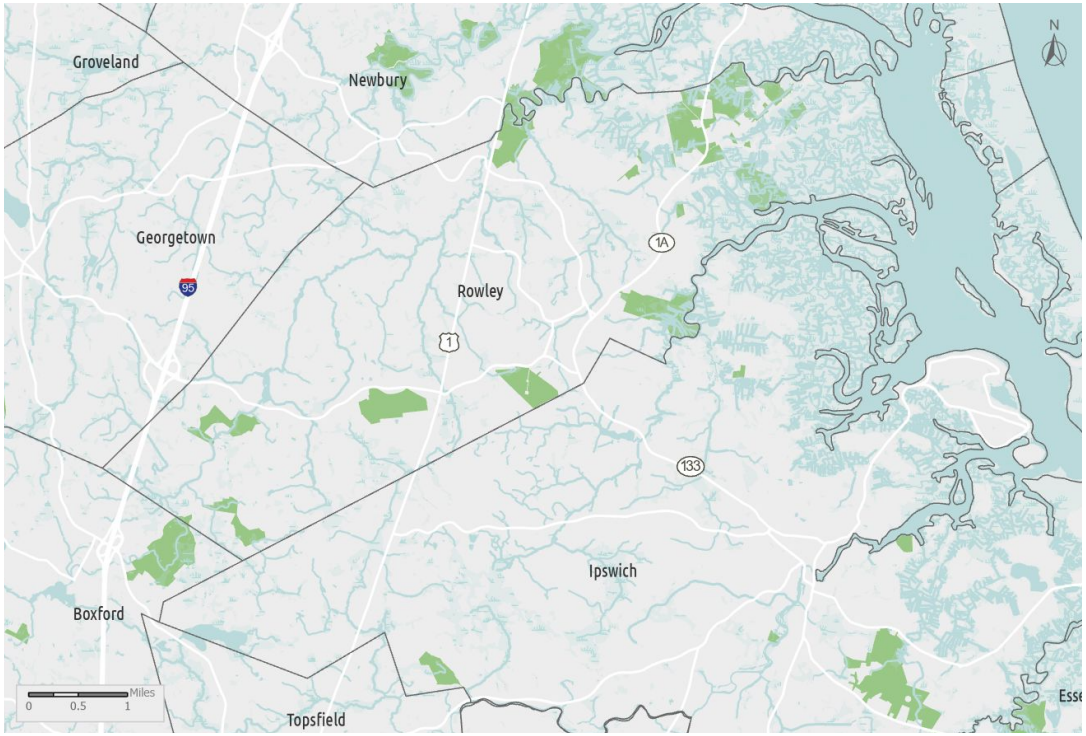
Greenbelt Internship Program

Projects

- Data creation & editing
- Database creation & management
- Trail mapping
- Data management
- Georeferencing
- Research
- Field work
- Cartography
- Analysis
- Story maps & web maps
- Drone photography, and more

Data Creation Example

- First Internship (Undergrad)
- Researched all of Greenbelt's "Assisted" projects from 1961-2013
- Mapped 78 projects -2,712 acres total
- Created database
- Product is a core dataset



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Trail Mapping

- Two rounds of trail guidebooks: 2014, 2022
- Trail data collection & editing
- Design research
- Cartography
- Proofing

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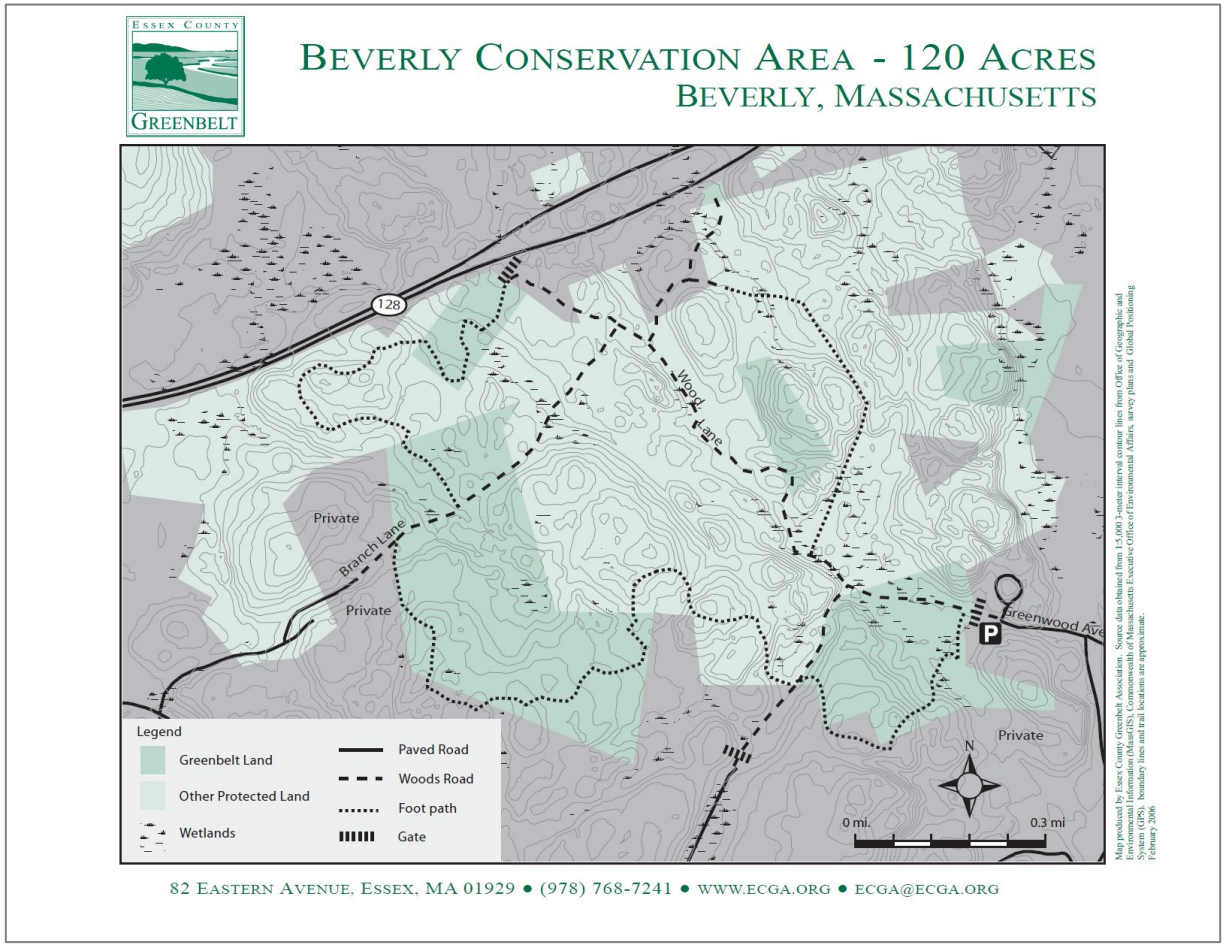
Trail Mapping 2006



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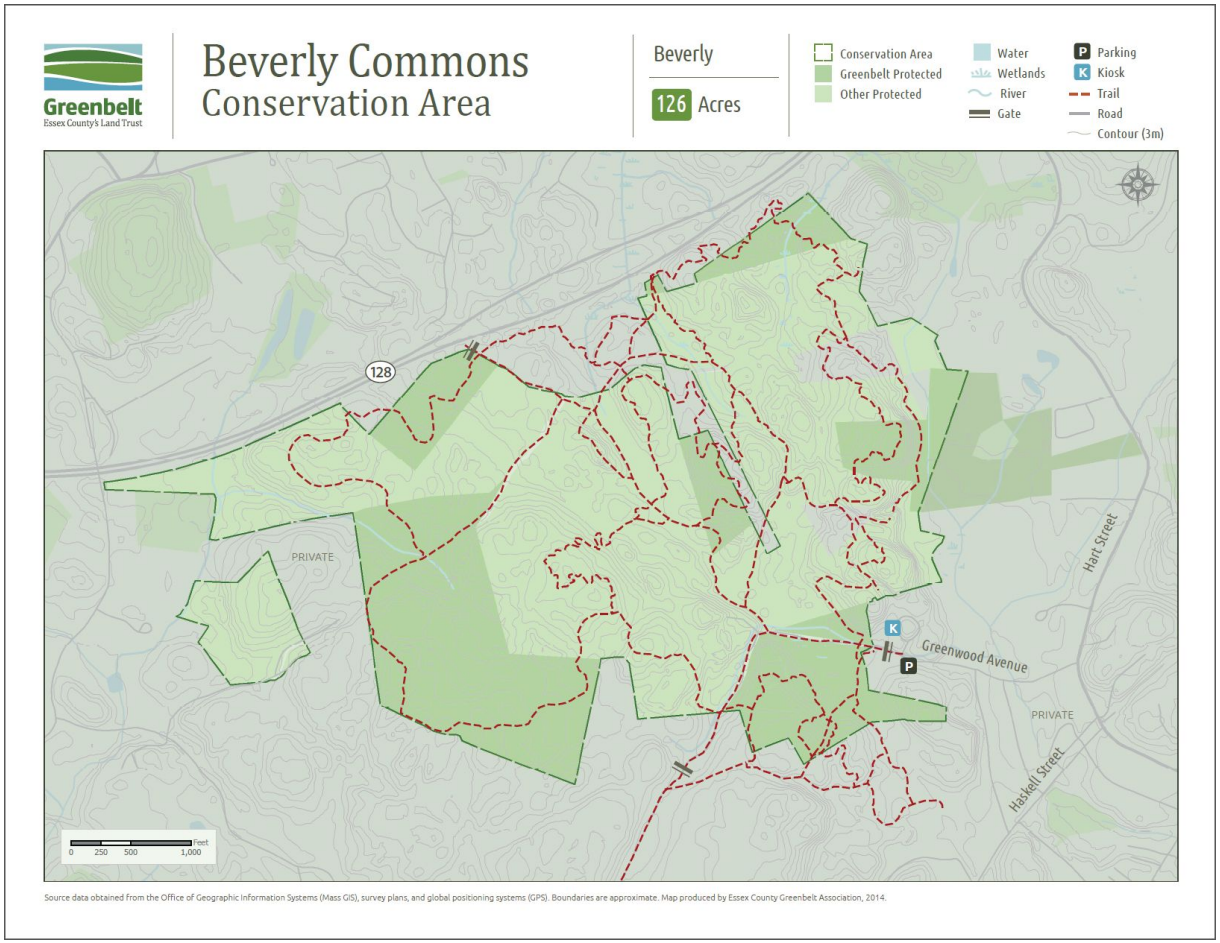
Trail Mapping 2014



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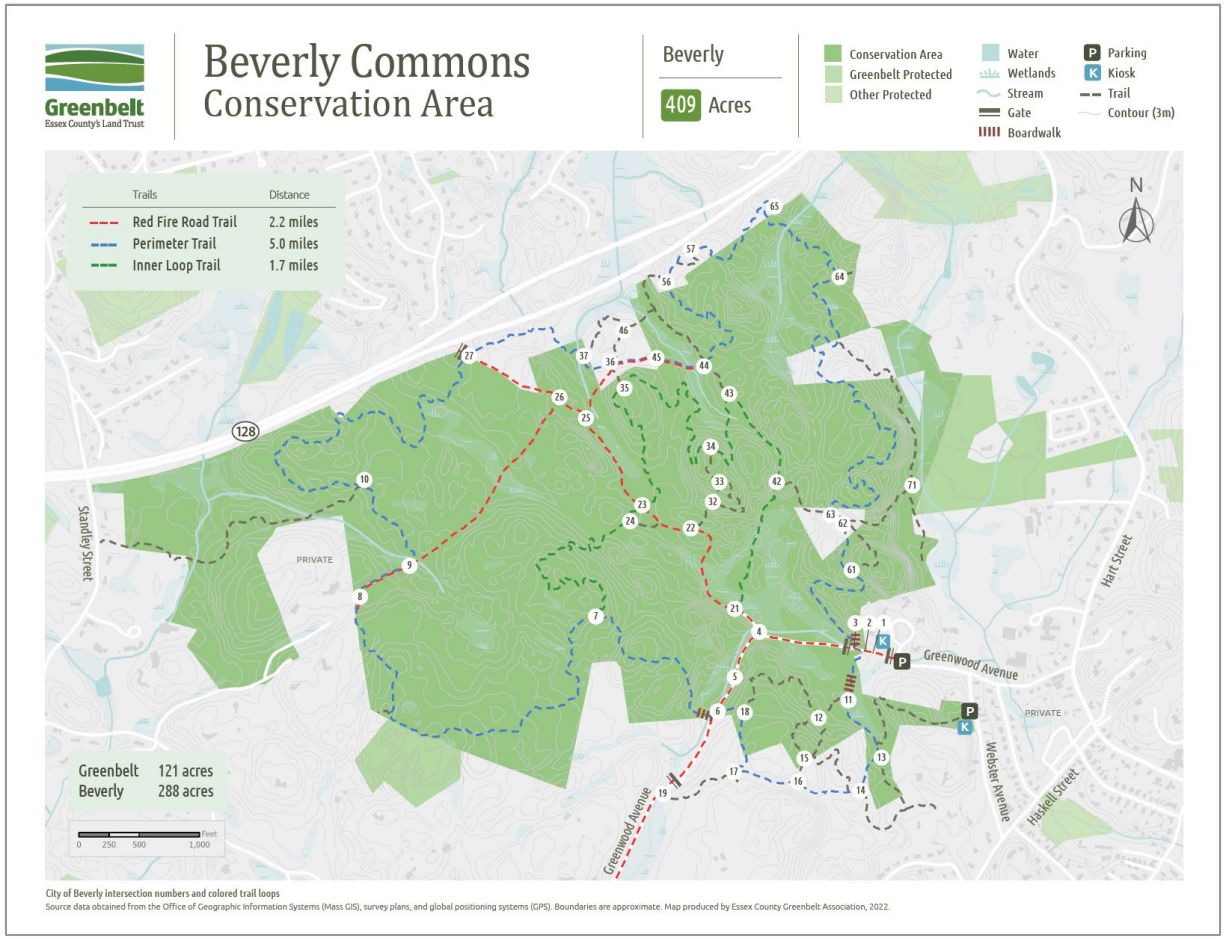
Trail Mapping 2022



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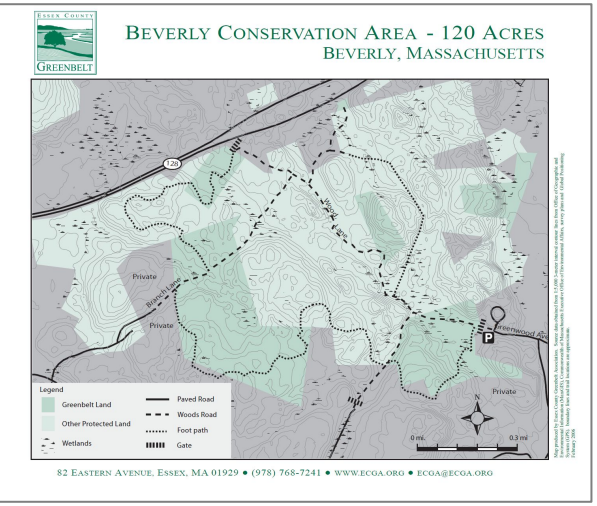
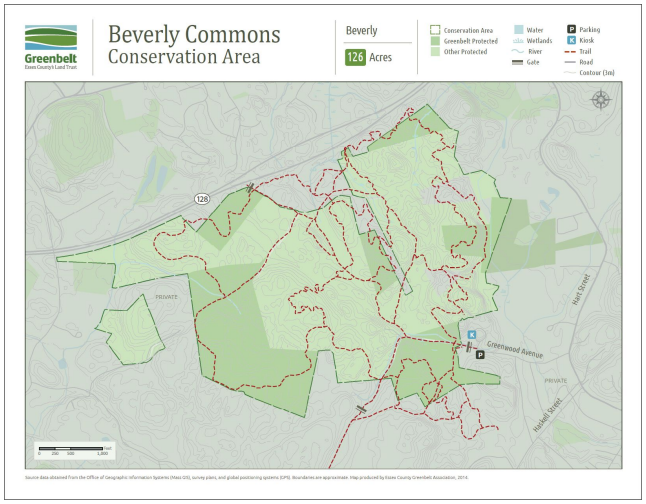
Trail Mapping

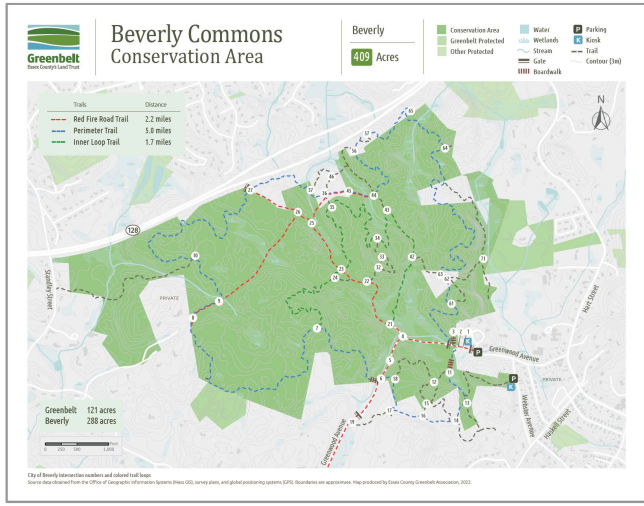
2006



2014

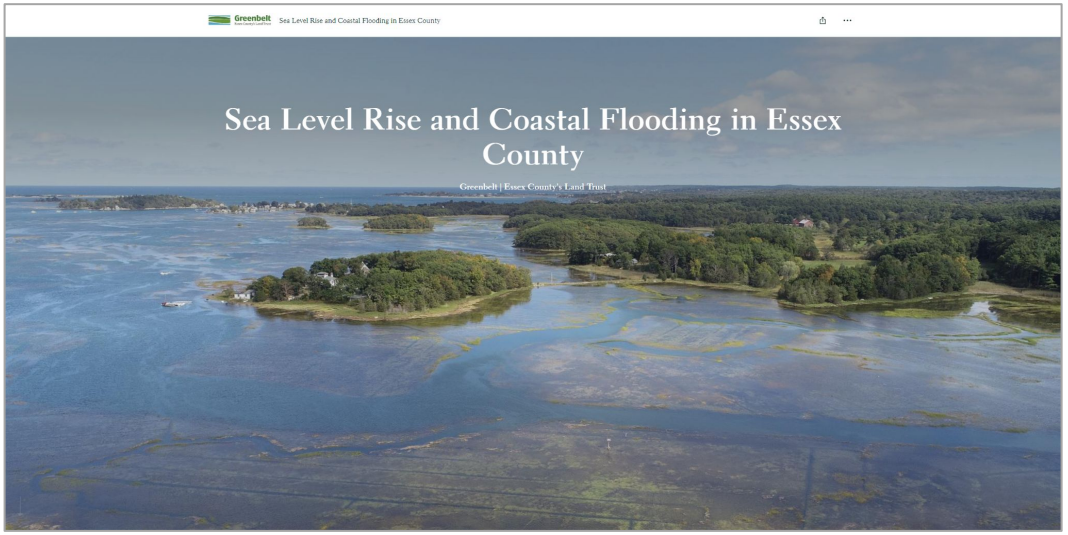


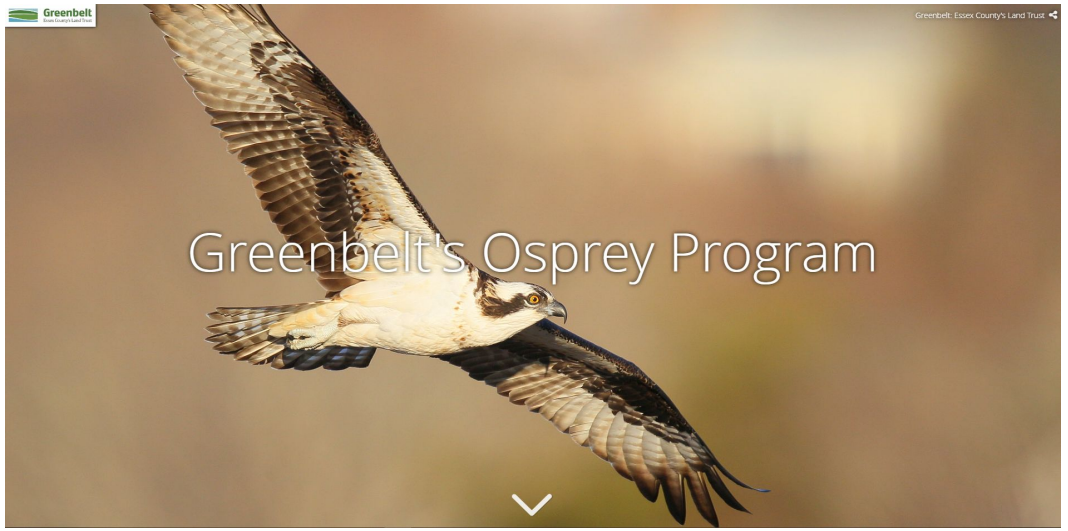
2022



Story Maps

- Interns worked on many of our story maps
- Contributed research, writing, video editing, creation of maps, graphics, & storymaps
- Allowed for pivot during COVID
- https://ecga.org/StoryMaps





Student Considerations

- Paid/unpaid
- Credit
- Safety
- Future employment
- Insurance for drones (Universities likely have their own)

Conclusions & Lessons Learned
Clark University

- GIS analysis and cartography informed by stakeholder needs
- Consistent engagement with communities allows for data integration and efficient applications in new locations
- Students benefit from interaction with conservation professionals
- There is a great opportunity to expand to new opportunities and concerns

Conclusions & Lessons Learned Greenbelt

- Significant benefit to productivity
- Cumulative nature of work
- Plan for staff time investment
- Funding is difficult
- Appropriate project types
- Many types of programs have GIS students
- Unintended benefits

Unintended Benefits
Greenbelt

- Relationship with the university
  - Class projects
  - Events
  - Professor engagement
  - Speaker series
  - Drone photography
- New perspectives and energy
- Staff pipeline
- Expertise & guidance of professors

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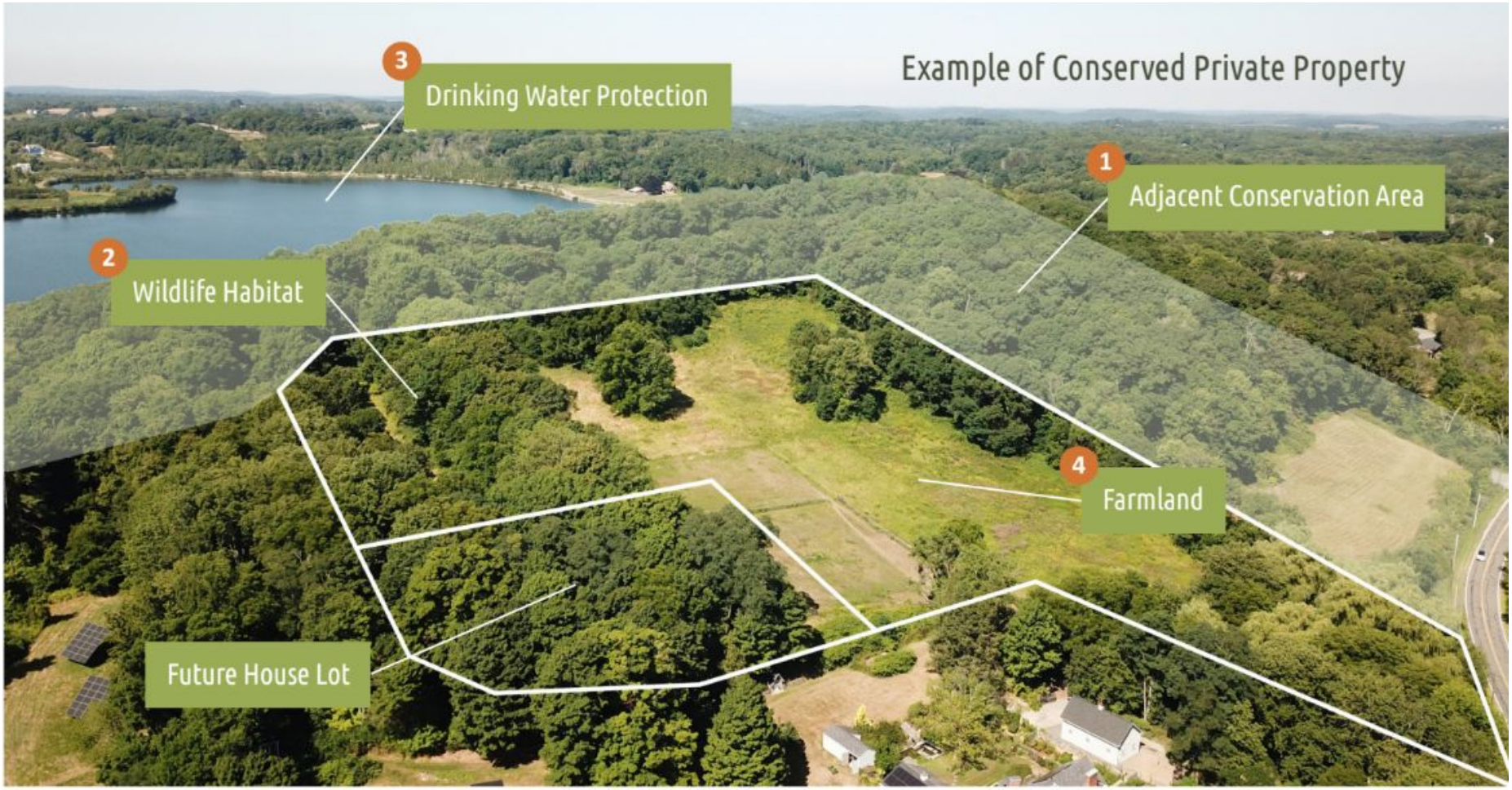

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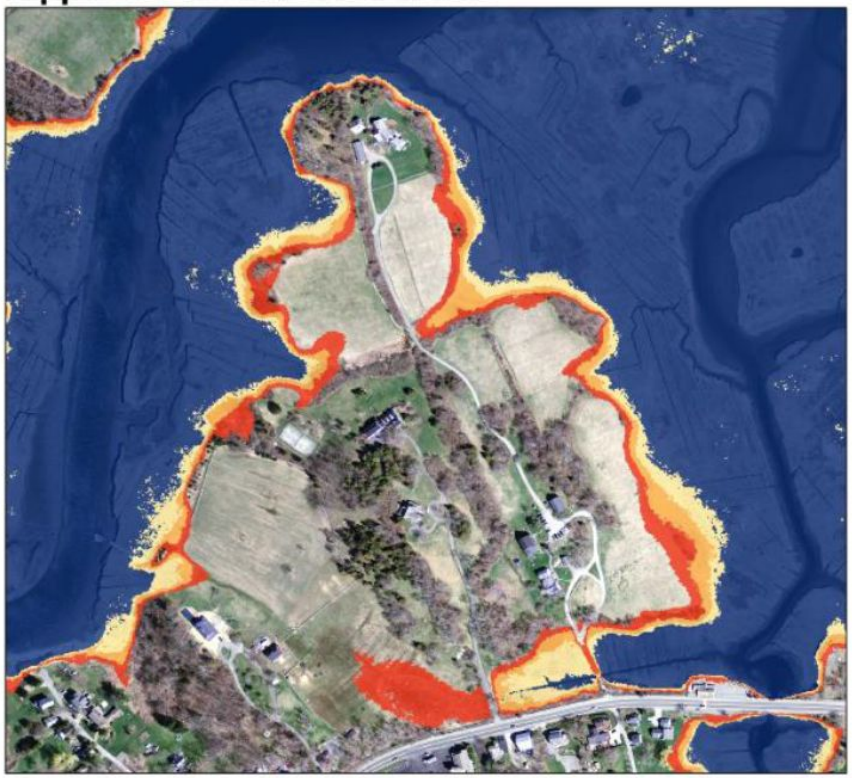
Appendix 2: Cox Reservation



Cox Reservation Sea Level Rise

The Mean High Higher Water levels (MHHW levels) are commonly used when mapping sea level rise vulnerability, because it represents the average of the mean higher high water elevations of each tidal day observed over the National Tidal Datum Epoch as defined by NOAA.

The perimeter of Cox Reservation, will be greatly impacted by sea level rise at the current border with the wetlands (transparent blue). At Mean High Higher Water levels sea water will inundate the land anywhere from 10 to 60 meters (or approximately 30 to 200 feet). Currently the area at the entry of the drive floods periodically during high tide. The flooding will expand significantly to the west over the next five decades, approximately 240 meters or 800 feet.

Mean Higher High Water Level MHHW

- MHHW 2013-2014
- Sea Level Rise 2030s
- Sea Level Rise 2050s
- Sea Level Rise 2070s

0 20 40 80 120 160 Meters

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TESTING PARK COOL ISLAND GIS ANALYSIS METHODS

FOR USE IN SEMI-URBAN CONSERVATION PLANNING

by

David Heacock

A thesis submitted to the Faculty of Salem State University in partial fulfillment of the requirements for the degree of Master of Science in Geo-Information Science

Summer 2020

Prioritizing Land for Urban Cooling

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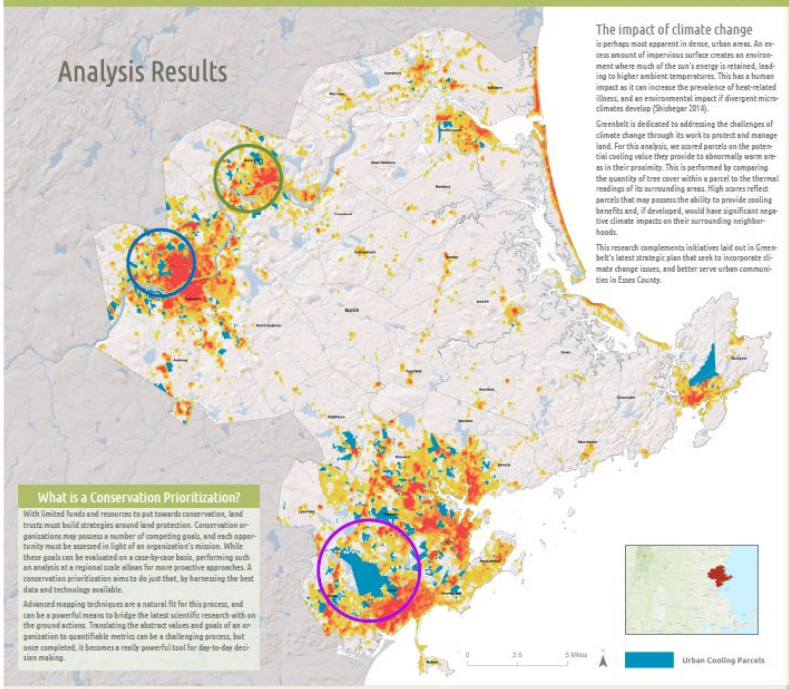
Analysis Results



The impact of climate change

is perhaps most apparent in dense, urban areas. An excess amount of impervious surface creates an environment where much of the sun's energy is retained, leading to higher ambient temperatures. This has a human impact as it can increase the prevalence of heat-related illness, and an environmental impact if divergent microclimates develop (Shishegar 2014).

Greenbelt is dedicated to addressing the challenges of climate change through its work to protect and manage land. For this analysis, we scored parcels on the potential cooling value they provide to abnormally warm areas in their proximity. This is performed by comparing the quantity of tree cover within a parcel to the thermal readings of its surrounding areas. High scores reflect parcels that may possess the ability to provide cooling benefits and, if developed, would have significant negative climate impacts on their surrounding neighborhoods.

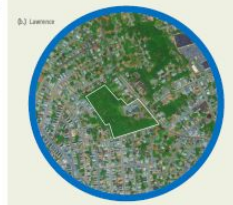
This research complements initiatives laid out in Greenbelt's latest strategic plan that seek to incorporate climate change issues, and better serve urban communities in Essex County.

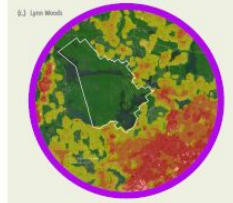
What is a Conservation Prioritization?

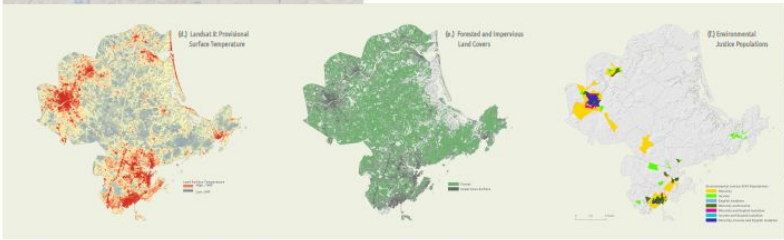
With limited funds and resources to put towards conservation, land trusts must build strategies around land protection. Conservation organizations may possess a number of competing goals, and each opportunity must be assessed in light of an organization's mission. While these goals can be evaluated on a case-by-case basis, performing such an analysis at a regional scale allows for more proactive approaches. A conservation prioritization aims to do just that, by harnessing the best data and technology available.

Advanced mapping techniques are a natural fit for this process, and can be a powerful means to bridge the latest scientific research with on the ground actions. Translating the abstract values and goals of an organization to quantifiable metrics can be a challenging process, but once completed, it becomes a really powerful tool for day-to-day decision making.

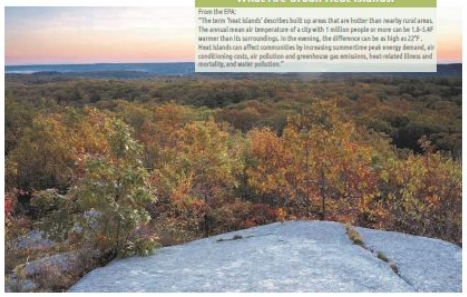

(a.) Haverhill


(b.) Lawrence


(c.) Lynn Woods



(a.) Haverhill	While these parcels may be small in acreage, they demonstrate the importance of preserving greenspace. If developed, the cooling pockets they provide could convert into heat island areas.
(b.) Lawrence	Lawrence is a highly developed community, making the preservation of forest areas that much more critical. The property shown occupies a particularly hot area in the city, making it an effective cooling parcel. The forested area on this parcel visibly contrasts the dense development surrounding it.
(c.) Lynn Woods	At over 2,200 acres, it's hard not to notice the cooling influence Lynn Woods has on its surrounding community. While downtown Lynn registers as one of the hottest areas of Essex County, this large forest helps to moderate the temperature and provide a place of refuge during heat waves.
(d.) Landsat 8: Provisional Surface Temperature	Measures surface temperature of different land cover types to compare temperature of a parcel to its surrounding area. Imagery captured 7/9/2018. Converted from Kelvin to Fahrenheit, and clipped to Essex County with a buffer of 1 mile to allow space for the individual buffers of parcels on the county border.
(e.) Forested and Impervious Land Covers	Parcels were assessed for acreage of forested land, which helps to combat heat islands. This data was derived from 2014 satellite imagery and developed by MassGIS.
(f.) Environmental Justice Populations	The urban heat island issue is of large importance to human health, particularly among populations who are already at-risk for heat-related illness. Environmental justice data helps add value to greenspace that is located in potentially vulnerable communities.



What Are Urban Heat Islands?

From the EPA:
"The term 'heat islands' describes built up areas that are hotter than nearby rural areas. The annual mean air temperature of a city with 1 million people or more can be 1.8–5.4F warmer than its surroundings. In the evening, the difference can be as high as 22°F. Heat islands can affect communities by increasing summertime peak energy demand, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and mortality, and water pollution."

Methods

For this analysis we defined heat islands as areas one standard deviation warmer than the mean for Essex County. A Landsat 8 Provisional Surface Temperature product captured on 7/9/2018 was used. Temperatures were converted from Kelvin to Fahrenheit, then clipped to the Essex County boundary plus one mile to allow space for buffers. The mean surface temperature for the imagery was 85.3°F with a standard deviation of 7.53. Areas over 93 °F were then extracted from the thermal raster to represent significantly warm areas in the analysis.

The buffer distance used to sum the surrounding thermal values for each parcel was 500 meters. This value has been used previously to measure urban heat island intensity (Cao et al., 2018), and was in line with the distances cited by several articles on the influence urban forest can have on cooling nearby areas (Doick, Peace and Hutchings 2014).

Since the study of urban heat islands is largely concerned with human impacts, we decided to incorporate an element of at-risk populations into the analysis, environmental justice areas. These have been identified by the Executive Office of Energy and Environmental Affair's Environmental Justice Policy as areas containing a high percentage of minority, non-English speaking, and/or low-income populations. These areas were intersected with urban heat islands in the analysis, and assigned a 40% bonus.

Potential UHI Cooling Score =

Percent Forest * Thermal Value + Residential Bonus + Environmental Justice Bonus / 10,000

Where Percent Forest is the percentage of the parcel that is forested.

Where Thermal Value is the sum of temperature values of pixels with temperatures of 1 SD+ above the average for the county (FAF=) and falling within a 500m buffer around the perimeter of the parcel.

Where Residential Bonus is 20% of the sum of temperature values of pixels with temperatures of 1 SD+ above the average for the county (FAF=) and falling within residential land use areas within a 500m buffer around the perimeter of the parcel.

Where Environmental Justice Bonus is 40% of the sum of temperature values of pixels with temperatures of 1 SD+ above the average for the county (FAF=) and falling within environmental justice areas within a 500m buffer around the perimeter of the parcel.

Scores are divided by 10,000 to adjust final scores to a more readable scale of 0 to 10.

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Questions?

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