Predicting Regional Allergy Hotspots in Future Climate Scenarios – Putting the Where and When on Wheezing

This research is funded by
U.S. EPA - Science To Achieve Results (STAR) Program
Grant # SU834359010

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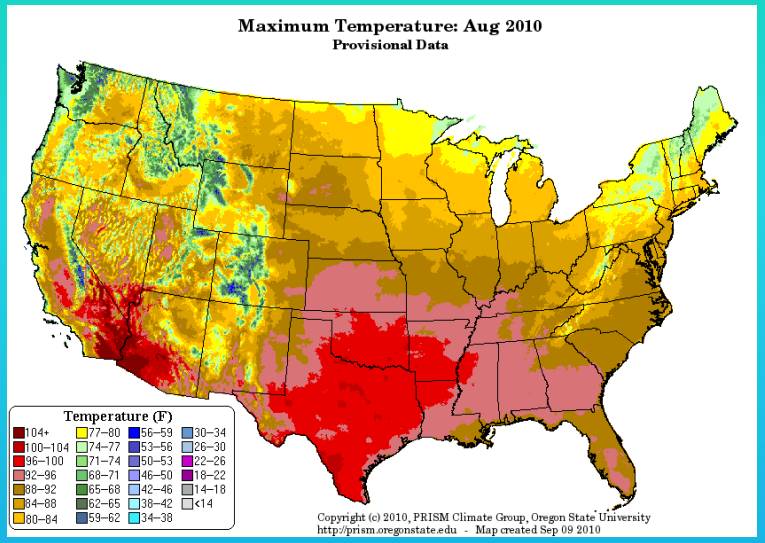
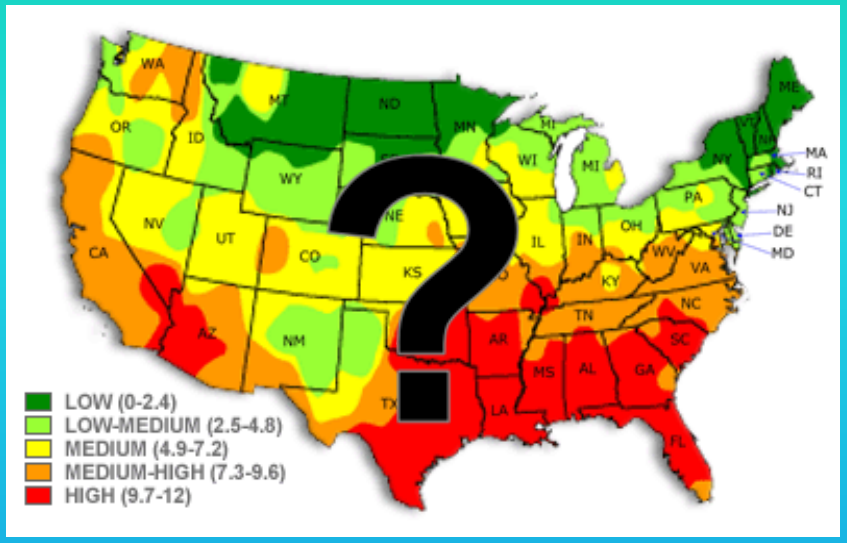
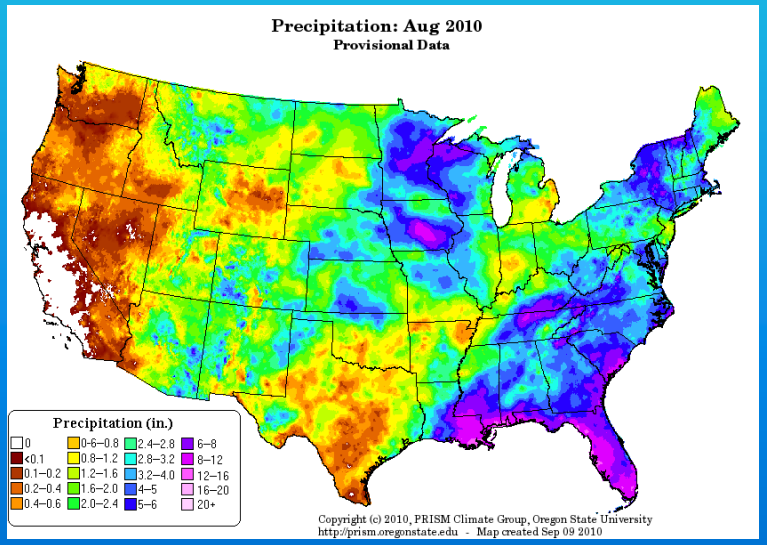
Scaling from climate to pollen counts





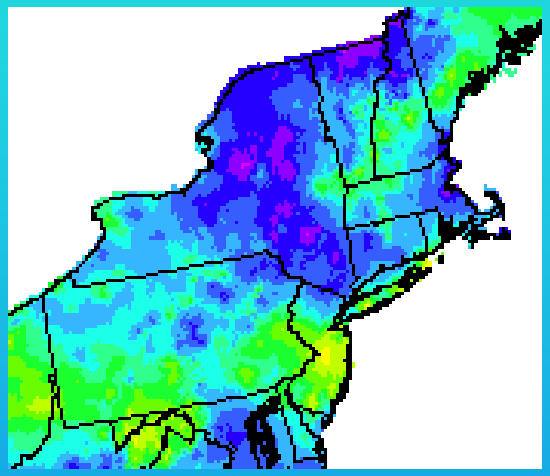


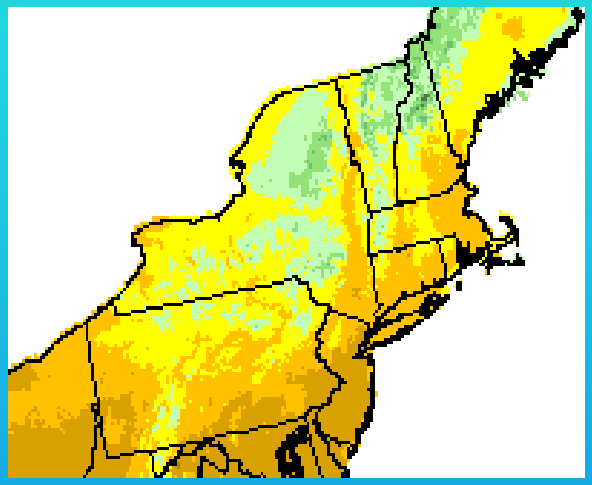
***Betula* (spring)**

***Ambrosia* (fall)**

Allergen *ecotypes* in a changing climate

PRISM: Regional Average Precipitation, Max T in New England





- captures regional climate variation
- considers genetic match of populations to local environment
- relevant scale for public health analysis

Common ragweed
Ambrosia artemisiifolia L.

- North American native weed
  - highly allergenic pollen, Amb-a1 protein
  - primary pollen allergen during Fall
  - Ecological significance
  - disturbance indicator past/present
  - drought, high temperatures
  - mono-dominance, crop pest
- Outlook for next century
  - > growth (Stinson & Bazzaz 2006)
  - > reproduction (Stinson & Bazzaz 2006)
  - > pollen output (Wayne *et al.,* 2006)
  - > flowering season (Rogers et al., 2008)

Three-Phase Research Plan

I. ***Regional model*** of present-day ragweed allergy risks (2010-2011)

II. ***Climate space envelope*** for breadth of ragweed pollen response (2011-2012)

III. ***Map of future allergy "hotspots"*** based on experimental and regional data (2012-2013)

Phase I. Regional modeling

Relates climate, land cover, census data to the following ***pollen risk factors:***

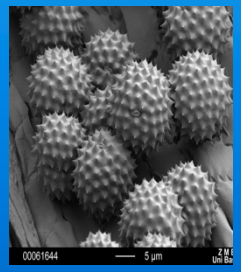
Abundance of atmospheric pollen

» Burkard ® pollen traps (population-to-landscape)

Timing of onset, peak, and duration of pollen season

» Flowering and abundance of ragweed populations

» Local settlement traps, vacuum samples



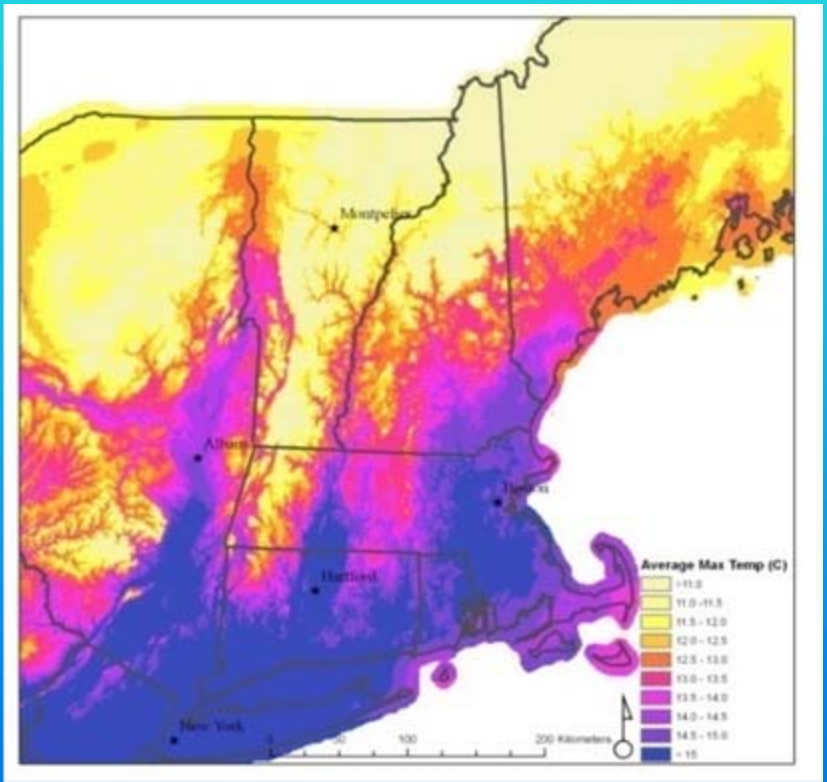
Allergen Potency

» Molecular [Amb a1] allergen assays

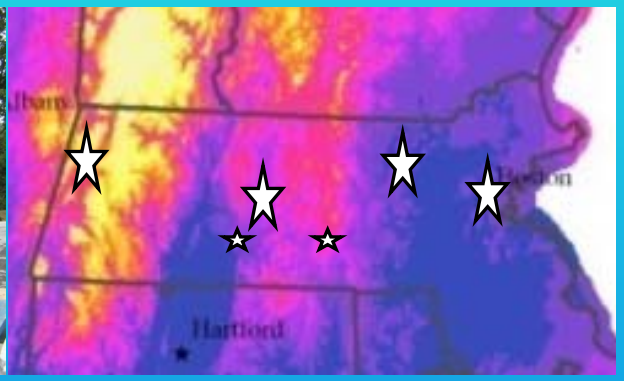
High resolution pollen counts

- 24 hour time series
- weekly collection
- Aug 1 – Oct 31
- laboratory stain and pollen grain count

Climate-pollen correlations

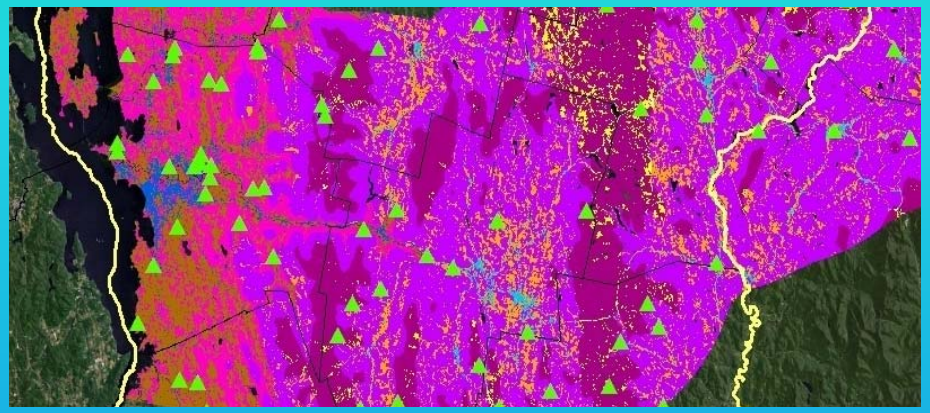


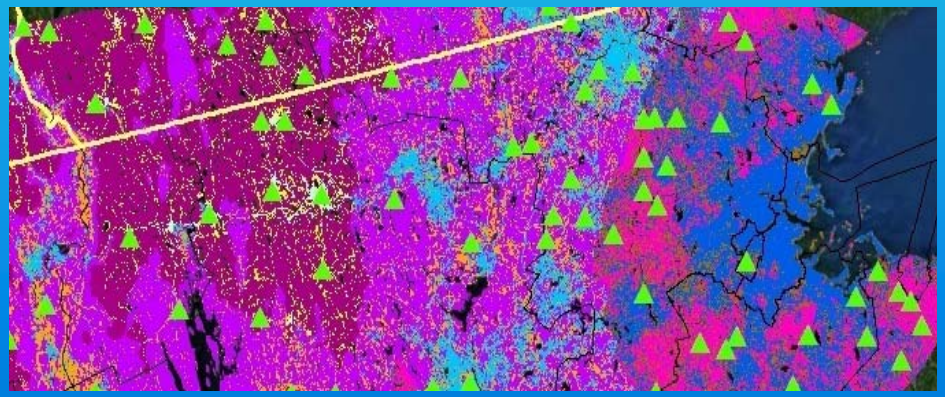
Boston-to-Berkshires as regional climate proxy

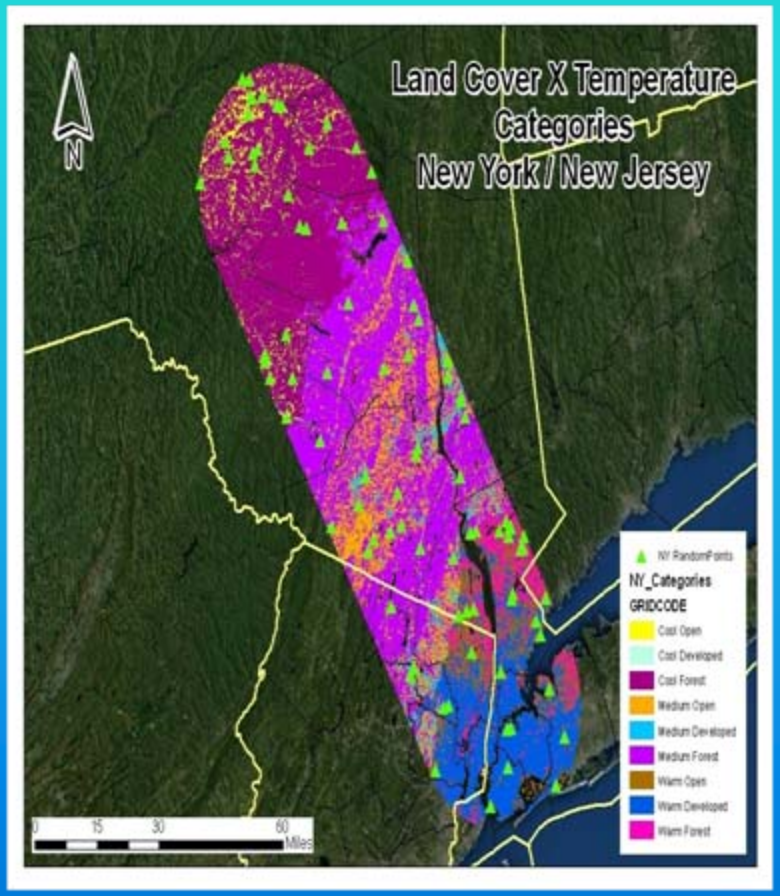


✓total pollen abundance/timing
✓Amb a1 allergen potency
✓ pollen risk factors in the field

Ragweed distribution survey



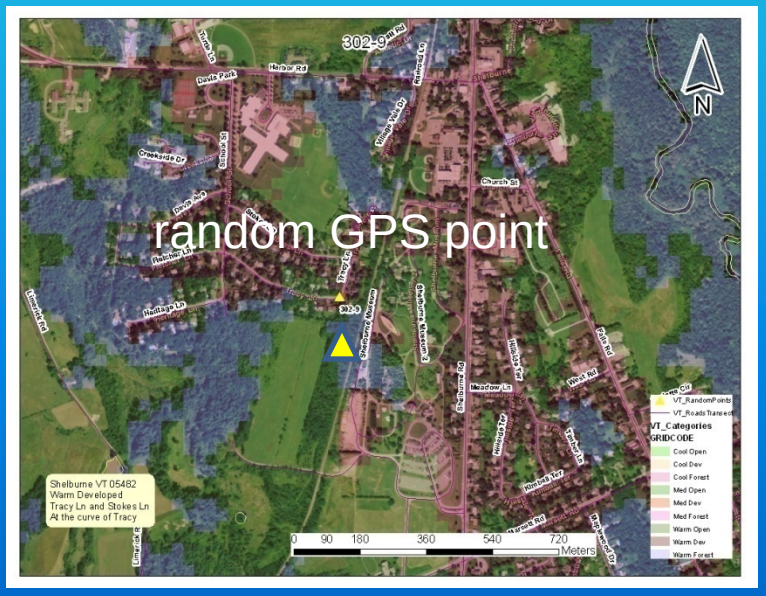




GIS based random sample of land cover/climate combinations

Presence/absence field methods

% cover measurements of
- Ragweed
- Lawn/Garden
- Bare Soil
- Agriculture
- Right of Way/Edge
- Pavement/Buildings
- Forest habitat



NW NE

SW 20 x 20 m plots SE

Population biology and remote sensing

Remotely sensed with GIS, GoogleEarth® and traditional maps of likely habitat

10+ populations per climate zone/trap

- ✓ flowering time/duration
- ✓ plant population growth
- ✓ allergen assays
- ✓ pollen output per plant

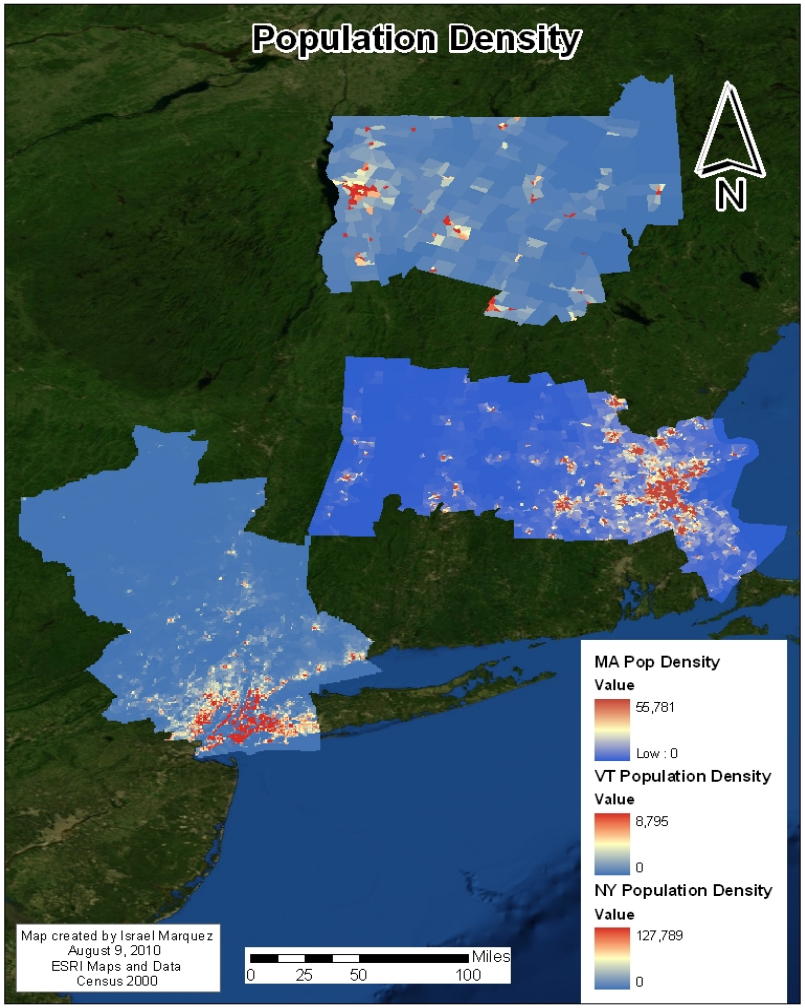
Modeling regional allergy risk

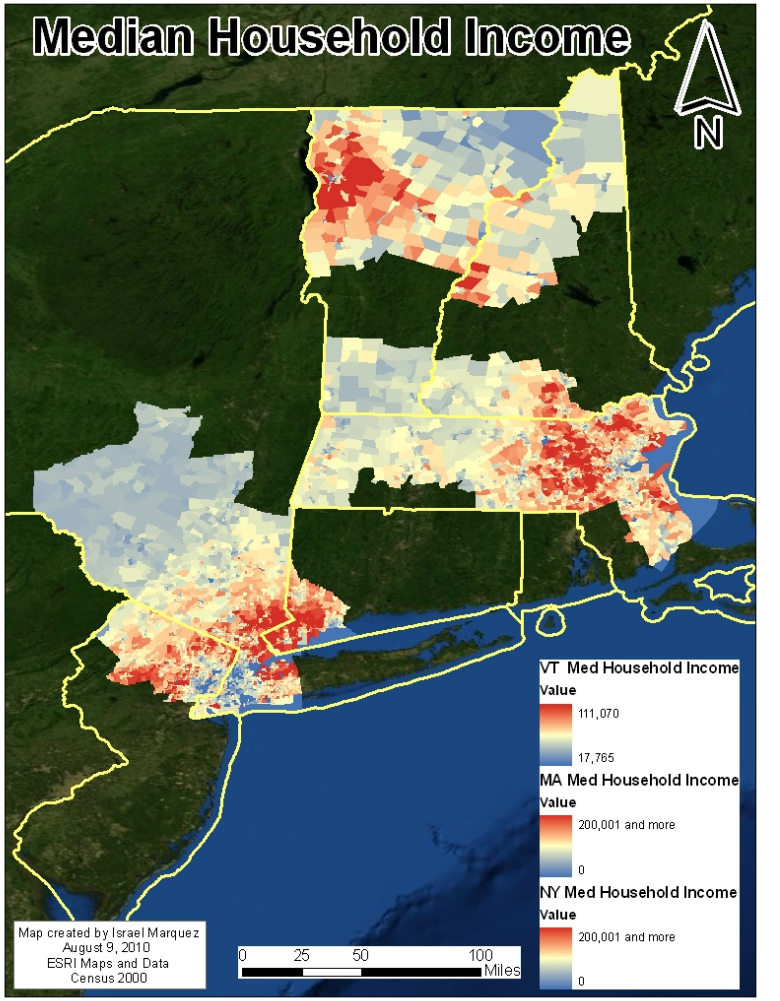
Risk factors measured by each dataset, and scales of field and predictor data.

Risk Factors	***Burkard traps***	***Tauber traps***	***Air samplers***	***Allergen assays***	***Plant phenology***	***Plant growth***	***Plant demography***
	i,ii	***ii,iii***	***i,ii,iii***	***iii***	***i***	***ii***	***ii***
Geographic scale							
local sample points	yes	yes	yes	yes	-	-	-
populations	-	yes	yes	yes	yes	yes	yes
Predictor variables							
temporal weather data	yes	yes *	yes	-	yes	yes	-
geographic climate	-	yes	yes	yes	yes	yes	yes
land cover	-	yes	yes	yes	yes	yes	yes

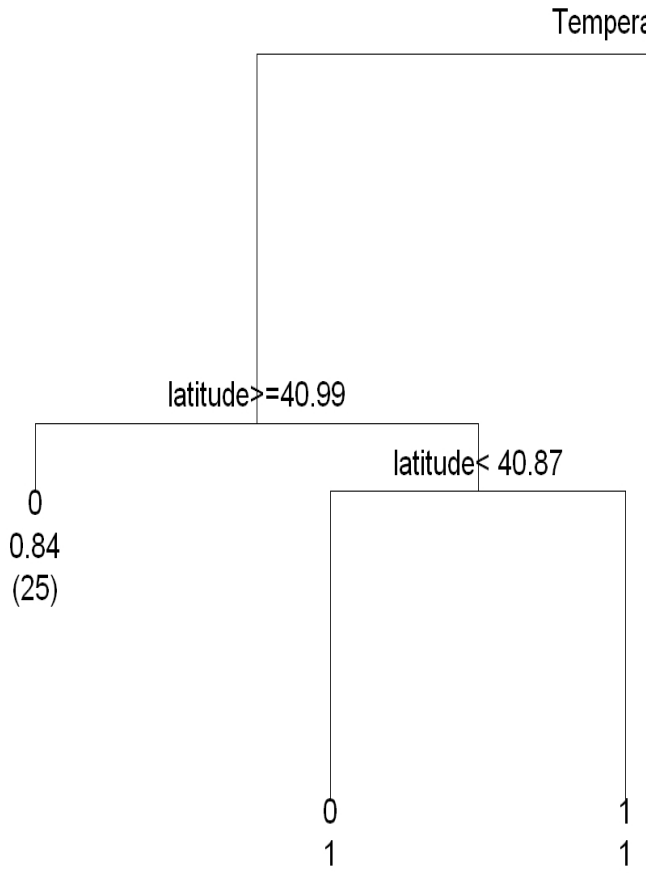
(i) timing, (ii) abundance, (iii) potency

Human exposure: US Census data





CART analysis for Massachusetts presence/absence with GIS predictor data



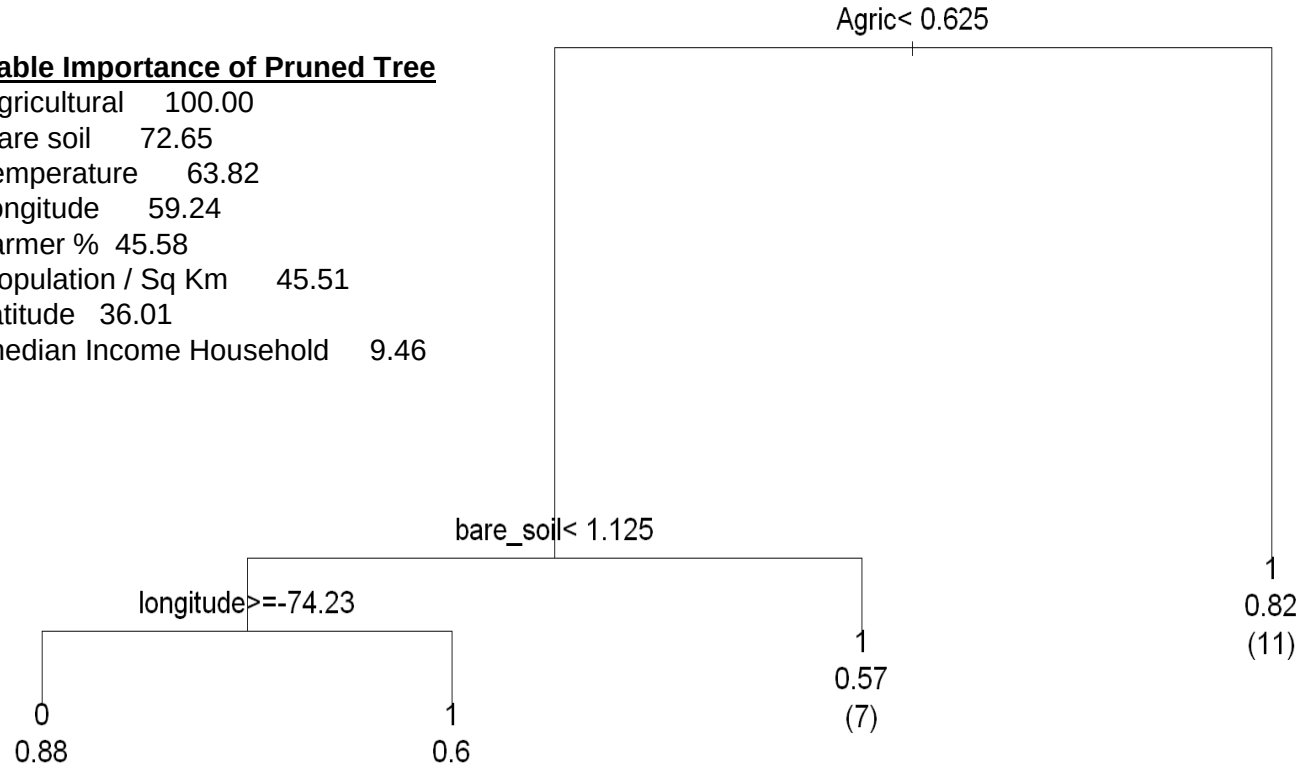
Variable Importance of Pruned Tree

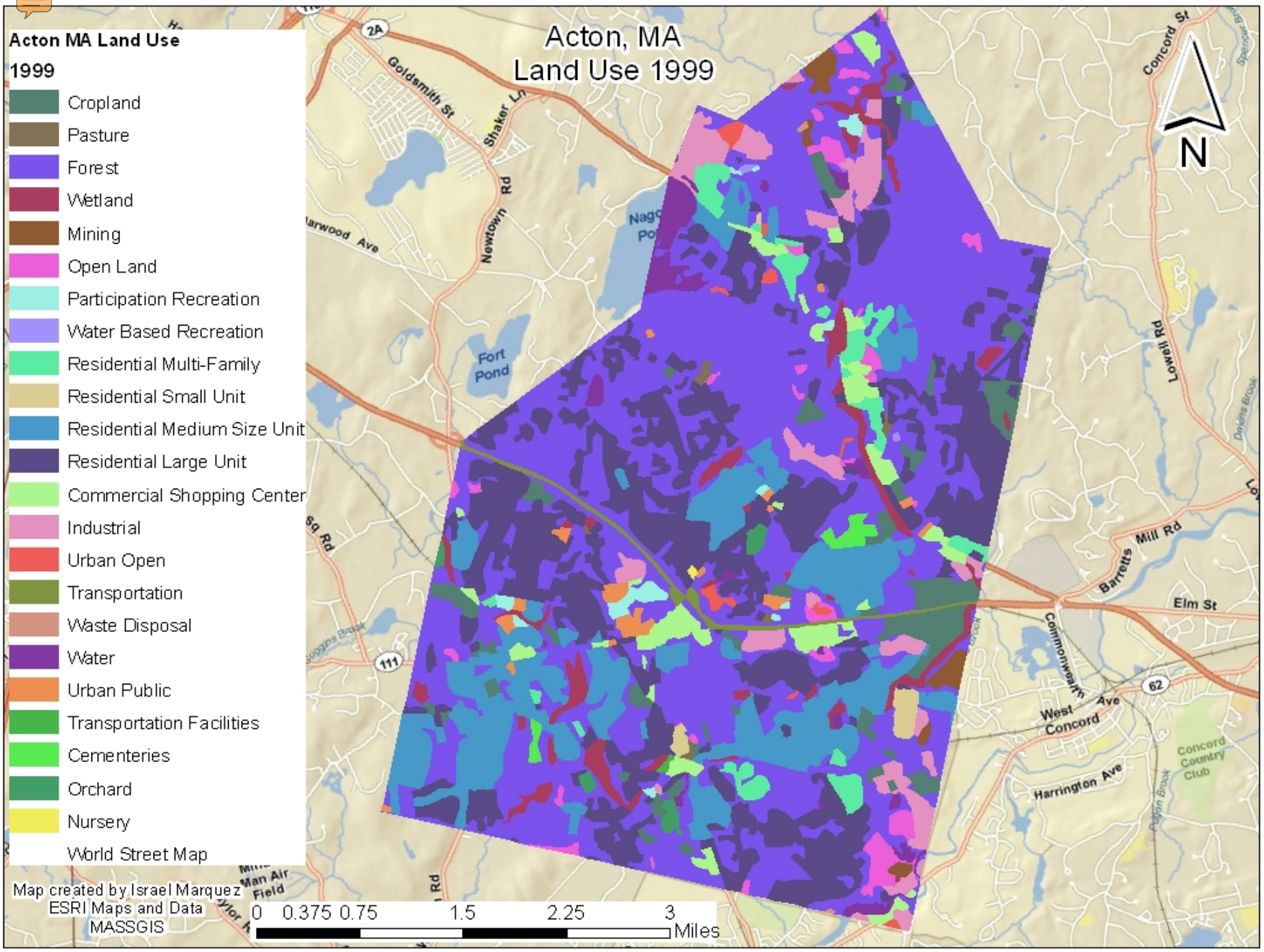
1	Latitude	100.00
2	Temperature	68.84
3	Longitude	61.11
4	Population per Sq Km	32.83
5	Median Income Household	23.31
6	Land Cover	20.39

CART analysis for Massachusetts presence/absence with GIS and field data

Variable Importance of Pruned Tree

1	agricultural	100.00
2	bare soil	72.65
3	temperature	63.82
4	longitude	59.24
5	farmer %	45.58
6	population / Sq Km	45.51
7	latitude	36.01
8	median Income Household	9.46




Acton, MA
Land Use 1999
Acton MA Land Use
1999
Cropland
Pasture
Forest
Wetland
Mining
Open Land
Participation Recreation
Water Based Recreation
Residential Multi-Family
Residential Small Unit
Residential Medium Size Unit
Residential Large Unit
Commercial Shopping Center
Industrial
Urban Open
Transportation
Waste Disposal
Water
Urban Public
Transportation Facilities
Cemeteries
Orchard
Nursery
World Street Map
N
Goldsmith St
Shaker Ln
Newtown Rd
Fort Pond
Concord St
Lowell Rd
Mill Rd
Barretts
Elm St
Commonwealth Ave
West Concord
Harrington Ave
Concord Country Club
Map created by Israel Marquez
ESRI Maps and Data
MASSGIS
0 0.375 0.75 1.5 2.25 3
Miles

ULTRA-X BOSTON PLAN

Remote Sensing
BU

Data Portal
Gopal/Furth

Scenarios

Conservation/Development	Foster, Woodcock,
Electricity	Kaufmann
Gray to Green	Furth, Phillips
Energy Balance changes	Furth, Hutyra, Phillips

Planning horizons
2010 MetroFuture
2012 GrowBostonGreen
2018 RGGI
2020 MertoFuture
2050 City of Boston master plan

Time Scales
Diel
Seasonal
Annual
Decadal
Future Scenarios

Human Health
Stinson/Foster
Ragweed - EPA Grant

Atmosphere

STILT+WRF	Wofsy/Hollinger
CO2 ppm	Hutyra/Wofsy/Dunn/Hollinger
Pic. isotopes	Hollinger
Aircraft	Wofsy
Energy Balance	
Car/truck/bike platform	

Waters
Harbor/Rivers
MA Ocean proj.
Buoy platforms?
BZI Model

Transportation (Furth/Ferriera)
Emissions factor+avg
cycles est. emissions
Link to traffic models thru VMT /traffic cnts/mode split
CPTS
Inspection data
Detailed TAZ + Mode-based est

Built land

Building footprint	Gopal*
Roads	Gopal*

Energy

Electricity+Oil+NatGas	Kaufmann
emissions (ft^2+usage)	Kaufmann, Gopal, Phillips
emissions (bld type+ft^2+usage)	Kaufmann, Gopal, Phillips
usage/production @250m	Kaufmann
EKC hypothesis testing	Kaufmann

Vegetated Land

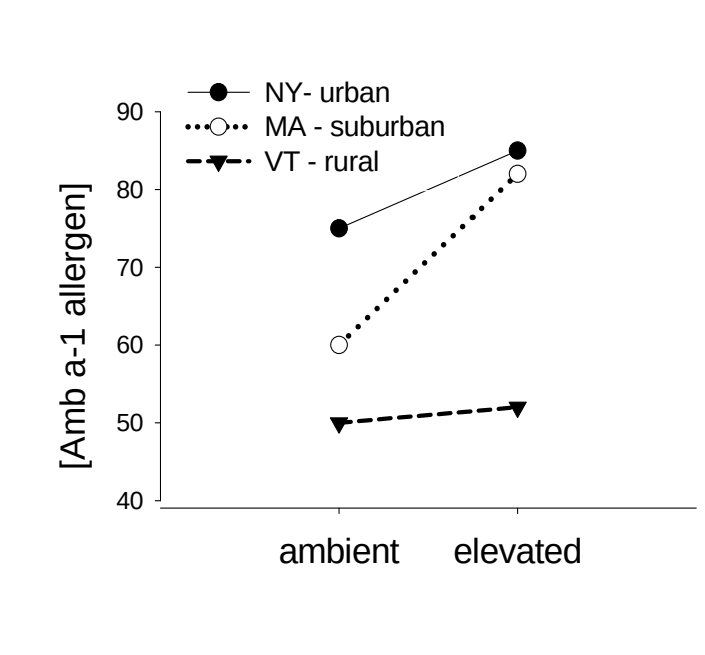
Classification	Friedl
Change Analysis	Woodcock, Friedl
VPRM	Phillips, Friedl, Hutyra, Wofsy(?)
plant efficiency differences	Phillips
phenology (beyond NDVI)	Friedl

Phase II. Climate space envelope

Open-top Chamber Experiment (2011)

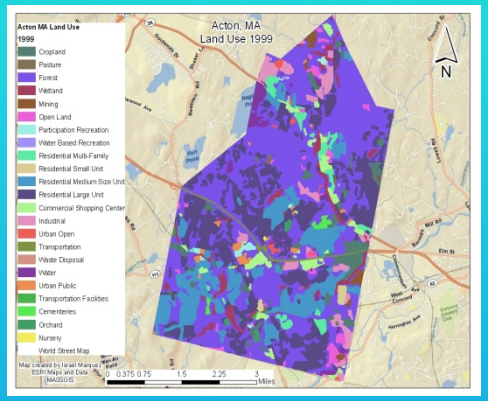
CO_2 x precipitation treatments

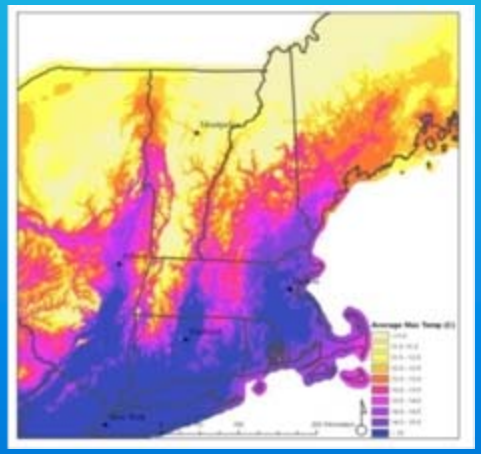
- Ecotypes from NY-VT transect (seed collecting 2010)
- Stand-alone dataset, also informs predictive model



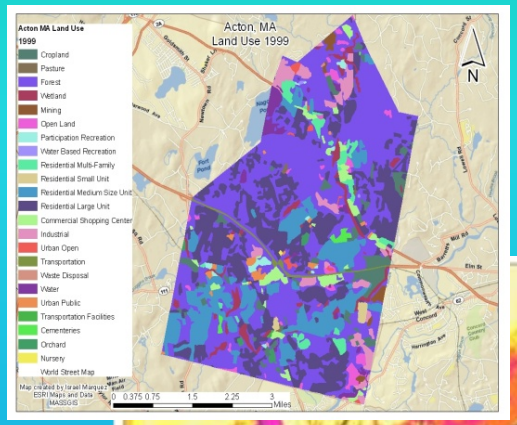
- Amb a1 potency
- Pollen output
- Flowering time and duration

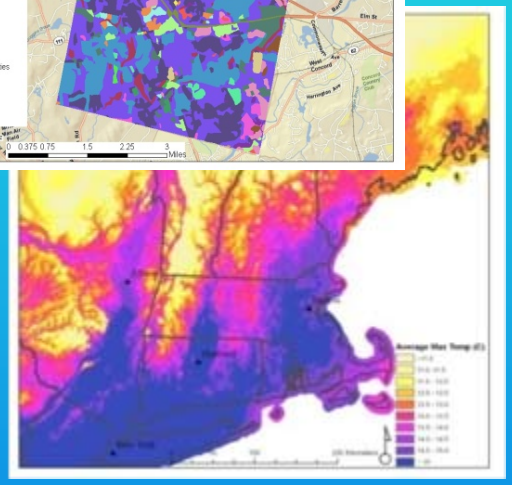
Phase III. Future allergy hotspot maps (2012-2013)

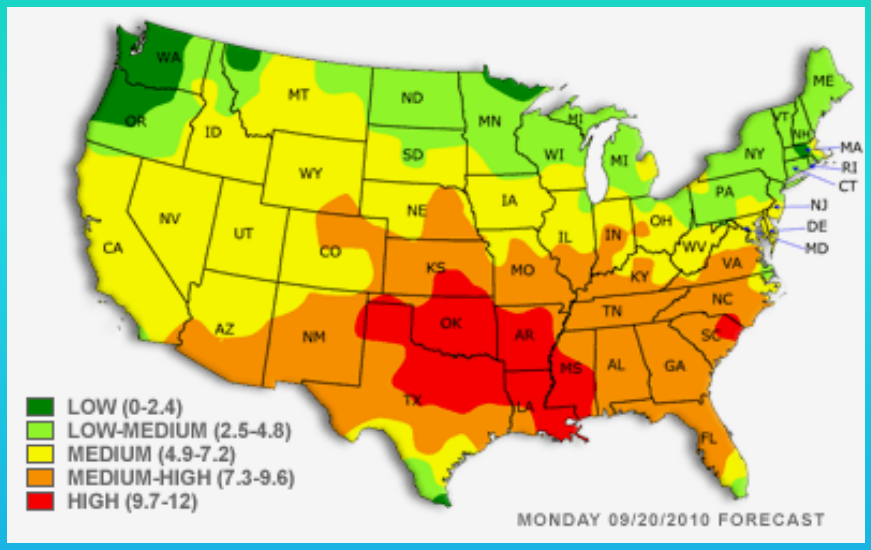




- High resolution pollen counts
- Local and regional data
  - ragweed populations
  - land cover
  - climate
- Overlay with IPCC and other future scenarios







***Betula* (spring)**

***Ambrosia* (fall)**