Mapping Climate Change Exposure for Northeastern Tree Species

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Adaptation and Restoration of Northern Forests

Collaborative Management of Forests at Risk Across the Urban to Rural Gradient

1. Co-development of forest restoration and adaptation approaches with key stakeholders, and assessments of broader perceptions of these approaches by natural resource managers;
2. Proactive application of forest restoration, adaptation and transition approaches in a variety of field trials; and
3. Aggregation of historical and projected forest change data layers into a **spatial forest exposure** and targeted adaptation and restoration **mapping tool**.

Climate Change Exposure

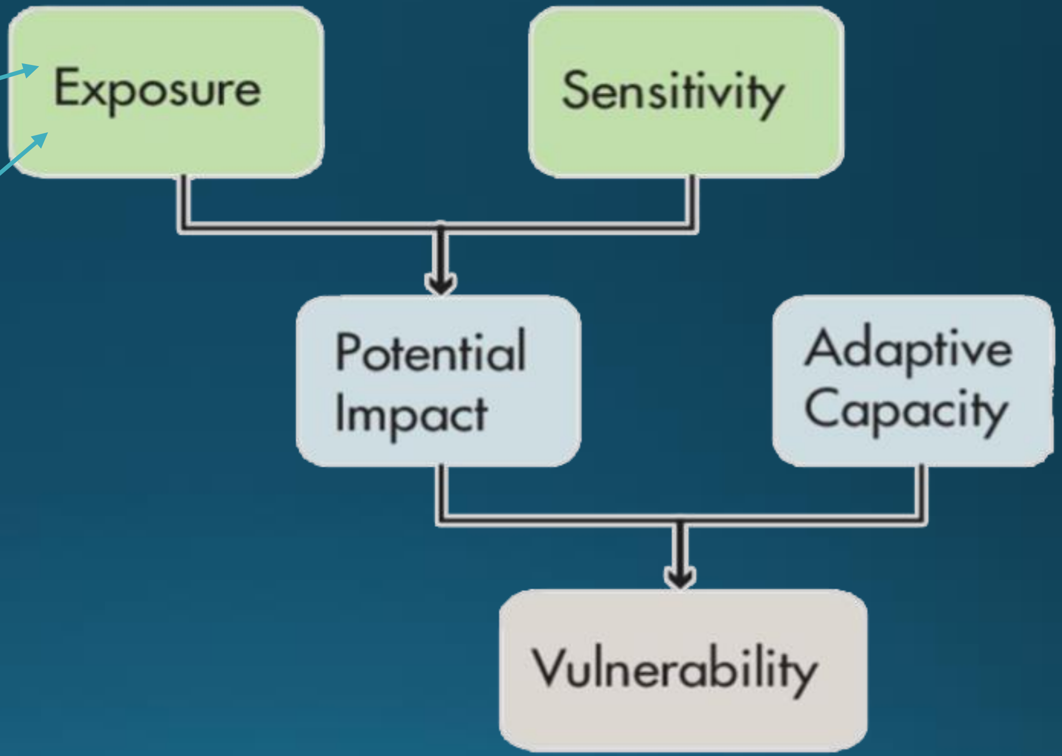
Direct Exposure

Changes in:

- Temperature
- Precipitation
- Extreme Events

Indirect Exposure

- Pests
- Pathogens
- Competition
- Disturbance patterns



Stein et al. (2014). Climate-Smart Conservation: Putting Adaptation Principles into Practice.

Climate Change Exposure - Methods

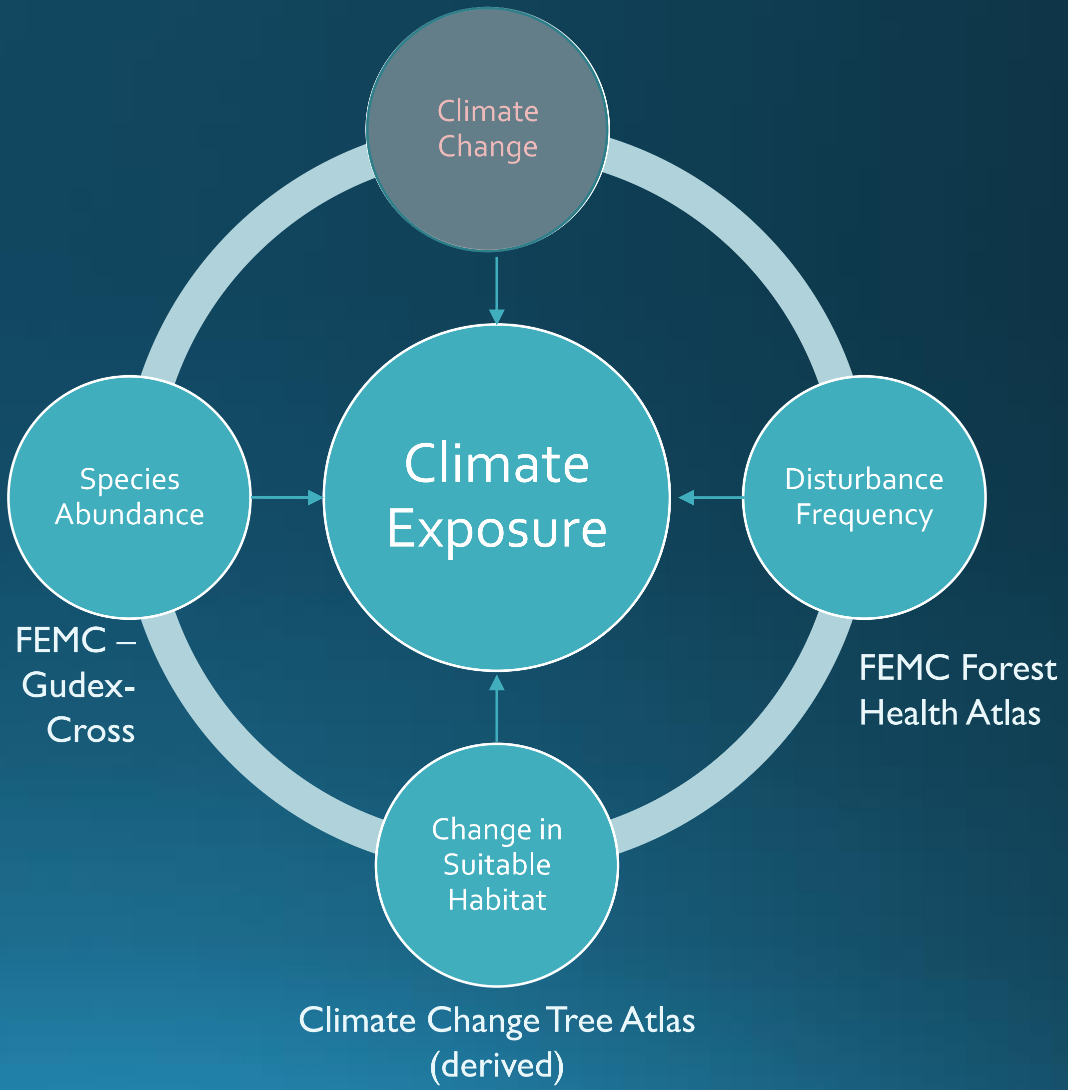
Approach:

Identify existing data layers to capture the spatial variability in key exposure metrics

Develop updated data layers to capture projected deviation from climate norms

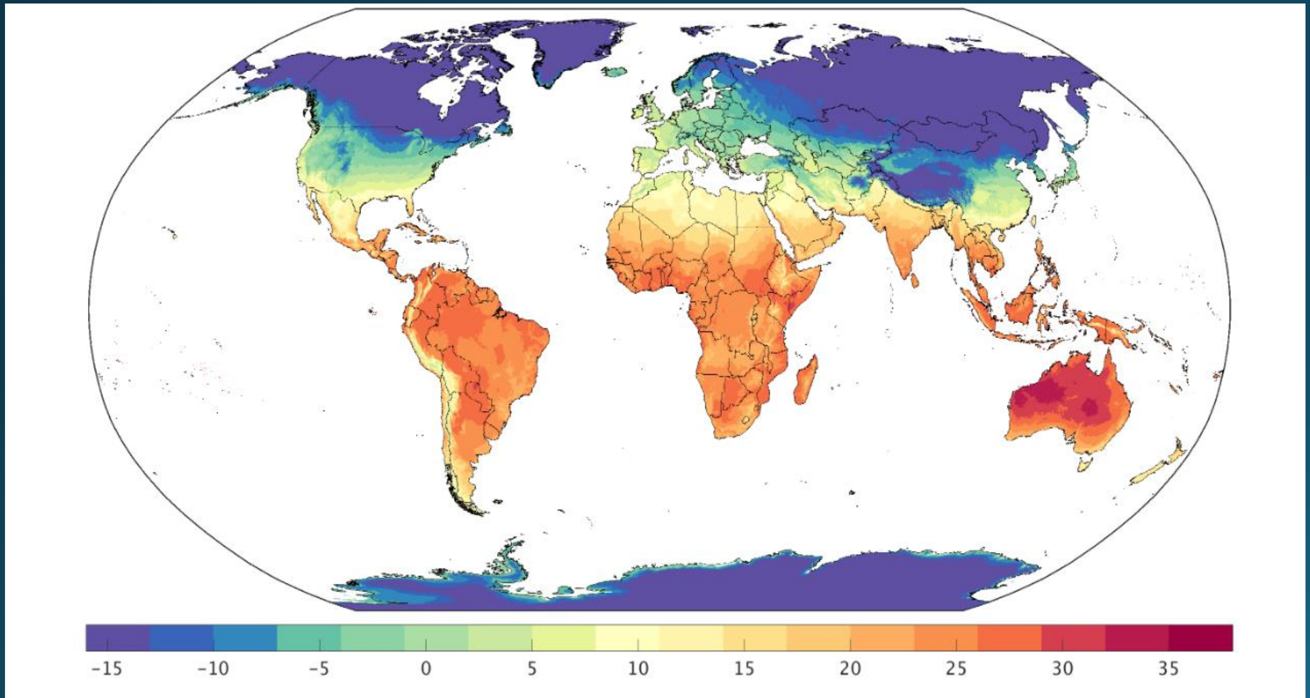
Aggregate these into a spatial model that synthesizes relative exposure across the landscape

- By species
- Stand – level (ecosystem aggregate)



Climate Change Exposure - Methods

TerraClimate



https://www.climatologylab.org/terraclimate.html

Primary Monthly Climate Variables:

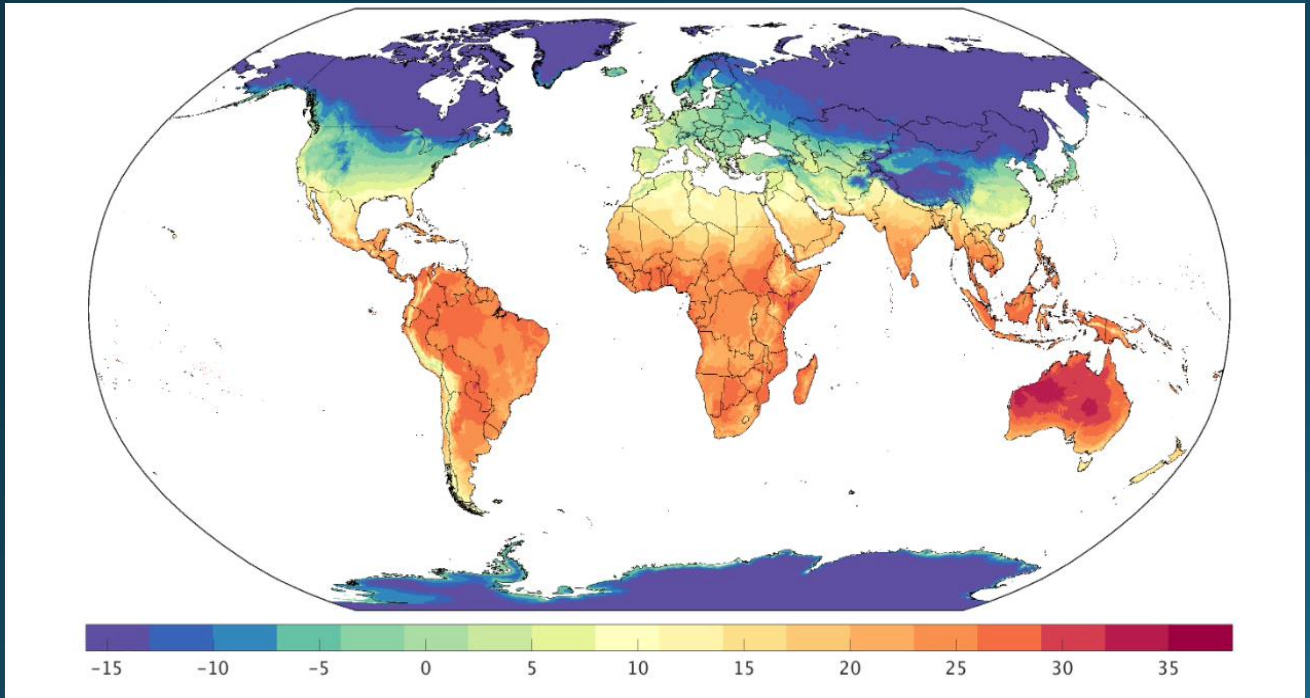
Maximum temperature
Minimum temperature
Precipitation

Derived Monthly Climate Variables:

Actual Evapotranspiration
Potential Evapotranspiration
Climate Water Deficit
Soil Moisture
Snow Water Equivalent

Climate Change Exposure - Methods

TerraClimate



Historical Norms (1981 – 2010)

Projected Global Mean +2° C

Projected Global Mean +4° C

https://www.climatologylab.org/terraclimate.html

Climate Change Exposure - Methods

Relative Climate Deviation (+2°C and +4°C)

92 unique climate variables

Historical Climate Norms

–

92 unique climate variables

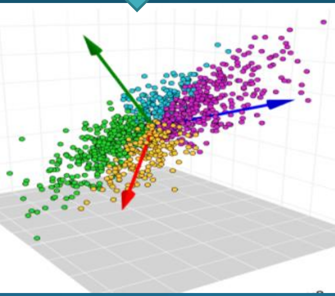
Climate Projections (+2°C and +4°C)

=

92 unique climate variables

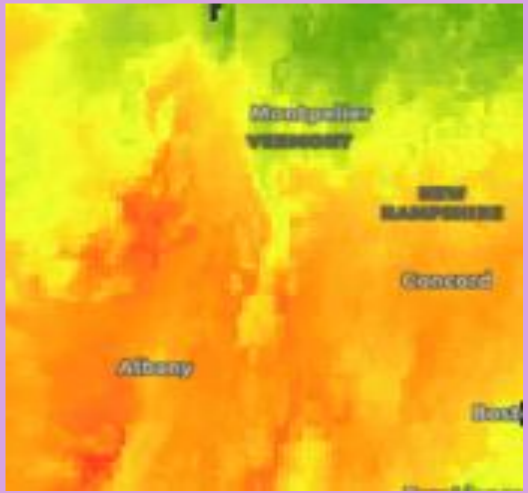
Climate Deviations (+2°C and +4°C)

Principal Component Analysis



1 PCA Layer

(+2°C and +4°C)

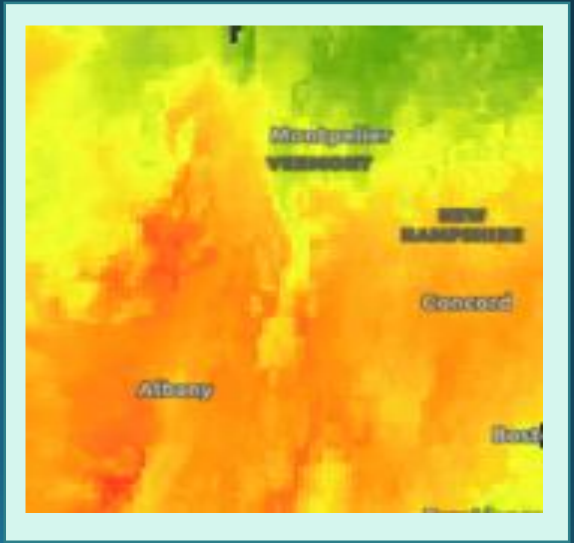


Climate Change Exposure - Methods

Relative Climate Deviation (+2°C and +4°C)

- Unit-less, aggregate metric
- quantifies relative deviation from climate norms
- Captures > 50% of the total variability in climate deviation across the region
- Dominated by deviations in SWE, AET, PET, Soil and PPT variables in the shoulder seasons

1 PCA Layer



NEW Data Layers

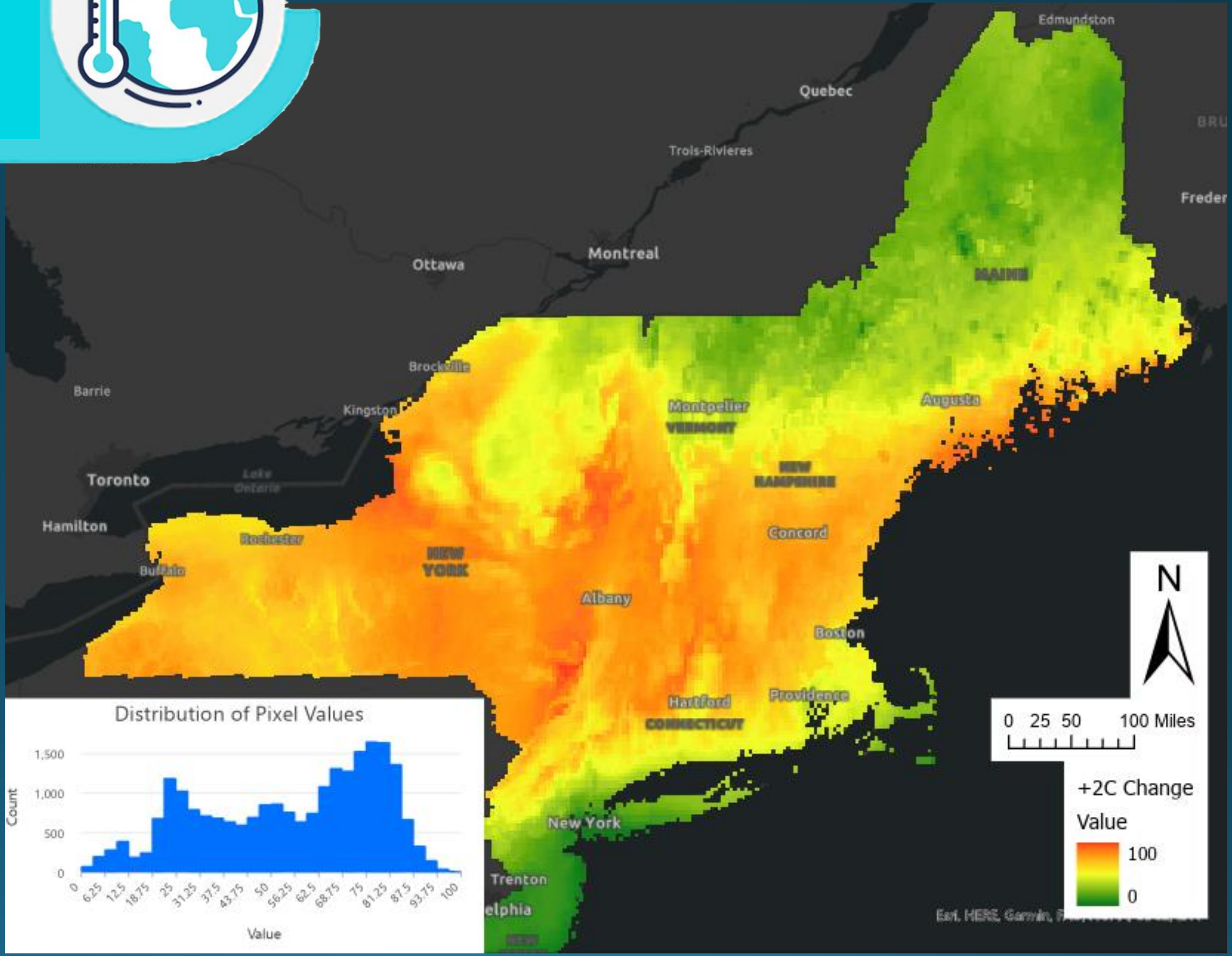
CLIM

CLIMATE DEVIATION

+2° C Scenario
+4° C Scenario

- Metric: Climate deviation from 30 year normal under +2° C and +4° C global mean temperature change
- Scale: 4km
- Source: TerraClimate PCA

Statistic	Value
Mean	55.0
Std. Dev	22.9
Range	[0, 100]
Median	60.0



Existing Data Layers

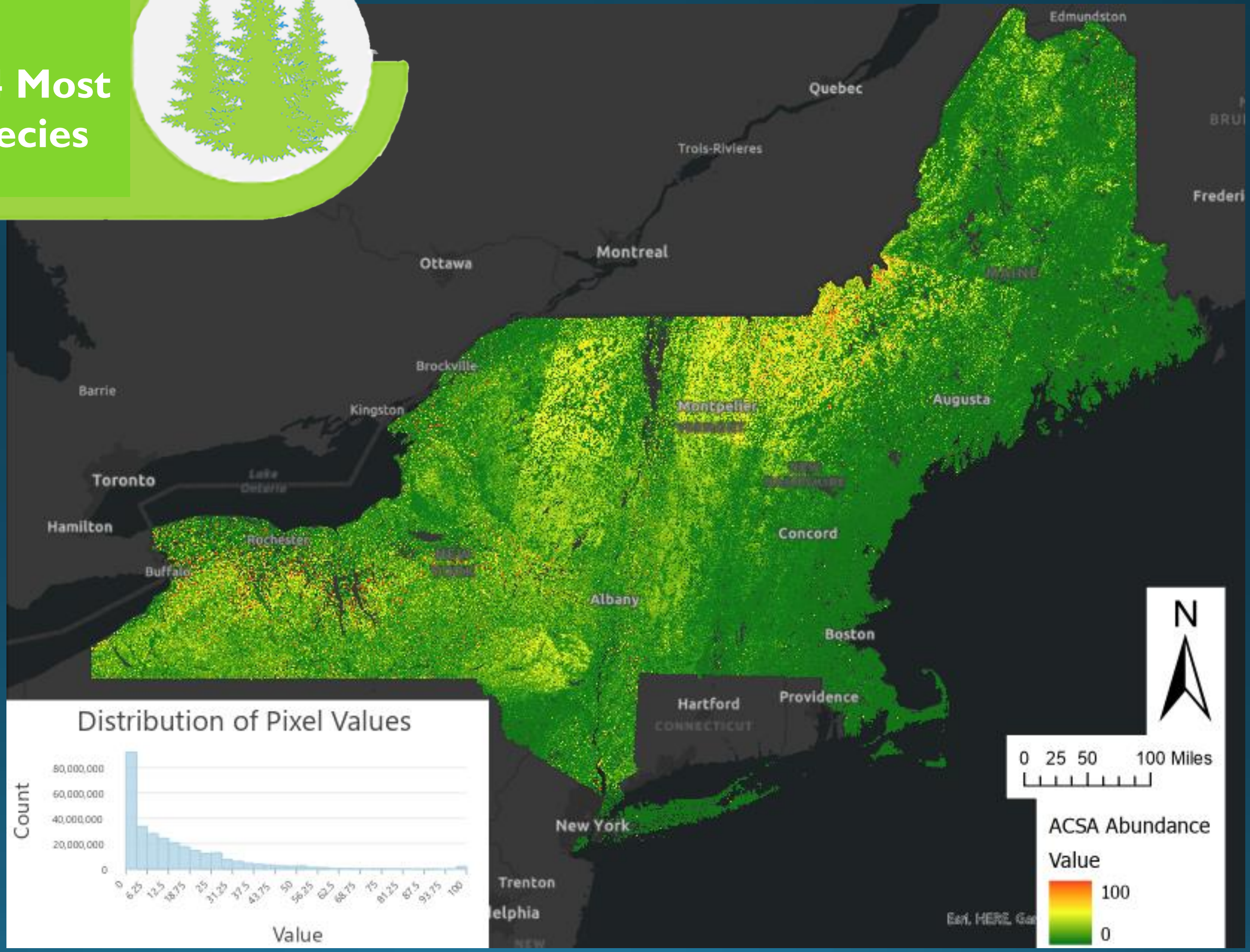
ABND

ABUNDANCE

New England's 14 Most Common Tree Species

- Metric: Percent of total basal area (0-100) – by species
- Scale: 30m
- Source: Gudex-Cross (2018) and FIA abundance

Statistic	Value
Mean	13.7
Std. Dev	16
Range	[0, 100]
Median	9.0



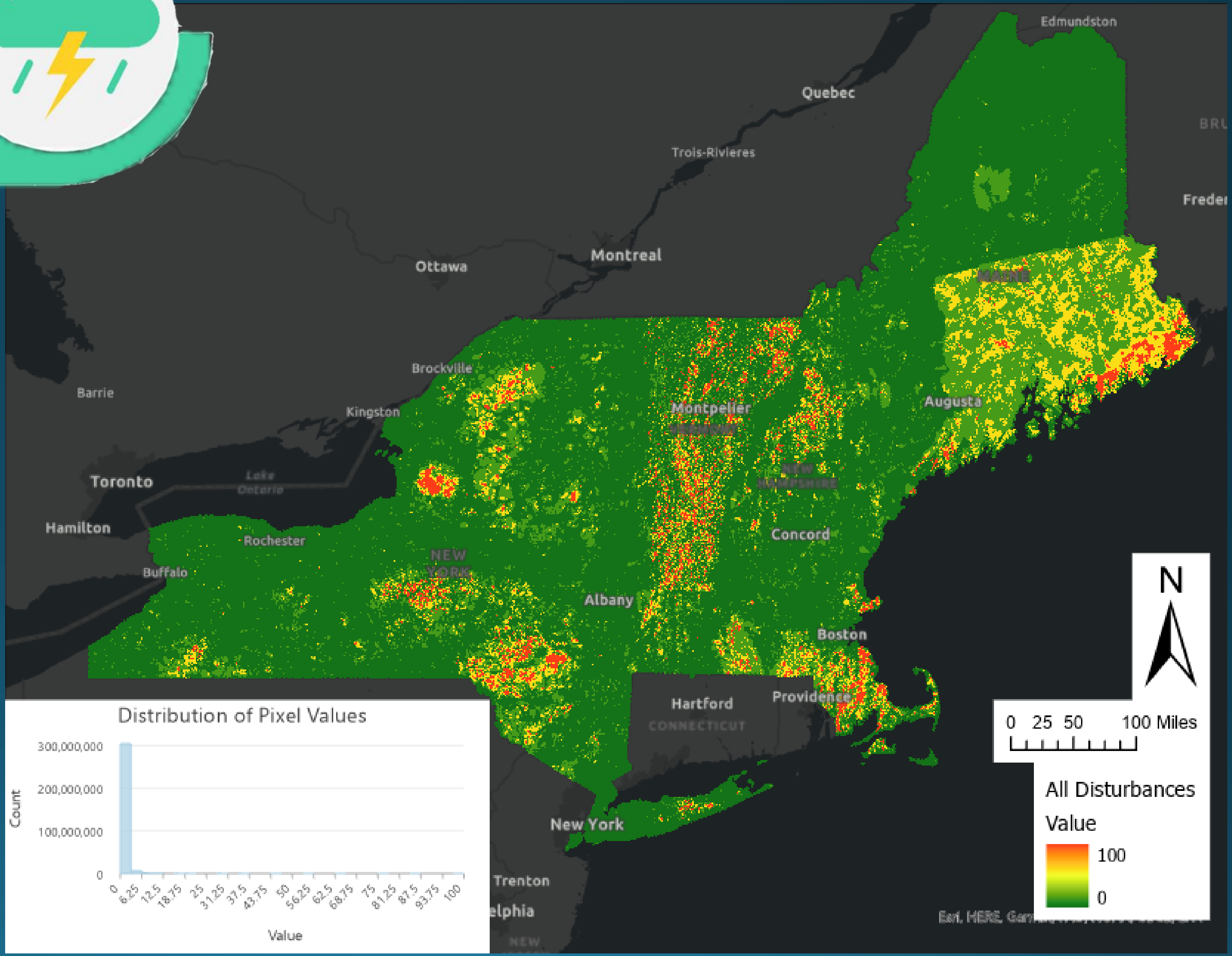
Existing Data Layers

DIST

DISTURBANCE

No Disturbance
Climate Disturbance
All Disturbance

- Source: FEMC - NE Forest Health Atlas
- Metric: Mapped count 1997-2020 (rescaled 0-100)
- Scale: 30 m
- Climate related only (Includes wind, flooding, drought, frost, and snow/ice events)
- All Disturbances (Includes all recorded disturbances (pests, pathogens, fire, etc.))



Derived Data Layers

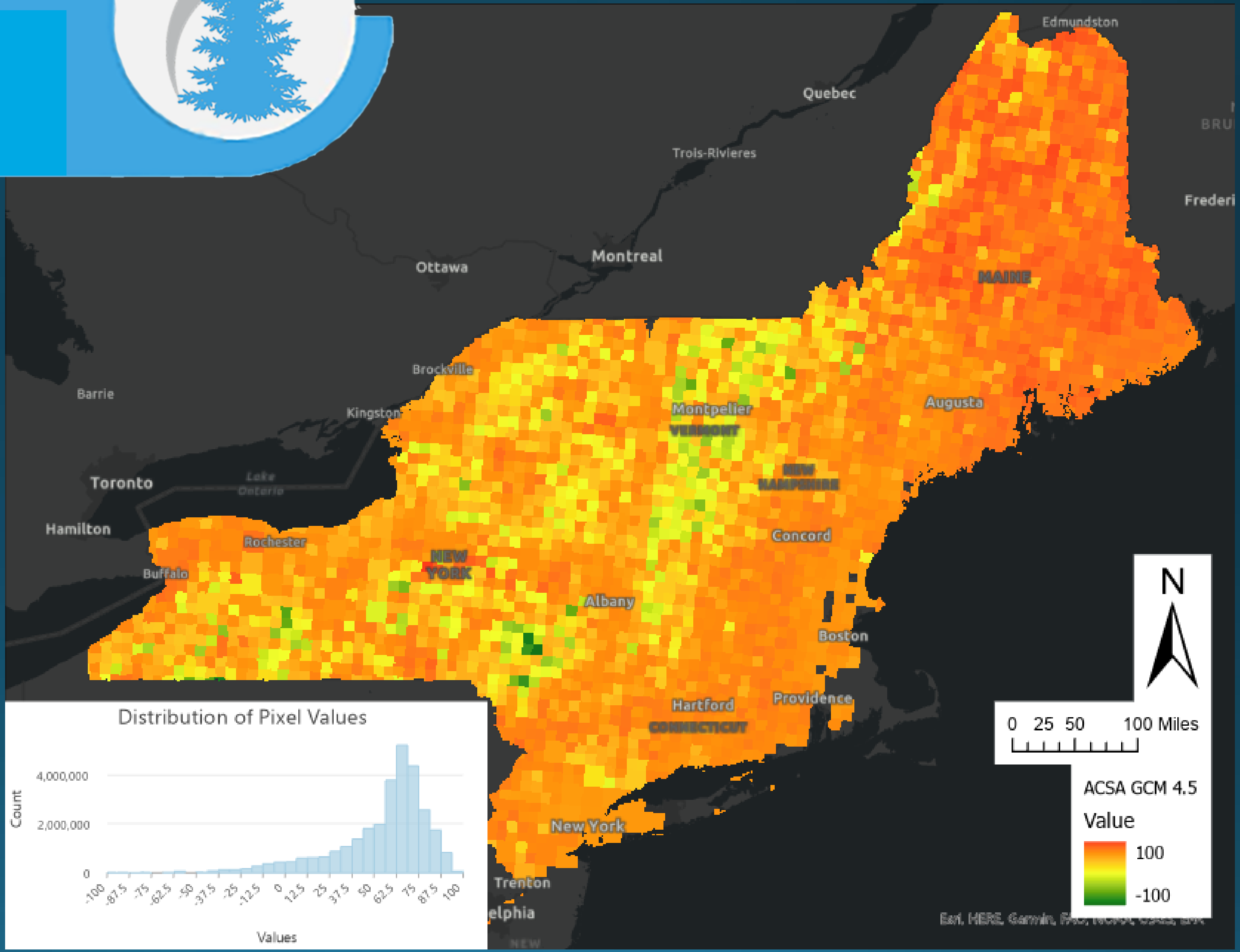
PCSH

PROJECTED CHANGE IN SUITABLE HABITAT

GCM 4.5 Scenario
GCM 8.5 Scenario
For each species

- Source: CCTA SHIFT maps via Matthew Peters (USFS)
- Metric: Change in Relative Importance Values (RIV) between current and GCM 4.5 and 8.5 scenarios – by species
- Scale: 100 m

Statistic	Value
Mean	54.52
Std. Dev	26.75
Range	[-100, 100]

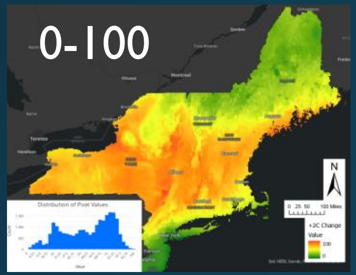


Climate Change Exposure - Methods

Aggregate Exposure – Species Level

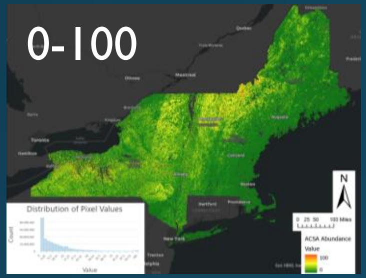
Simple Additive Calculation

0-100



+

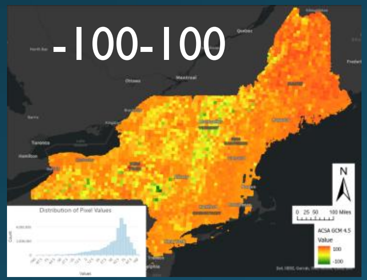
0-100



+

+

-100-100



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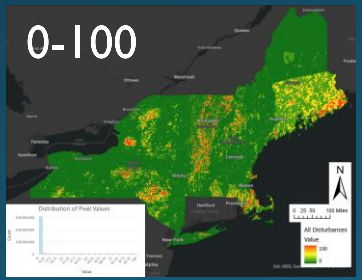
0-100



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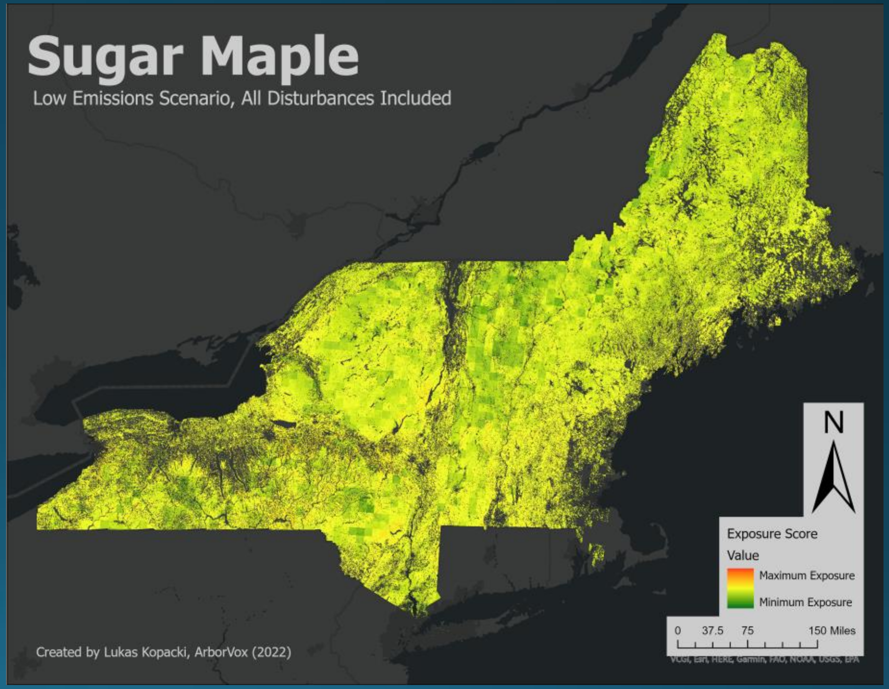
Relative Climate Exposure



-100
Low Exposure

400
High Exposure

Climate Change Exposure - Methods

Scenarios Run

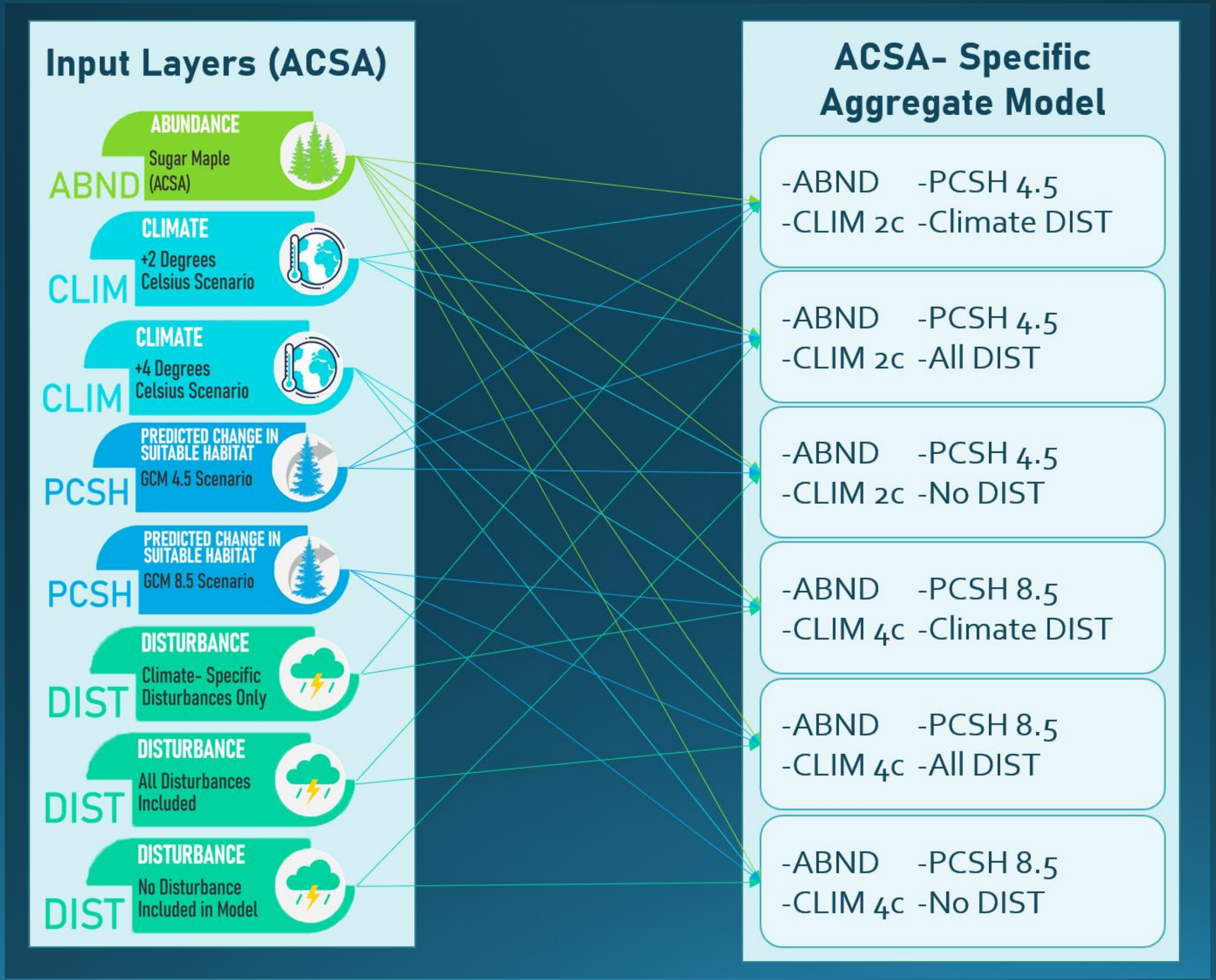
Repeat for Scenarios:

Climate:

- Low Emissions
- High Emissions

Disturbance

- None
- Climate Related
- All



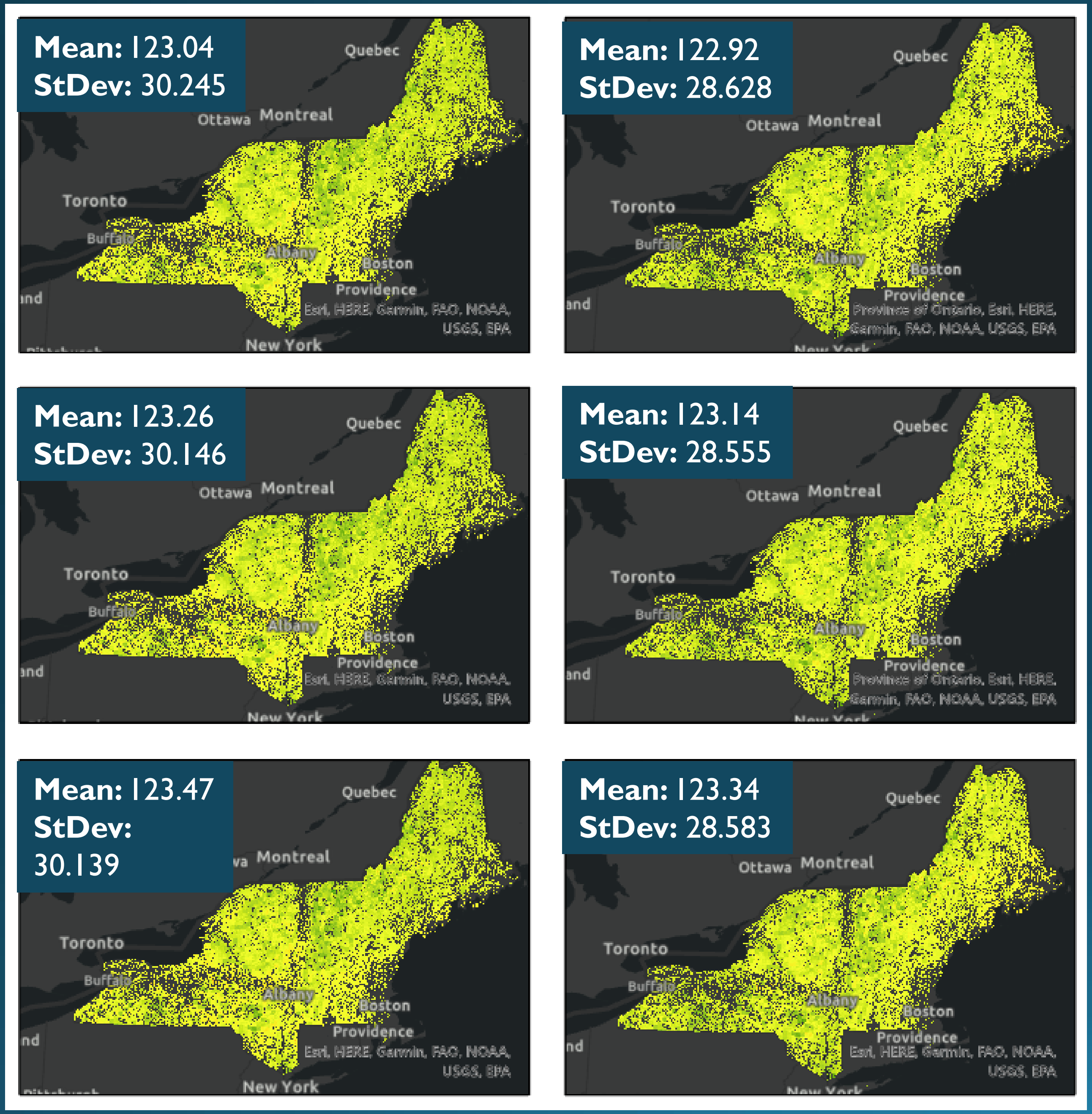
Sugar Maple

Low Emissions Scenario | High Emissions Scenario

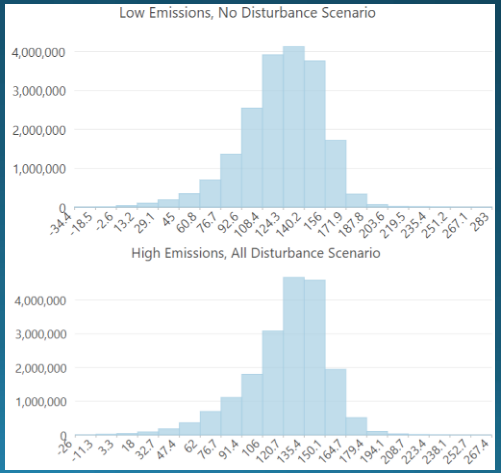
No Disturbance

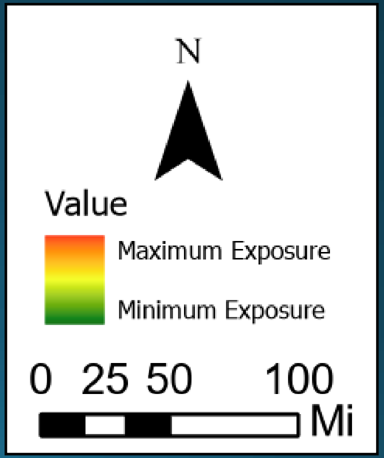
Climate Related Disturbance

All Disturbance



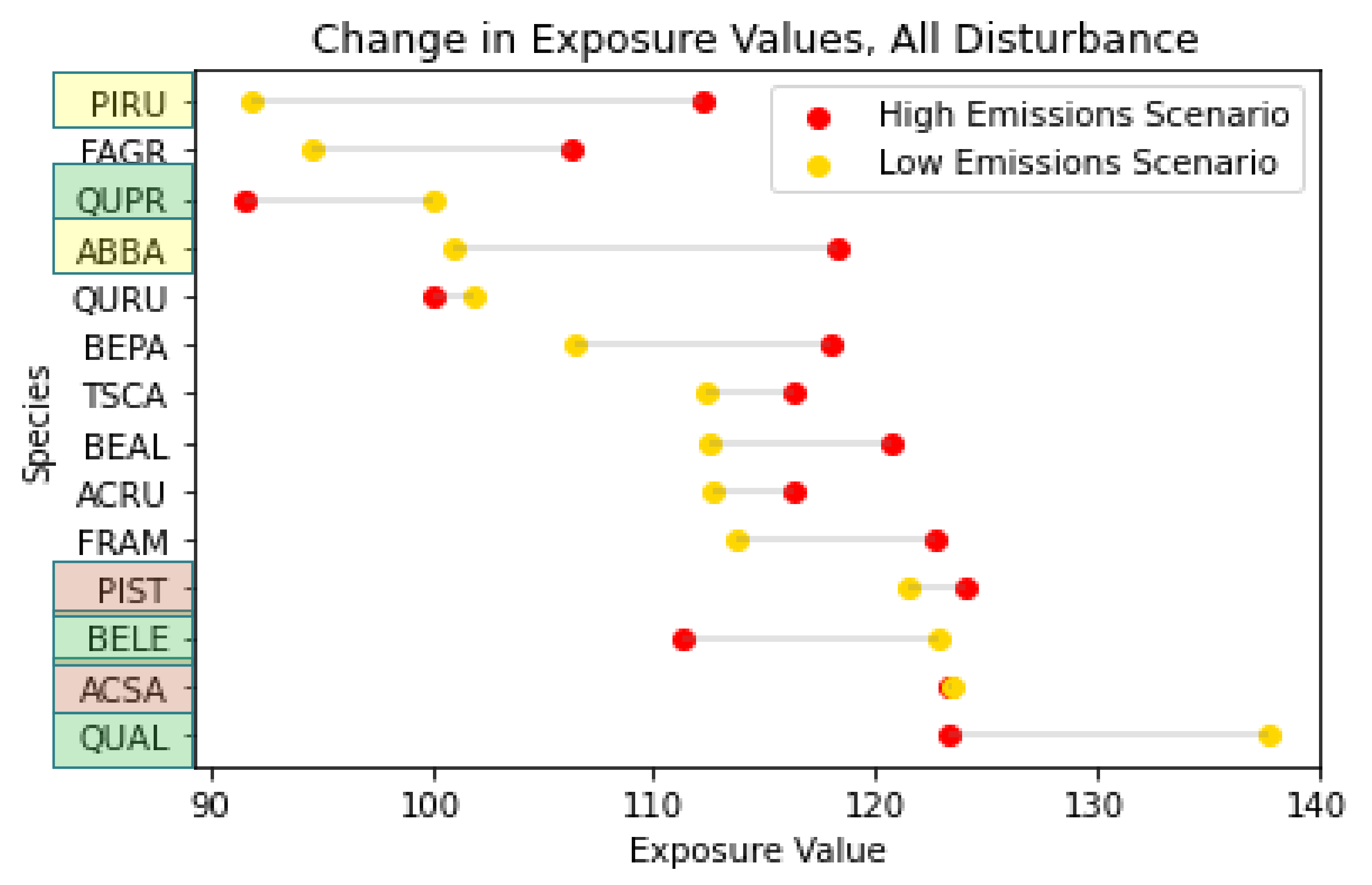
- Average exposure value: 123
  - 2nd highest among modeled species
- No significant difference between low and high scenarios
- High Exposure Regions: Mohawk, Hudson, & Susquehanna Valleys; eastern Catskills & White Mountains
- Low Exposure Regions: northern VT and NH, western Catskills





Distribution of Mean Exposure Value by Species

Species	Code
Balsam Fir	ABBA
Red Maple	ACRU
Sugar Maple	ACSA
Yellow Birch	BEAL
Black Birch	BELE
Paper Birch	BEPA
American Beech	FAGR
White Ash	FRAM
Red Spruce	PIRU
Eastern White Pine	PIST
White Oak	QUAL
Chestnut Oak	QUPR
Northern Red Oak	QURU
Eastern Hemlock	TSCA



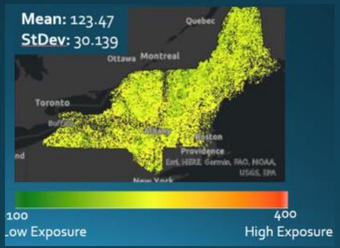
Exposure high but stable	= climate “limbo”
Exposure increases with increasing emissions	= climate "losers"
Exposure decreases with increasing emissions	= climate "winners"

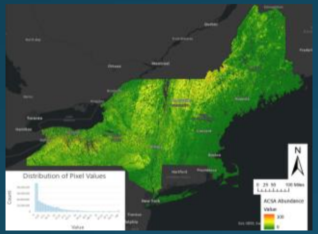
Climate Change Exposure - Methods

Aggregate Exposure – Stand Level (Ecosystem Aggregate)

For each 30m pixel

Species Exposure × Species % BA = **Species Weighted Exposure**





Repeat for all species, sum weighted exposure scores

$$\frac{\Sigma\ (\text{All Species Weighted Exposures})}{\Sigma(\text{All Species \% Basal Area})}$$

Stand Level Exposure

-100
Low Exposure

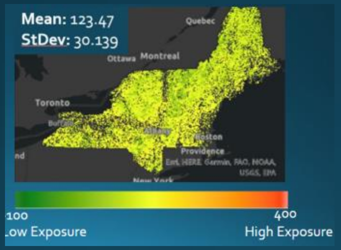
400
High Exposure

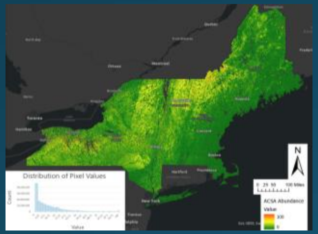
Climate Change Exposure - Methods

Aggregate Exposure – Stand Level (Ecosystem Aggregate)

For each 30m pixel

Species Exposure × Species % BA = **Species Weighted Exposure**





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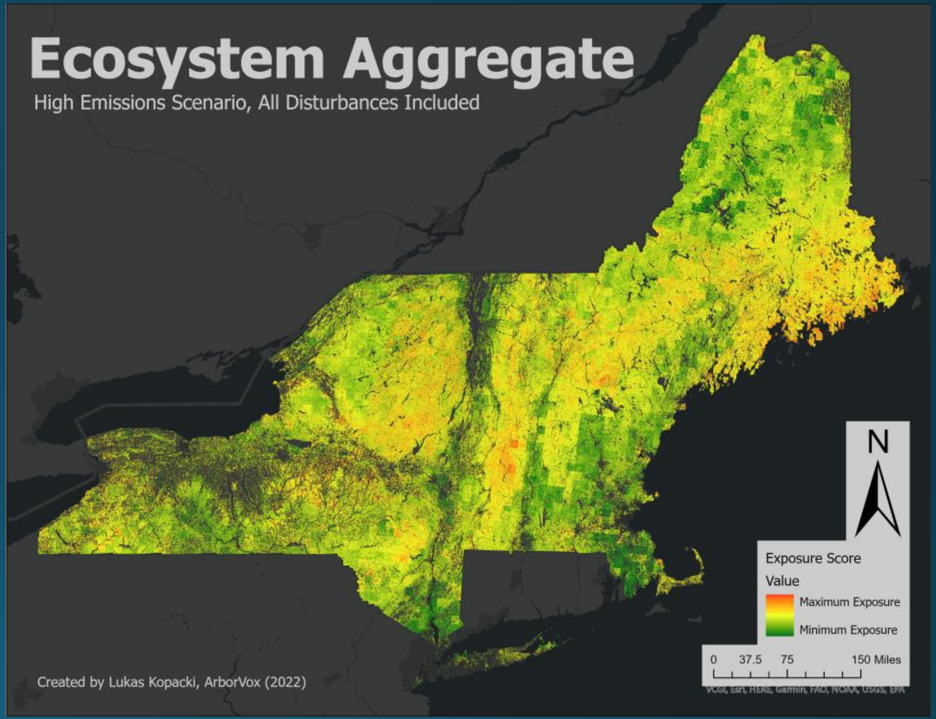
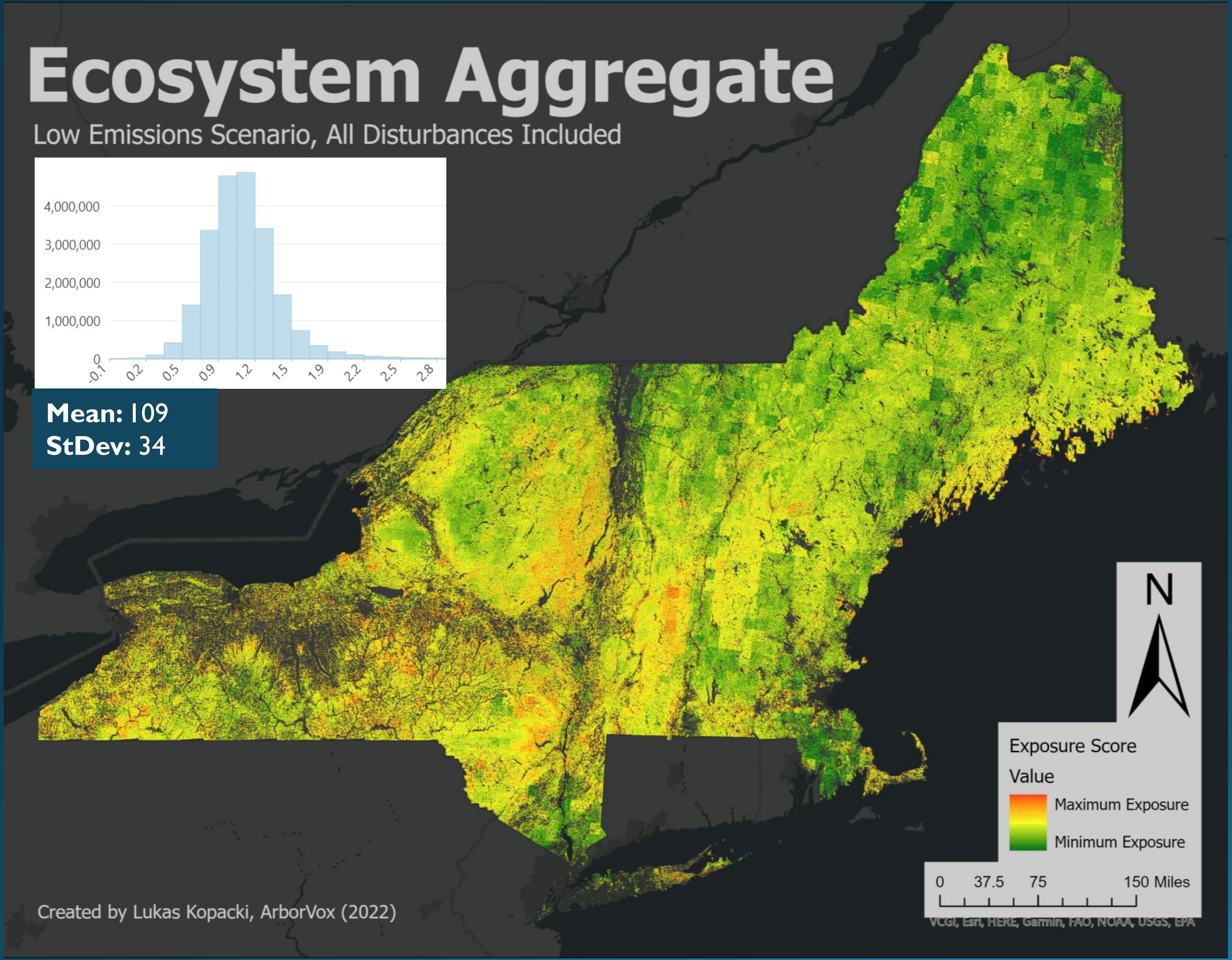


Stand Level Exposure

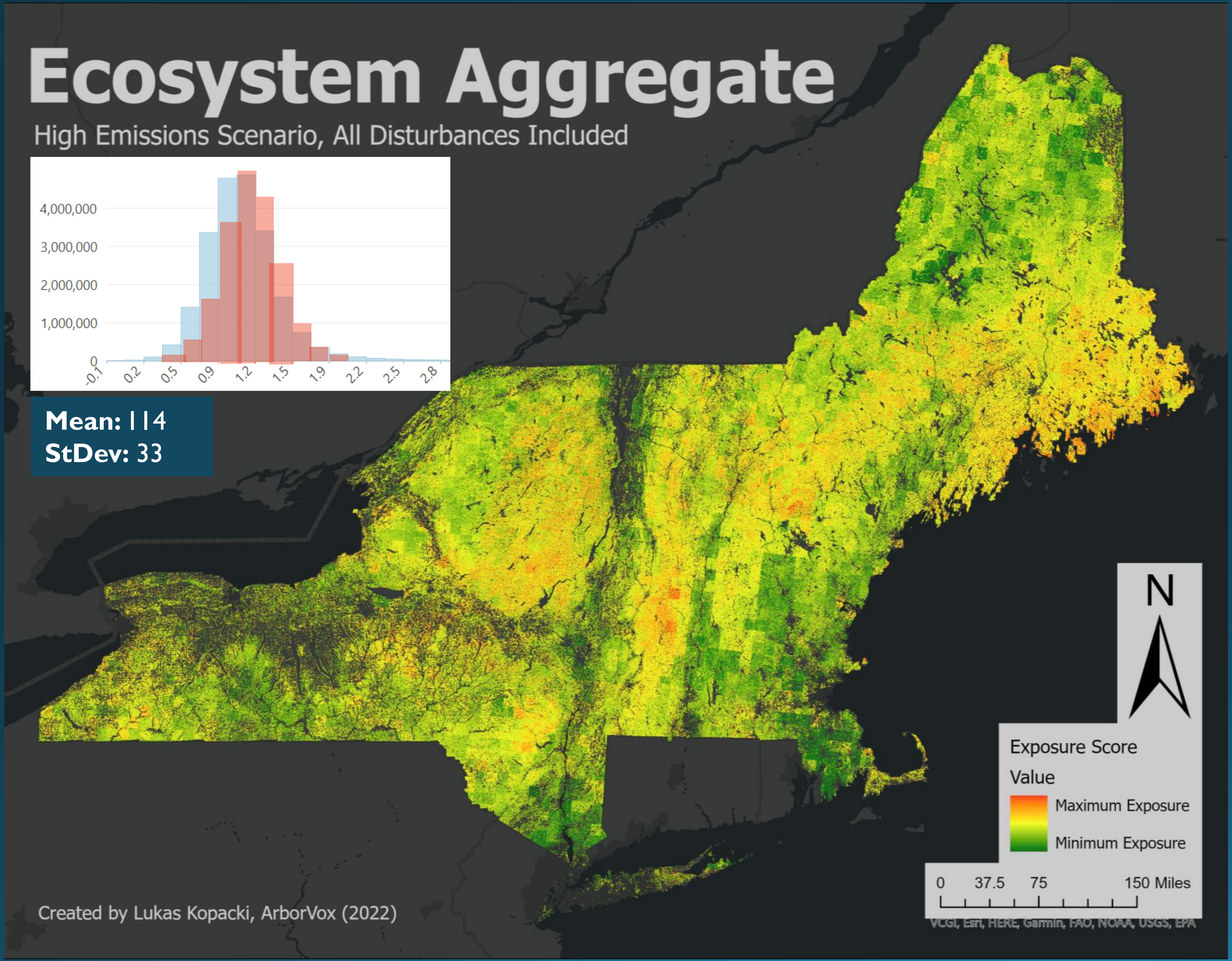
-100 Low Exposure

400 High Exposure



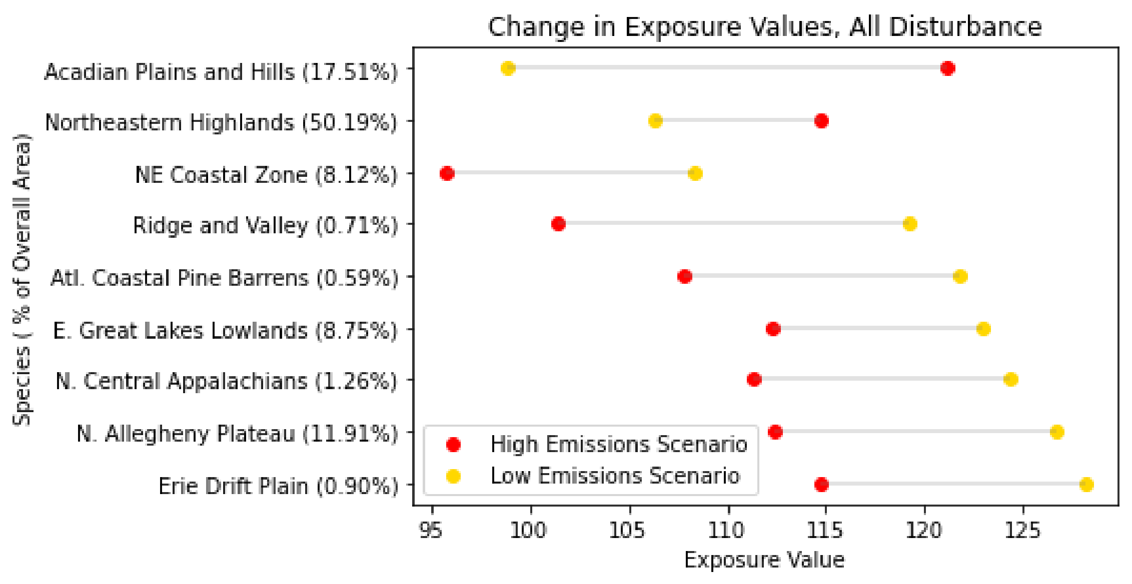
Low Emissions, All Disturbance

- Average Exposure across all species present in any given pixel
- High stand-level Exposure :
  - •Catskills,
  - •Eastern Adirondacks,
  - •Southern Green/ Berkshire Mountains,
  - •White Mountains,
  - •Mohawk River valley
- Low stand-level Exposure :
  - • Coastal Massachusetts (excluding Cape Cod),
  - •Northern Maine/ New Hampshire,
  - •Hudson Highlands

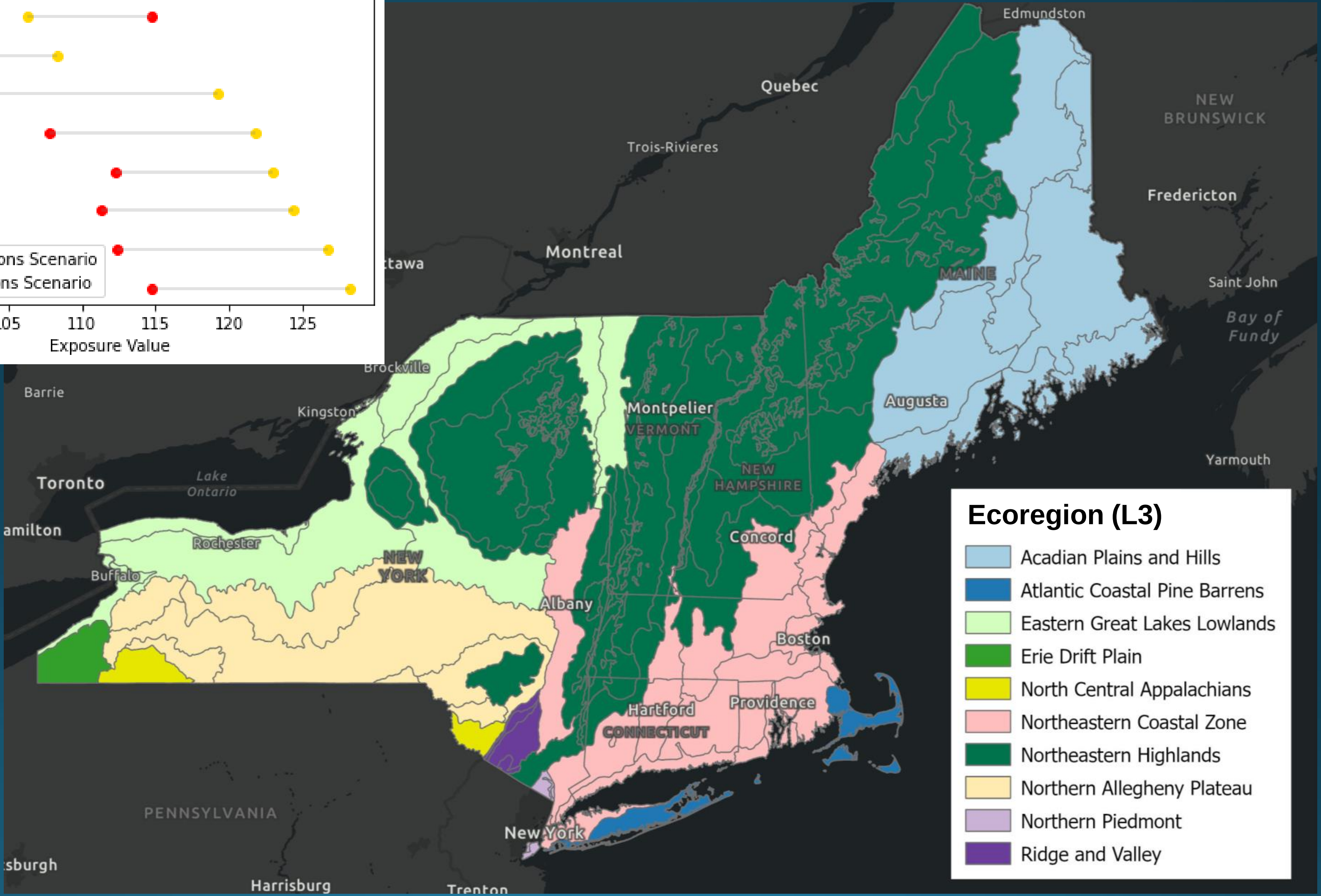


High Emissions, All Disturbance

- A ~4% increase in exposure was observed between 2c and 4c scenarios across the region.
- Driven primarily by increases at the low end of exposure values
- High stand-level Exposure :
  - High elevation regions (Catskills, Adirondacks, Greens, Berkshires, Whites)
  - Mohawk River valley
  - Downeast Maine
- Low stand-level Exposure :
  - Major river valleys
  - Southern New York
  - Coastal Massachusetts
  - Northern Maine
  - Hudson Highlands



Ecoregion Differences for Ecosystem Aggregate



Climate Change Exposure – Conclusions

- Across the region forested ecosystems will be exposed to changing climate conditions, with potential impacts on forest health, disturbance patterns and competition dynamics.
- In our region, exposure is driven primarily by changes in shoulder season climate metrics and projected changes in suitable habitat

Climate Change Exposure – Conclusions

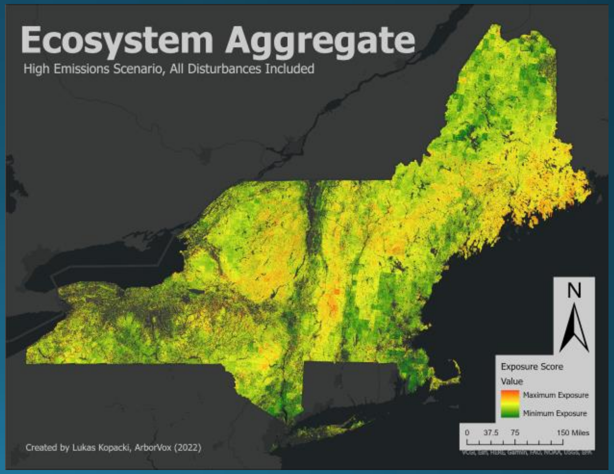
- Exposure differs across species
  - Potential exposure "winners": QUAL, QUPR, BELE
  - Potential exposure "losers": PIRU, ABBA
  - Exposure stable/high: ACSA, PIST

Oak dominant – Mixed Hardwood systems

Spruce-Fir systems

Northern Hardwood systems

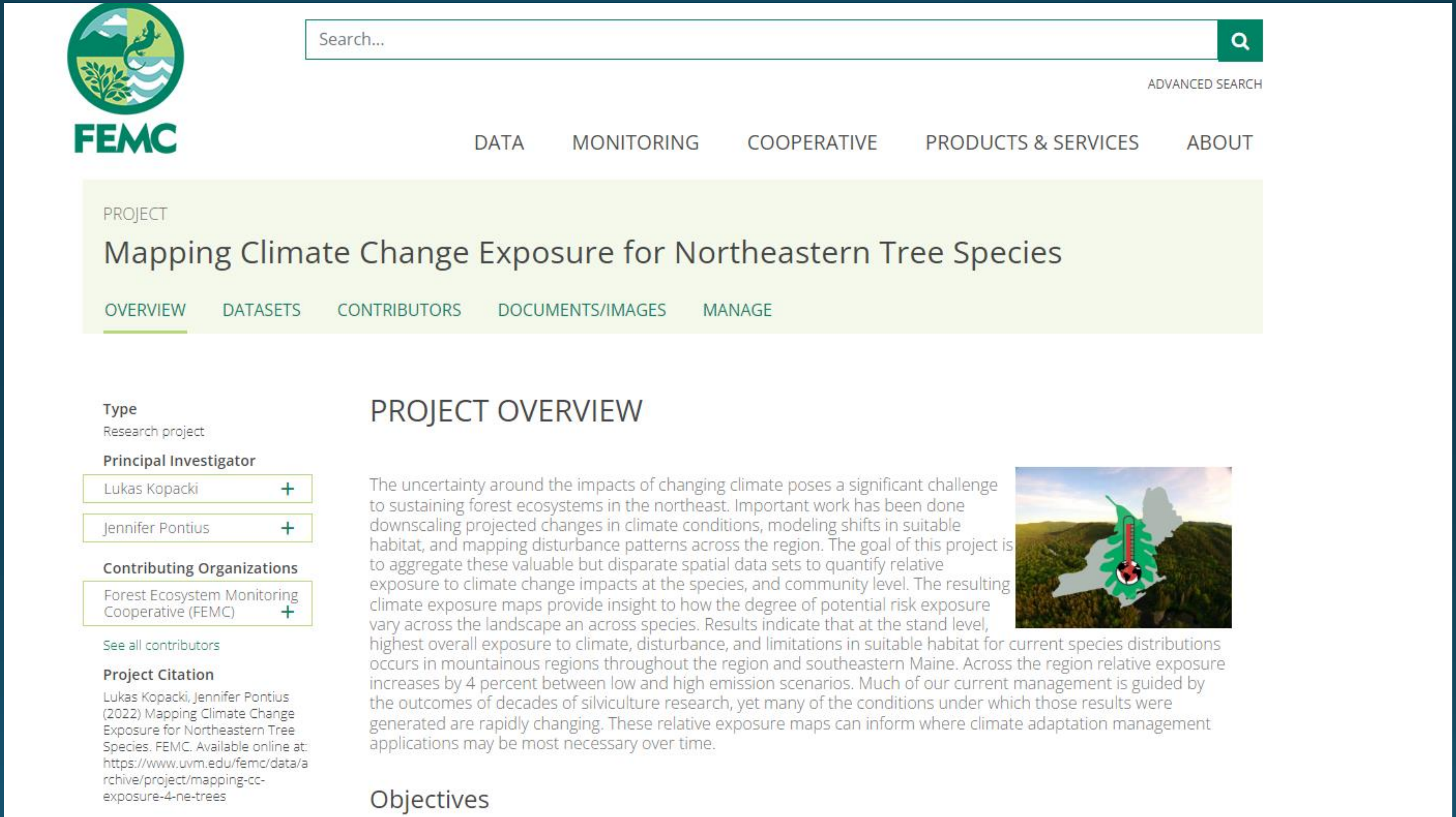
- Exposure differs across the region
  - <u>High Exposure:</u> Northeastern Highlands, Acadian Plains and Hills
  - <u>Low Exposure:</u> Southern NE and NY, NE Coastal Zone



Climate Change Exposure – Next Steps

- Exposure model validation vs forest inventory data
- Interpretation guide
- Stakeholder engagement:
  - How is this data useful?
  - Guidelines for integrating with targeted adaptive management efforts?
- Data access and application support

Climate Change Exposure – Data Access



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PROJECT

Mapping Climate Change Exposure for Northeastern Tree Species

OVERVIEW | DATASETS | CONTRIBUTORS | DOCUMENTS/IMAGES | MANAGE

Type
Research project

Principal Investigator
Lukas Kopacki +
Jennifer Pontius +

Contributing Organizations
Forest Ecosystem Monitoring Cooperative (FEMC) +

See all contributors

Project Citation
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PROJECT OVERVIEW

The uncertainty around the impacts of changing climate poses a significant challenge to sustaining forest ecosystems in the northeast. Important work has been done downscaling projected changes in climate conditions, modeling shifts in suitable habitat, and mapping disturbance patterns across the region. The goal of this project is to aggregate these valuable but disparate spatial data sets to quantify relative exposure to climate change impacts at the species, and community level. The resulting climate exposure maps provide insight to how the degree of potential risk exposure vary across the landscape an across species. Results indicate that at the stand level, highest overall exposure to climate, disturbance, and limitations in suitable habitat for current species distributions occurs in mountainous regions throughout the region and southeastern Maine. Across the region relative exposure increases by 4 percent between low and high emission scenarios. Much of our current management is guided by the outcomes of decades of silviculture research, yet many of the conditions under which those results were generated are rapidly changing. These relative exposure maps can inform where climate adaptation management applications may be most necessary over time.

Objectives

https://www.uvm.edu/femc/data/archive/project/mapping-cc-exposure-4-ne-trees