



National Aeronautics and
Space Administration



Central Park Ecological Conservation II

Assessing Drought and Vegetation Health
Conditions in New York City's Central Park
with Earth Observation Data

Lucas Chuk, Tessa DeMann, Mel Guo, & Charlie Orben
(Analytical Mechanics Associates)

Pop-Up Project – Hunter College | Summer 2025



Outline

01



Project Overview

Concerns & Objectives

02



Methodology

Earth Observations & Methods

03



Results

2002 Drought Analysis

2024 Flash Drought Analysis

04



Conclusions

Results & Uncertainties

05



Feasibility

Partner Implementation



Lucas Chuk



Tessa DeMann



Mel Guo



Charlie Orben



Study Area & Period

New York City's
Central Park 🌳

January 1986 to
📅 July 2025



Image Credit: NAIP

Basemap Credit: Esri, NYC Planning, NYC Open Data 3



Partner – Central Park Conservancy

Serve the People:
Past, Present, and Future

Image Credit: Central Park Conservancy



Community Concerns



Green Space Accessibility



Vegetation Health



Environmental Sustainability Framework

Image Credit: Lucas Chuk



Image Credit: Lucas Chuk



Objectives

01



Compare satellite-derived indices to meteorological drought conditions

02



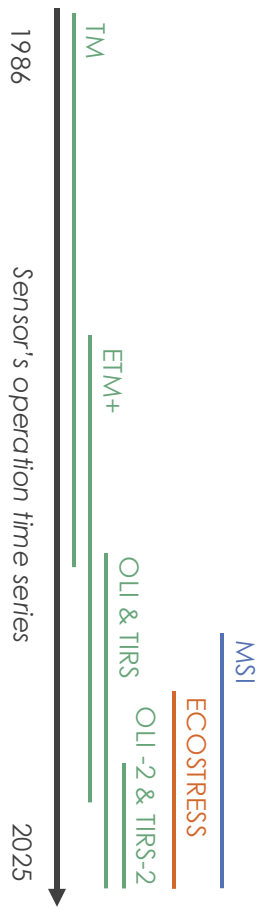
Analyze vegetation response to key drought events

03



Identify drought-vulnerable zones within Central Park

Earth Observations



Harmonized Data (HLS)
LS8, LS9 & S-2

Sentinel-2 MSI
Vegetation Greenness,
Vegetation Moisture
Stress

Landsat 5 TM | Landsat 8 OLI & TIRS
Landsat 7 ETM+ | Landsat 9 OLI-2 & TIRS-2
Vegetation Greenness,
Vegetation Moisture
Stress

ISS ECOSTRESS
Evapotranspiration



Image Credit: NASA, Rama

Previous Term – Summer 2024



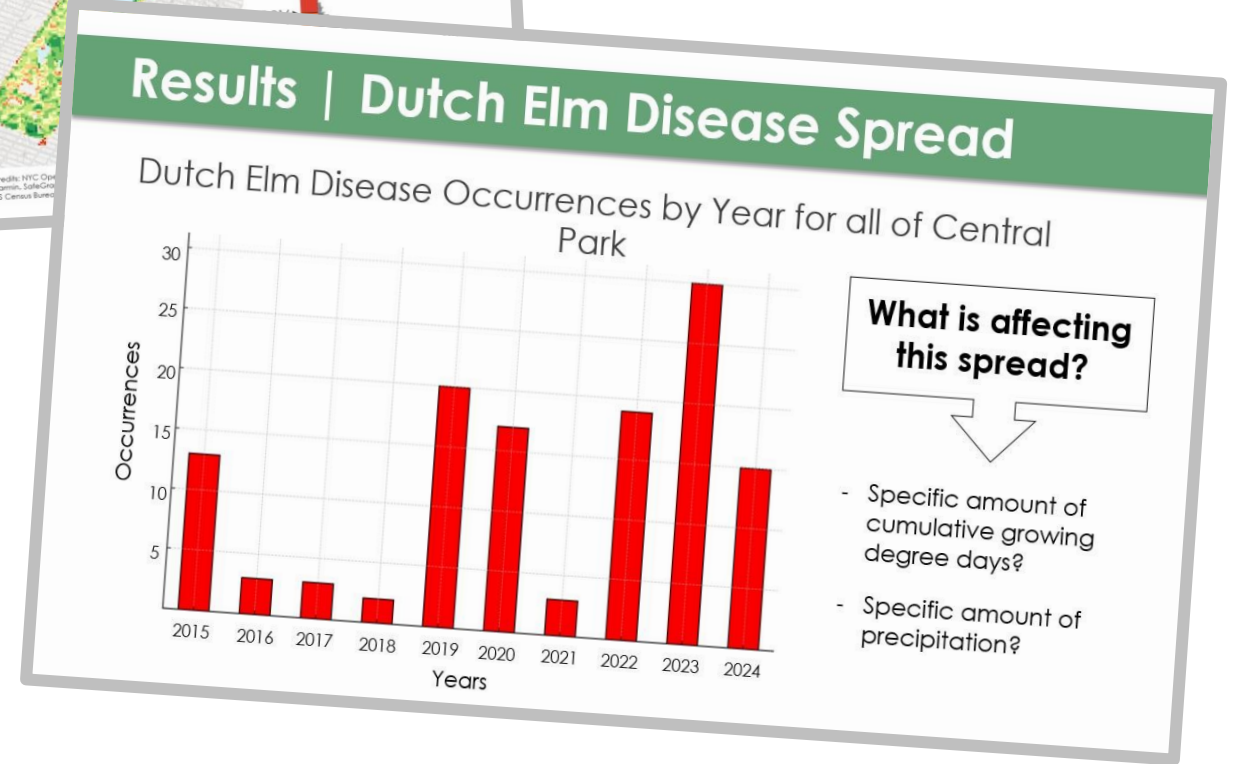
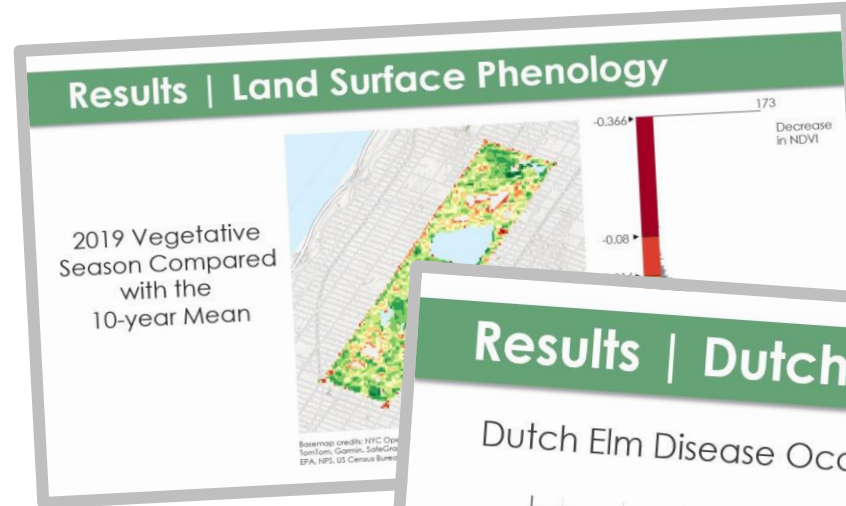
Dutch Elm Disease



Growing Degree Days

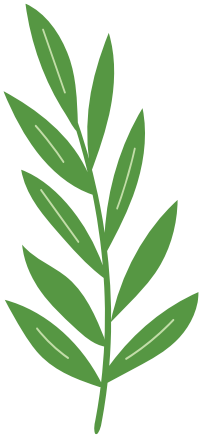


Land Surface Phenology



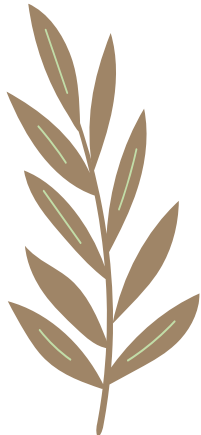
Normalized Difference Vegetation Index (NDVI)

HEALTHY



NDVI = 0.72

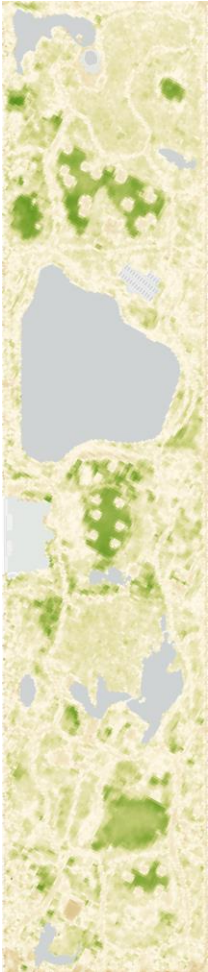
STRESSED



NDVI = 0.25

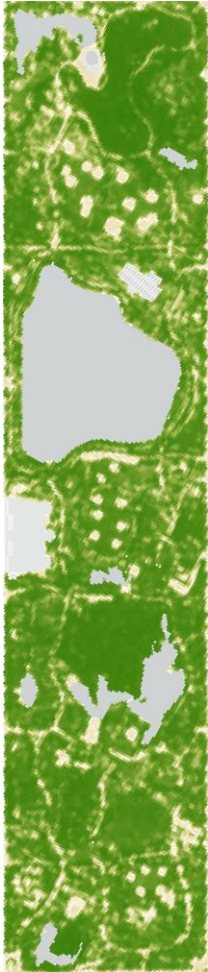
$$\text{NDVI} = \frac{\text{Near Infrared} - \text{RED}}{\text{Near Infrared} + \text{RED}}$$

Winter

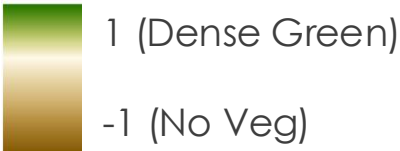


January 27, 2022

Summer

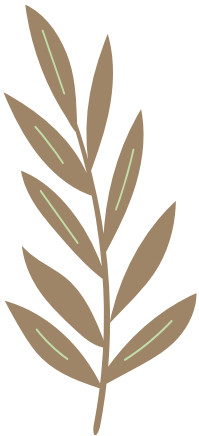


July 7, 2022



Moisture Stress Index (MSI)

STRESSED



MSI = 1.4

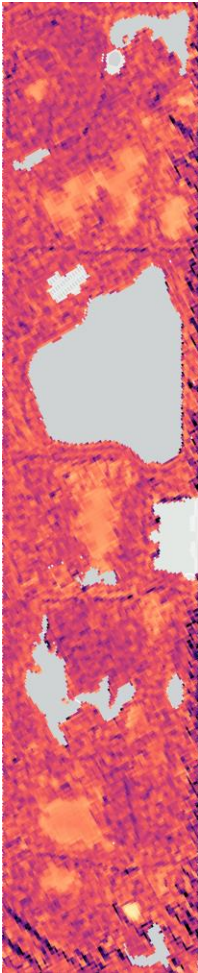
HEALTHY



MSI = 0.32

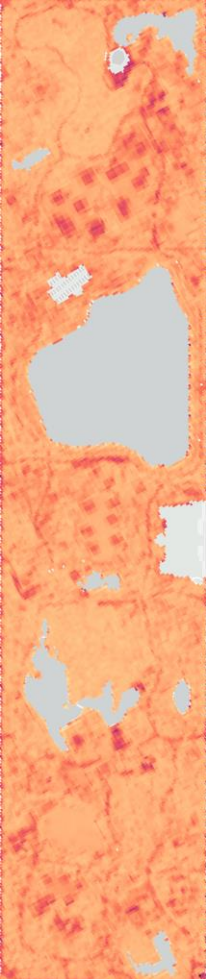
$$\text{MSI} = \frac{\text{Shortwave Infrared}}{\text{Near Infrared}}$$

Winter

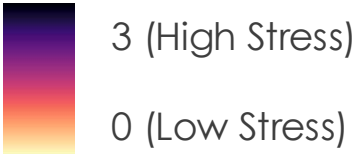


January 27, 2022

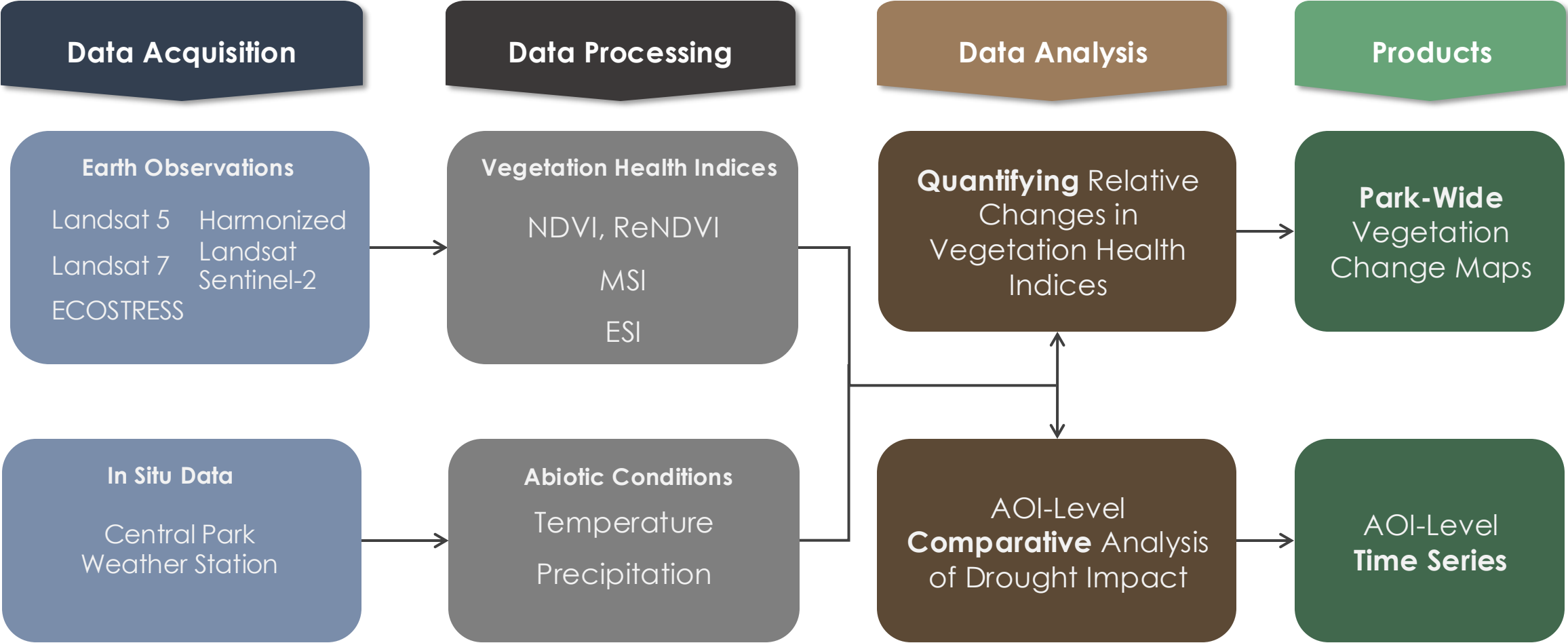
Summer



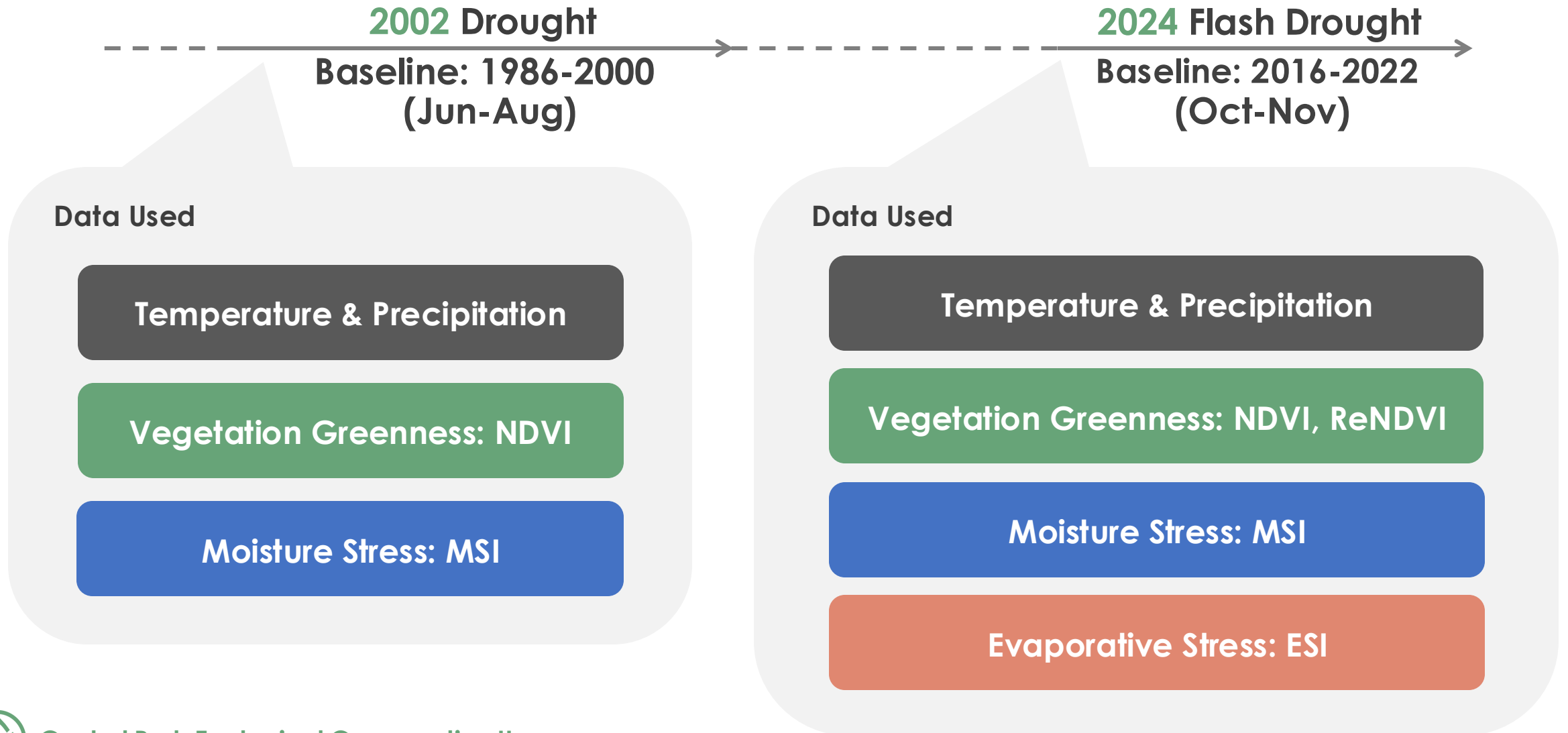
July 7, 2022



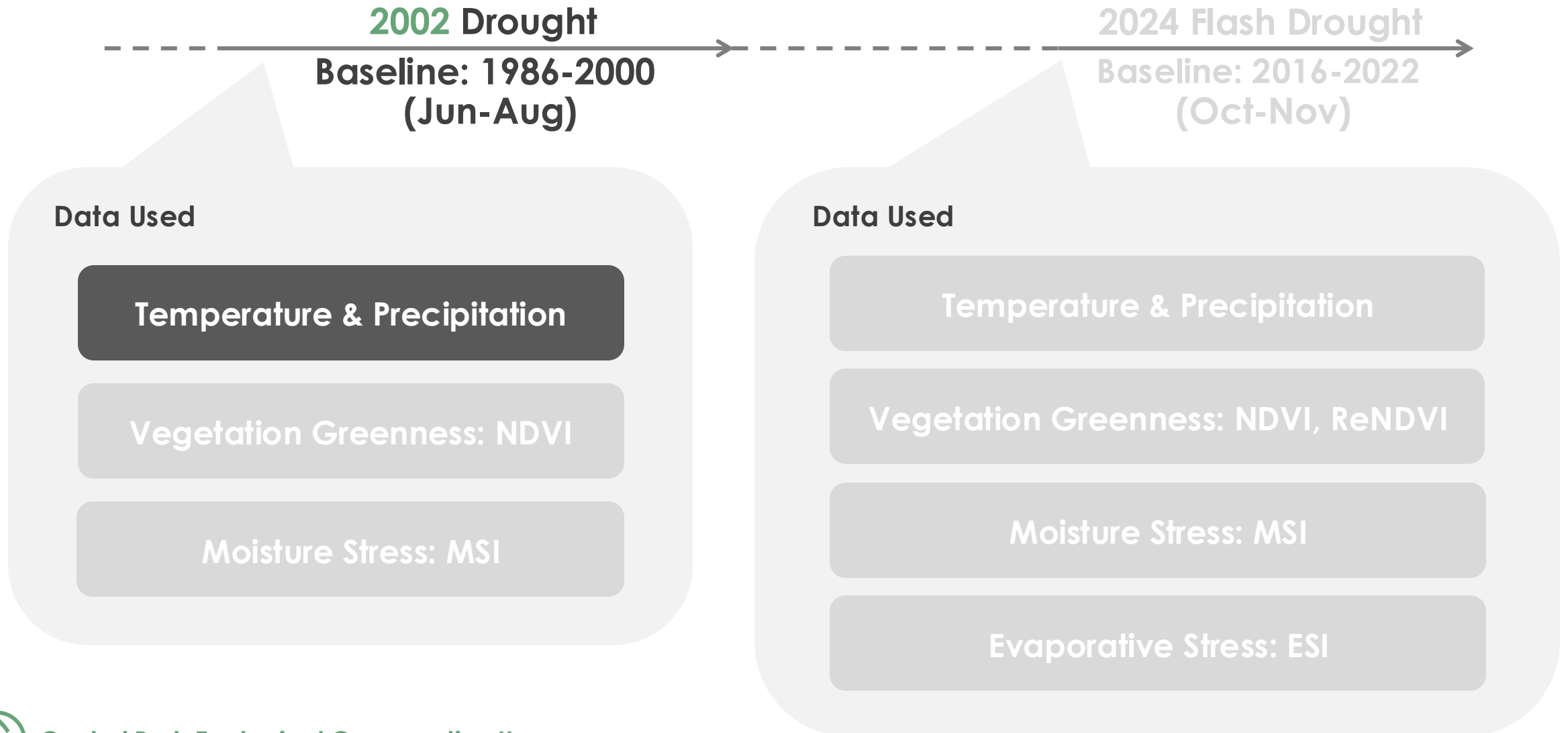
Methodology



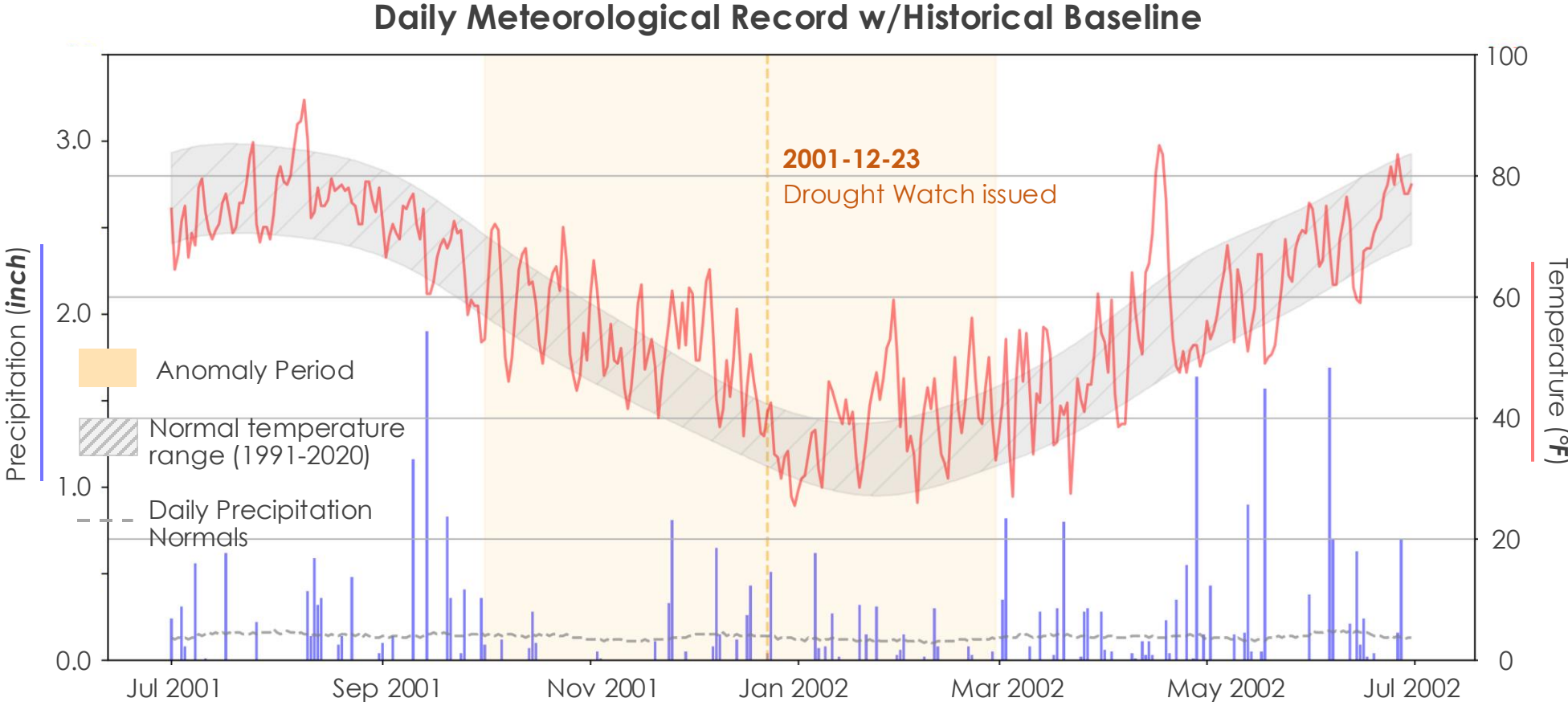
Results – Roadmap



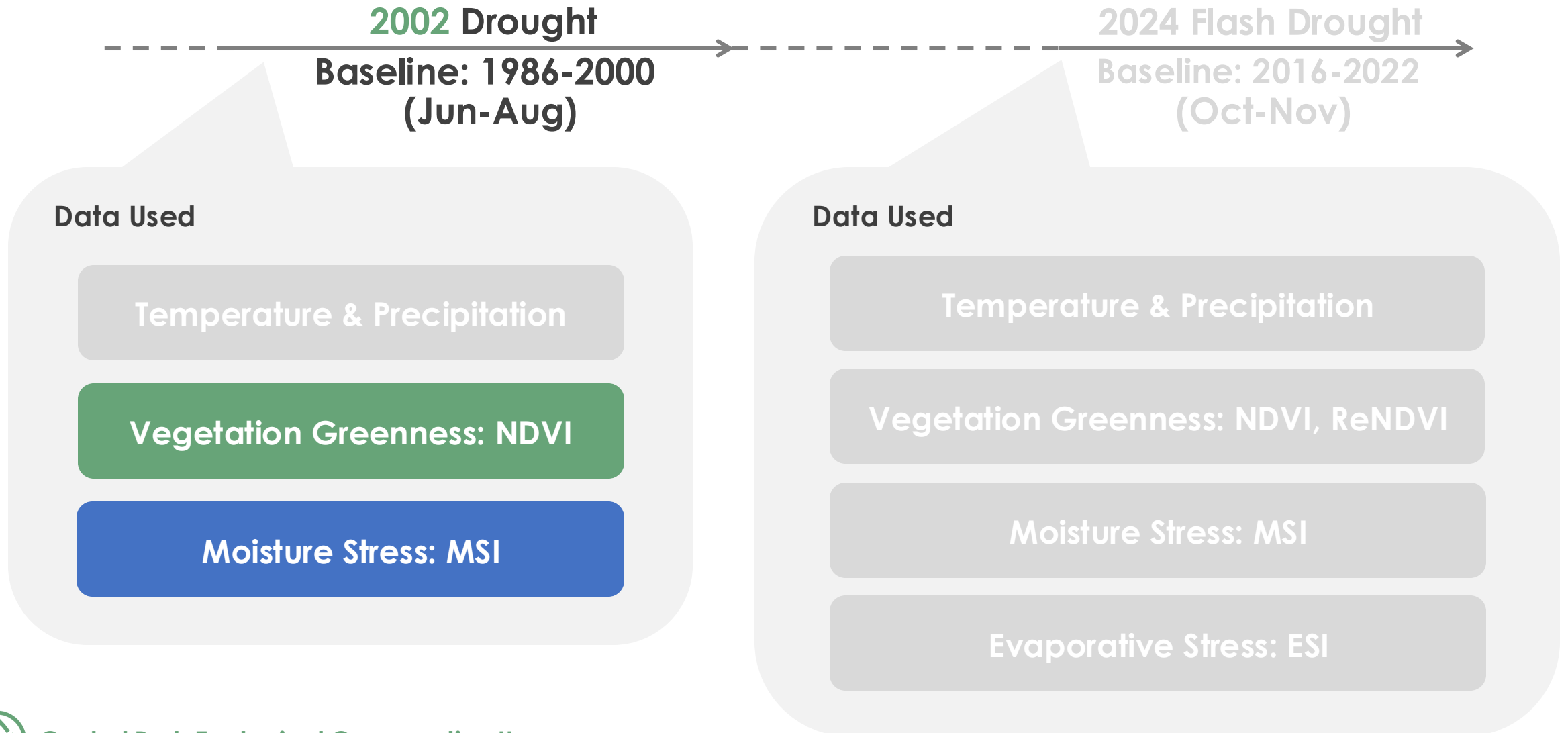
Results – Roadmap



2002 Drought – Meteorological Record



Results – Roadmap



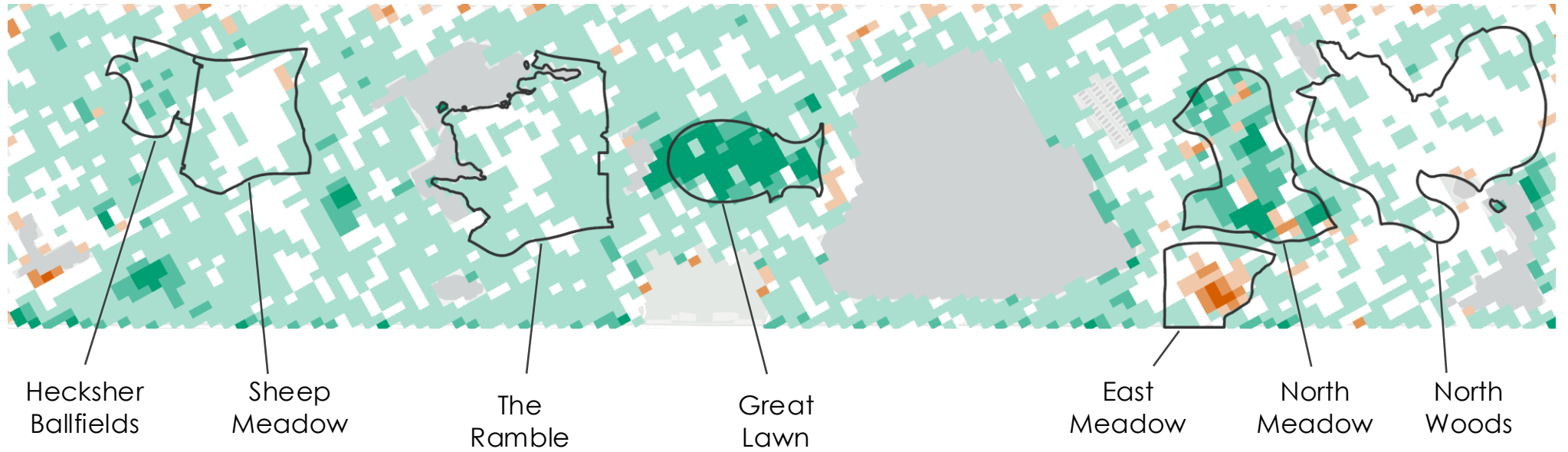
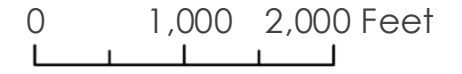
Summer 2001 Relative NDVI



% Change Compared to Baseline



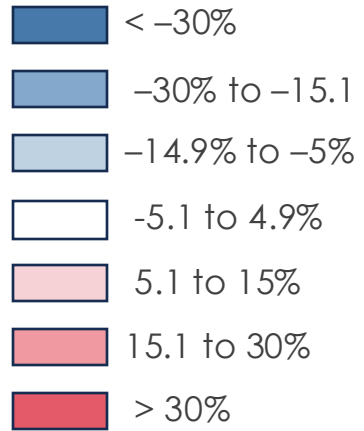
Baseline: Median Jun-Aug 1986-2000



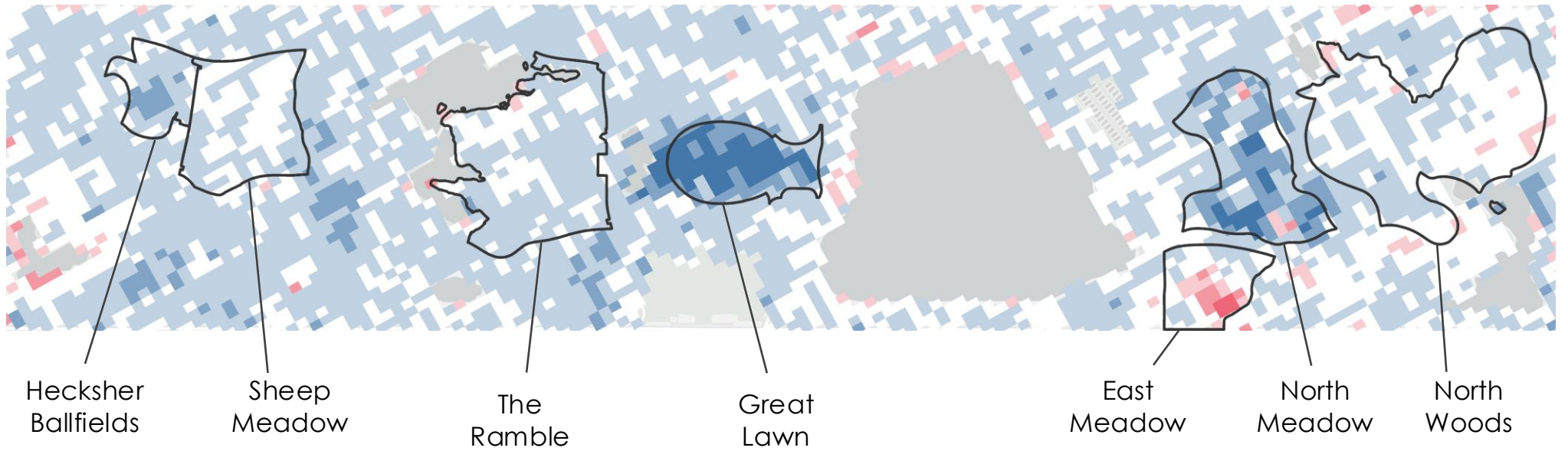
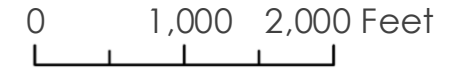
Summer 2001 Relative MSI



% Change Compared to Baseline



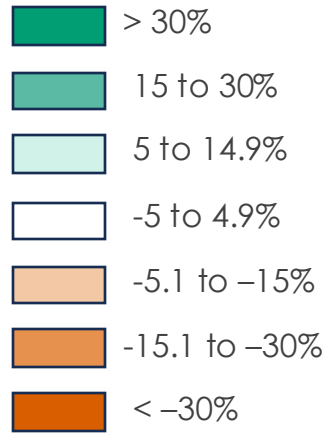
Baseline: Median Jun-Aug 1986-2000



Summer 2001 Relative NDVI/MSI

Pre-
During- Drought
Post-

NDVI Percent Change



Baseline: Median Jun-Aug 1986-2000



Hecksher
Ballfields

Sheep
Meadow

The
Ramble

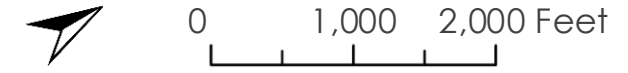
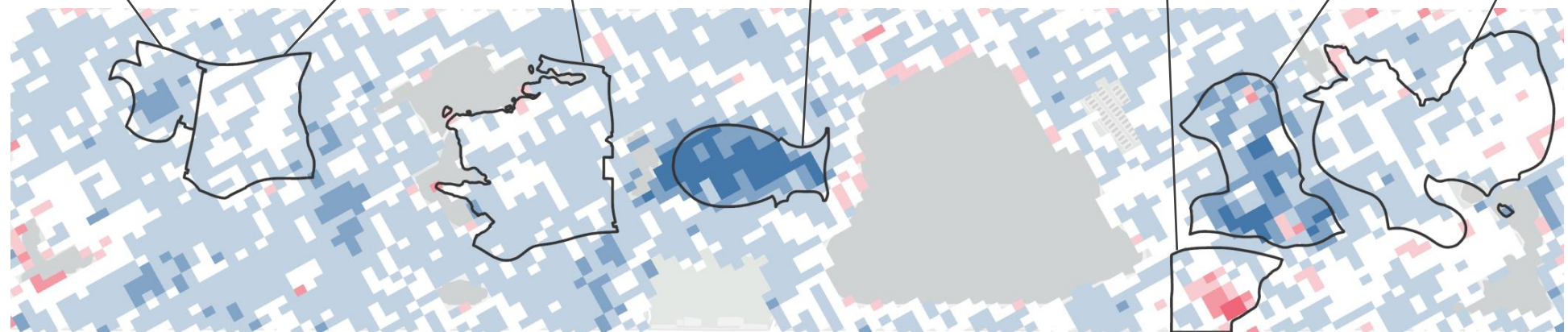
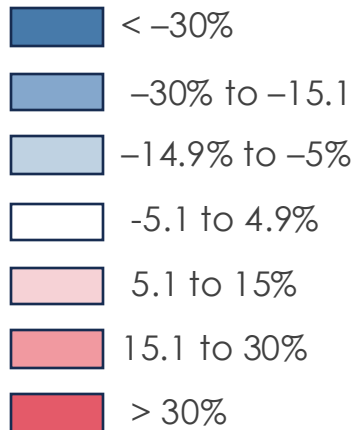
Great
Lawn

East
Meadow

North
Meadow

North
Woods

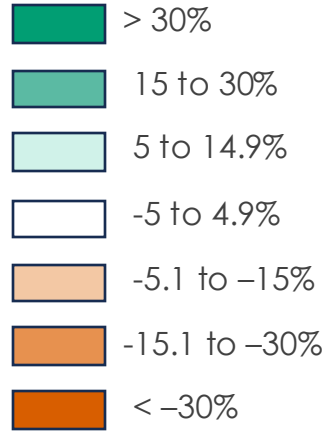
MSI Percent Change



Summer 2002 Relative NDVI/MSI

Pre-
During- Drought
Post-

NDVI Percent Change



Baseline: Median Jun-Aug 1986-2000



Heckscher
Ballfields

Sheep
Meadow

The
Ramble

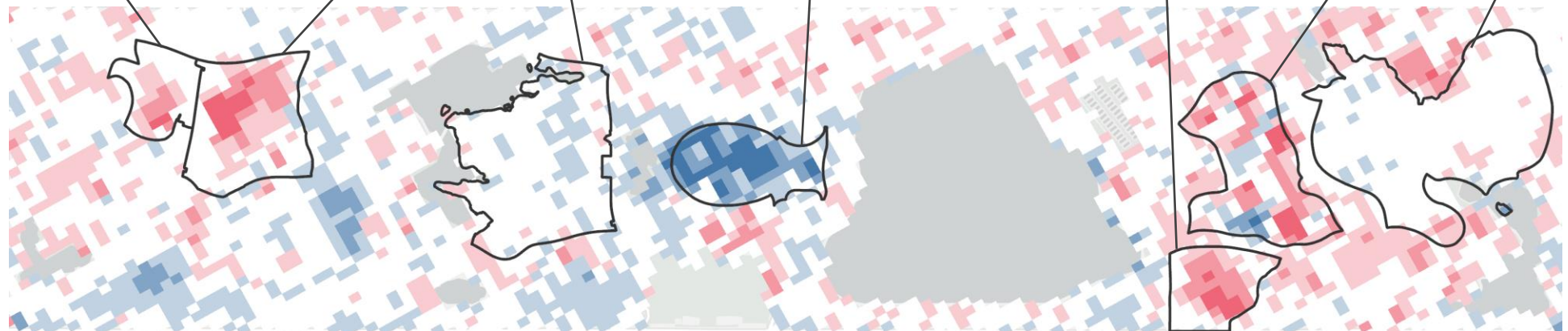
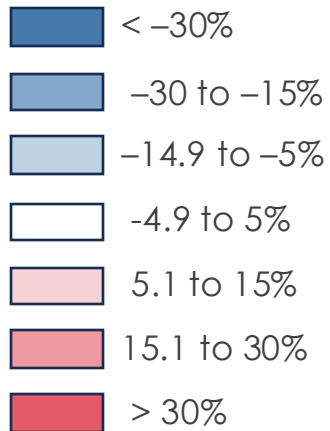
Great
Lawn

East
Meadow

North
Meadow

North
Woods

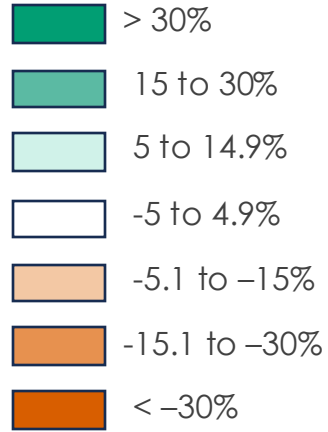
MSI Percent Change



Summer 2003 Relative NDVI/MSI

Pre-
During- Drought
Post-

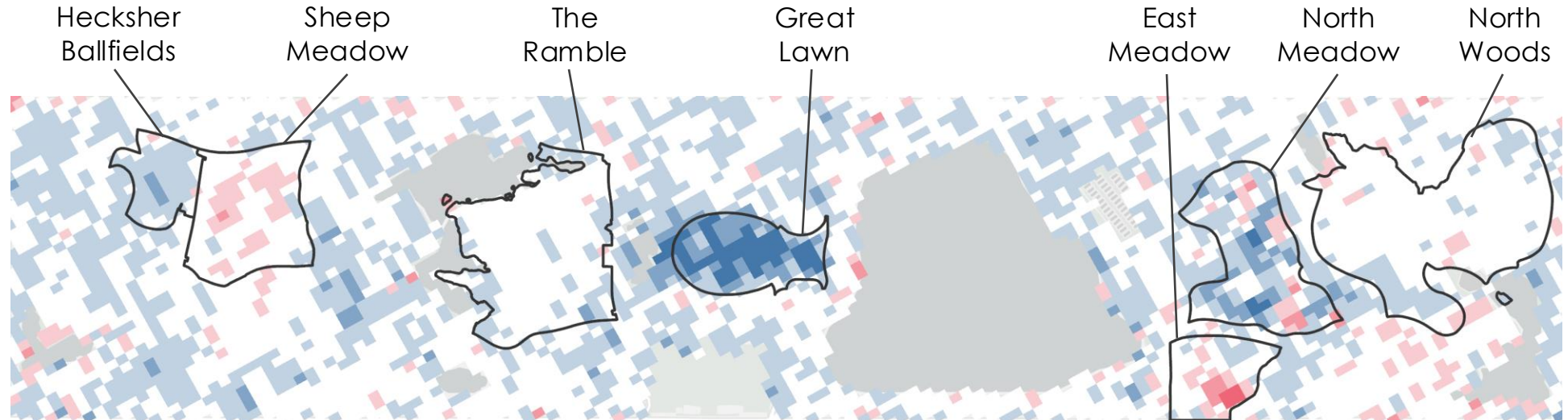
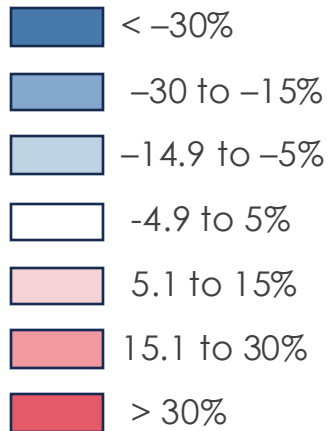
NDVI Percent Change



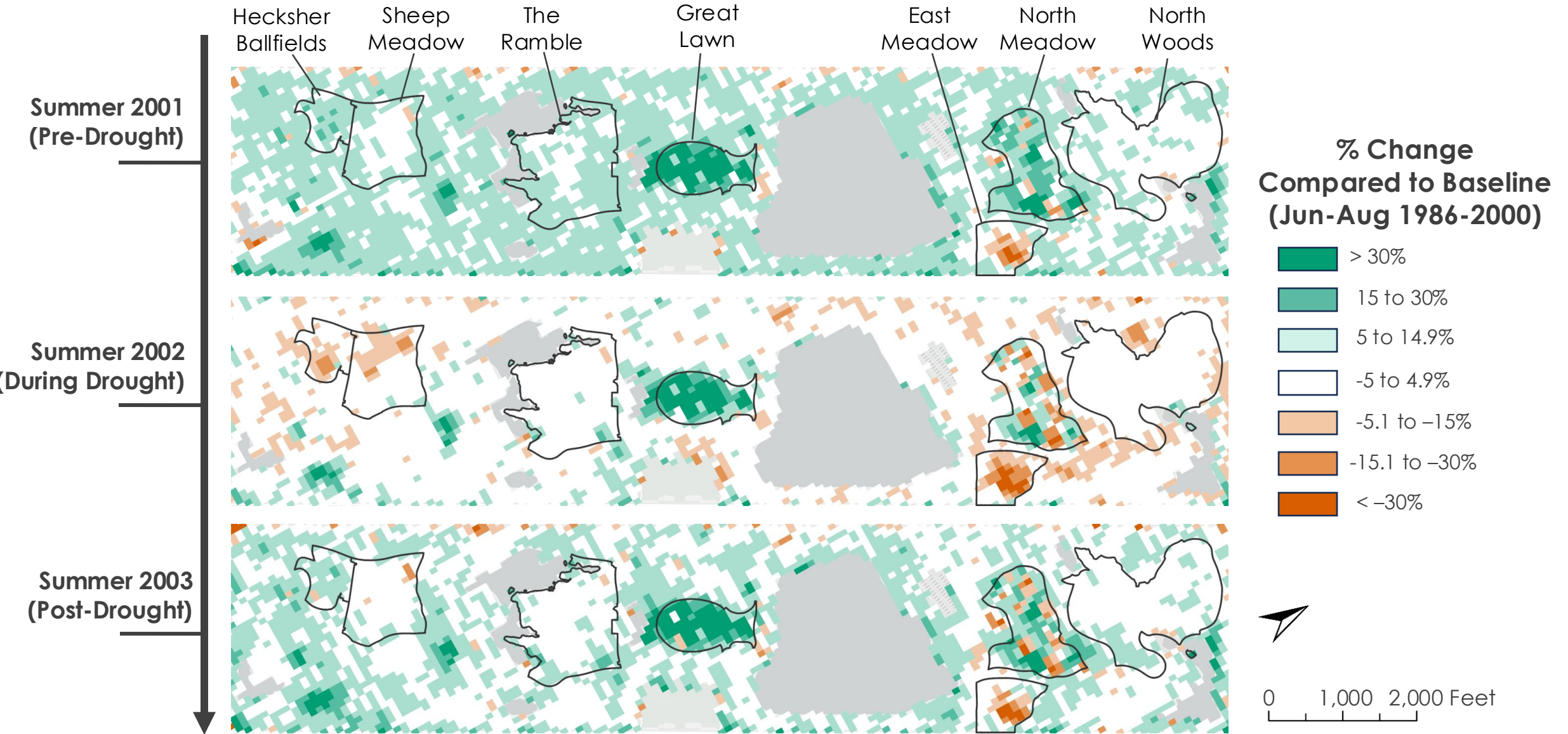
Baseline: Median Jun-Aug 1986-2000



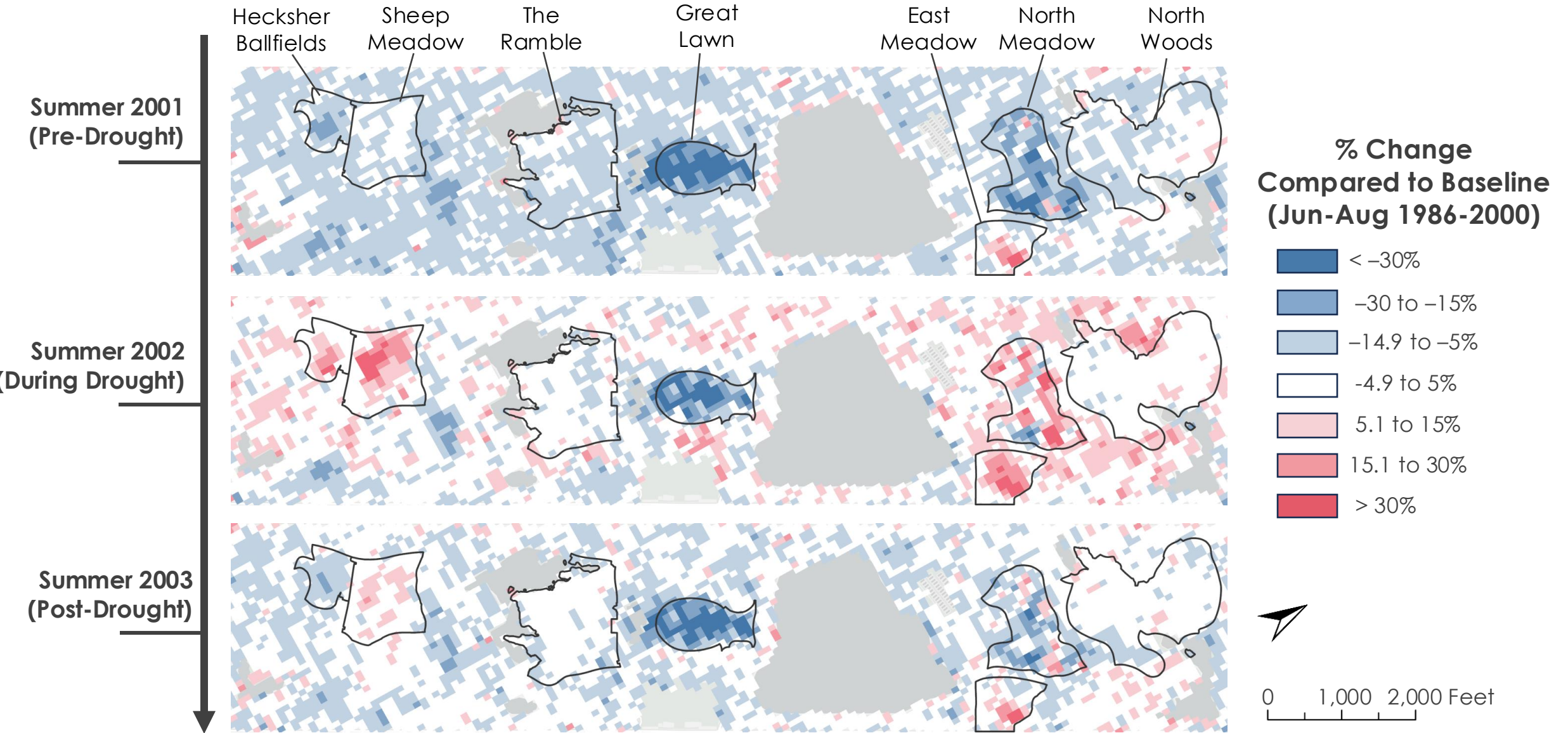
MSI Percent Change



2002 Drought Recovery – Relative NDVI Change



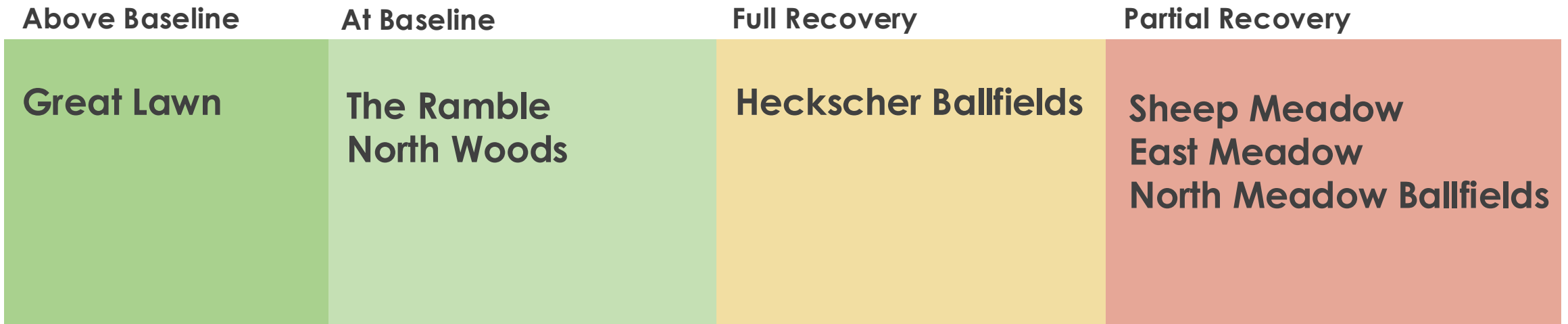
2002 Drought Recovery – Relative MSI Change



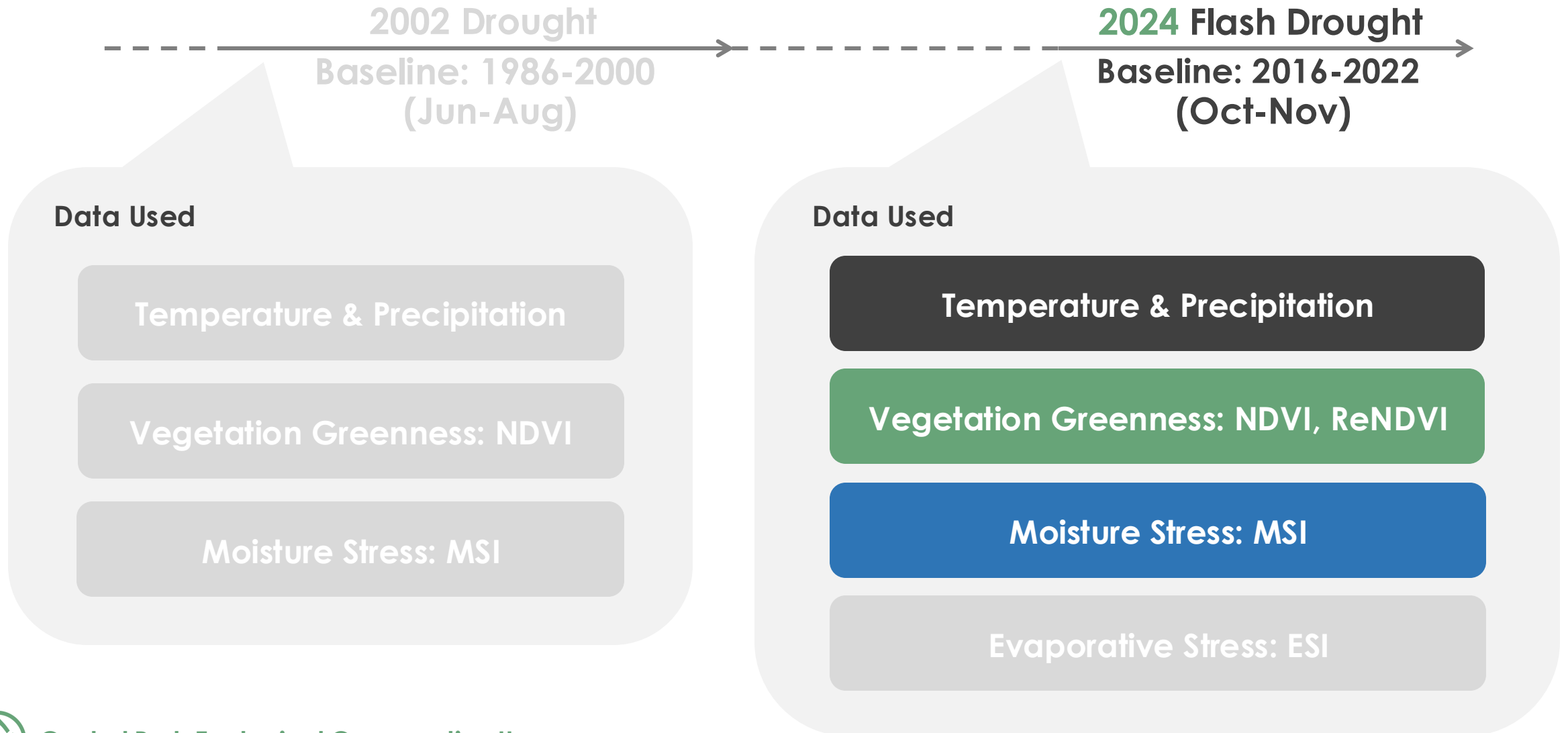
Recap – 2002 Drought Response

(Jun-Aug)
Baseline: 1986-2000

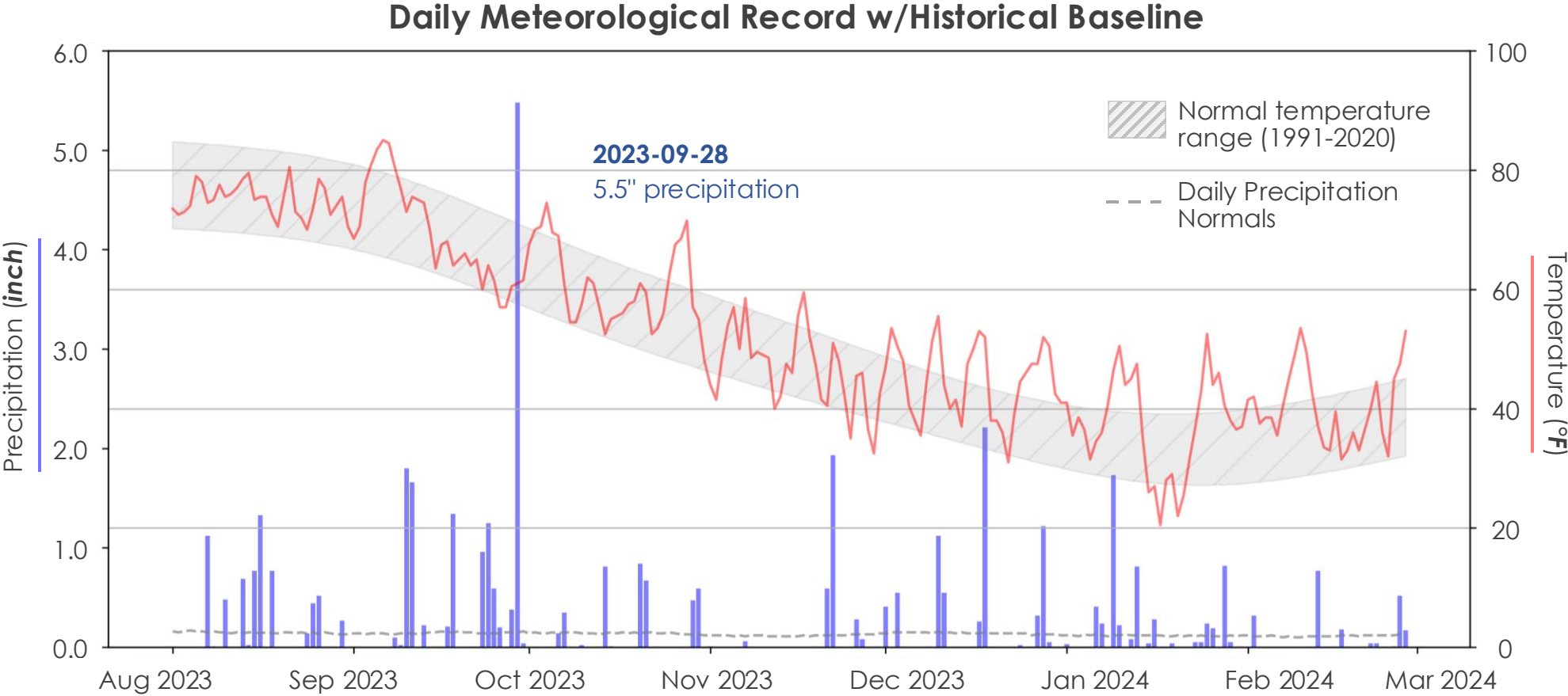
- **Widespread recovery** from drought impacts
- MSI **more sensitive** to deviations from baseline
- Woodlands remained the most **stable**



Results – Roadmap

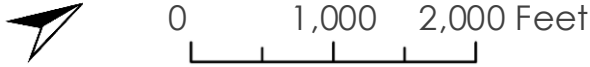


2023 Pre-Drought – Meteorological Record

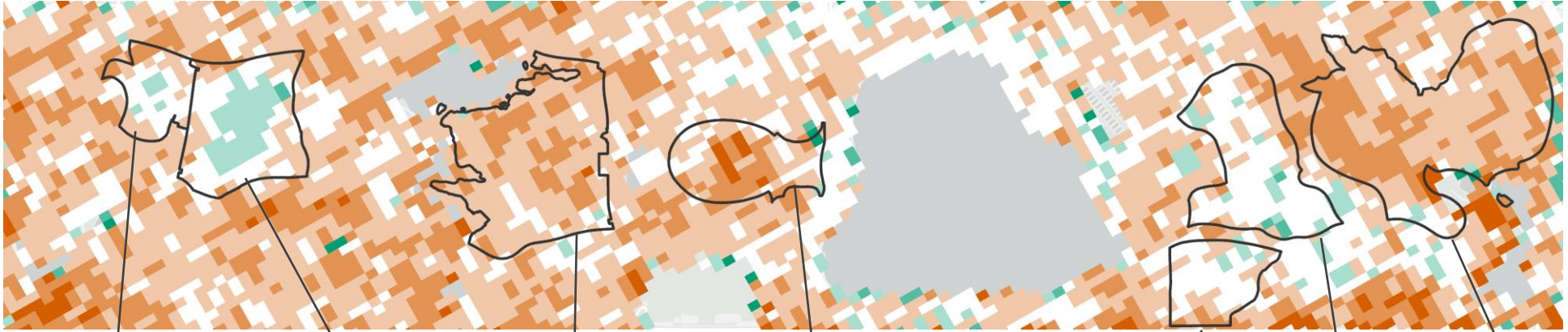


Fall 2023 Relative NDVI/ReNDVI

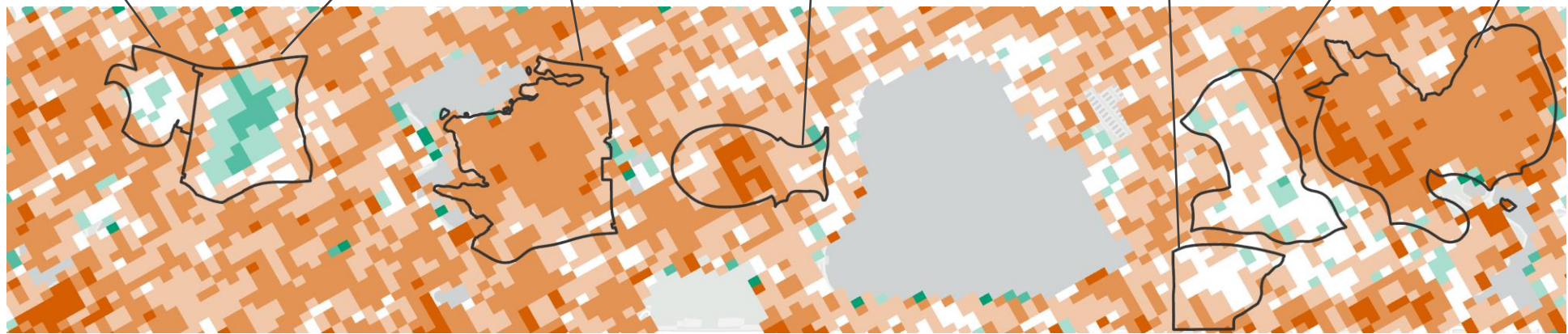
Pre-
During- Drought
Post-



NDVI



Hecksher Ballfields Sheep Meadow The Ramble Great Lawn East Meadow North Meadow North Woods



ReNDVI

% Change Compared to Baseline (Oct-Nov 2016-2022)

- > 30%
- 15 to 30%
- 5 to 14.9%
- 5 to 4.9%
- 5.1 to -15%
- 15.1 to -30%
- < -30%

Fall 2023 Relative ReNDVI/MSI

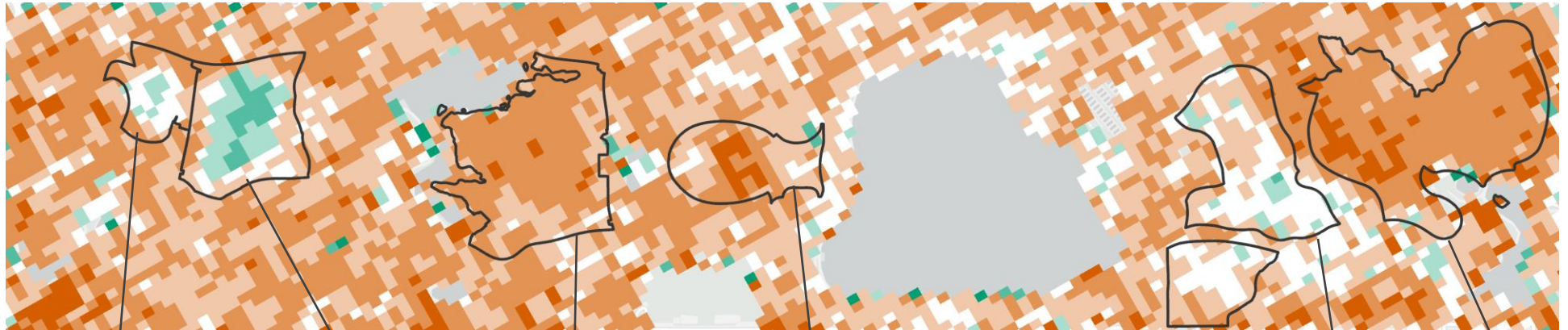
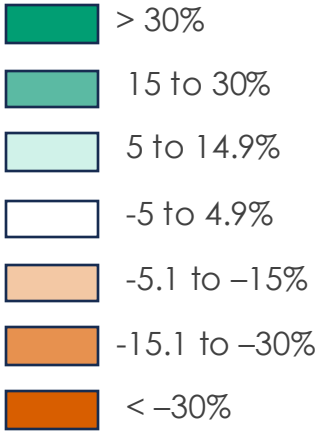
Pre-
During- Drought
Post-



0 1,000 2,000 Feet

ReNDVI Percent Change

Baseline: Median Oct-Nov 2016-2022



Hecksher
Ballfields

Sheep
Meadow

The
Ramble

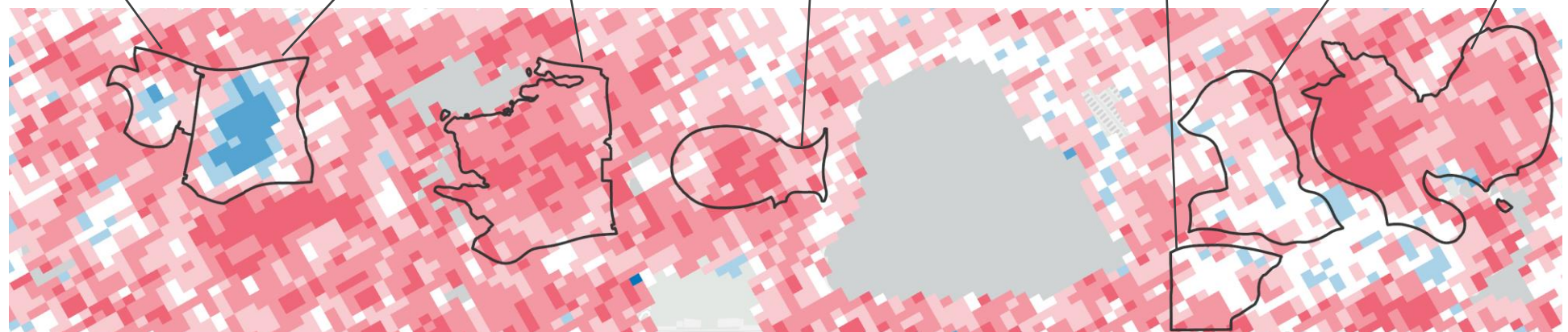
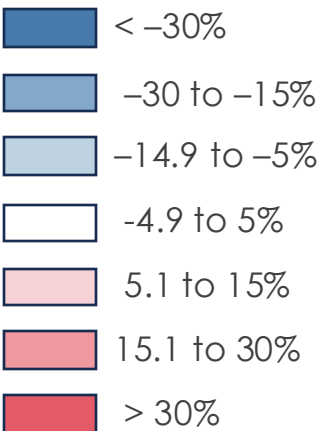
Great
Lawn

East
Meadow

North
Meadow

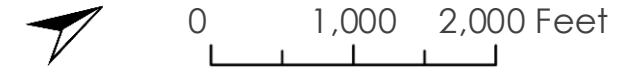
North
Woods

MSI Percent Change



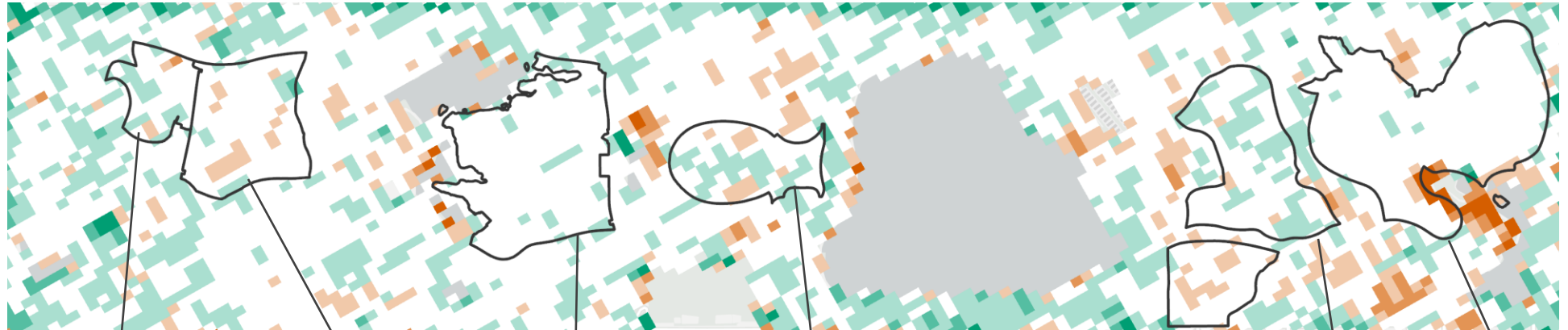
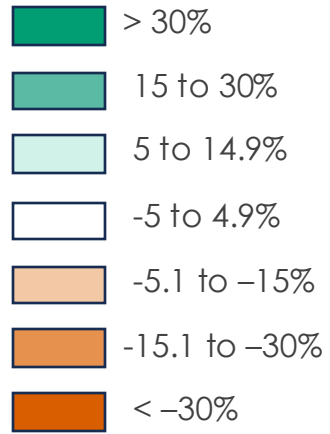
Spr/Sum 2024 Relative ReNDVI/MSI

Pre-
During- Drought
Post-



ReNDVI Percent Change

Baseline: Median May-July 2016-2022



Hecksher
Ballfields

Sheep
Meadow

The
Ramble

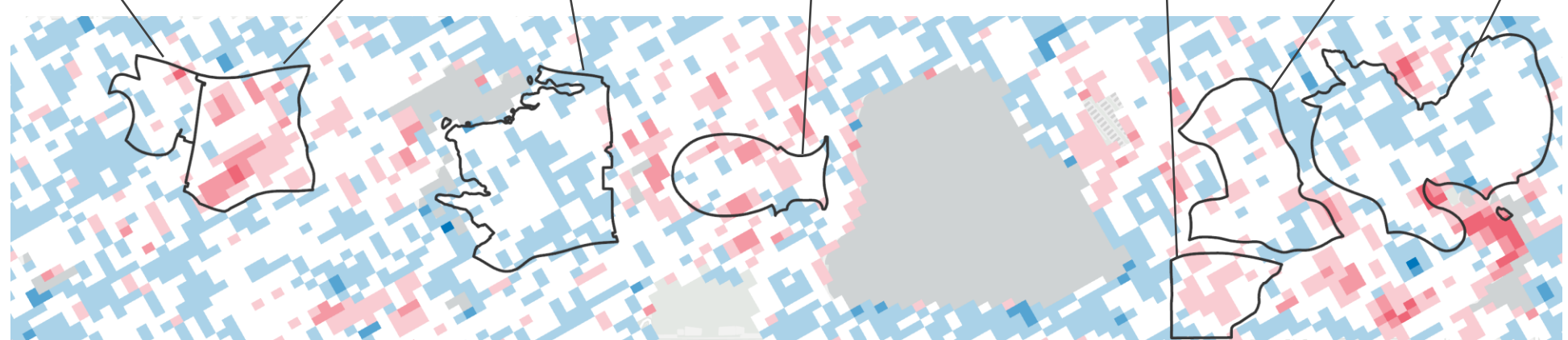
Great
Lawn

East
Meadow

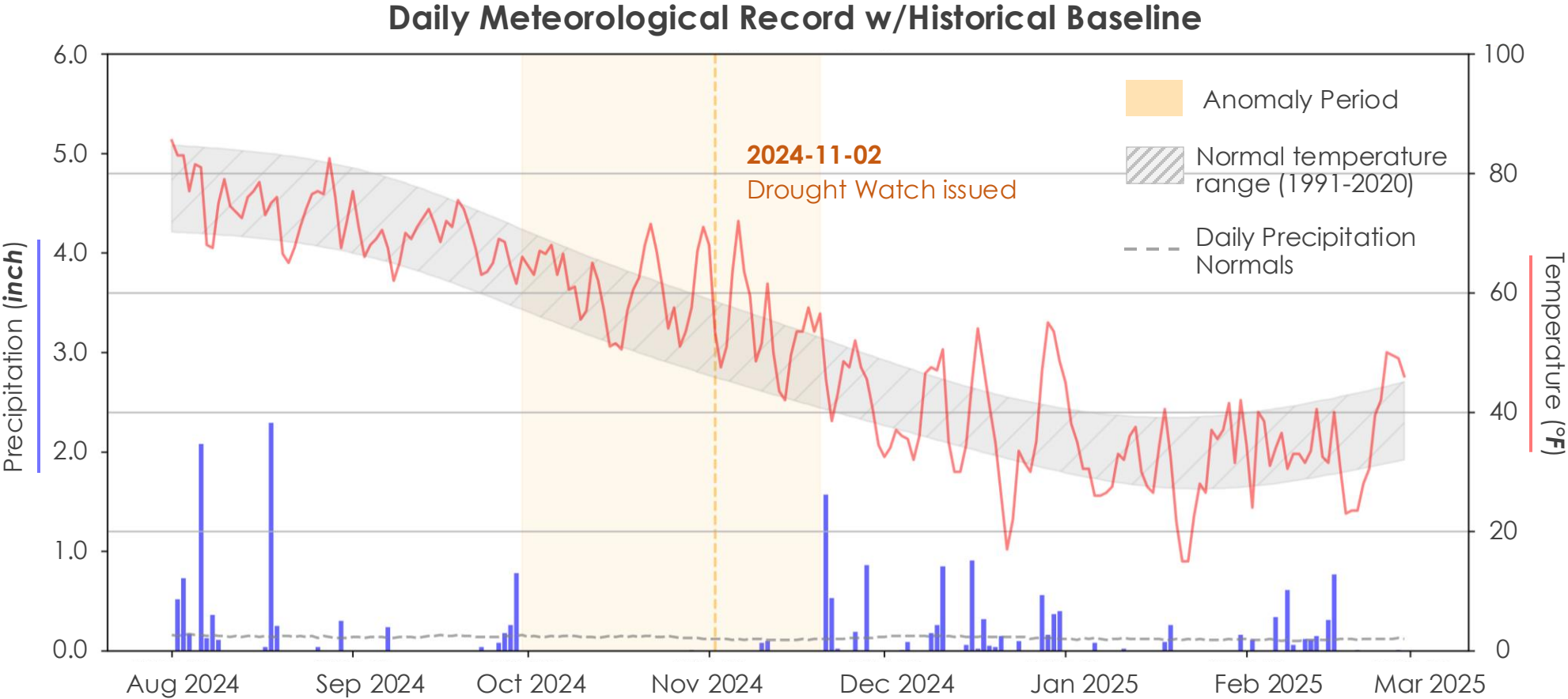
North
Meadow

North
Woods

MSI Percent Change



2024 Drought – Meteorological Record



Fall 2024 Relative ReNDVI/MSI

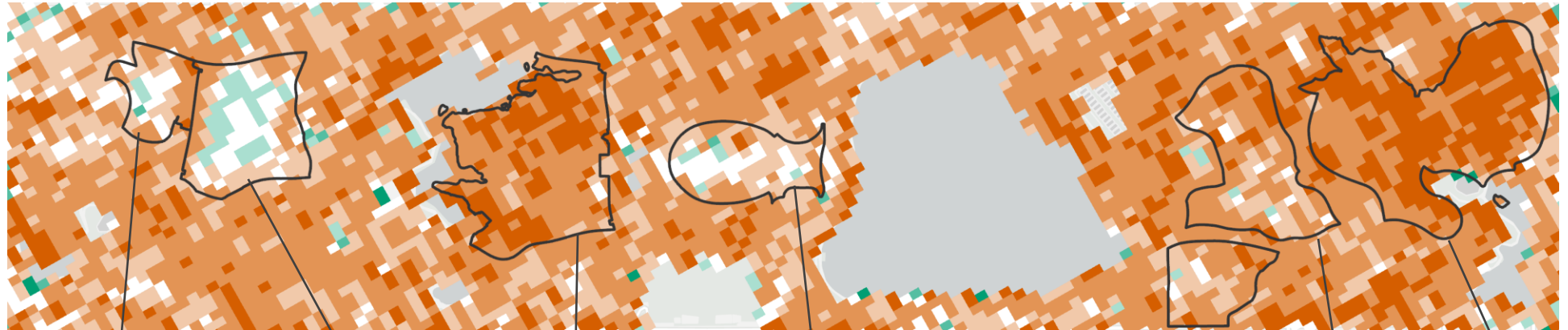
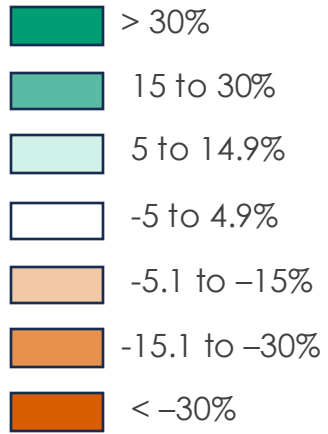
Pre-
During- Drought
Post-



0 1,000 2,000 Feet

ReNDVI Percent Change

Baseline: Median Oct-Nov 2016-2022



Hecksher
Ballfields

Sheep
Meadow

The
Ramble

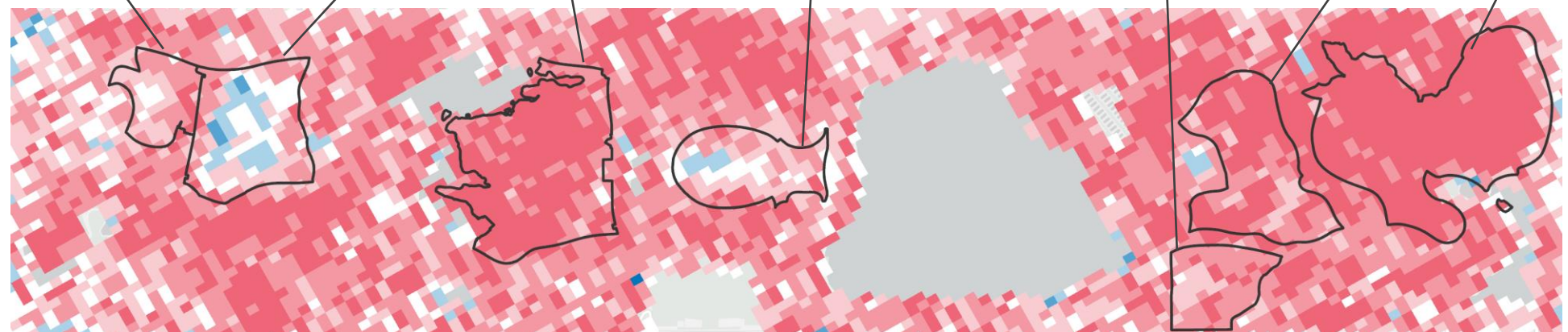
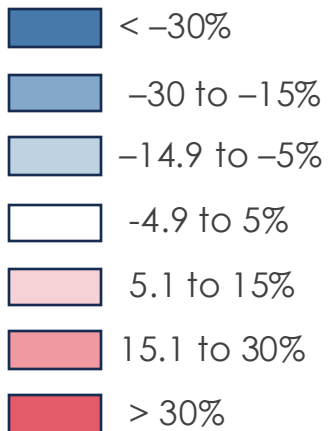
Great
Lawn

East
Meadow

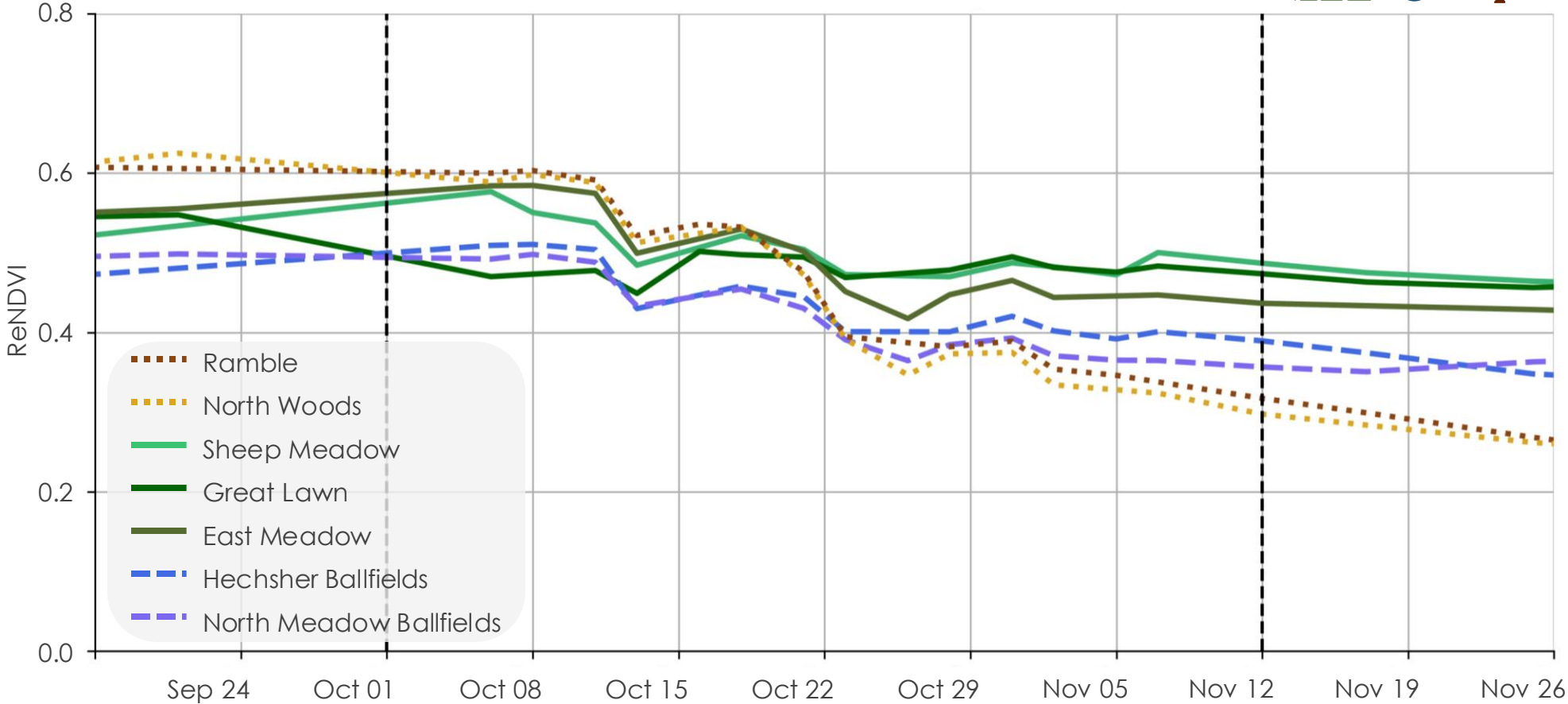
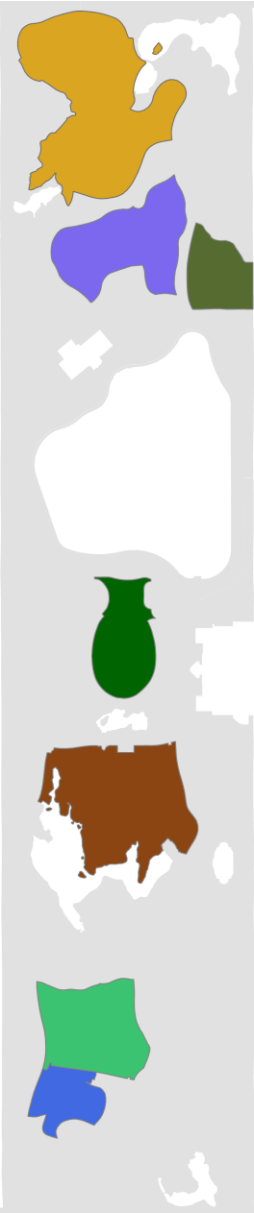
North
Meadow

North
Woods

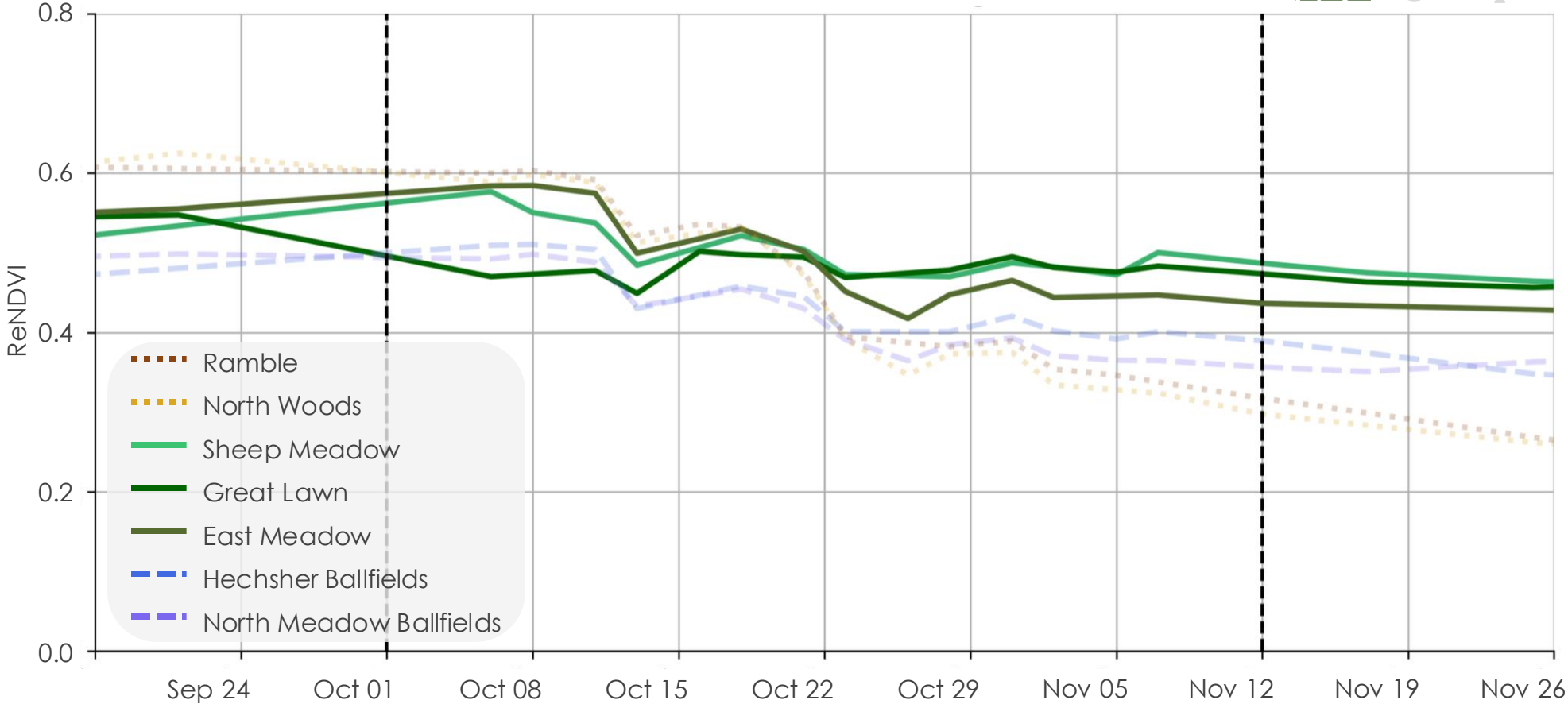
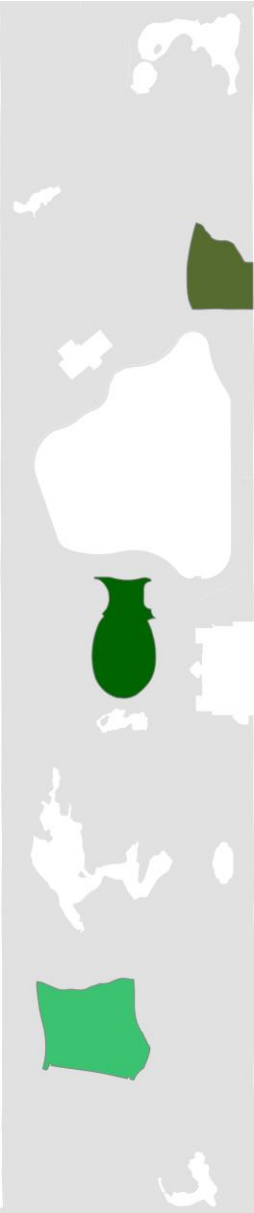
MSI Percent Change



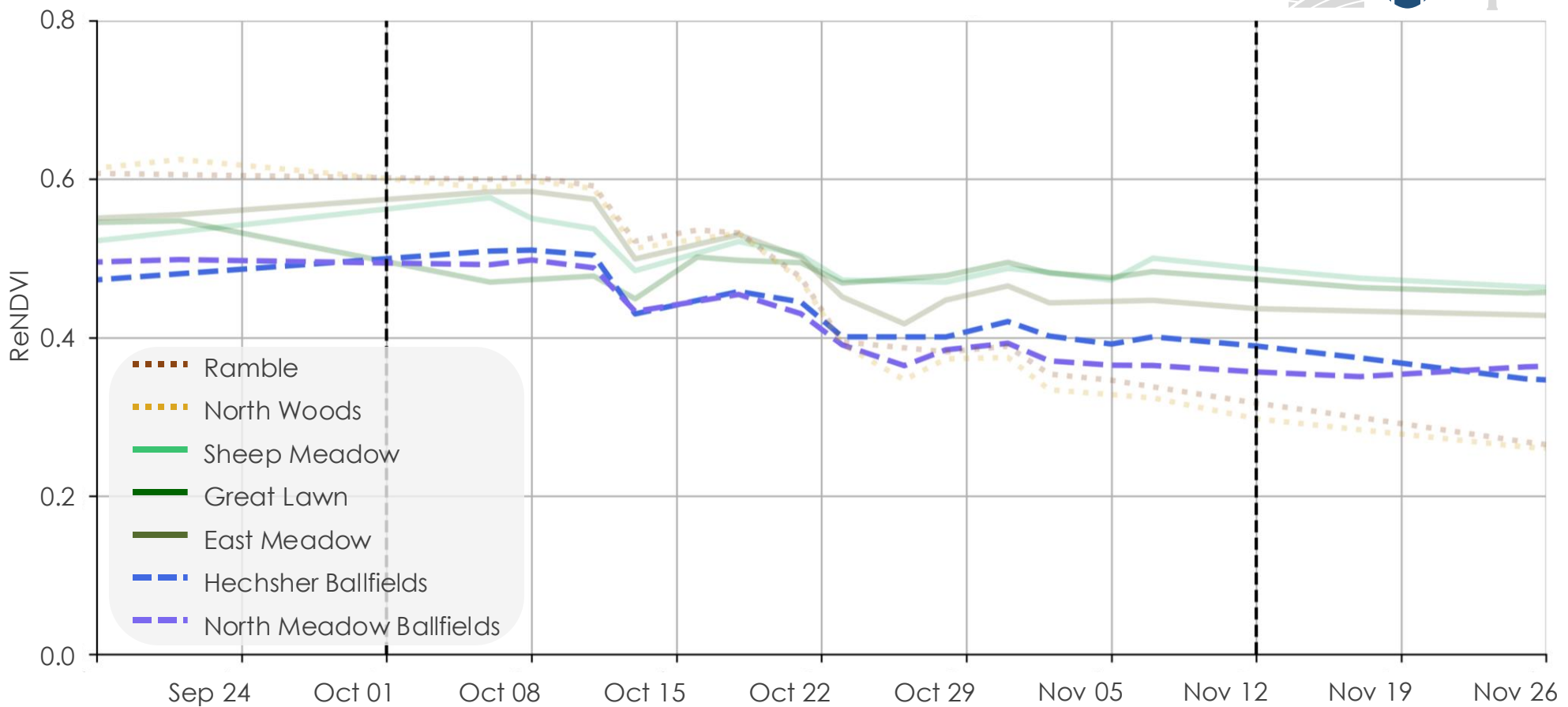
Fall 2024 ReNDVI Across AOIs



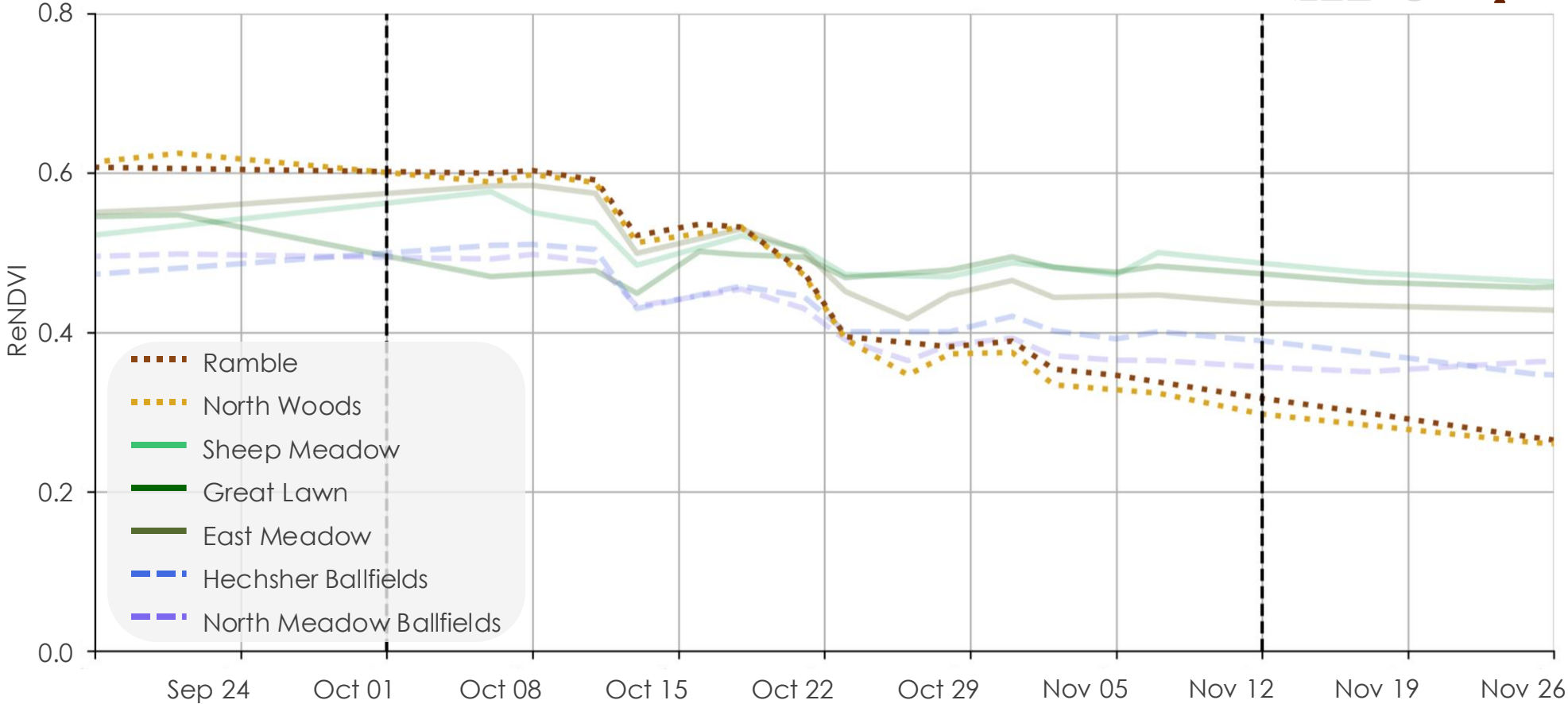
Fall 2024 ReNDVI Across Lawns



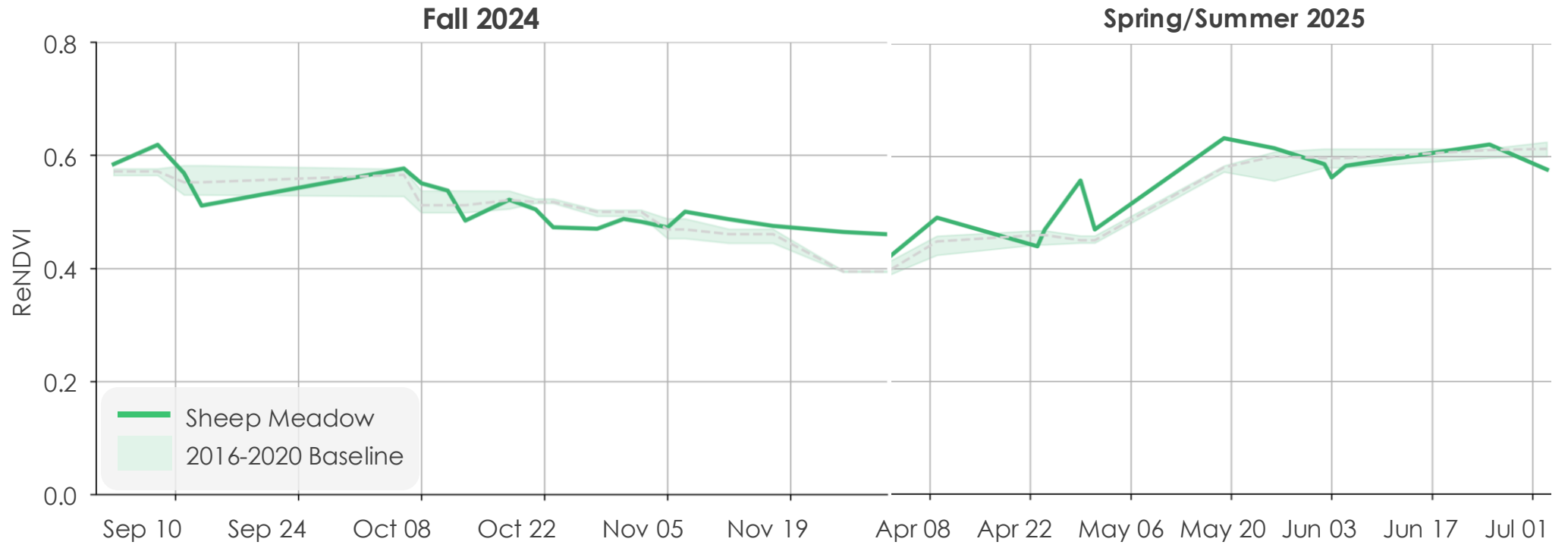
Fall 2024 ReNDVI Across Ballfields



Fall 2024 ReNDVI Across Woodlands



2024-25 Relative ReNDVI – Sheep Meadow

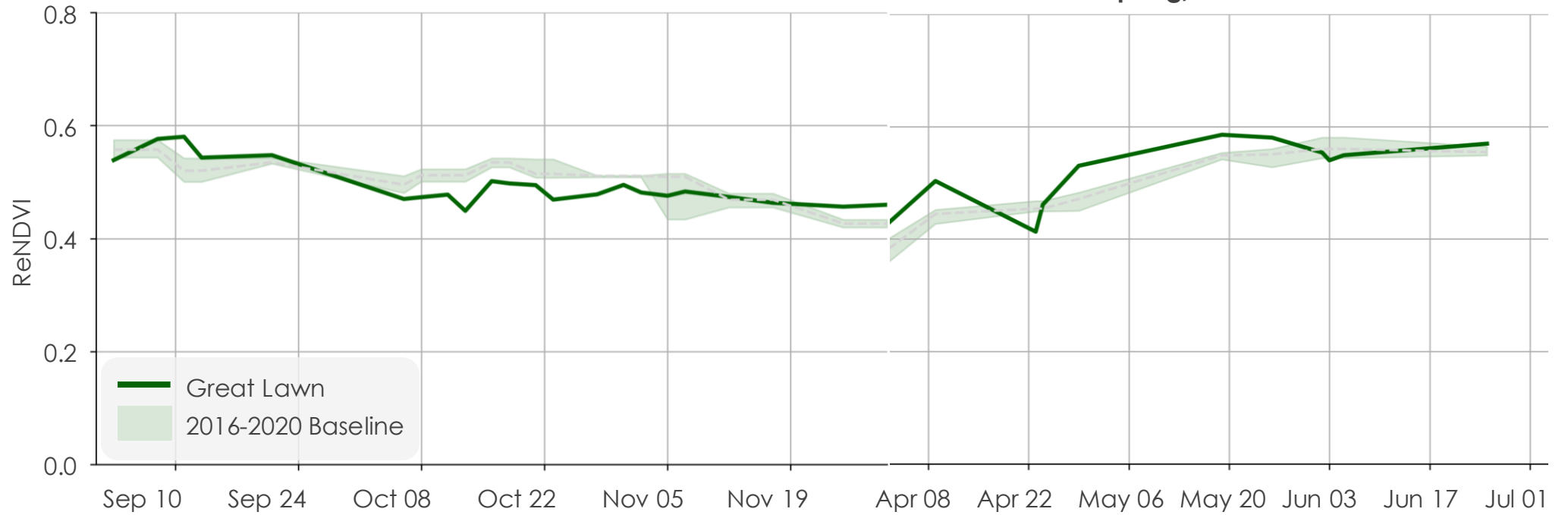


2024-25 Relative ReNDVI – Great Lawn

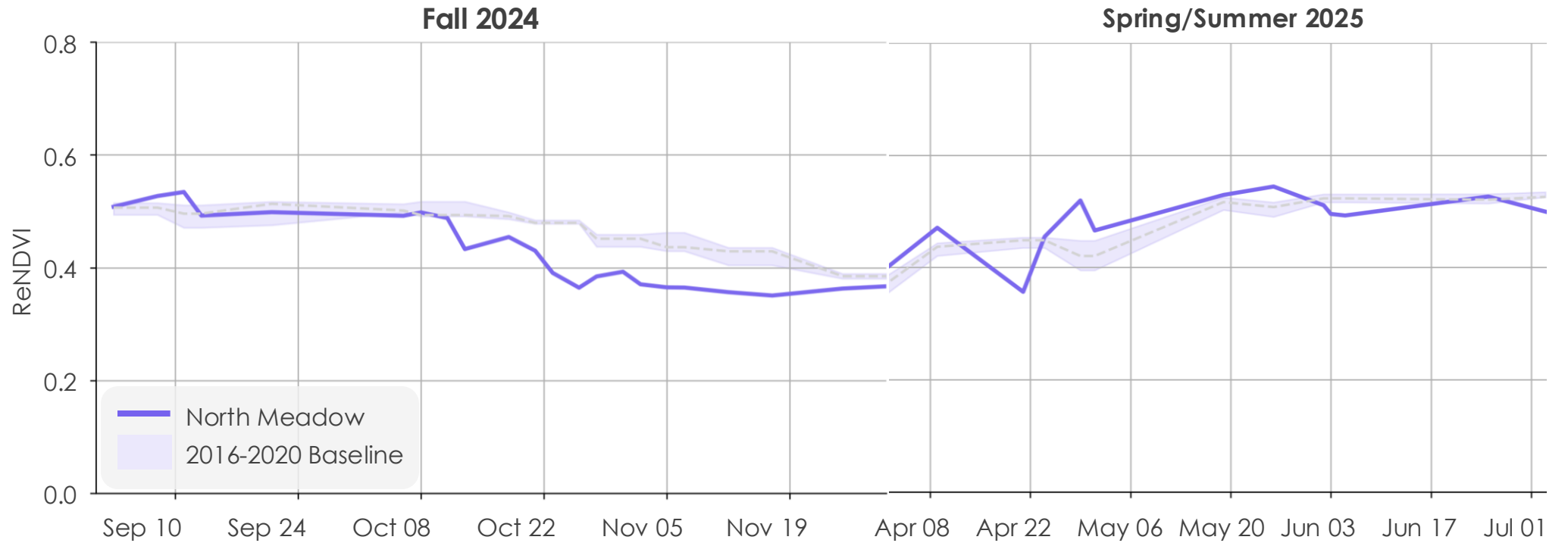


Fall 2024

Spring/Summer 2025



2024-25 Relative ReNDVI – North Meadow Ballfields



2024-25 Relative ReNDVI – North Woods



Spr/Sum 2025 Relative ReNDVI/MSI

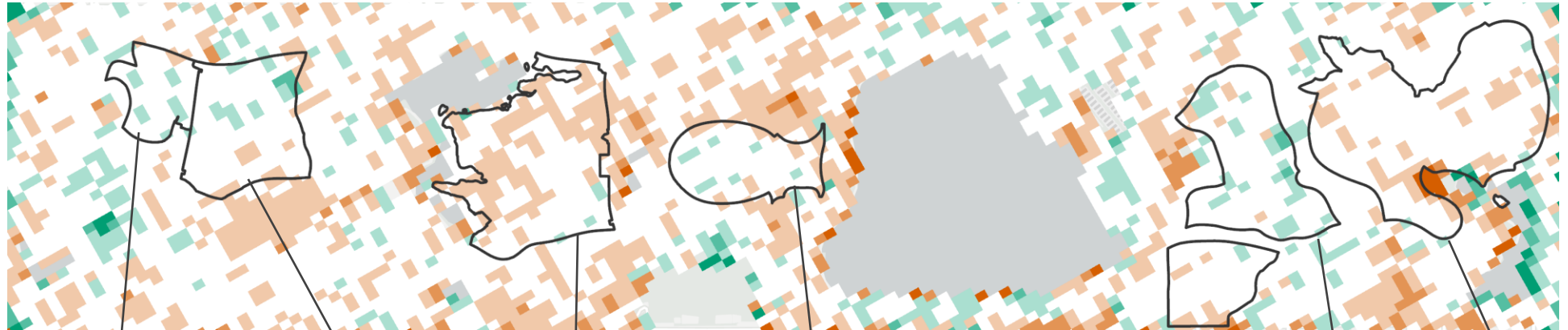
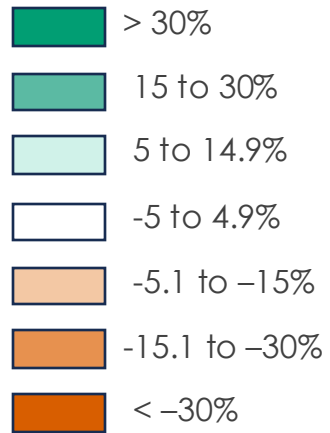
Pre-
During- Drought
Post-



0 1,000 2,000 Feet

ReNDVI Percent Change

Baseline: Median May-July 2016-2022



Hecksher
Ballfields

Sheep
Meadow

The
Ramble

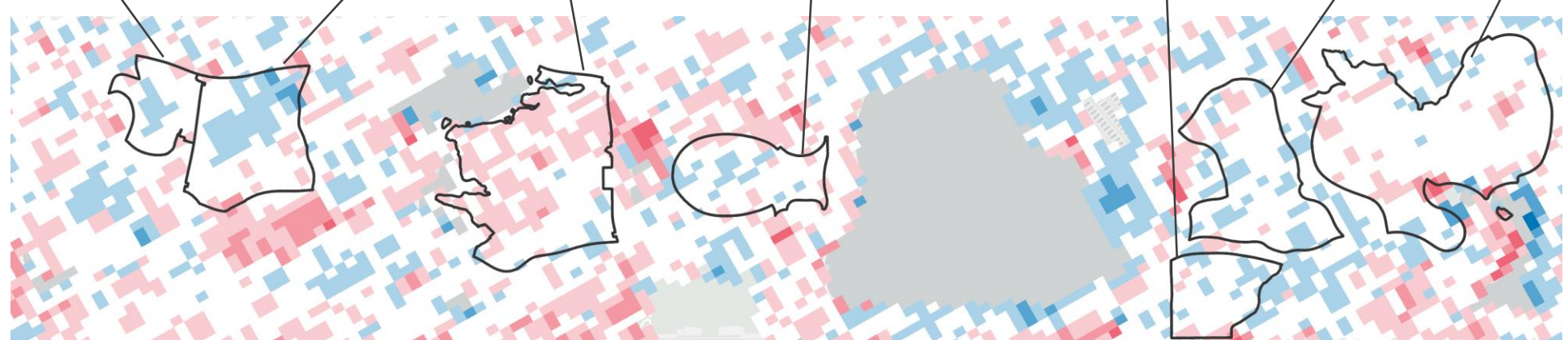
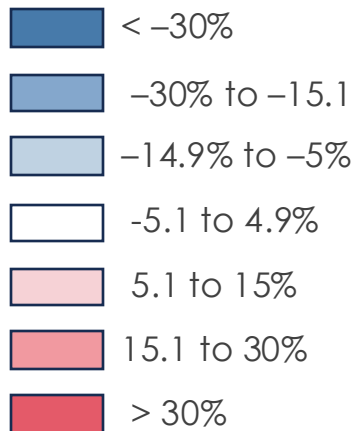
Great
Lawn

East
Meadow

North
Meadow

North
Woods

MSI Percent Change



Spr/Sum 2025 Relative ReNDVI/MSI

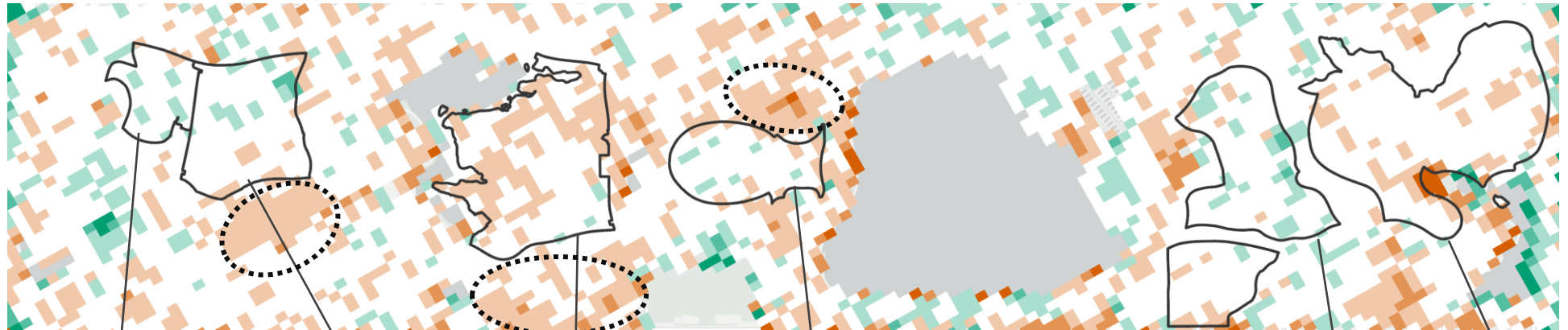
Pre-
During- Drought
Post-



0 1,000 2,000 Feet

ReNDVI Percent Change

Baseline: Median May-July 2016-2022



Hecksher
Ballfields

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The
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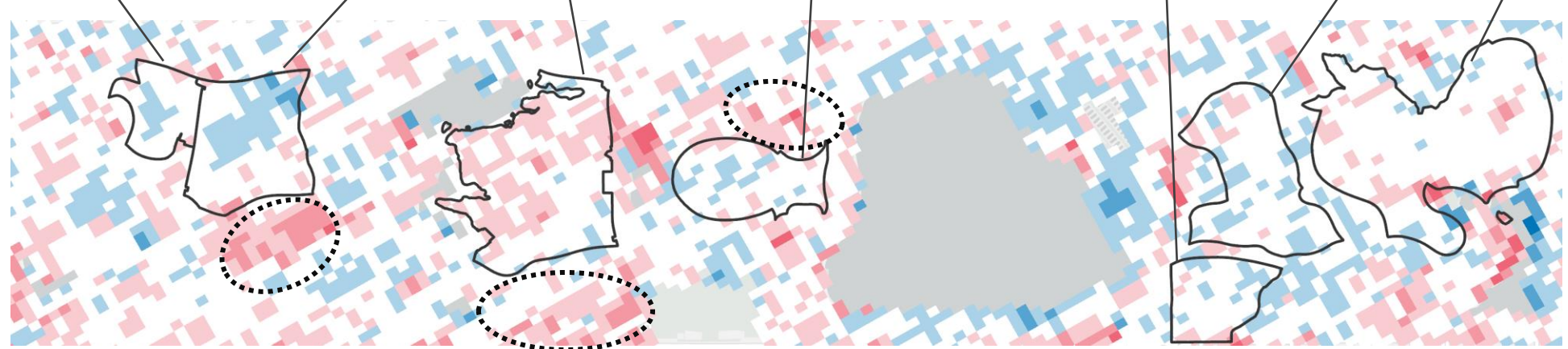
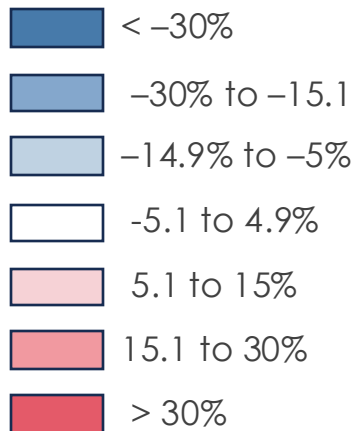
Great
Lawn

East
Meadow

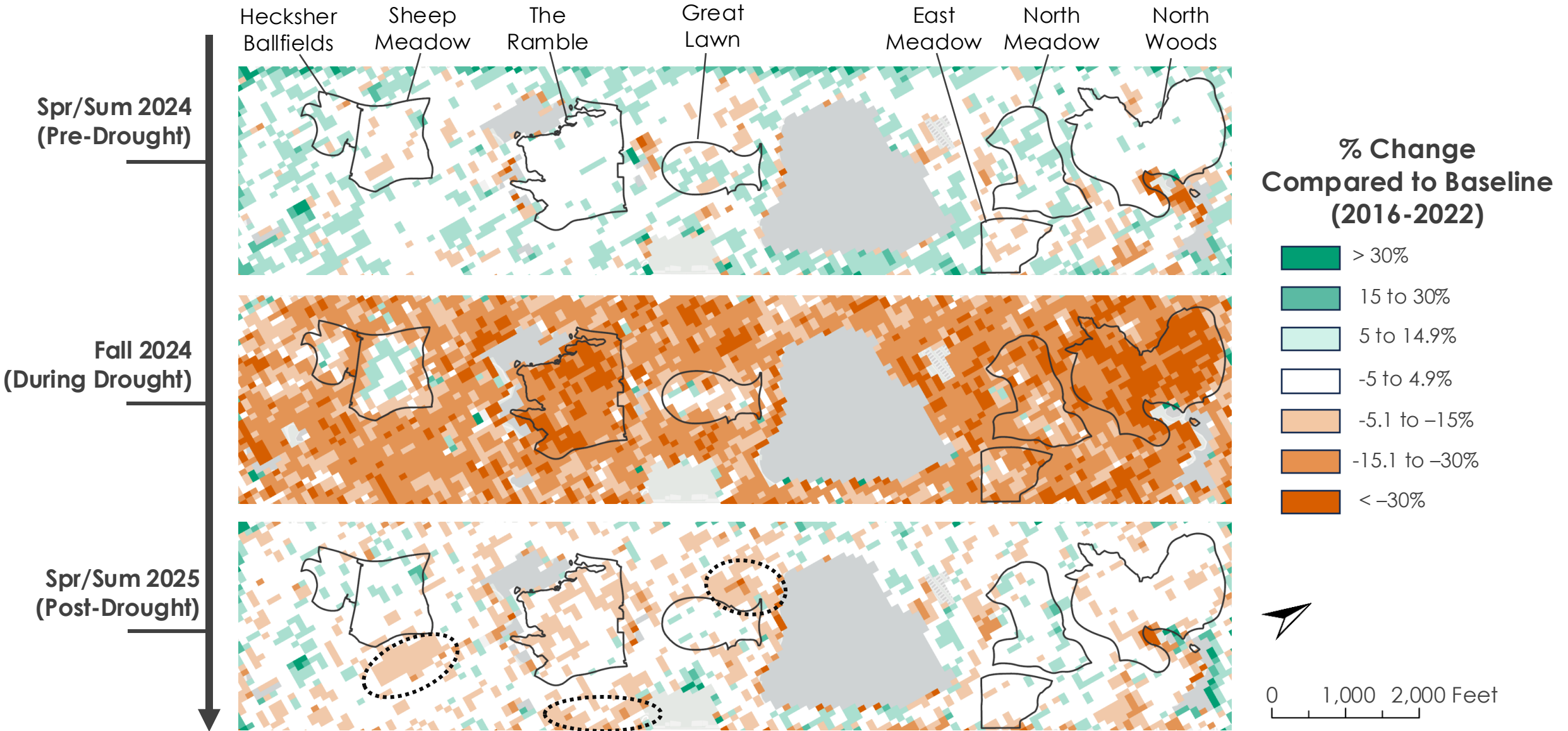
North
Meadow

North
Woods

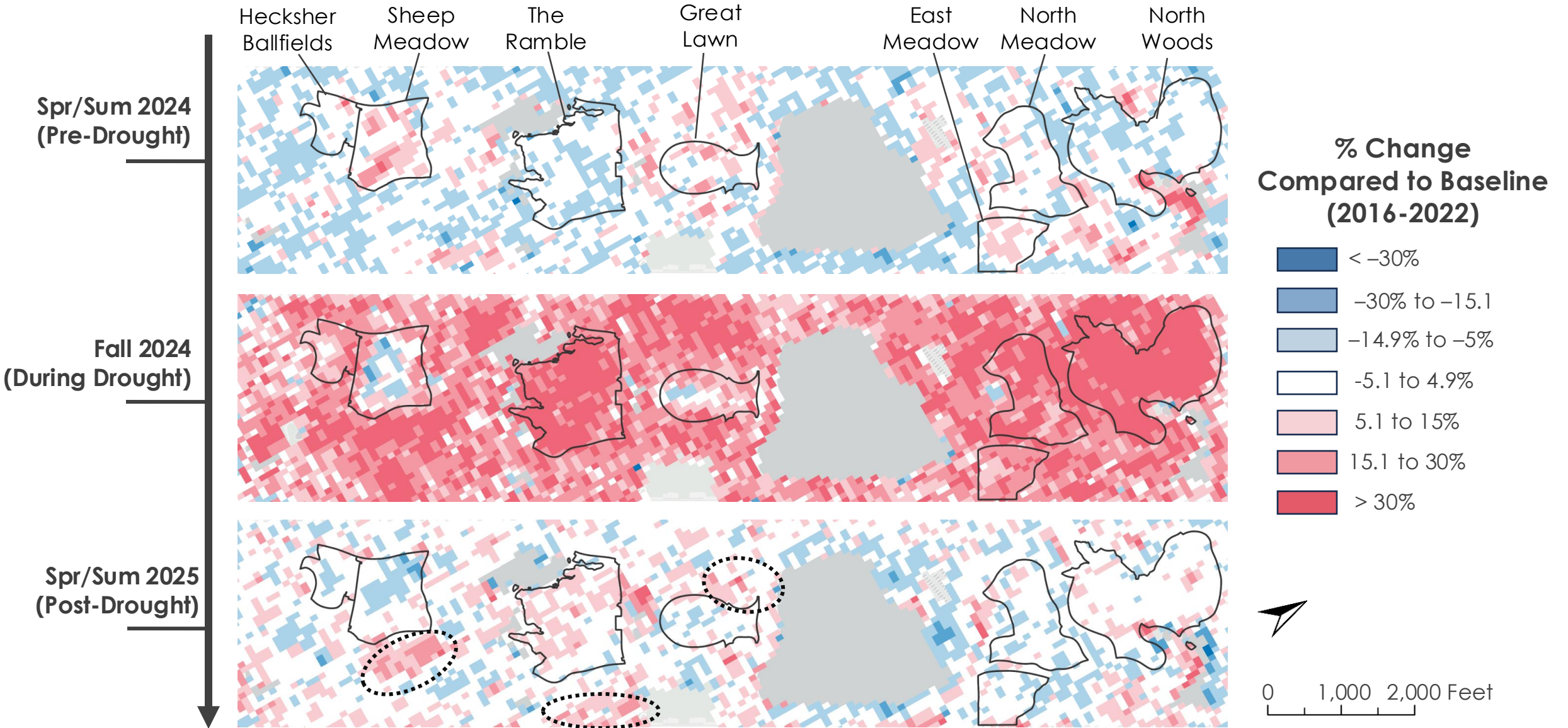
MSI Percent Change



2024 Drought Recovery – Relative ReNDVI Change



2024 Drought Recovery – Relative MSI Change



Recap – 2024 Drought Response

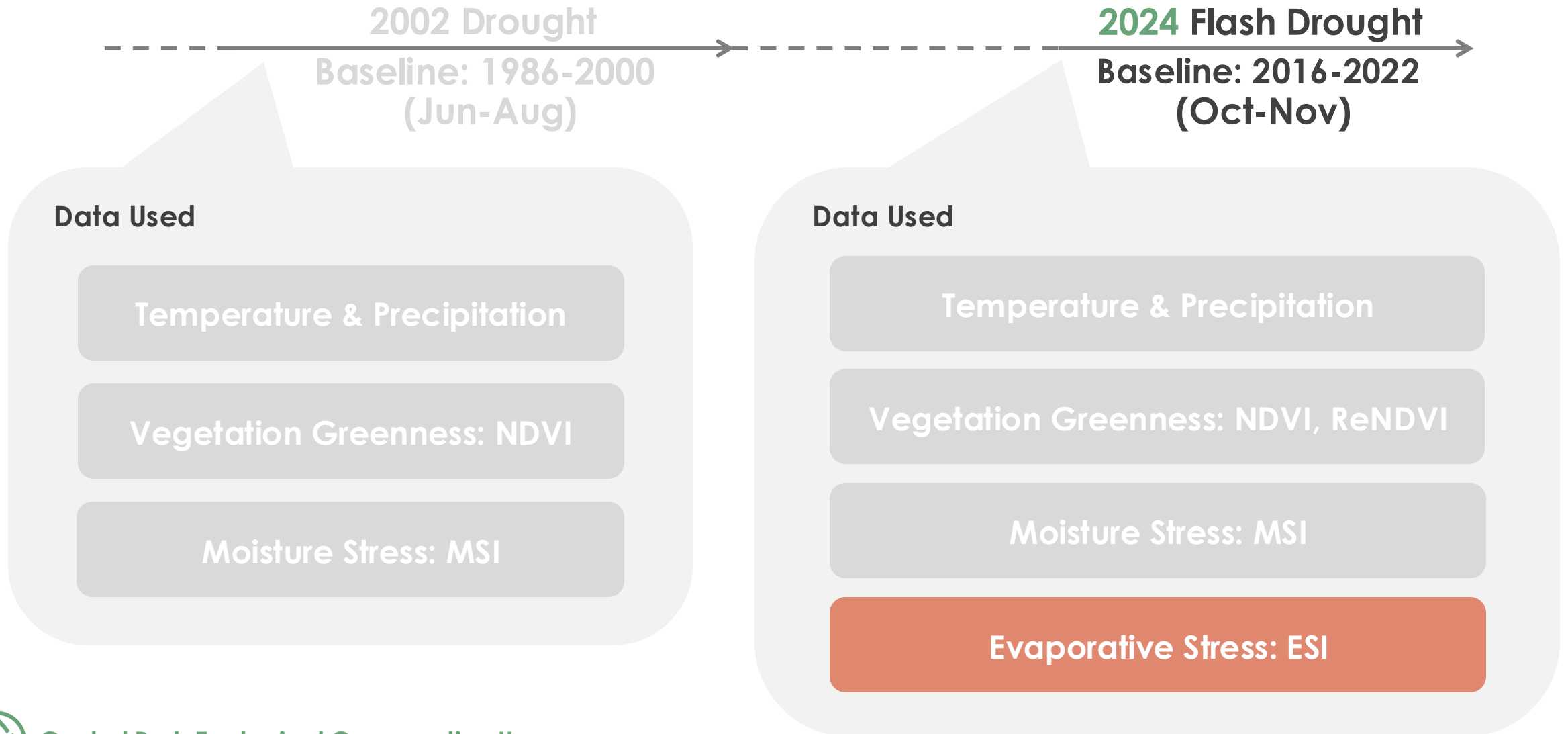
Baseline: 2016-2022

- **Earlier fall senescence** → widespread ReNDVI & MSI decline
 - Ramble, North Woods, North Meadow Ballfields most impacted
- **Lawns & Ballfields** recovered by Summer 2025
- Four Areas still below baseline in Summer 2025

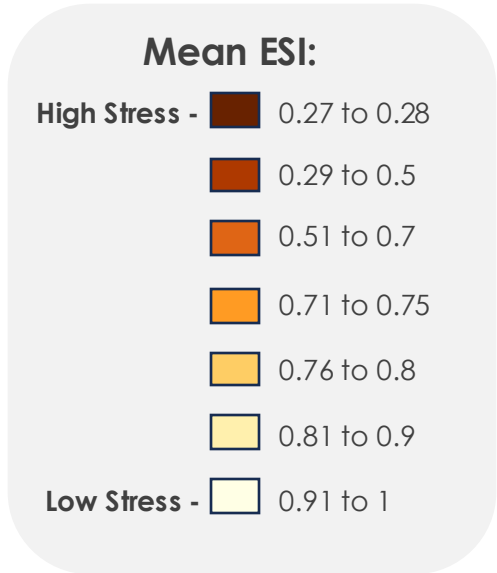
Above Baseline	At Baseline	Full Recovery	Partial Recovery
Center of Sheep Meadow	Center of Great Lawn	Heckscher Ballfields North Meadow Ballfields East Meadow North Woods	The Ramble The Mall Great Lawn West South of MET



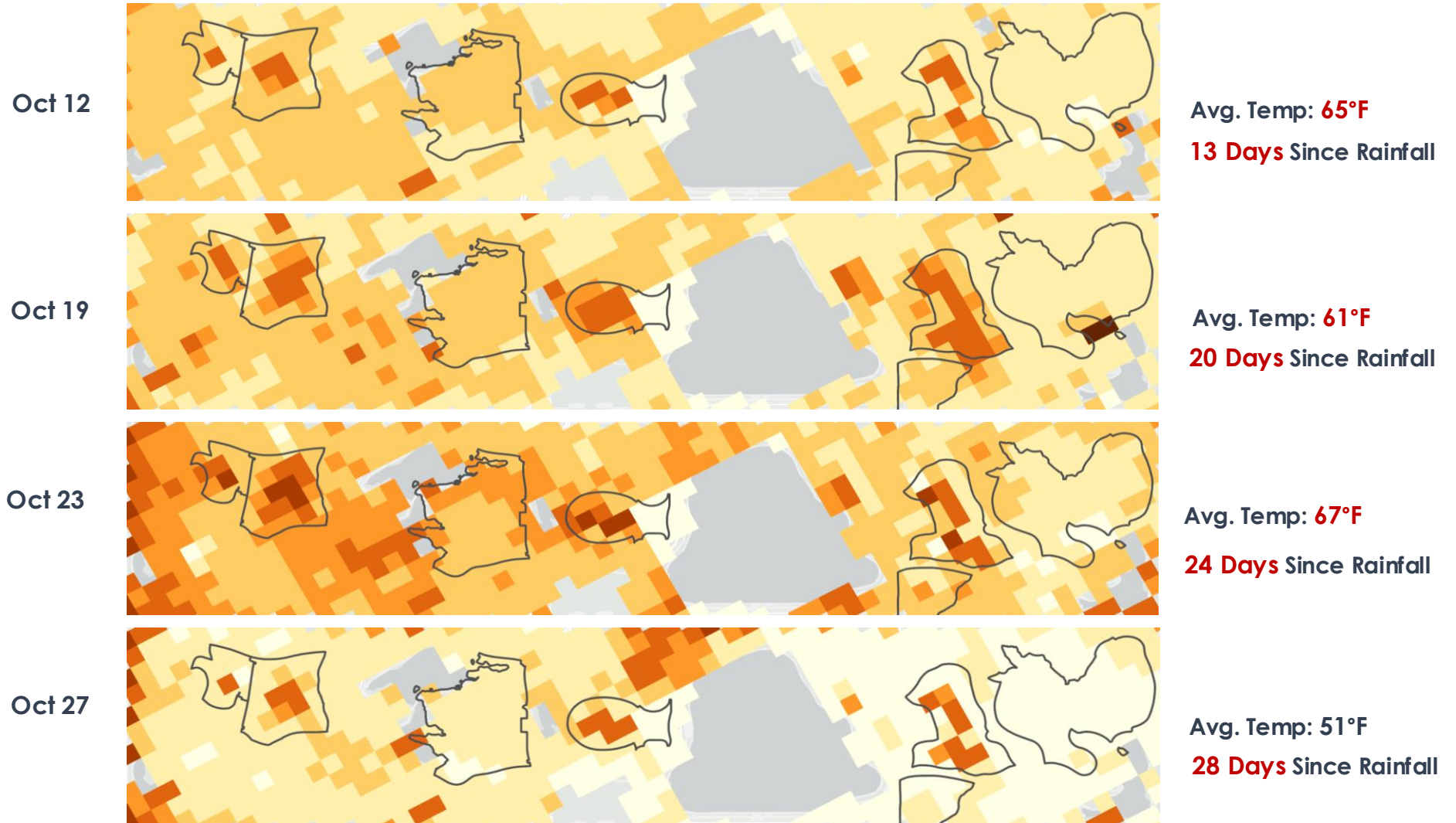
Results – Roadmap



October 2024 Evaporative Stress Index (ESI)



$$ESI = \frac{ET}{PET}$$



Conclusion

Key Findings

- **2002 Drought**
 - **NDVI & MSI:** Widespread recovery by Summer '03
- **2024 Drought**
 - **NDVI:** Widespread recovery by Summer '25
 - **ReNDVI & MSI:** Partial recovery by Summer '25

Satellite Index Takeaways

- **NDVI/ReNDVI/MSI:** Strong *Visual* Correlation
- **ReNDVI:** More sensitive than NDVI
- **MSI:** Most sensitive to baseline deviations
- **ESI:** Highly sensitive to short-term weather



Image Credit: Lucas Chuk



Limitations & Uncertainties



Baseline Limitations

2002 Drought Baseline: 1986-2000

2024 Drought Baseline: 2016-2022



Park Development

Strategy shifts

Land use changes



Fall Senescence

2024 Flash Drought



Feasibility & Partner Implementation

**CPC Environmental
Sustainability
Framework**

**Meet Water
Efficiency
& Reduction
Targets**

**Strategic
Irrigation**

**Satellite-Based
Drought
Monitoring**



Acknowledgements

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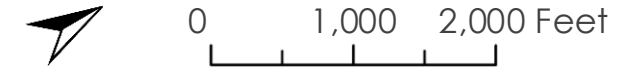


Additional Slides

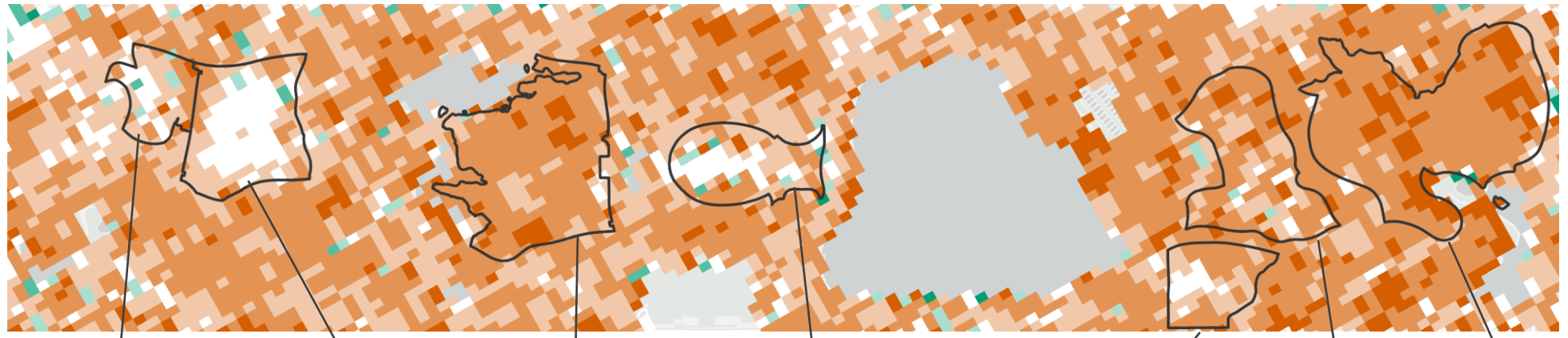


Fall 2024 Relative NDVI/ReNDVI

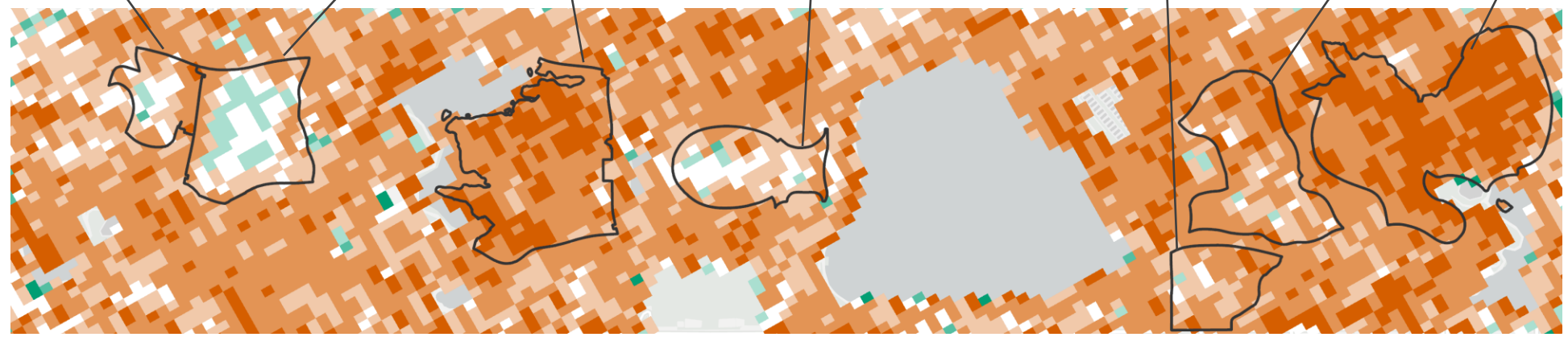
Pre-
During- Drought
Post-



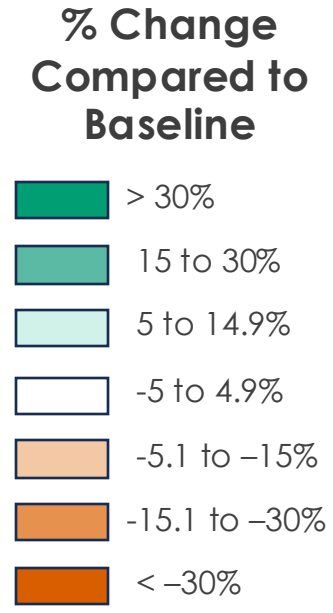
NDVI



Hecksher Ballfields Sheep Meadow The Ramble Great Lawn East Meadow North Meadow North Woods

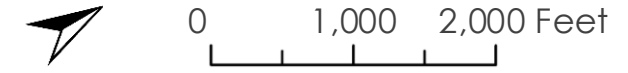


ReNDVI

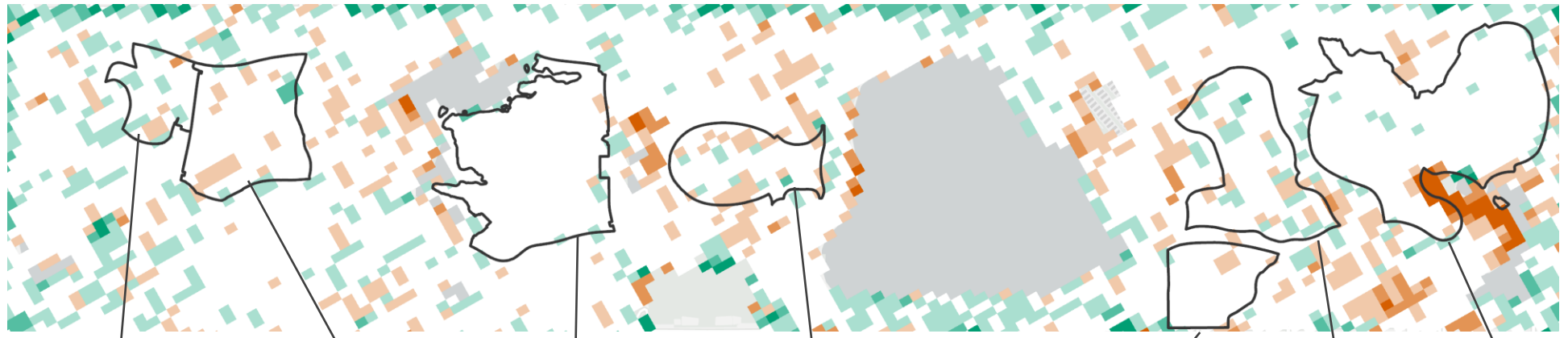


Spr/Sum 2024 Relative NDVI/ReNDVI

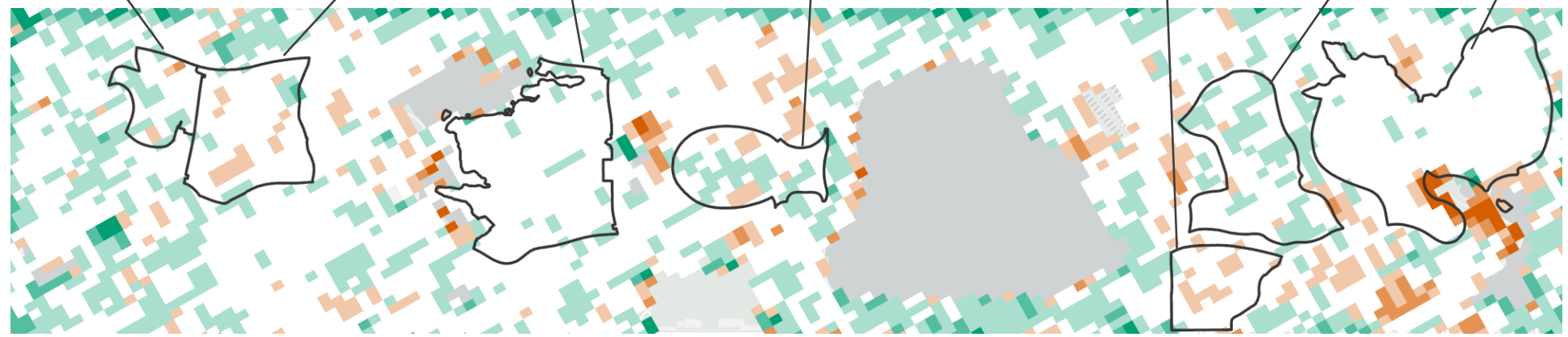
Pre-
During- Drought
Post-



NDVI



Hecksher Ballfields Sheep Meadow The Ramble Great Lawn East Meadow North Meadow North Woods



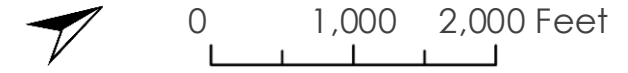
ReNDVI

% Change Compared to Baseline

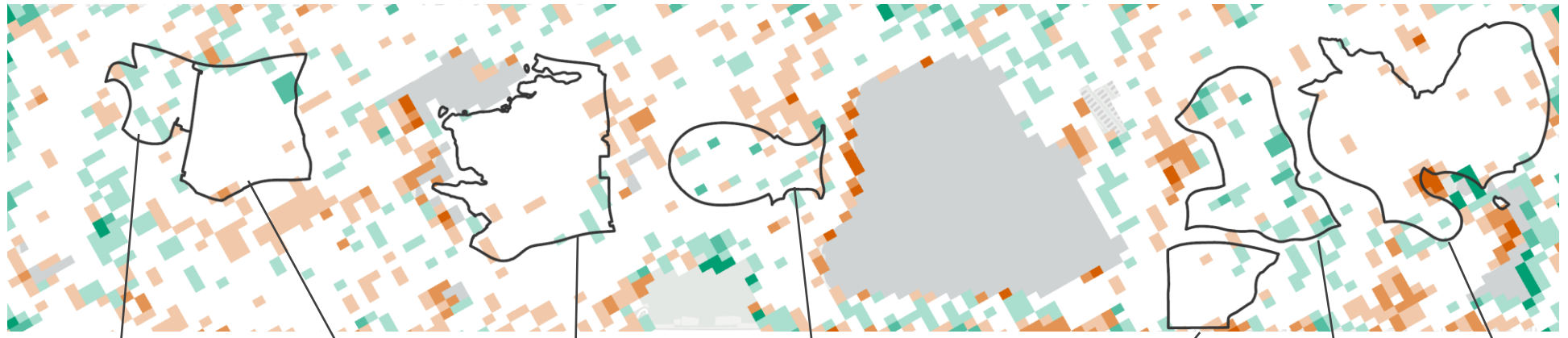


Spr/Sum 2025 Relative NDVI/ReNDVI

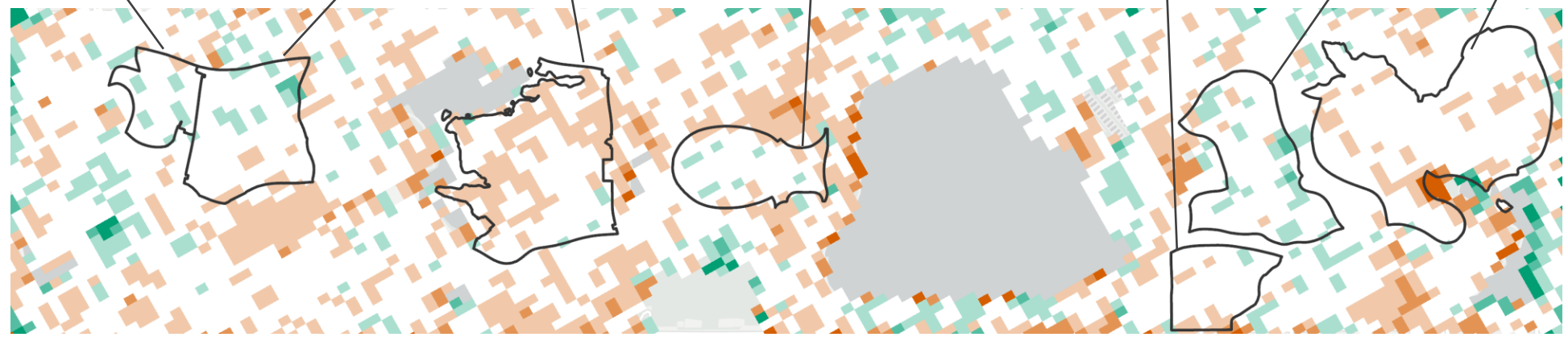
Pre-
During- Drought
Post-



NDVI

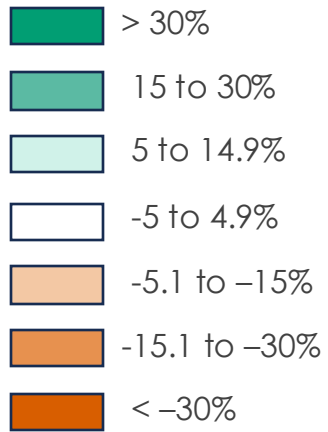


Hecksher Ballfields Sheep Meadow The Ramble Great Lawn East Meadow North Meadow North Woods

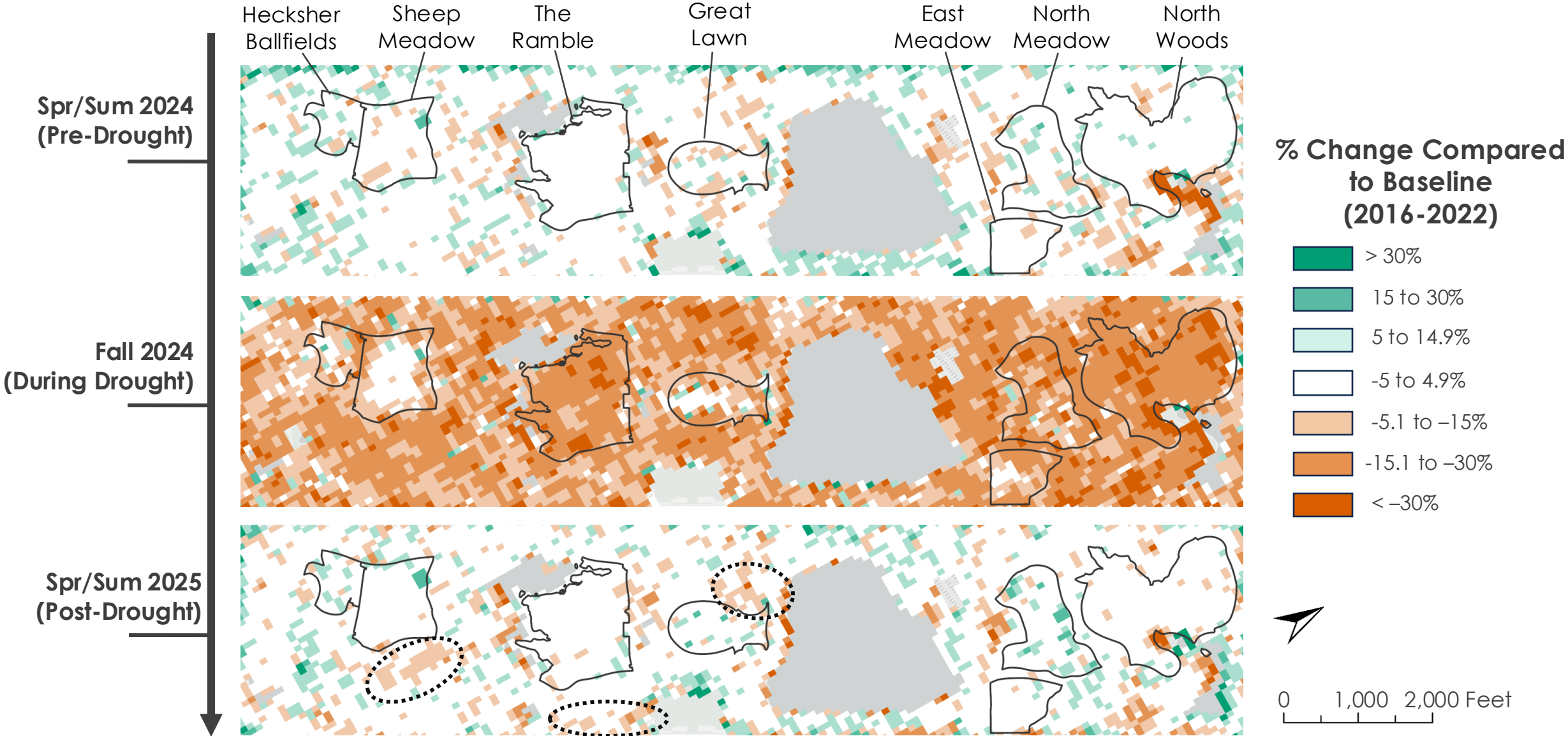


ReNDVI

% Change Compared to Baseline



2024 Drought Recovery – Relative NDVI Change



Recap — 2024 Drought Response

Baseline: 2016-2022

- **Earlier fall senescence** → widespread NDVI & MSI decline
 - Ramble, North Woods, North Meadow Ballfields most impacted
- All **7 AOIs recovered** by Summer 2025

