

# **Locating Optimal Lands for Reforestation in the Baraboo Hills, Wisconsin**

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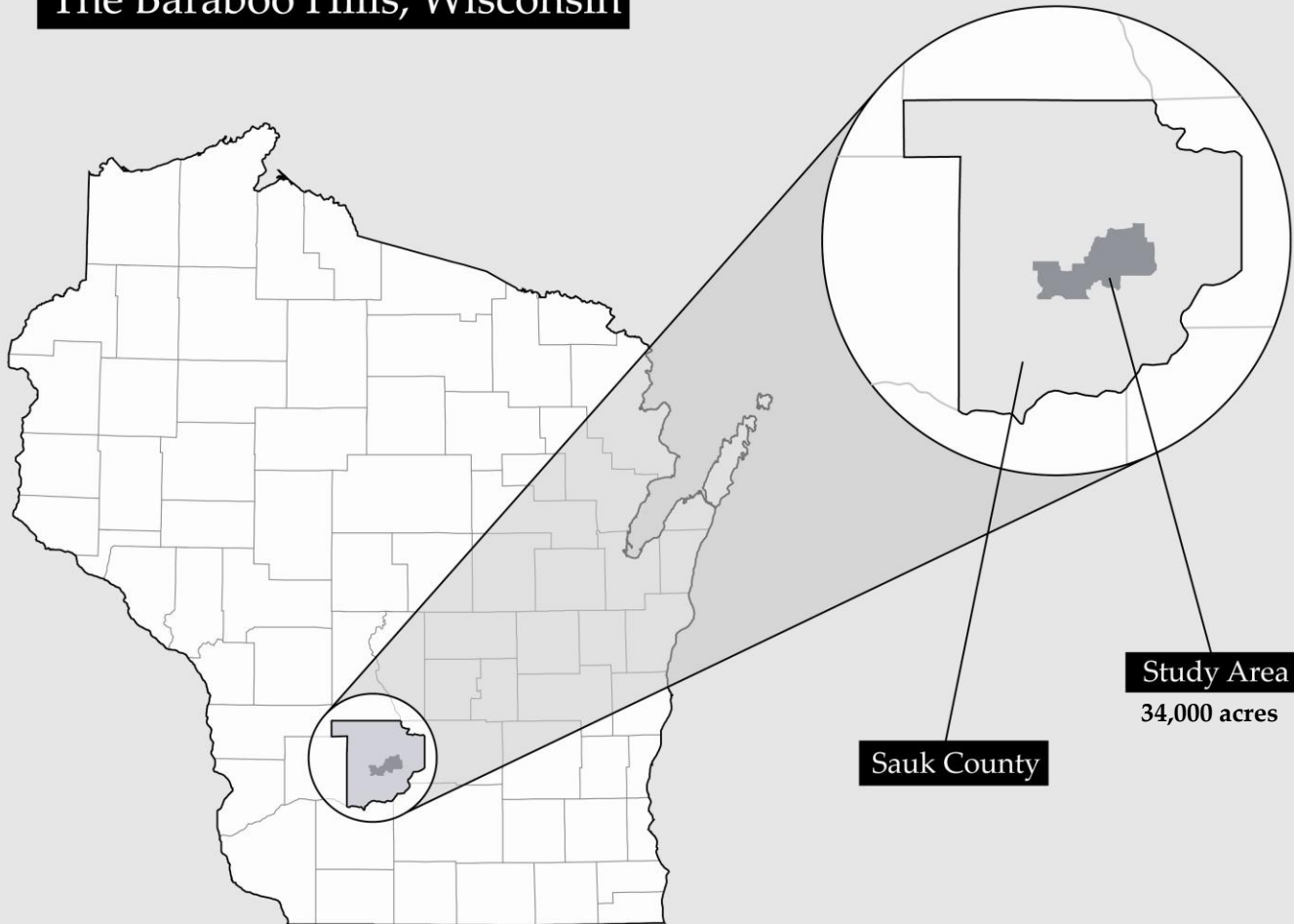
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# Introduction

## The Baraboo Hills, Wisconsin



# Introduction

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## - Why is this natural area so important?

- \* One of oldest rock formations in North America
- \* Largest remaining forest block in Southern Wisconsin
- \* Home to 1,800 species of flora and fauna, many of which are not found elsewhere in the Midwest
- \* Rapidly deforested in the first half of the century

# Introduction

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**- This is where the Nature Conservancy comes into the picture:**

- \* Since the 1960s, the Conservancy has acquired 7,841 acres of land in the hills
- \* Early years spent slowing the deforestation, but now we would like to focus on active reforestation in the area

# Analysis Criteria

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- **The Conservancy has developed several criteria, borrowing from multiple disciplines, for choosing optimal lands for reforestation**
- **These criteria break nicely into three categories:**
  1. Characteristics that improve lands for reforestation
  2. Characteristics that exclude lands for reforestation
  3. Characteristics that increase the amount of interior forest

# Analysis Criteria

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## - Characteristics that improve lands for reforestation:

### 1. Proximity to High Diversity Habitat

- \* within 200 meters

- \* 1.5 = High Diversity Habitat

### 2. Forest Seed Suitability

- \* 0 = poor

- \* 1 = fair

- \* 1.25 = good

- \* 1.5 = very good

# Analysis Criteria

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## - Characteristics that exclude lands for reforestation:

1. Forest Seed Size
  - \* less than 160 acres
2. Distance from major roads and power lines
  - \* within 50 meters
3. Distance from houses and developed areas
  - \* within 50 meters
4. Currently forested



# Analysis Criteria

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- **By habitat fragmentation, deforestation provides exotic species easier access into the forest**

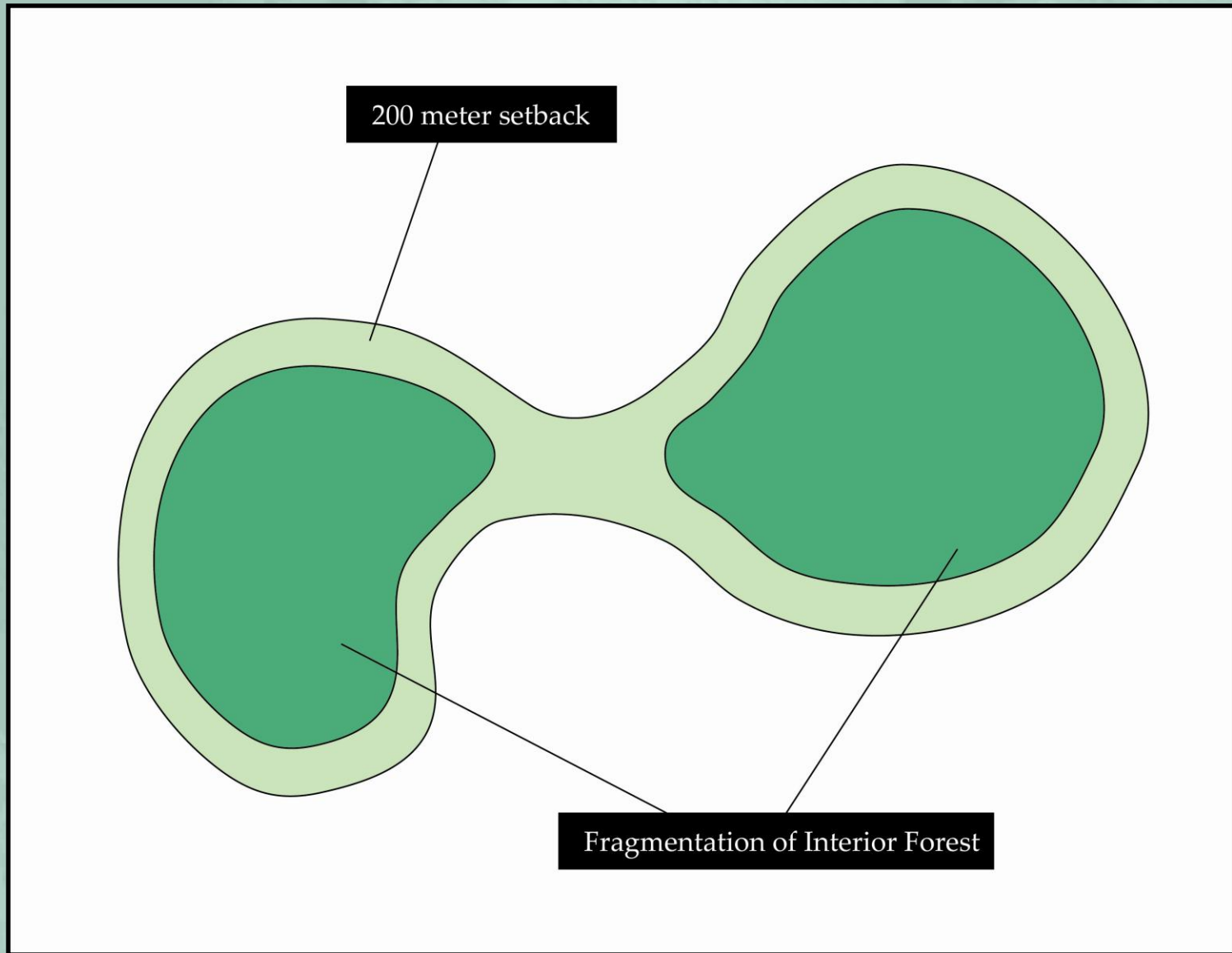
\* The Nature Conservancy has established that the exotic species in Baraboo Hills can penetrate up to 200 meters into the forest

- ***Interior Forest* – forest beyond this 200 meters that acts as a sanctuary for native species**



# Analysis Criteria

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# Convolution

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- **The idea is that we want to reduce this perimeter in which the invasive species can penetrate, while increasing the interior forest area.**
  - \* Want to add more than one acre of interior forest for every acre we reforest
  - \* So we need to somehow analyze the shape of the forest polygons
- ***Compactness* – a commonly measured characteristic of shape**

$$C = \frac{\sqrt{Area}}{0.282Perimeter}$$

# Convolution

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- **Why will the concept of compactness alone not help us analyze where to reforest?**
  1. The most compact shape is a circle
    - It is not plausible to simply convert all of our polygons into large circles
  2. There is no way to incorporate the other analysis criteria
  3. Because multiple different sizes and shapes can yield the same compactness ratio, it can only be used to compare changes that are made, not actually suggest what changes to be made
    - Puts us right back to where we started

# Convolution

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- In response, we propose to expand the uses of convolution in a novel way
- ***Convolution*** – a spatial processing technique that takes a kernel of coefficients or weights and moves it throughout the entirety of the image
  - \* At each pixel, the neighbors included in the kernel are calculated given the particular expression and the resulting value is set as the digital number for that pixel
  - \* Also called a *Moving Window Analysis*

# Convolution

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- The values in each cell, the kernel size, and the calculation placed in the center are parameters that are set at the start of the convolution

1	1	1
1	1	1
1	1	1

## - For our analysis:

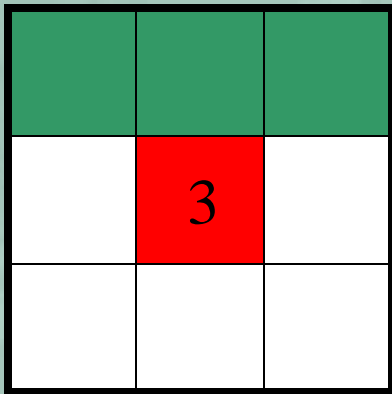
1. The cell value is 1 for each
2. The kernel size is 3x3
3. The center pixel will get the sum of the nine values in the window

# Convolution

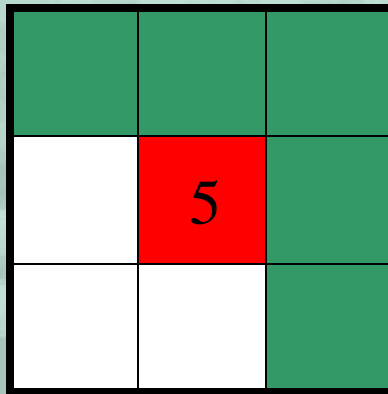
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## - How will this analysis solve our problem?

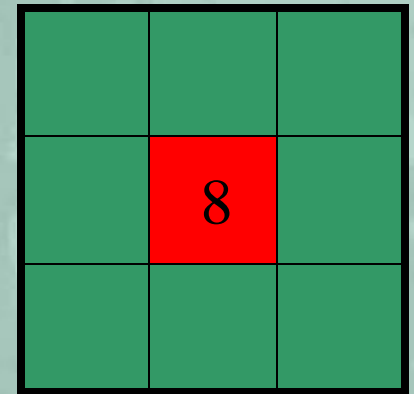
\* There is a direct relationship to the sum placed in the center and the compactness value



EX1. The addition of the center pixel adds two sides of perimeter by only adding one pixel of area



EX2. The addition of the center pixel adds one pixel of area, but does not add any perimeter

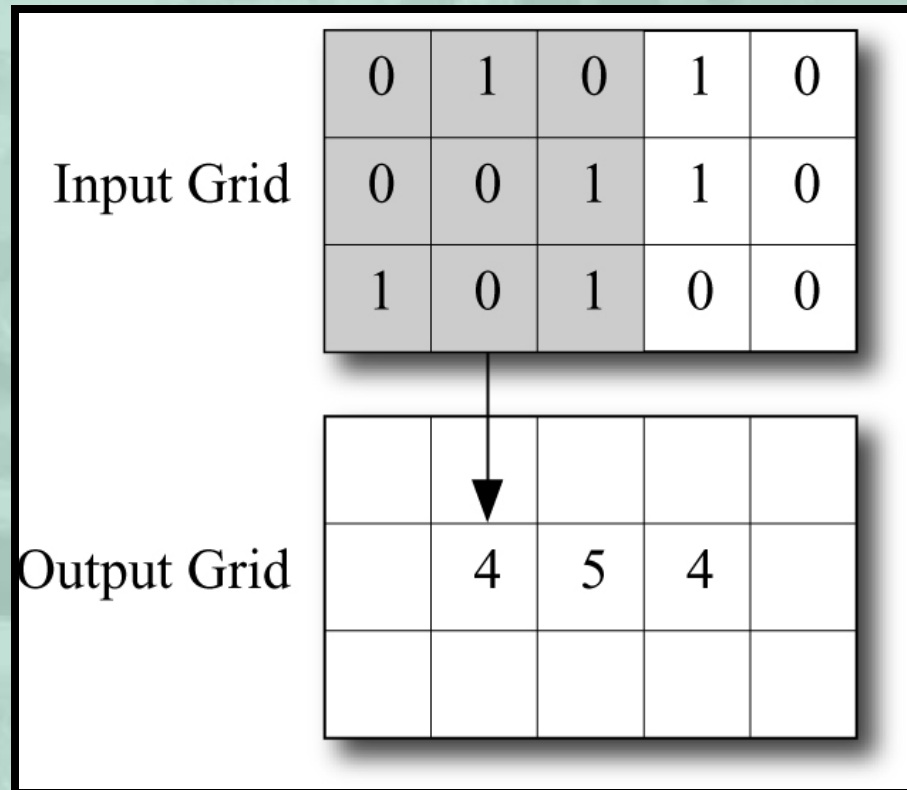


EX3. The addition of the center pixel actually removes four sides of perimeter while still adding one pixel of area

# Convolution

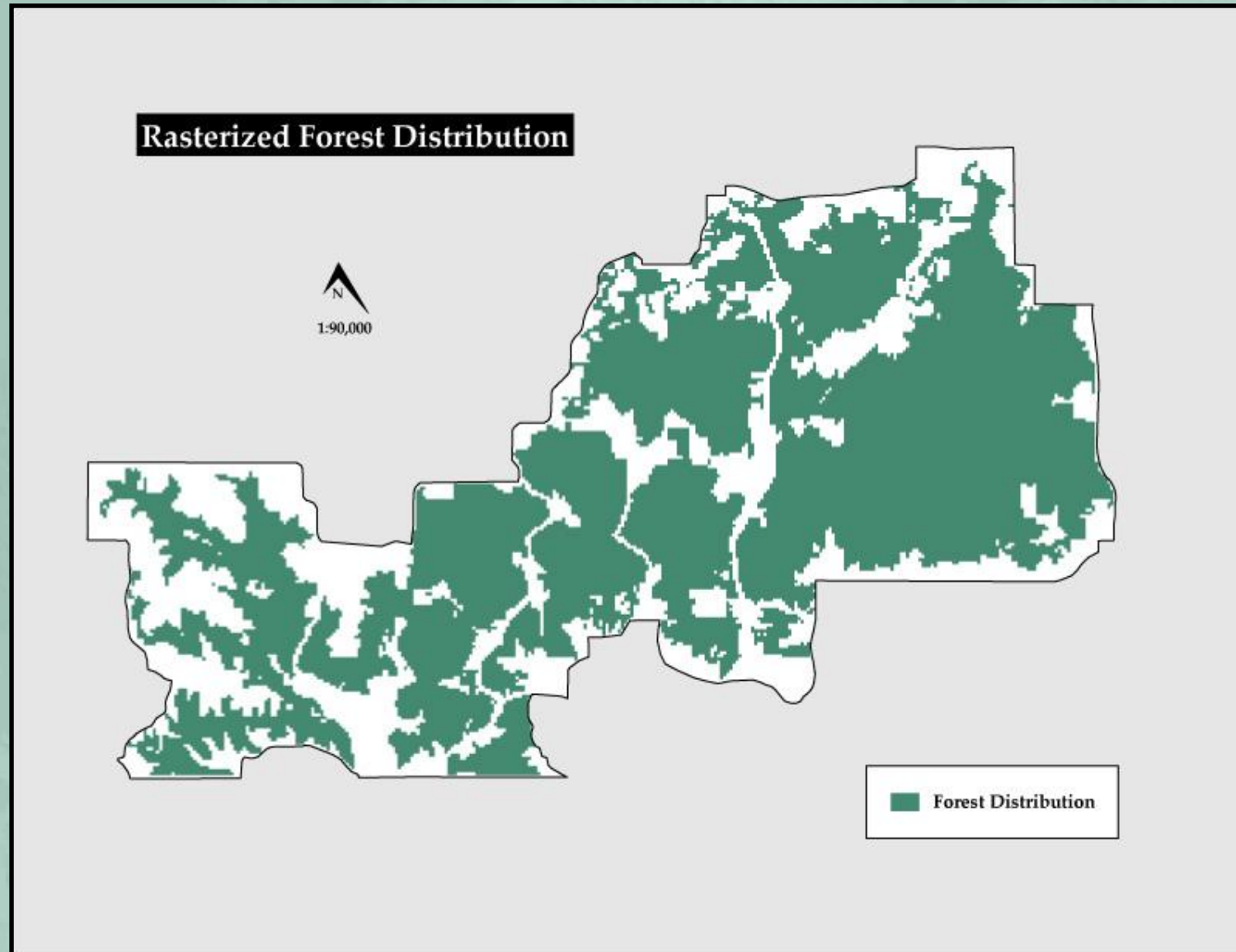
- It is necessary to rasterize and codify the original forest distribution

- \* 0 = nonforested areas
- \* 1 = forested areas

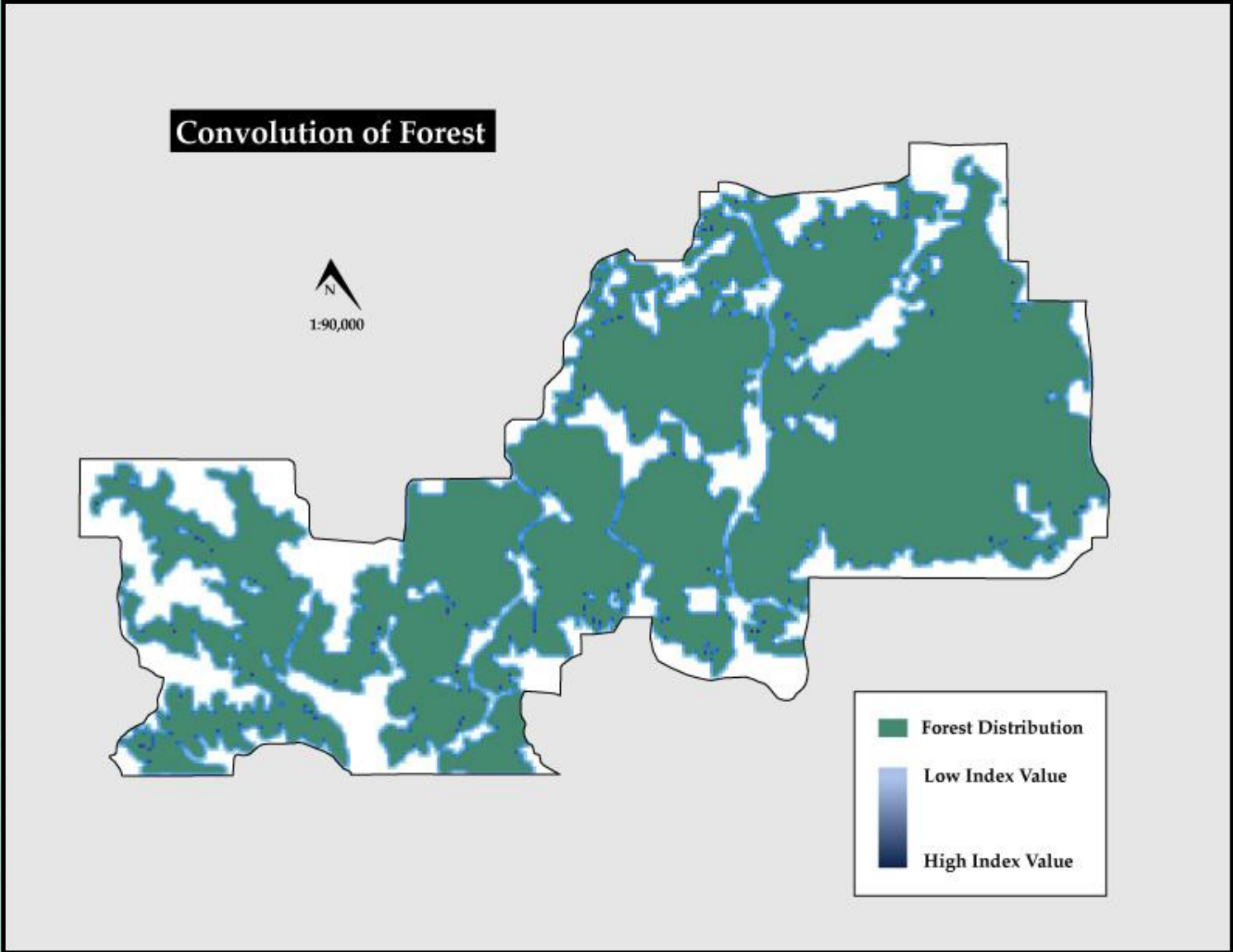




# Implementation

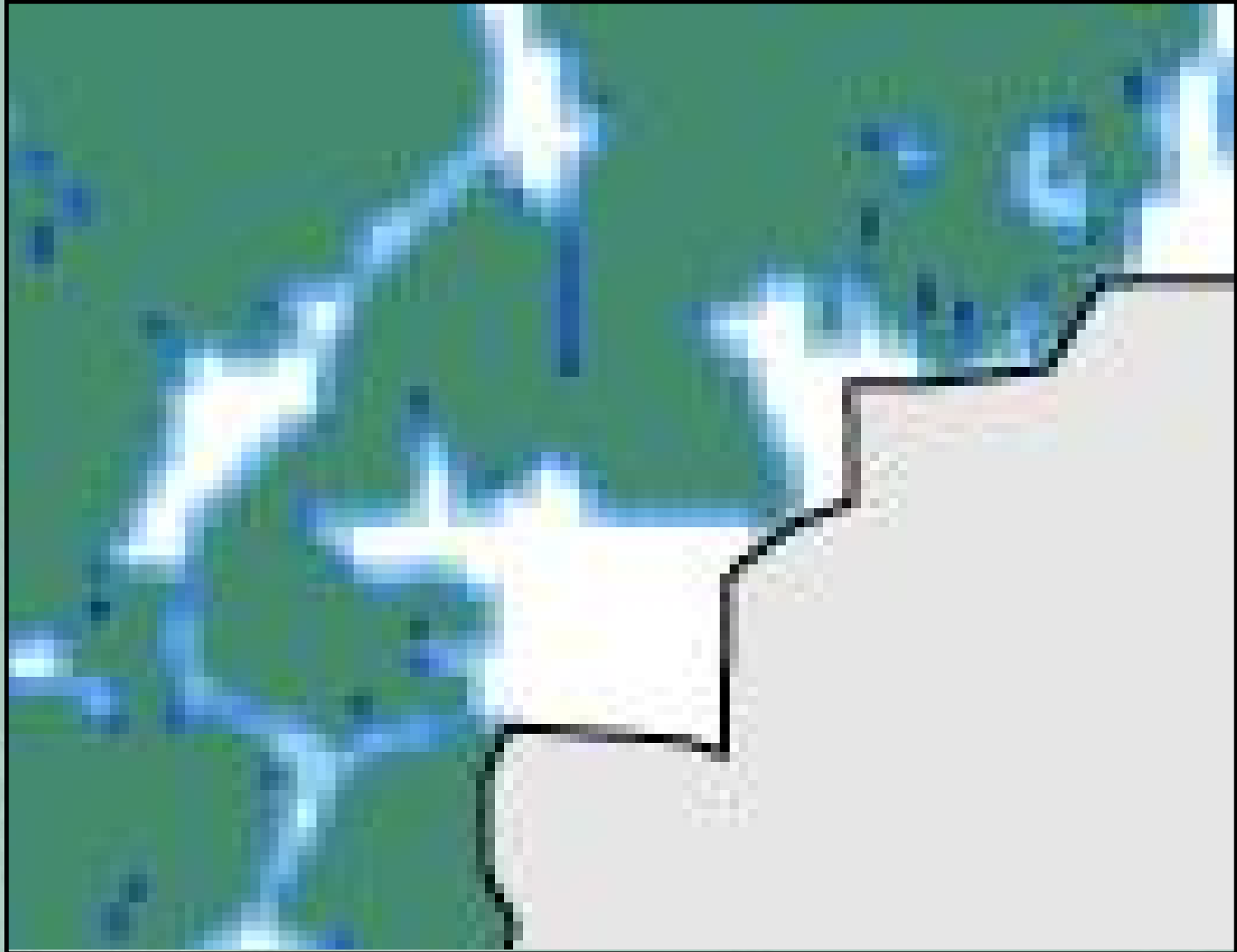


# Implementation



# Implementation

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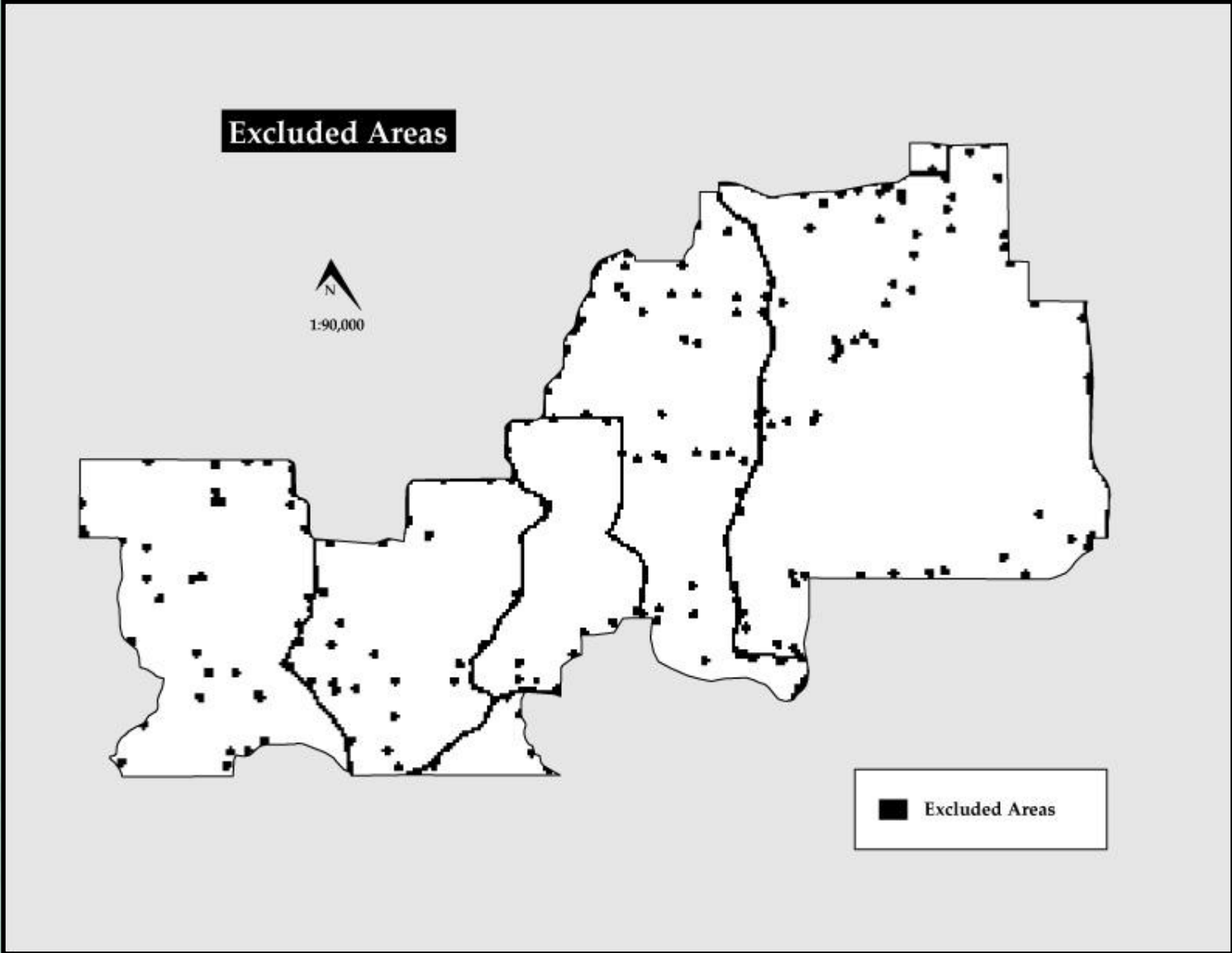


# Implementation

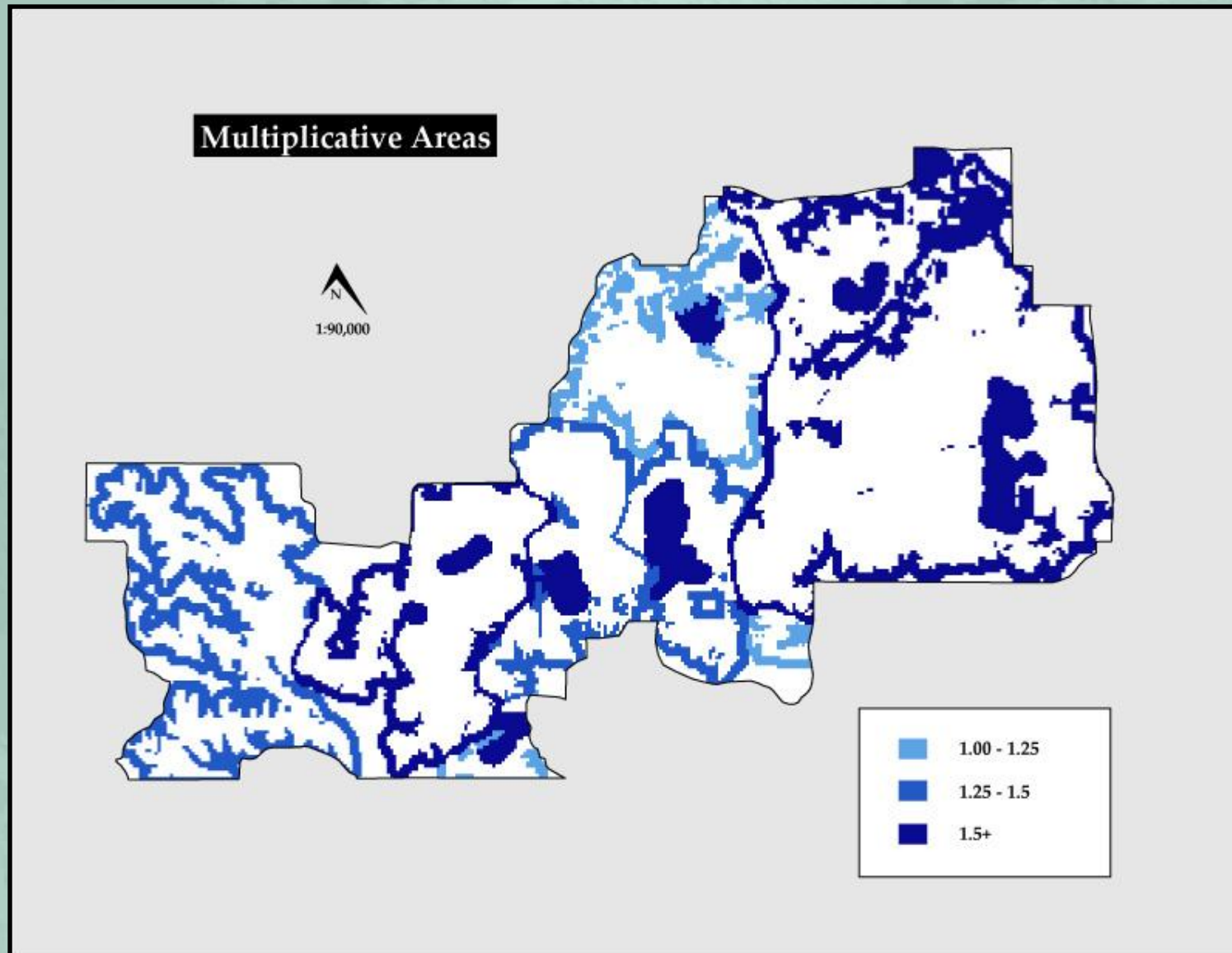
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- **We then integrate the other analysis criteria outlined by the Nature Conservancy**
  
- **These layers must also be rasterized and codified:**
  - \* 0 = excluded areas
  - \* >1 = multiplicative areas
    - Different values can be attributed as weight, allowing incorporation of even more information

# Implementation



# Implementation





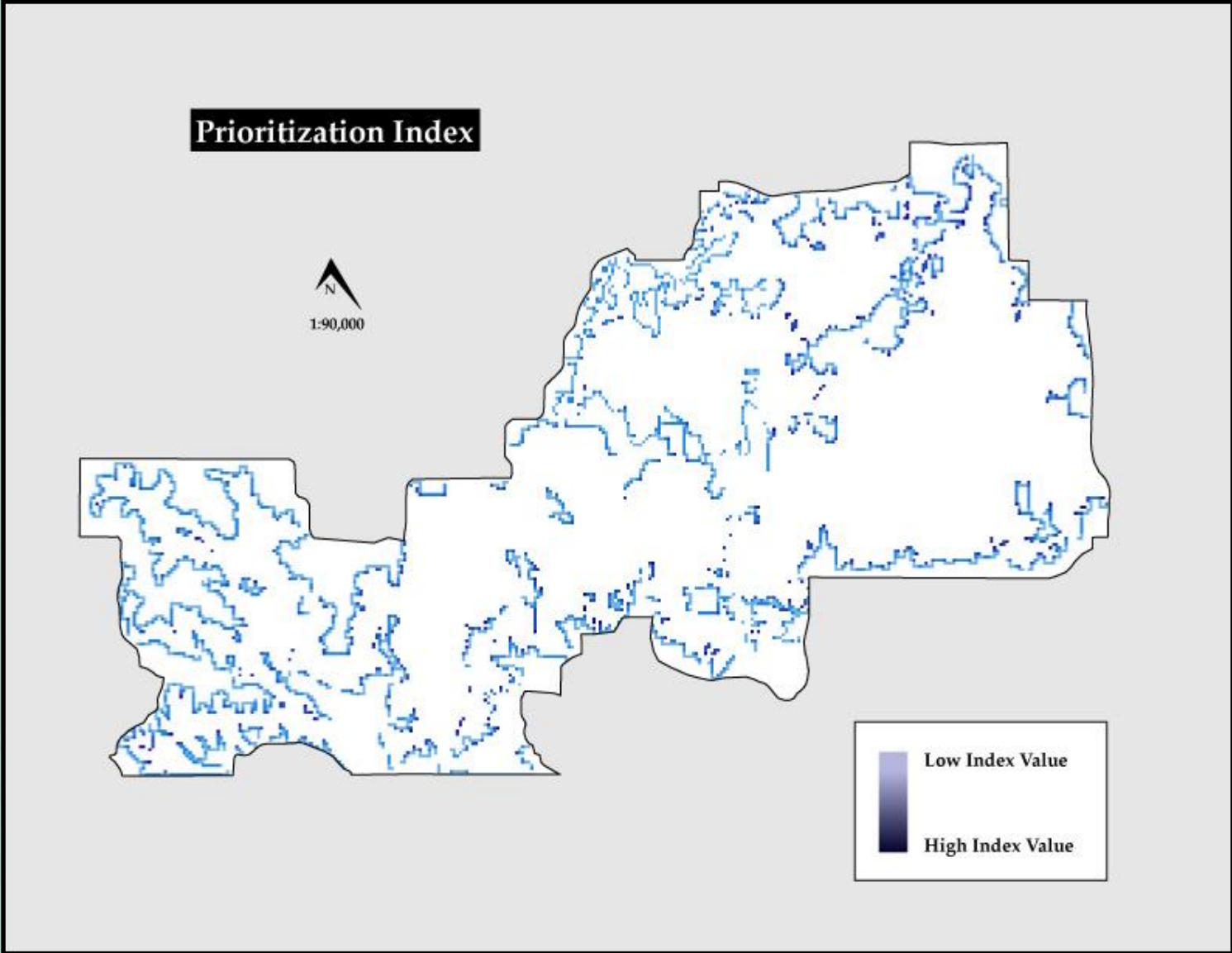
# Implementation

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- **These other raster layers will then be multiplied with the convoluted image by a raster calculator**
  - \* The output will be a grid containing a single value that has all three types of information desired by the Nature Conservancy embedded within it
  - \* Difficult to say such a complex phenomenon can be quantified by a single value, but here the resulting index has great significance



# Implementation



# Implementation

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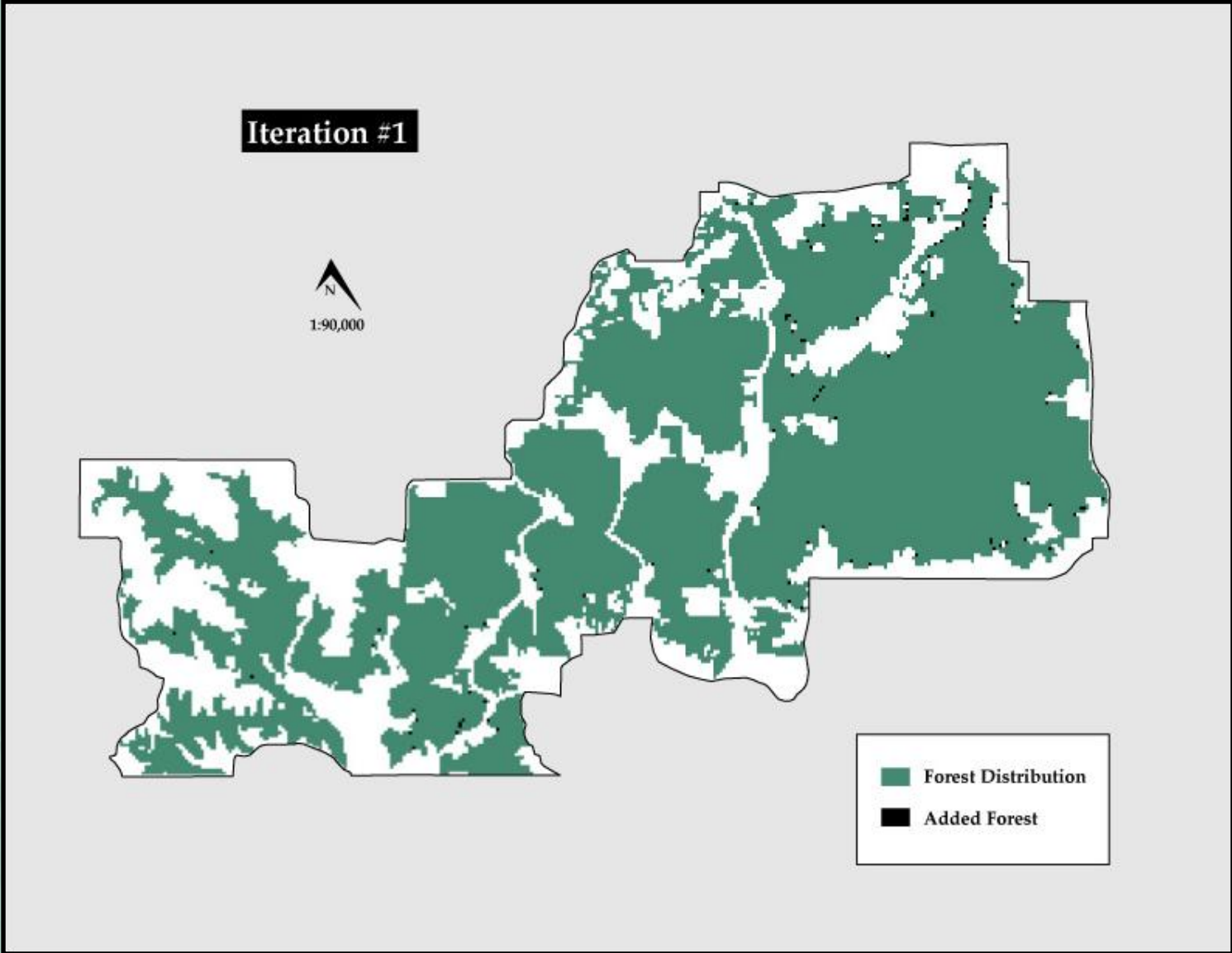
- **An important aspect to this analysis is determining the critical value**

- \* Found a natural break between 6 and 6.25

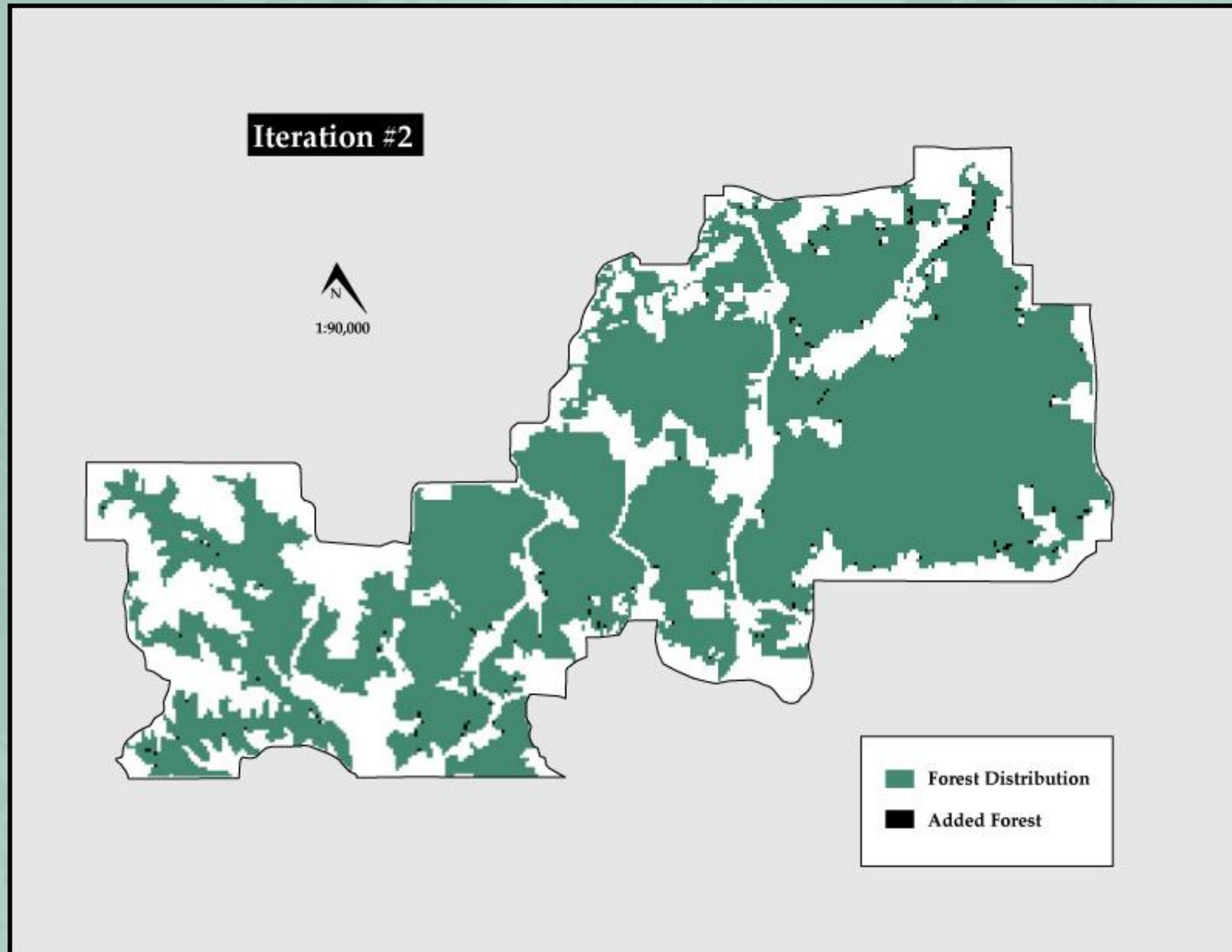
- **Once the critical value is determined, we run as many iterations necessary to gather the desired amount of acreage for reforestation**

- \* The Nature Conservancy has budgeted for 800 acres in the next 10 years.

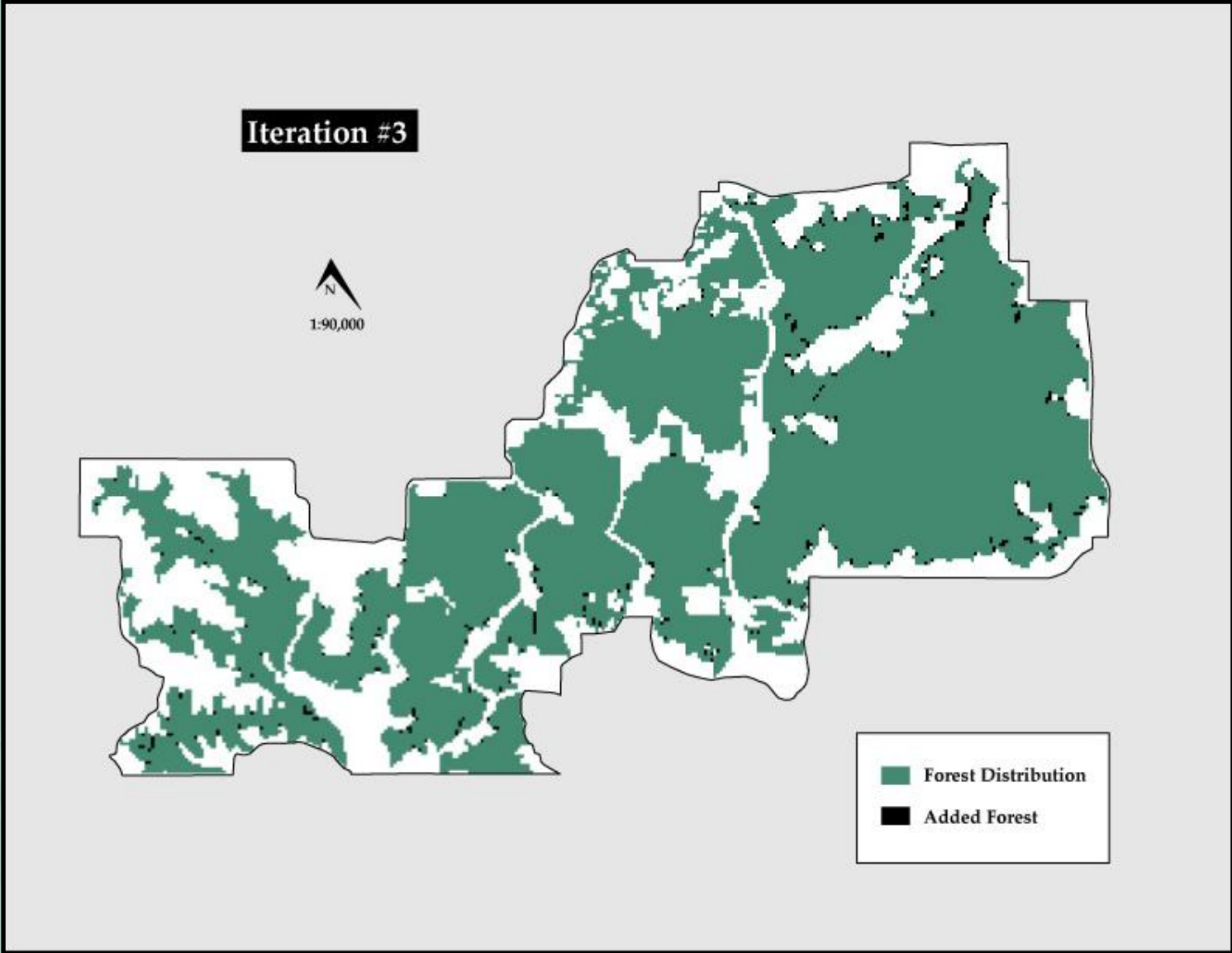
# Implementation



# Implementation

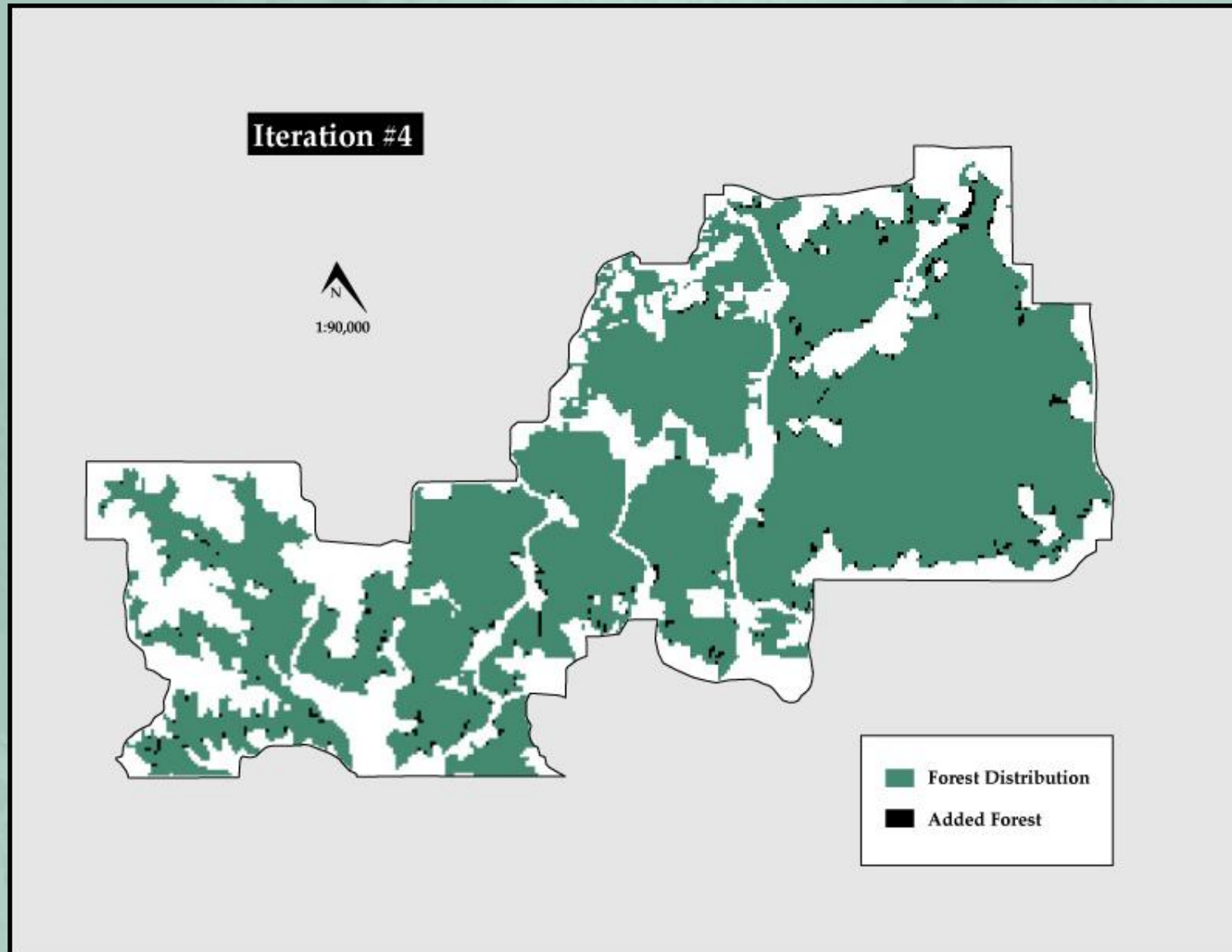


# Implementation

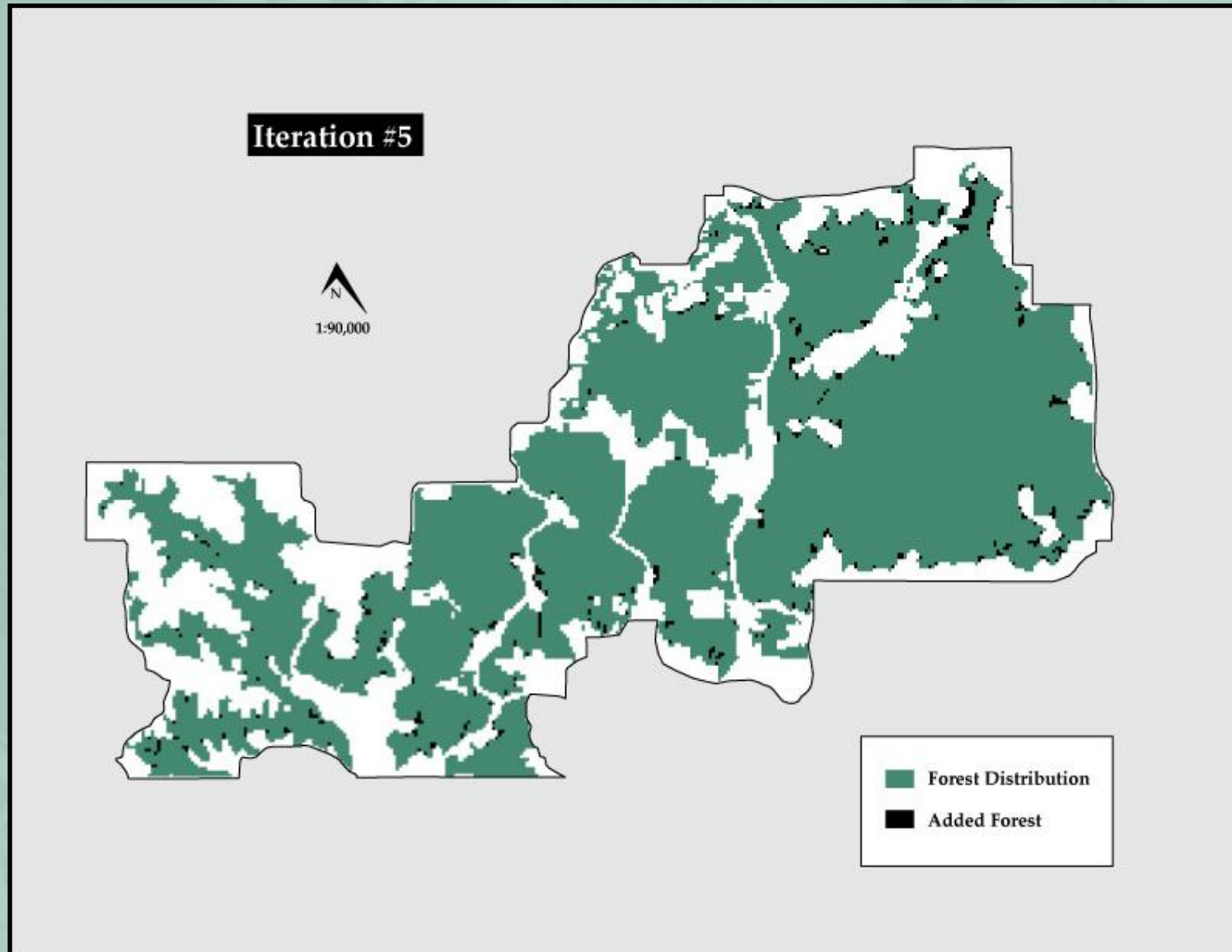




# Implementation

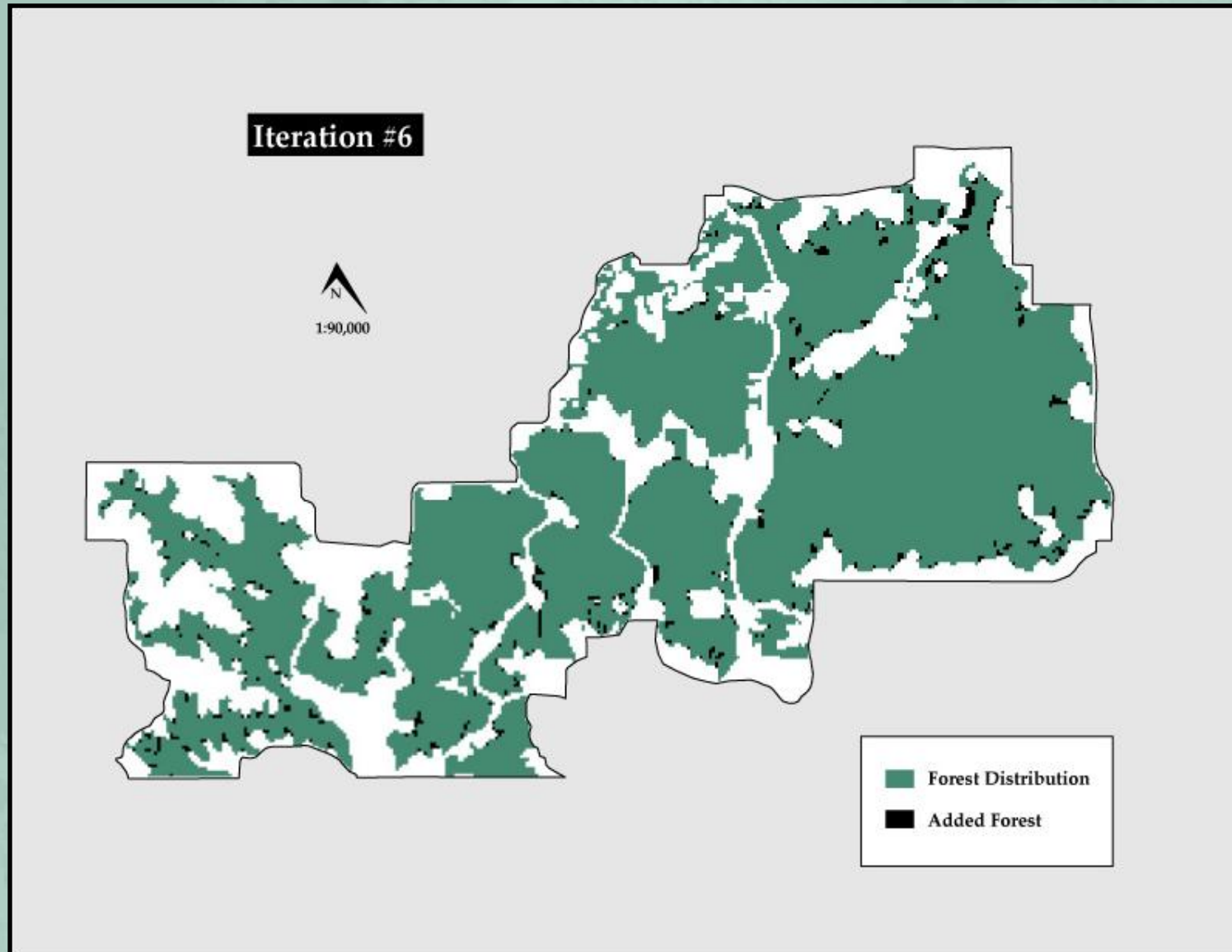


# Implementation

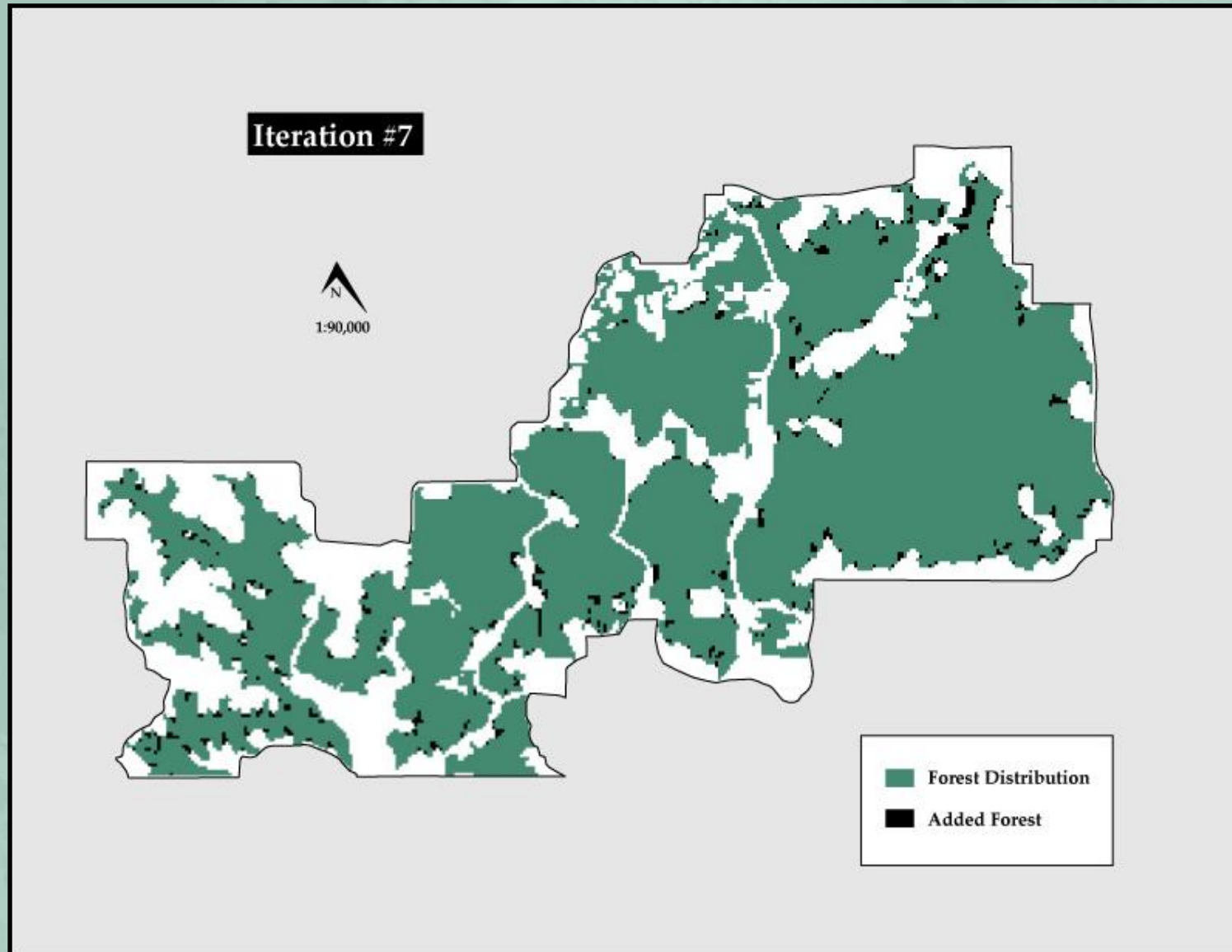




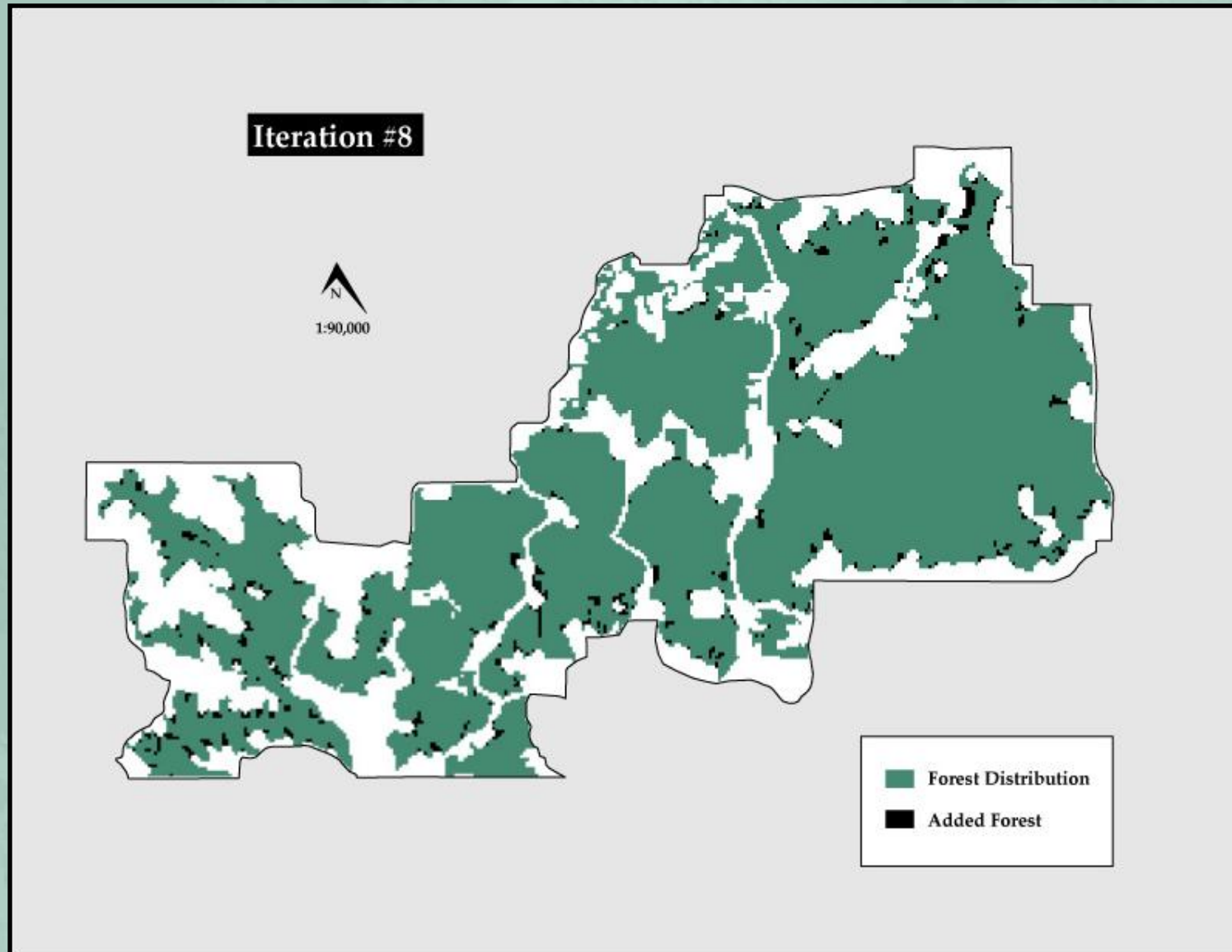
# Implementation



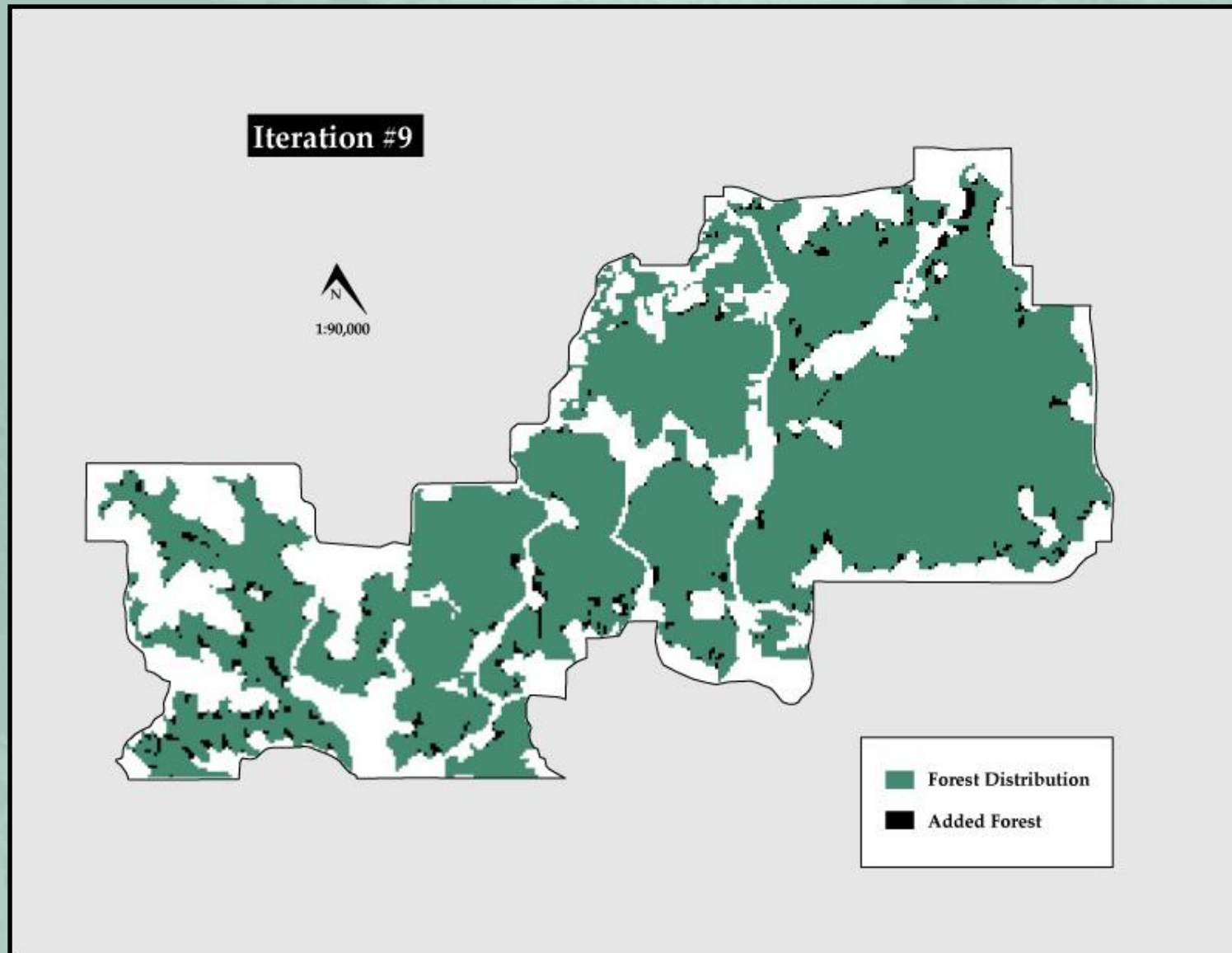
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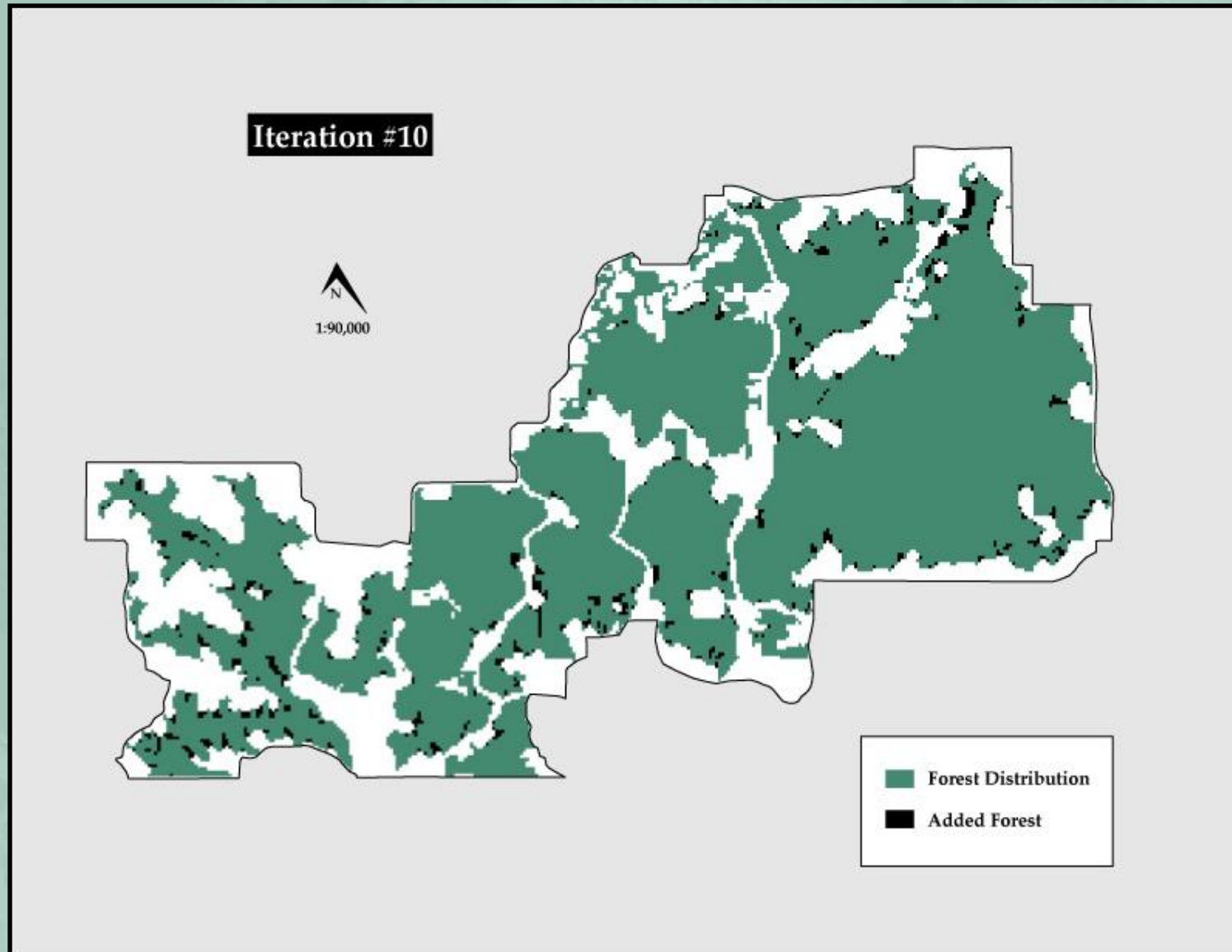
# Implementation



# Implementation



# Implementation





# Results

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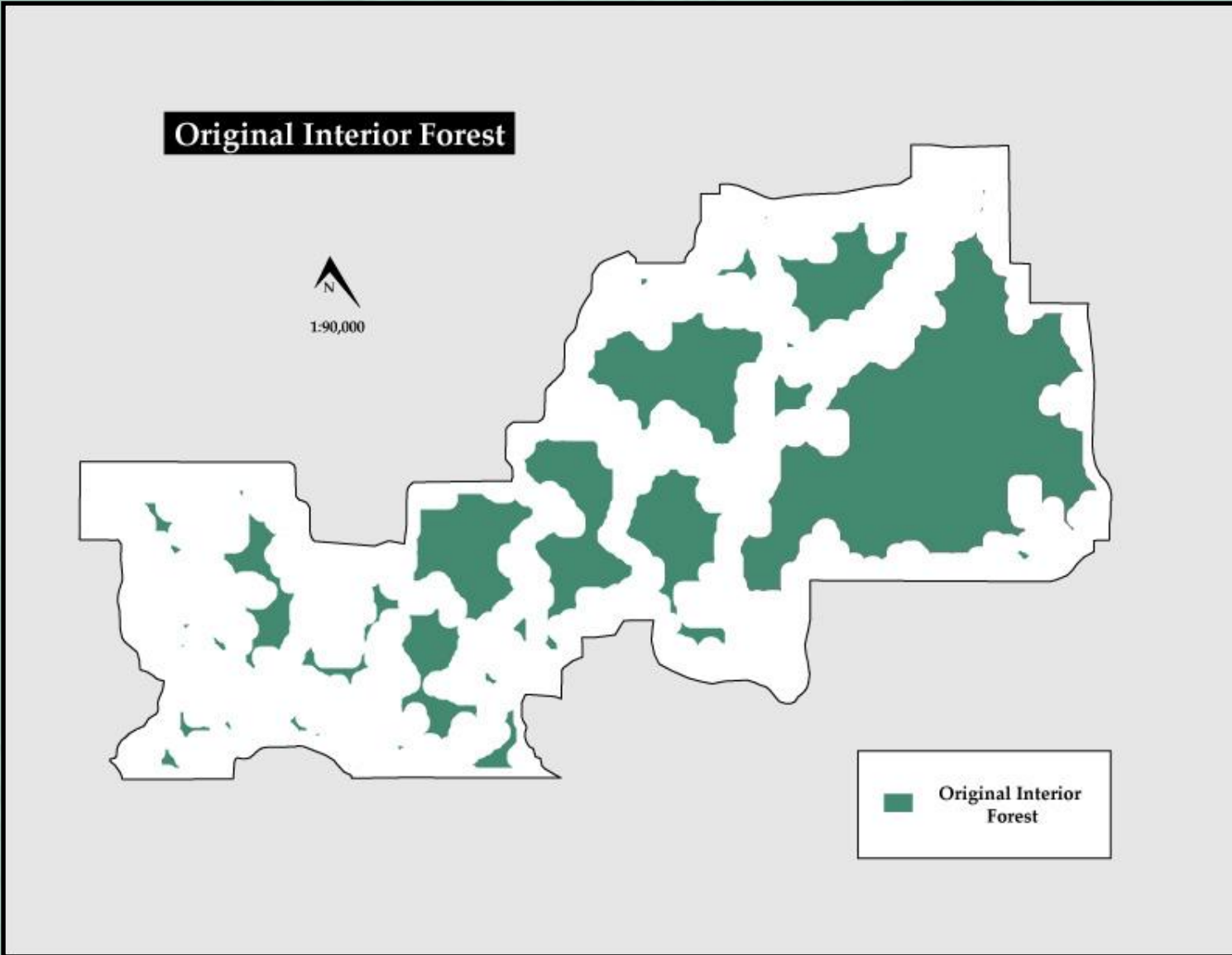
- **The analysis suggests 950 acres total**

- \* The Nature Conservancy will use ground-truthing to further reduce this amount to the allocated 800 acres

- **So does this approach work?**

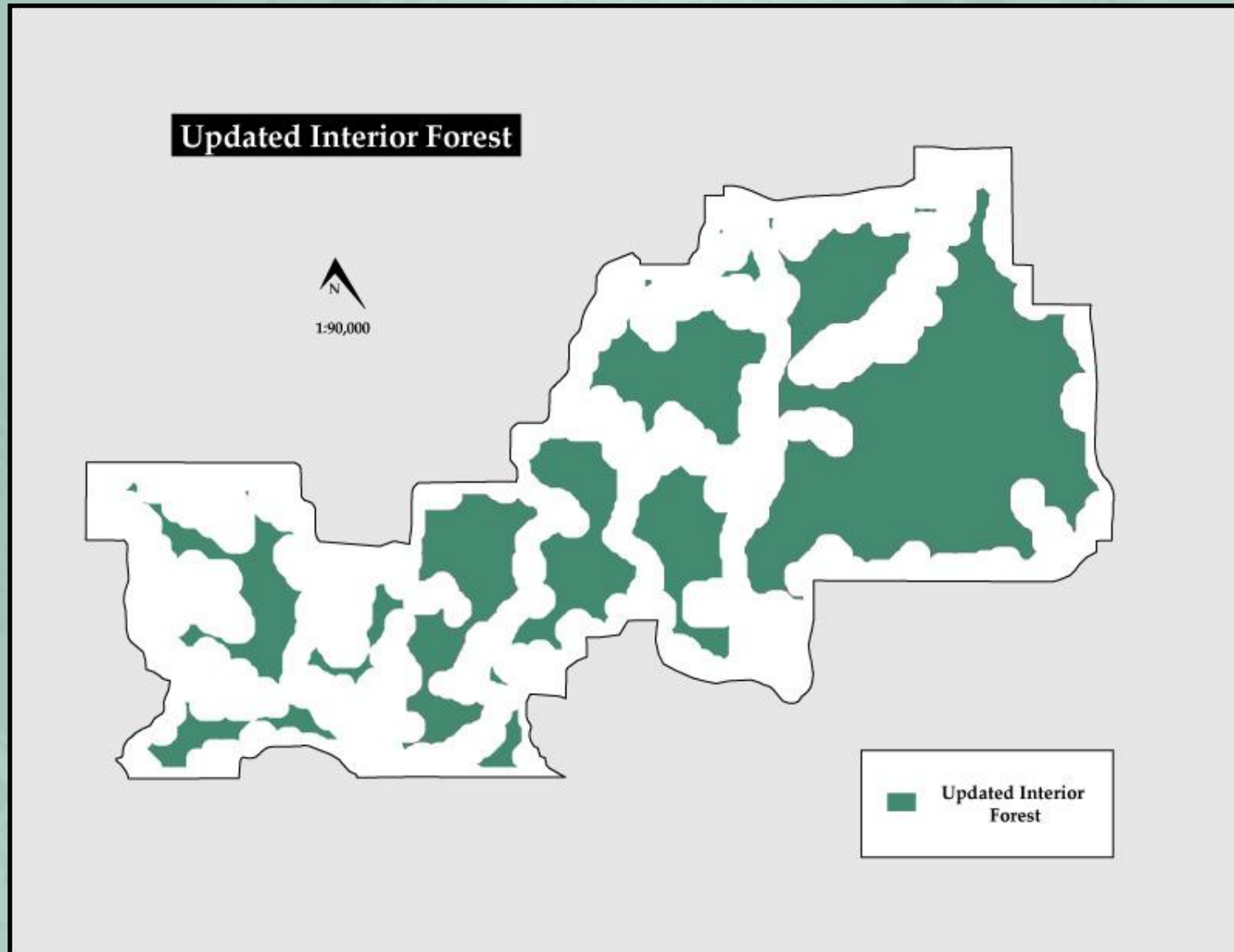
- \* We cannot just look at the exterior forest edge
- \* Compare the amount of interior forest we originally had to the amount of interior forest we added through our analysis

# Results

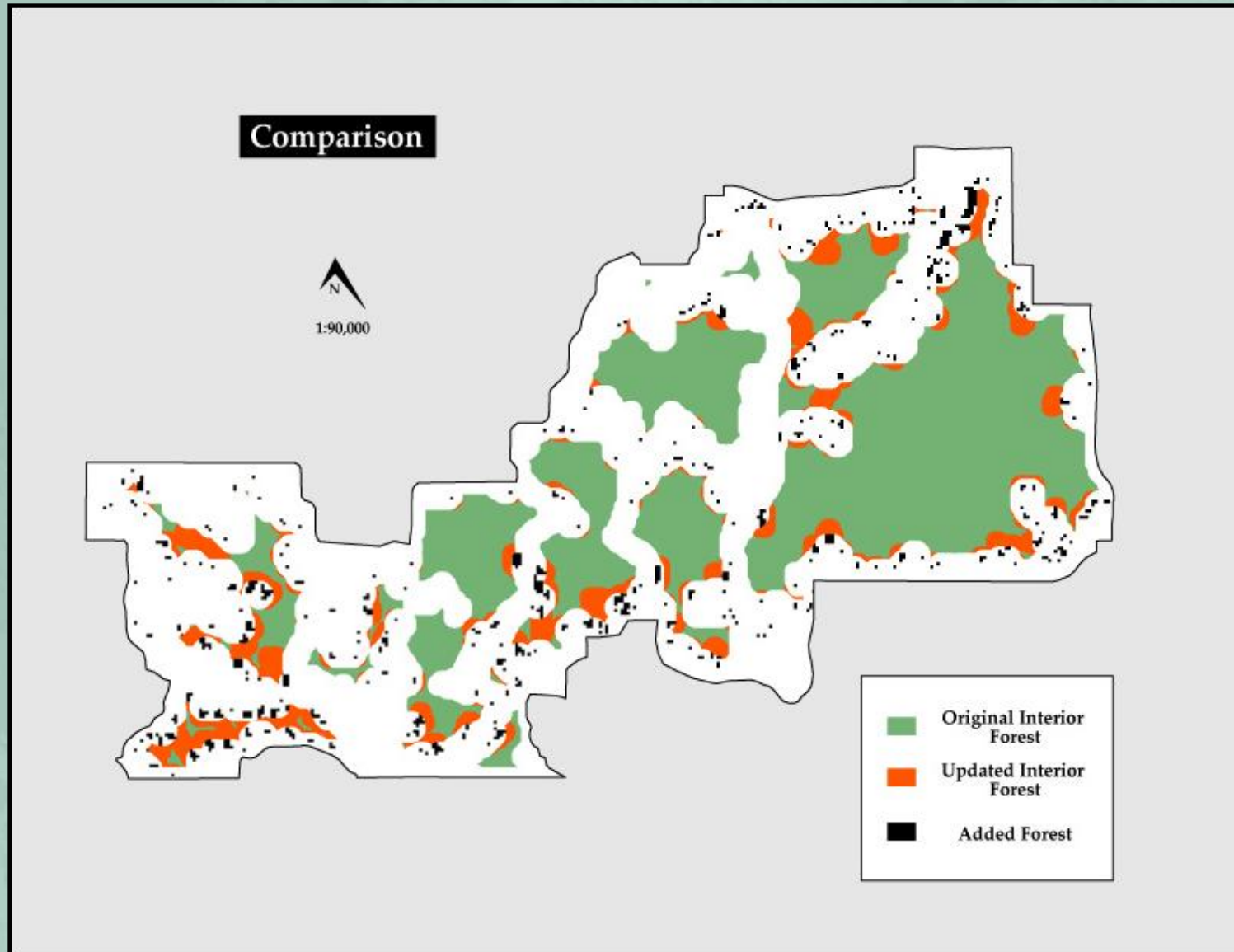




# Results



# Results



# Results

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## - Findings:

\*Original Compactness Ratio: 0.08989

\*Updated Compactness Ratio: 0.11269

\*Original Interior Forest: 11,187 acres

\*Updated Interior Forest: 13,414 acres

\*Difference: 2,227 acres

**- Thus, because we added 950 acres total, we got a 235% return on our reforestation**

# Results

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## - Questions to ponder:

- \* How much inaccuracy does rasterization introduce?
- \* Was a 3x3 window appropriate or would a larger window produce different results?
- \* How would the results differ if the multiplicative values were different?
- \* Was our critical threshold of 6-6.25 appropriate?

# Questions?

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**~ Thank you for your time**