Predicting landscape vulnerability to non-native plants using a CART model in Interior Alaska

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Alaska has been "The Last Frontier" for invasive plants due to cold climate and geographical isolation from population centers; however, the recent rapid inflow of non-native plant species is raising concerns. Although several studies have been conducted to predict the distribution and potential impacts of non-native plants in Alaska, a comprehensive model that considers all non-native plant species in Alaska with multiple factors that potentially affect plant invasion (climate, habitat condition, and anthropogenic infrastructure) has not been made. The purpose of this study is to identify (1) which factor or combination of factors among climate, habitat, and anthropogenic infrastructure make the landscape ecologically vulnerable to plant invasion in interior Alaska, and (2) where are the areas that are most at risk for plant invasion currently and in the future (2020s and 2060s). The hypothesis is that the anthropogenic land use would be the most influential factor. These objectives were addressed by constructing a decision tree (CART model) that classifies a multitude of climate, habitat, and anthropogenic variables based on how they interact with the current non-native plant distribution. The model suggested that anthropogenic land use is the single most influential factor, followed by two climate factors, summer warmth index and January precipitation. While few changes are expected in the near future, more substantial changes are anticipated in the long-term future. Western Alaska needs a long-term management strategy as it is currently undersampled and predicted to experience a rapid expansion in human population and plant invasion by 2060s.

Predicting landscape vulnerability to non-native plants in central Alaska

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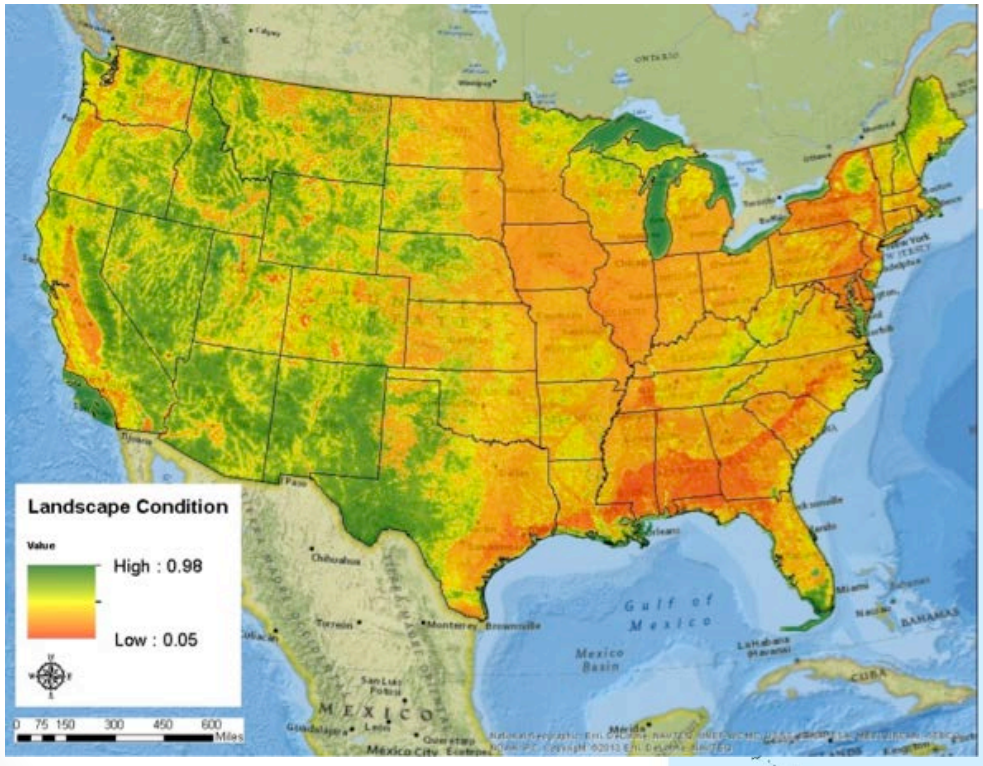
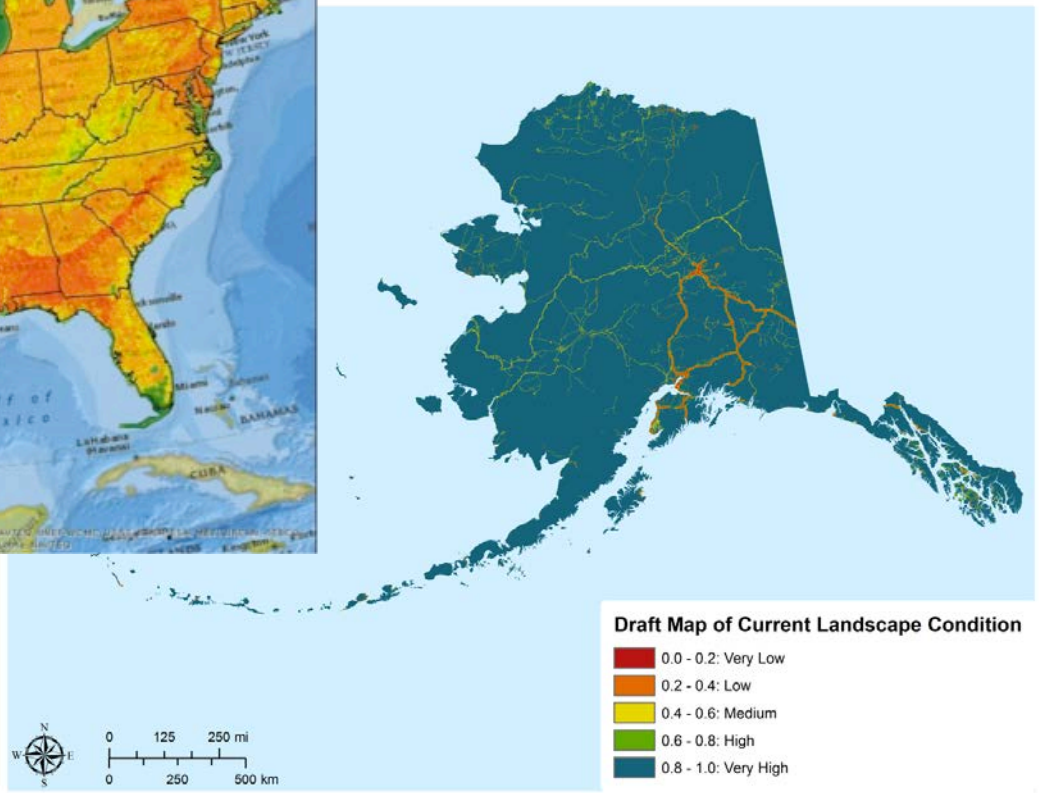
Introduction:
Why does Alaska have less of a weed problem than most other states?





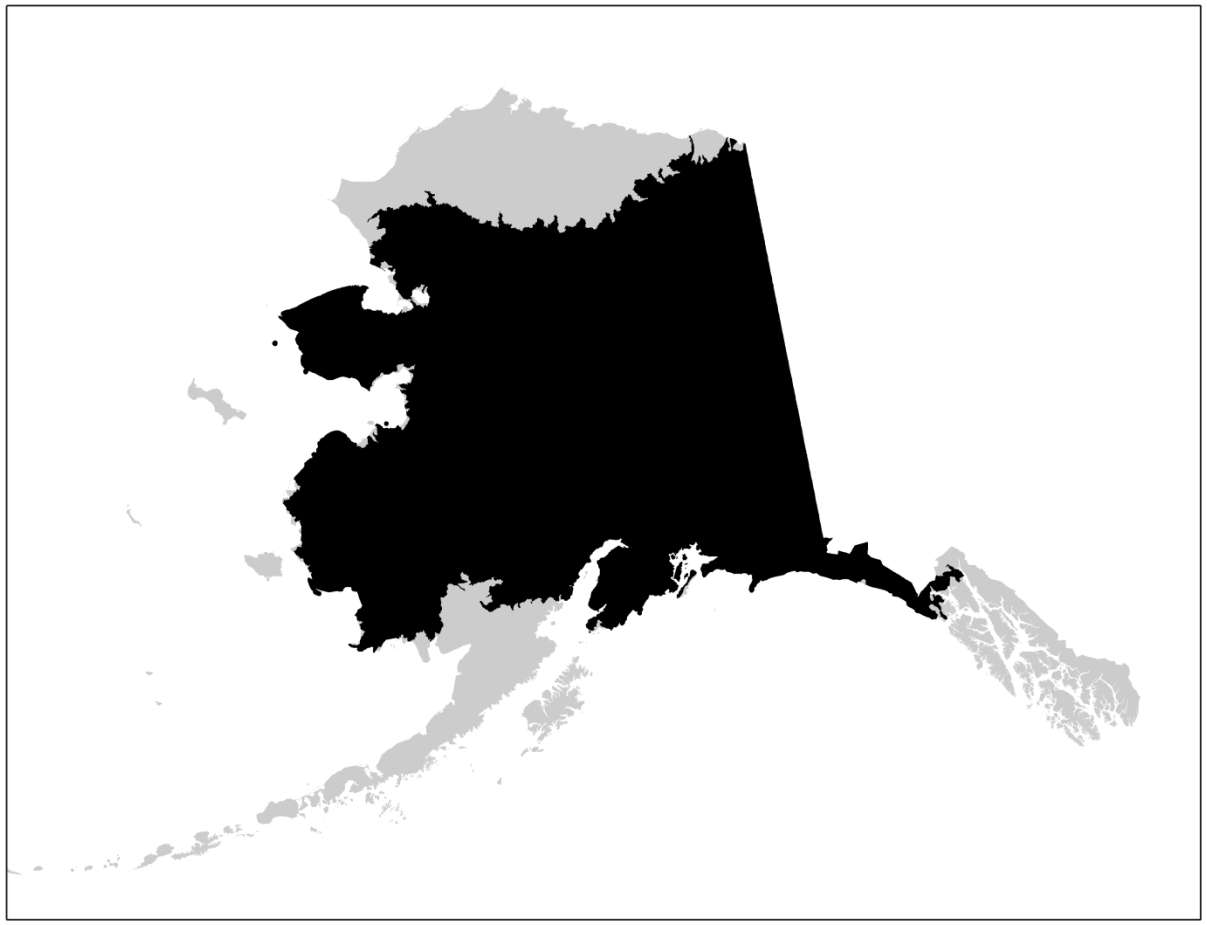
Introduction: Why synthetic approach?

- Invasion ecology is complex and idiosyncratic
- Multi-species
- Multivariate
- Landscape approach

Introduction: Objectives

1. Identify the climate, habitat, or anthropogenic factors that make the landscape more vulnerable to plant invasion
2. Predict the critical areas for invasion control in 2020s and 2060s

Methods:
Study Area



Methods: Overview

- Objective 1 (Identify factors for invasion)
  - Classification and Regression Tree (CART) analysis
- Objective 2 (Predict the critical areas)
  - Mapping

Methods: Objective 1
Why use CART?

- CART uses a decision tree to make a prediction model by splitting values of predictor variables
  - Handles collinearity among predictor variables
  - Accounts for non-linear relationships
  - Flexibility of input data format
  - Tree-based diagram is easy to interpret

Methods: Objective 1 Response Variables

- Merged non-native plant database by watersheds
  - Alaska Exotic Plants Information Clearinghouse (AKEPIC)
  - Consortium of Pacific Northwest Herbaria (includes ALA, UAAH, etc.)
  - Toolik Field Station Herbarium
- Created a “weediness” index by watersheds
  - quantify the levels of invasive plants risk
  - Watersheds are “infested” if they have at least one highly invasive species and at least 10 non-native species

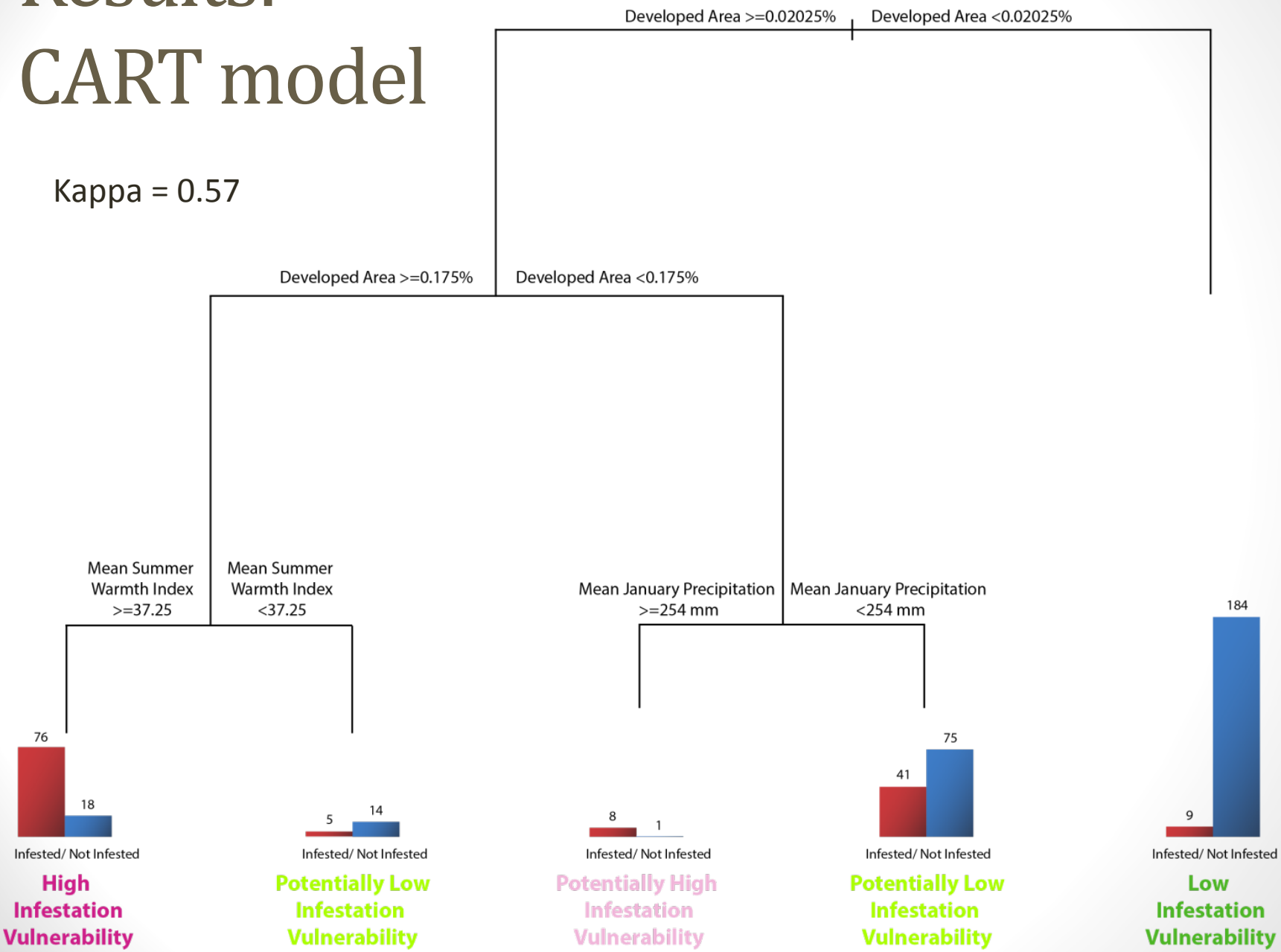
Methods: Objective 1 Predictor Variables

- 10 climate
- 4 habitat
- 7 human variables
- Summarized by watersheds

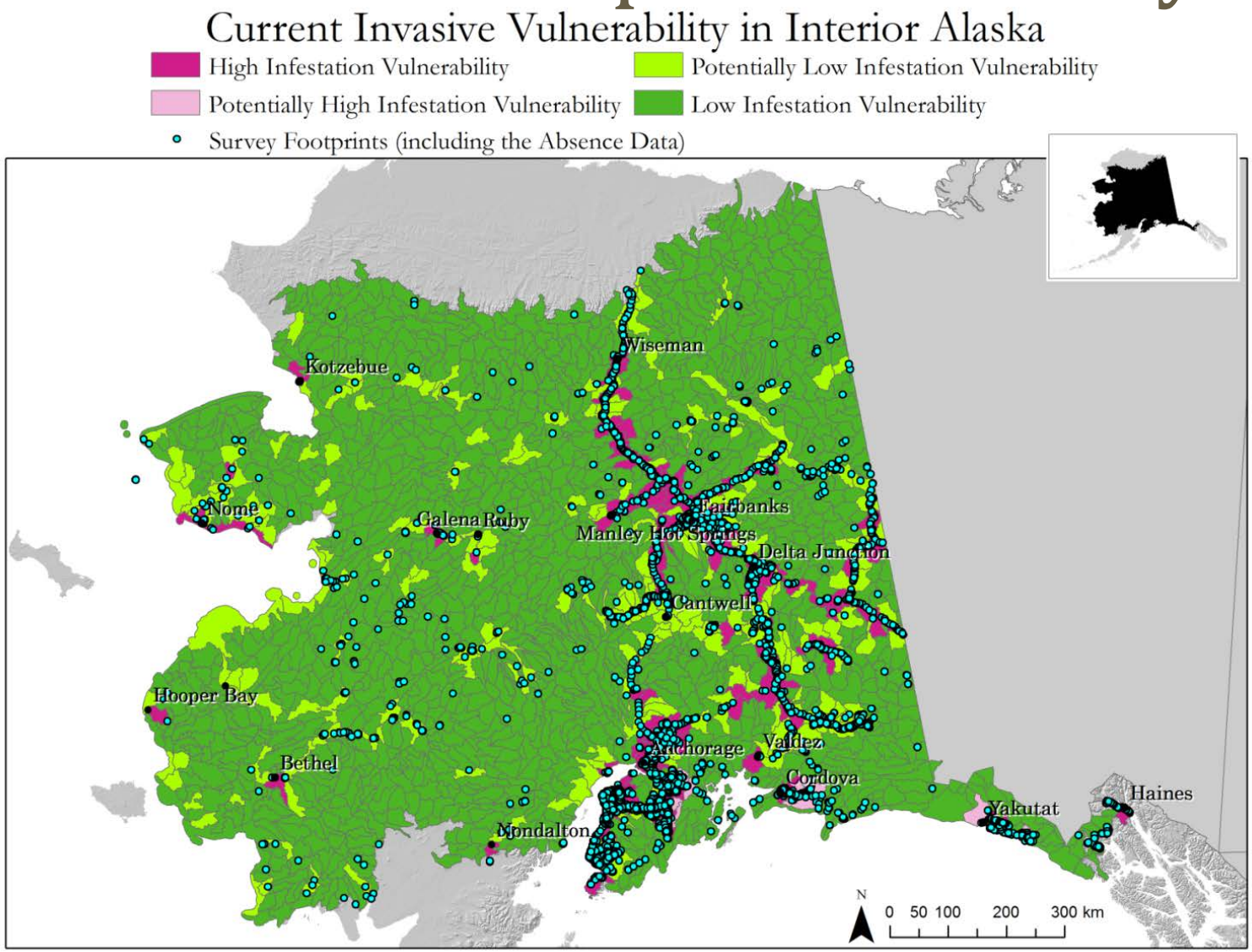
Name of Independent Variable	Source
Mean Annual Precipitation in each watershed (mm)	SNAP, UAF
Mean Annual Temperature (°C)	SNAP, UAF
Mean January Precipitation (mm)	SNAP, UAF
Mean January Temperature (°C)	SNAP, UAF
Mean July Precipitation (mm)	SNAP, UAF
Mean July Temperature (°C)	SNAP, UAF
Mean Date of Thaw (Julian Days)	SNAP, UAF
Mean Date of Freeze (Julian Days)	SNAP, UAF
Mean Summer Warmth Index	SNAP, UAF
Mean Length of Growing Season (Days)	SNAP, UAF
Percent Area of Permafrost (%)	SNAP, UAF
Density of Rivers (m/m^2)	ADNR
Variety of Landcover Coarse Classes	AKNHP, UAA
Variety of Landcover Fine Classes	AKNHP, UAA
Percent of Human Developed Areas (%)	USGS
Total Population	U.S. Census
Total Income ($)	U.S. Census
Density of Highways (m/m^2)	ADNR
Density of Secondary Roads (m/m^2)	ADNR
Density of Trails (m/m^2)	ADNR
Traffic Volume on Highways and Secondary Roads	ADTPF

Results: CART model

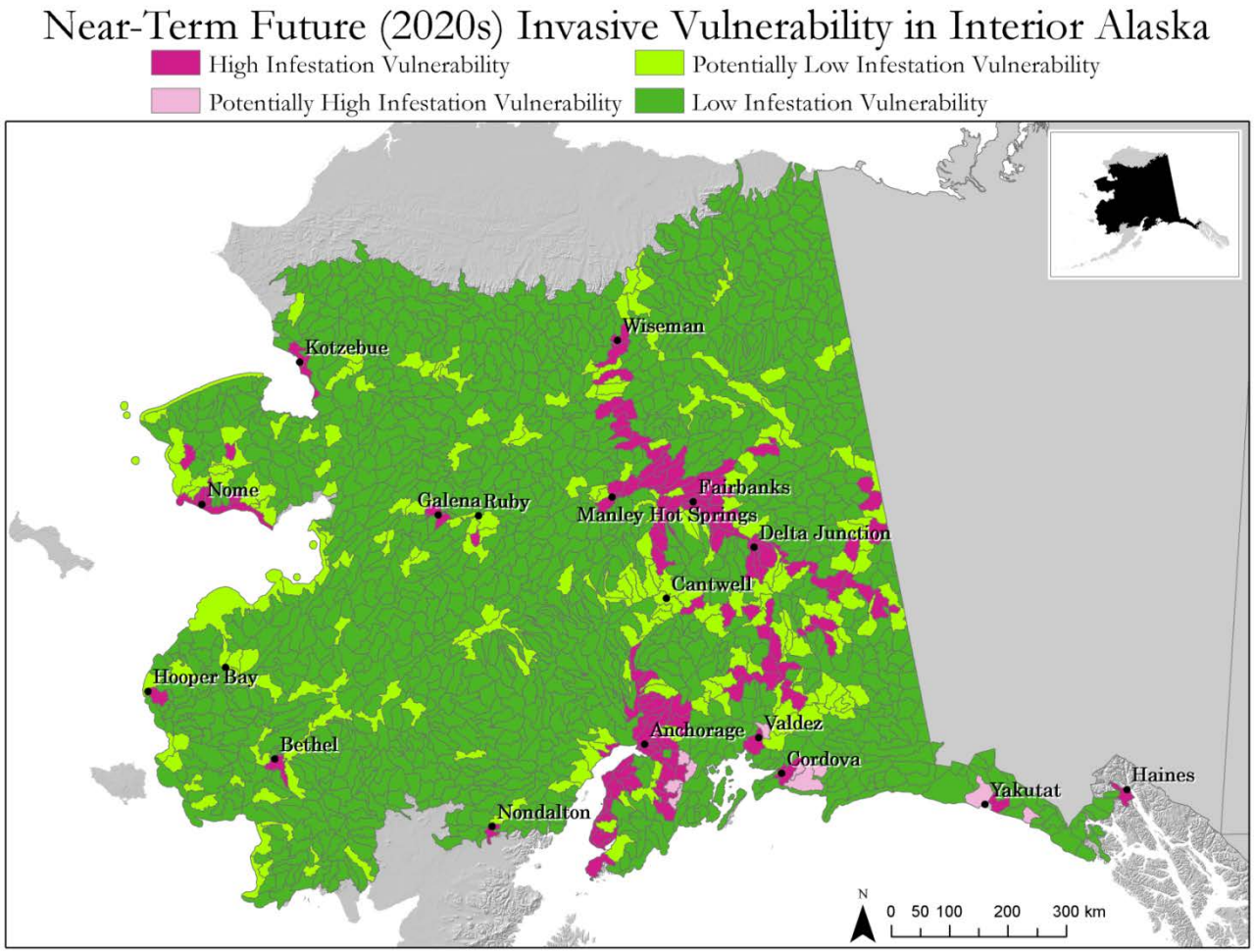
Kappa = 0.57



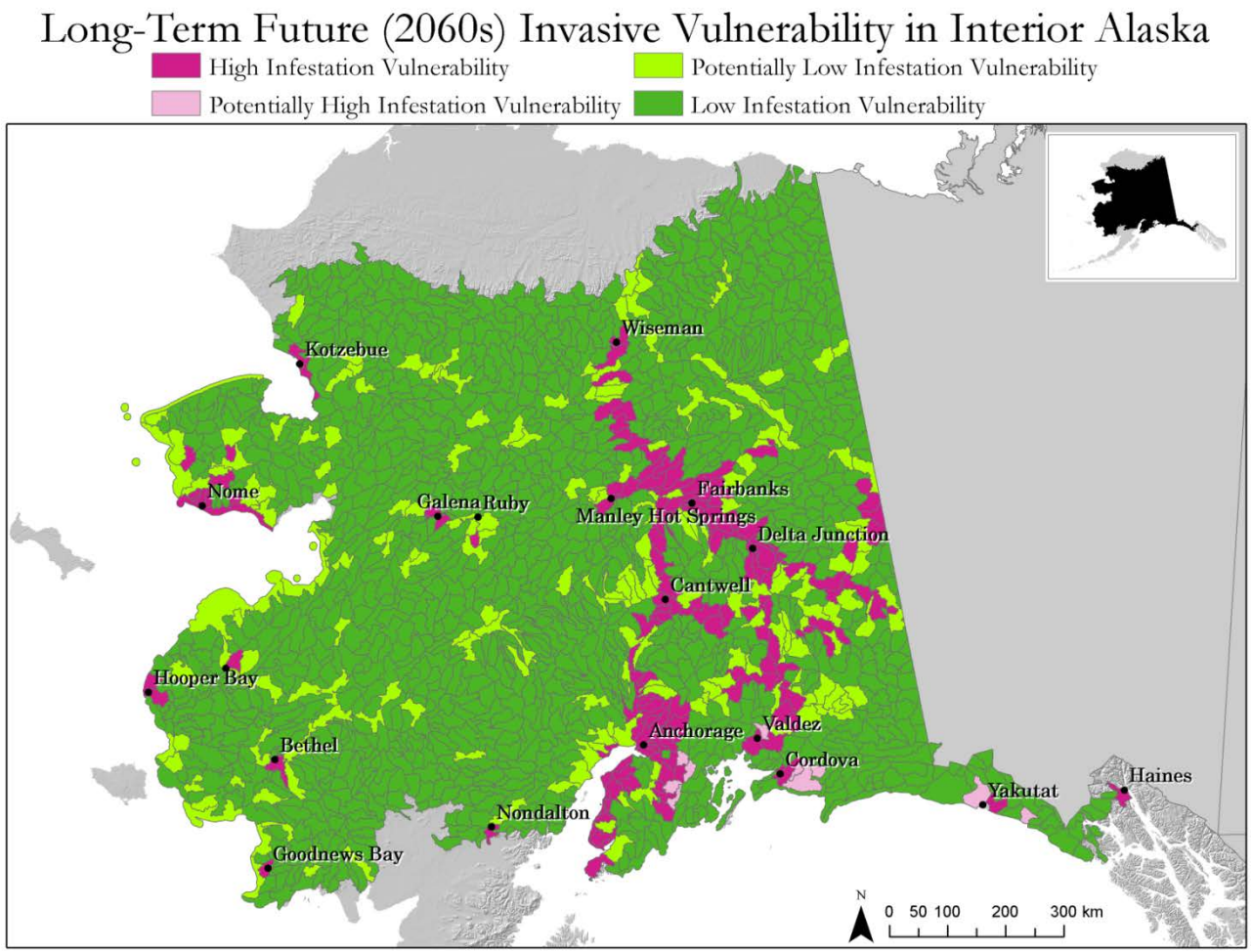
Results:
Current Landscape Vulnerability



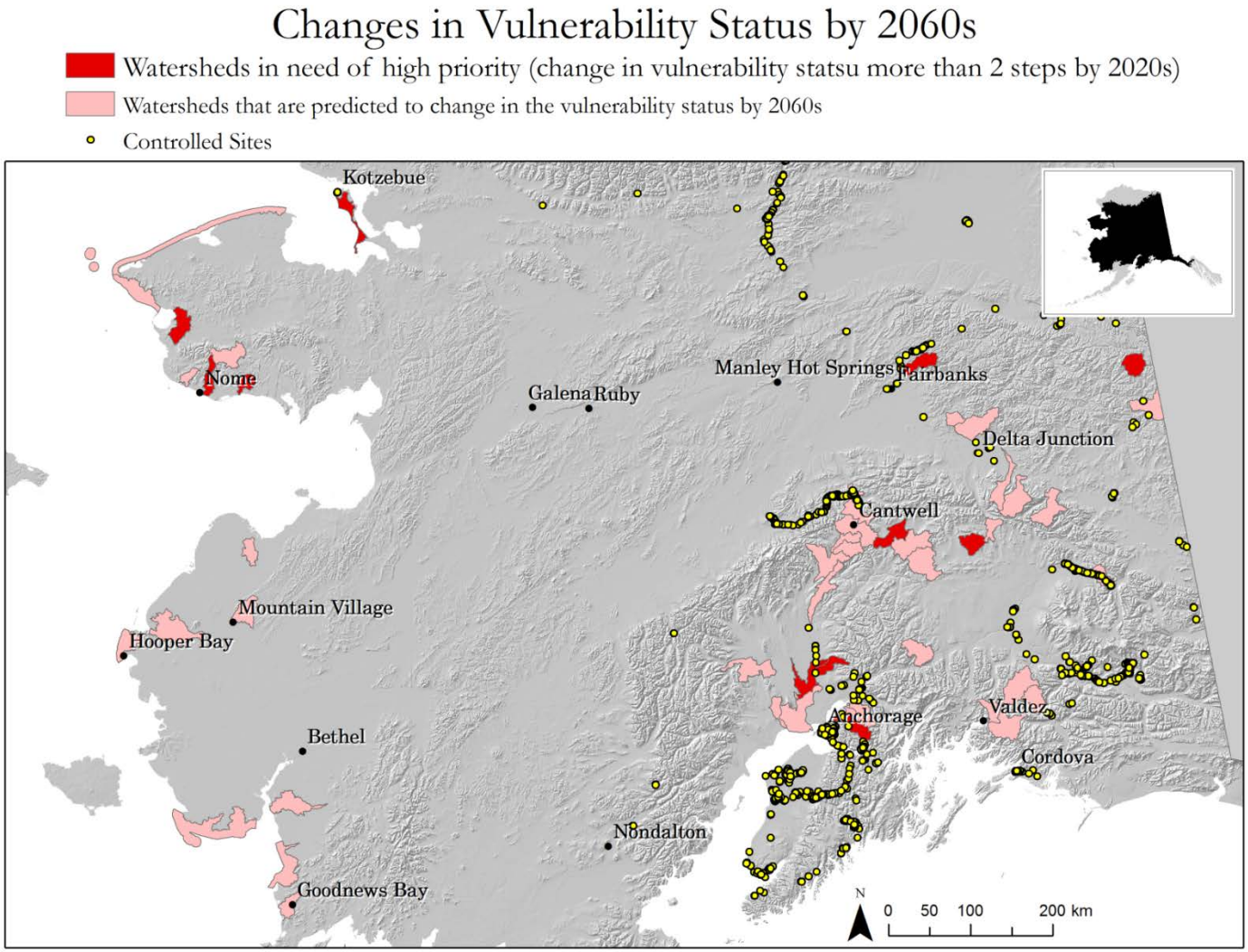
Results:
Near Future
Landscape Vulnerability (2020s)



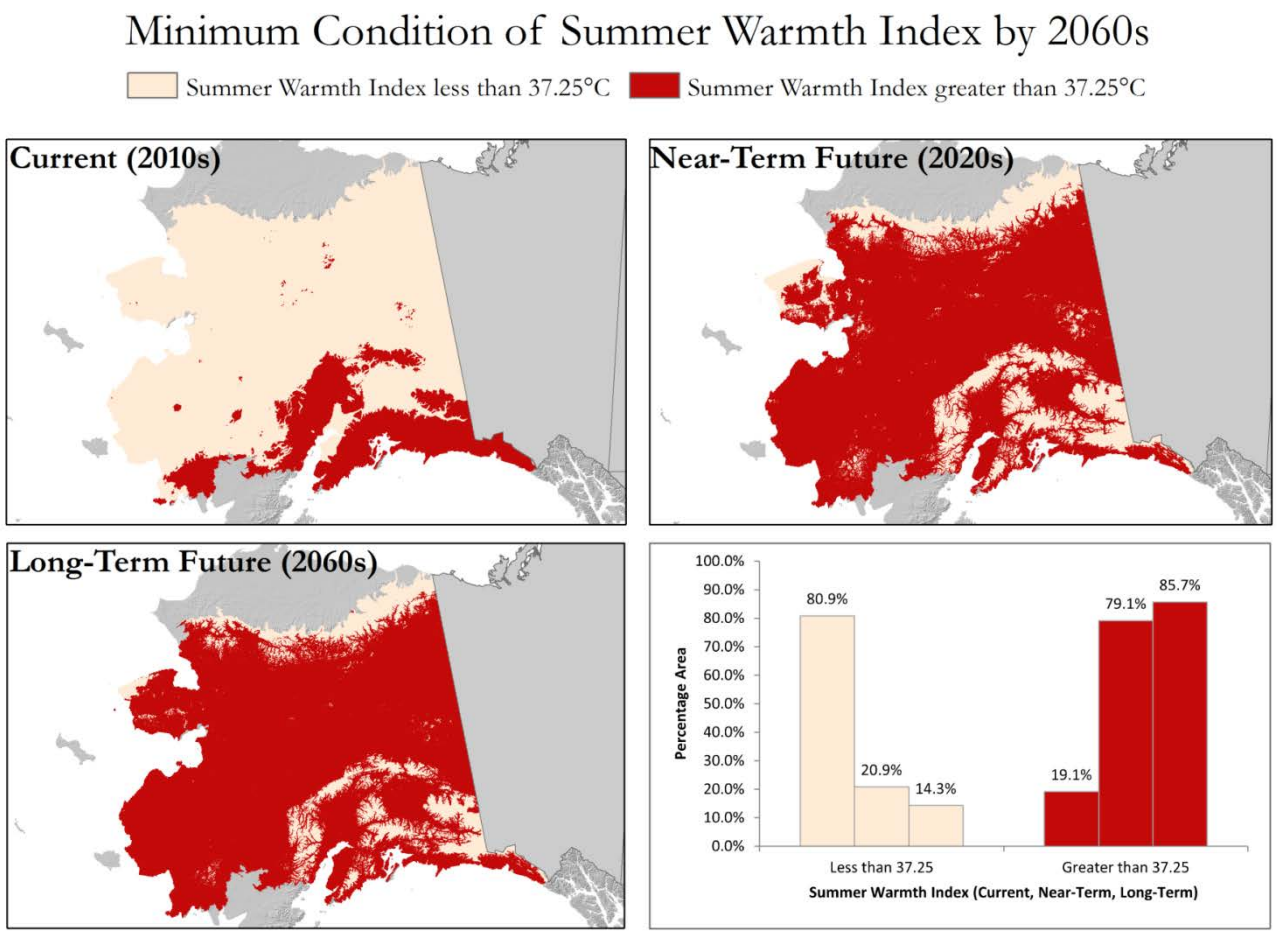
Results:
Long Future
Landscape Vulnerability (2060s)



Results:
Changes in Vulnerability Status by 2060s



Results:
Minimum Condition of Climate



Summary

- We integrated the relationships among non-native plants and climate, habitat, and anthropogenic factors.
- Percent developed area is most important for explaining the potential for watersheds being infested. Climate is secondarily important.
- There are 11 watersheds that are predicted to have a big change by near future.
- Watersheds in west Alaska would need long-term monitoring.