Fuel Treatment Effectiveness in Reducing Fire Intensity and Spread Rate

An Experimental Overview

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Outline

- Introduction
- Study site
- Fire behavior measurement
- Fuel consumption measurement
- Preliminary results
  - Quantitative and qualitative
- Future perspectives

Introduction

- 3-year goal – To study the effectiveness of fuel treatment
  - $5.6 billion (USD) spent in the past 10 years for hazardous fuel reduction in the United States
  - "The agencies, for example, still lack a measure of the effectiveness of fuel reduction treatments and therefore lack information needed to ensure that fuel reduction funds are directed to the areas where they can best minimize risk to communities and natural and cultural resources" - Government Accountability Office, 2009

Introduction

- Two-pronged approach
  - Experimentation
    - Direct observation of fire-environment in relation to treatment measures on 3D canopy structure and forest floor loading
      - Will consist of two experimental prescribed fires
        - **1) High intensity – high loading and ladder fuels**
        - 2) Low intensity – low loading (recently treated)
  - Numerical modeling
    - Cheaply conduct a large number of simulations over a range of both fuel loadings and environmental conditions
      - To be carried out with a physics-based, computational fluid dynamics model:
        Wildland-urban Interface Fire Dynamics Simulator (WFDS)

Study Site

- New Jersey Pinelands

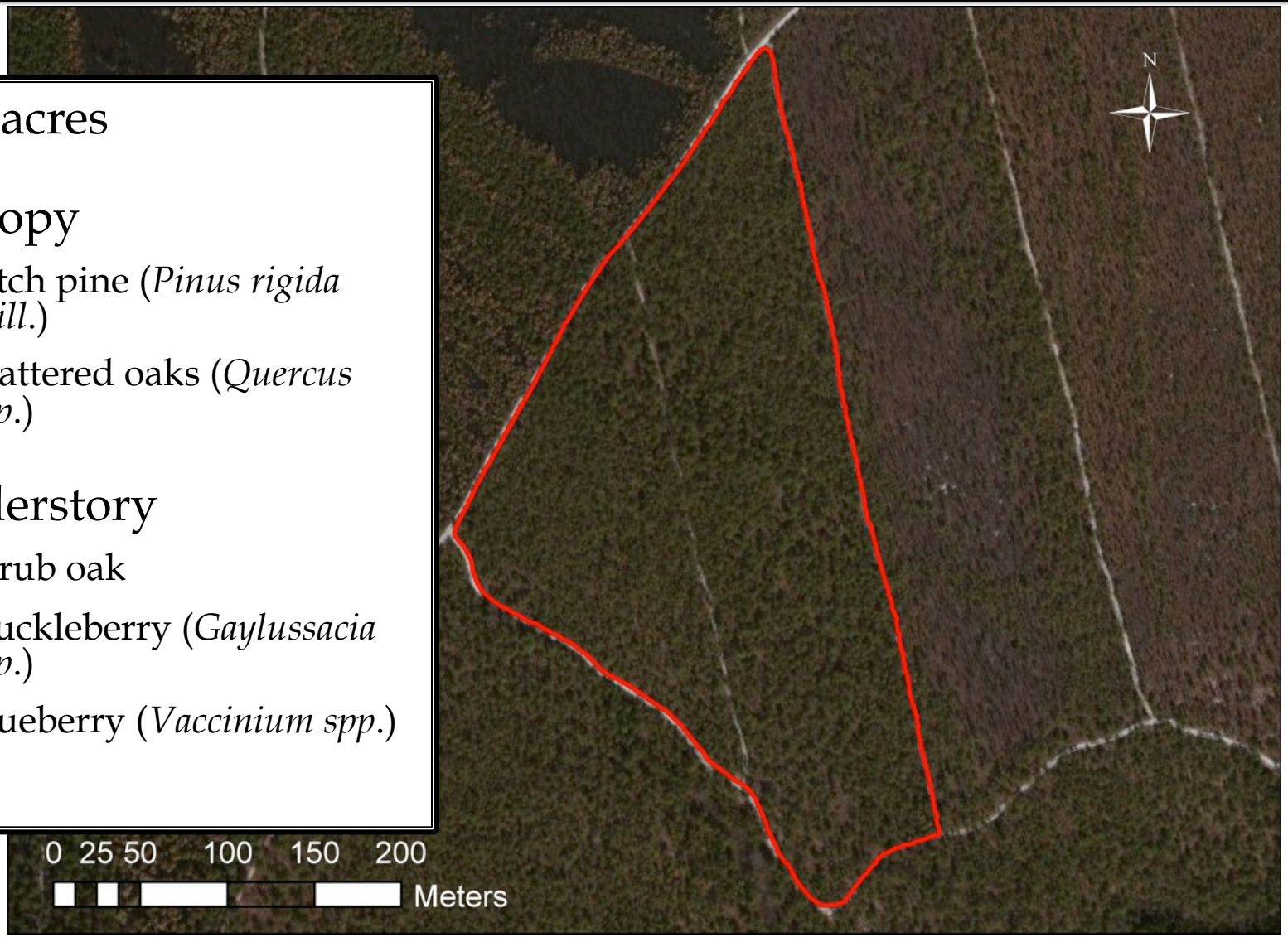
Study Site

- New Jersey Pinelands National Reserve
  - 1.1 million acres ~23% of NJ
  - Cool temperate climate
    - Mean monthly temperatures between 0.3˚C and 24.3˚C
    - Mean annual precipitation of 1159 mm

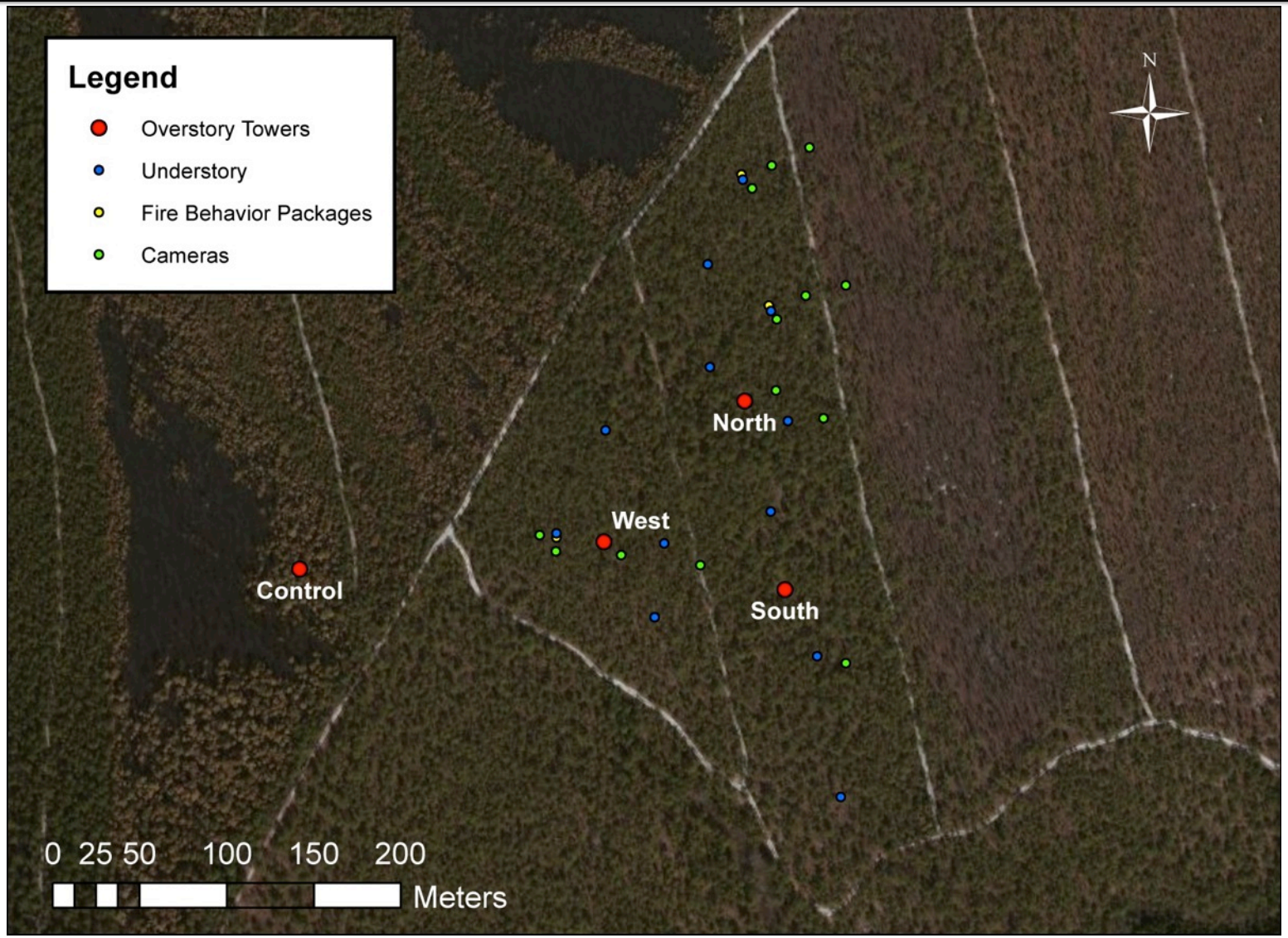
- Averages 1500 wildfires (ca. 7500 acres) per year
- Large crown-fire event every 5-10 years
- High level of WUI
  - RxB conducted on 16,000-24,000 acres per year

Study Site - Aerial View

- ~15 acres
- Canopy
  - Pitch pine (*Pinus rigida Mill.*)
  - Scattered oaks (*Quercus spp.*)
- Understory
  - Scrub oak
  - Huckleberry (*Gaylussacia spp.*)
  - Blueberry (*Vaccinium spp.*)



Fire Measurement – Instrument Locations



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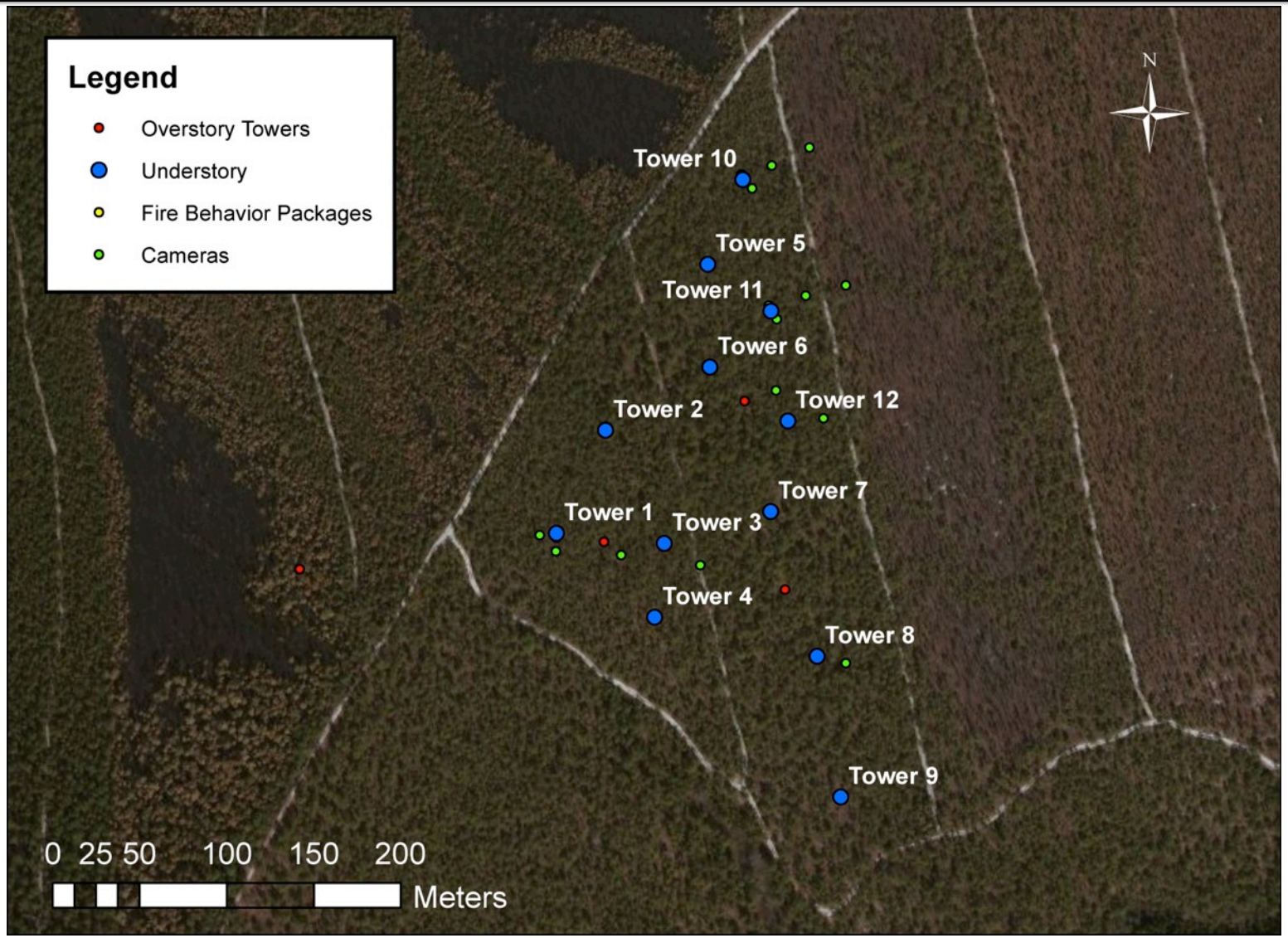
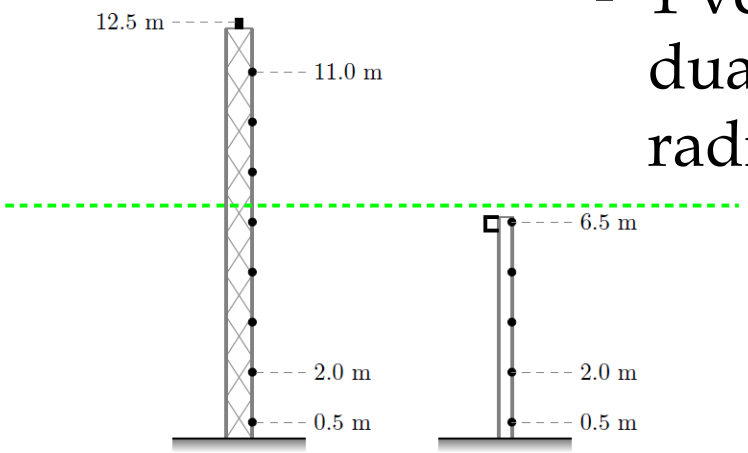


Fire Measurement – Towers

- Overstory
  - 8 K-type thermocouples
  - 1 3D Sonic Anemometer
- Understory
  - 5 K-type thermocouples
  - 1 vertically oriented flow sensor
  - 1 vertically oriented dual-band radiometer



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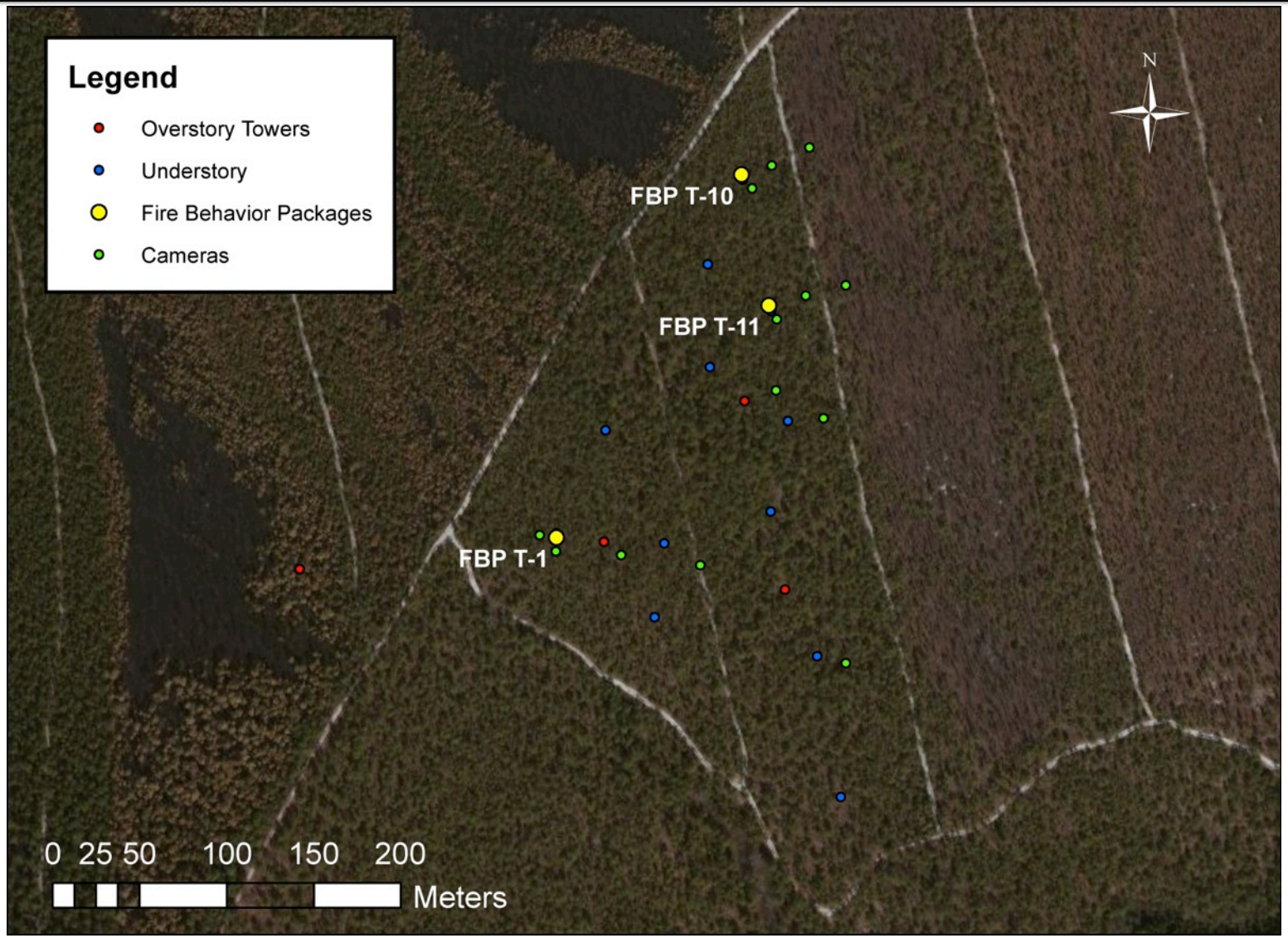
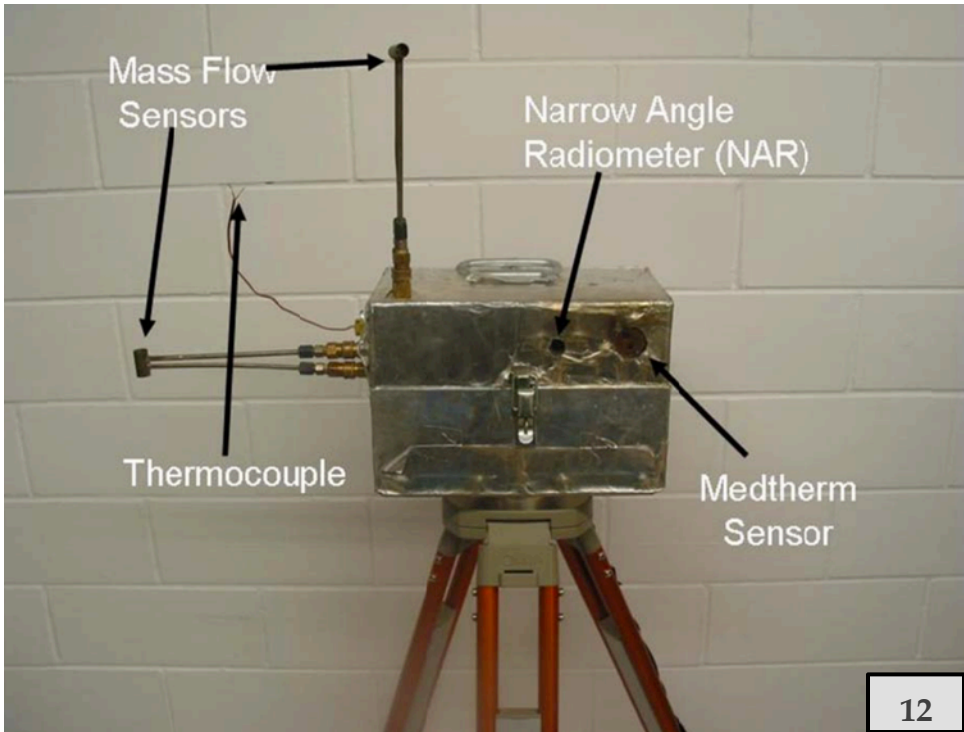


Fuel Measurement – FBPs

- 3 Fire Behavior Packages (FBP) - developed by USDA Forest Service
- Provide measurements of:
  - Temperature
    - 1 thermocouple
  - Heat flux
    - 1 Medtherm dual heat flux guage
    - 1 narrow angle radiometer
  - Flow
    - 1 horizontal probe
    - 1 vertical probe



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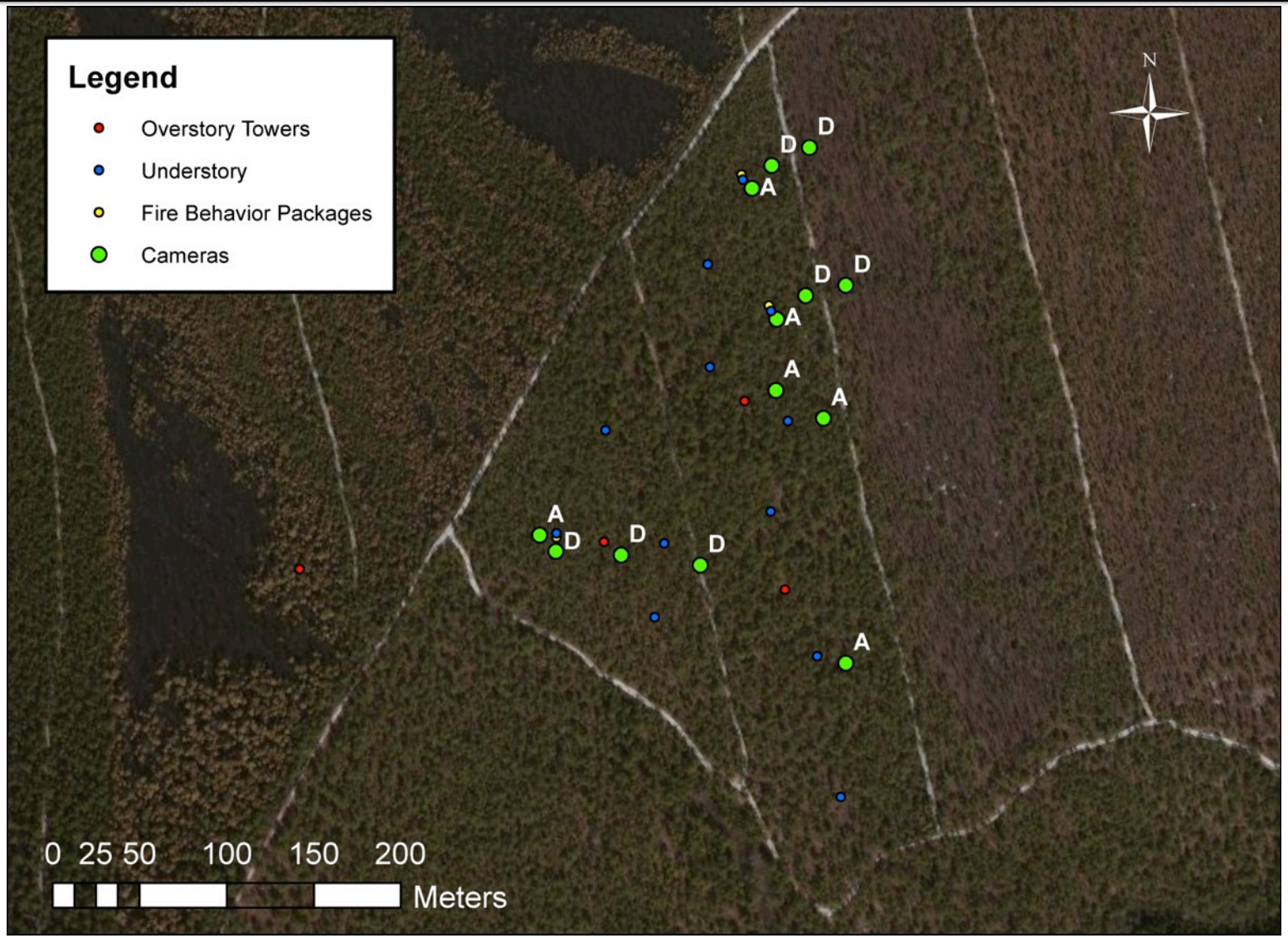


Fire Measurement – Infrared

- Series of aerial stills taken using RIT's Wildfire Airborne Sensor Program (WASP)
  - 3 bands of IR - 640x512 pixel
    - SWIR: 0.9-1.7 μm
    - MWIR: 3-5 μm
    - LWIR: 8-9.2 μm
  - Visible – 4000x2672
  - Georeferenced

Fuel Measurement – Field Sampling

- Three 1 m^2 clip plots taken at each understory tower (36 total)

Consumption [g m^{-2} dry mass]						
Forest floor					Shrubs and Oaks	
Fine	Repro.	1hr Wood	10hr Wood	100hr Wood	1hr Wood	10hr Wood
503.1 ± 94.9	-7.8 ± 39.6	153.3 ± 127.5	67.3 ± 124.6	101.1 ± 103.5	267.4 ± 173.7	16.6 ± 173.7
Total	**1101.2 ± 299.3**					

- Fuel moisture content

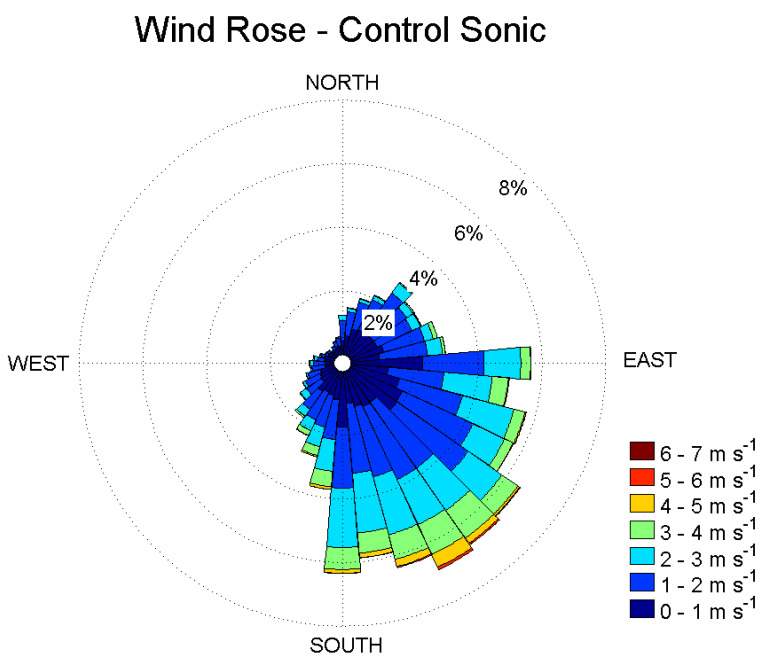
Classification		Mean % ±1 SD
Pitch Pine	Live needles	114.4 ± 2.5
	Live stems (1 hour)	85.2 ± 6.7
Understory	Shrub stems (1 hour)	62.2 ± 5.7
	Oak stems (1 hour)	60.9 ± 7.3
Forest floor	1 hour wood	15.6 ± 2.7
	10 hour wood	32.2 ± 17.6
	Needle litter	22.5 ± 11.2
	Oak leaf litter	15.7 ± 7.0

Fuel Measurement – LiDAR

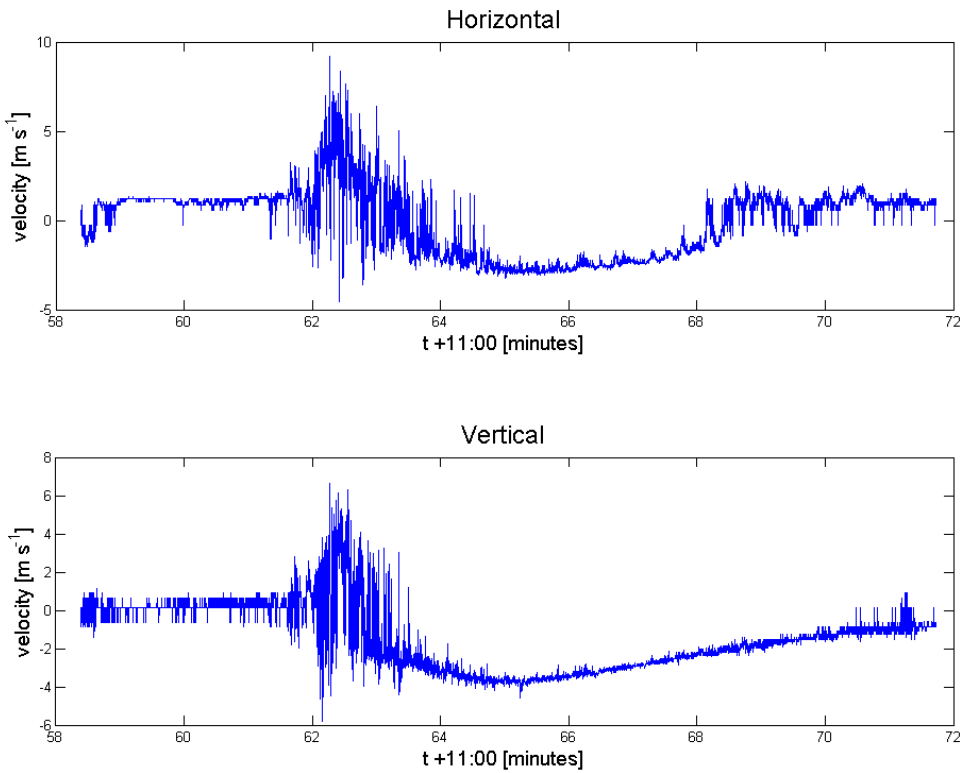
- Pre- and post-fire flights of Airborne Laser Scanning data (ALS).
  - Collected at 400 kHz, with a pulse density ca. 5.12 points m^{-2}
- Will provide canopy height profiles and canopy bulk densities (calibrated by upward sensing LiDAR)
- Resolution of 10 x 10 x 1 m
- Critical for:
  - Assessment of treatment level
  - Assessment of fire behavior
  - Formulation of model inputs
  - Assessment of model accuracy

Preliminary Results – Wind

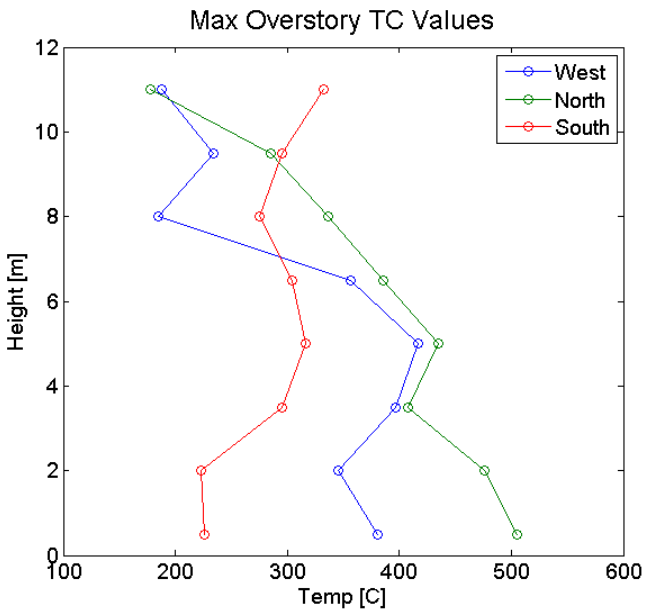
- Ambient

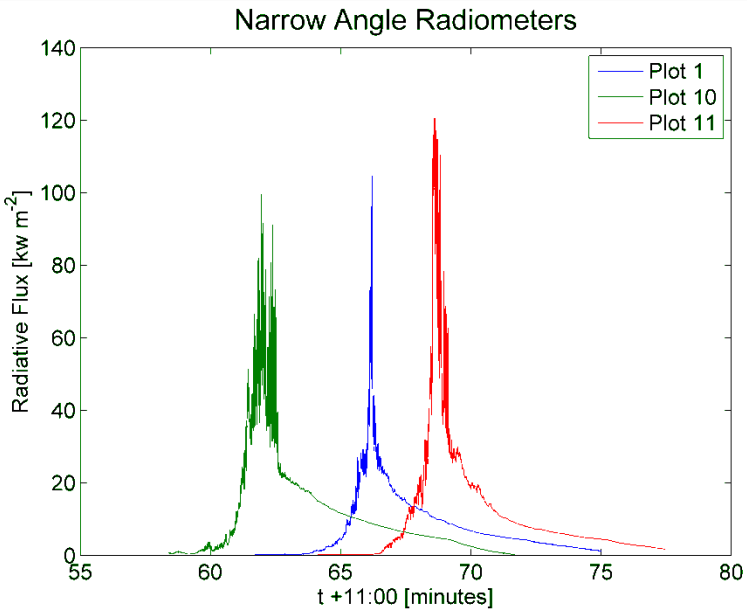


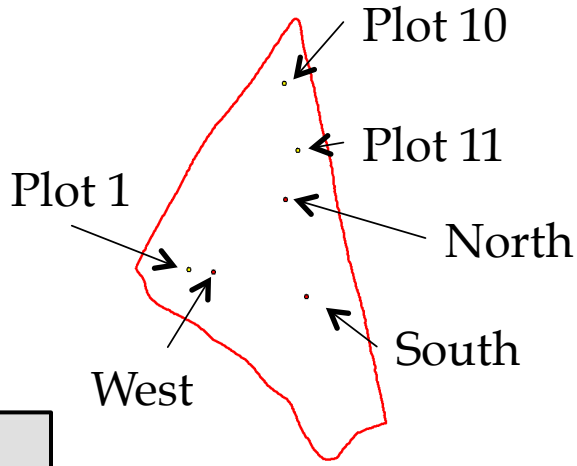
- Local (Plot 10 -FBP)



Preliminary Results – Fire Behavior





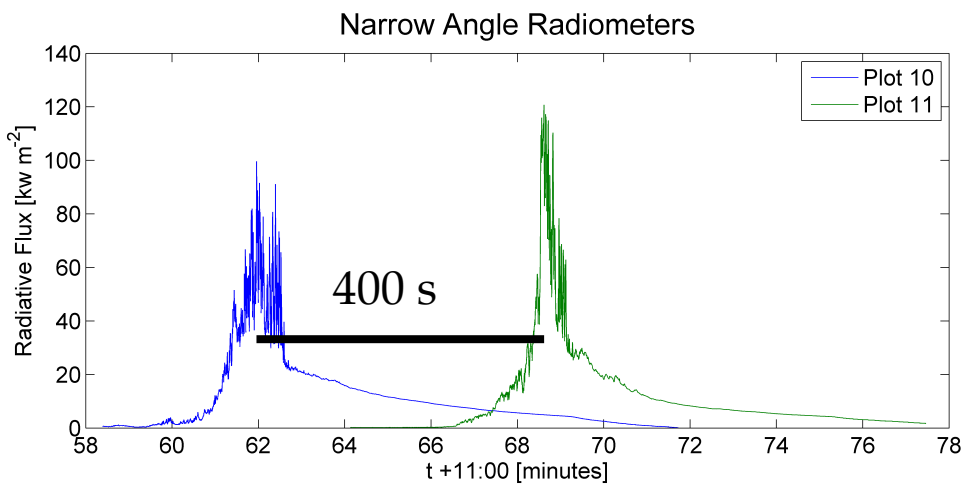


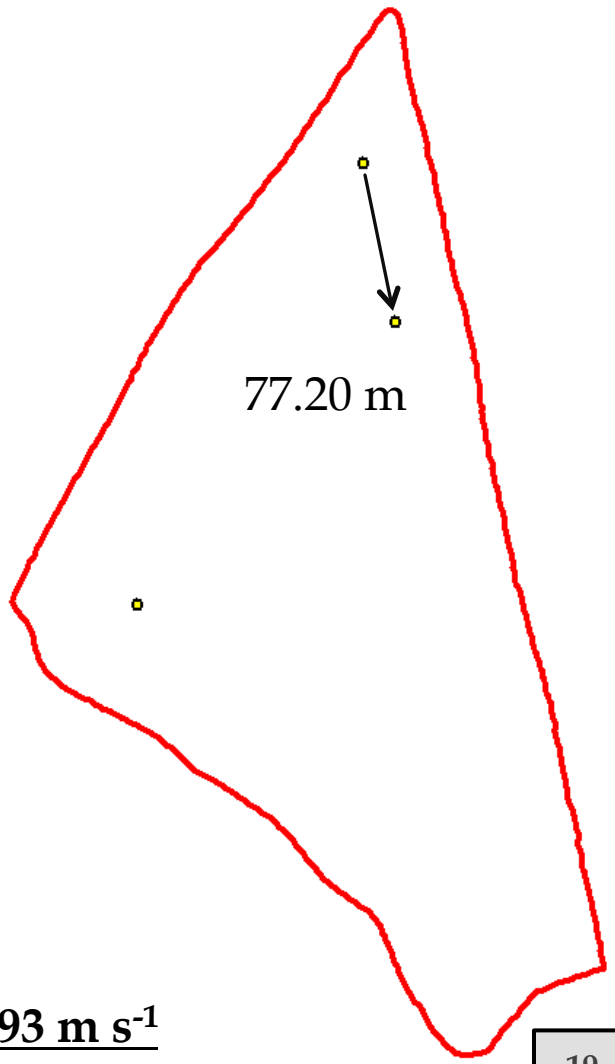
Integral radiative flux:

- Plot 1: 6026 kJ m^{-2}
- Plot 10: 8810 kJ m^{-2}
- Plot 11: 8503 kJ m^{-2}

Preliminary Results – Spread Rate

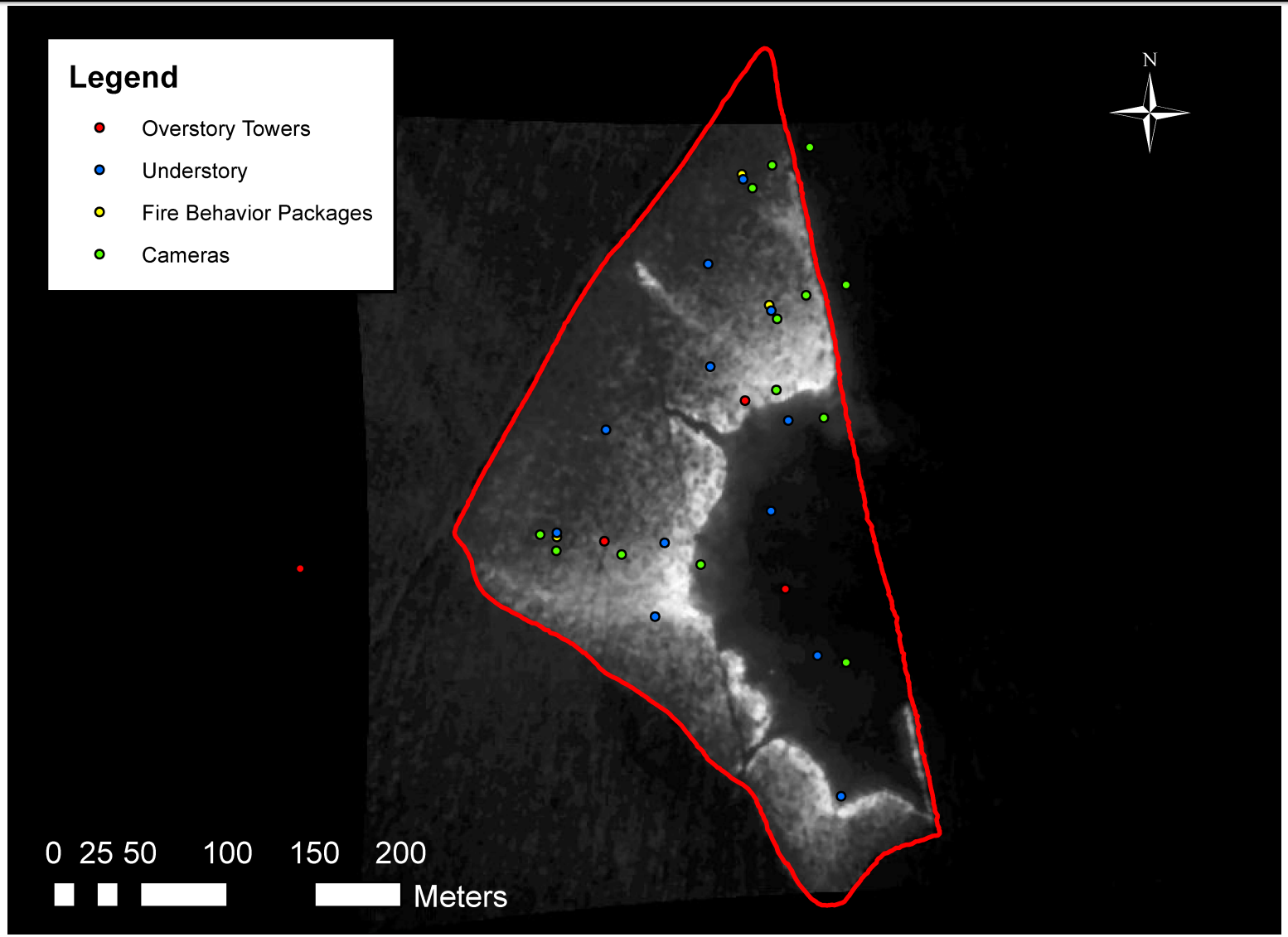
- Assuming the fireline progresses parallel to the path between the two packages





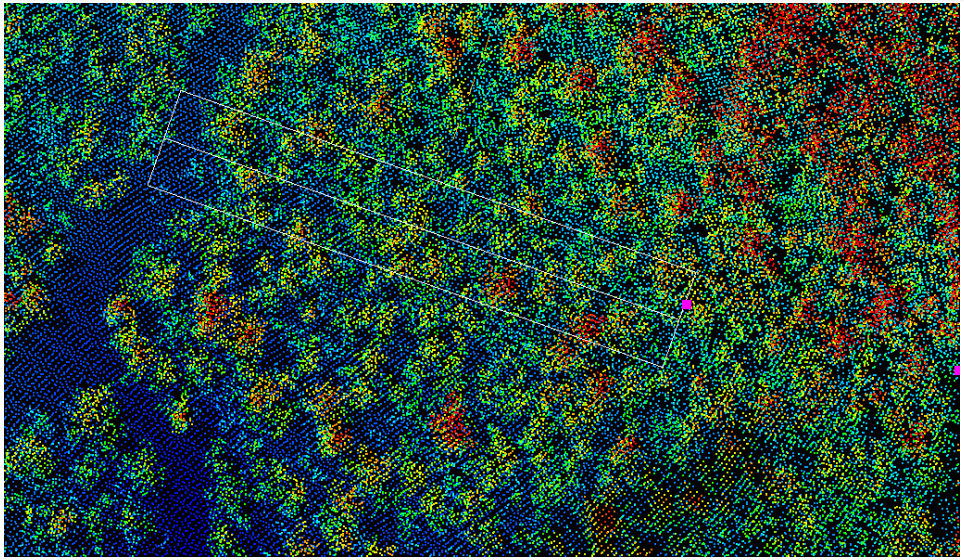
ROS: 0.193 m s^{-1}

Preliminary Results – IR (8-9.2 μm)

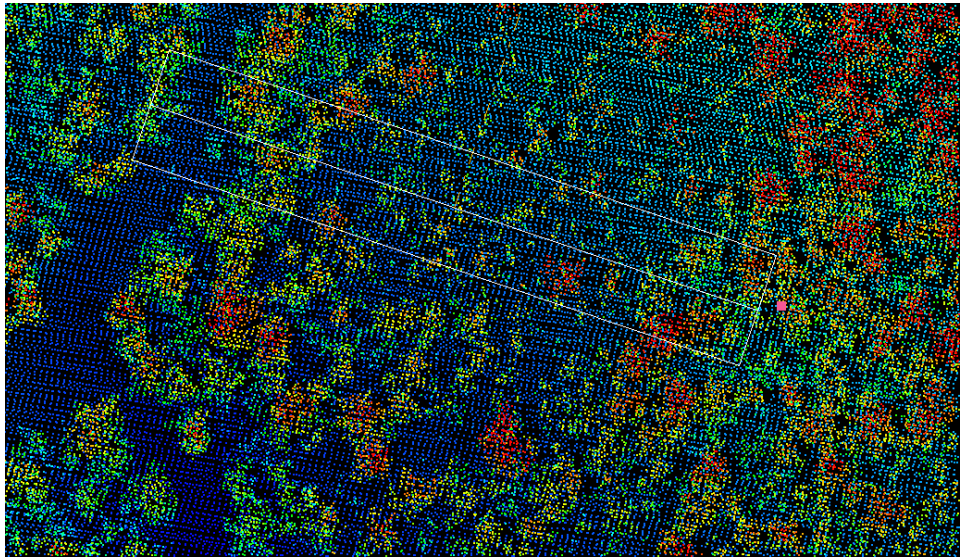


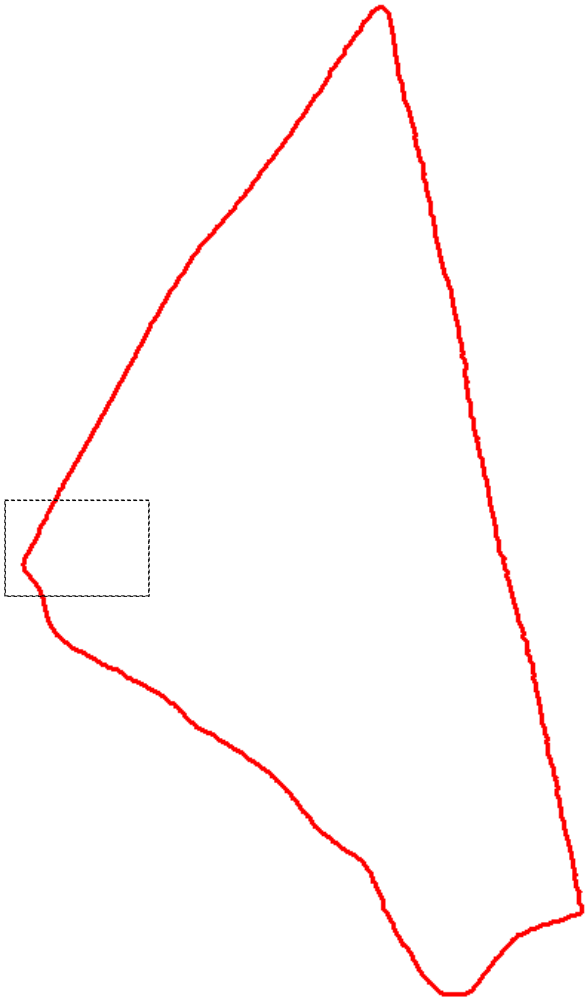
Preliminary Results – LiDAR

- Pre-



- Post-





Work Ahead

- Continued data analysis
  - Coupled assessment of aerial IR imagery and local point measurements of fire behavior – fire timeline reconstruction
  - Comparison between fuel consumption and spread rate – local fire intensity
- Modeling phase
  - Translation of LiDAR and field sampling variables into model inputs
  - Assessment of model's ability to recreate fire timeline and local fire intesity
- Repeat!

Thank You

- Questions?

- Thank You to the Joint Fire Science Program for funding this project

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