Remotely Sensed Data and Wildfire Management - Developing Techniques for the ‘New Normal’

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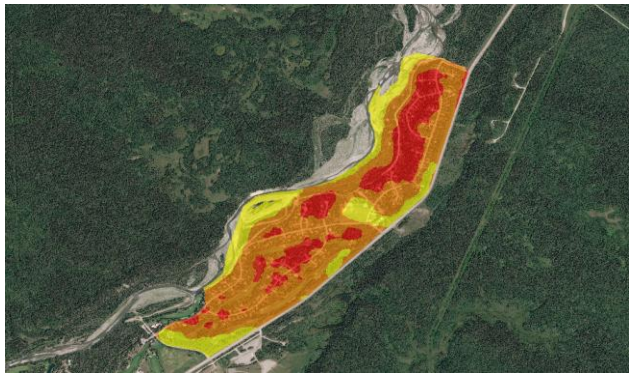
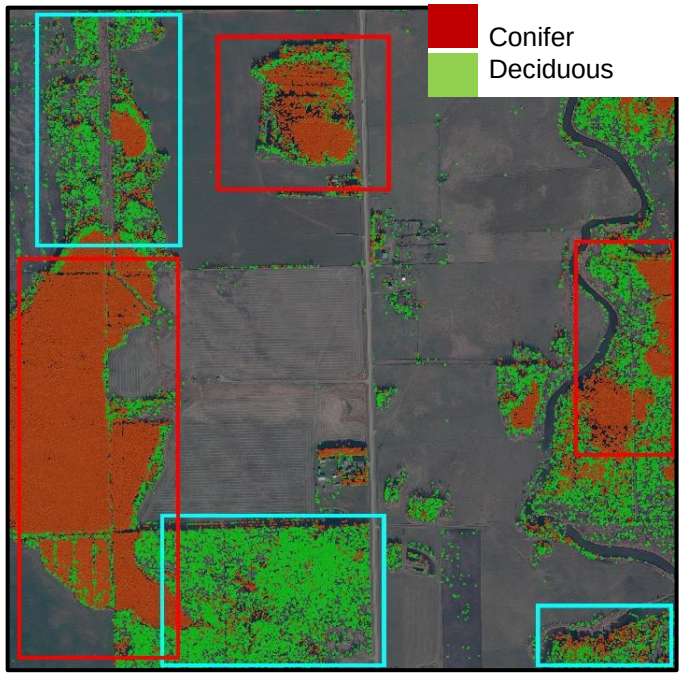
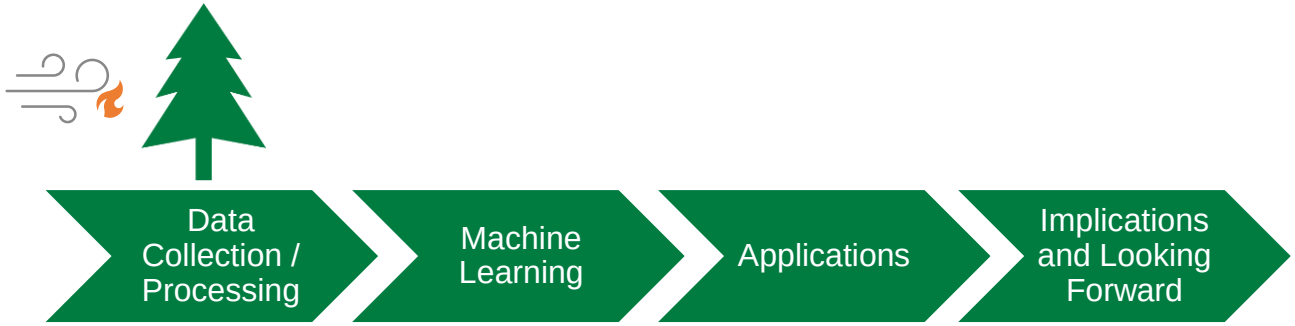
Project Summary

- **Mission statement: Improve utilization and usefulness of data in wildfire management**
- Remote sensing technology already exists, and is integration ready
- Tools can be developed to leverage these technologies and aid/inform existing wildfire management activities
  - Hazard assessment
    - Community
    - Structure
  - Fuel mapping



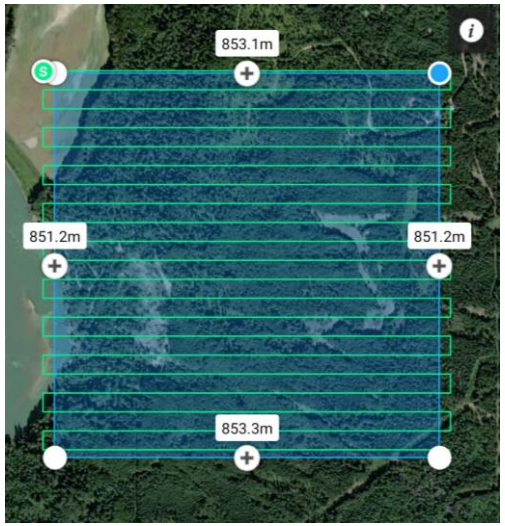


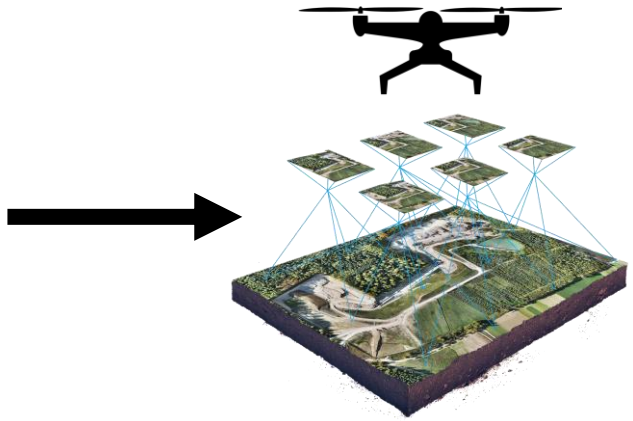


Data Collection and Processing

Drone and Satellite

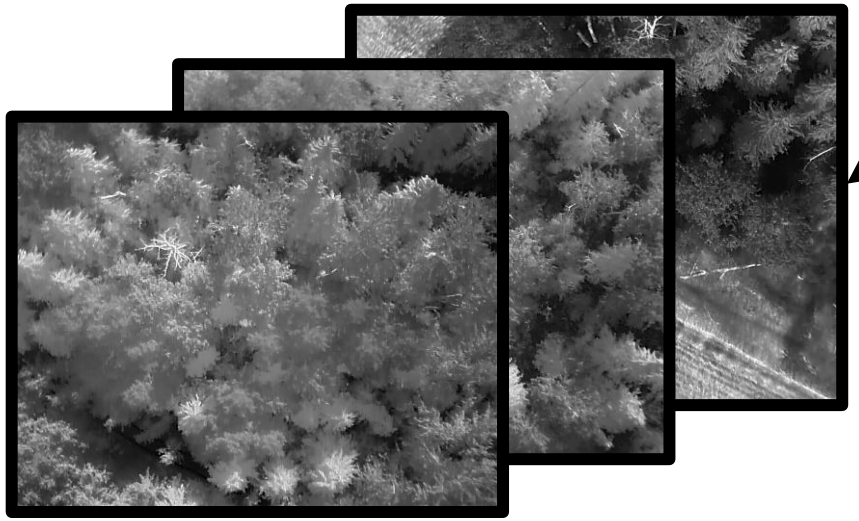
Data Collection - Drone





- Flight is planned above forest or property
- Survey is completed in a fully automated fashion, collecting RGB and thermal imagery

Thermal

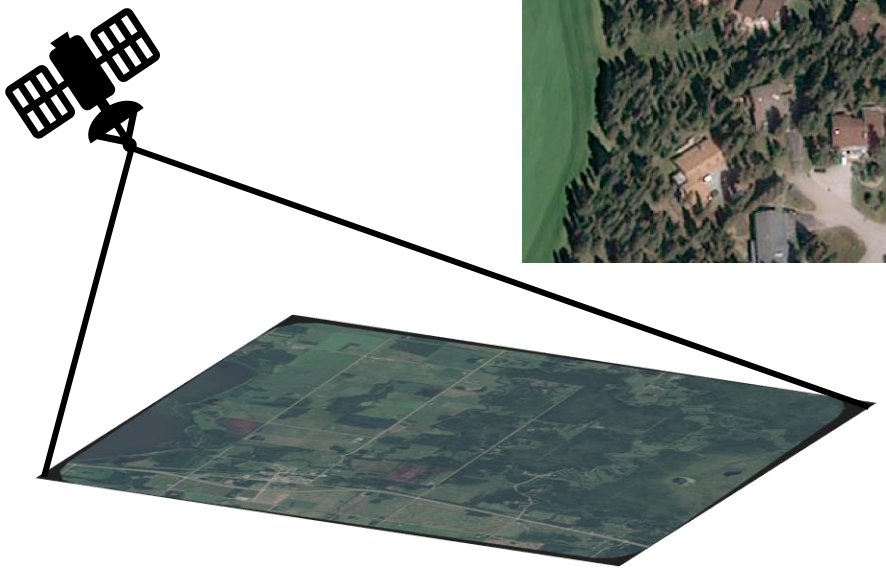


High-Res RGB

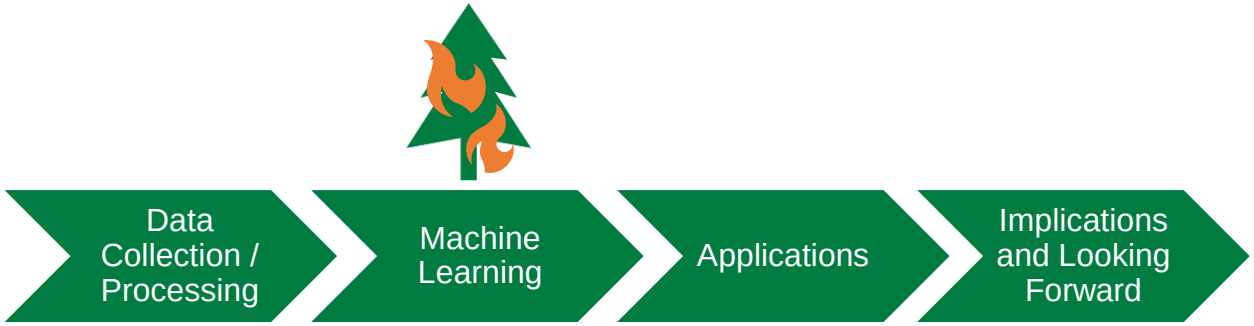
Drone – Data Processing

- After flights, images can be further processed into a suite of outputs, including
  - Orthomosaic
  - Point cloud (structure from motion)
  - 3D Mesh
  - DEM
- These outputs can then be used to detect trees, classify detections, and extract tree characteristics
- All processing can be done on-site

Data Collection - Satellite



- Satellite imagery is selected based on a number of criteria
  - Degrees off-nadir, season, time of day, cloud cover, resolution
- Two images are selected
  - Winter (after dormancy, before snow) and summer
- Now have 0.5 m / px RGB + NIR imagery in winter and summer
- Can gather data in a large area affordably, rapidly, recently

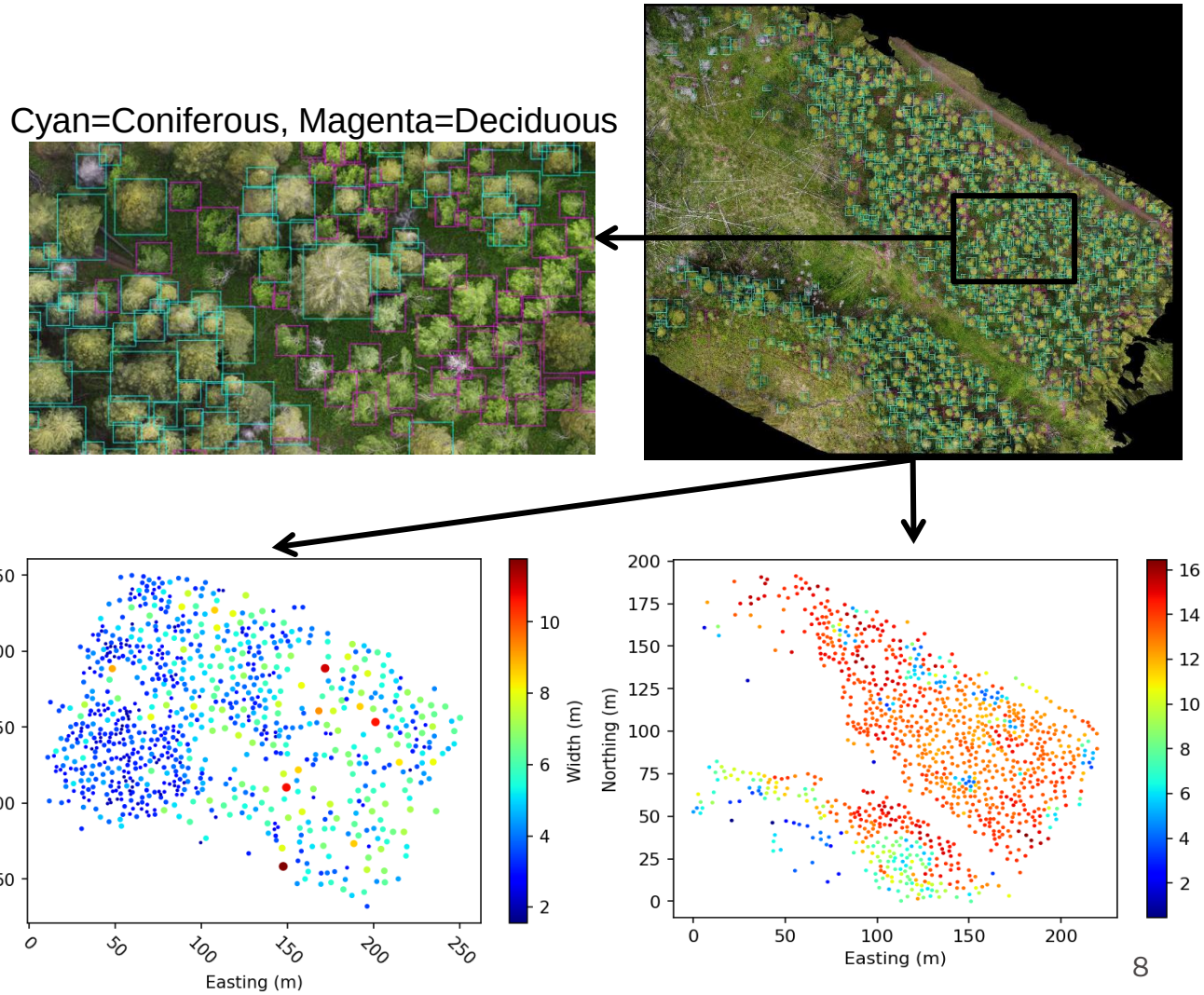


Machine Learning

Tree Identification Results

Drone – Tree Detection and Classification

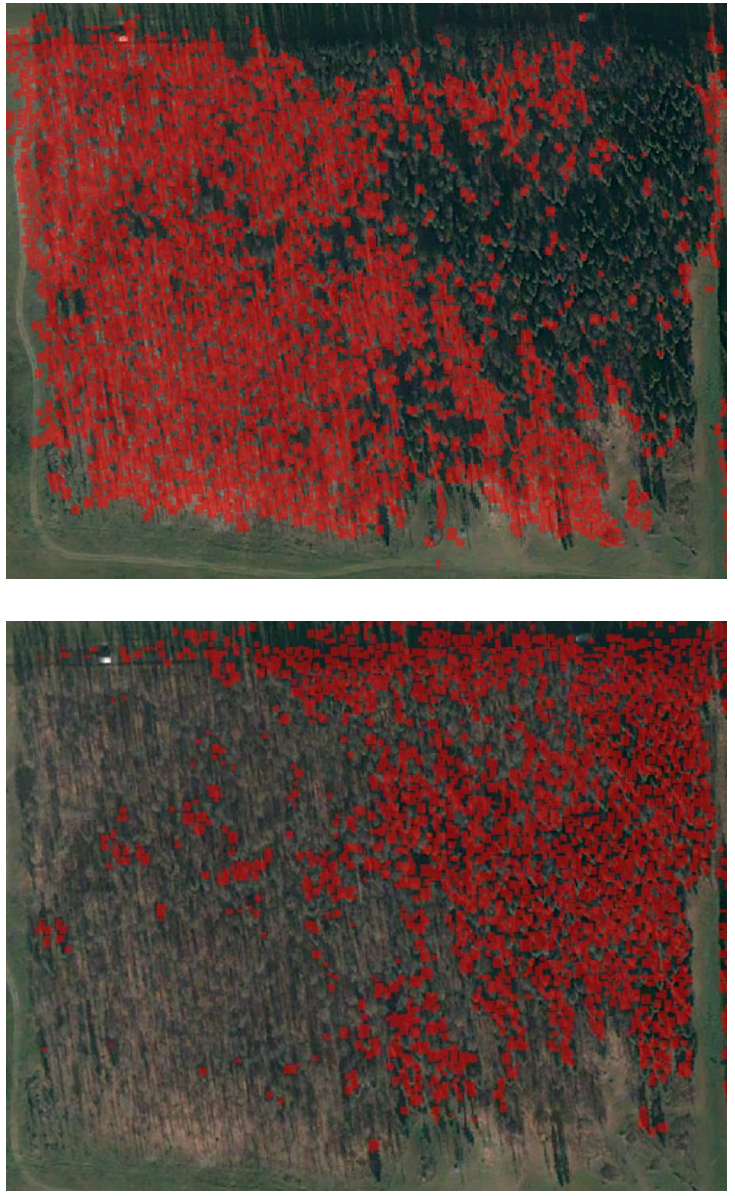
- A neural network can be constructed and trained using manual annotations drawn on previous surveys
- Neural network can then be applied to new surveys to detect (box) trees and classify as coniferous or deciduous
- Accuracy: 83% recall, 69% precision, 95% stem recall (improves with additional imagery)
- Can use the other outputs to determine tree characteristics
  - Tree height: r^2=0.93 vs. pictometry
  - Tree size: bounding box size
  - Stand density
    - Drone r^2=0.90 vs. manual
  - Conifer/Deciduous: ~90% accurate vs. manual
- All from a consumer grade drone that anyone can purchase or fly



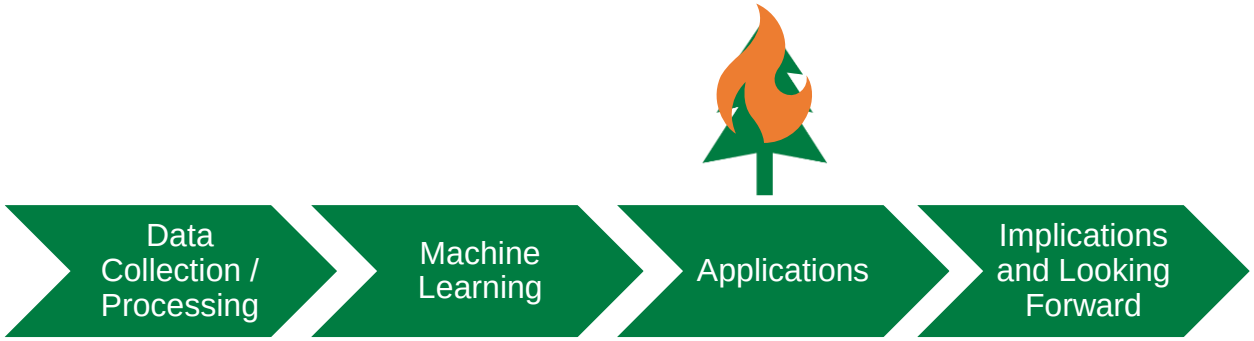
Satellite – Tree Detection and Classification

- A similar process can be applied to satellite imagery
- A separate neural network can be trained using manual annotations on satellite imagery (RGB + NIR), and used to make detections on new imagery
- Here, classifications are not able to be made directly from summer imagery (insufficient resolution), but winter imagery can be leveraged
  - Result is still a fully automated process

Satellite – Tree Detection and Classification



- R^2 of 0.8 when comparing detection densities to manual
- Clustering process based on colour after dormancy can be used to make broad distinctions between ‘green in winter’ and ‘dormant’ areas

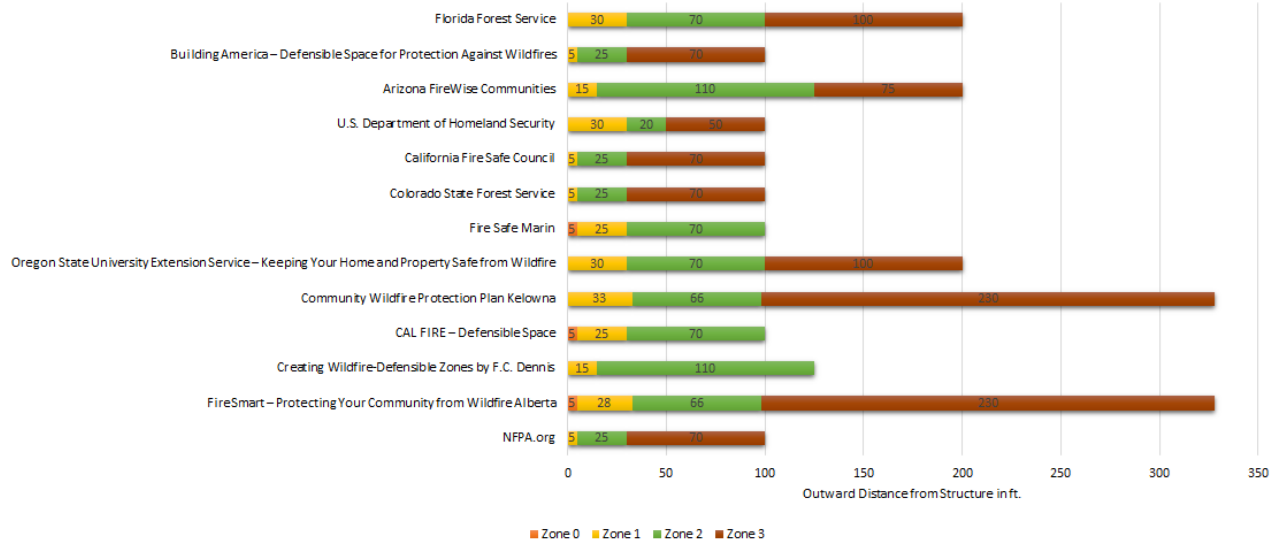


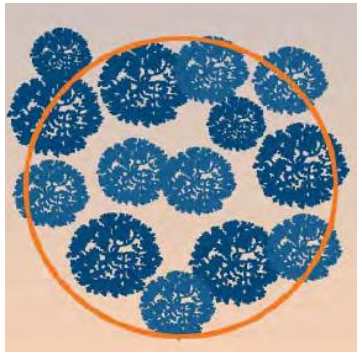
Applications

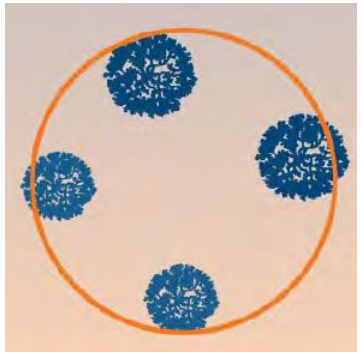
Proposed applications to wildfire management

VAR Hazard Assessments

- In order to triage VARs, plan evacuations, and make response plans, individual VARs are often assessed by local fire departments
- Many factors input to this assessment, including
  - Local topography
  - Building materials, existing mitigations
  - Local vegetation
- Tree characteristics are often assessed within three zones around a VAR
  - Species composition, tree density, VAR proximity are important inputs when determining structure defensiblity



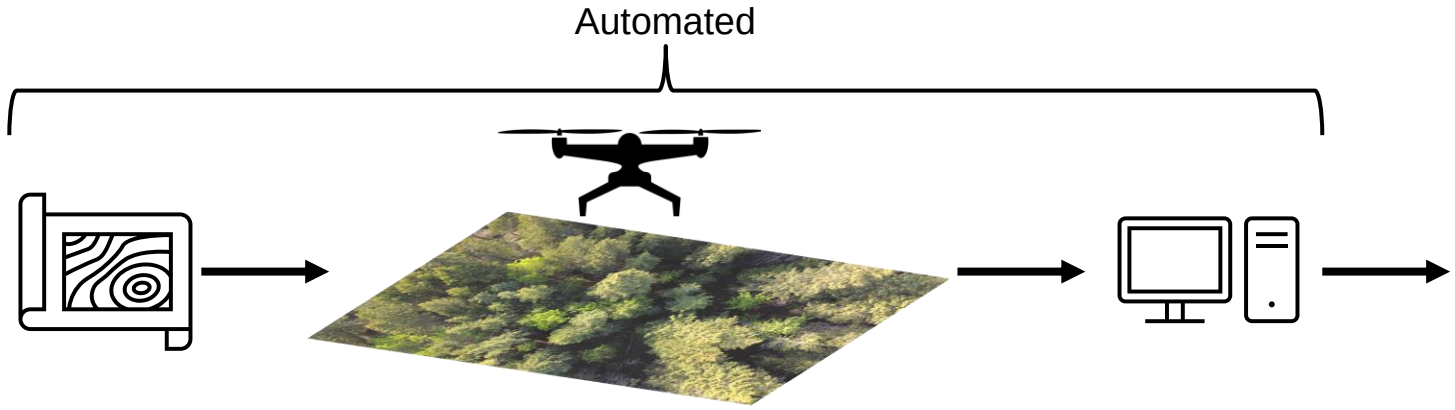




Partners in Protection. (2003). FireSmart: Protecting Your Community from Wildfire. Natural Resources Canada.

Drone – Hazard Assessments on VAR Scale

- Preliminary proximity based hazard assessments can be performed using tree detections
  - Consider the classification – coniferous and deciduous
- Finally - simple, digestible maps can be generated in a fully automated fashion
- Worth noting that these do not contain the full story of a complete property hazard assessment – based only on overstory trees

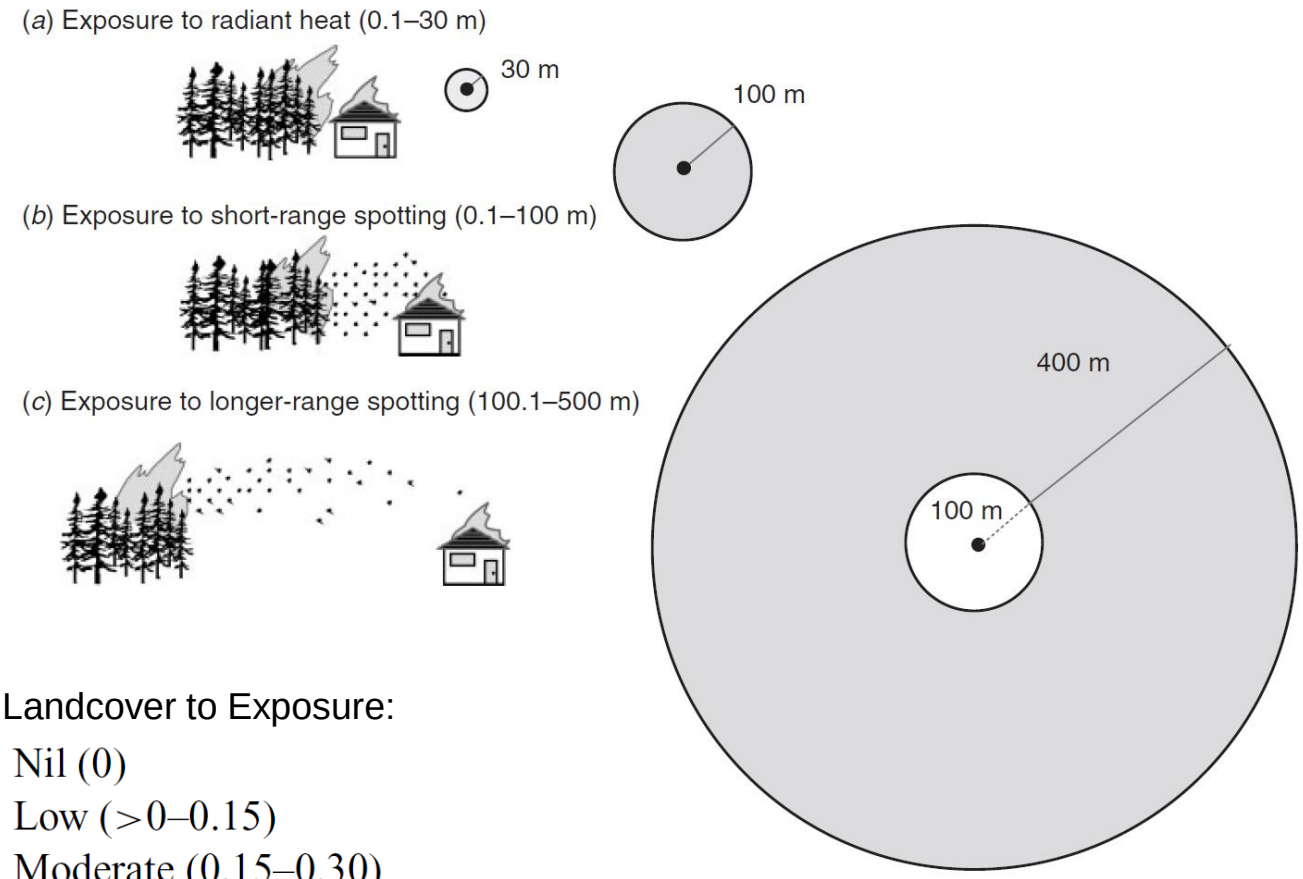


Plan flight | Perform survey | Process data into outputs | Decision making

Landcover to Community Exposure

- Three ignition processes are used by FireSmart Alberta
- For each ignition process, a different range and set of FBP fuel types are considered
- Landcover proportions are then translated to ignition exposure ratings

(a) 30 m: conifer, mixedwood, and grass fuels
(b) 100 m: conifer, mixedwood, and grass fuels
(c) 100 – 500 m: conifer, mixedwood fuels



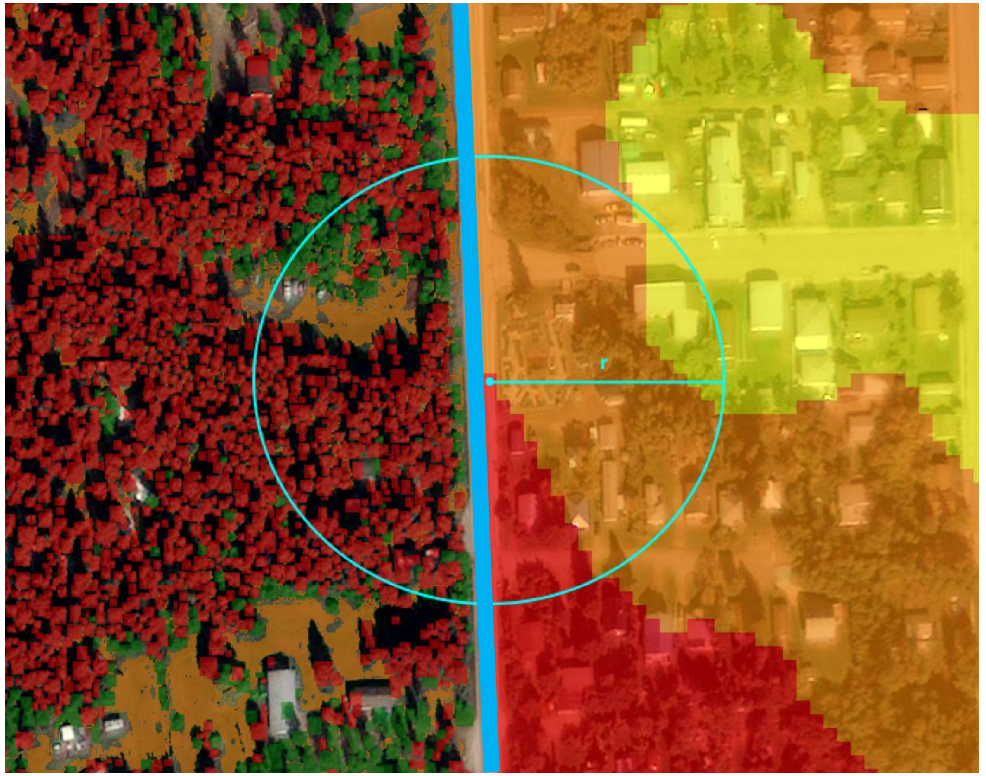
Landcover to Exposure:

Nil (0)
Low (>0–0.15)
Moderate (0.15–0.30)
High (0.30–0.45)
Extreme (>0.45)

Beverly, J. L., Bothwell, P., Conner, J. C. R., & Herd, E. P. K. (2010). Assessing the exposure of the built environment to potential ignition sources generated from vegetative fuel. *International Journal of Wildland Fire*, *19*(3), 299. https://doi.org/10.1071/WF09071

Satellite Community Assessment

- Define community bounds, create grid within bounds
- At each cell, draw circle of radius r, calculate landcover proportion of ‘hazard fuels’ (grass and coniferous fuels) within the circle using the generated predictions



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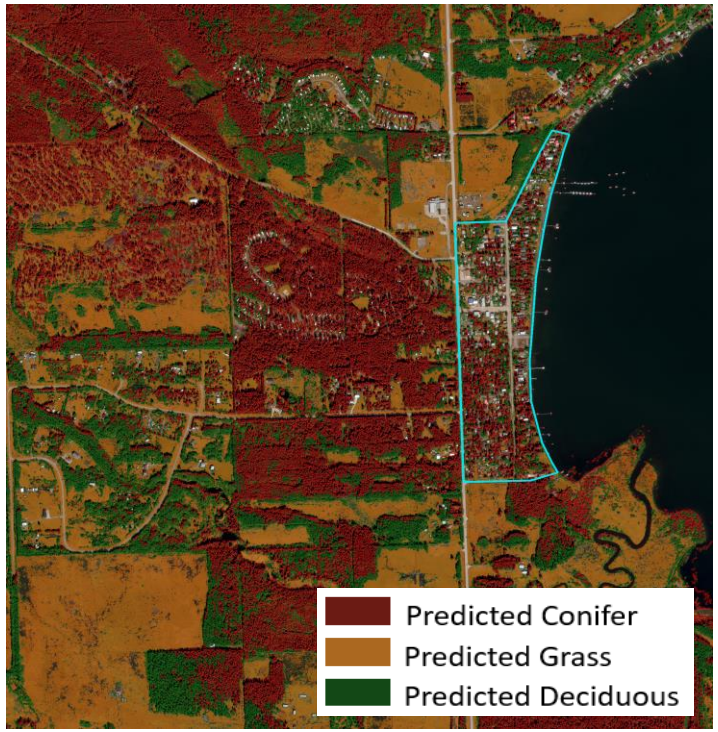
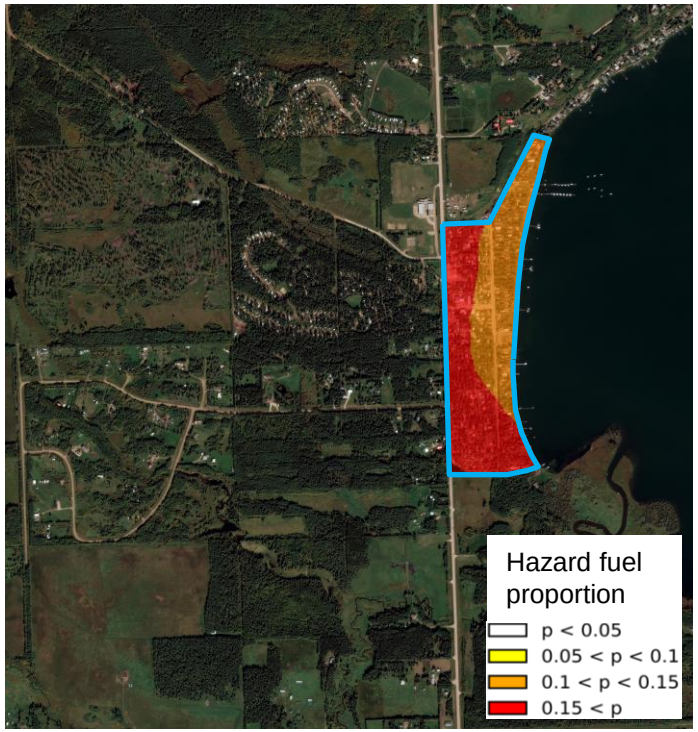
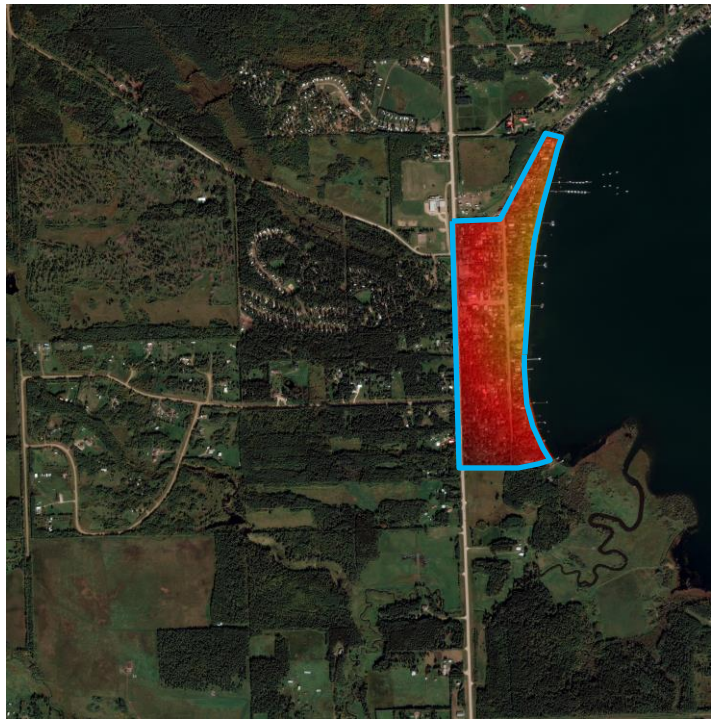
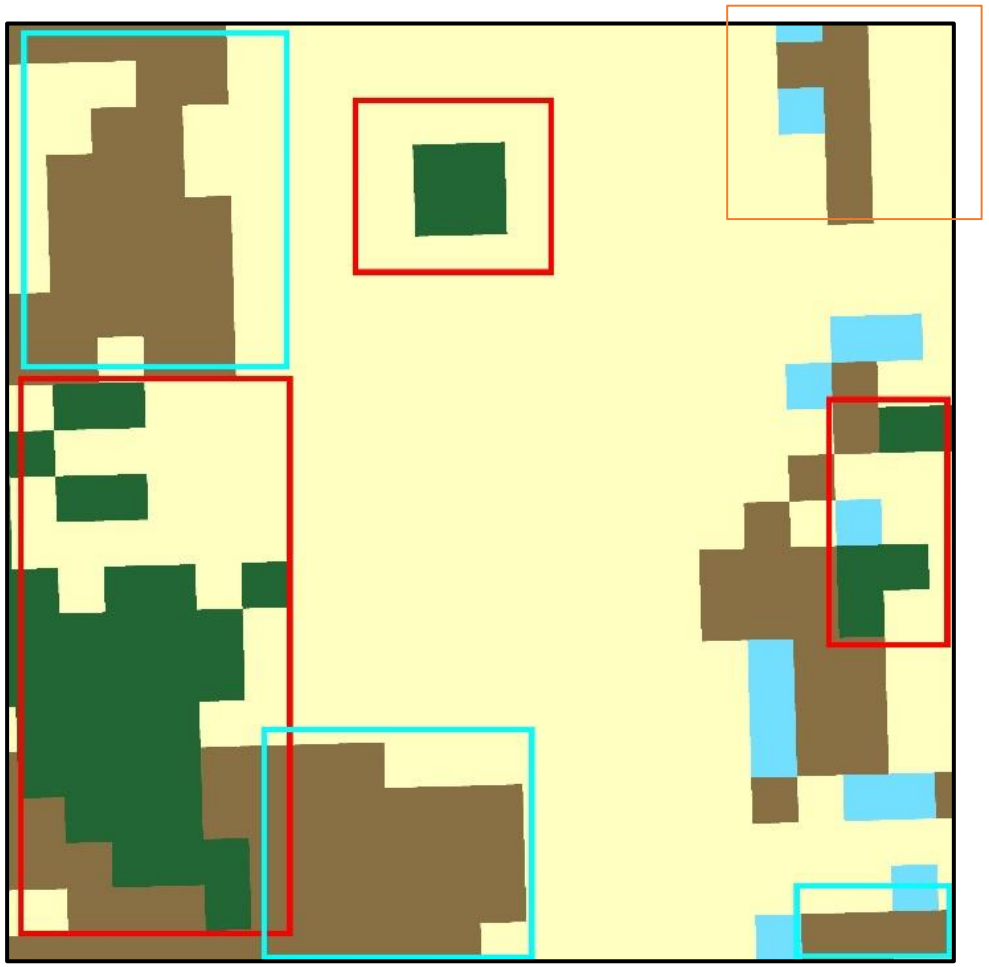




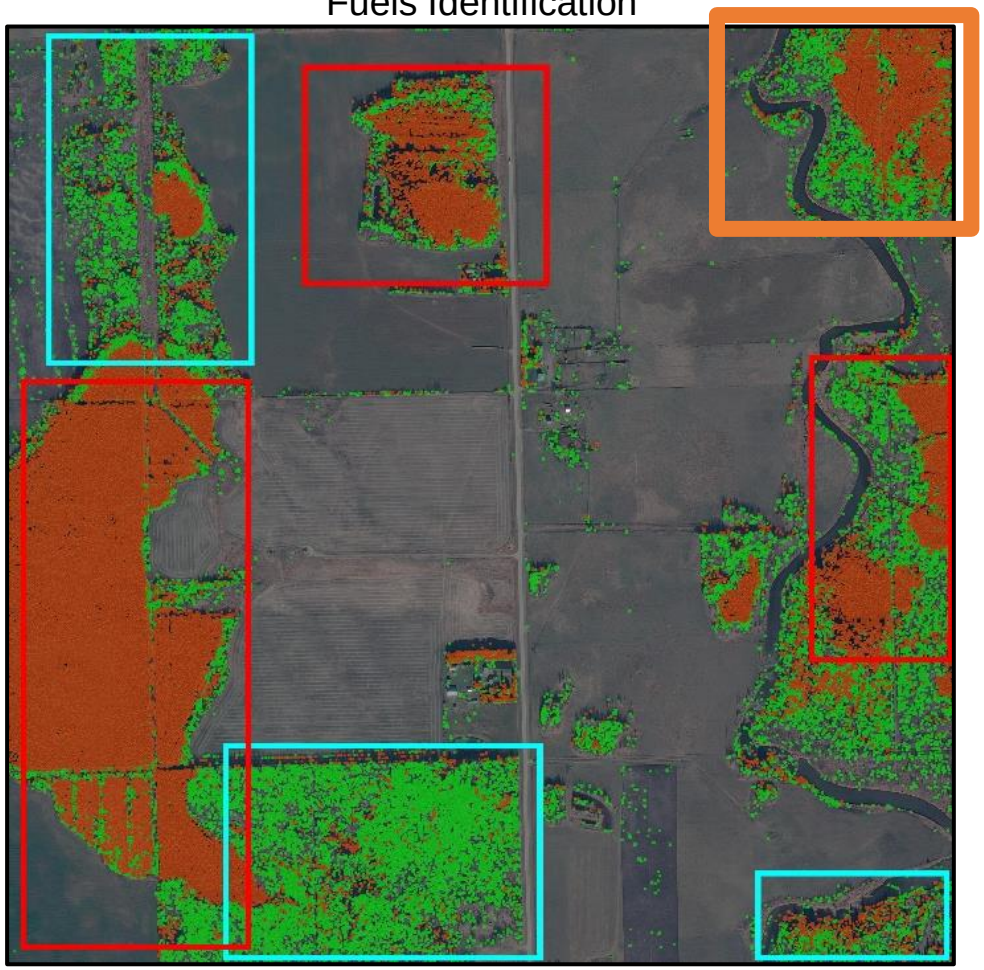


Fuel Maps

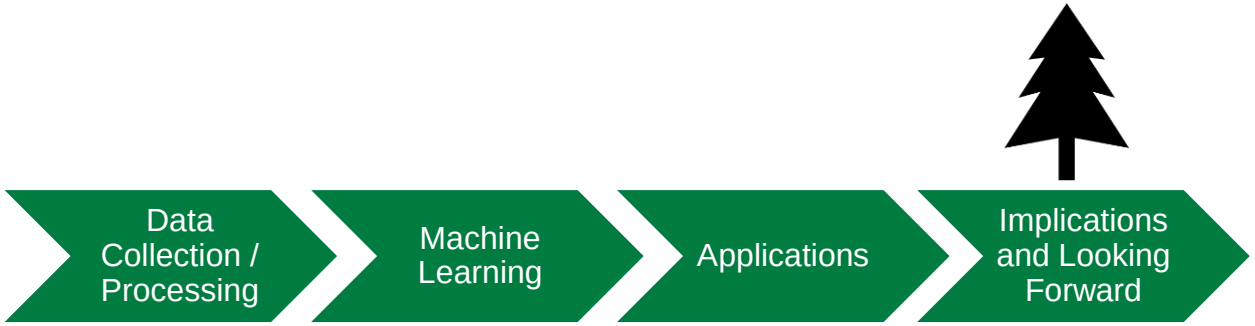
50m Alberta Fuel Map



Machine Learning
Fuels Identification



Why not use existing fuel maps?



Implications and Looking Forward

Leveraging Data in the ‘New Normal’

Drone and Satellite

- Different remote sensing technologies better fit different applications

Drone

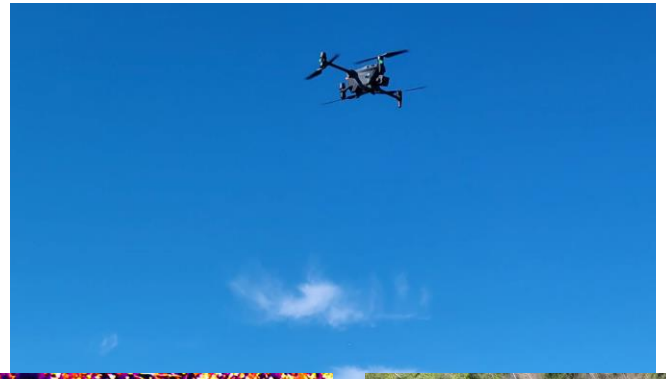
- Very high resolution (~2 cm / px)
- Suite of outputs including species, tree height, size, precise tree locations
- Higher accuracies
- Smaller areas surveyed
- More labour per sq. km. than satellite
- Can be limited by weather, airspace, and privacy considerations

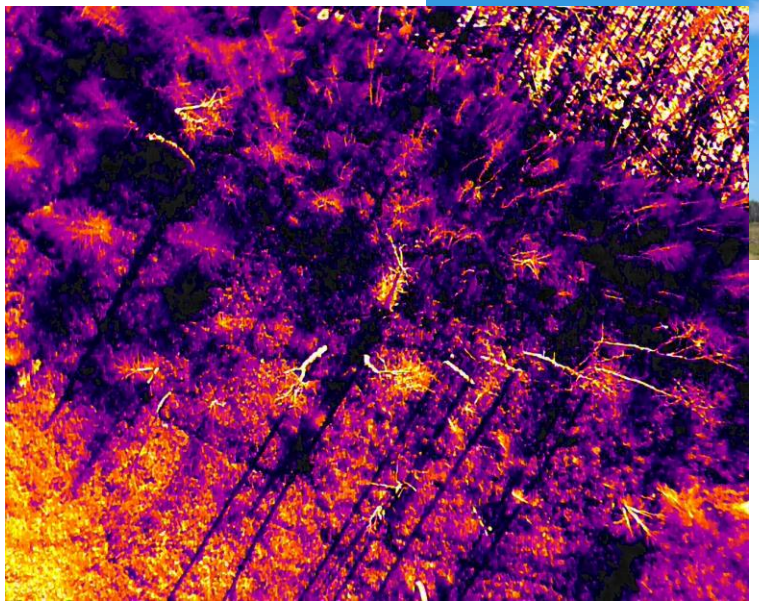
Satellite

- Lower resolution (0.5 m / px)
- Outputs limited to tree locations and coniferous / deciduous
- Lower accuracies
- Huge areas able to be done at little cost
- Fast, automated, almost no labour required

Implications and Looking Forward

- DJI M30T enables simultaneous collection of RGB and thermal imagery
- Exploring operational uses in wildfire response
  - Hotspot detection
  - Firefighter safety
  - Mop-up operations





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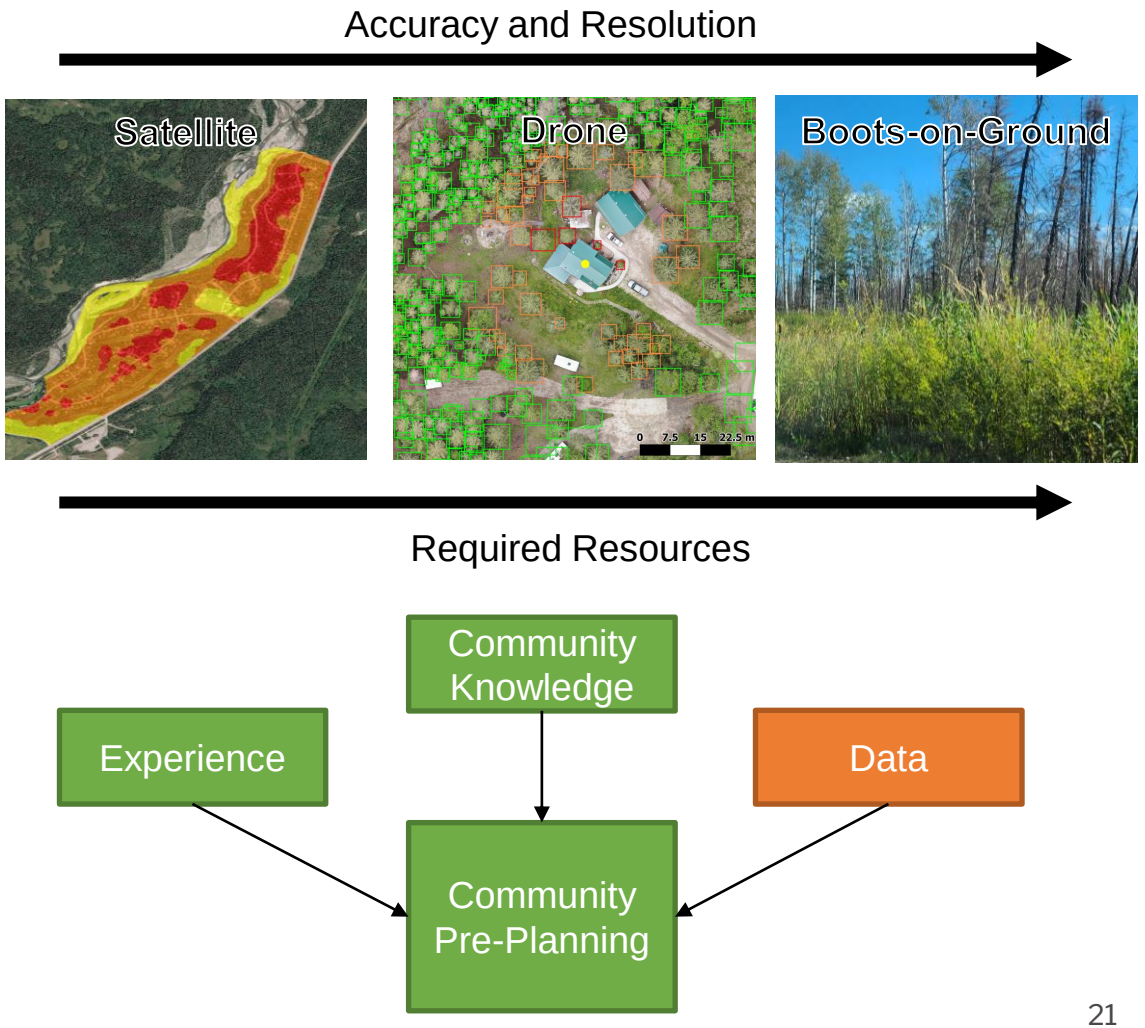
- Resource limitations can exist regarding hazard assessments, as they require trained professionals to individually visit each property
- Despite limitations, the technology and methods exist for remote hazard assessment application on a wide scale
- This can reduce the barrier of entry to detailed preplanning on a property-level scale
- Seeking to supplement and aid preplanning activities – AI cannot preplan response for a community, but it can act as an information source to trained experts