UAS Data Enabled Operational Fire Spread Simulation

Dr. Xiaolin Hu
Computer Science Department
Georgia State University
Atlanta, GA, USA

UAS Integration for Fire Operation
Workshop, 11/17/2021

Outline

- Simulation of Wildfire Behavior
  - Fire spread simulation
  - Fire suppression simulation
  - Fire ignition simulation
- UAS Data Enabled Operational Fire Spread Simulation
  - UAS data
  - Data assimilation
  - Simulation results

Collaborative Autonomy and Safety for Teamed Human – Unmanned Aircraft Systems in Fast Evolving Wildfire Environment

Three Research Thrusts

1. Cooperative fire and wind sensing and advanced data assimilation.
2. Multi-UAS coordination and path planning in fast-evolving wildfire environment.
3. Human-directed autonomy to support teamed human-UASs collaboration.

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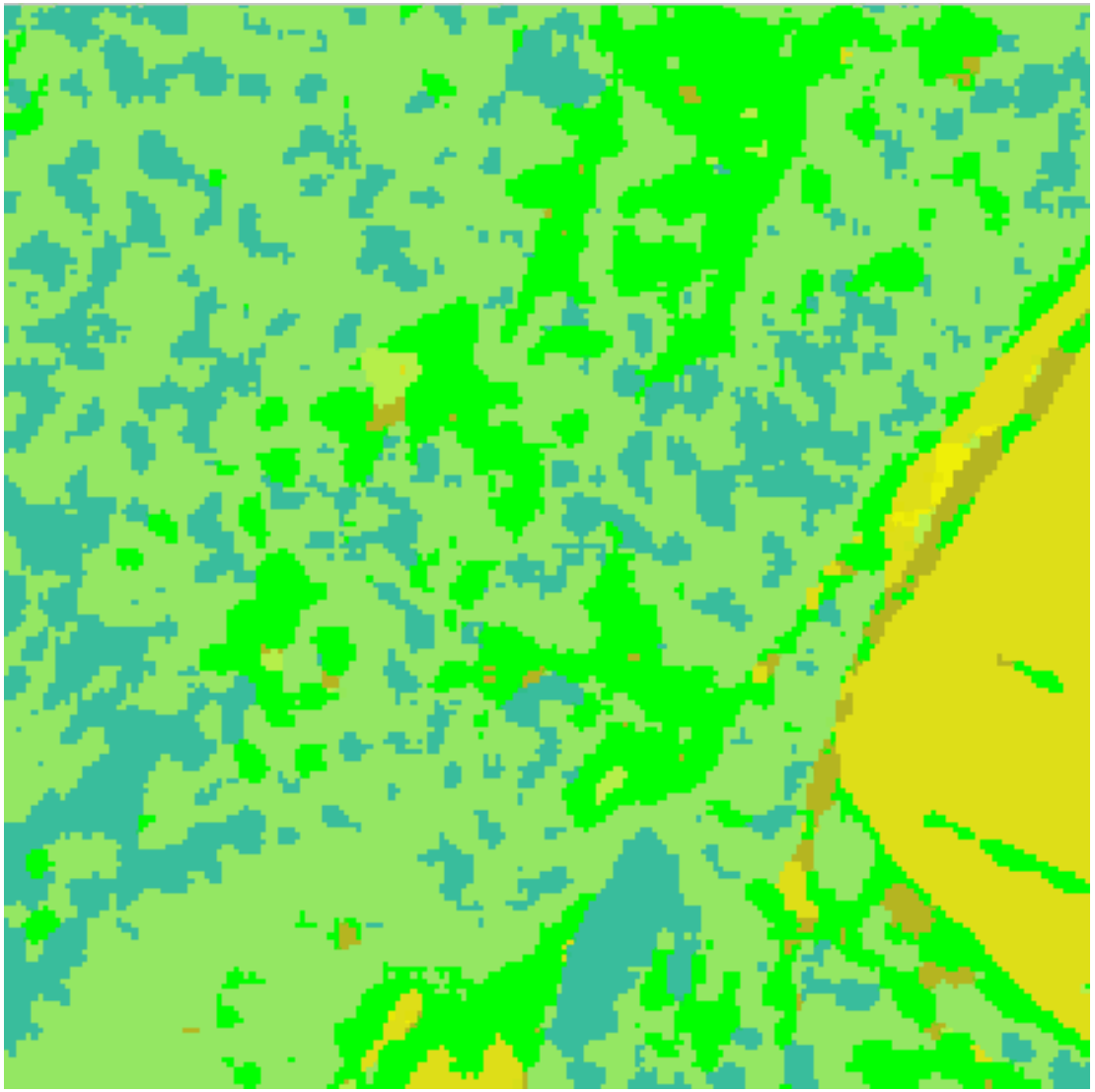
Fire Spread Simulation

(Huntsville area, Texas)

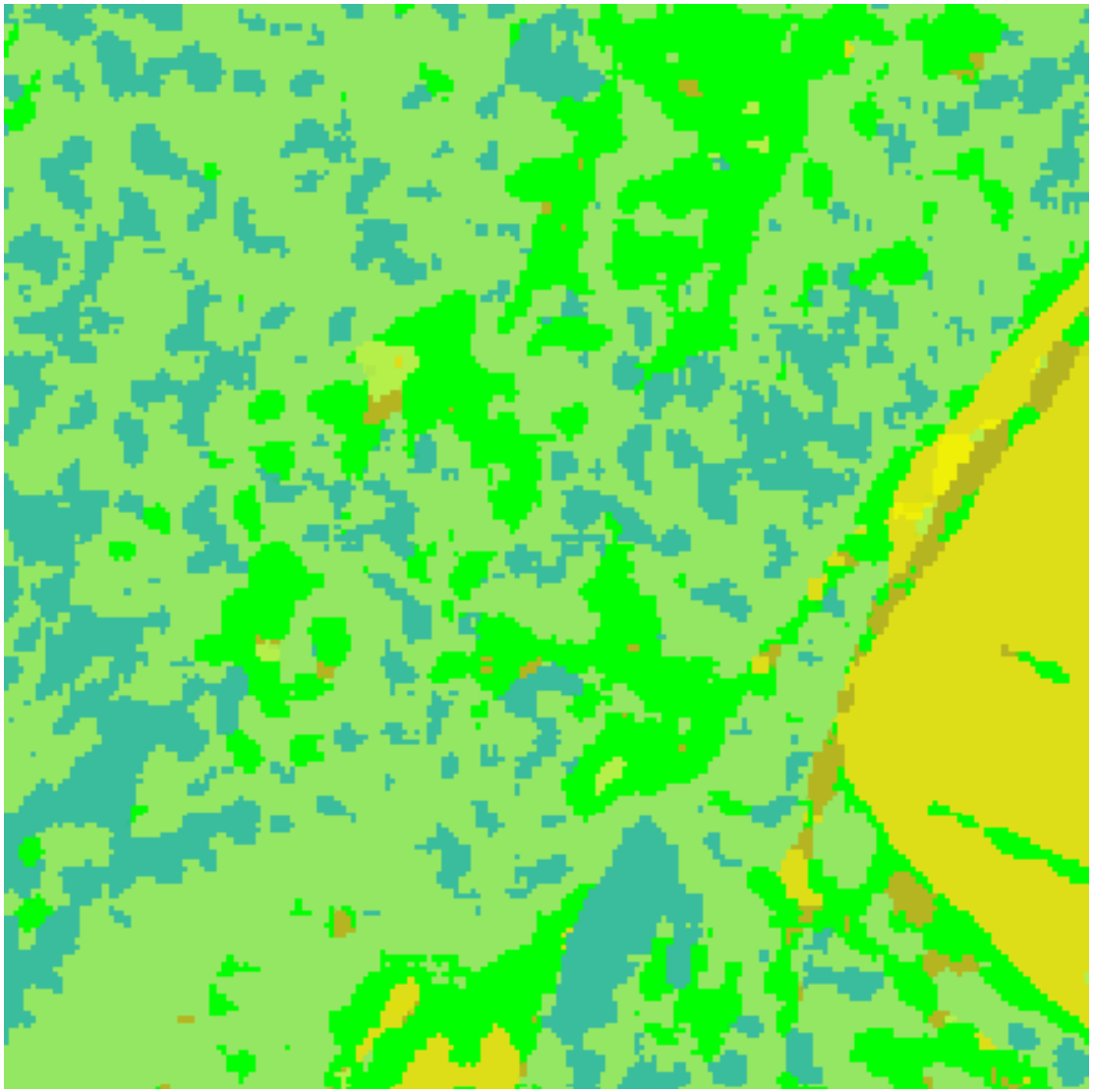
- DEVS-FIRE is a discrete event simulation model for surface wildfire spread simulation and fire suppression simulation.
- DEVS-FIRE uses a cell space to represent the fire area and employs Rothermel's fire behavior model to compute the direction and rate of spread for each cell.
- DEVS-FIRE has been used to simulate historical wildfires, and to evaluate dispatch plans of firefighting resources.



Fire Suppression Simulation

Different Fire Suppression Tactics:

- **Direct Attack**: fireline is constructed on the flaming fire front.
- **Parallel Attack**: fireline is constructed parallel to, but at a safe distance (offset) away from, the fire perimeter.
- **Indirect Attack**: fireline is constructed according to a predetermined route.
- **One or more groups** can work on the same fire.



Prescribed Fire Ignition

- Wildfires are free burn fires where the fire growth is mainly driven by the spread of burning fire fronts.
- Prescribed fires, on the other hand, are ignited intentionally by crew members according to some ignition plans.

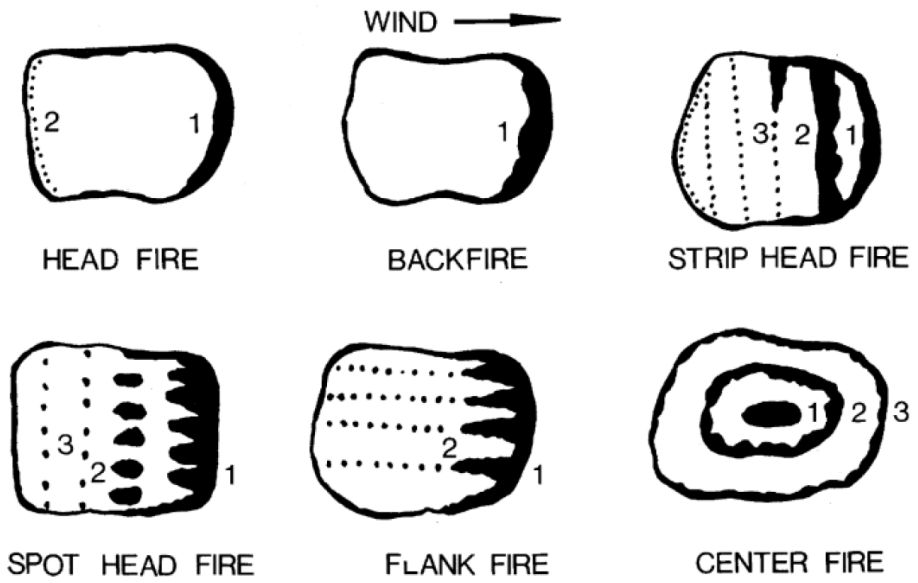
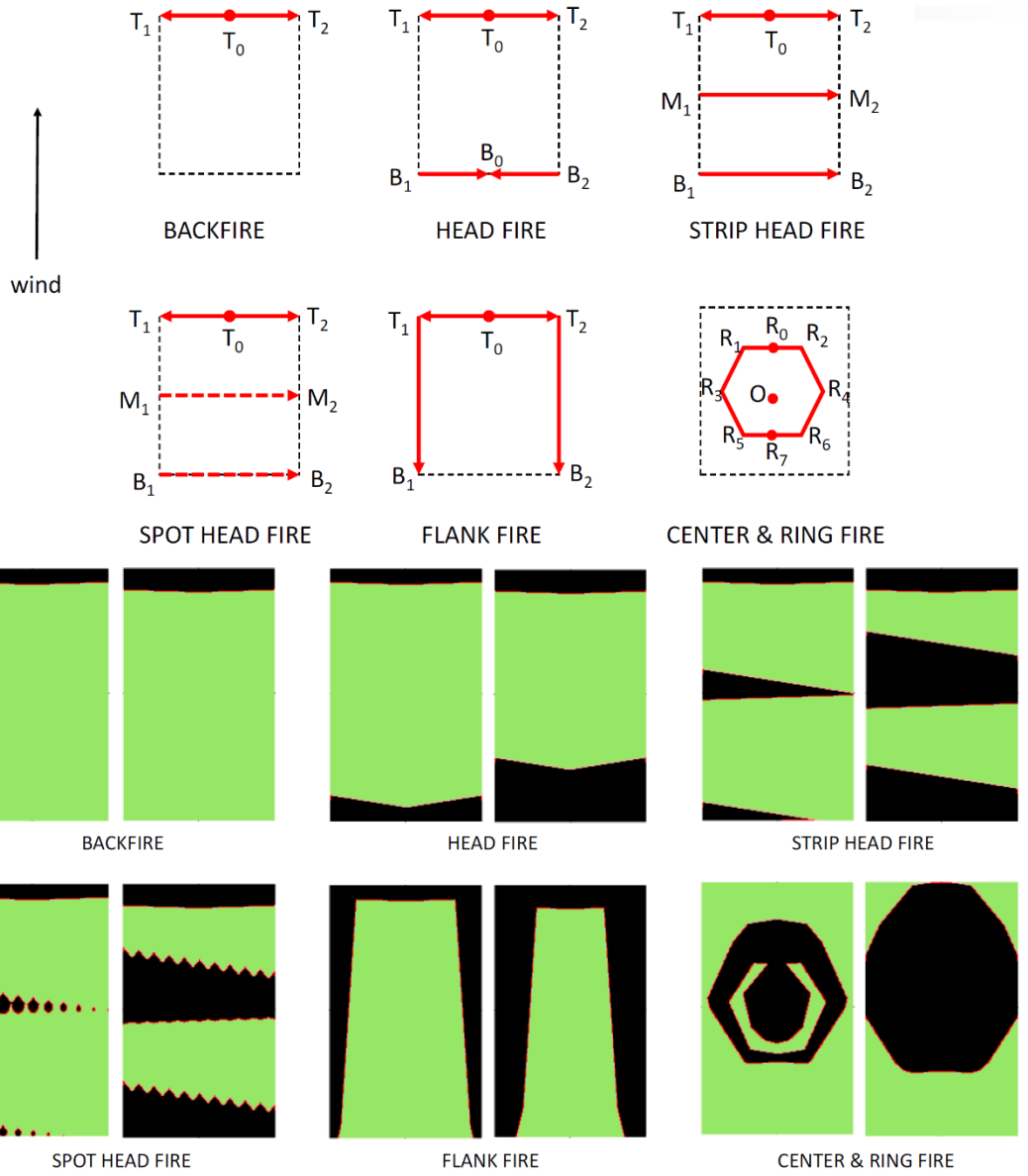


Figure 1: Basic firing techniques used in prescribed burning (Martin and Dell, 1978)

Prescribed Fire Ignition Simulation

- Prescribed fire ignition is a complex activity:
  - Different Ignition techniques
  - Other factors such as ignition speed, number of teams, start and end locations and timing of different ignition lines.
- **A systematic modeling approach** for prescribed fire ignition is needed.



Web-based Wildfire Simulation

- https://sims.cs.gsu.edu/sims/devsfire

UAS Data Enabled Operational Fire Spread Simulation

- Need for real time wildfire data
  - Operational fire spread simulation needs real time data about the spread of a wildfire.
  - The most important data is the location data of the evolving fire front.
- UAS for wildfire sensing
  - UAS shows major advantages for wildfire monitoring and data collection when compared to other technologies such as satellite systems, ground fire sensors/monitor towers, and manned aircrafts.
  - We are developing path planning algorithms to support automated wildfire monitoring.
- Data Assimilation
  - Noisy observation – USA data is noisy.
  - Partial observation – a UAS can cover only a portion of the fire area at any time.
  - We are developing particle filter-based data assimilation method to assimilate real time UAS data into the DEVS-FIRE simulation model.

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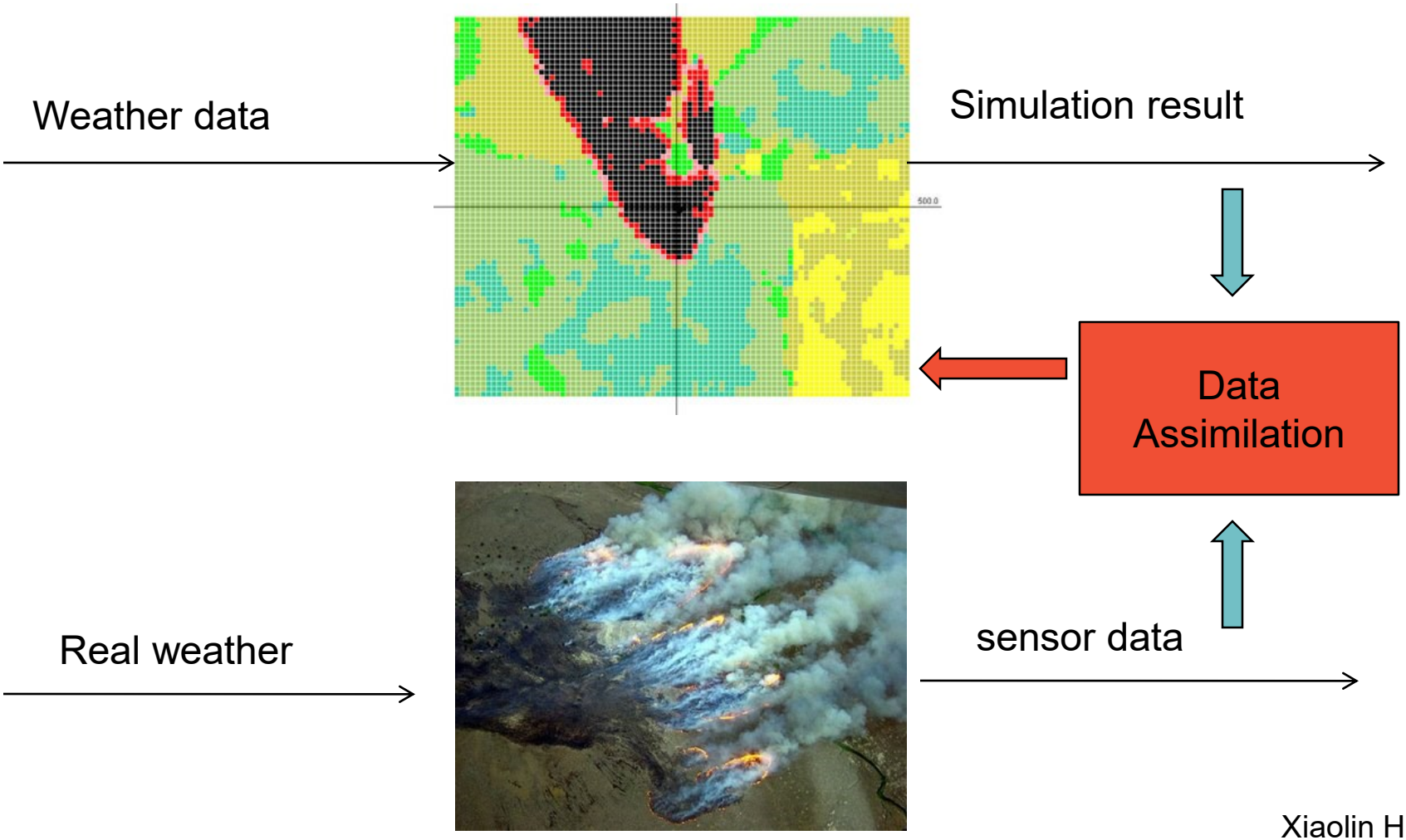
Dynamic Data Driven Simulation (DDDS)



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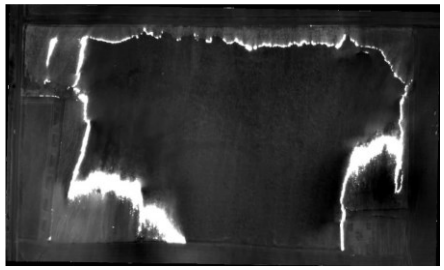
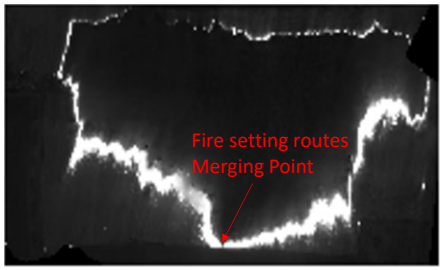
Fire Spread Simulation using UAS Data

- Experiment results show that the DEVS-FIRE spread simulation model, when coupled with UAS-based data, is able to simulate the overall growth of the prescribed fire.
- Fire ignition process can significantly impact fire behavior.

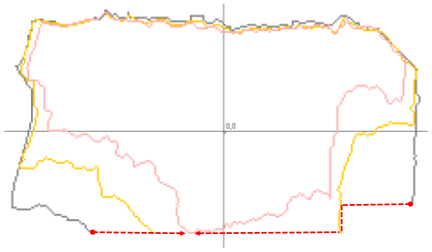
Loop 2 (ending time: 34min 14s)

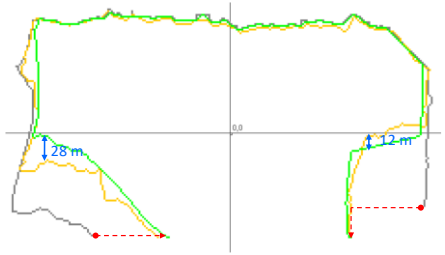


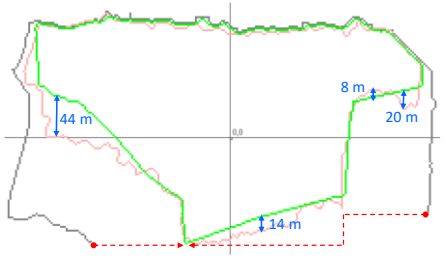
Loop 3 (ending time: 38min 33s)



Loop 4 (ending time: 41min 17s)







Fire spread simulation in comparison with real fire fronts (gray: initial fire front; green: simulated fire fronts; orange & pink: real fire fronts; red: ignition routes)

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NSF SCC-PG: Smart and Safe Prescribed Burning for Rangeland and Farmland Communities

Goal: Develop a community sensing, planning, & learning infrastructure to support smart and safe prescribed burning for communities that use prescribed fires for land management.

10/1/2021 – 9/30/2022

For More Information

- https://sims.cs.gsu.edu/sims/
- xhu@gsu.edu

- Thank you!
- Questions & Comments