COUPLED FIRE-ATMOSPHERIC MODELING APPLICATIONS

ICAMS 2ND FIRE WORKSHOP
JUNE 2, 2022

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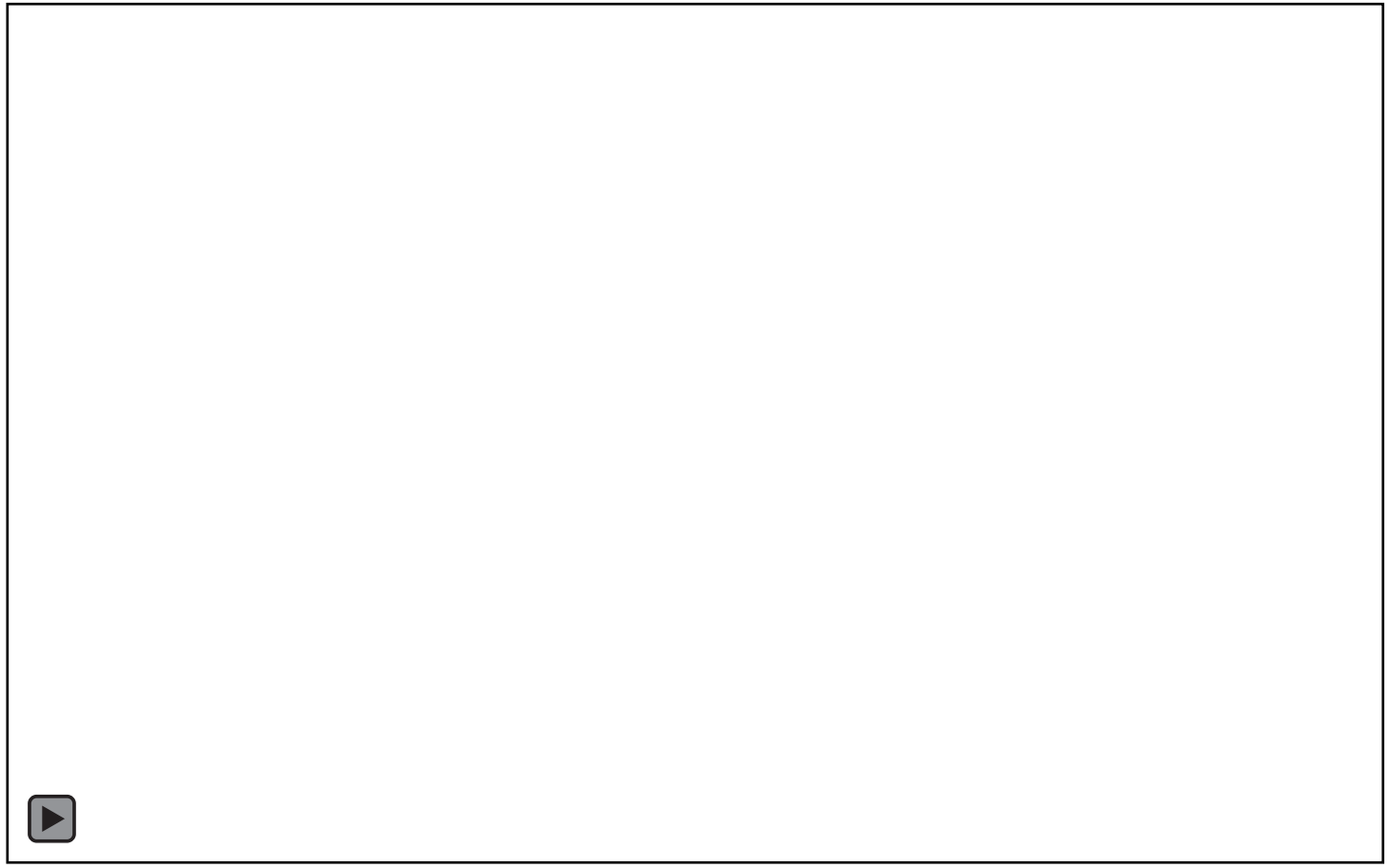
USGS Wildland Fire Science Strategic Plan
https://doi.org/10.3133/cir1471

APPLICATIONS FOR COUPLED FIRE ATMOSPHERIC MODELS

- Prescribed Fire Planning
- Fuel Treatment Effectiveness Evaluations
- Advanced Training
- Ember Transport
- Ecological Fire Effects



QUIC-Fire

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INCREASED PRESCRIBED FIRE TREATMENTS ARE NEEDED

npr wfsu PUBLIC MEDIA

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NEWS ARTS & LIFE MUSIC PODCASTS & SHOWS SEARCH

CLIMATE

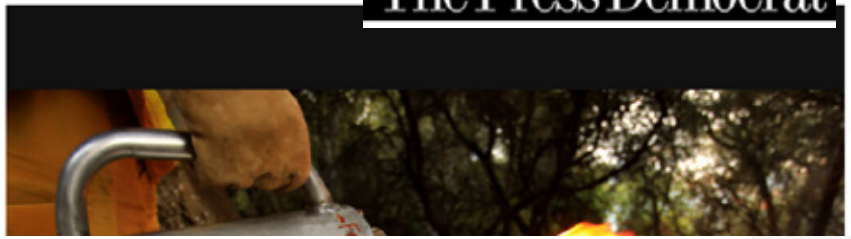
Why The South Is Decades Ahead Of The West In Wildfire Prevention

August 31, 2021 · 5:08 AM ET

Heard on Morning Edition

New bill expected to encourage use of 'good fire'

The Press Democrat



Los Angeles Times

Newsom signs 'monumental' law paving way for more prescribed burns

PEW

Stateline

California May Need More Fire to Fix its Wildfire Problem

STATELINE ARTICLE | September 18, 2020 | By: Sophie Quinton & Alex Brown | Read time: 10 min

PRESCRIBED BURNING IS INCREASINGLY COMPLEX

We need 21st century tools for a 21st century landscape

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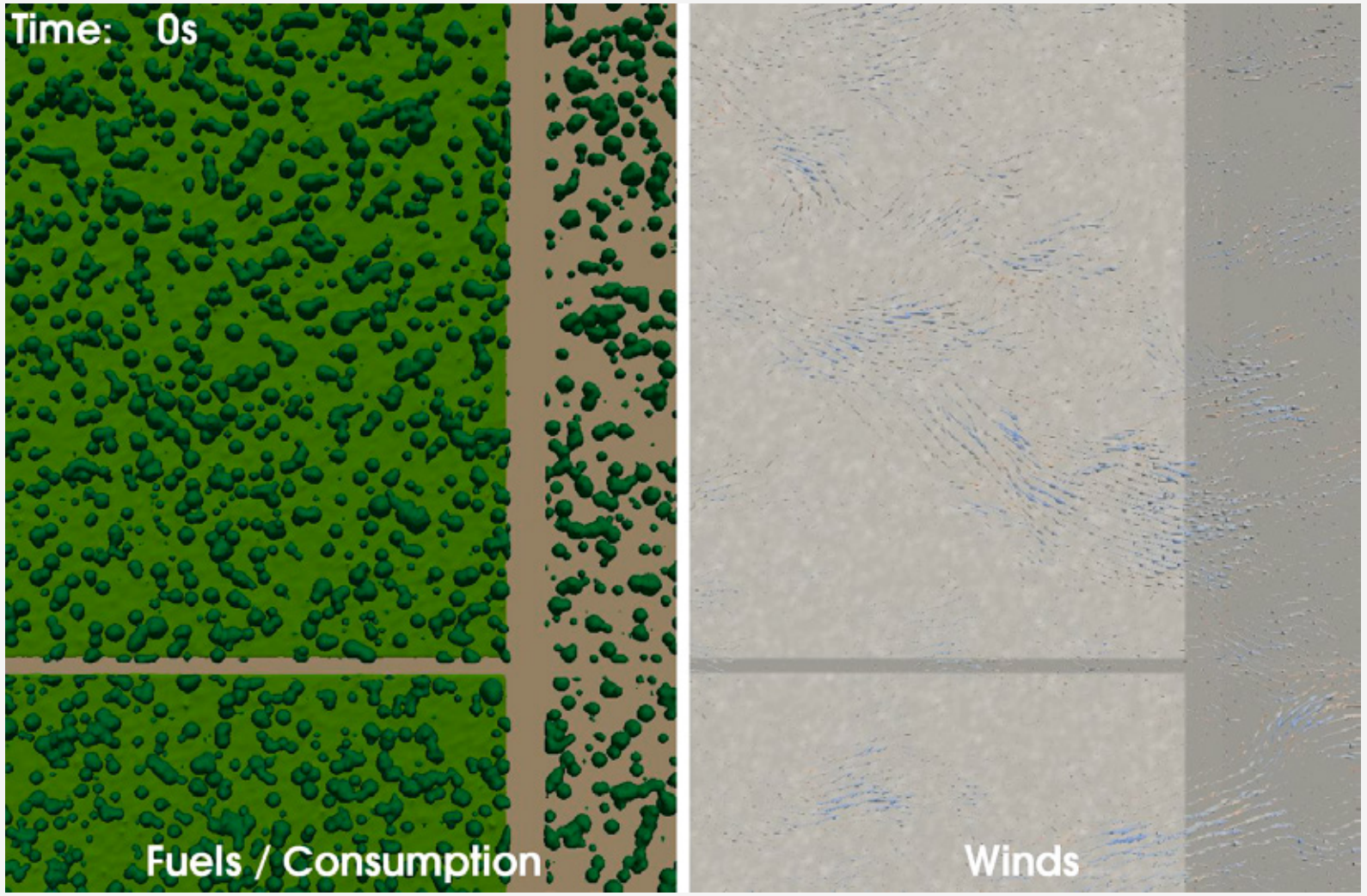
PRESCRIBED FIRE PLANNING

CFA tools allow exploration of ignition patterns and outcomes for burn objectives



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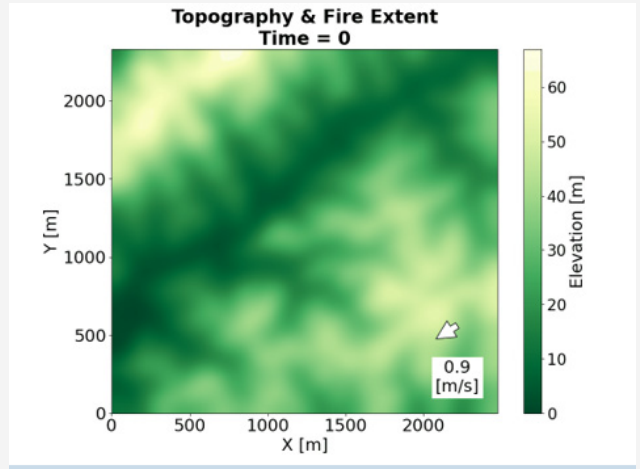
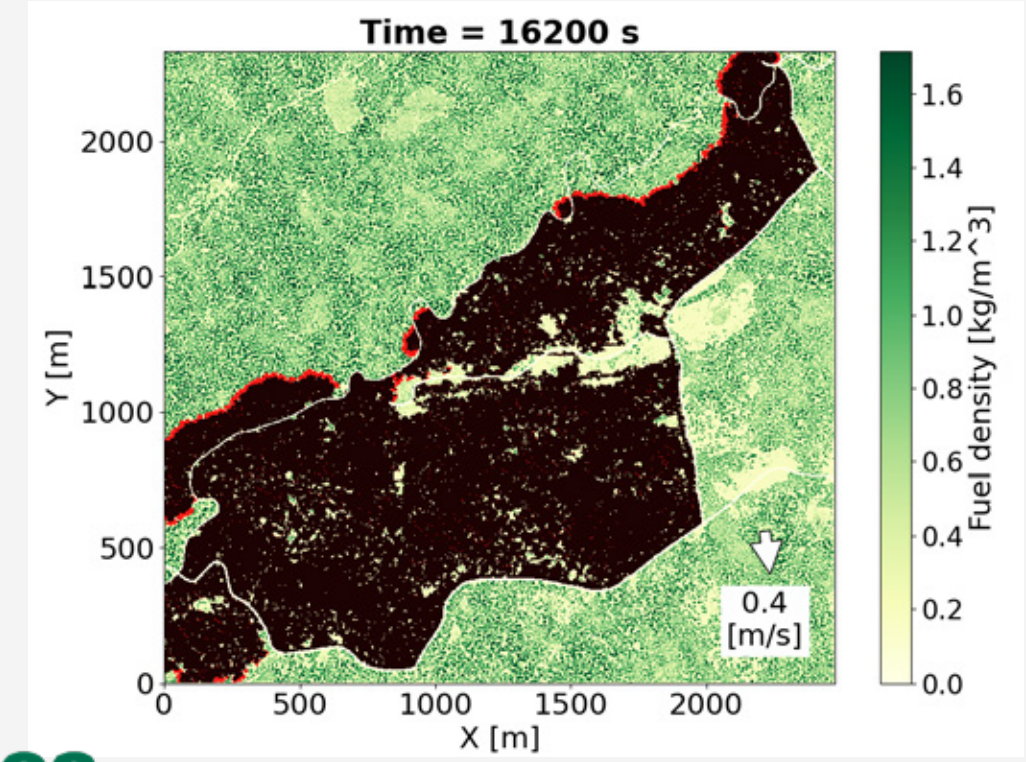
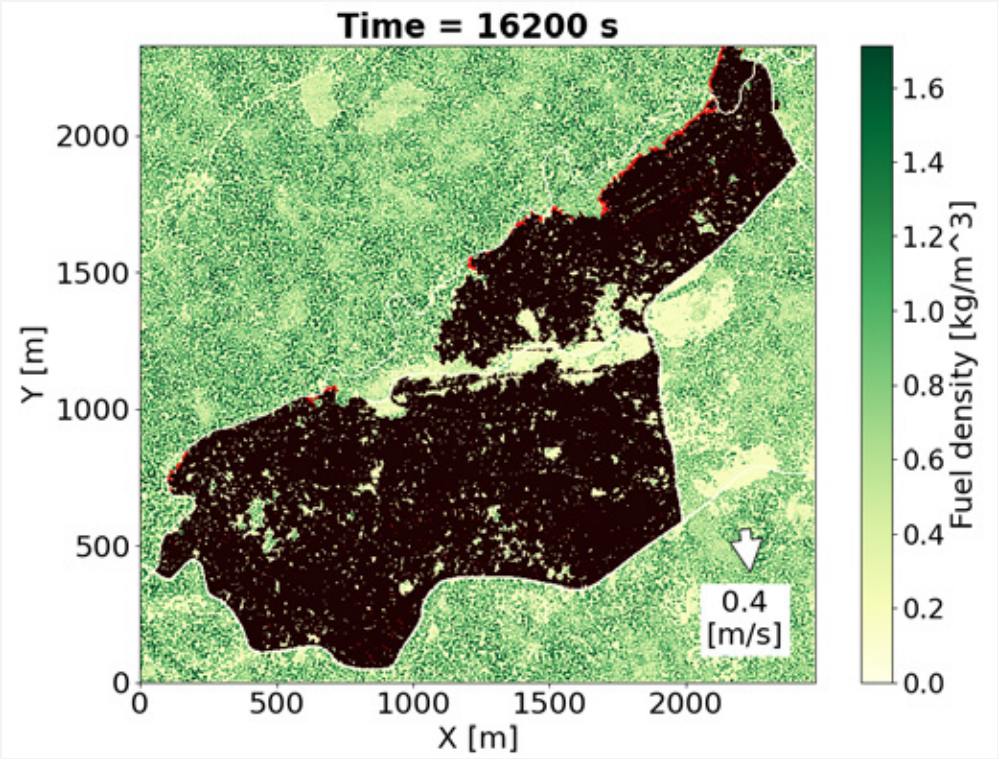
QUIC-FIRE SIMULATION WITH MODIFIED FMC





Original Simulation Homogenous Fuel Moisture



Final Burn Plot of the
Modified FMC Simulation

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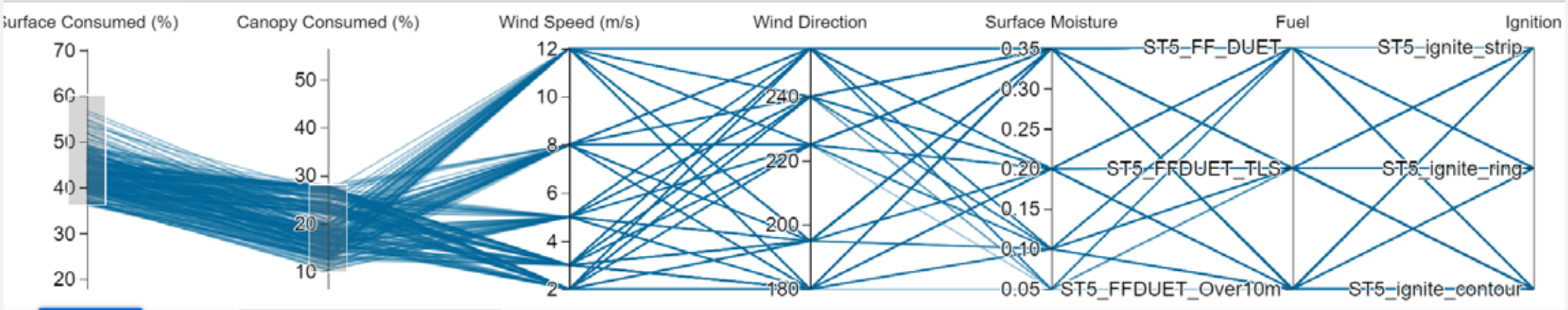
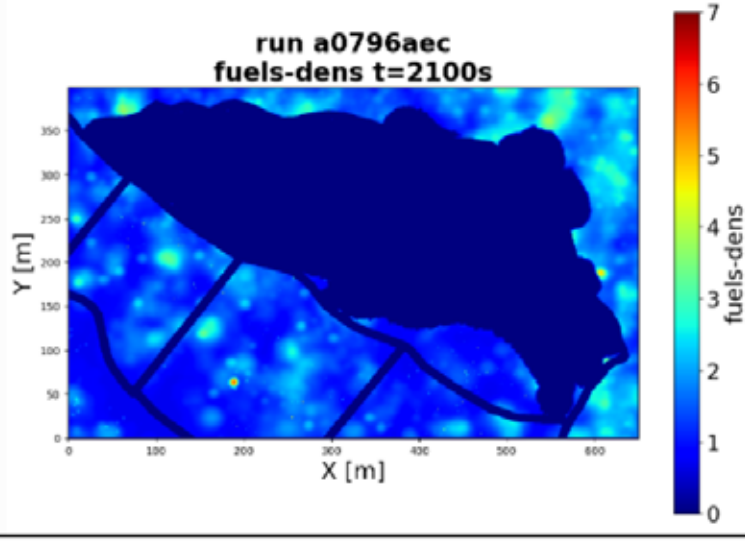
BURNPRO3D ENSEMBLE PRESCRIPTION WINDOW

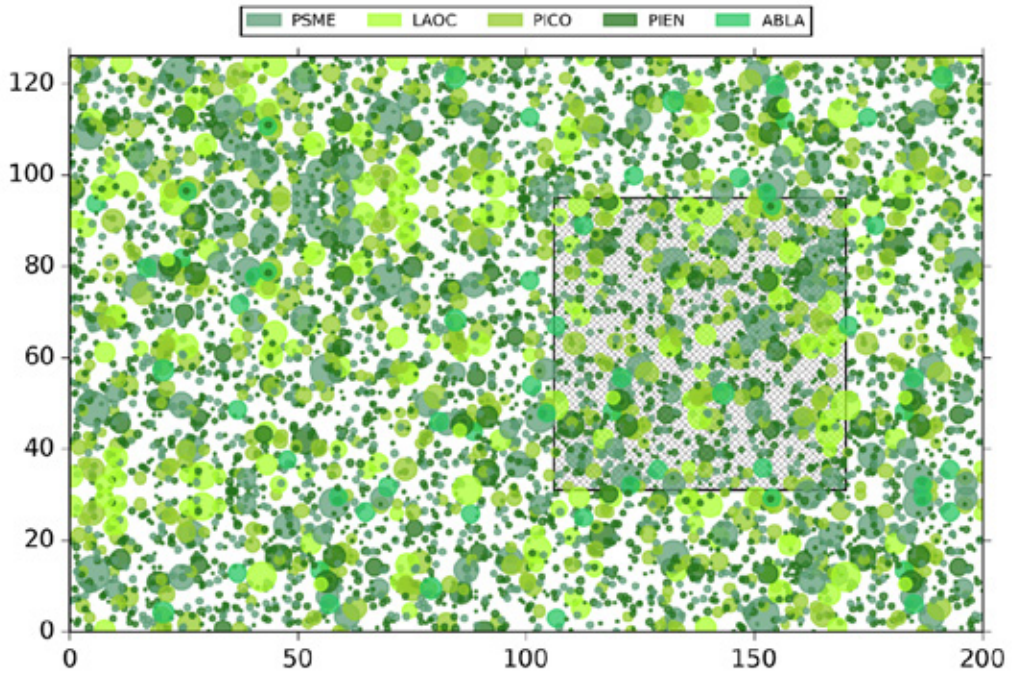


Reset Color: None

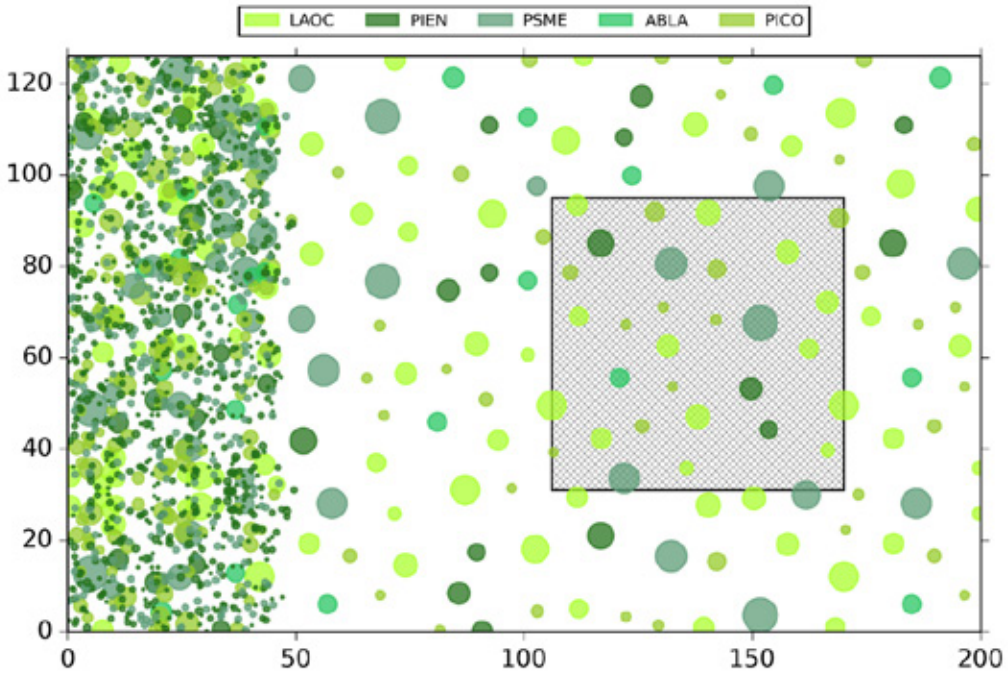
Surfac...	Canop...	Wind ...	Wind ...	Surfac...	Fuel	Igniti...
42.11	27.49	2	180	0.05	ST5_FF...	ST5_ig...
45.82	27.38	3	255	0.05	ST5_FF...	ST5_ig...
43.57	27.88	2	240	0.05	ST5_FF...	ST5_ig...
43.35	27.99	2	255	0.05	ST5_FF...	ST5_ig...
42.93	27.6	2	225	0.05	ST5_FF...	ST5_ig...
41.57	27.07	2	240	0.05	ST5_FF...	ST5_ig...
41	26.96	2	255	0.05	ST5_FF...	ST5_ig...
41.8	25.86	3	255	0.05	ST5_FF...	ST5_ig...
44.78	27.62	3	255	0.05	ST5_FF...	ST5_ig...
45.5	27.2	3	195	0.1	ST5_FF...	ST5_ig...
42.89	26.28	3	255	0.1	ST5_FF...	ST5_ig...



TREATMENT EFFECTIVENESS ASSESSMENTS



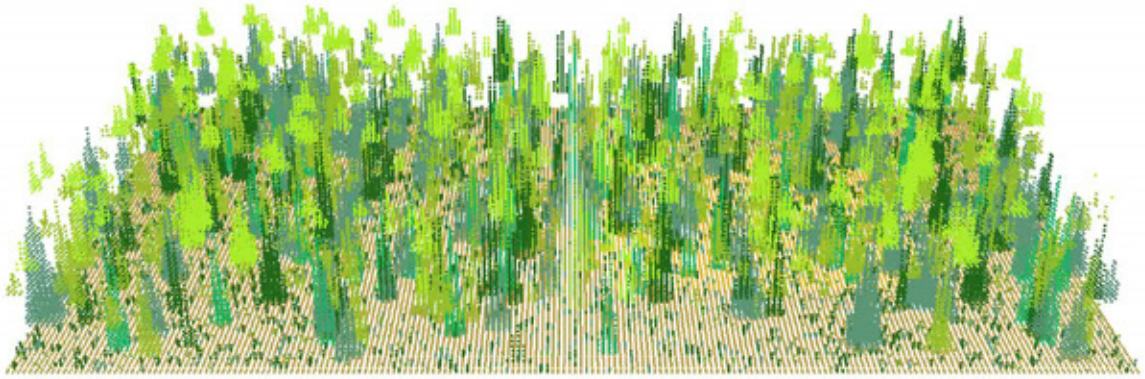
SWAN Site – Control (no thinning or pruning)

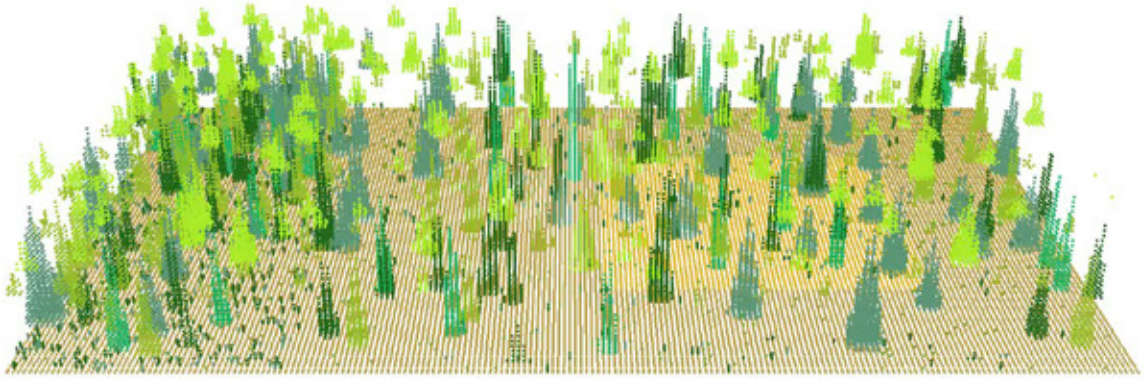


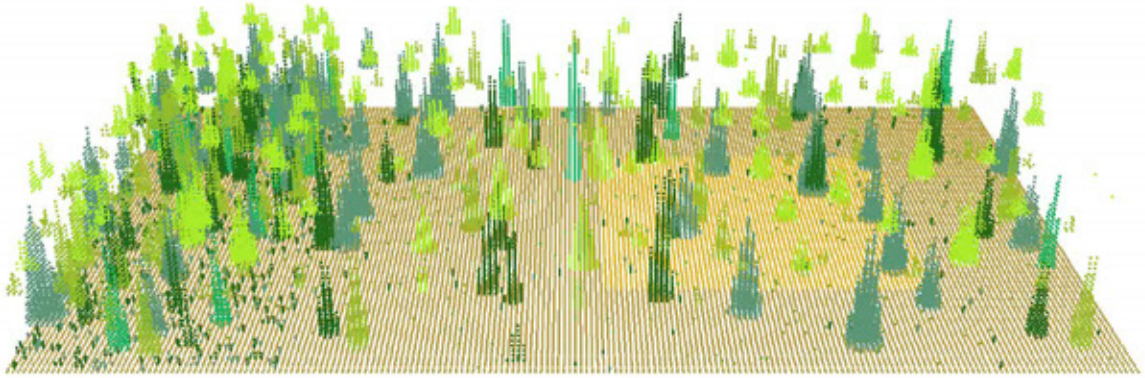
SWAN Site – 15’ Crown Space Thinning

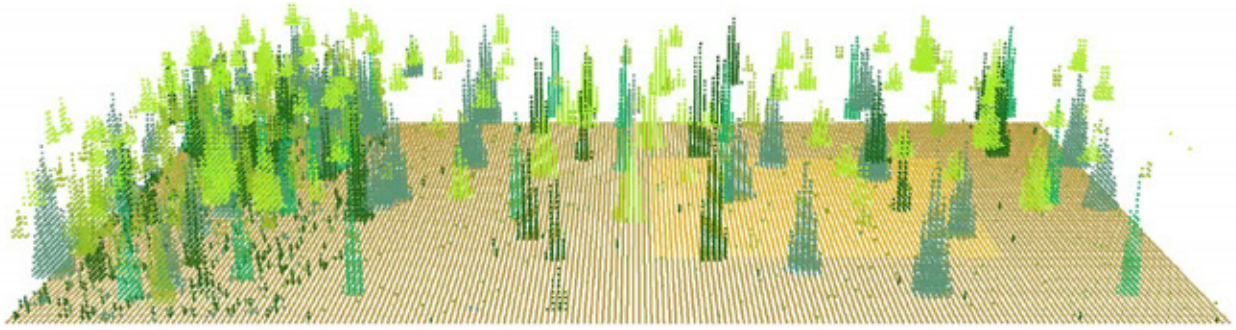
Courtesy Russ Parsons, US Forest Service, RMRS Firelab

STANDFIRE – A prototype 3D Fuel and WFDS



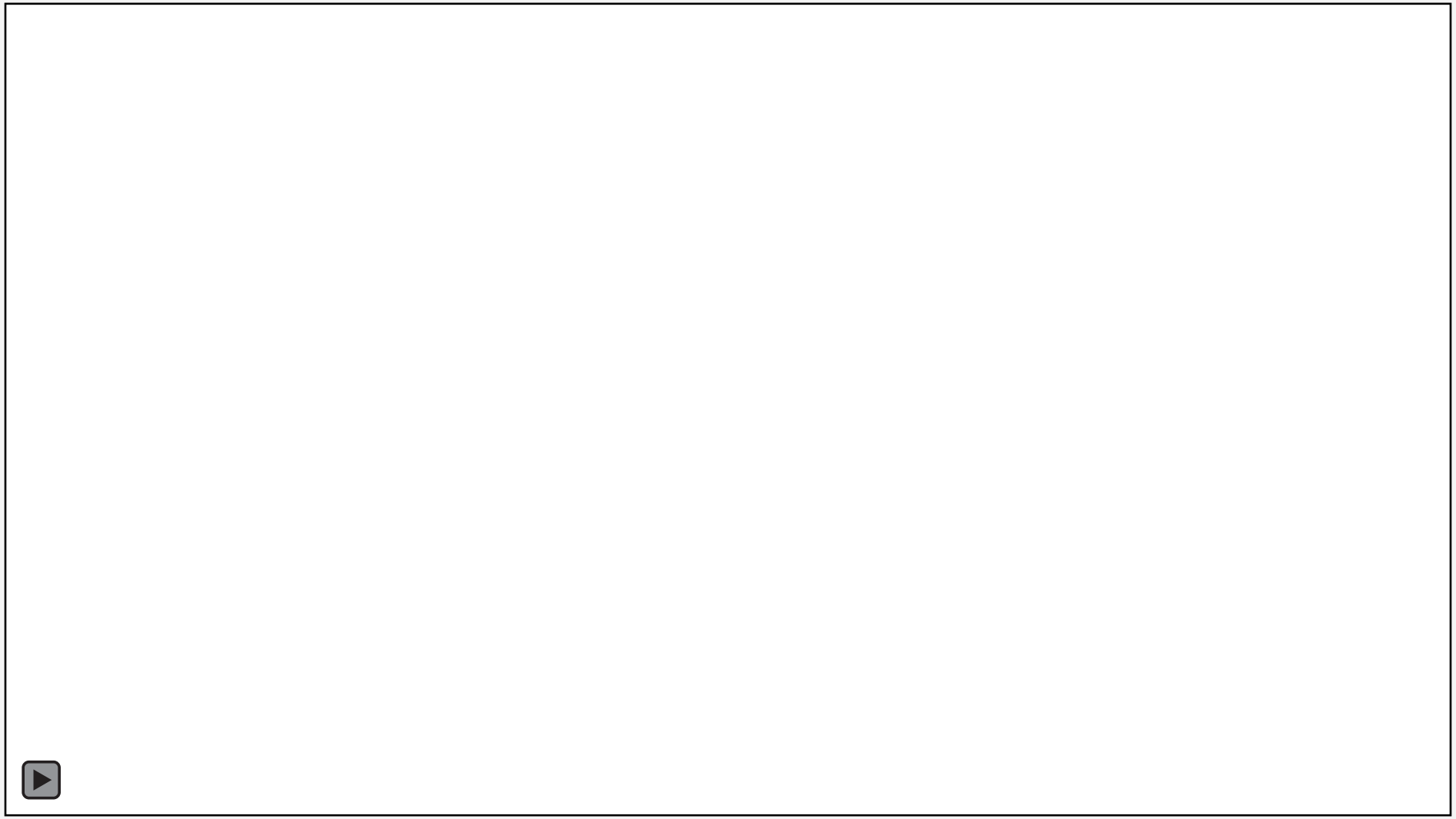




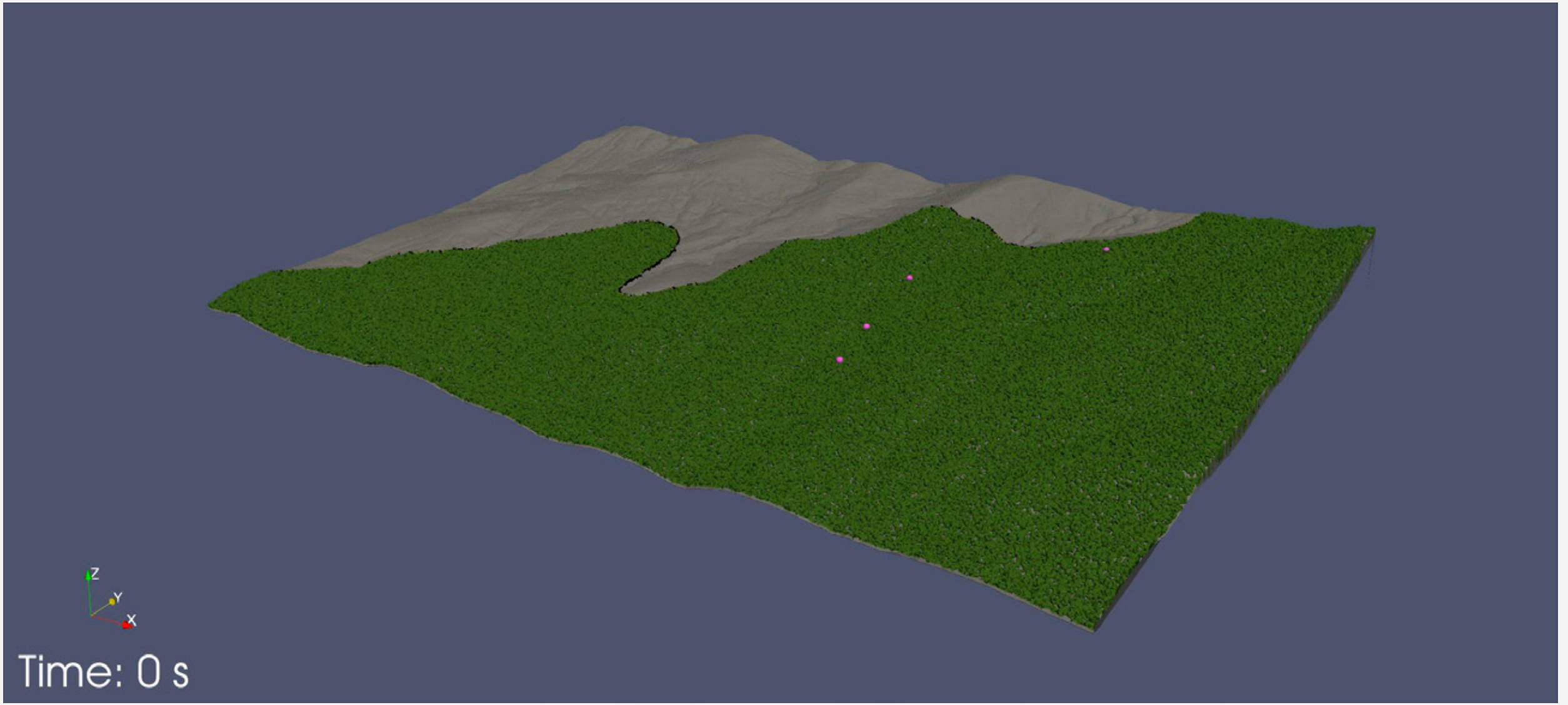


Courtesy Russ Parsons, US Forest Service, RMRS Firelab

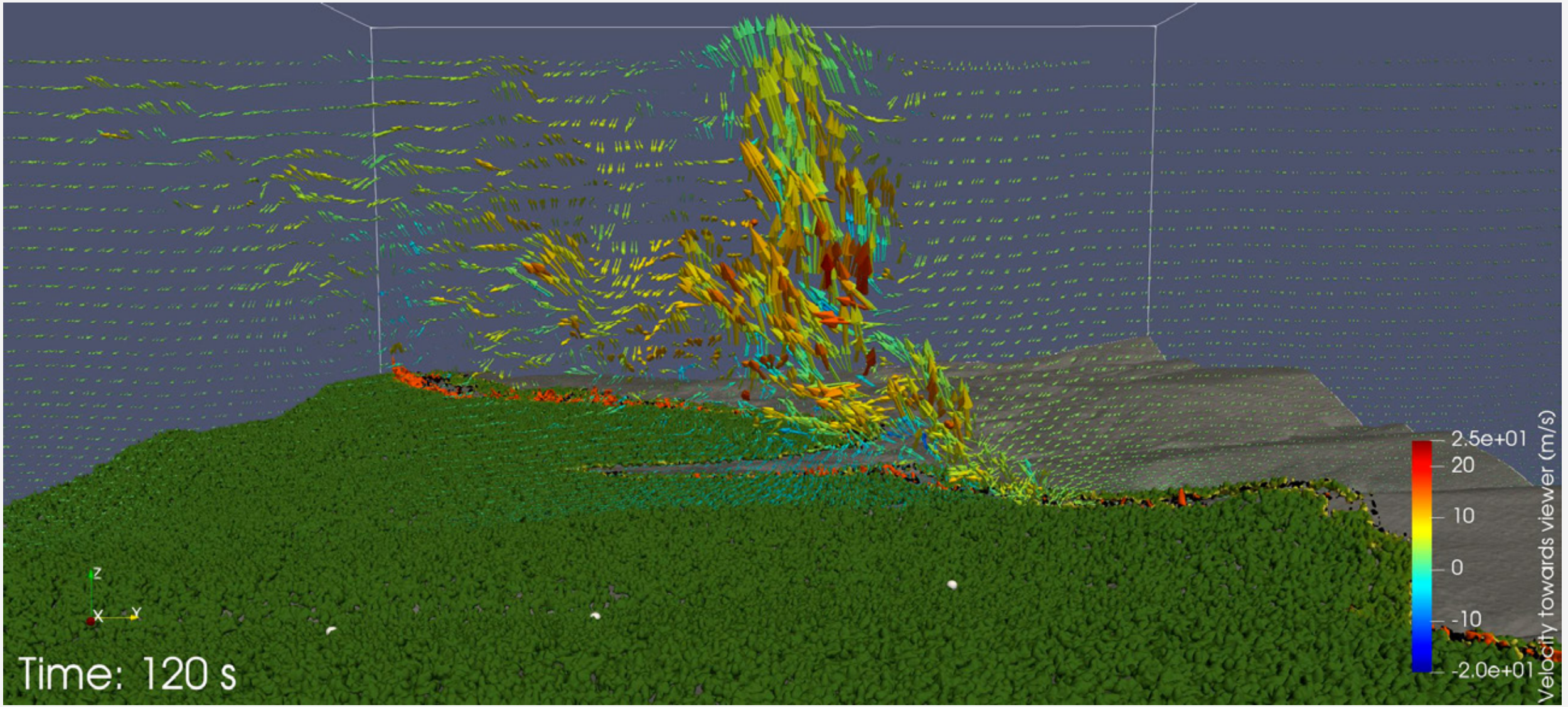
VIRTUAL REALITY: A "FLIGHT SIMULATOR" FOR BURN BOSSES



LESSONS LEARNED ON RARE EVENTS



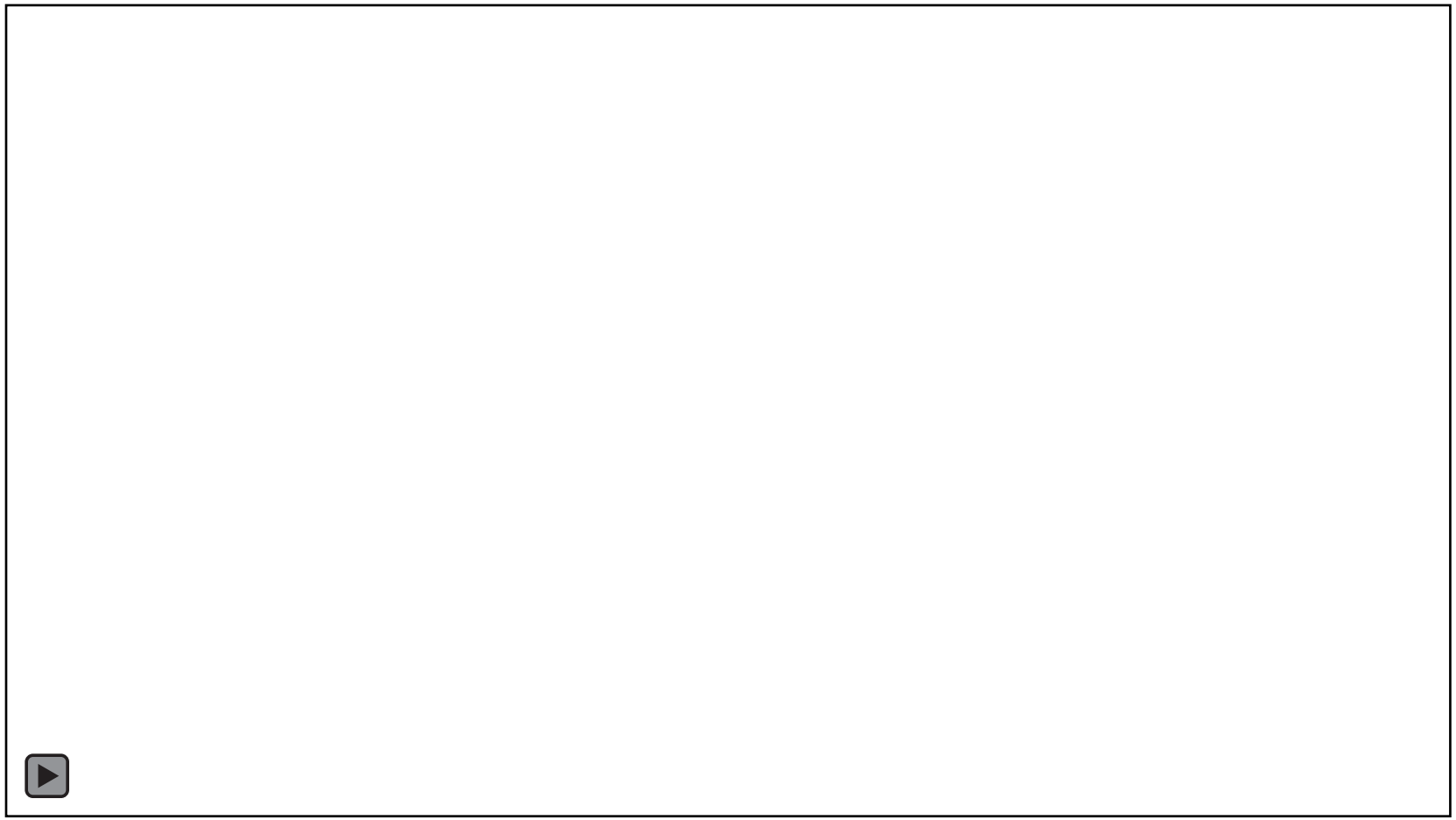
LESSONS LEARNED: DUDE FIRE VIRTUAL STAFF RIDE



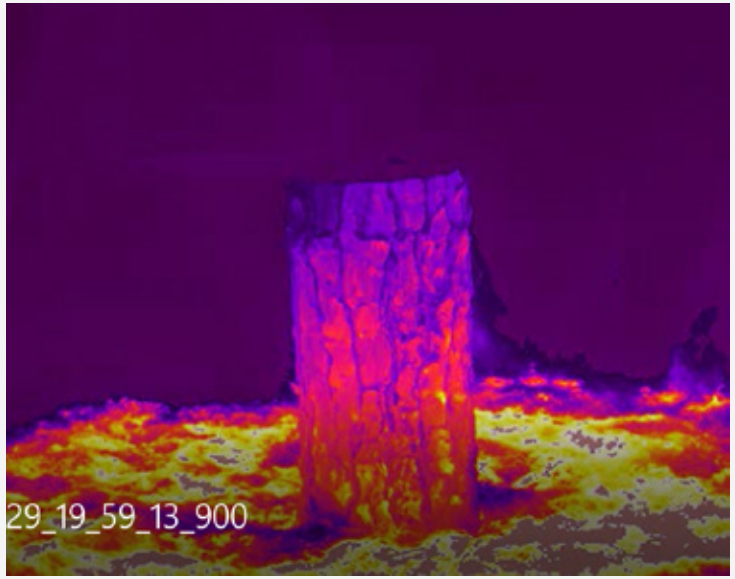
UNDERSTANDING EMBER TRANSPORT AND SPOT FIRE POTENTIAL

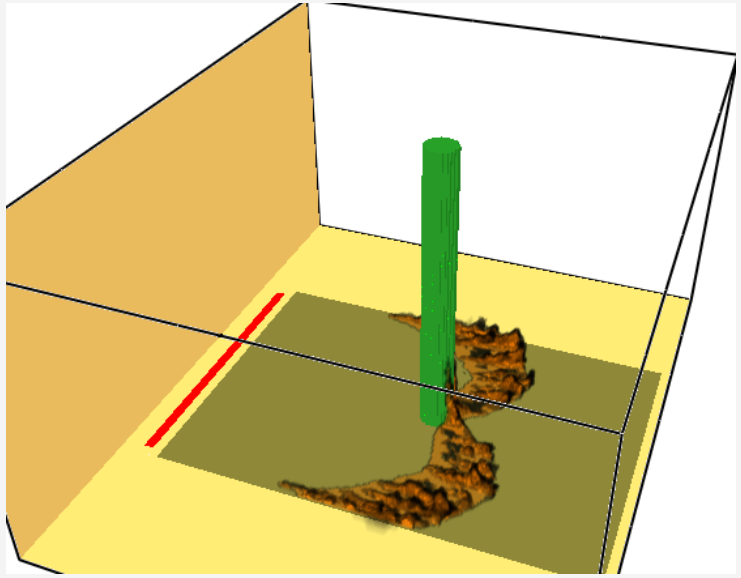
Critical to account for coupled fire/atmosphere interaction

- Potential impact of strategic fuels treatment for managing fire spread across discontinuities.
- Consider the importance of longer-range spotting for facility protection.



MECHANISTIC FIRE EFFECTS: ENERGY DOSE





WFDS, courtesy Ruddy Mell

- Energy dose to trees is critical for predicting fire effects (Smith et al. 2016)
- Determining how variation in energy drives ecological response is needed to predict fire's role in an uncertain future (O'Brien et al. 2018)

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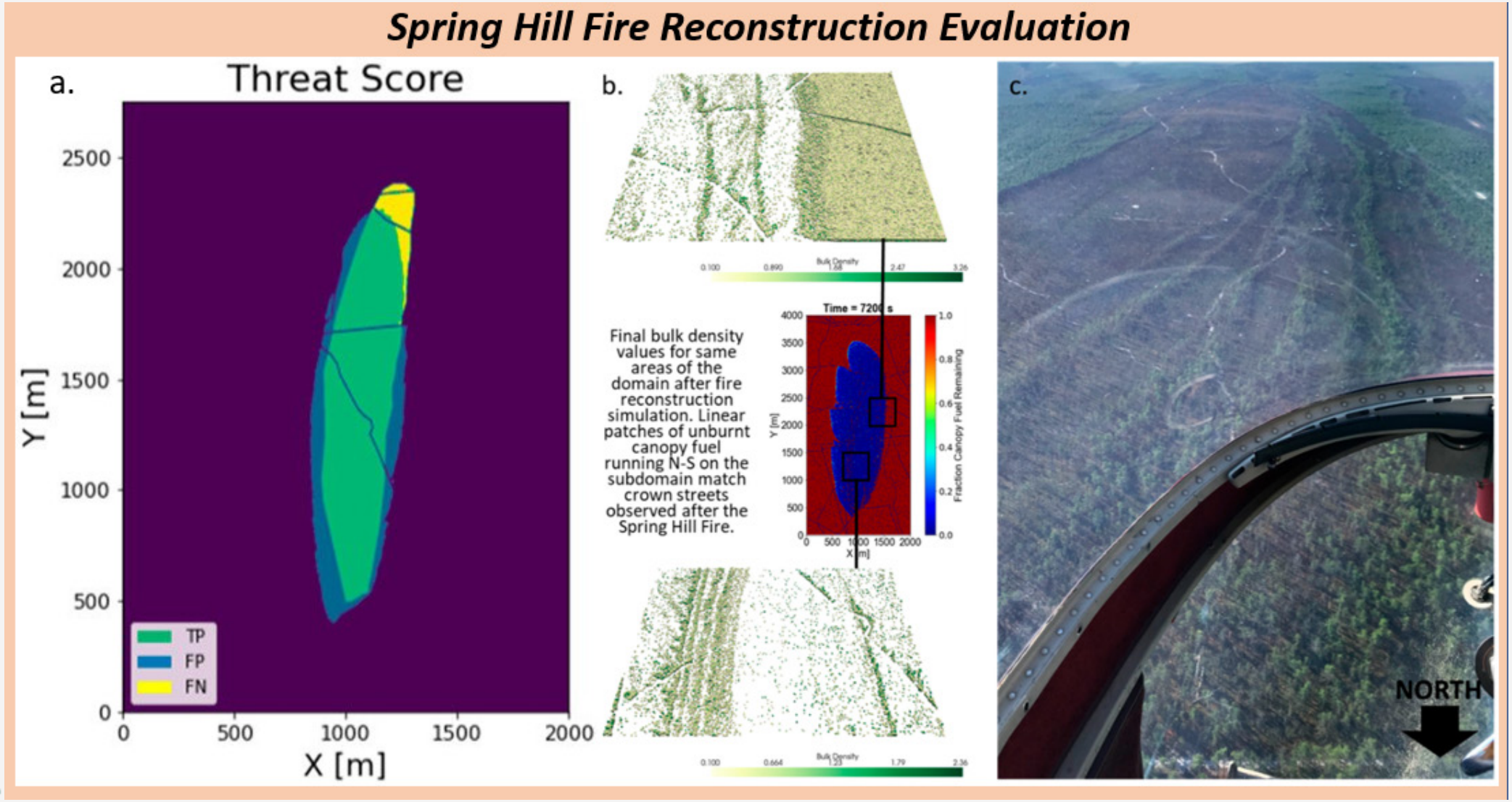
PREDICTING FIRE EFFECTS: CROWN STREETS



Gallagher et al. (2021)

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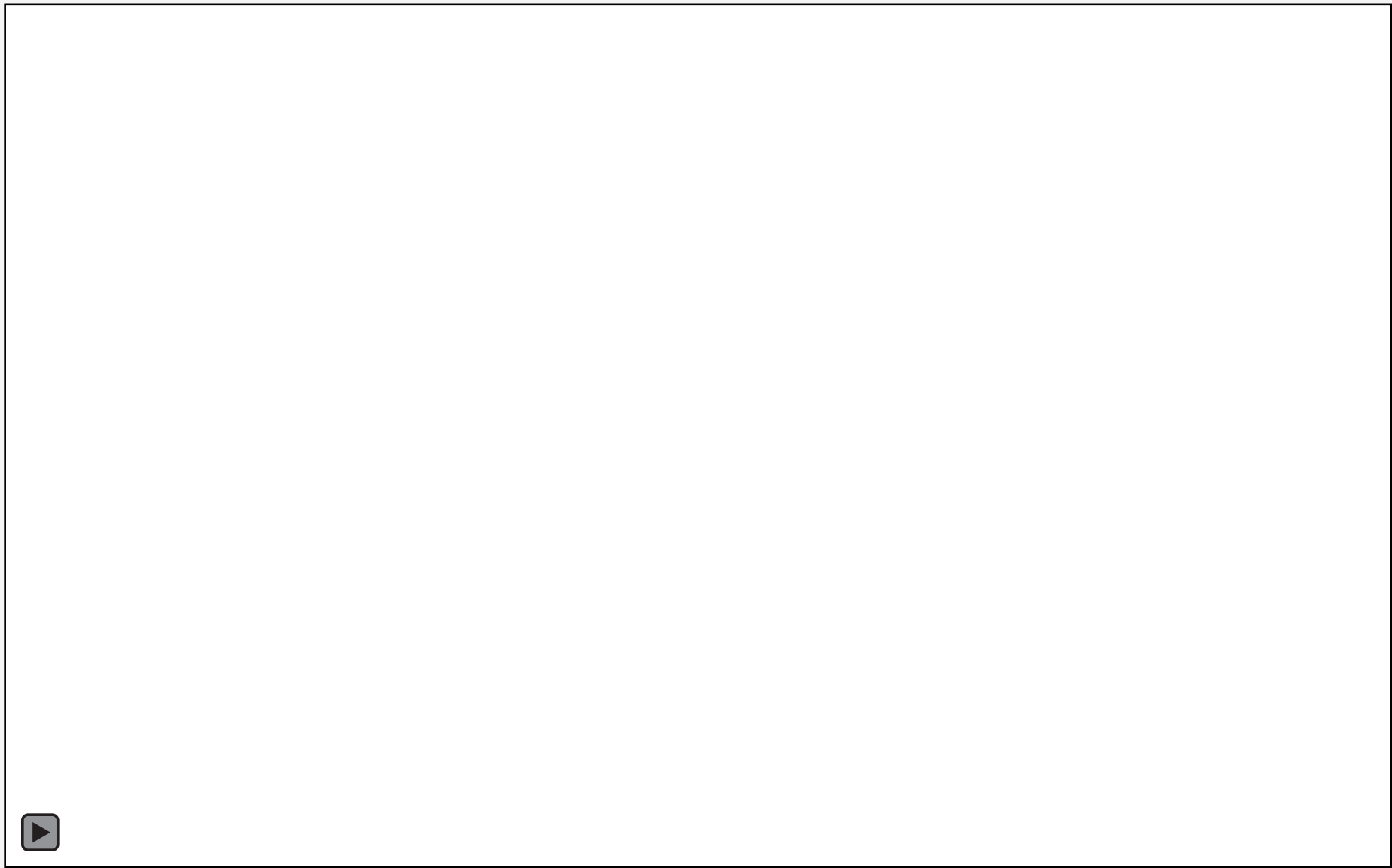
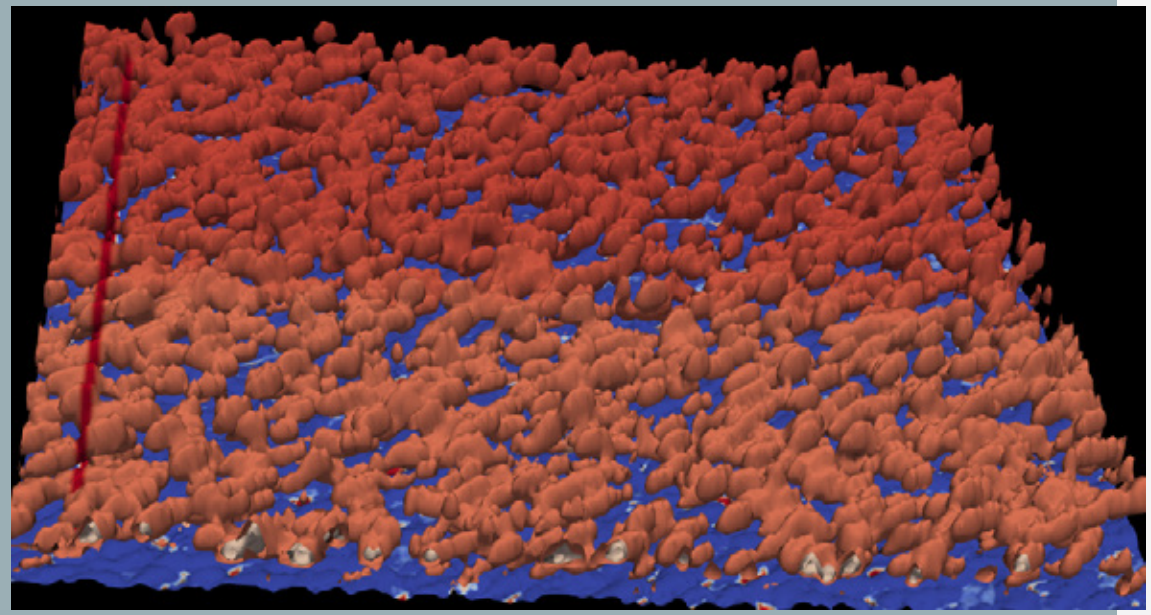
TRANSIENT & SPATIALLY HETEROGENOUS FUEL MOISTURE & TEMPERATURE

- Variation in vegetative properties governed by ecosystem processes can be linked to fire behavior

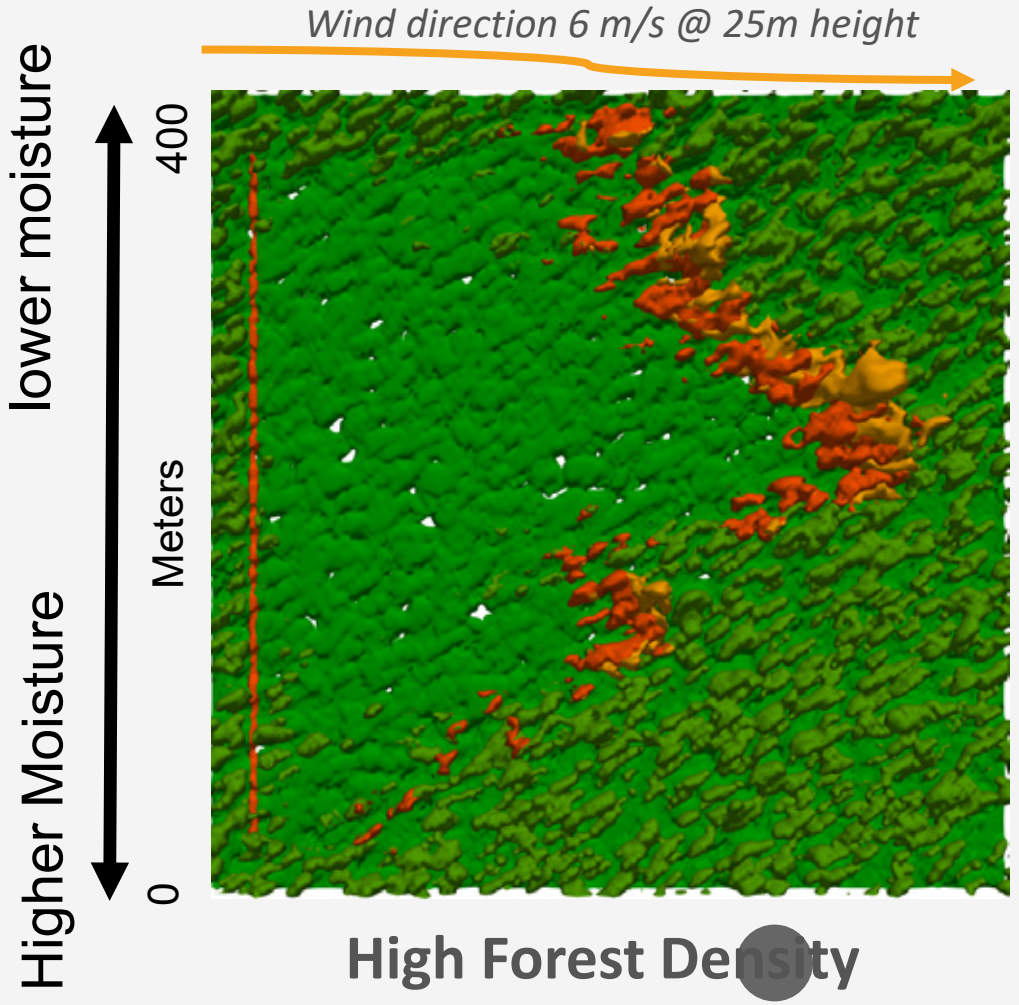
Courtesy Adam Atchley, Los Alamos National Lab



SPATIALLY HETEROGENOUS SOIL MOISTURE VEGETATIVE DRYING



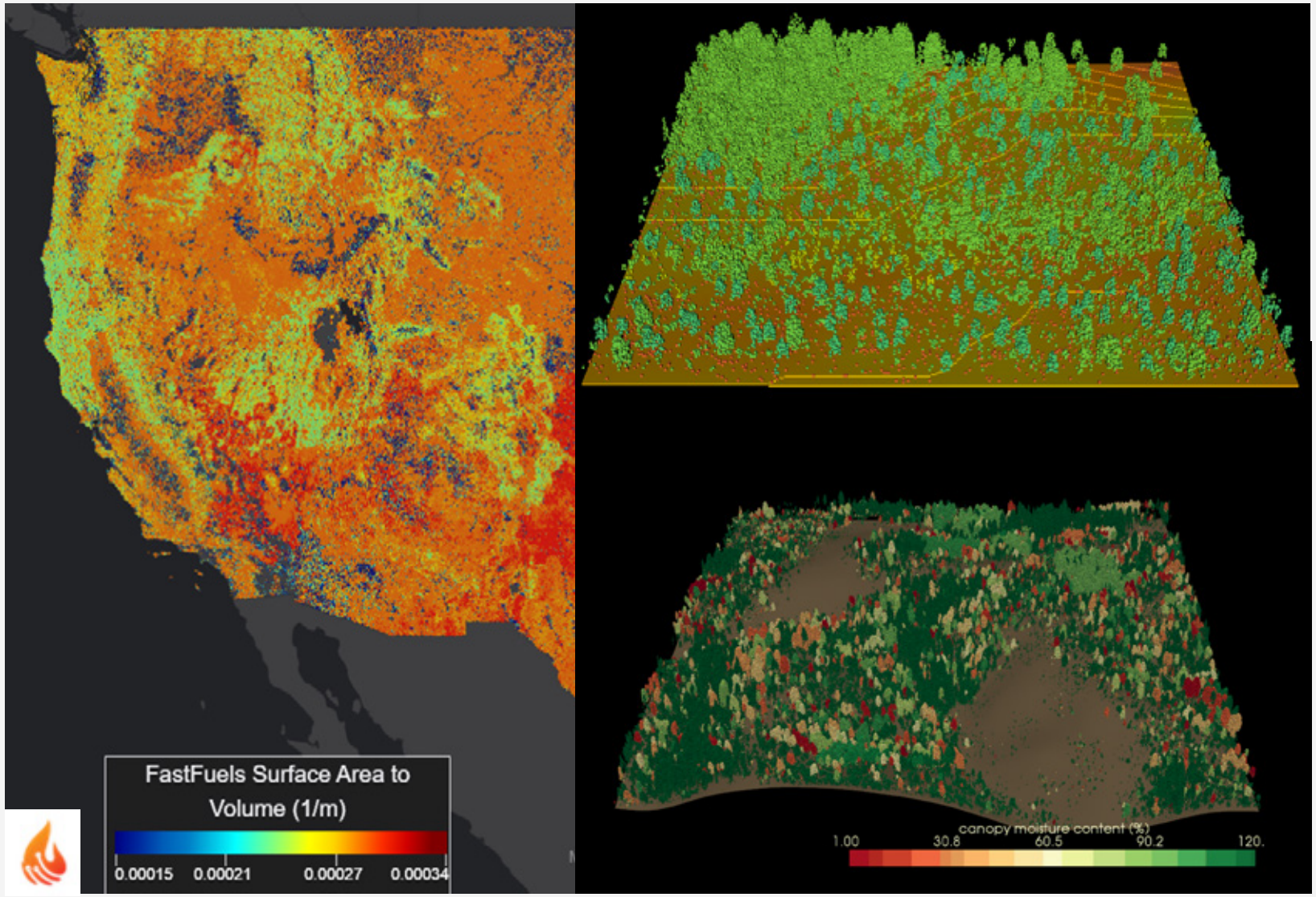
High Forest Density Fuel Moisture Loading [-]



High Forest Density

SCALING ADVANCED FIRE MODELING TOOLS TO OPERATIONS THROUGH PARTNERSHIPS AND DATA

- WIFIRE Commons/ BurnPro3d (UCSD)
- FastFuels (R. Parsons-USFS)
- AI Convergence and data fusion to increase "on ramps" to fuel inputs and refresh rates (I. Altintas-UCSD)



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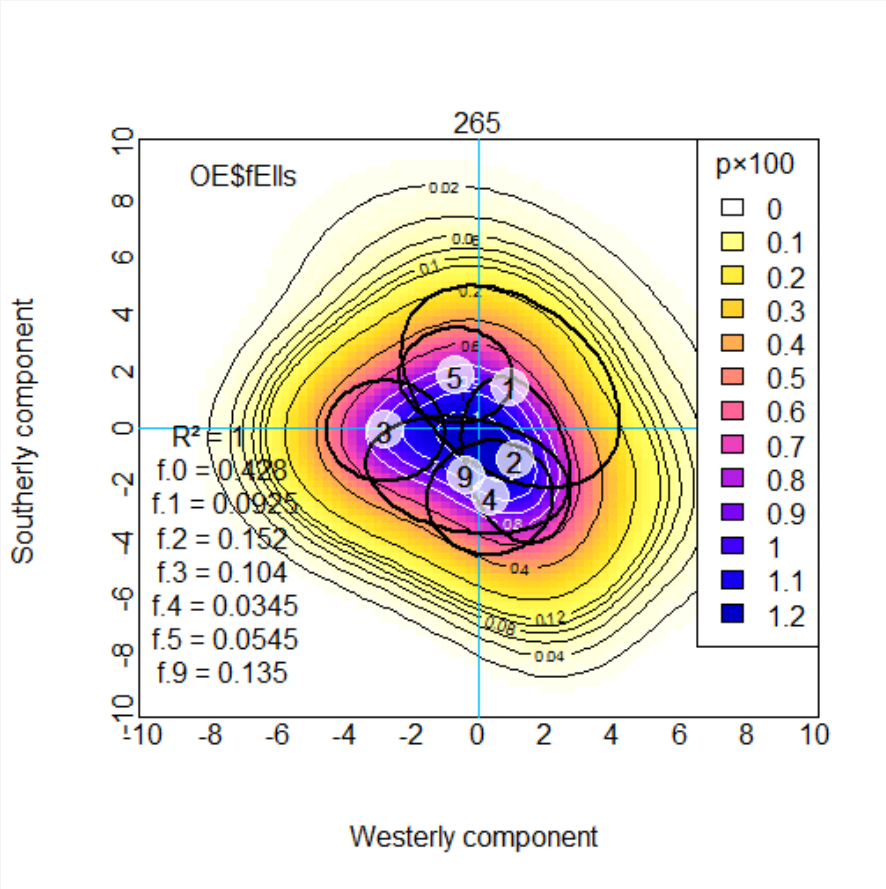
DEVELOPING WIND INPUTS TO ENABLE CFA MODEL APPLICATIONS

- High resolution winds are needed for ensembles
- Mean winds are not enough: Variability is a feature not a bug
- Initializing wind in complex terrain are critical for CFA applications
- How to incorporate wind variability for long-term planning?



SERDP RC-1298: Characterizing high resolution wind modes across months

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BARRIERS TO APPLYING ADVANCED MODELING

- Fire is a "journeyman" culture
  - Experience is currency
    - Operational modeling is often viewed with skepticism
- Historically, one model has structured operational understanding of fire
  - The Rothermel spread model has dominated investment of fire behavior funds in US
  - Users are assumed to be firefighters so multiple tools are overwhelming
- CFA models provide a chance to learn WITH the modeling community

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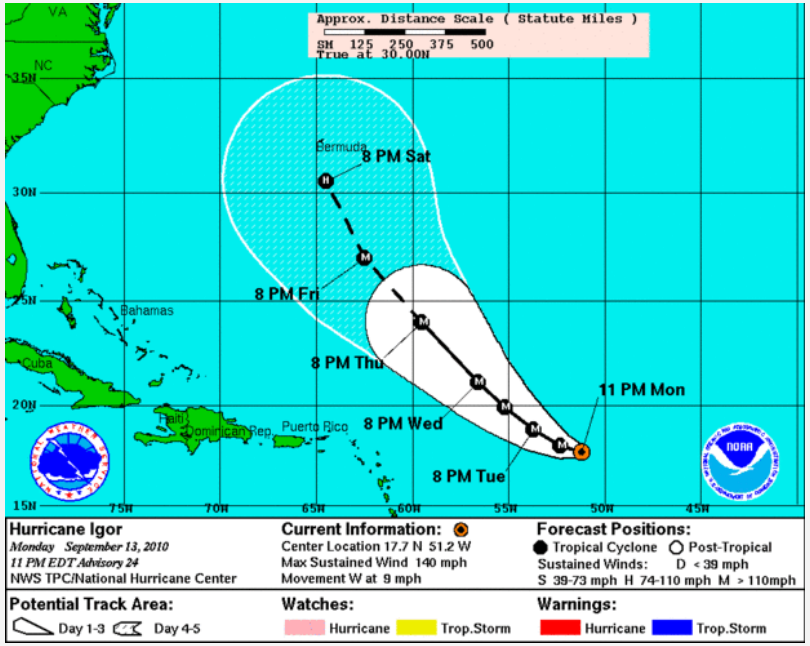
BRIDGING THE GAP WITH MANAGERS

Managers overwhelmingly agreed that CFD solutions were appropriate and met prescribed fire expectations (Furman et al., 2018)

- Centrally fund validation and curation of models
- Demonstration landscapes and collaboration with fire managers (USFS/USFWS/USGS Hubs)
- Investment in efforts to dramatically improve data inputs
- Ensembles of models help bound uncertainty (Confidence not RMSE!)
- R2E2O model of building, testing of new and emerging tools



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INTERAGENCY ADVANCED FIRE & ECOSYSTEM MODELING COLLABORATIVE

What

- Community of willing experts – modeling, analytics, data
- Extend concept of NSF-funded WiFire Commons – we are all partners

Why

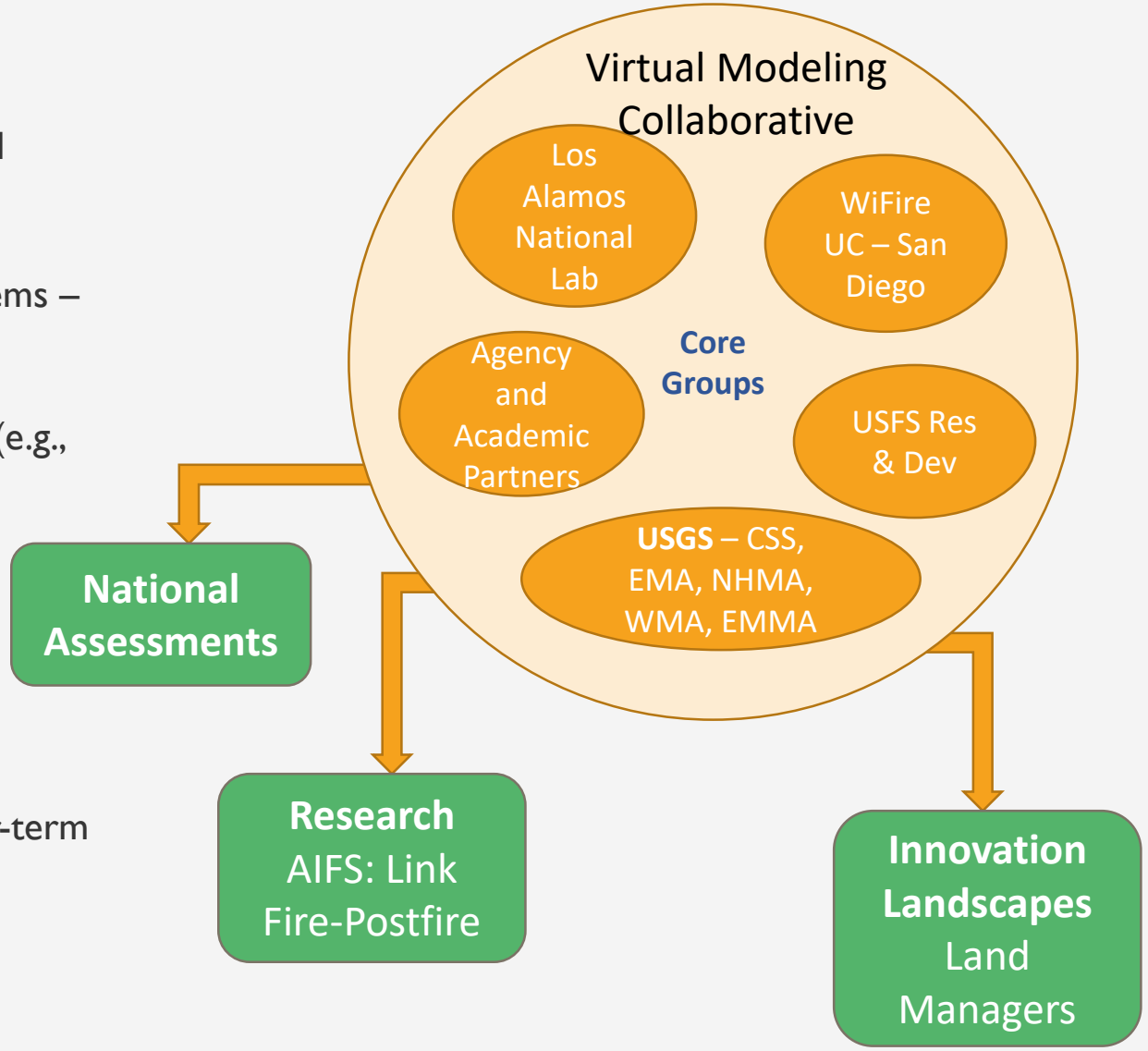
- Need to join efforts to solve science and management problems – transformational
- Complicated, quickly changing, existential need
  - Fire linked to climate, carbon, wildlife, ecosystem services (e.g., water, grazing), invasive species, vegetation growth, …

How

- Organized partnership – MOU, charter
- Some core funding, home, operational principles
- Data and models - Open source, code curation and data
- Application targets – science and management

Next Steps

- Assemble leads from core groups, identify principles and near-term operational aspects
- Establish Fire Science Enterprise Architecture



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Questions?

How to get Science-to-management: Demonstration Landscape network

- Develop a network of landscapes for applications
  - Continuous focus - Local managers/staff, post-doc, facilitation, regional experts
  - When needed – special expertise and support
- Multiple landscapes will have guiding science team, interdisciplinary
- National coordinator and access to national data and science support
- Converging local to national

Data Sets

- EROS - Landfire
- MTBS & Fire Boundaries
- Invasive Species
- Plant & Wildlife Distribution
- Ecosystem Status
- Weather
- Values – e.g., infrastructure, ecosystem services

Model & Science Support

- Fire Behavior & Risk
- Invasive Spp Spread
- Climate Change
- Post-fire Risks
- Fire Ecology
- Wildlife Habitat
- Water Flow & Quality

Landscape Team

- Land Manger(s) – Treatments, Values/outcomes, Plans
- Post-Doc & Scientists – Modeling & Analysis, Data, Monitoring
- Facilitator/Planner

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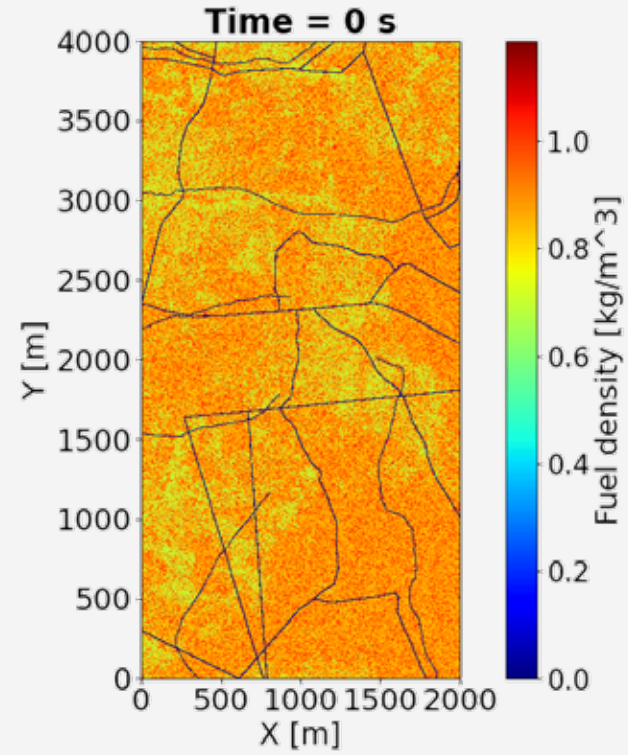
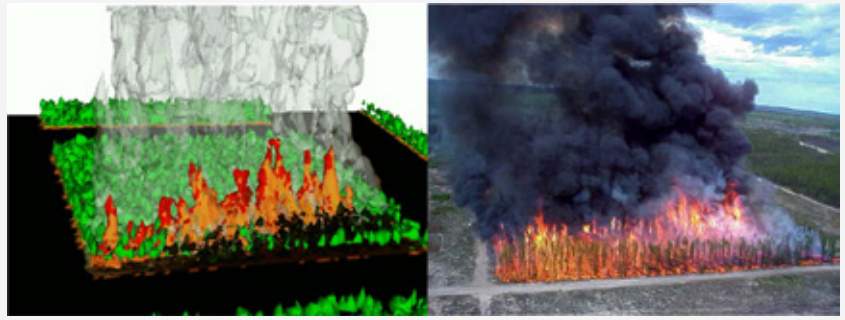
BEYOND RATES OF SPREAD

- Fireline interactions with the atmosphere produce predictable phenomena.
- Cheney plots (Cheney et al. 1993, 1998)
  - Long line-short line ignitions and forward spread rates differ
  - Laid critical foundation for validation approach to CFD and CFA models
- Managers overwhelmingly agreed that CFD solutions were realistic (Furman et al. 2018).
- Building on this phenomenological approach: a series of critical canonical phenomena driven by CFA dynamics as test.
- Specify inputs and document ensemble performance against CFD tools.

EMPIRICAL DATA IS USEFUL BUT FLAWED FOR CFA VALIDATION



- Existing fires commonly used for validation/ demonstration:
  - ICFE
  - Fireflux
  - RxCADRE
  - Cheney Plots
  - Springhill Wildfire (NJ)
- Specify initializing inputs for fuels, wind, and ignition to reduce uncertainty
- Deviation in model performance is actually important (i.e., we don't want all models to give the same answer all the time) to improving models over time and understanding what model limitations may exist



Short Line-Long Line

- Length of the head fire changes the spread rate
- Kinetic energy of cross flow is the mechanism for slower spread rates of shorter fire lines