Toward fuels monitoring at the push of a button - Automated laser scanning for plot-level fuel loading and fire effects

NRS Rooted in Research
2/3/21

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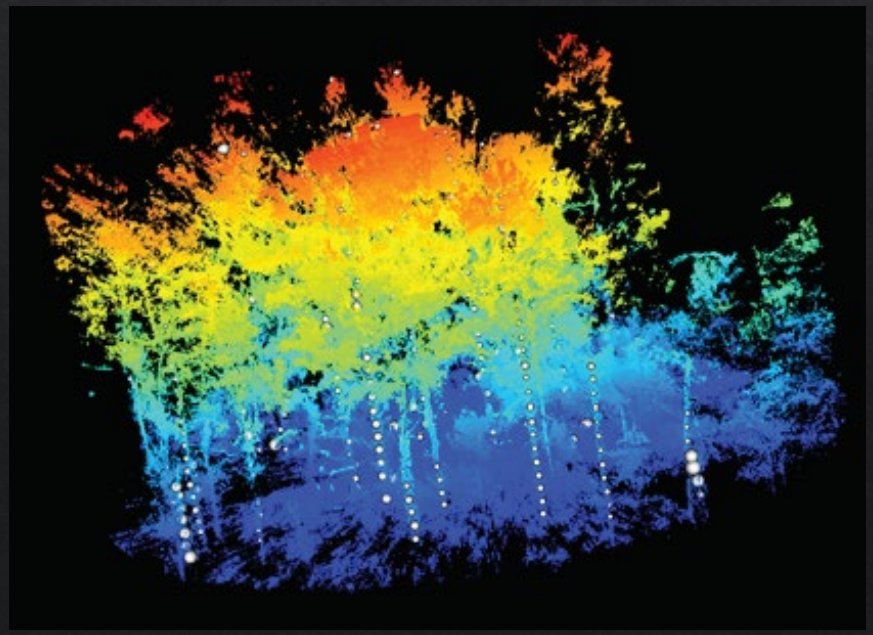

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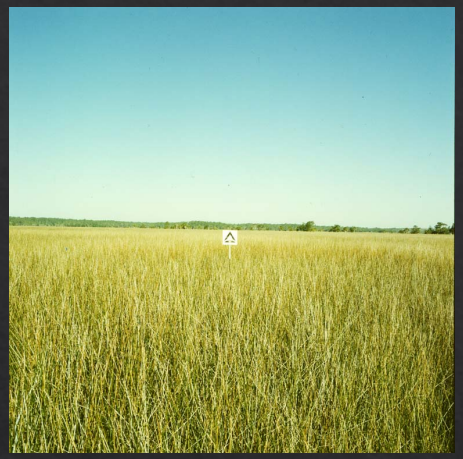
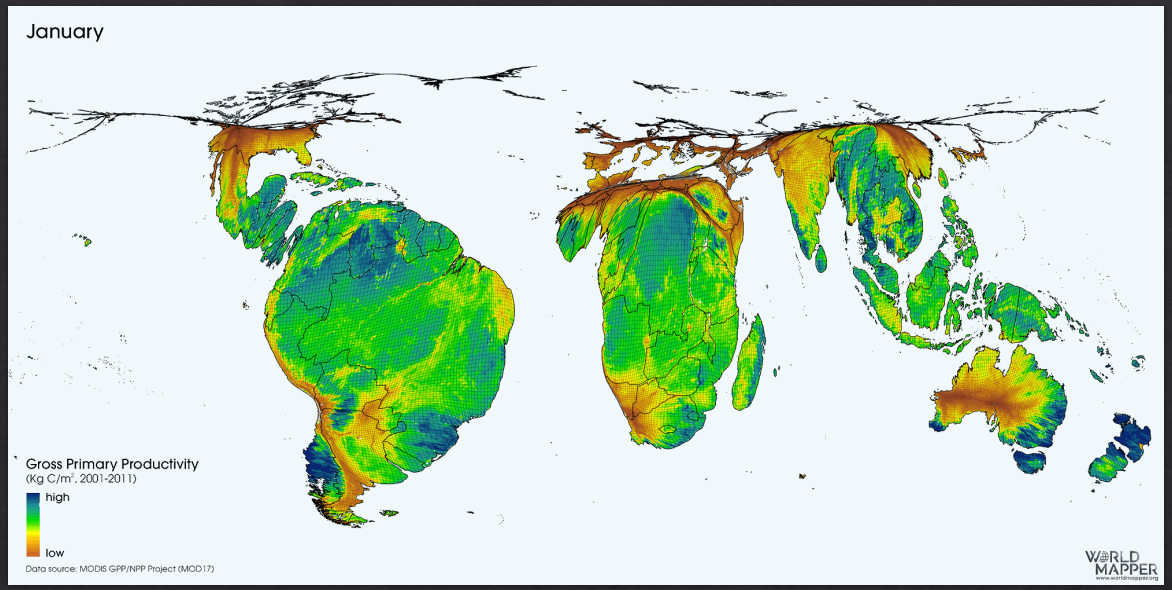
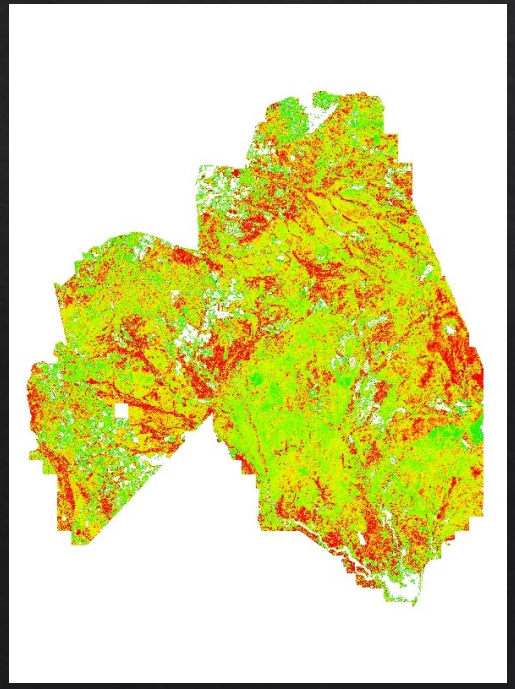
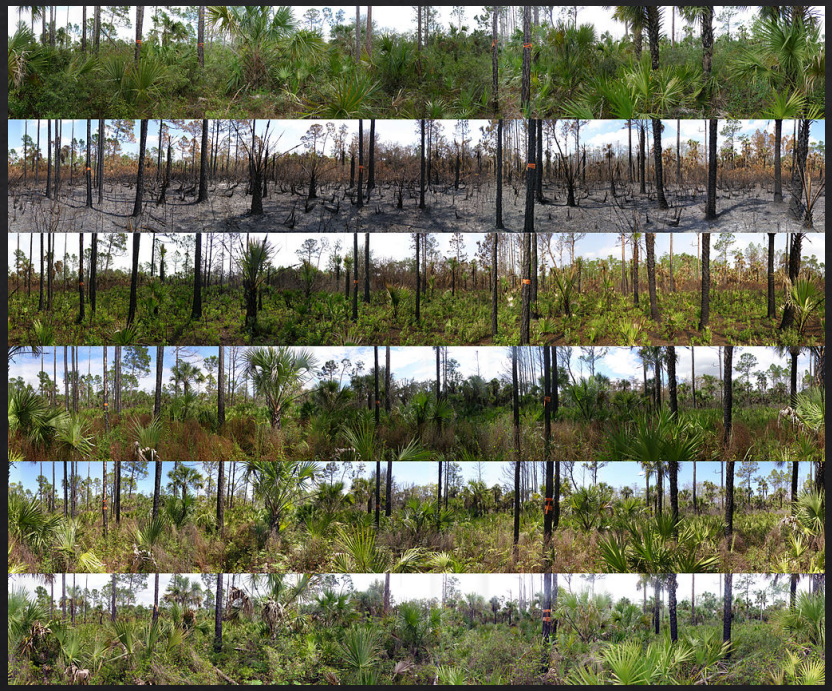


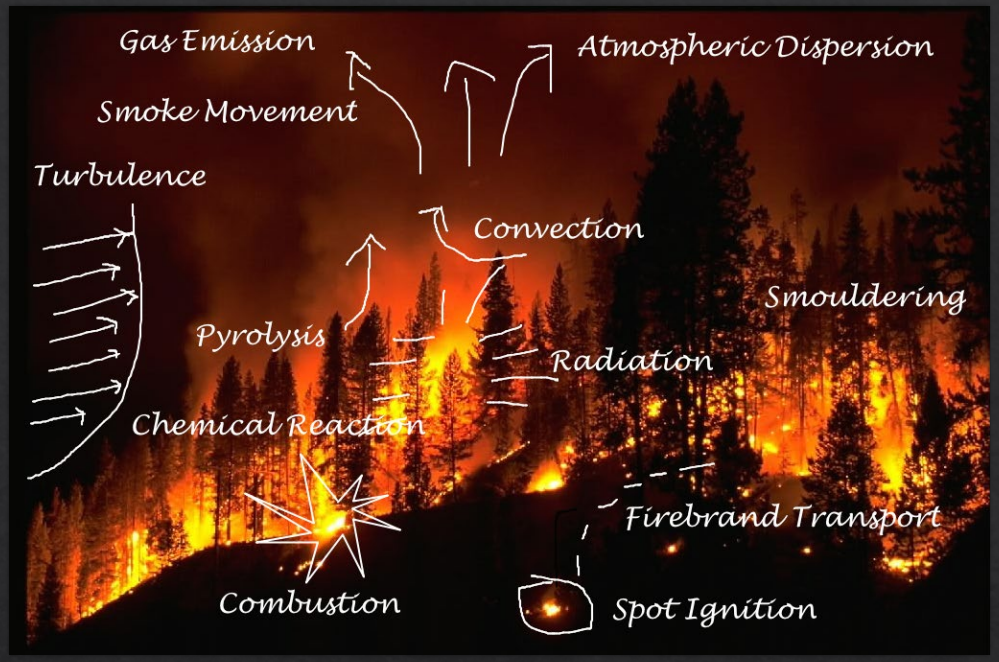
Stratum		Category
Canopy		Trees, snags, ladder fuels
Shrubs		Primary and secondary layers
Nonwoody vegetation		Primary and secondary layers
Woody fuels		Sound wood, rotten wood, stumps, and woody fuel accumulations
Litter-lichen-moss		Litter, lichen, and moss layers
Ground fuels		Duff, basal accumulations, and squirrel middens

Figure 1: FCCS fuelbed strata used in describing the characteristics of fuels, including fuel structure and loading.

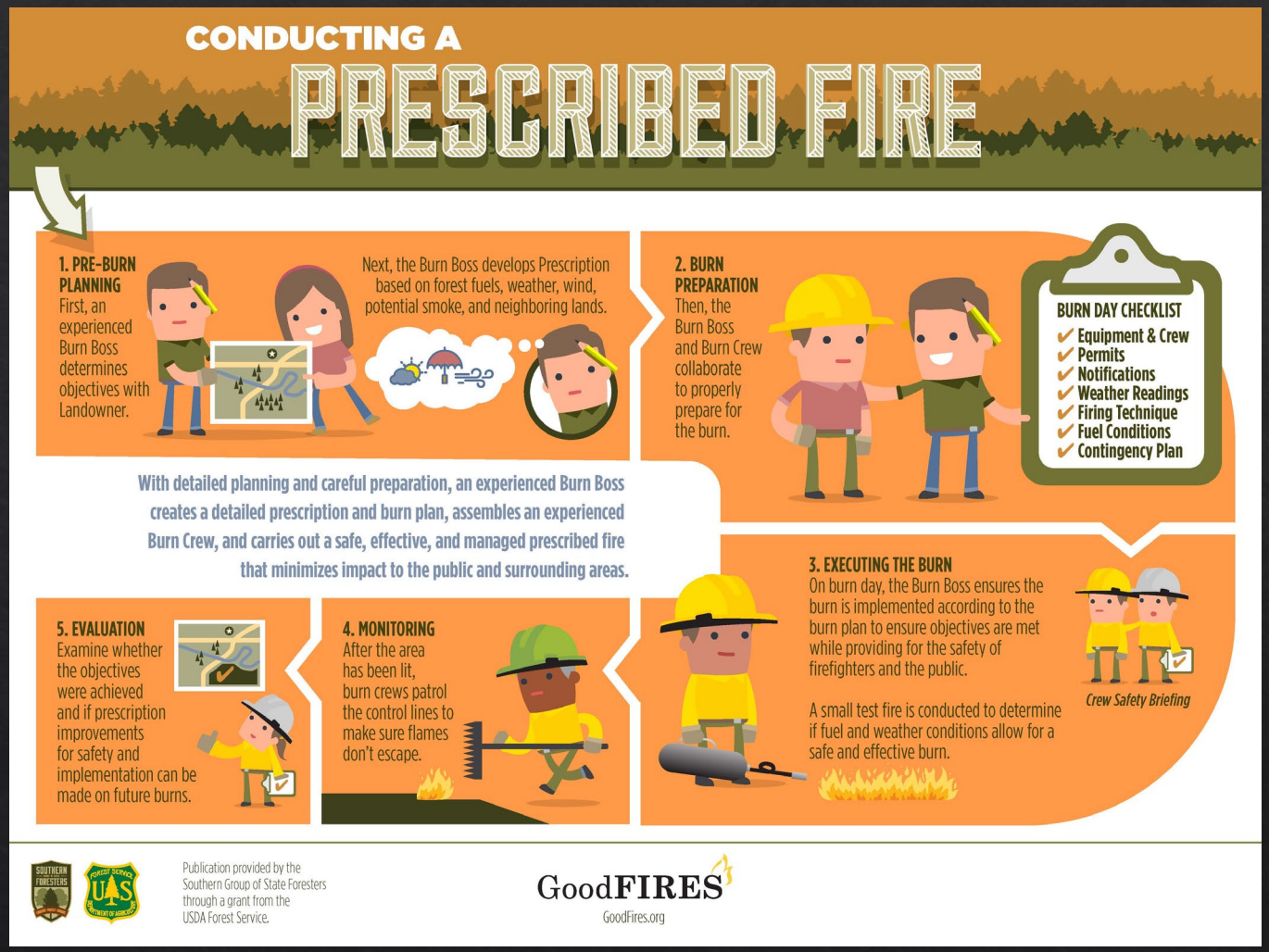

January
Gross Primary Productivity
(Kg C/m², 2001-2011)
high
low
Data source: MODIS GPP/NPP Project (MOD17)
WORLD MAPPER
www.worldmapper.org

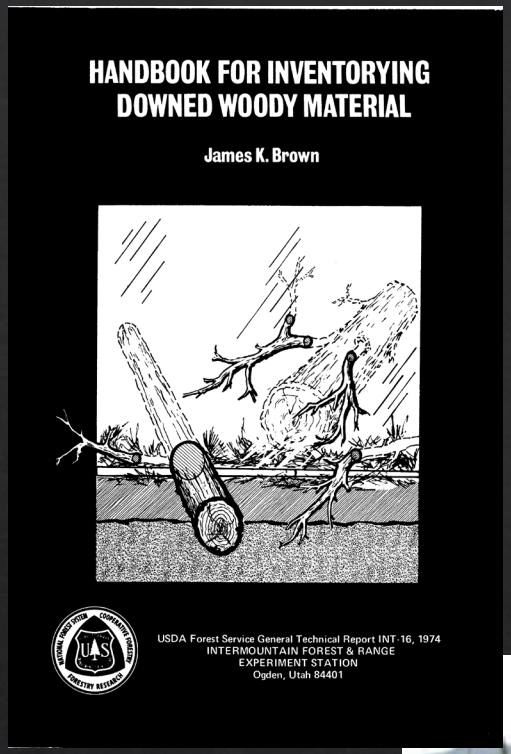





Gas Emission
Atmospheric Dispersion
Smoke Movement
Turbulence
Convection
Smouldering
Pyrolysis
Radiation
Chemical Reaction
Firebrand Transport
Combustion
Spot Ignition

Why monitor fuels?





Monitoring techniques

Ground fire
Canopy fire

Field data:

Composite burn index (CBI)

A. Substrates

B. Herbs

C. Tall shrubs

D. Intermediate trees

E. Big trees

FIREMON LA Form

BURN SEVERITY -- COMPOSITE BURN INDEX (BI)

PD - Abridged	Examiners:		Fire Name:		
Registration Code		Project Code		Plot Number	
Field Date mmddyyyy	/ /	Fire Date mmyyyy	/		
Plot Aspect		Plot % Slope		UTM Zone	
Plot Diameter Overstory		UTM E plot center		GPS Datum	
Plot Diameter Understory		UTM N plot center		GPS Error (m)	
Number of Plot Photos		Plot Photo IDs			

BI – Long Form	% Burned 100 feet (30 m) diameter from center of plot =							Fuel Photo Series =	
STRATA RATING FACTORS	BURN SEVERITY SCALE								FACTOR SCORES
	No Effect	Low		Moderate		High			
	0.0	0.5	1.0	1.5	2.0	2.5	3.0		
A. SUBSTRATES									
% Pre-Fire Cover: Litter =	Duff =		Soil/Rock =	Pre-Fire Depth (inches): Litter =		Duff =	Fuel Bed =		∑ =
Litter/Light Fuel Consumed	Unchanged	--	50% litter	--	100% litter	>80% light fuel	98% Light Fuel		
Duff	Unchanged	--	Light char	--	50% loss deep char	--	Consumed		N =
Medium Fuel, 3-8 in.	Unchanged	--	20% consumed	--	40% consumed	--	>60% loss, deep ch		
Heavy Fuel, > 8 in.	Unchanged	--	10% loss	--	25% loss, deep char	--	>40% loss, deep ch		$\bar{X}$ =
Soil & Rock Cover/Color	Unchanged	--	10% change	--	40% change	--	>80% change		
B. HERBS, LOW SHRUBS AND TREES LESS THAN 3 FEET (1 METER):									
Pre-Fire Cover =	% Enhanced Growth =								∑ =
% Foliage Altered (blk-brn)	Unchanged	--	30%	--	80%	95%	100% + branch loss		
Frequency % Living	100%	--	90%	--	50%	< 20%	None		N =
Colonizers	Unchanged	--	Low	--	Moderate	High-Low	Low to None		
Spp. Comp. - Rel. Abund.	Unchanged	--	Little change	--	Moderate change	--	High change		$\bar{X}$ =
C. TALL SHRUBS AND TREES 3 to 16 FEET (1 TO 5 METERS):									
Pre-Fire Cover =	% Enhanced Growth =								∑ =
% Foliage Altered (blk-brn)	0%	--	20%	--	60-90%	> 95%	Signifcnt branch loss		
Frequency % Living	100%	--	90%	--	30%	< 15%	< 1%		N =
% Change in Cover	Unchanged	--	15%	--	70%	90%	100%		
Spp. Comp. - Rel. Abund.	Unchanged	--	Little change	--	Moderate change	--	High Change		$\bar{X}$ =
D. INTERMEDIATE TREES (SUBCANOPY, POLE-SIZED TREES)									

A. SUBSTRATES

% Pre-Fire Cover: Litter =	Duff =		Soil/Rock =	Pre-Fire Depth (inches): Litter =		Duff =	Fuel Bed =		∑ =
Litter/Light Fuel Consumed	Unchanged	--	50% litter	--	100% litter	>80% light fuel	98% Light Fuel		
Duff	Unchanged	--	Light char	--	50% loss deep char	--	Consumed		N =
Medium Fuel, 3-8 in.	Unchanged	--	20% consumed	--	40% consumed	--	>60% loss, deep ch		
Heavy Fuel, > 8 in.	Unchanged	--	10% loss	--	25% loss, deep char	--	>40% loss, deep ch		$\bar{X}$ =
Soil & Rock Cover/Color	Unchanged	--	10% change	--	40% change	--	>80% change		

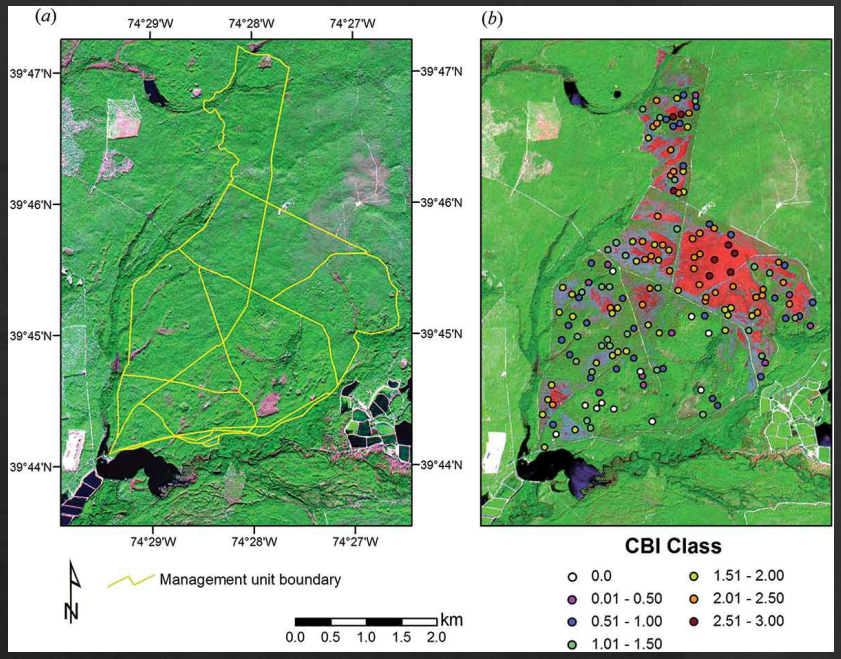
Post Fire: %Girdled = %Felled = % Tree Mortality =

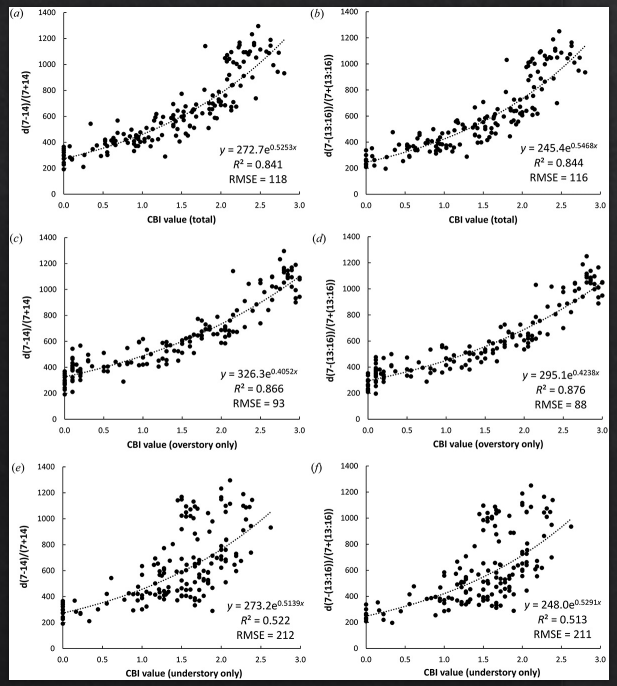
Community Notes/Comments:	CBI = Sum of Scores / N Rated:	Sum of Scores	N Rated	CBI
	Understory (A+B+C)			
	Overstory (D+E)			
	Total Plot (A+B+C+D+E)			

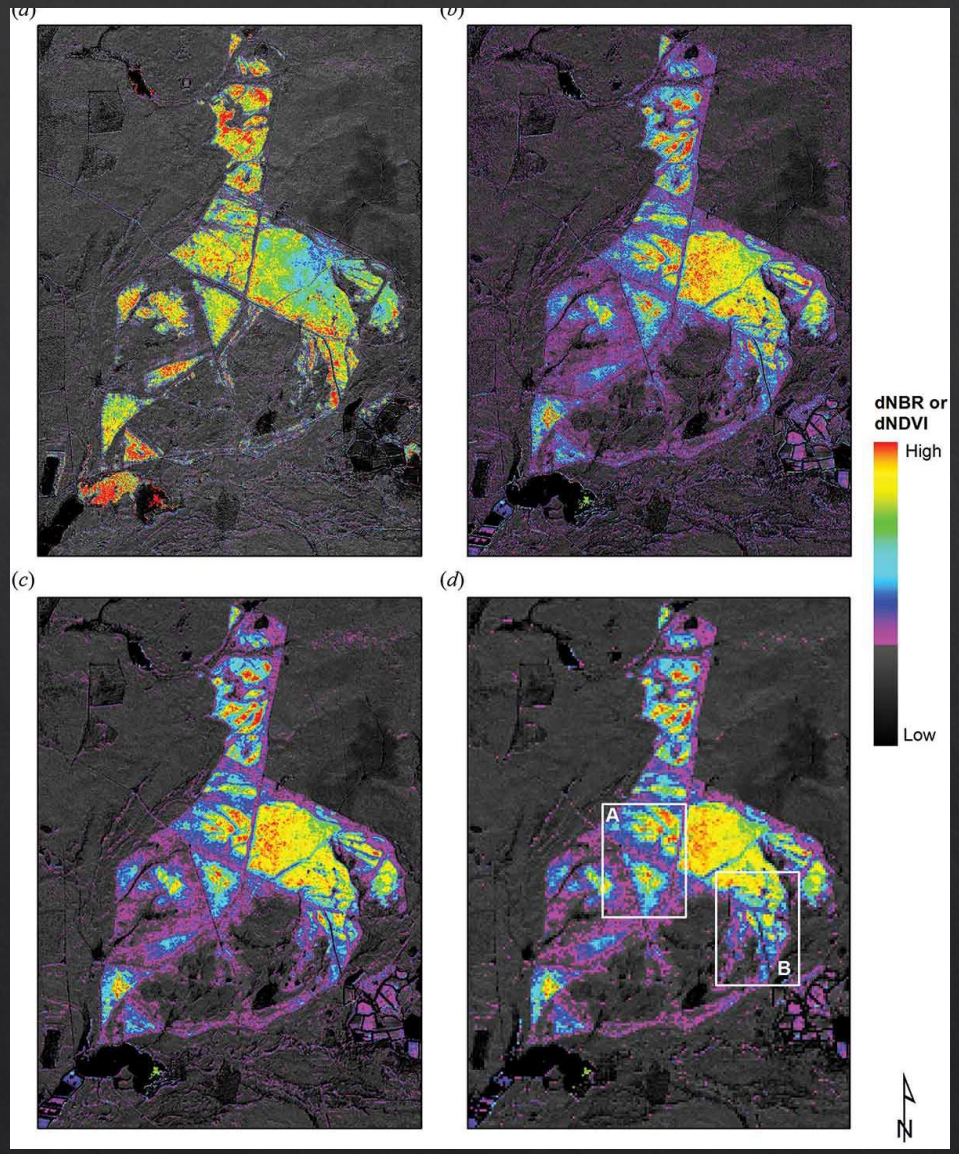
Key, C. H., & Benson, N. C. (2006). Landscape assessment (LA).*FIREMON: Fire effects monitoring and inventory system. Gen. Tech. Rep. RMRS-GTR-164-CD, Fort Collins, CO: US Department of Agriculture, Forest Service, Rocky Mountain Research Station.*

Effects Class:
NO EFFECT

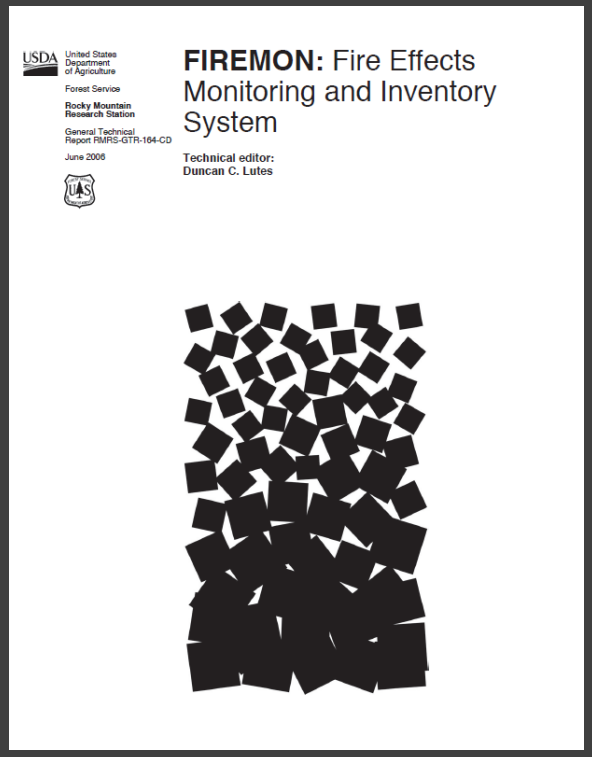
Burn Severity
Score: 0.1



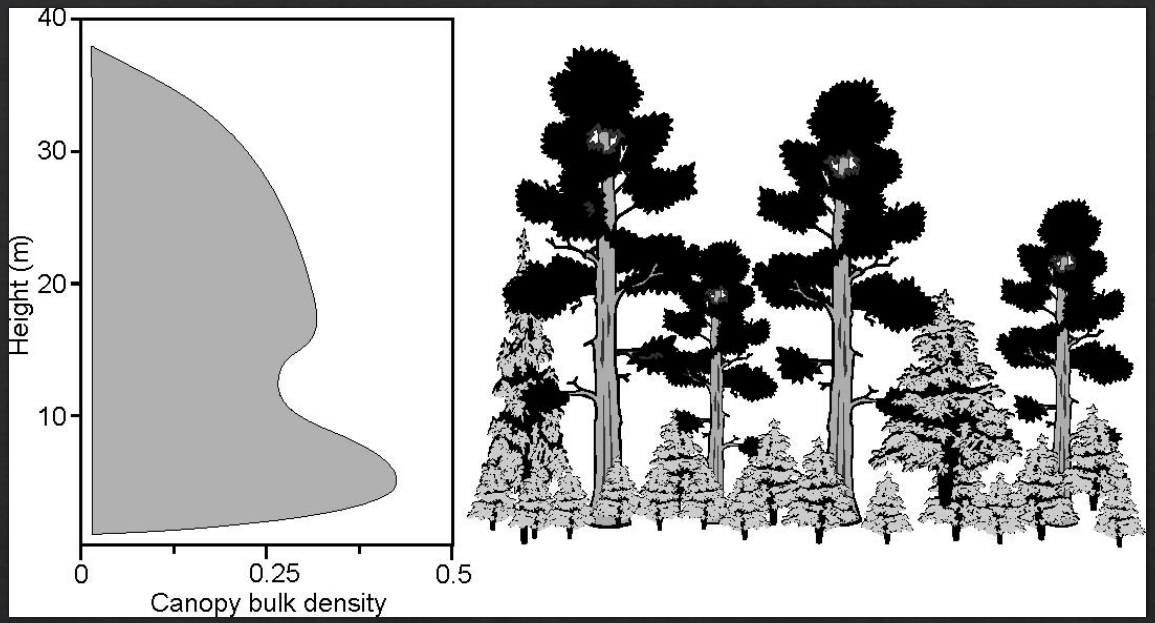


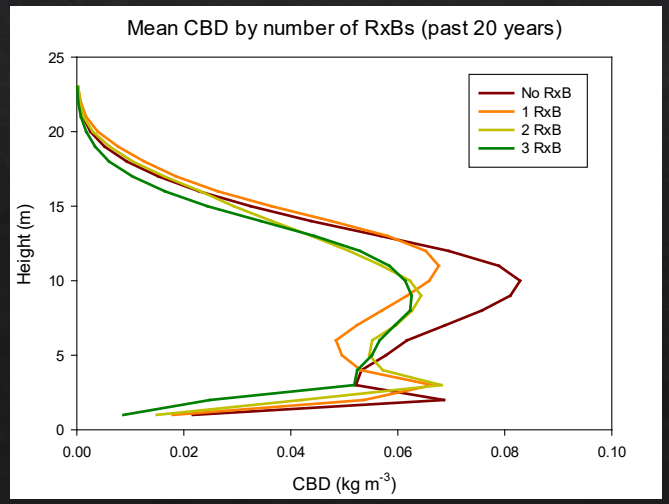


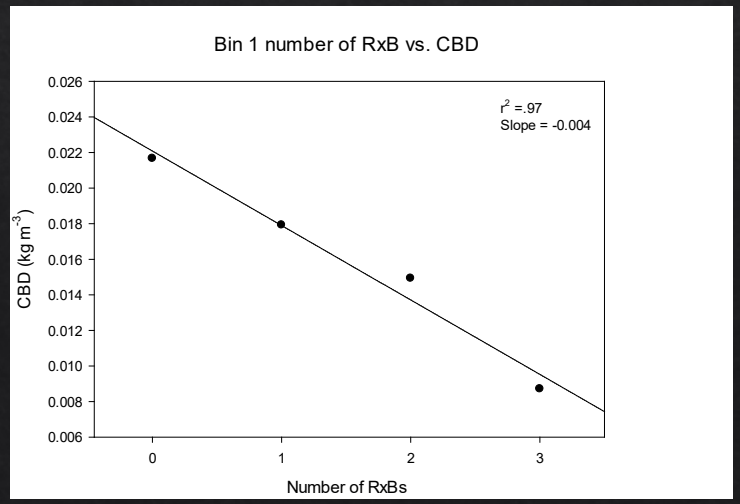
Timothy A. Warner, Nicholas S. Skowronski & Michael R. Gallagher (2017) High spatial resolution burn severity mapping of the New Jersey Pine Barrens with WorldView-3 near-infrared and shortwave infrared imagery, International Journal of Remote Sensing, 38:2, 598-616, DOI: 10.1080/01431161.2016.1268739



Monitoring protocols


Height (m)
40
30
20
10
0
0.25
0.5
Canopy bulk density

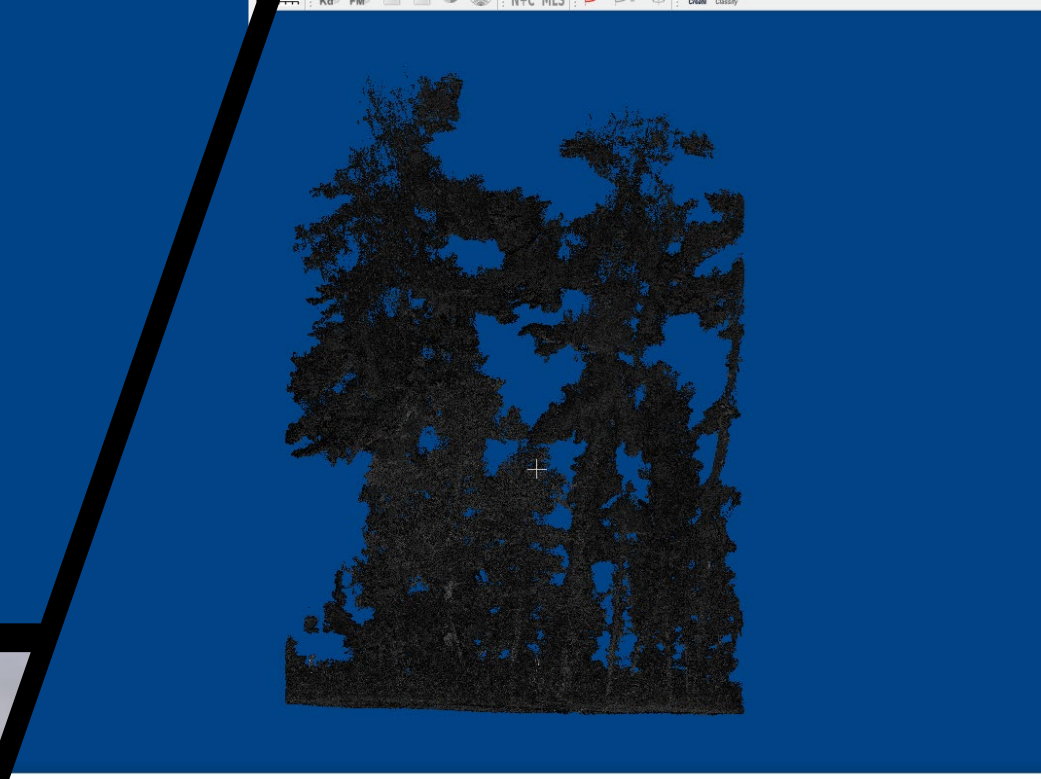

Mean CBD by number of RxBs (past 20 years)
No RxB
1 RxB
2 RxB
3 RxB
Height (m)
25
20
15
10
5
0
0.00
0.02
0.04
0.06
0.08
0.10
CBD (kg m-3)


Bin 1 number of RxB vs. CBD
r2 =.97
Slope = -0.004
CBD (kg m-3)
0.026
0.024
0.022
0.020
0.018
0.016
0.014
0.012
0.010
0.008
0.006
0
1
2
3
Number of RxBs

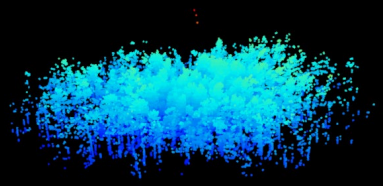
Guiding concepts for a new method

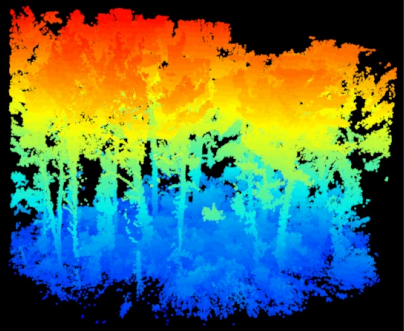
- Captures 3-D structure.
- Metrics that are consistent across fuel-types.
- Repeatable and able to measure pre- and post-fire effects
- Simple to lay-out and operate
- Scalable across landscapes
- Automated metric processing

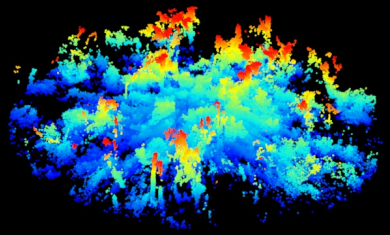
default line width

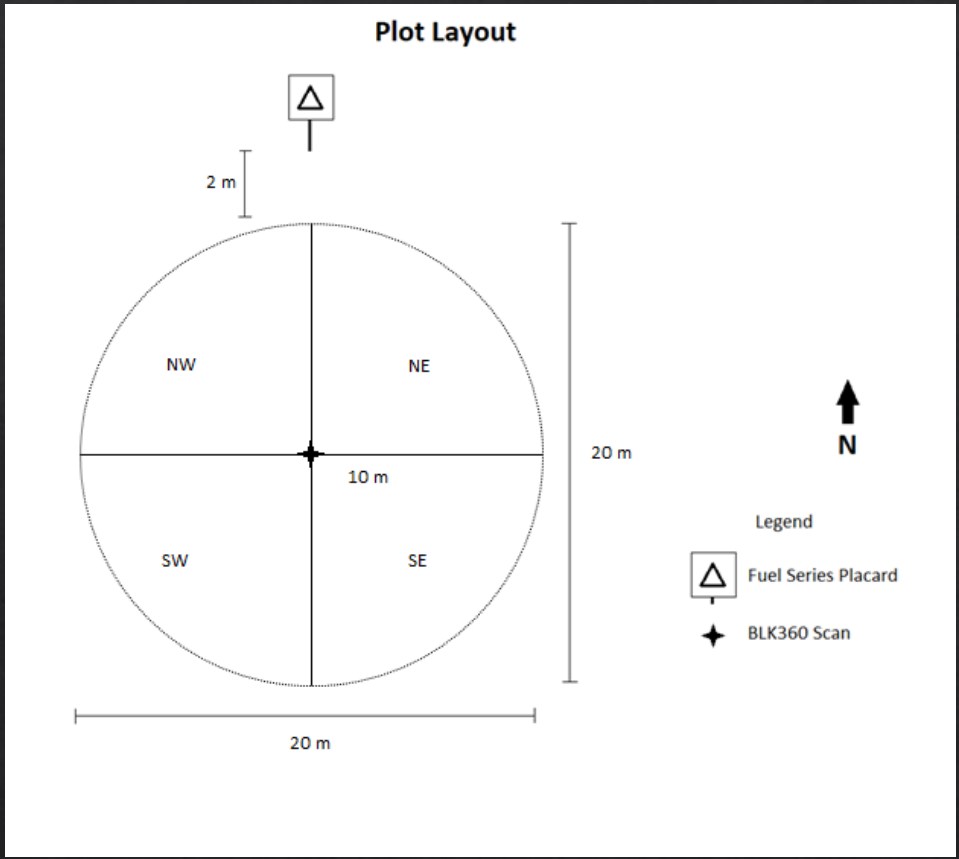


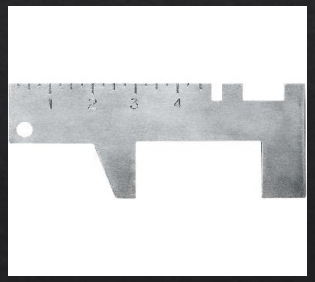
Leica



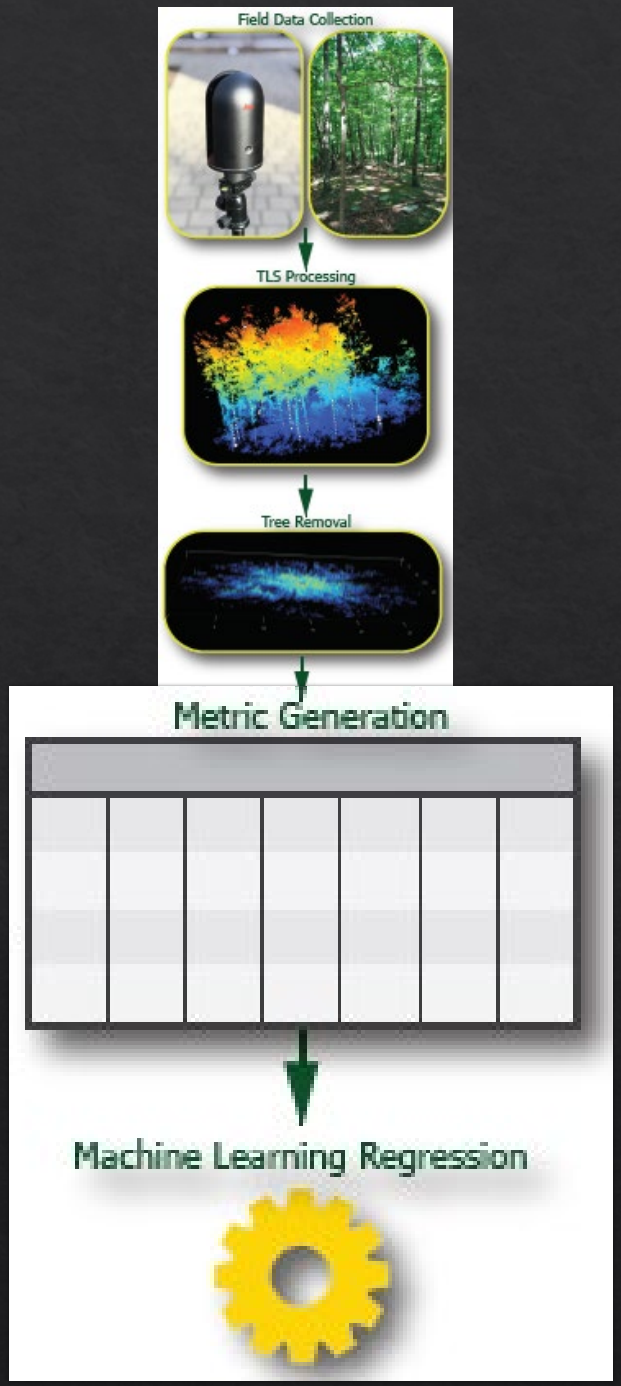


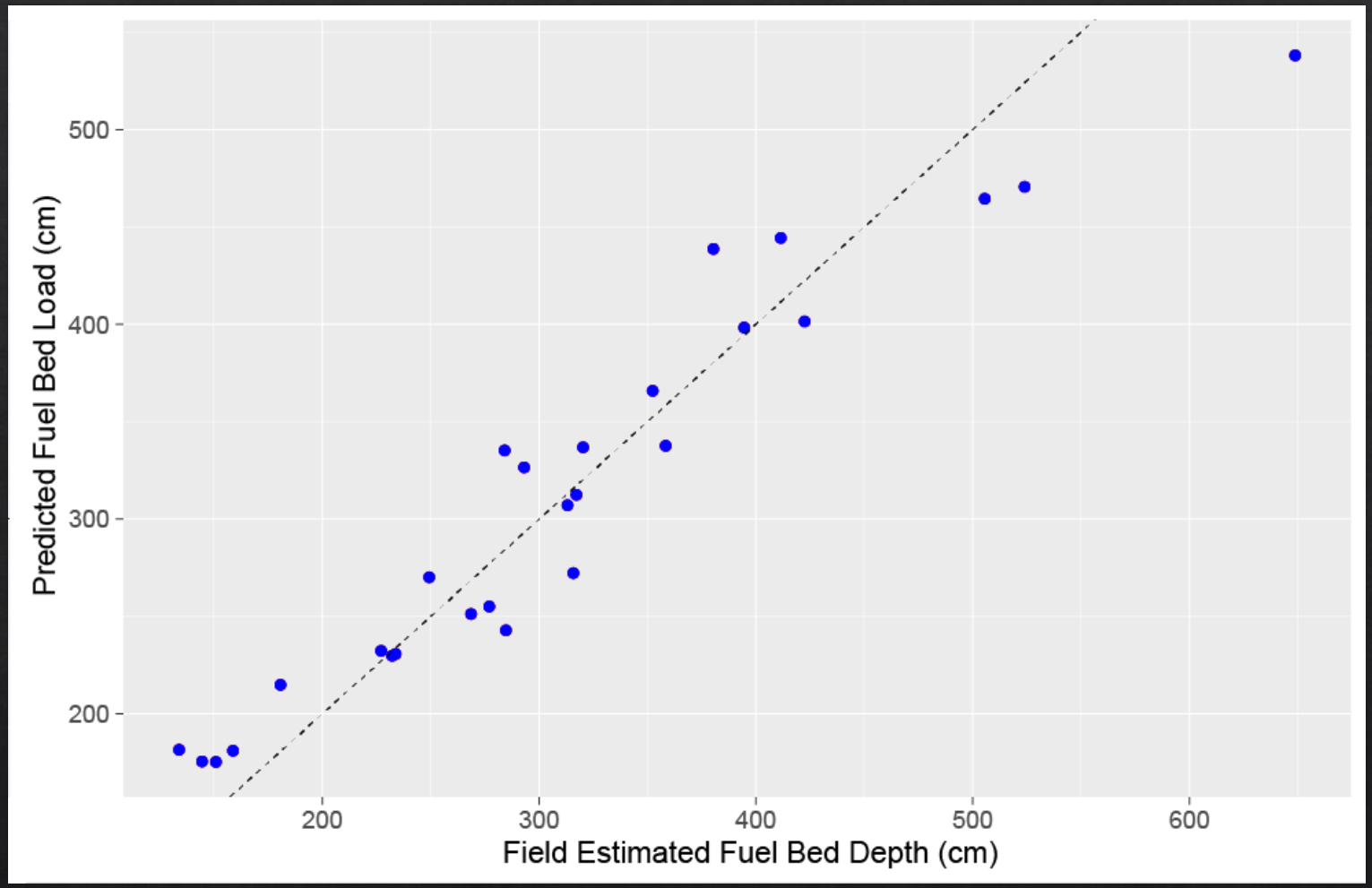






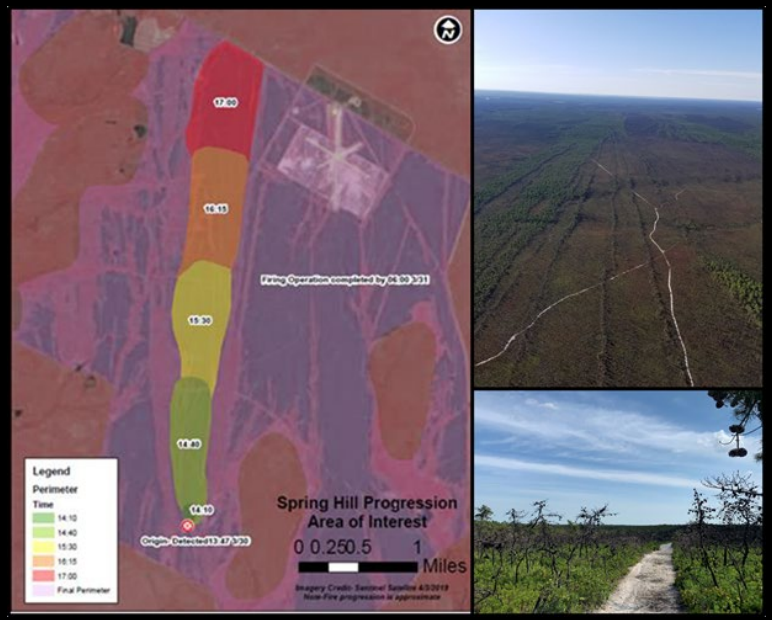
Coarse Woody		TOTAL
1 hr Fuel (0.1”- 0.25”)		
10 hr Fuel (0.25”- 1”)		
100 hr fuel (1”- 3”)		
1000 hr fuel (>3”)		
PINE CONES		

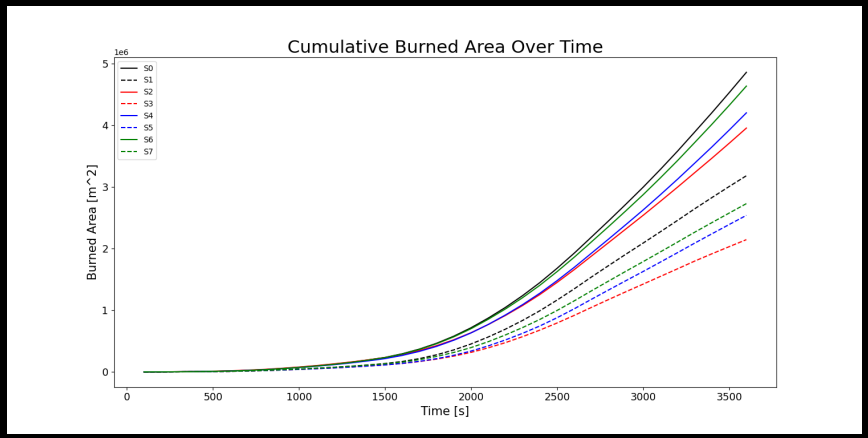

Field Data Collection
TLS Processing
Tree Removal
Metric Generation
Machine Learning Regression

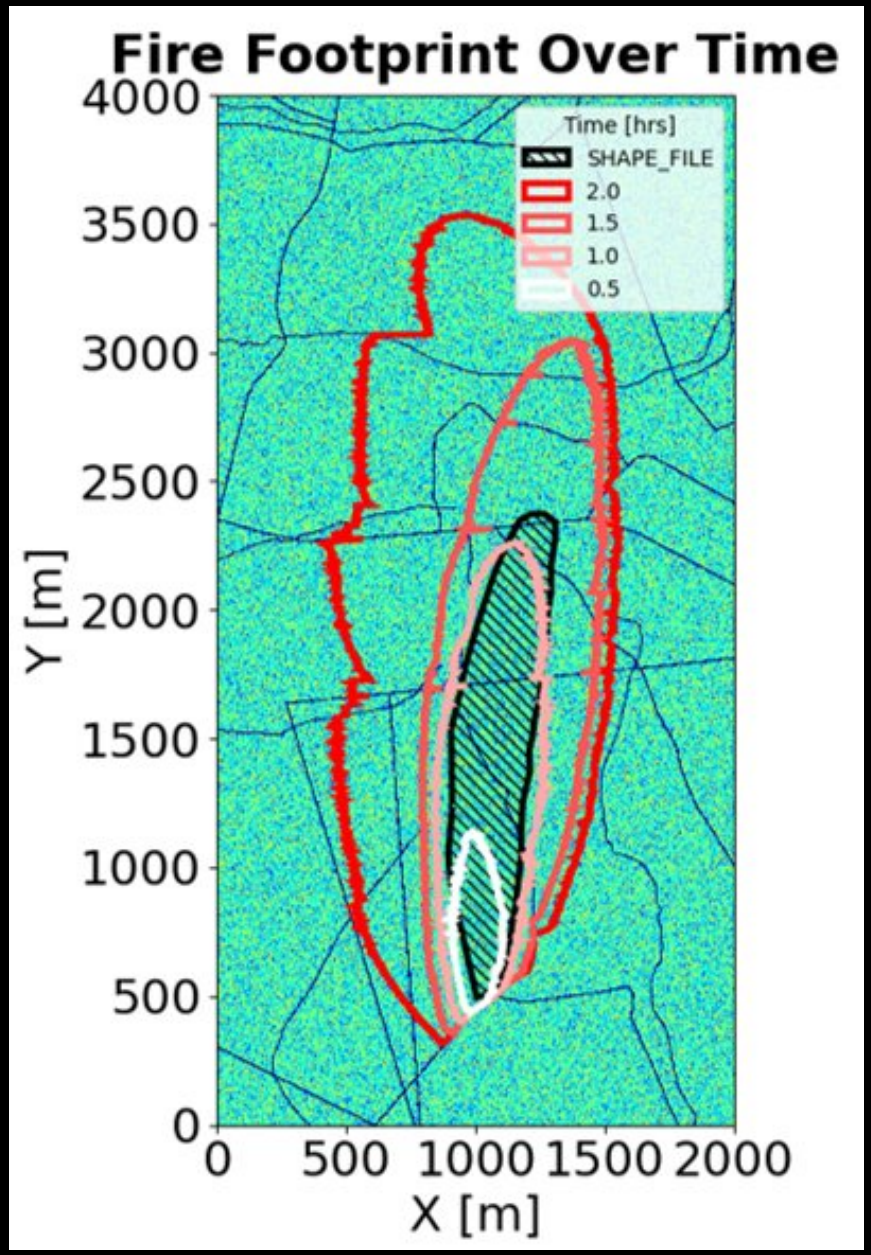

Predicted Fuel Bed Load (cm)
500
400
300
200
200
300
400
500
600
Field Estimated Fuel Bed Depth (cm)

Benefits

- Measurements of 3-D canopy structure which can be used for a variety of applications
- Easily repeatable, allowing for measurements of trajectories through time.
- Eliminates data collection bias.
- Simple, one-button operation.
- Spatially explicit training data for remote sensing platforms.
- Provides input data for next-generation fire models.


17:00
16:15
15:30
14:40
14:10
Legend
Perimeter
Time
14:10
14:40
15:30
16:15
17:00
Final Perimeter
Spring Hill Progression
Area of Interest
0 0.25 0.5 1
Miles


Cumulative Burned Area Over Time
1e6
S0
S1
S2
S3
S4
S5
S6
S7
Burned Area [m^2]
Time [s]
0
500
1000
1500
2000
2500
3000
3500


Fire Footprint Over Time
Time [hrs]
SHAPE_FILE
2.0
1.5
1.0
0.5
Y [m]
X [m]
0
500
1000
1500
2000
2500
3000
3500
4000

Next steps

Refine	Refine estimation of current fuel metrics
Add	Add three-dimensional density metrics
Grow	Grow into new ecological systems
Explore	Explore time series (pre- and post-fire; recovery through time)

Thank you!