Relationships between pre-fire fuels, fire radiative energy, and post-fire ash

- Andrew Hudak: USFS-RMRS, Moscow, ID
- Roger Ottmar, Clint Wright, Robert Vihnanek: USFS-PNW, Seattle
- Matthew Dickinson: USFS-NRS, Delaware, OH
- Robert Kremens: Rochester Institute of Technology, Rochester, NY
- Eva Strand, Kevin Satterberg, Alistair Smith: University of Idaho, Moscow, ID

Introduction

$$M = A \times B \times \alpha \times \beta$$

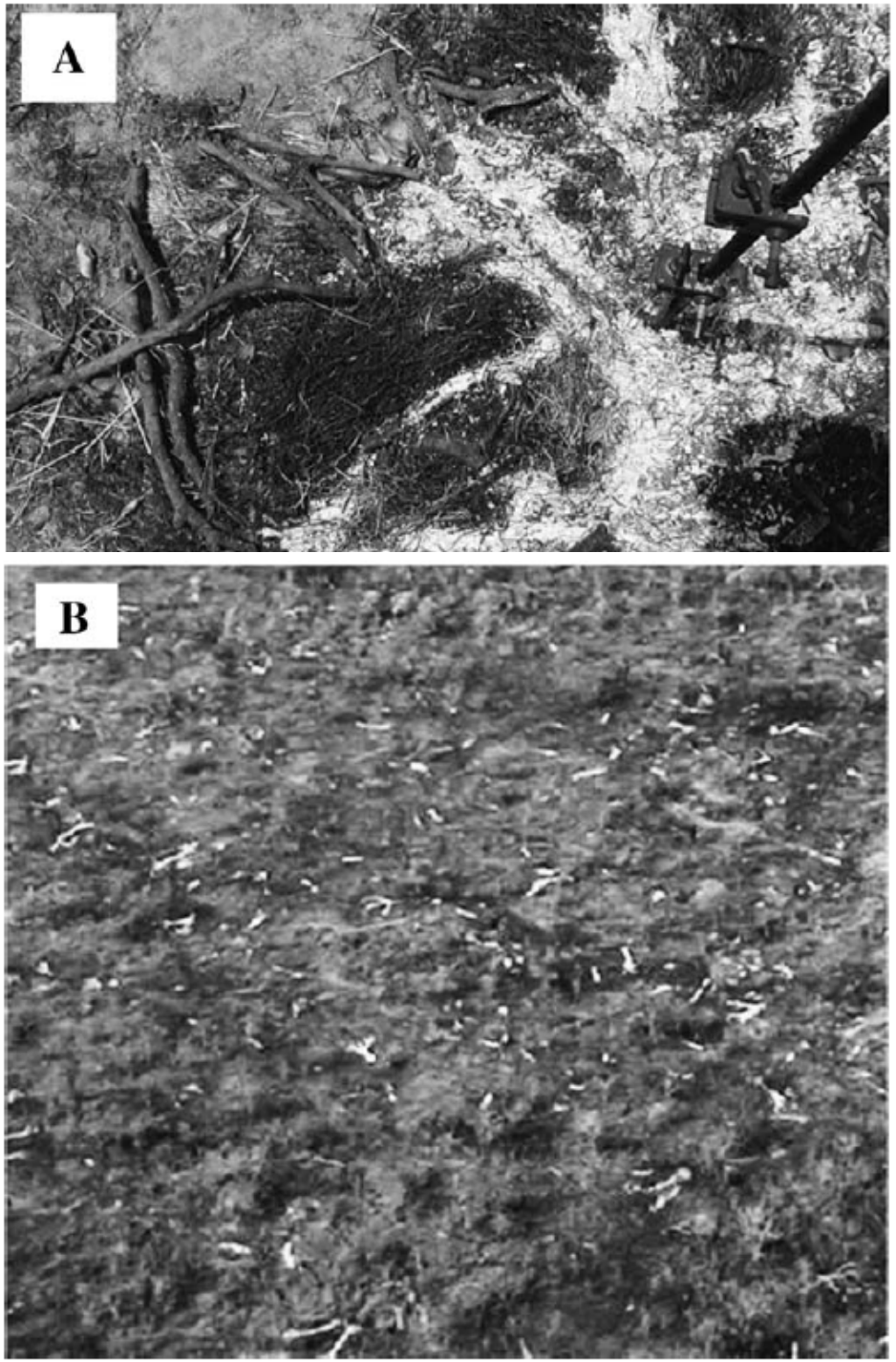
M = burnt biomass (g)
A = burnt area (m^2)
B = biomass density (g/m^2)
α = fraction of aboveground biomass burnt (%)
β = burning efficiency (%)

White ash fraction: <1%

Pyrogenic emissions: >90%

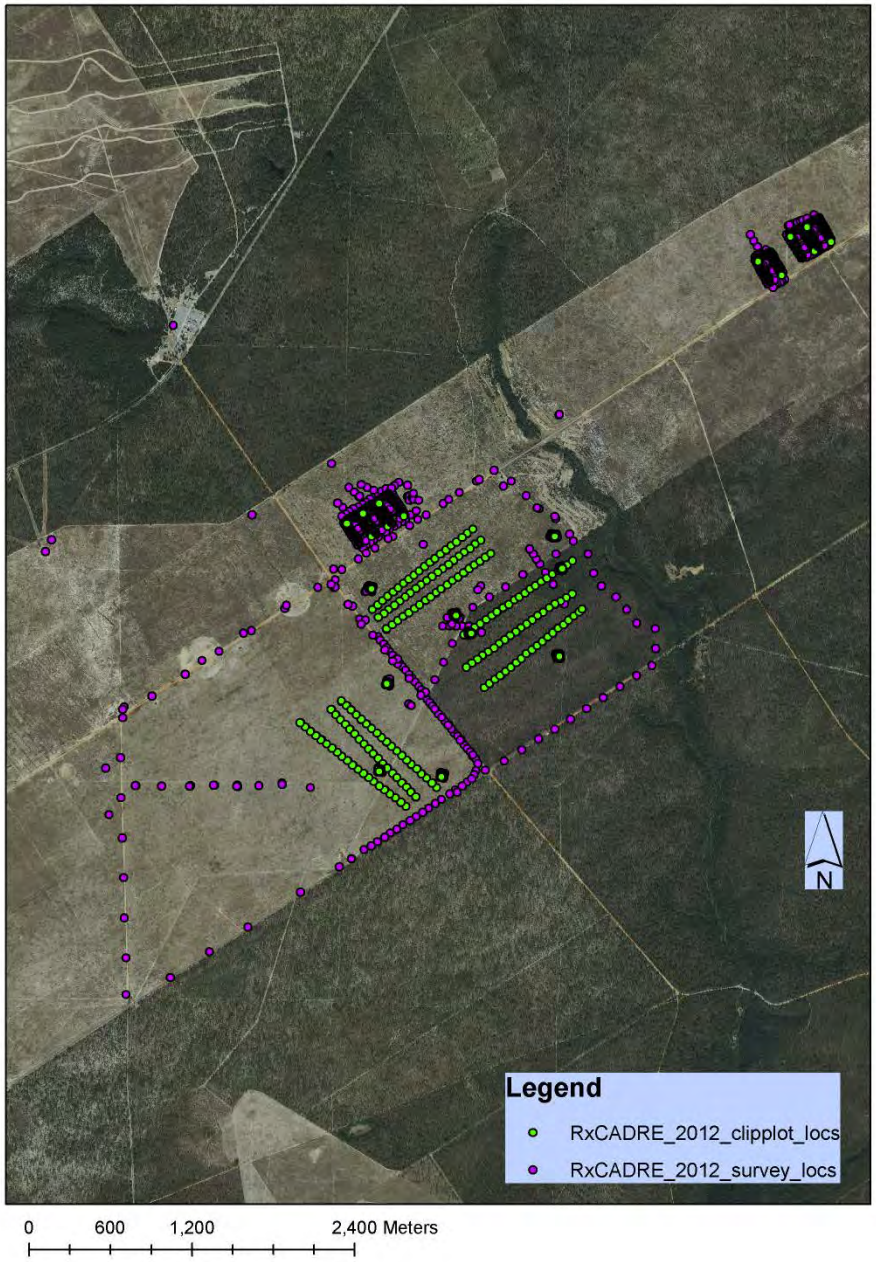
Smith & Hudak (2005) *International Journal of Wildland Fire* 14: 1-4.

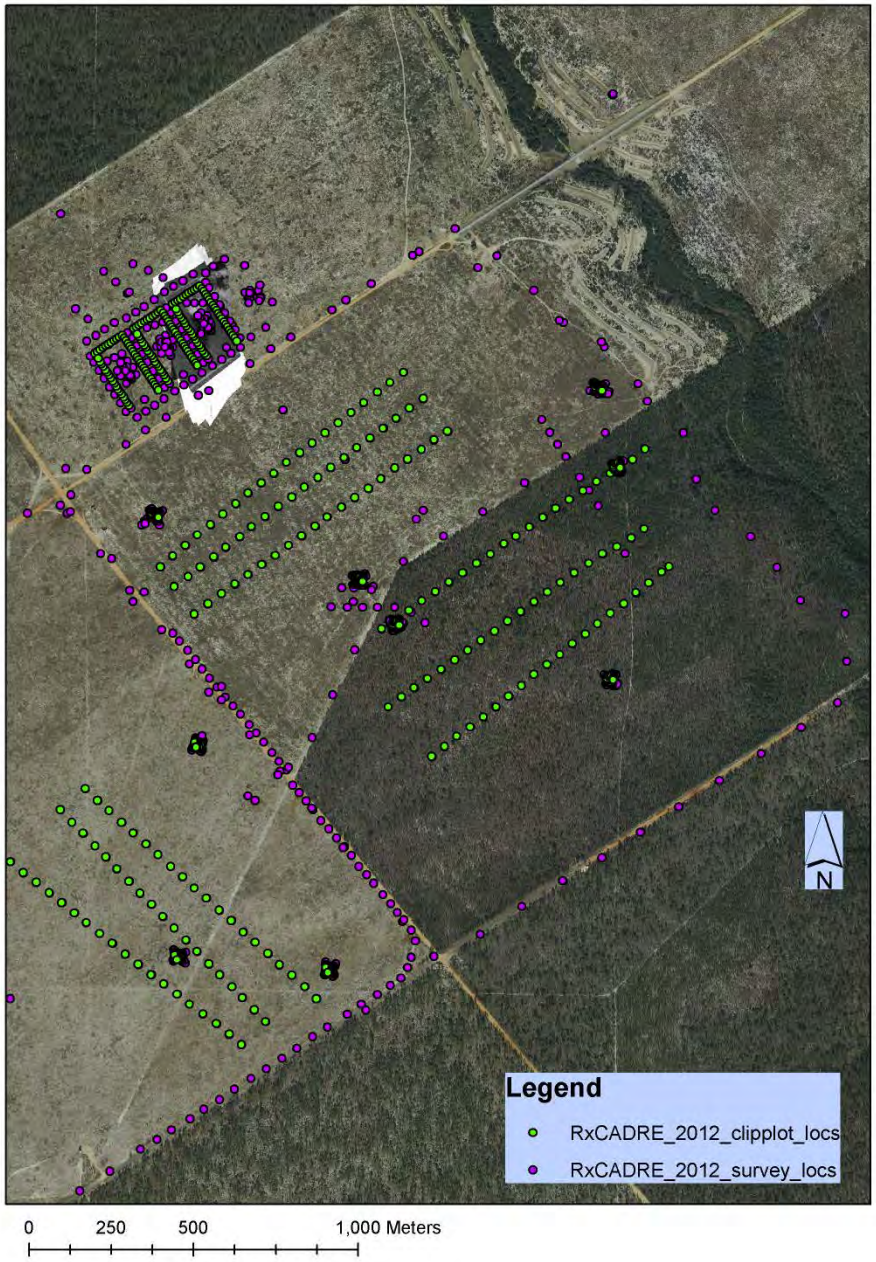
Smith et al. (2005) *Remote Sensing of Environment* 97: 92-115.



Post-Fire


Pre-Fire Airborne LiDAR
Post-Fire Ash Cover
Fuel Combusted
Active Fire Thermal IR Imagery


N
Legend
RxCADRE_2012_clipplot_locs
RxCADRE_2012_survey_locs
0
600
1,200
2,400 Meters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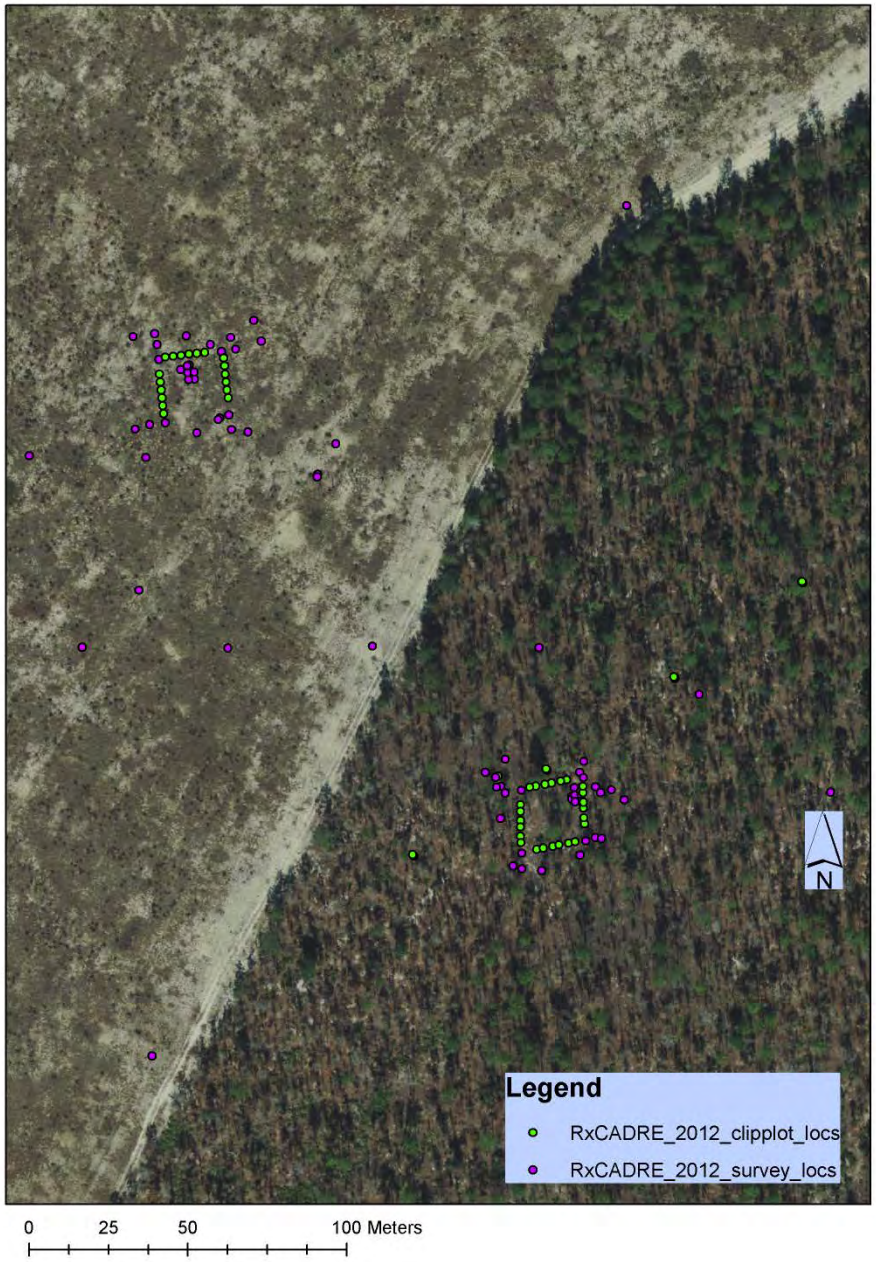
Legend
RxCADRE_2012_clipplot_locs
RxCADRE_2012_survey_locs
0
250
500
1,000 Meters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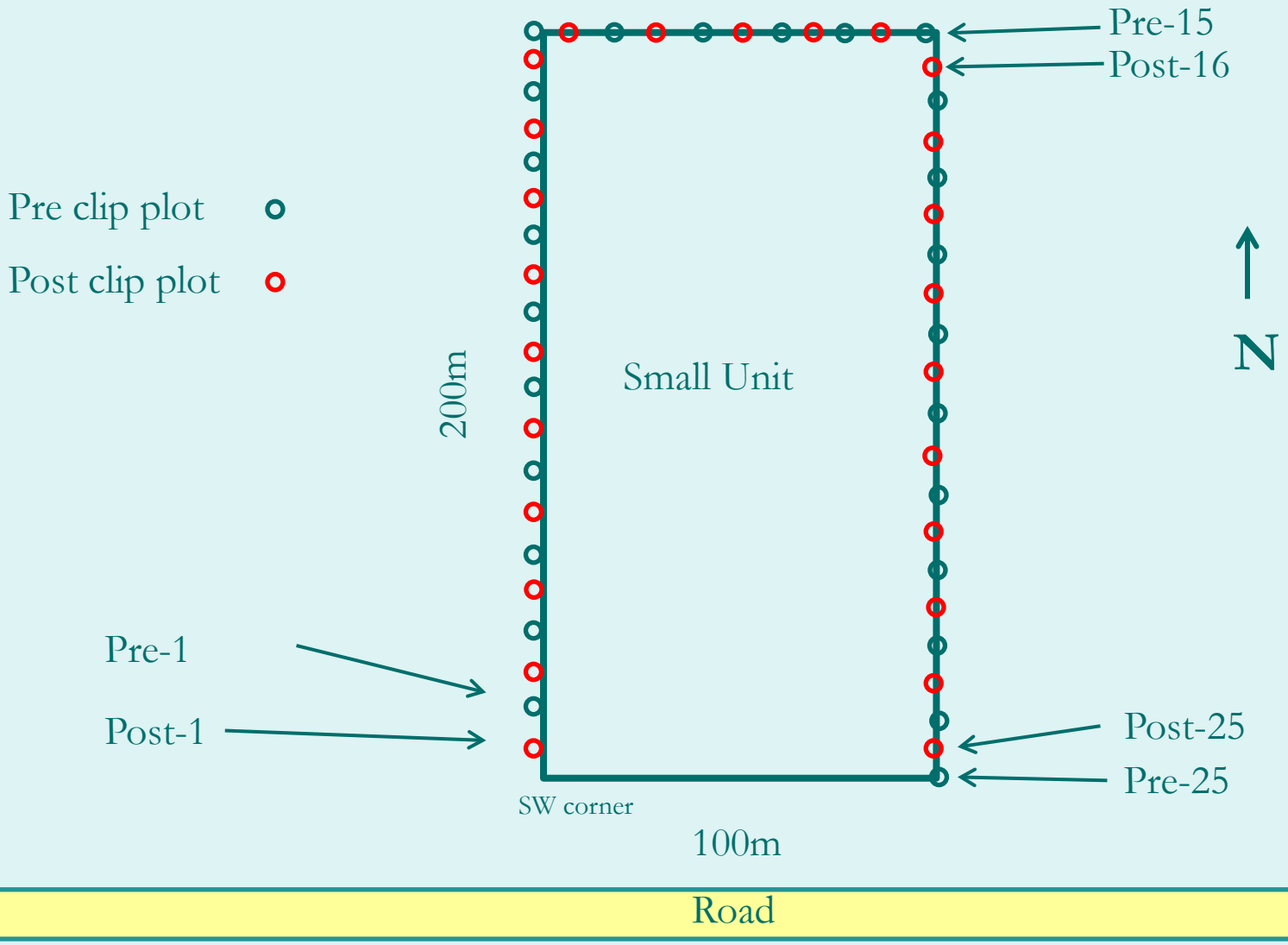
Legend
RxCADRE_2012_clipplot_locs
RxCADRE_2012_survey_locs
0
25
50
100 Meters

Pre-Fire

Post-Fire


Pre clip plot
Post clip plot
Pre-15
Post-16
Small Unit
200m
N
Pre-1
Post-1
Post-25
Pre-25
SW corner
100m
Road

Fuel Loadings & Consumption vs. Postfire Cover Fractions

(Spearman correlations, n=28)

	Green (%)	NPV (%)	Char (%)	Ash (%)	Soil (%)
Prefire Fuel (tons/acre)	-0.37	0.64***	0.66***	0.73***	-0.78***
Postfire Fuel (tons/acre)	-0.10	0.55**	0.44*	0.58**	-0.77***
Consumption (tons/acre)	-0.39*	0.46*	0.56**	0.74***	-0.51**
Consumption (%)	-0.11	-0.32	-0.18	-0.28	0.55**

RxCADRE Burn Units

2008: 5 forested burn units

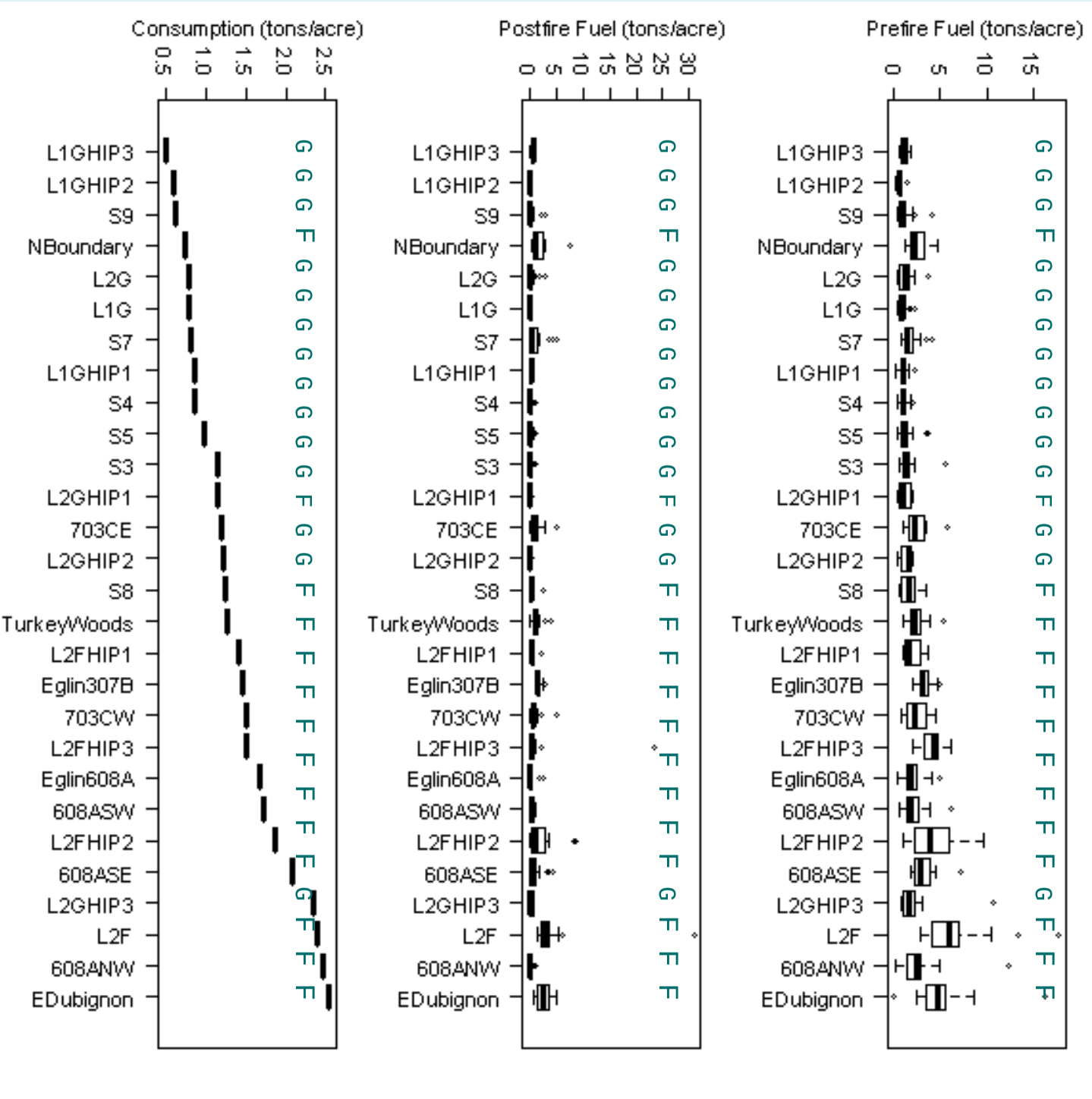
- Eglin Air Force Base, FL
  - 608A
  - 307B
- Jones Ecological Research Center at Ichauway, GA
  - Turkey Woods (Homefield)
  - North Boundary
  - East Dubignon (St. John the Baptist)

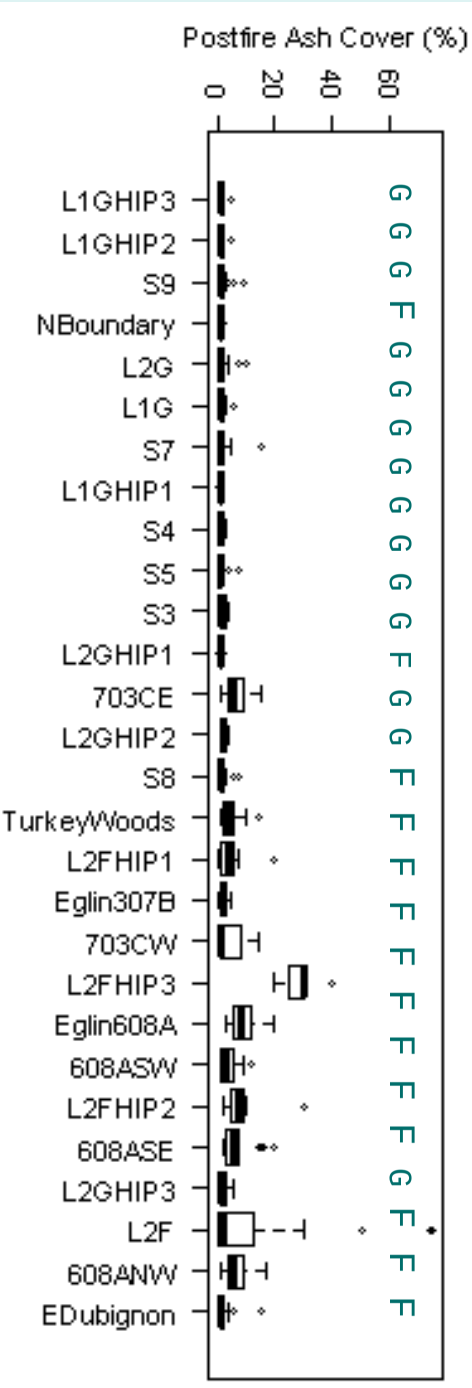
2011: 2 forested burn units with 5 HIPS

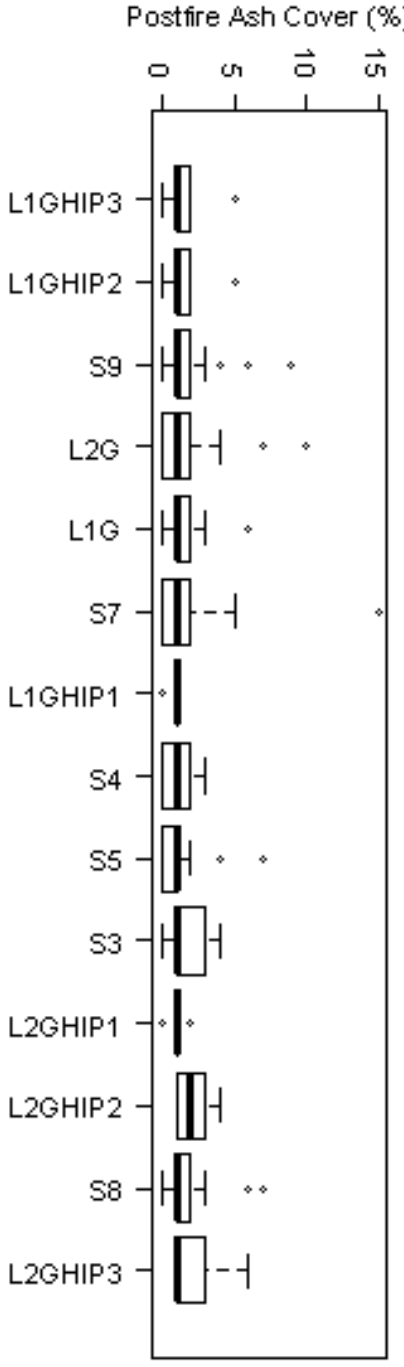
- 703CW, 703CE
- 608ANW, 608ASW, 608ASE

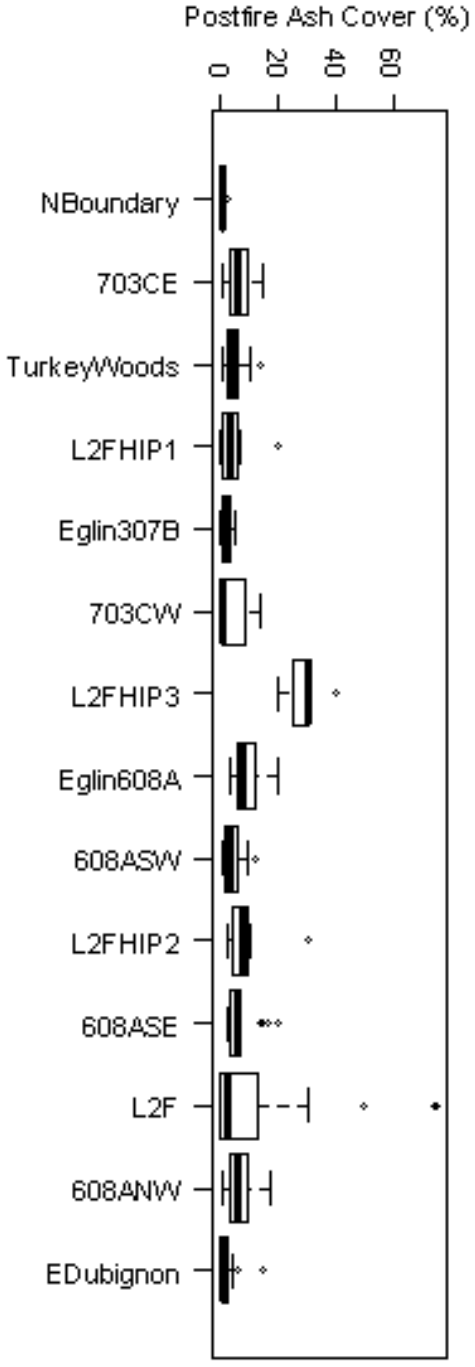
2012: 6 small burn units, 3 large burn units with 9 HIPS

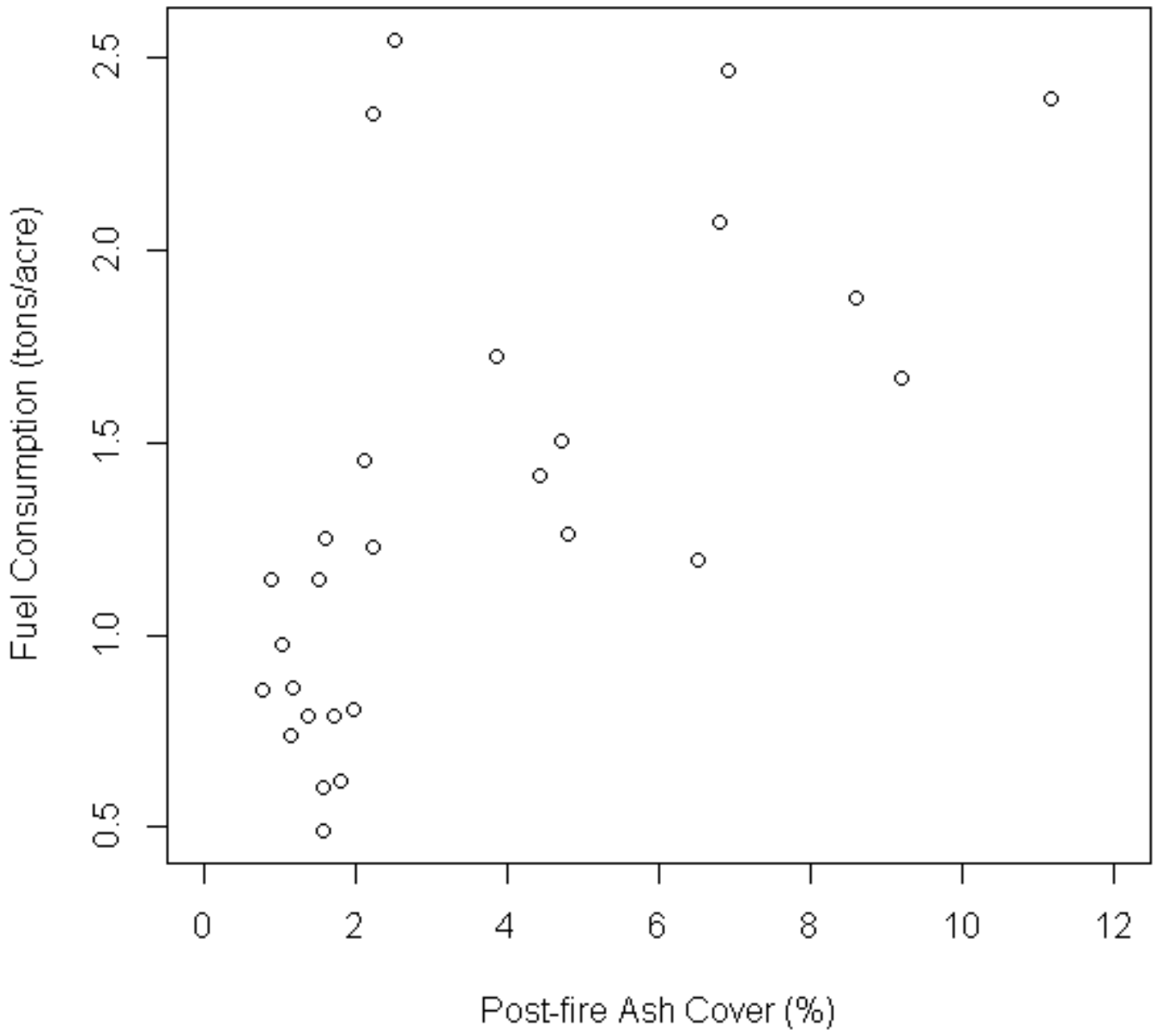
- S3, S4, S5, S7, S8, S9
- L1G, L1GHIP1, L1GHIP2, L1GHIP3
- L2G, L2GHIP1, L2GHIP2, L2GHIP3
- L2F, L2FHIP1, L2FHIP2, L2FHIP3

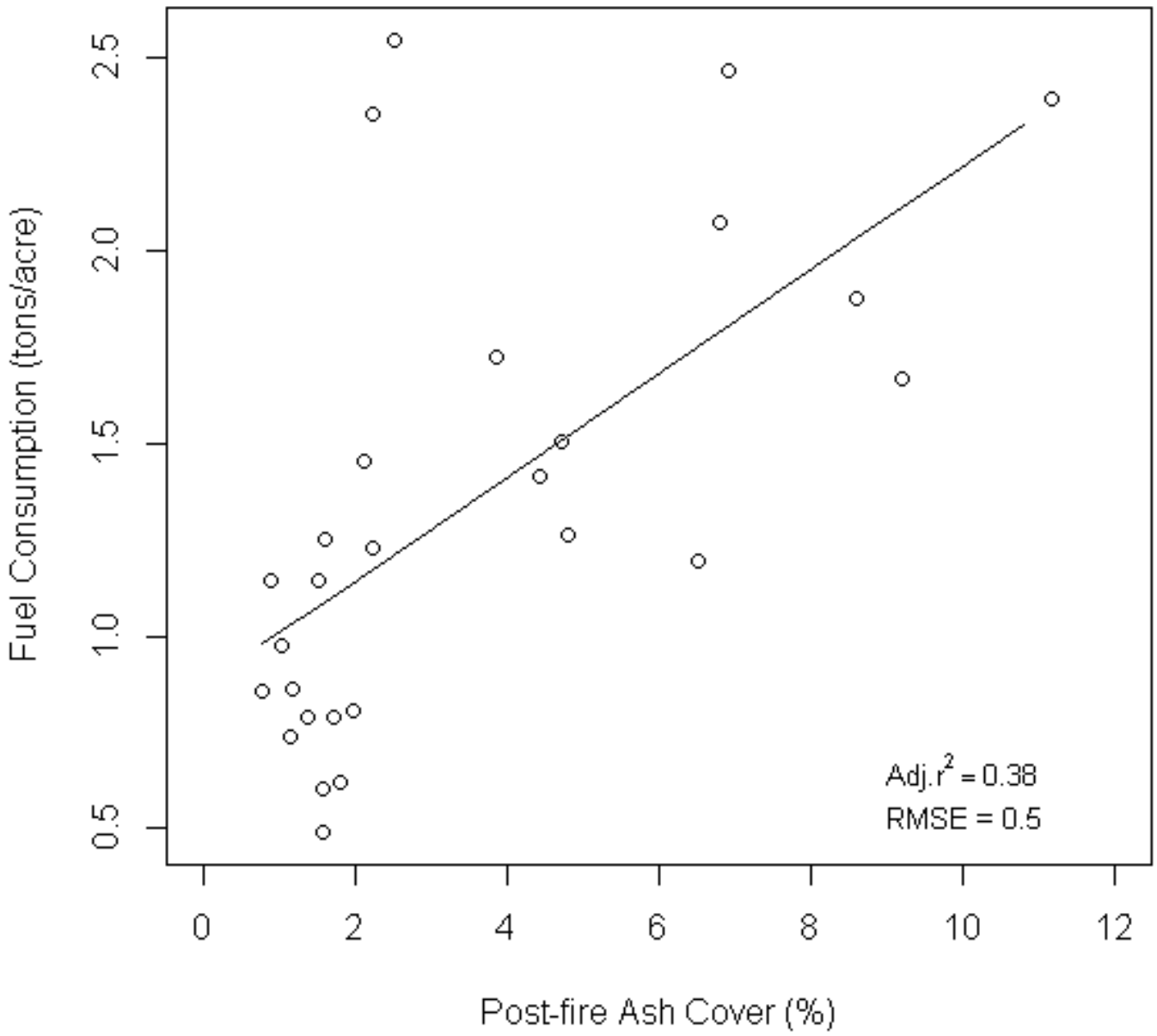

Consumption (tons/acre)
0.5
1.0
1.5
2.0
2.5
L1GHIP3
L1GHIP2
S9
NBoundary
L2G
L1G
S7
L1GHIP1
S4
S5
S3
L2GHIP1
703CE
L2GHIP2
S8
TurkeyWoods
L2FHIP1
Eglin307B
703CW
L2FHIP3
Eglin608A
608ASW
L2FHIP2
608ASE
L2GHIP3
L2F
608ANW
EDubignon
G G G F G G G G G G G G G F G G F F F F F F F F F F F F F
Postfire Fuel (tons/acre)
0
5
10
15
20
25
30
L1GHIP3
L1GHIP2
S9
NBoundary
L2G
L1G
S7
L1GHIP1
S4
S5
S3
L2GHIP1
703CE
L2GHIP2
S8
TurkeyWoods
L2FHIP1
Eglin307B
703CW
L2FHIP3
Eglin608A
608ASW
L2FHIP2
608ASE
L2GHIP3
L2F
608ANW
EDubignon
G G G F G G G G G G G G G F G G F F F F F F F F F F F F F
Prefire Fuel (tons/acre)
0
5
10
15
L1GHIP3
L1GHIP2
S9
NBoundary
L2G
L1G
S7
L1GHIP1
S4
S5
S3
L2GHIP1
703CE
L2GHIP2
S8
TurkeyWoods
L2FHIP1
Eglin307B
703CW
L2FHIP3
Eglin608A
608ASW
L2FHIP2
608ASE
L2GHIP3
L2F
608ANW
EDubignon
G G G F G G G G G G G G G F G G F F F F F F F F F F F F F


Postfire Ash Cover (%)
0
20
40
60
L1GHIP3
L1GHIP2
S9
NBoundary
L2G
L1G
S7
L1GHIP1
S4
S5
S3
L2GHIP1
703CE
L2GHIP2
S8
TurkeyWoods
L2FHIP1
Eglin307B
703CW
L2FHIP3
Eglin608A
608ASW
L2FHIP2
608ASE
L2GHIP3
L2F
608ANW
EDubignon
G G G F G G G G G G G G F G G F F F F F F F F F F F G F F F


Postfire Ash Cover (%)
0
5
10
15
L1GHIP3
L1GHIP2
S9
L2G
L1G
S7
L1GHIP1
S4
S5
S3
L2GHIP1
L2GHIP2
S8
L2GHIP3


Postfire Ash Cover (%)
0
20
40
60
NBoundary
703CE
TurkeyWoods
L2FHIP1
Eglin307B
703CW
L2FHIP3
Eglin608A
608ASW
L2FHIP2
608ASE
L2F
608ANW
EDubignon


Fuel Consumption (tons/acre)
0.5
1.0
1.5
2.0
2.5
0
2
4
6
8
10
12
Post-fire Ash Cover (%)


Fuel Consumption (tons/acre)
0.5
1.0
1.5
2.0
2.5
0
2
4
6
8
10
12
Post-fire Ash Cover (%)
Adj.r^2 = 0.38
RMSE = 0.5

Active Fire


Pre-Fire Airborne LiDAR
Fuel Combusted
Post-Fire Ash Cover
Active Fire Thermal IR Imagery

Eglin 703c Fire Front Movement

By: Kevin Satterberg
2/12/2013
Data From: USFS
Projection and datum: GCS_WGS_84

N

0 250 500 1,000 Meters

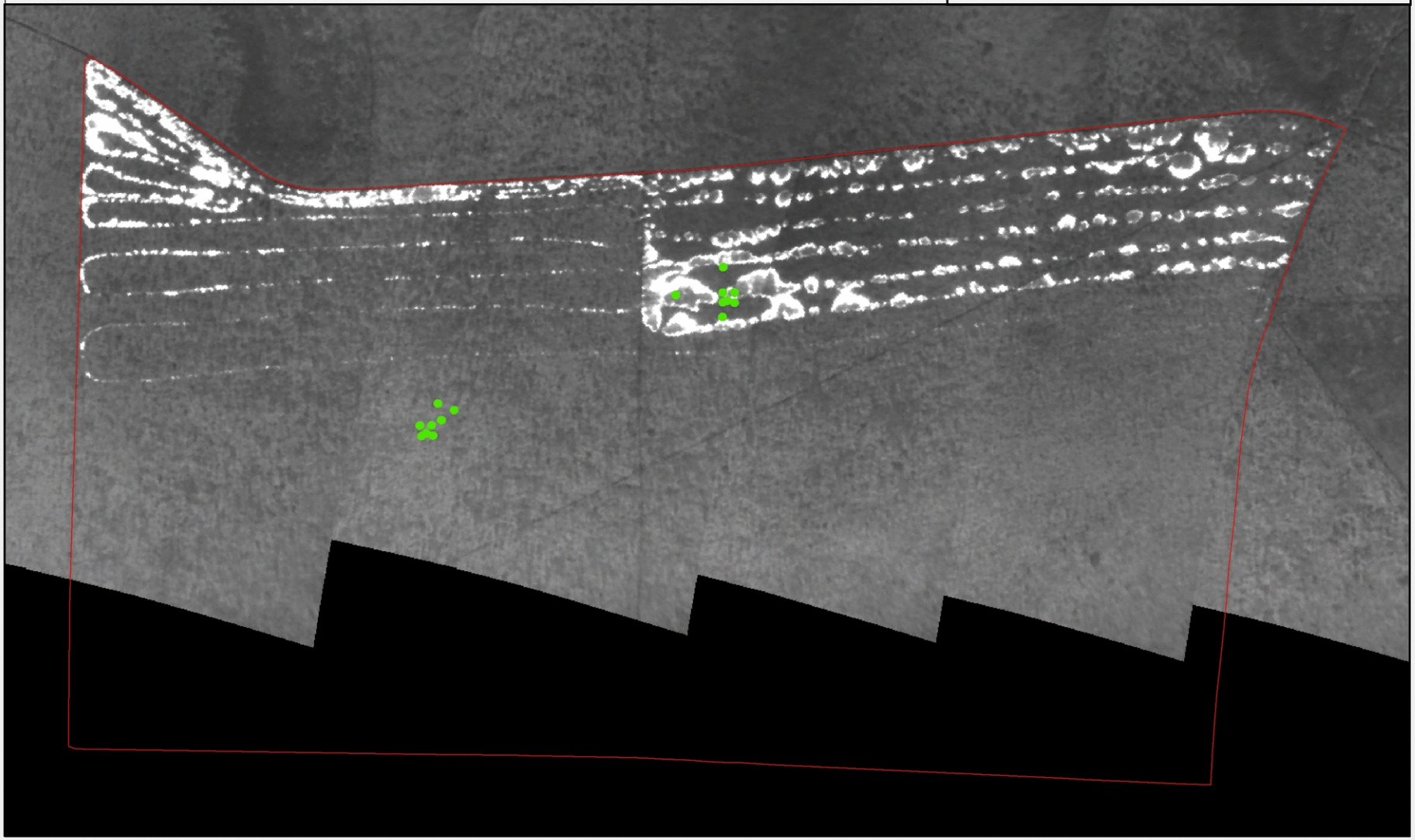
Thermal Aerial Images in KW/m^2

Perimeter

Radiometer locations

High

Low



Eglin 608a Fire Front Movement

By: Kevin Satterberg
2/14/2013
Data From: USFS
Projection and datum: GCS_WGS_84

N

0 250 500 1,000 Meters

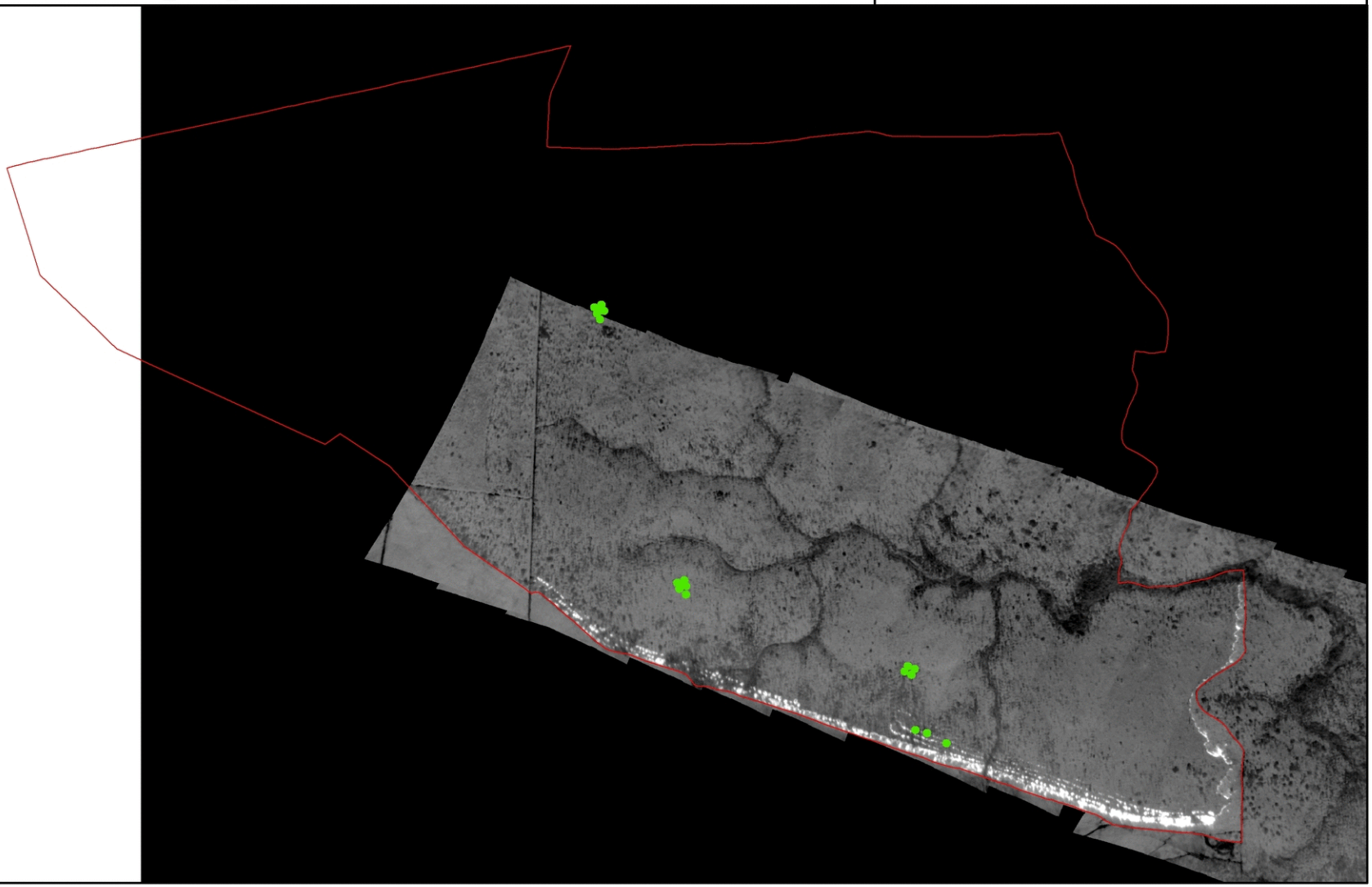
Thermal Aerial Images in KW/m^2

Perimeter

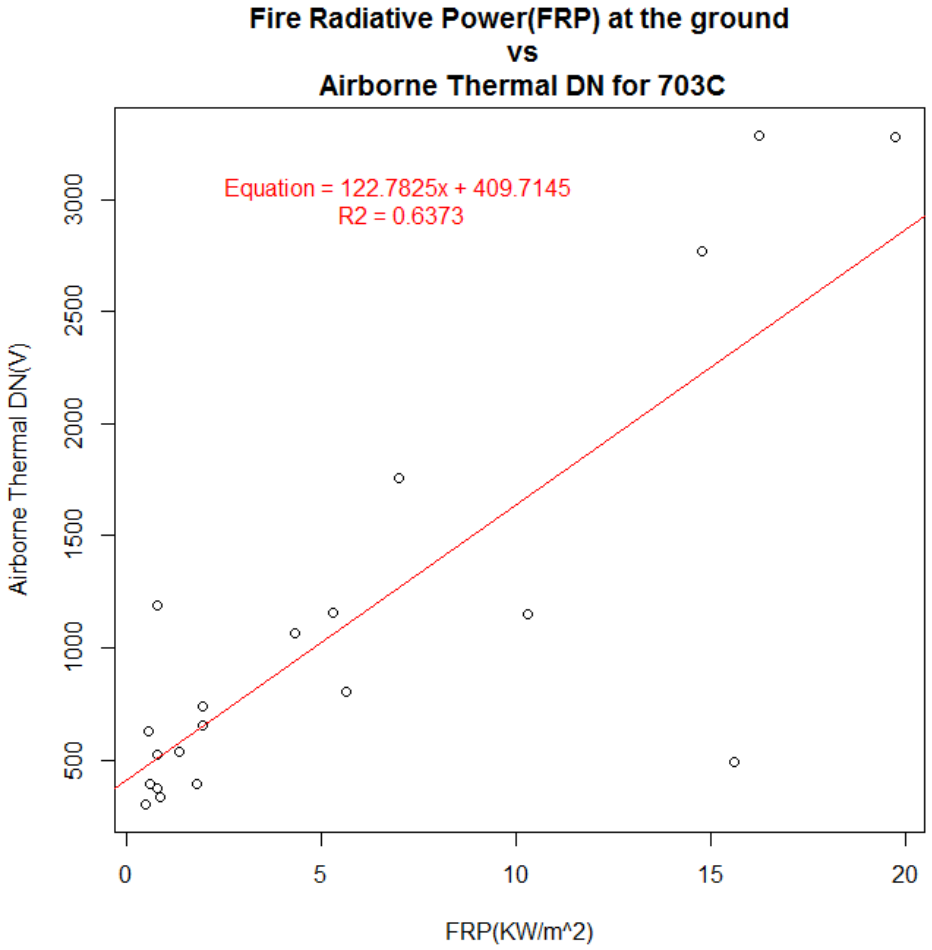
Radiometer locations

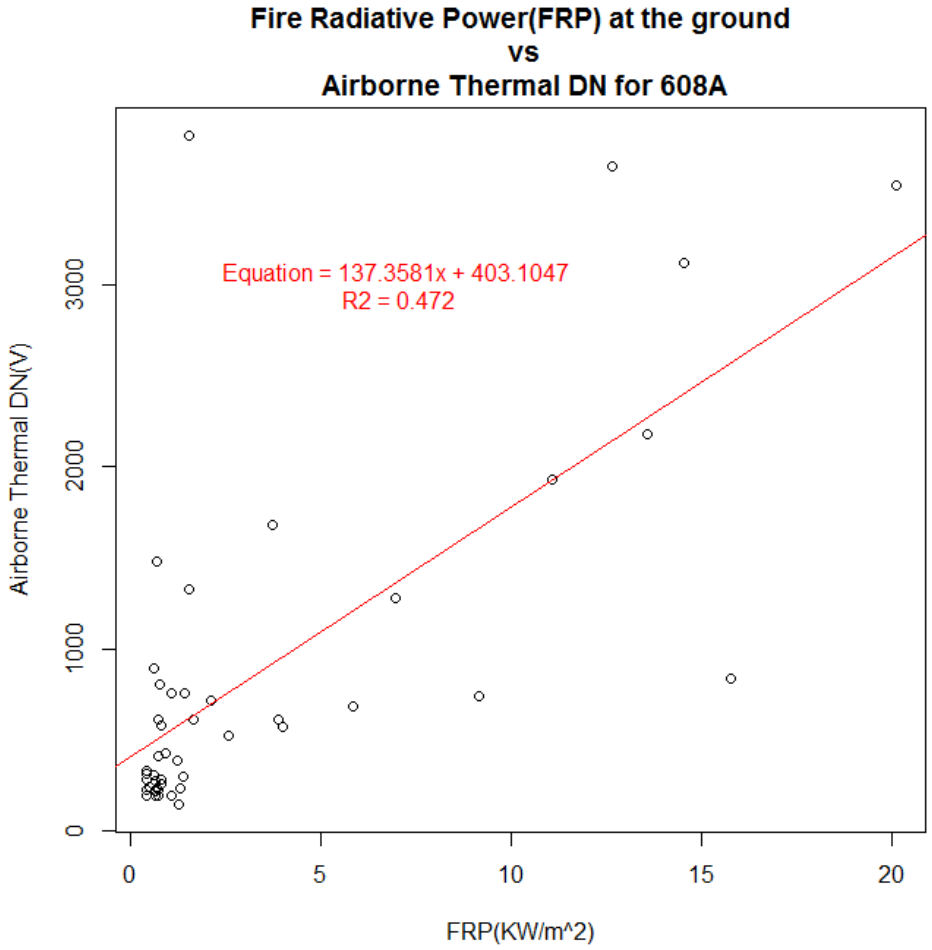
High

Low

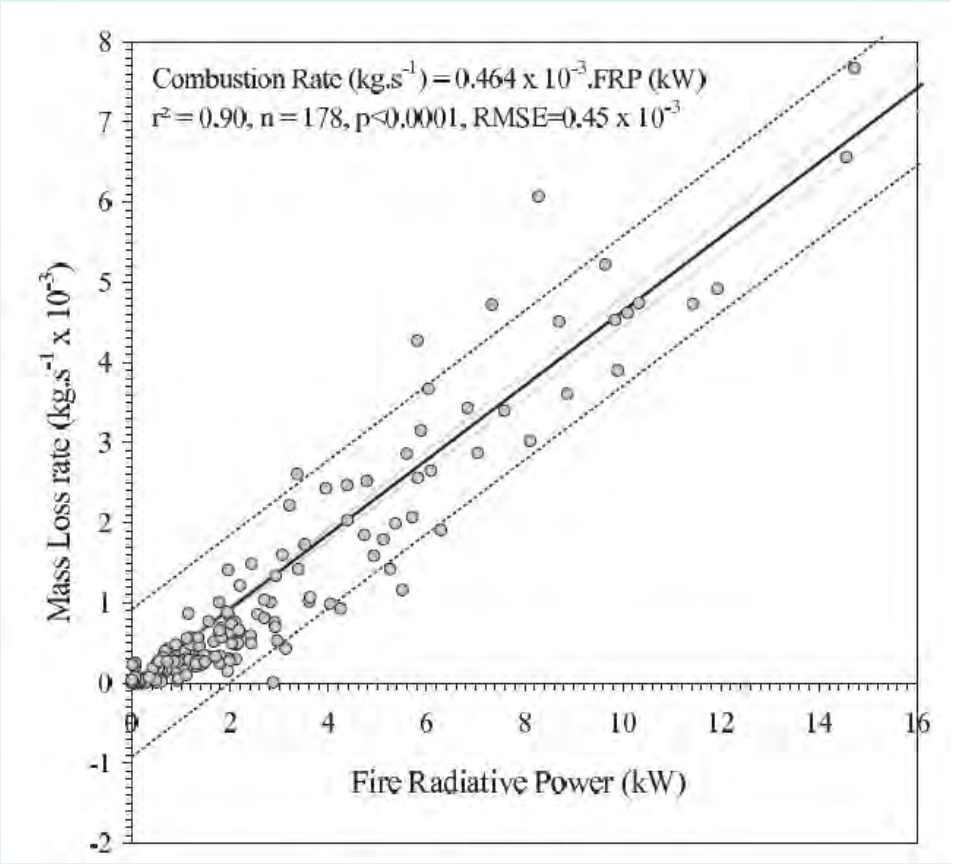


2011 WASP Calibration Equations

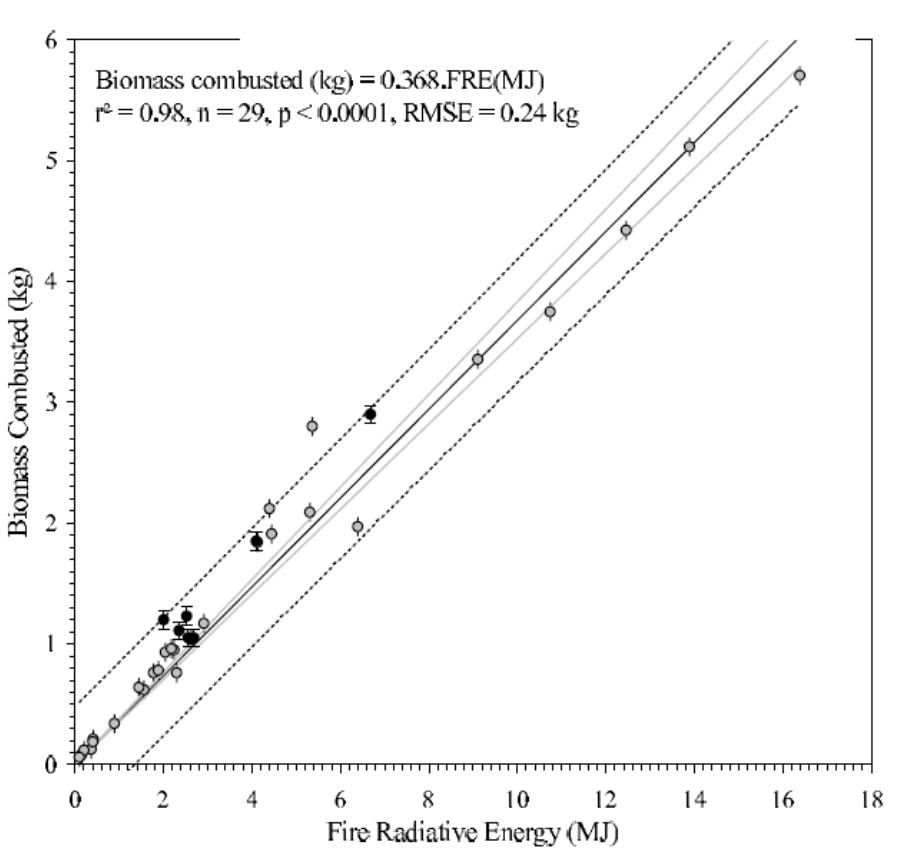




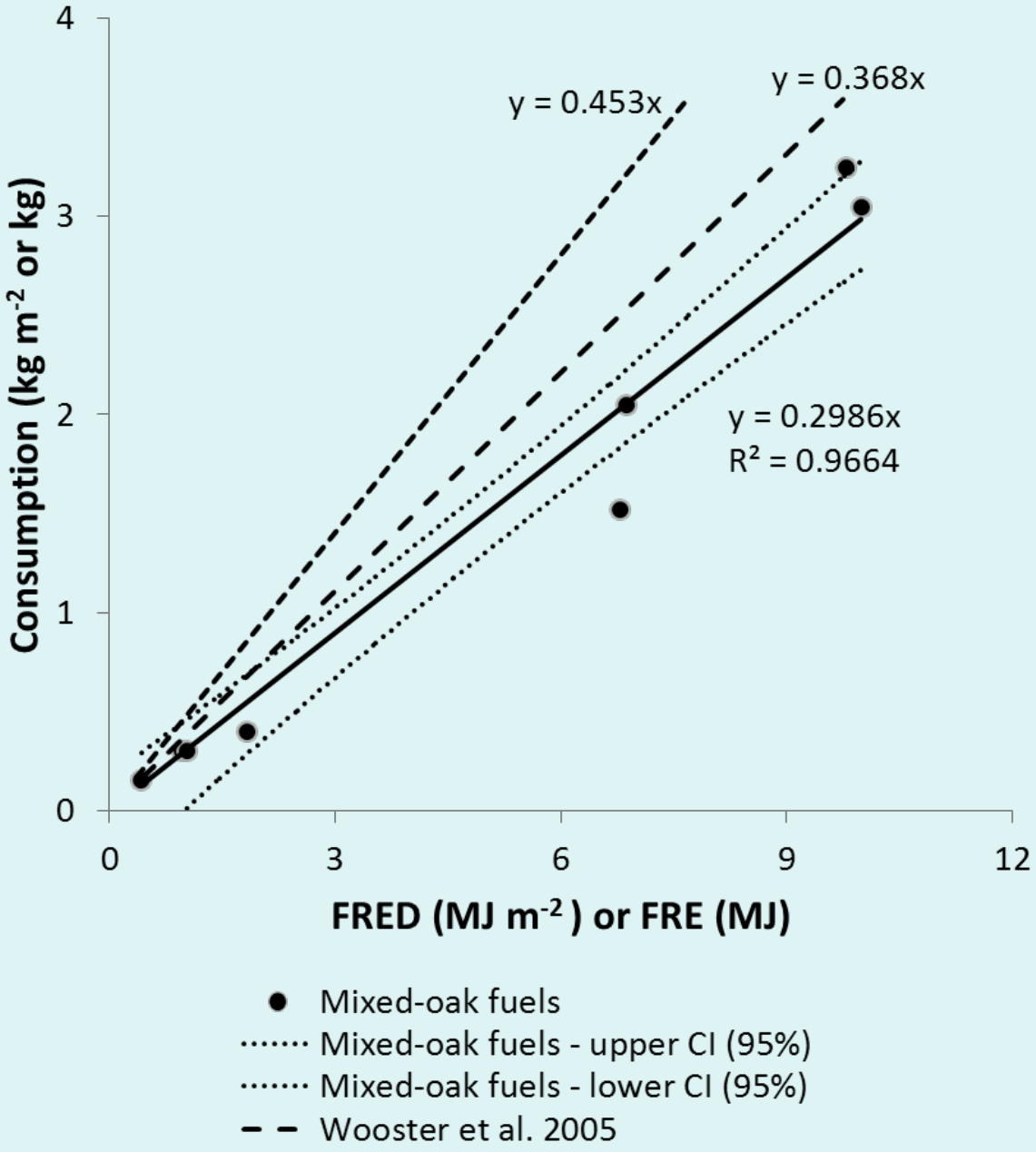
Fire Radiative Power (FRP)



Fire Radiative Energy (FRE)

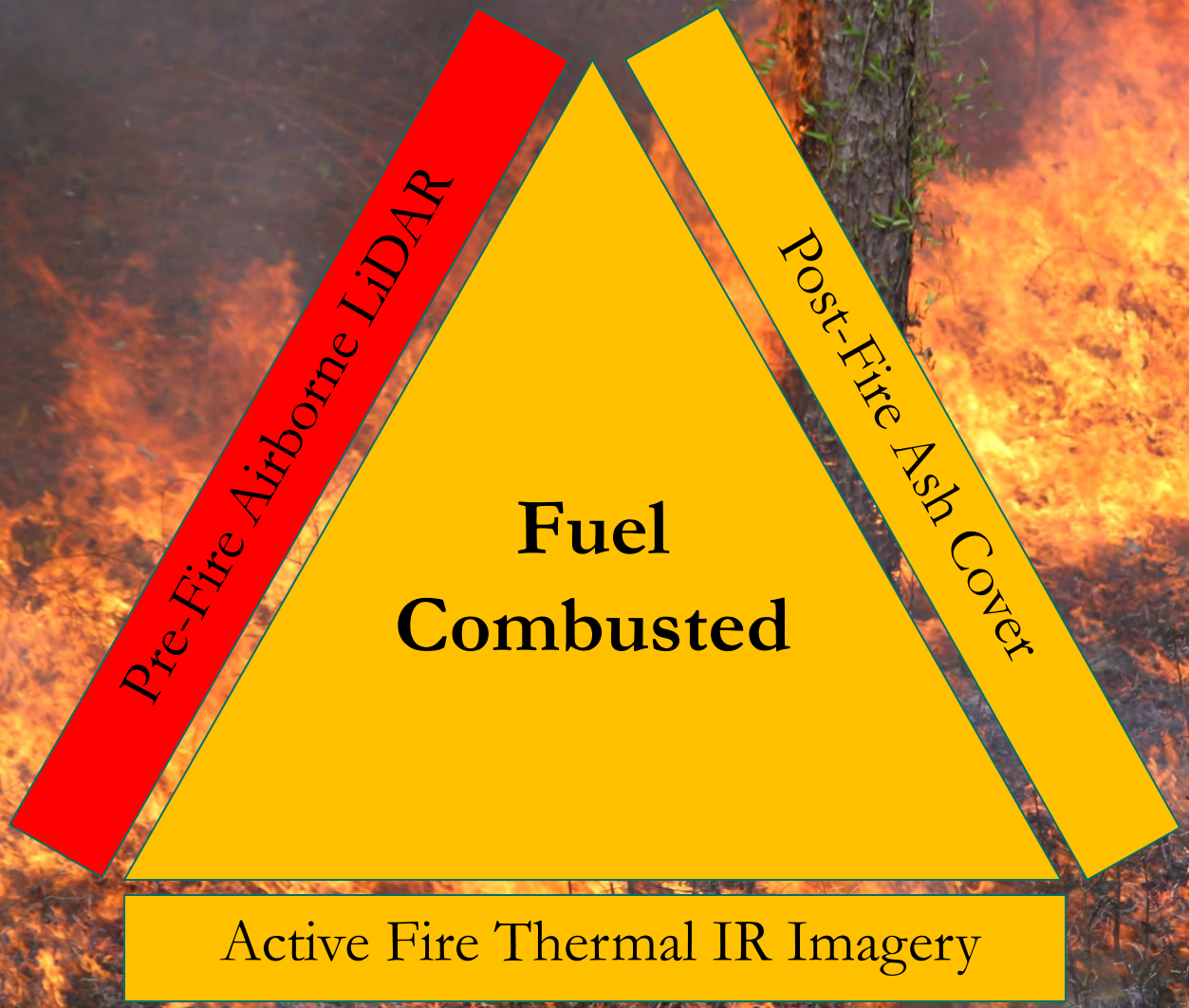


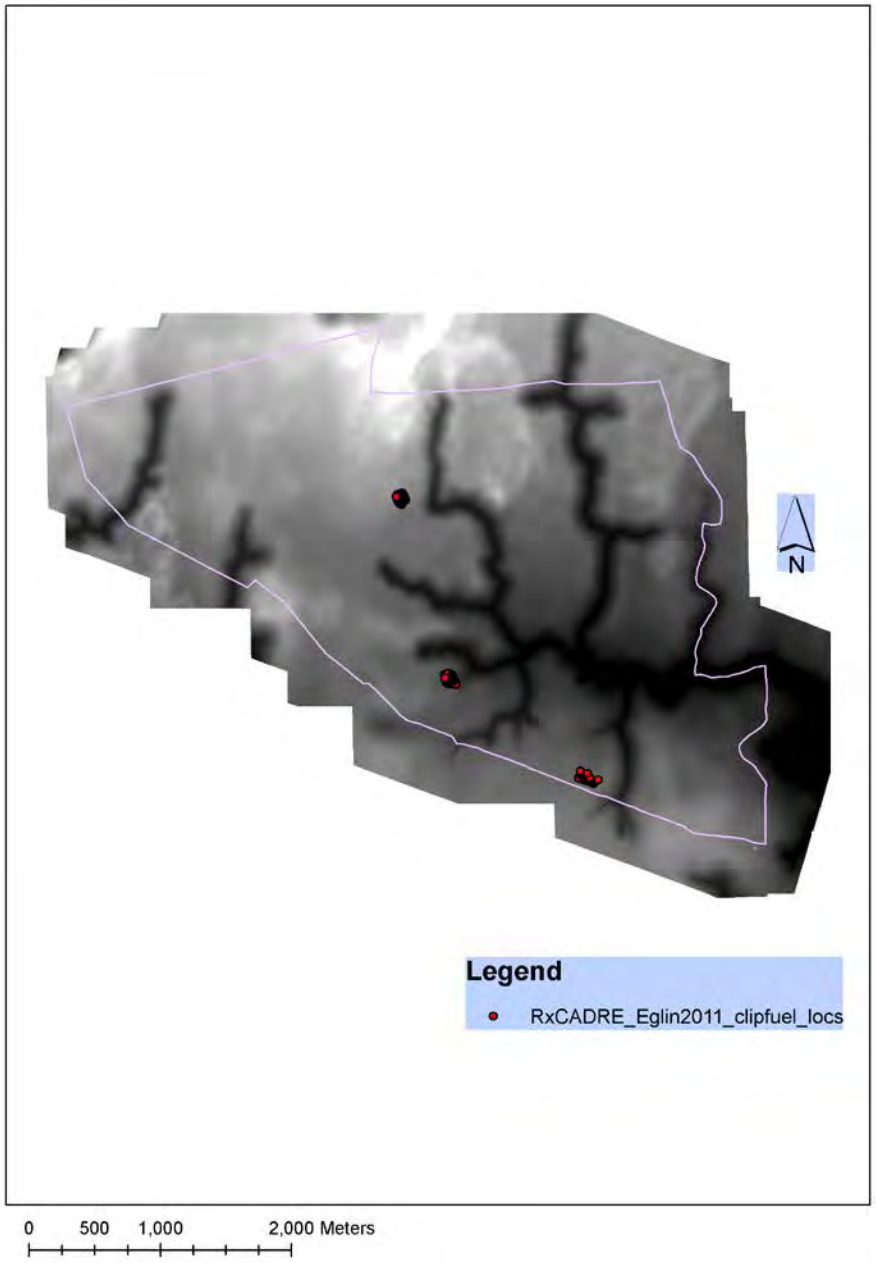
Wooster et al. (2005) *Journal of Geophysical Research* 110: D24311, 24 p.

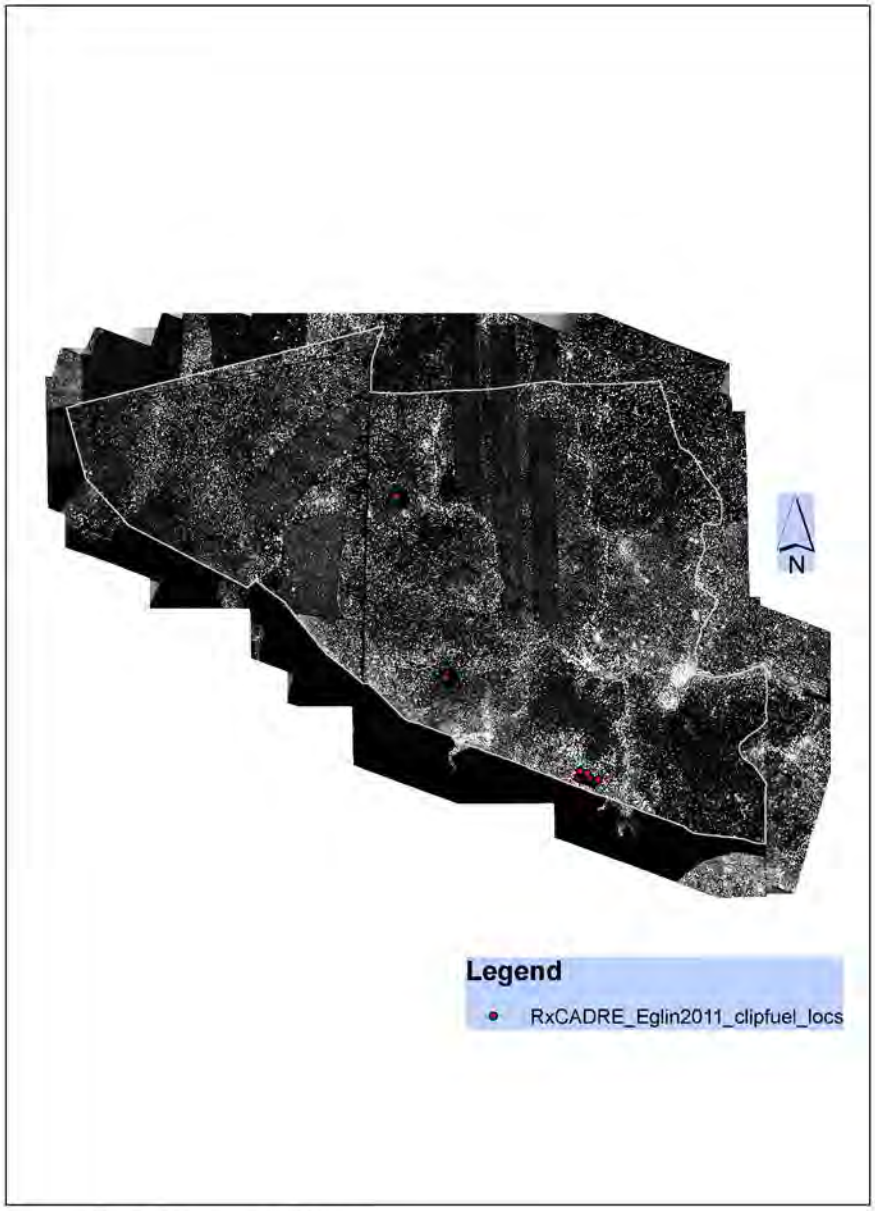


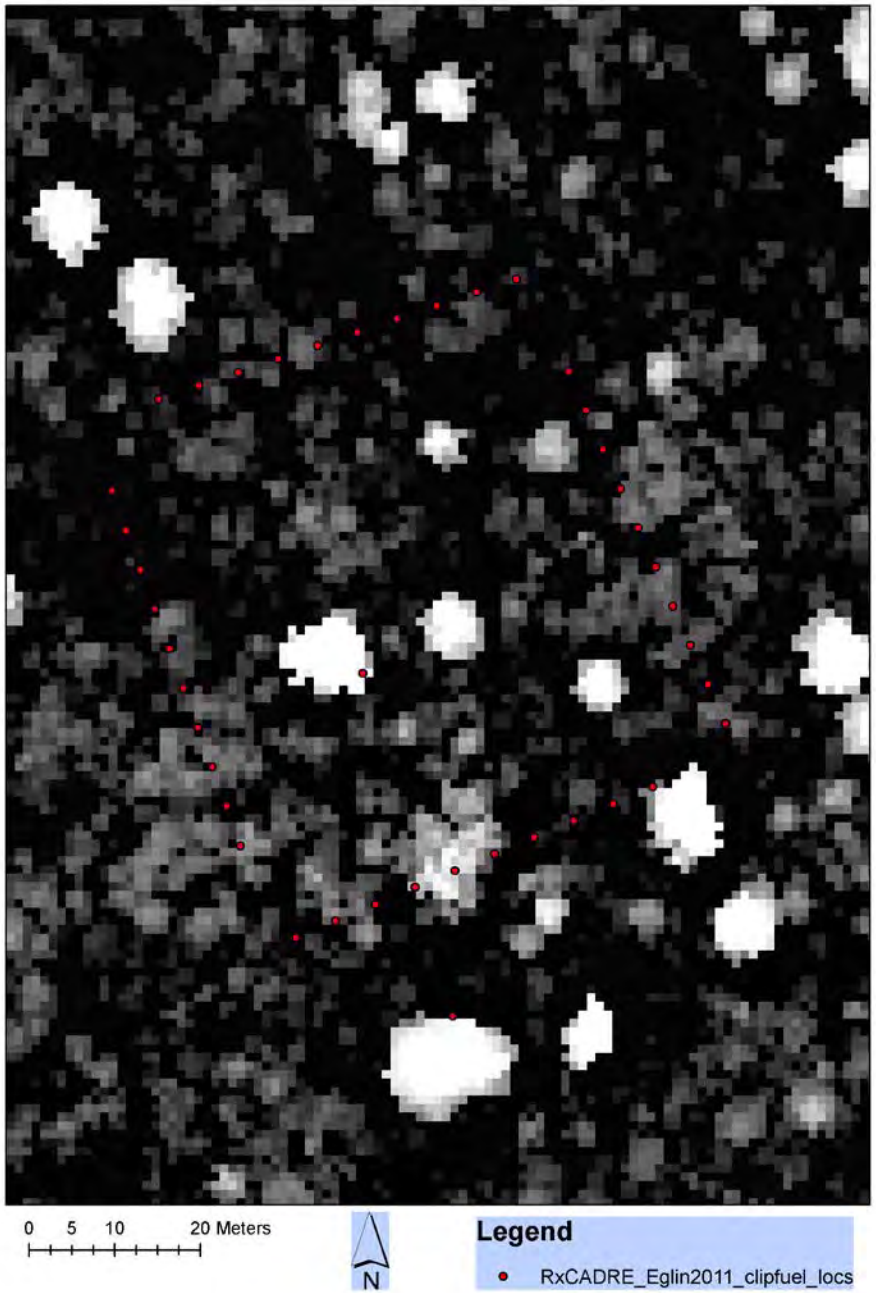
From Kremens et al. 2012

Pre-fire

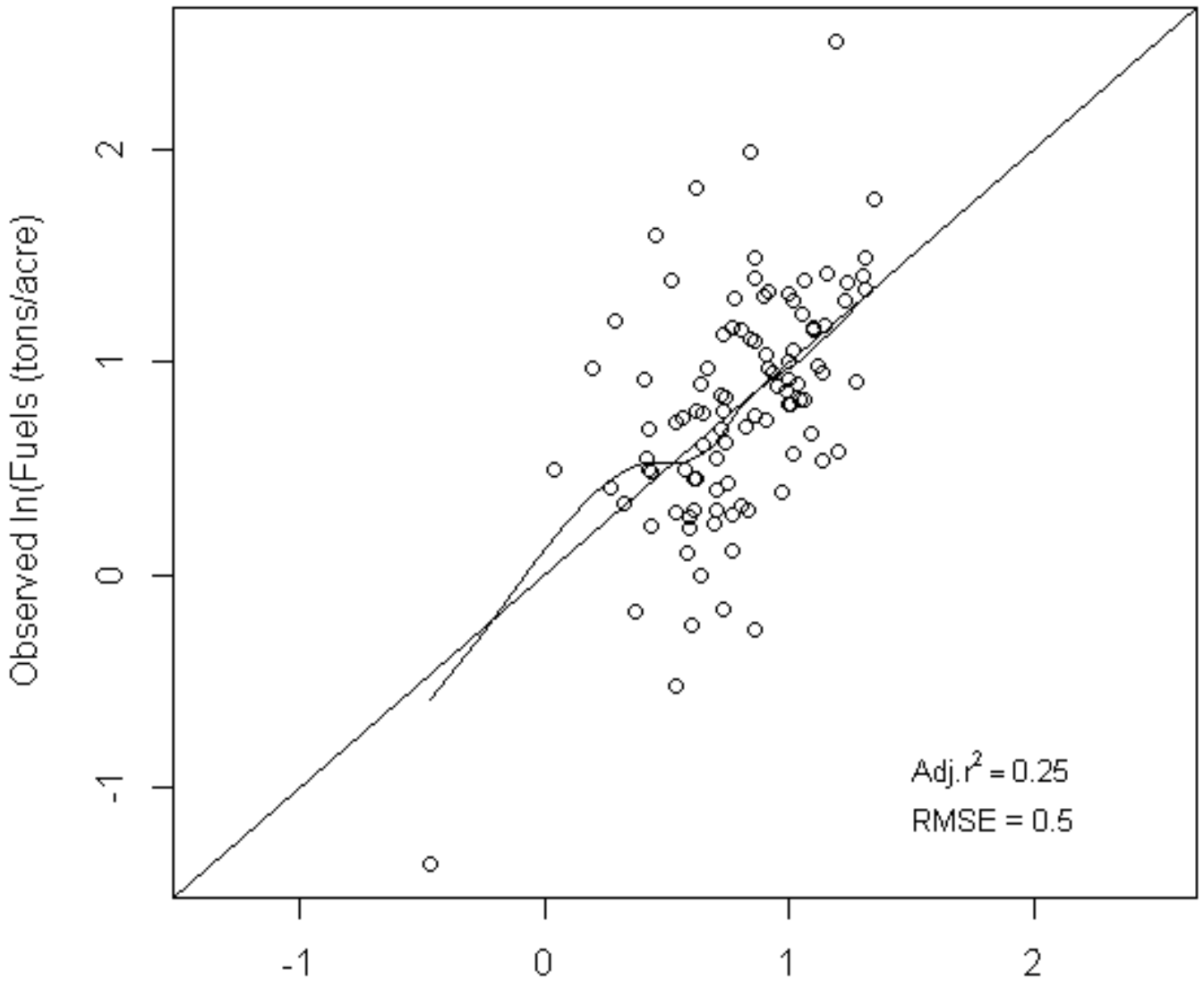

Pre-Fire Airborne LiDAR
Post-Fire Ash Cover
Fuel Combusted
Active Fire Thermal IR Imagery


N
Legend
RxCADRE_Eglin2011_clipfuel_locs
0
500
1,000
2,000 Meters


N
Legend
RxCADRE_Eglin2011_clipfuel_locs
0
500
1,000
2,000 Meters


0 5 10 20 Meters
N
Legend
RxCADRE_Eglin2011_clipfuel_locs

Prefire Fuels Predicted from Airborne LiDAR



Conclusions (Progress)

- Post-fire ash cover best retrospective indicator of fuel consumption
- Post-fire ash cover better indicator of absolute consumption than relative consumption
- Have unit wide FRP maps (2011) but still need FRE mapped to compare to plot-level and unit-level estimated fuel consumption
- Have tree canopy mapped unit wide (2008 and 2011) and can predict surface fuels but still need to apply unit wide
- Need to quantify FRP & FRE attenuation by the overstory (LiDAR)

Questions?


Rocky
Mountain
Research Station
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Research Supporting Sound Decisions