Understanding the effects of wildfire on soil moisture dynamics, plant water uptake, and recharge using electrical resistivity

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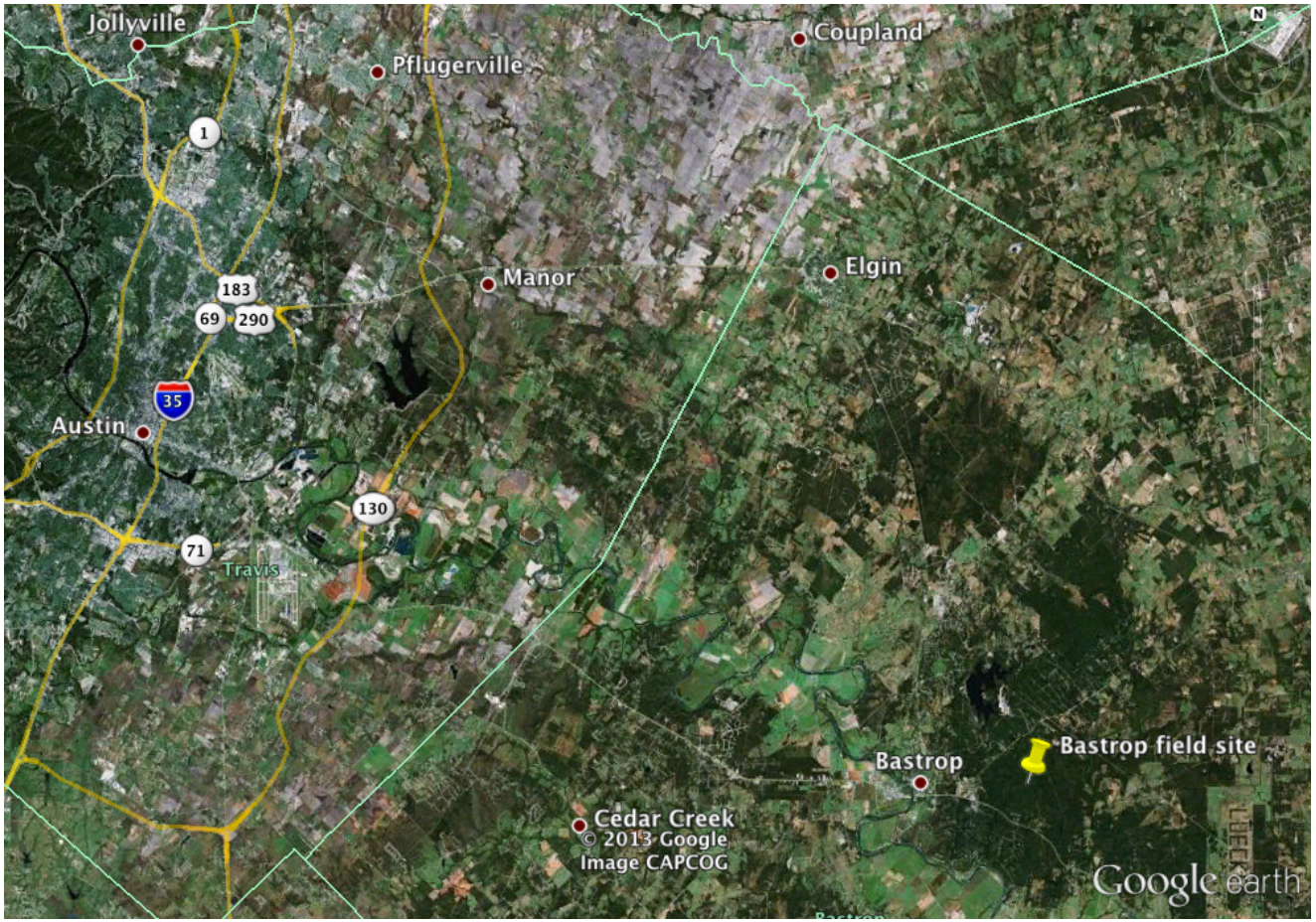
Research questions

- How does wildfire affect soil moisture dynamics in the vadose zone?
- What effect do the subsequent changes in vegetative cover and the hydrophobic effects of fire have on soil moisture?
- What can electrical resistivity imaging and other moisture sensors tell us about these effects?

Bastrop State Park

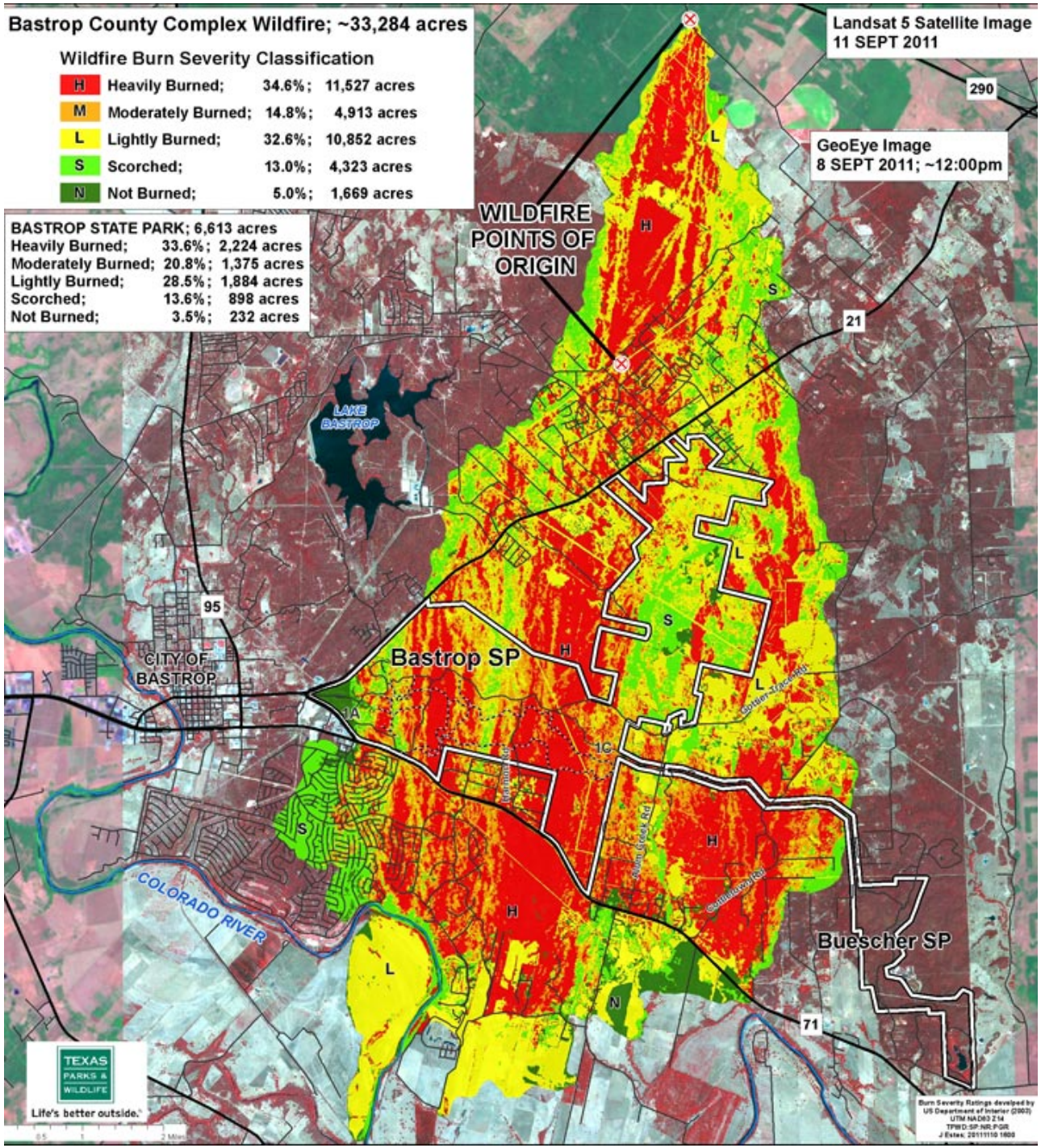


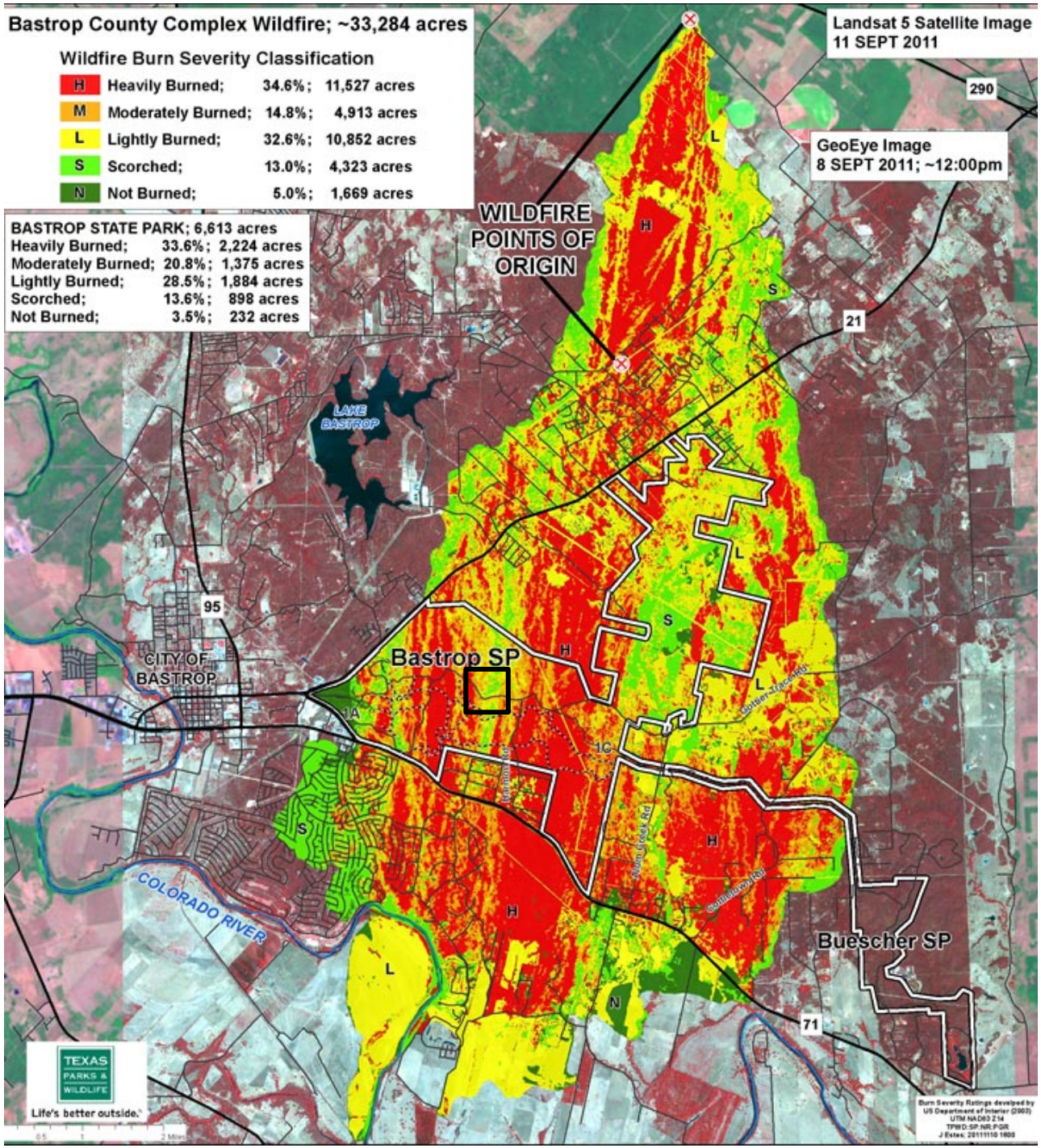
- ~30 miles SE of Austin
- 6,500-acre park
- Home to “Lost Pines”
- Loblolly pine dominates

2011 wildfire

Reuters

- More than 33,000 acres were burned
- Burned 96% of Bastrop State Park


Bastrop County Complex Wildfire; ~33,284 acres
Wildfire Burn Severity Classification
H Heavily Burned; 34.6%; 11,527 acres
M Moderately Burned; 14.8%; 4,913 acres
L Lightly Burned; 32.6%; 10,852 acres
S Scorched; 13.0%; 4,323 acres
N Not Burned; 5.0%; 1,669 acres
BASTROP STATE PARK; 6,613 acres
Heavily Burned; 33.6%; 2,224 acres
Moderately Burned; 20.8%; 1,375 acres
Lightly Burned; 28.5%; 1,884 acres
Scorched; 13.6%; 898 acres
Not Burned; 3.5%; 232 acres
Landsat 5 Satellite Image
11 SEPT 2011
GeoEye Image
8 SEPT 2011; ~12:00pm
WILDFIRE POINTS OF ORIGIN
LAKE BASTROP
CITY OF BASTROP
Bastrop SP
Buescher SP
COLORADO RIVER
290
21
95
71
TEXAS PARKS & WILDLIFE
Life's better outside.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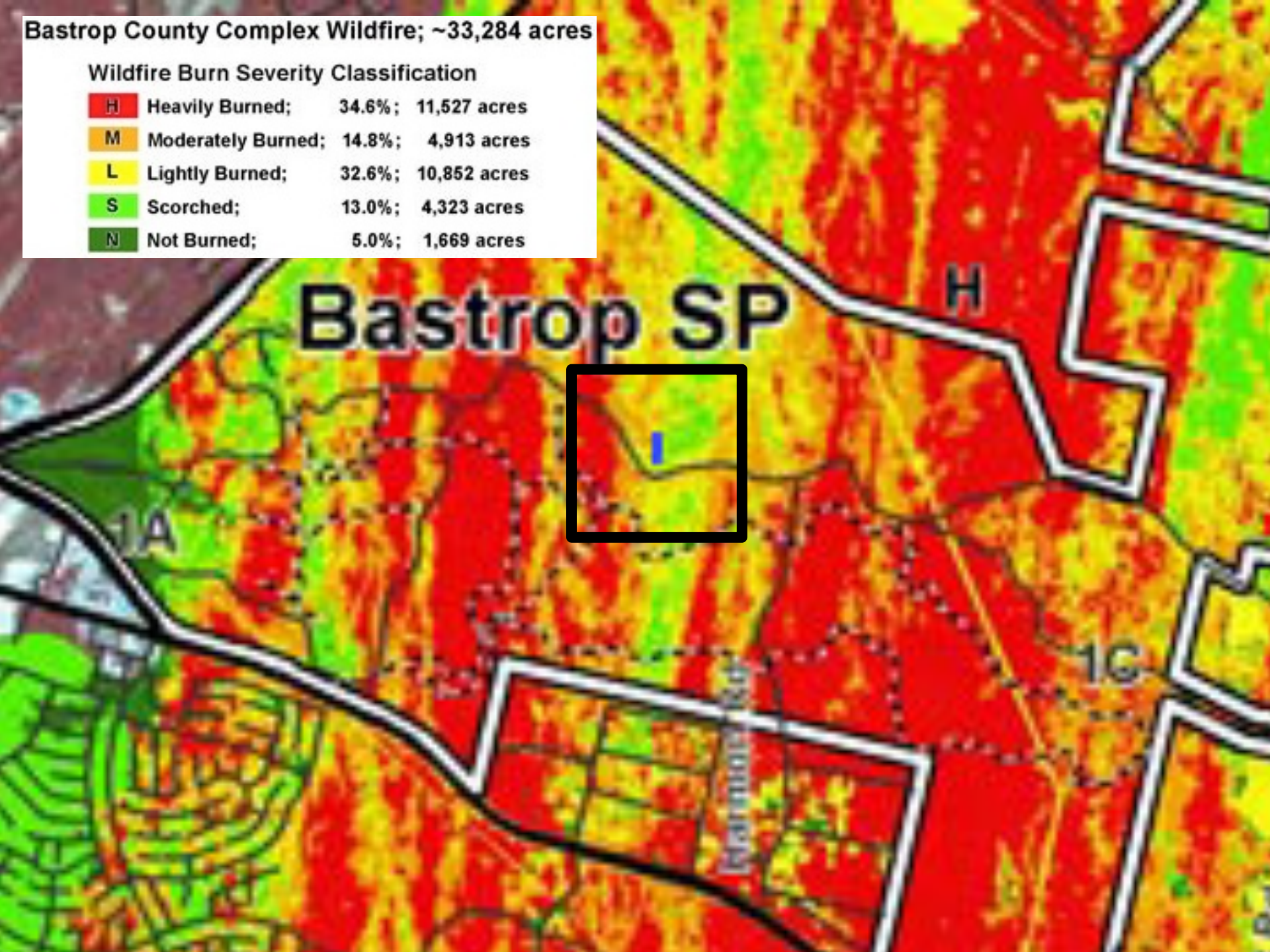
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Bastrop SP
H
1A
1C

Field site

- On border of moderately burned and scorched areas
- Study transect runs north-south
- Work has become increasingly hazardous as trees fall

Unburned end, looking north

Burned end, looking south

165 m

0 m

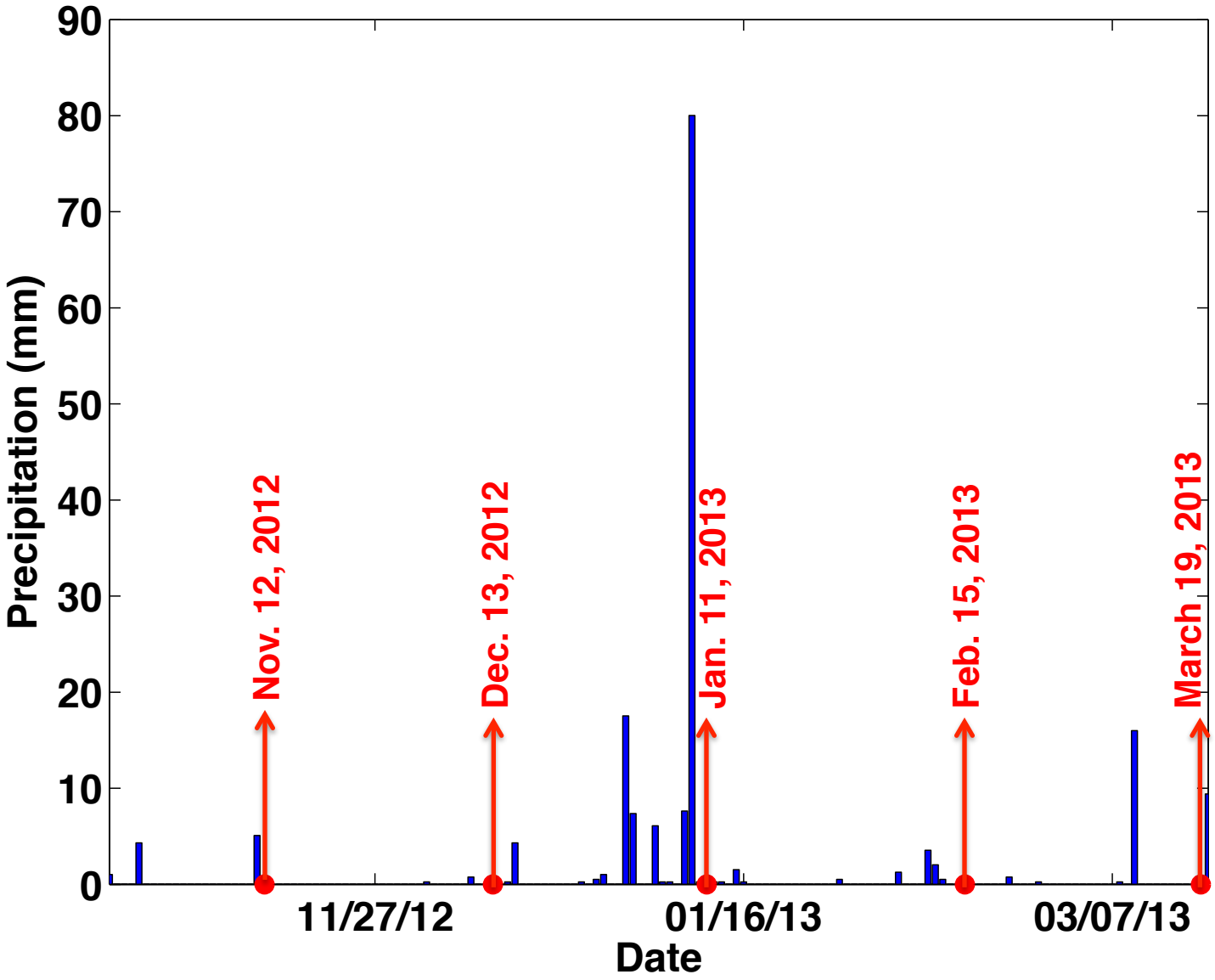
N

Loblolly pine (*Pinus taeda*)

- Favor extensive shallow lateral root systems
- Roots typically spread farther than tree crowns
- Rooting depth varies, but usually found no deeper than ~50 cm in mature trees

Texas Parks & Wildlife Department

Precipitation data and trip dates



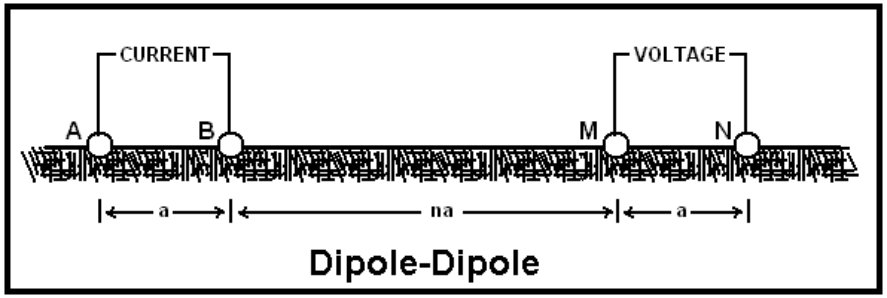
Electrical resistivity

- Resistivity can be affected by soil moisture, geology, salinity
- Based on Ohm's law: R = V / I

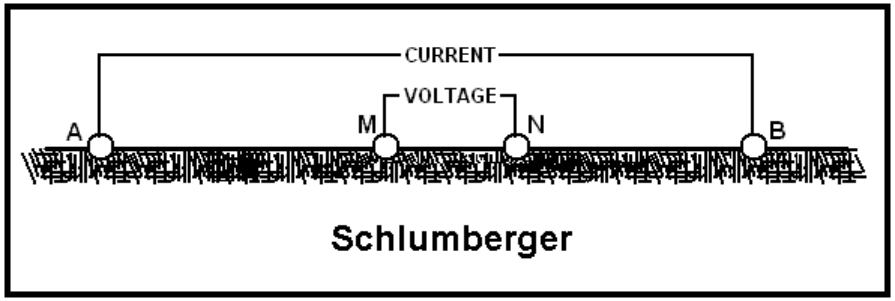
  R = calculated resistance

  V = potential difference measured

  I = injected current
- Used to calculate apparent resistivity (ρ_a = R * K), which was inverted into resistivity using Res2D software
- Surveys (Dipole-dipole and Schlumberger) conducted monthly using Advanced Geoscience Inc.'s SuperSting
- 165 m transect, with 56 electrodes spaced 3 m apart



1800geophysics.com



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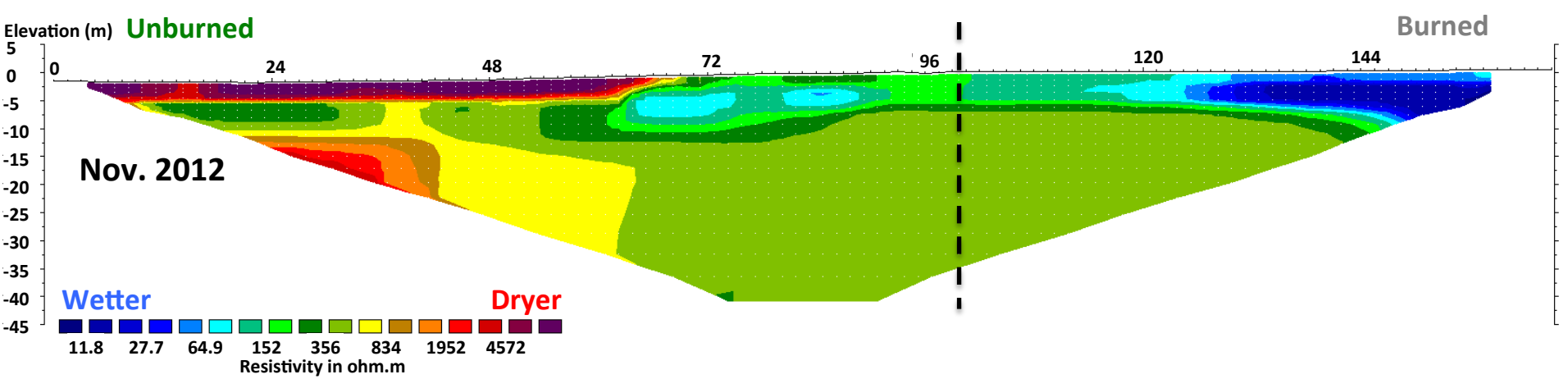
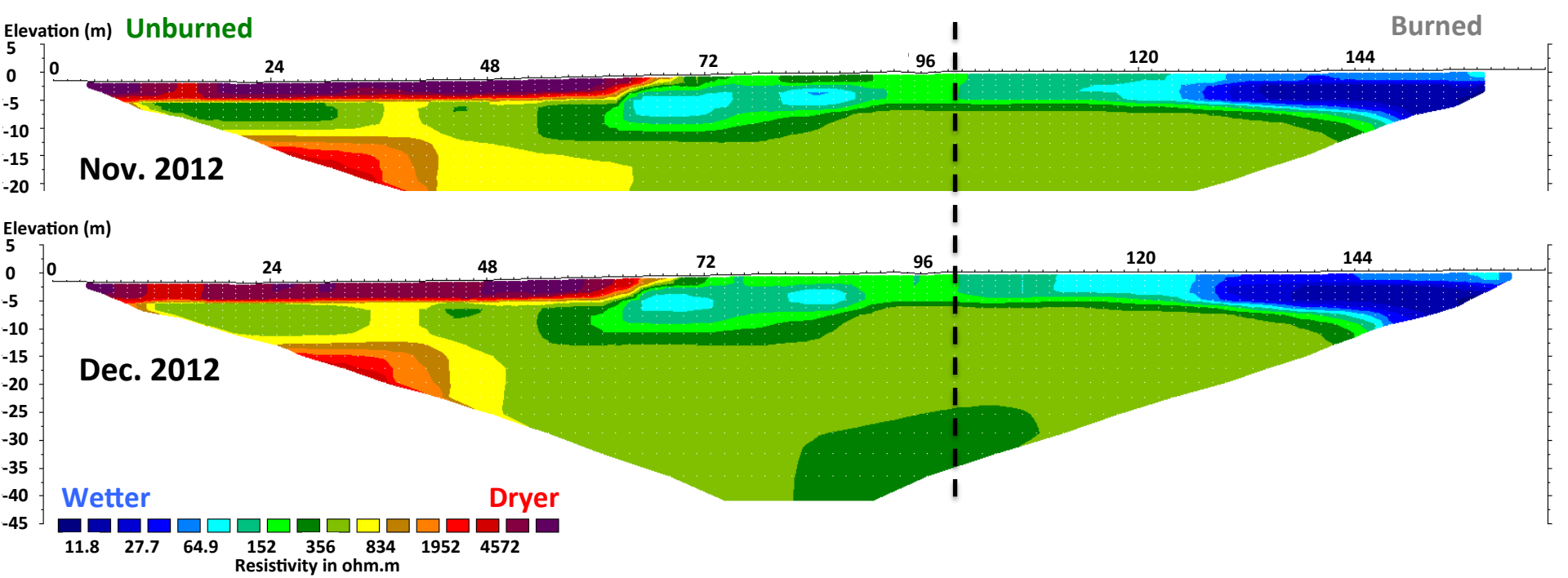

Elevation (m)
Unburned
Burned
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
0
24
48
72
96
120
144
Nov. 2012
Wetter
Dryer
11.8
27.7
64.9
152
356
834
1952
4572
Resistivity in ohm.m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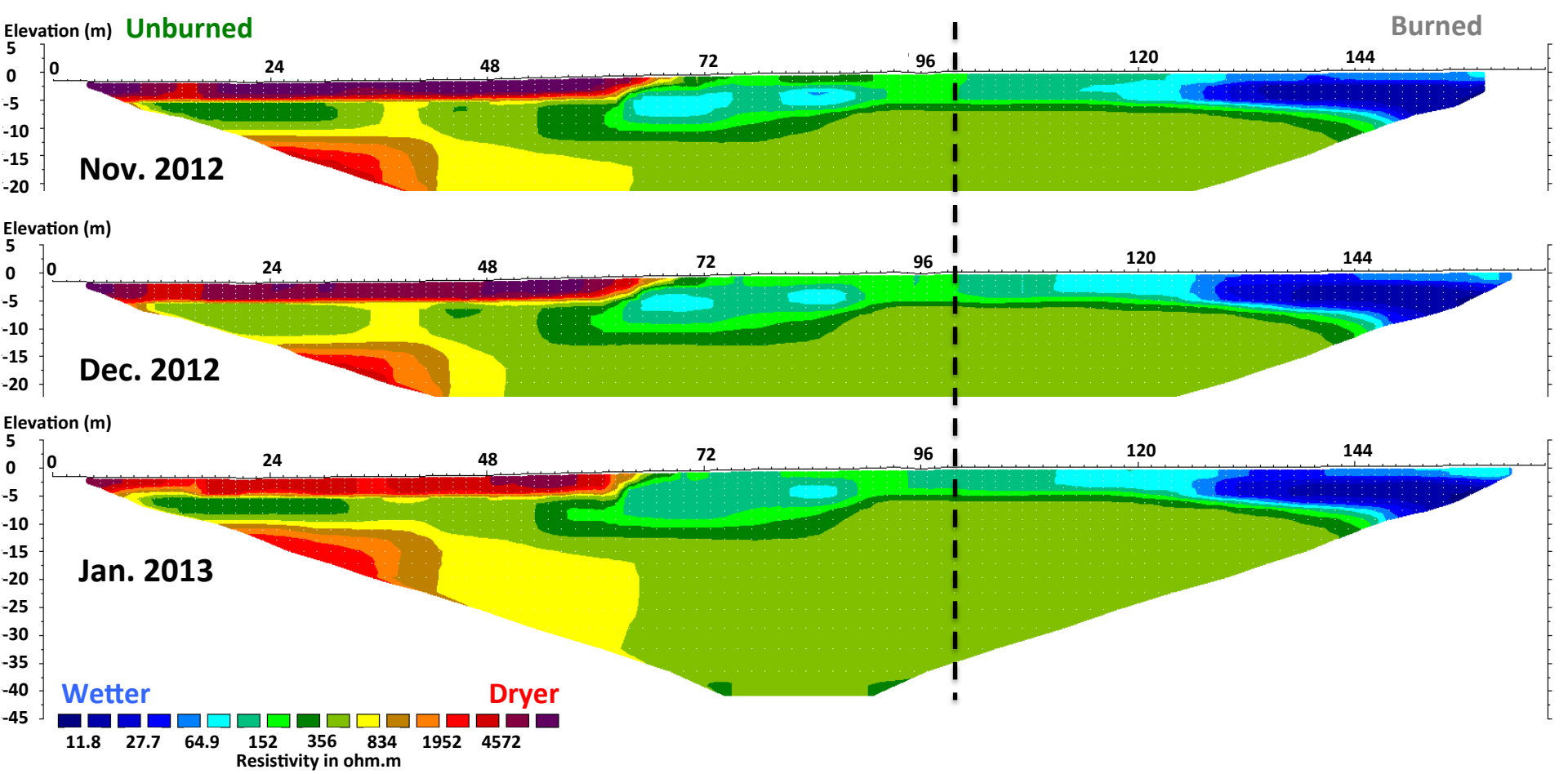
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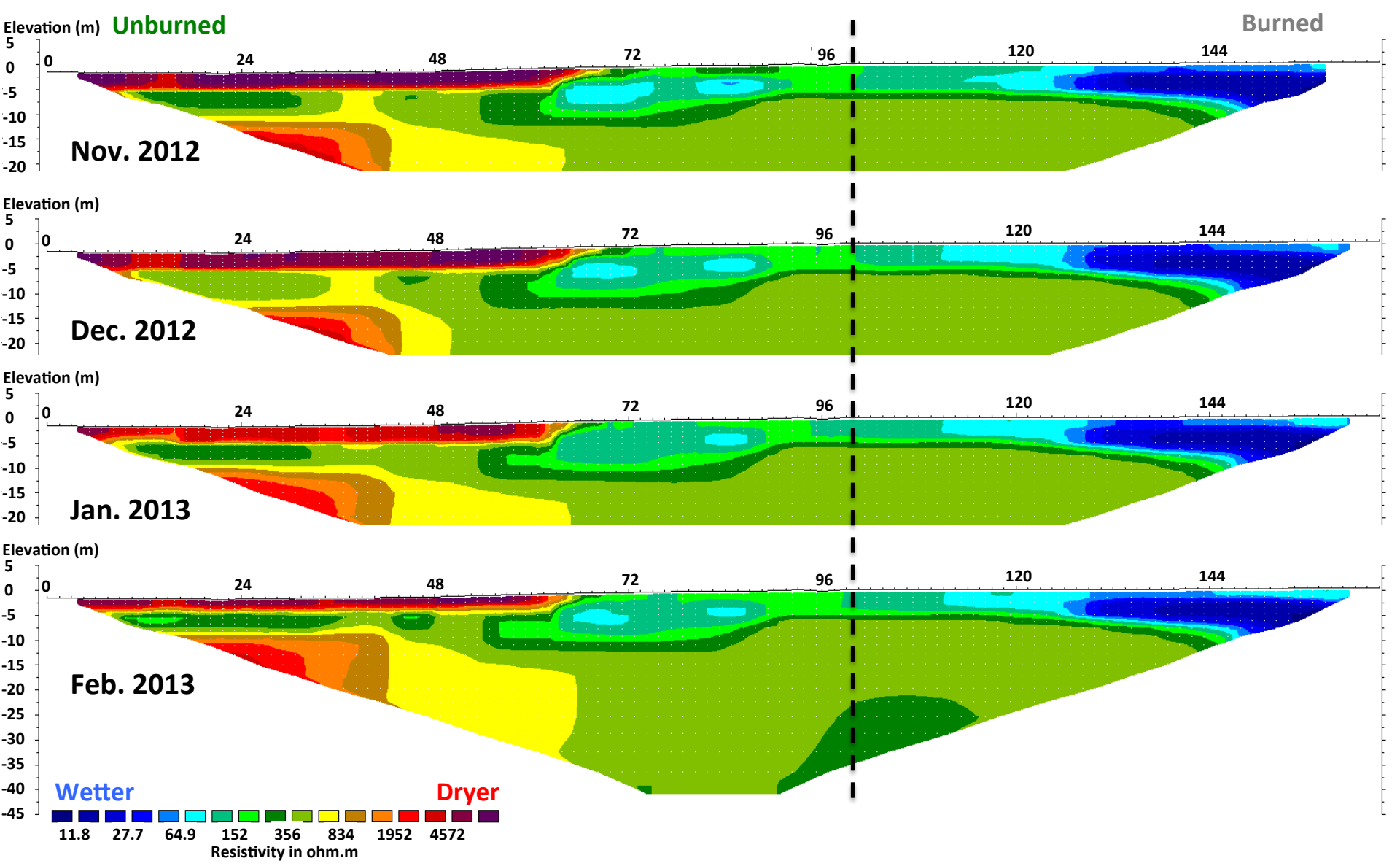
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Unburned
Burned
5
0
-5
-10
-15
-20
0
24
48
72
96
120
144
Nov. 2012
Elevation (m)
Dec. 2012
Elevation (m)
Jan. 2013
Elevation (m)
-25
-30
-35
-40
-45
Feb. 2013
Wetter
Dryer
11.8
27.7
64.9
152
356
834
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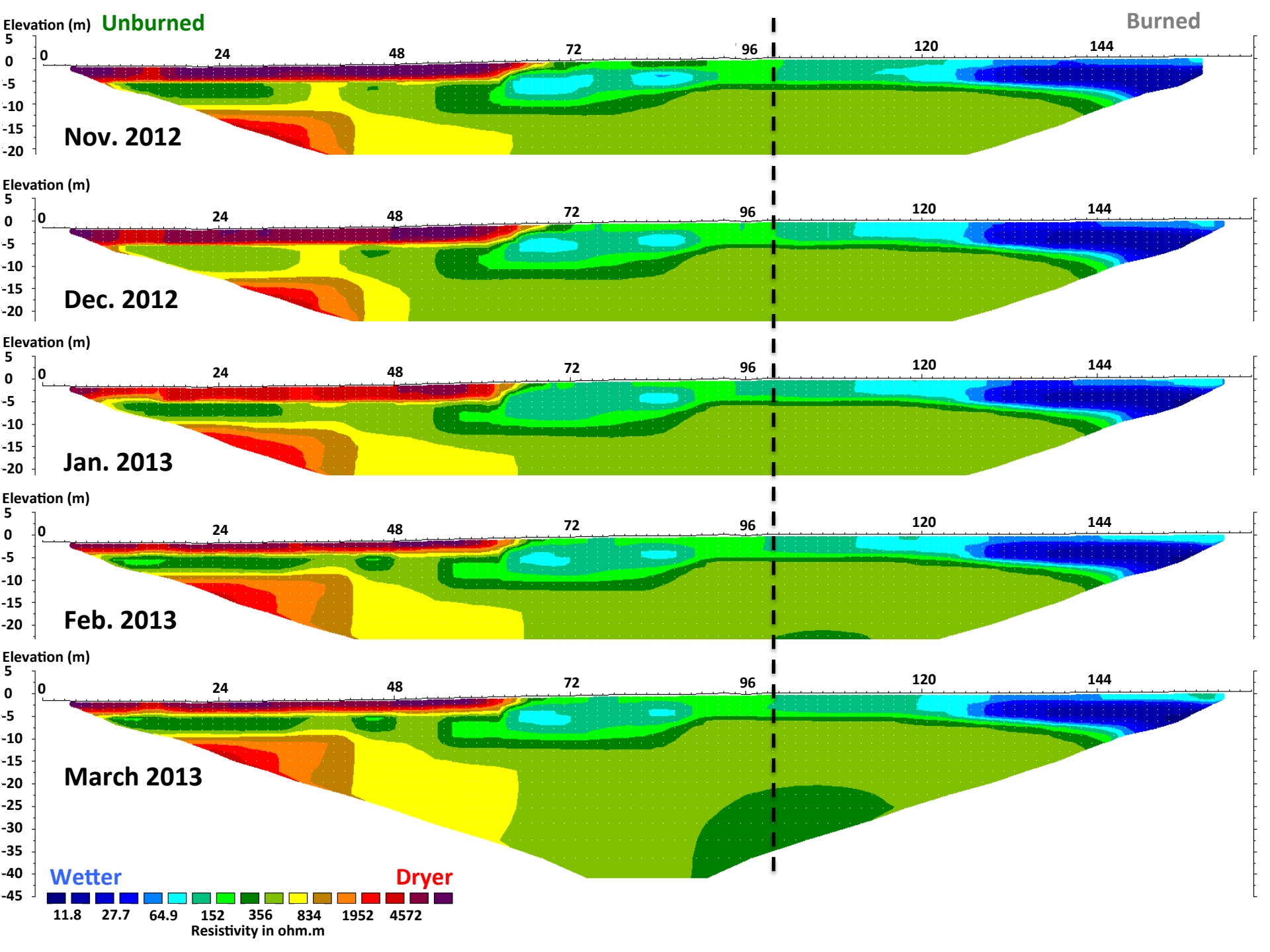
Resistivity in ohm.m


Elevation (m)
Unburned
Burned
Nov. 2012
Dec. 2012
Jan. 2013
Feb. 2013
March 2013
0
24
48
72
96
120
144
5
0
-5
-10
-15
-20
-25
-30
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-40
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Theta probe

Delta-T Devices

- Measurements taken at each electrode along the transect
- Senses dielectric constant of the soil, which is converted to soil moisture
- Reads soil moisture at the surface

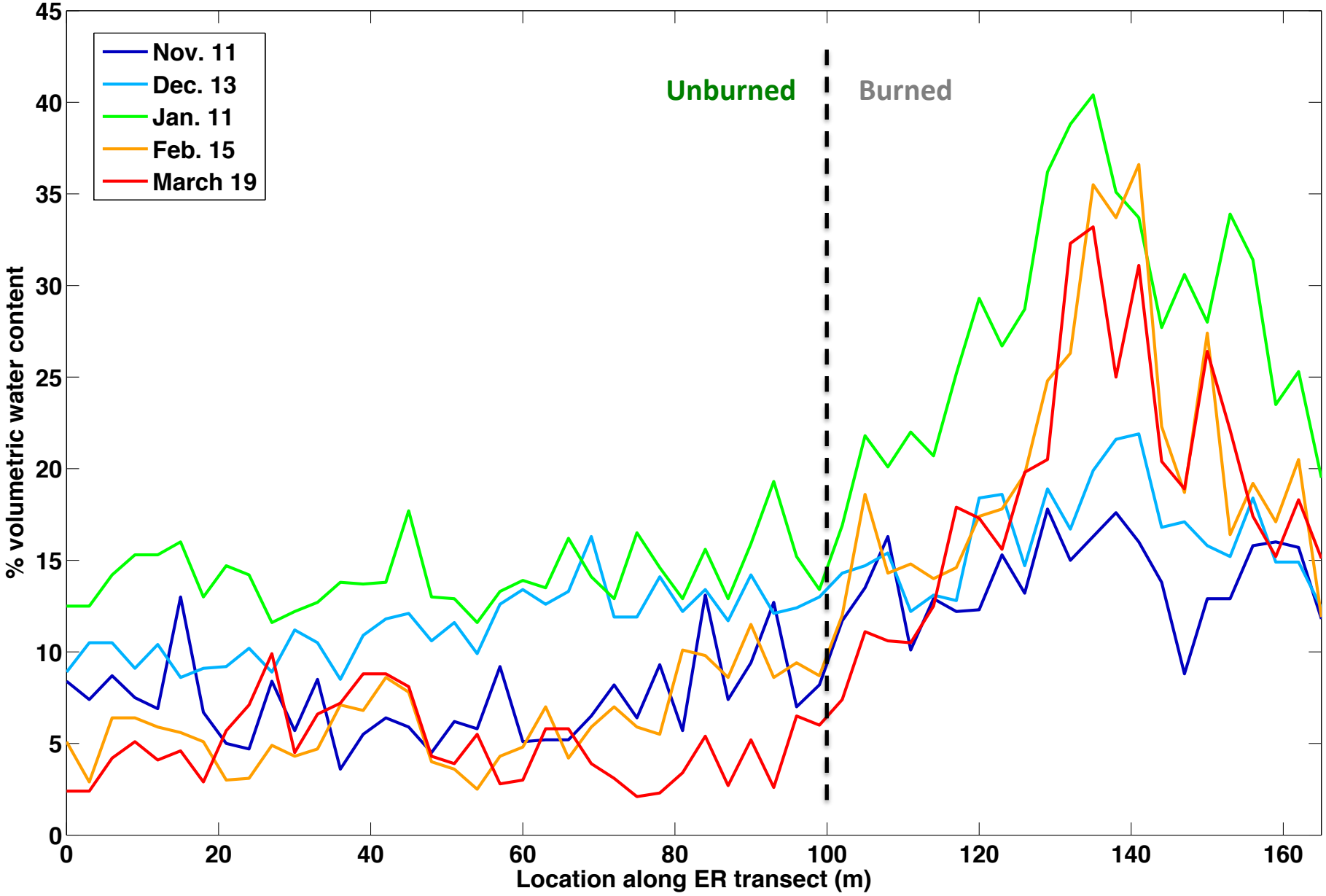
165 m

0 m

x Theta probe readings

N

Surface soil moisture distribution



PR2 profile probe

Delta-T Devices

- Monthly measurements taken at 4 points along study transect
- Measures a vertical moisture profile at 6 depths, up to 1 m
- Uses EM fields to measure permittivity, which is converted to soil moisture

165 m

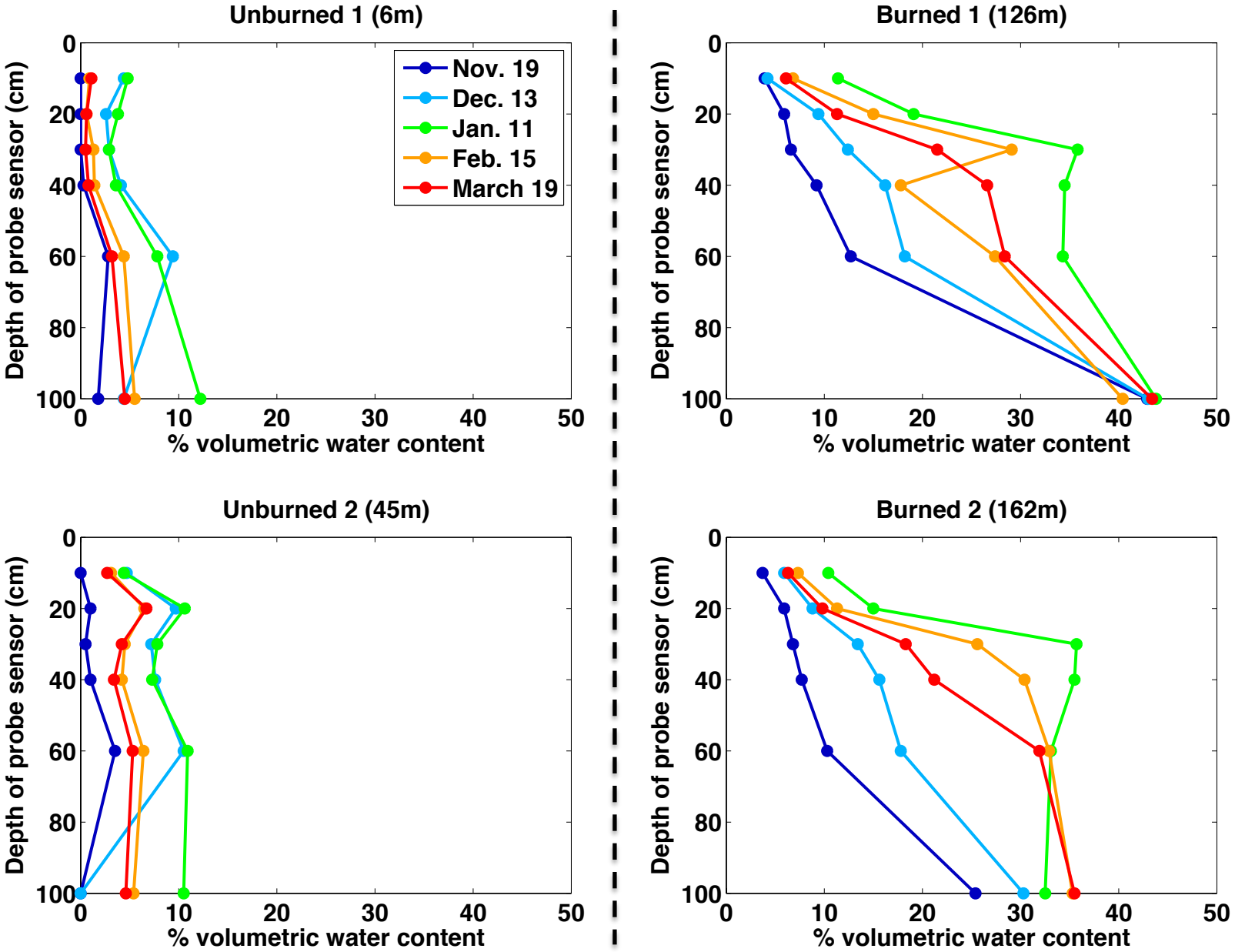
0 m

x Theta probe readings

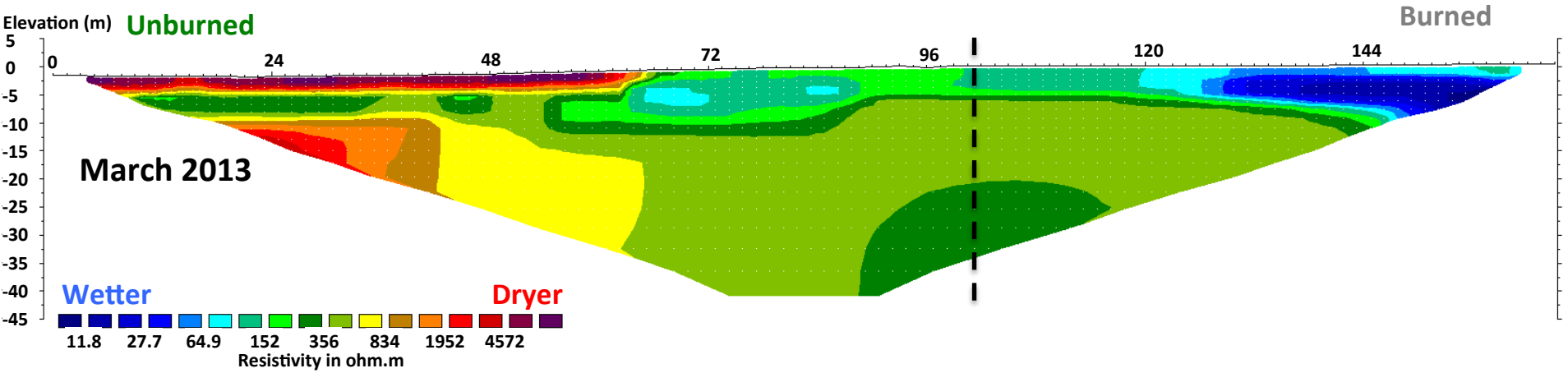
o PR2 probe readings

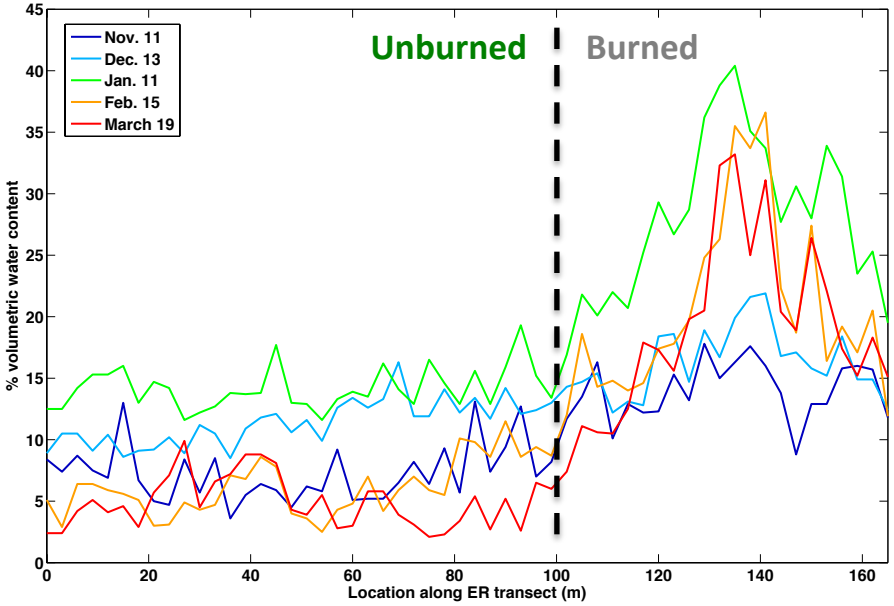
N

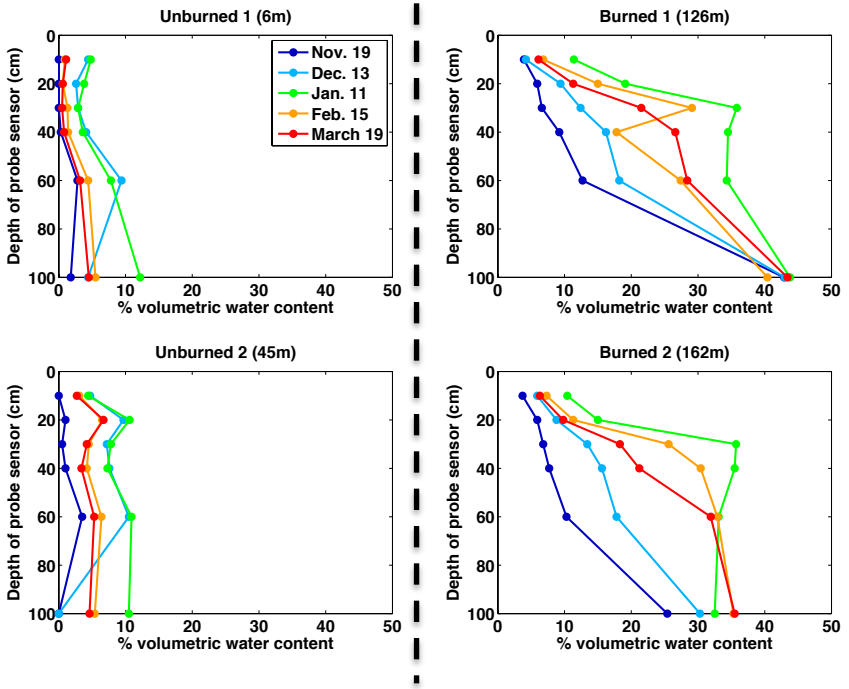
Vertical soil moisture profiles



Putting it together







Conclusions

- The soil is much wetter at the burned end of the transect than at the unburned end
- The increase in soil moisture below 60 cm at the unburned end of the transect suggests trees are taking up much of the soil moisture there
- Wildfire could have long-term effects on soil moisture, impacting infiltration and recharge

Future work

- Additional monthly trips to further study effects of seasonality
- Better constrain soil physical properties: more ground truthing; grain size analysis; hydraulic conductivity measurements
- Use resistivity to calculate soil moisture
- Repeat this study using more ER transects

Acknowledgments

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Burning questions?