Wind Erosion from Soils Burned by Wildfire

Natalie Wagenbrenner[1,3]

Matthew Germino[2], Brian Lamb[3], Peter Robichaud[1], Randy Foltz[1]

[1]Rocky Mountain Research Station, [2]USGS, [3]Washington State University

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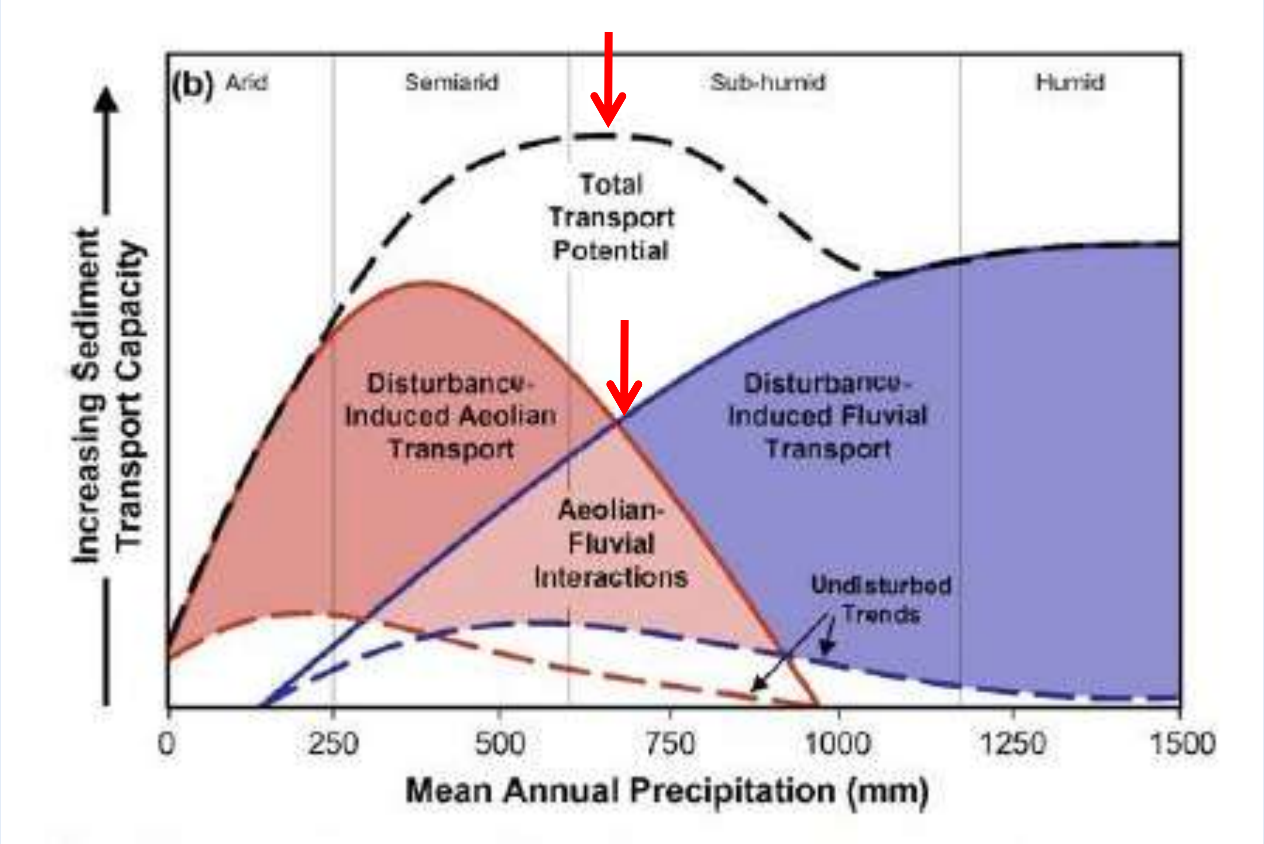
Motivation

Wind erosion understudied compared to fluvial processes in the post-fire environment

Is likely an important process in many burned landscapes



Field et al., 2009

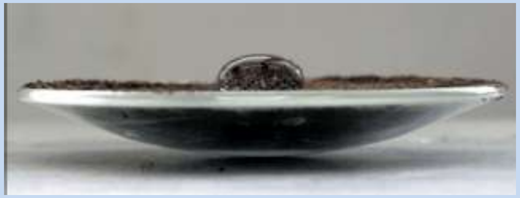
Wind Erosion after Wildfire

- 2000 Cerro Grande Fire, New Mexico
  - Continued emissions 3 years post-fire due to drought (Whicker et al., 2006)
- 2007 Milford Flat Fire, Utah
  - Air quality issues in populated regions downwind
  - Visibility issues caused closures of major transportation corridor
  - Seeding mitigation efforts ineffective
  - Continued wind erosion 3 years after fire *(Miller et al., 2010)*

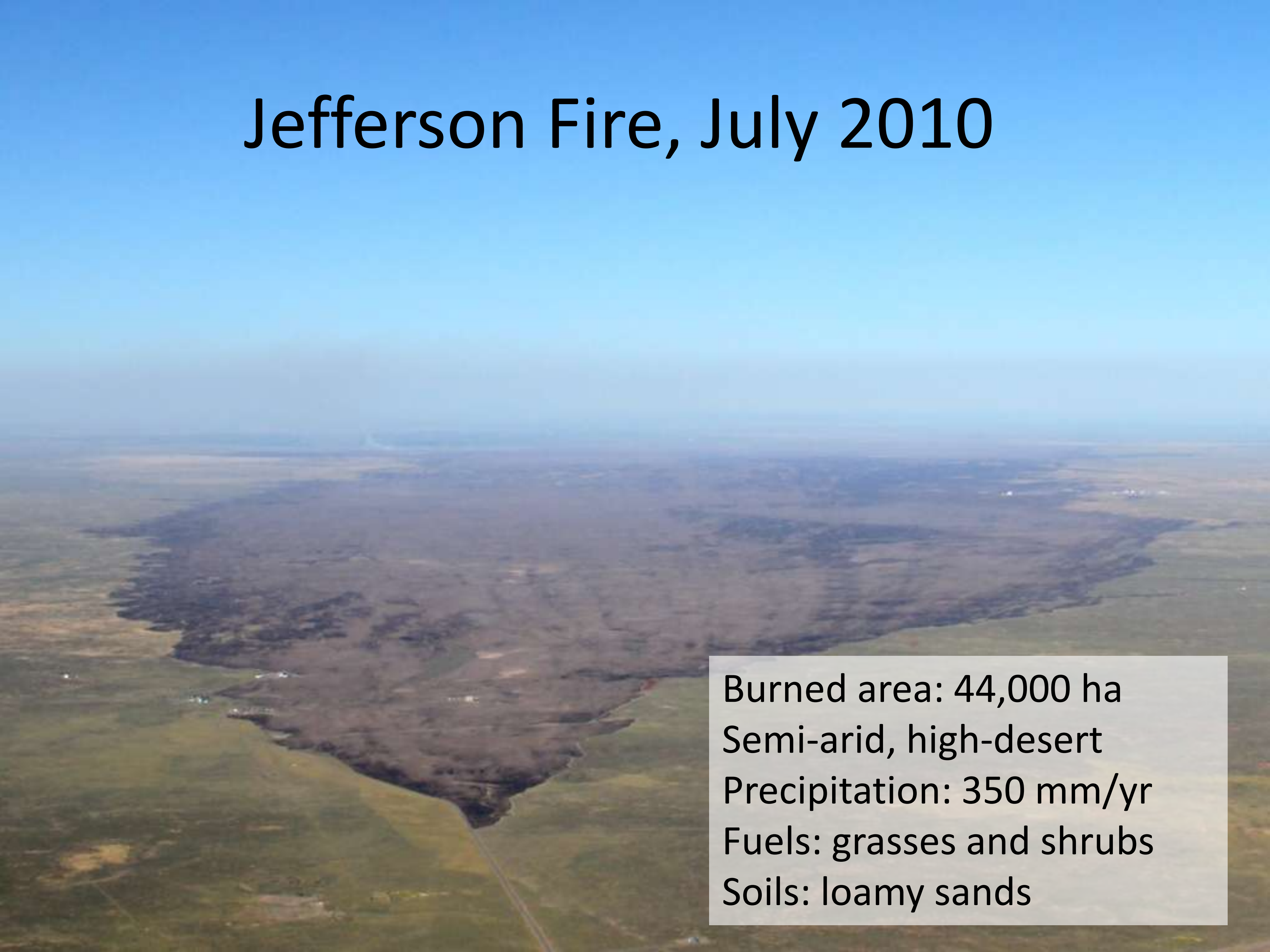
- Sankey et al., 2009

Fire Increases Wind Erodibility

- Loss of ground cover
- Fire-induced soil water repellency (*Ravi et al., 2006*)
- Destruction of naturally occurring soil crusts (*Ford and Johnson, 2006*)
- Aggregate break-up (*Varela et al., 2010*)
  - Pressure differences from heat of fire
  - More erodible particles after fire
- Wildfire ash (*Woods and Balfour, 2010*)
  - Suspected to be highly erodible
  - Super-dessicated, non-cohesive, low packing density

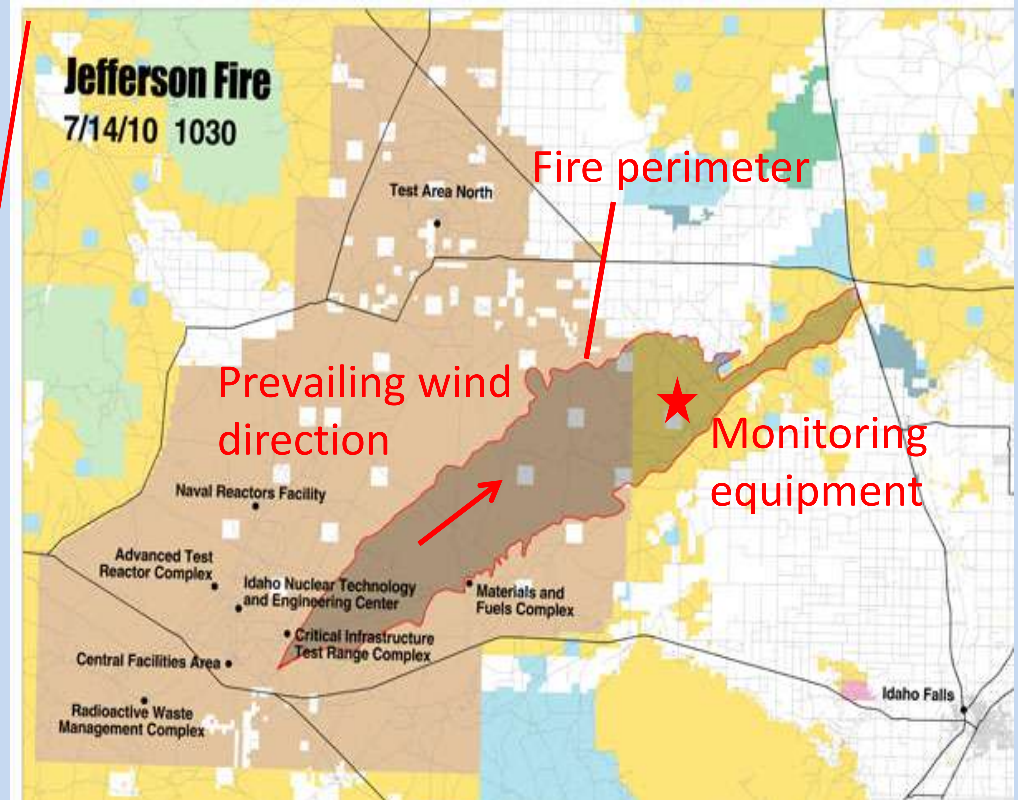


Jefferson Fire, July 2010



Burned area: 44,000 ha
Semi-arid, high-desert
Precipitation: 350 mm/yr
Fuels: grasses and shrubs
Soils: loamy sands

Post-fire Field Study



Jefferson Fire Field Site

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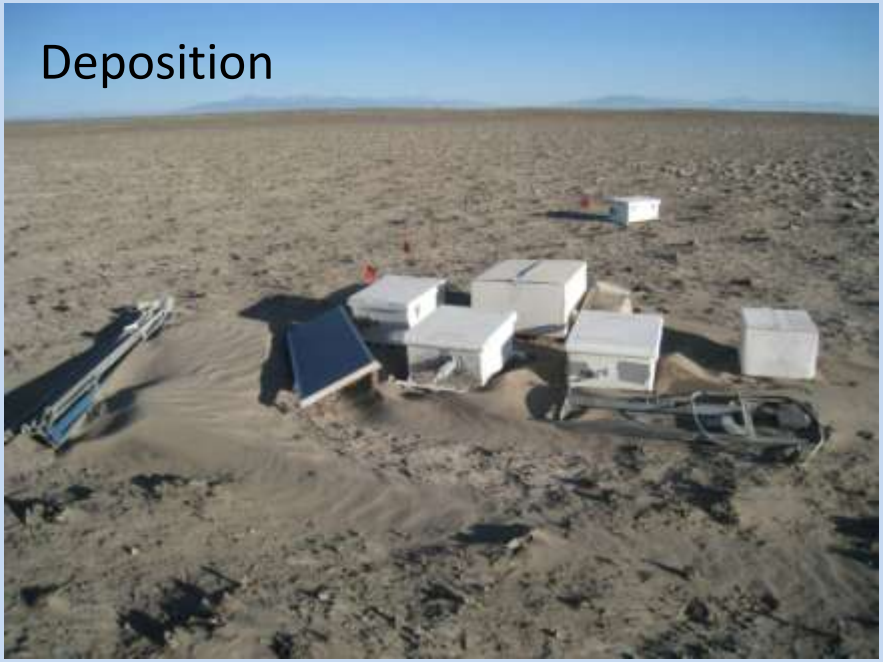
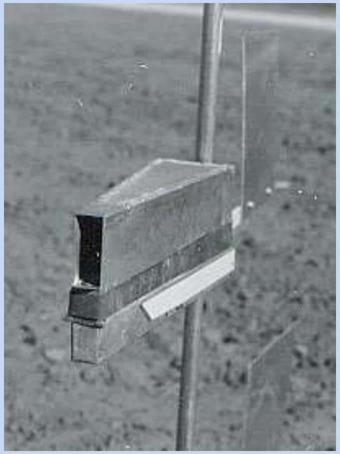
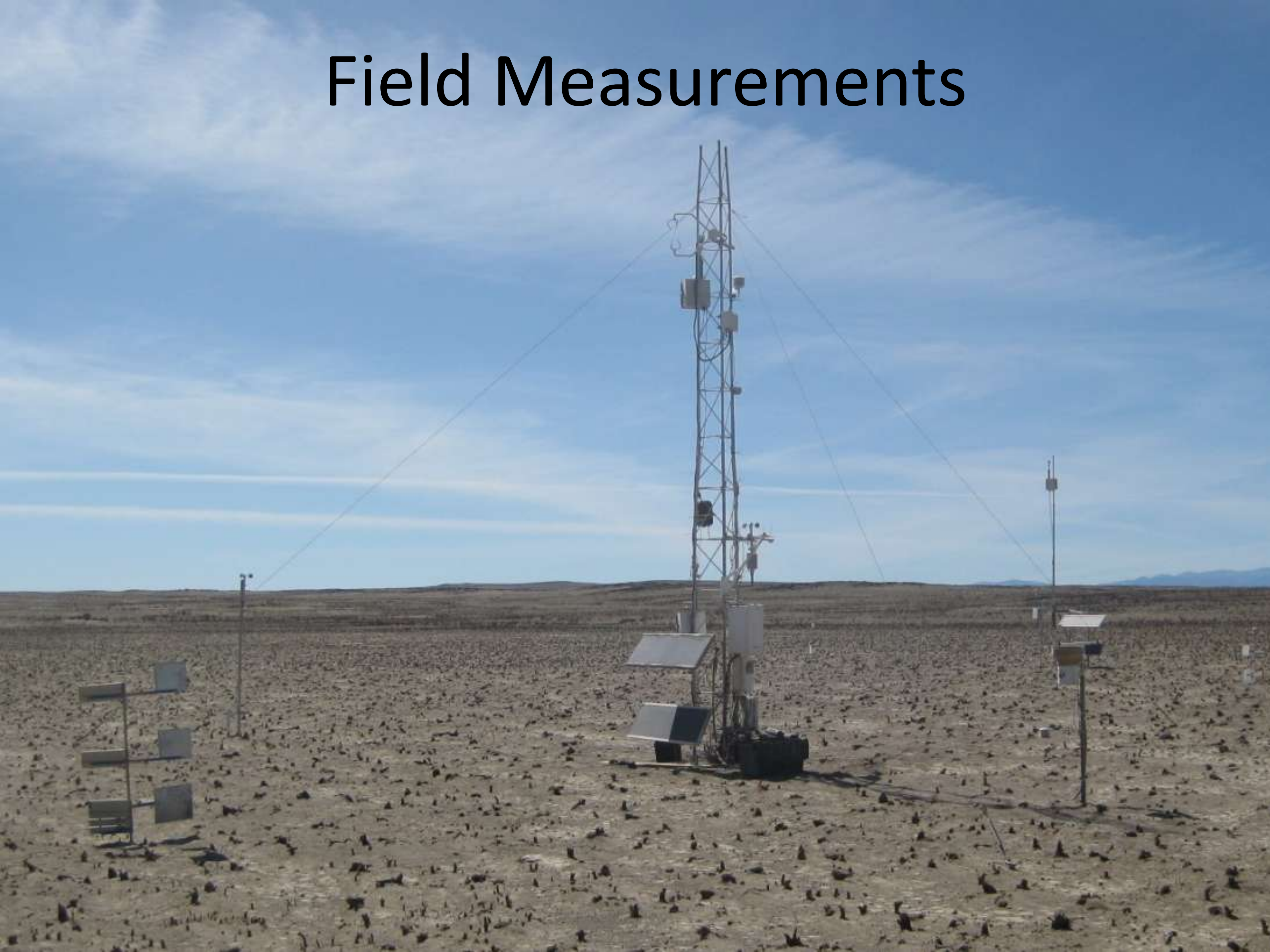


Field Measurements

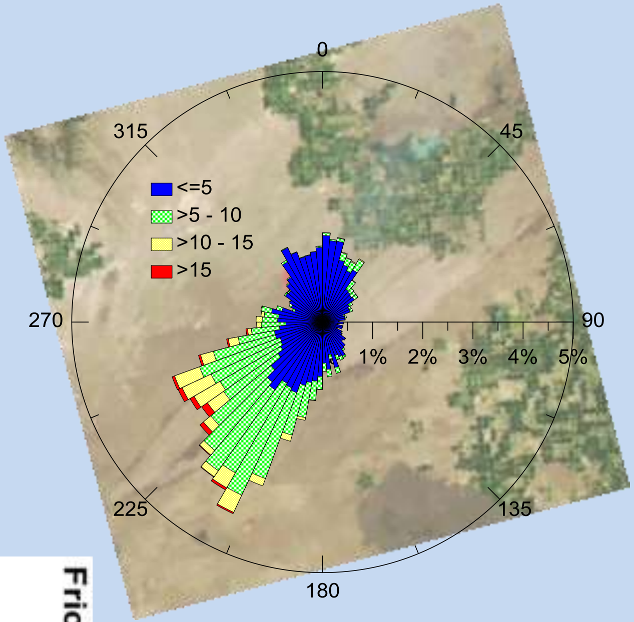
- Passive sediment traps (BSNEs)
  - 5, 10, 20, 55, and 100 cm above soil surface
- Real-time PM_{10} concentrations
  - E-Sampler (MetOne)
  - 2 and 5 m
- 3-D sonic anemometer
- RH, soil moisture, precipitation, solar radiation

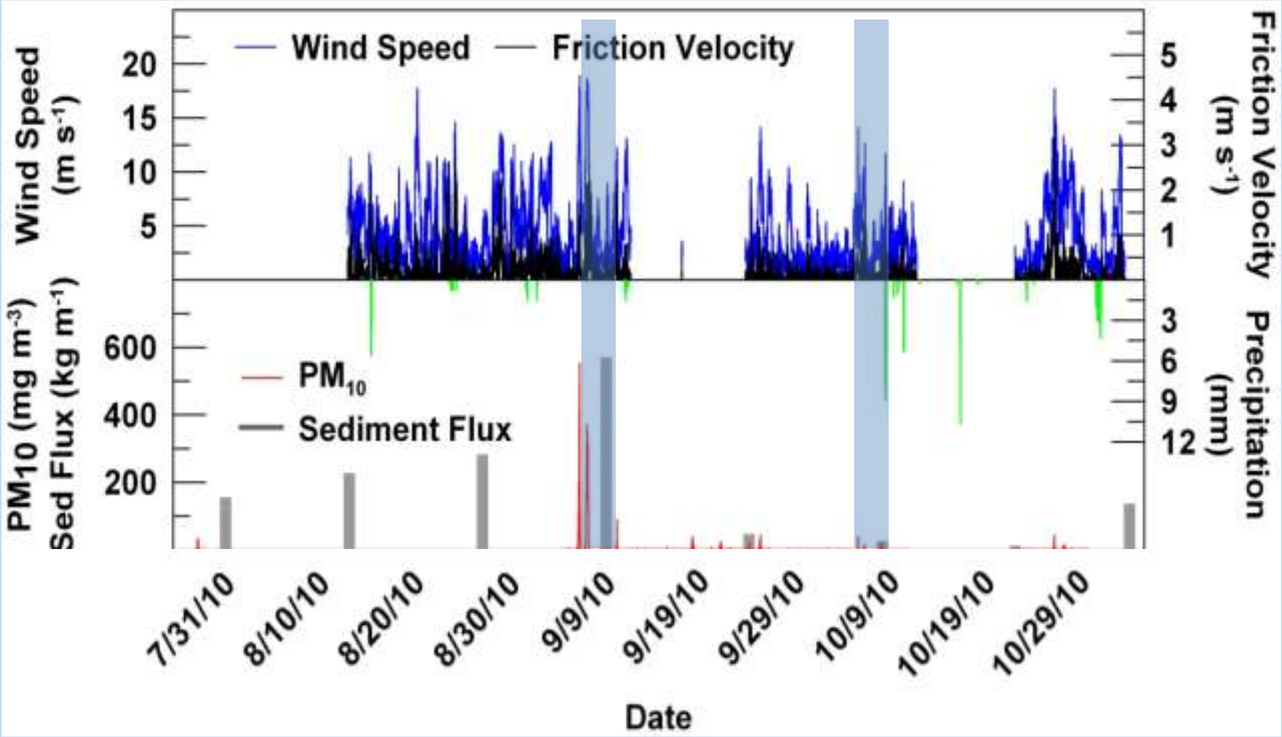


Field Measurements



Results: Fall 2010





4-5 September: Sediment Flux

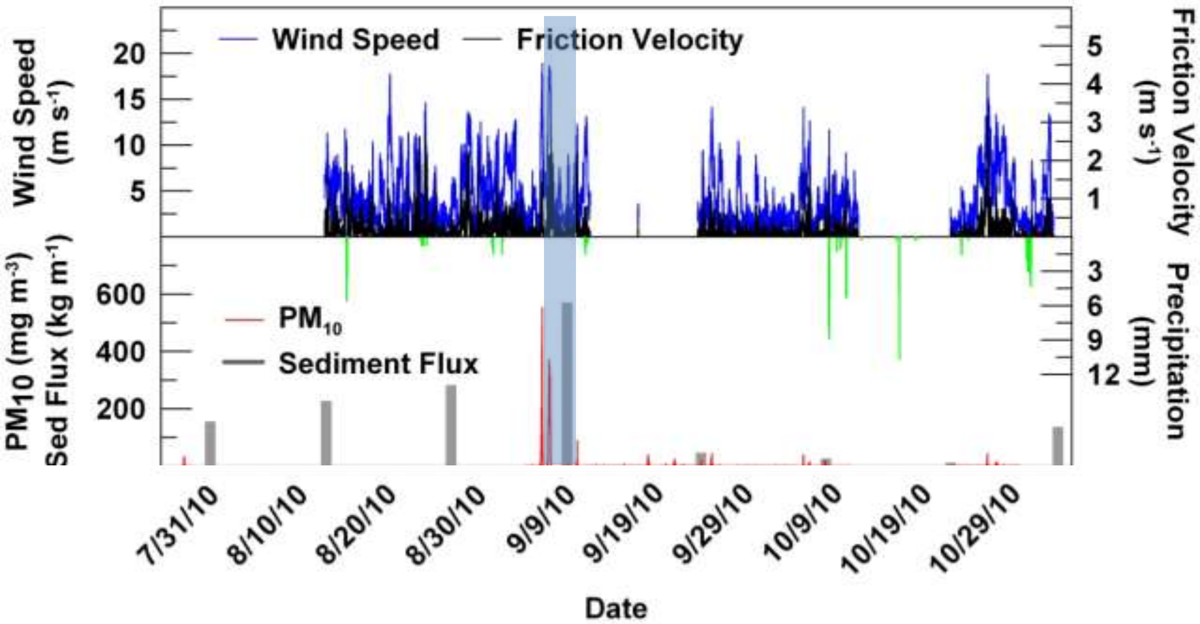
- Strongest wind event after fire
- 13 mm of rain prior to event
- Lower sediment traps completely filled

Horizontal Sediment Flux:

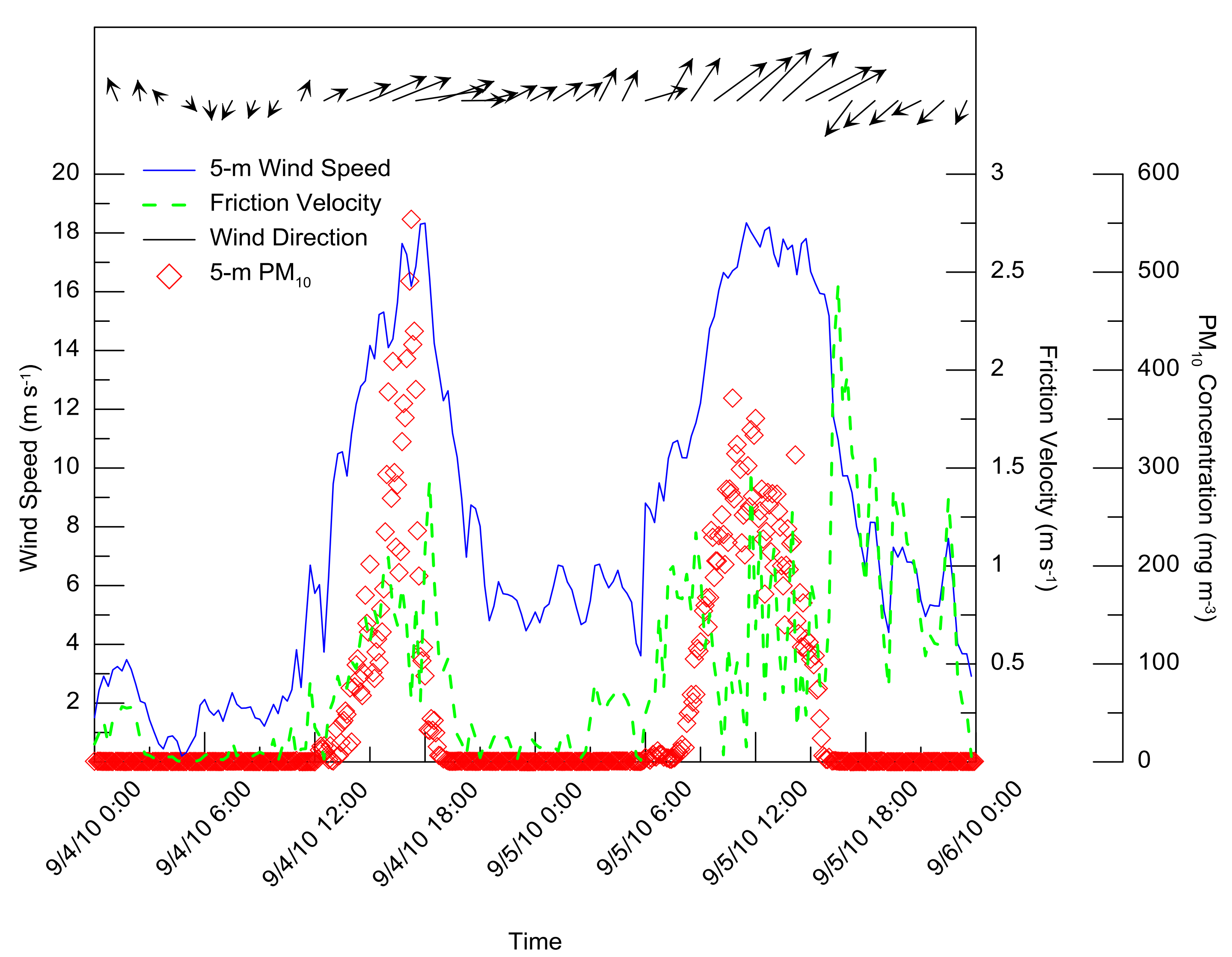
570 kg/m

570,000 kg/km

(width of burned area)

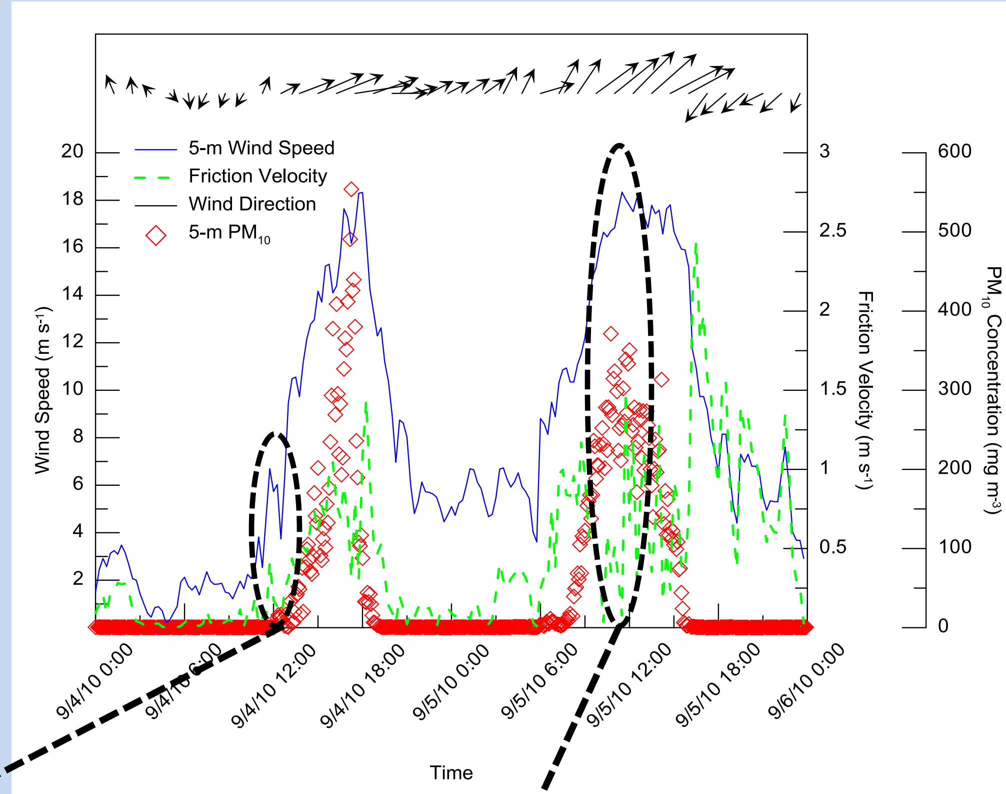


4-5 September: PM_{10} Emissions

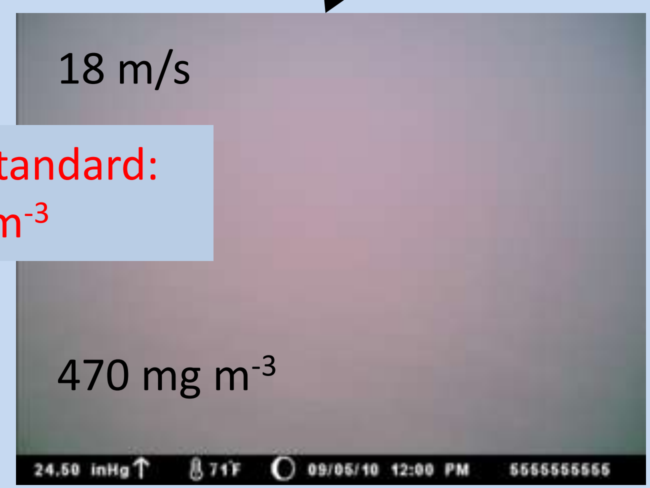


4-5 September

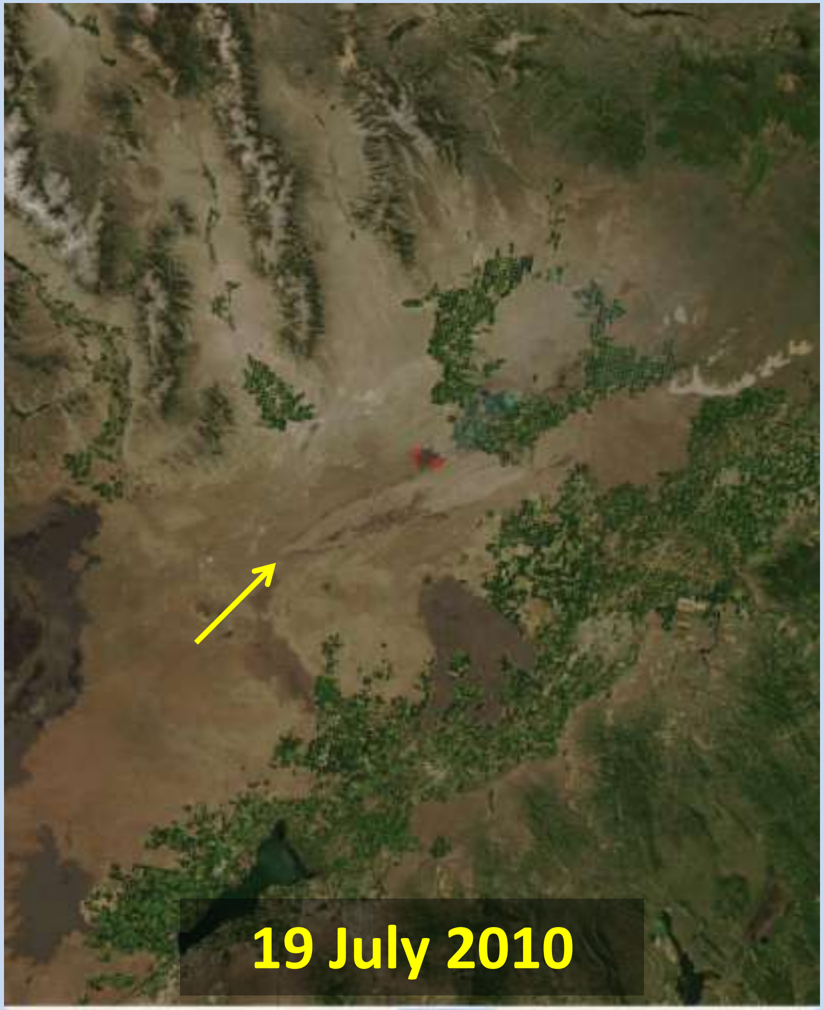
- After 13 mm precipitation
- Elevated emissions through night

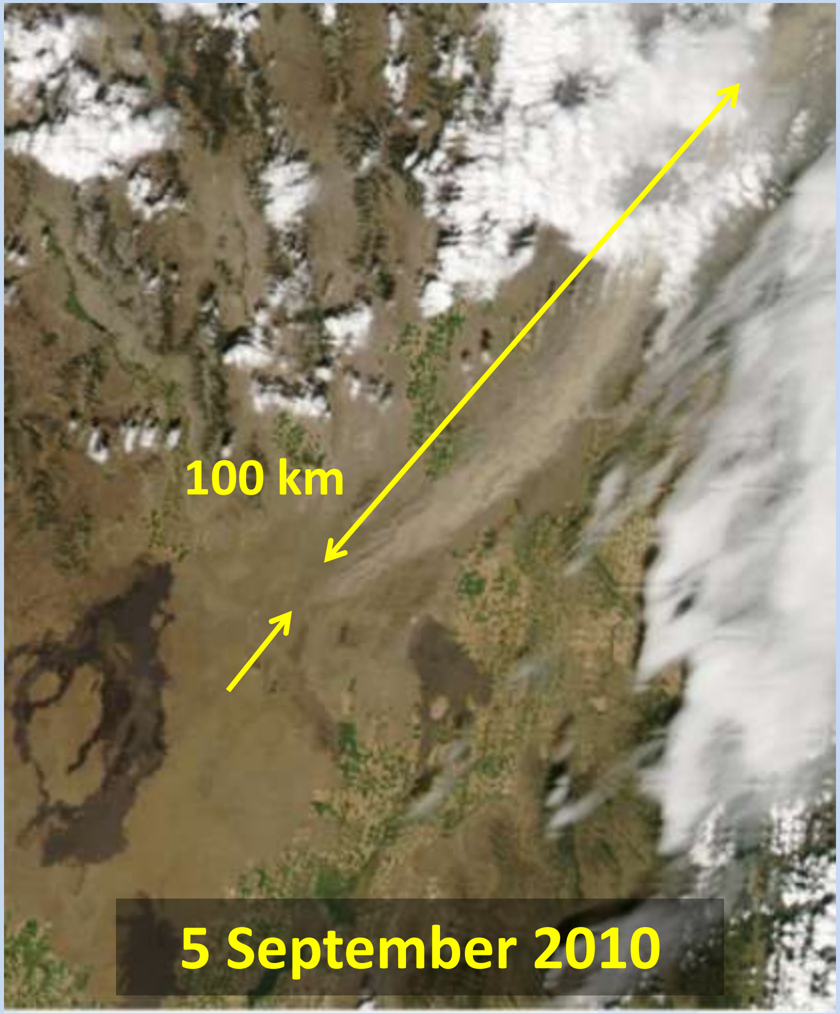


US EPA 24-hr Standard: 0.15 mg m^{-3}



4-5 September:
Dust plume extended at least 100 km downwind

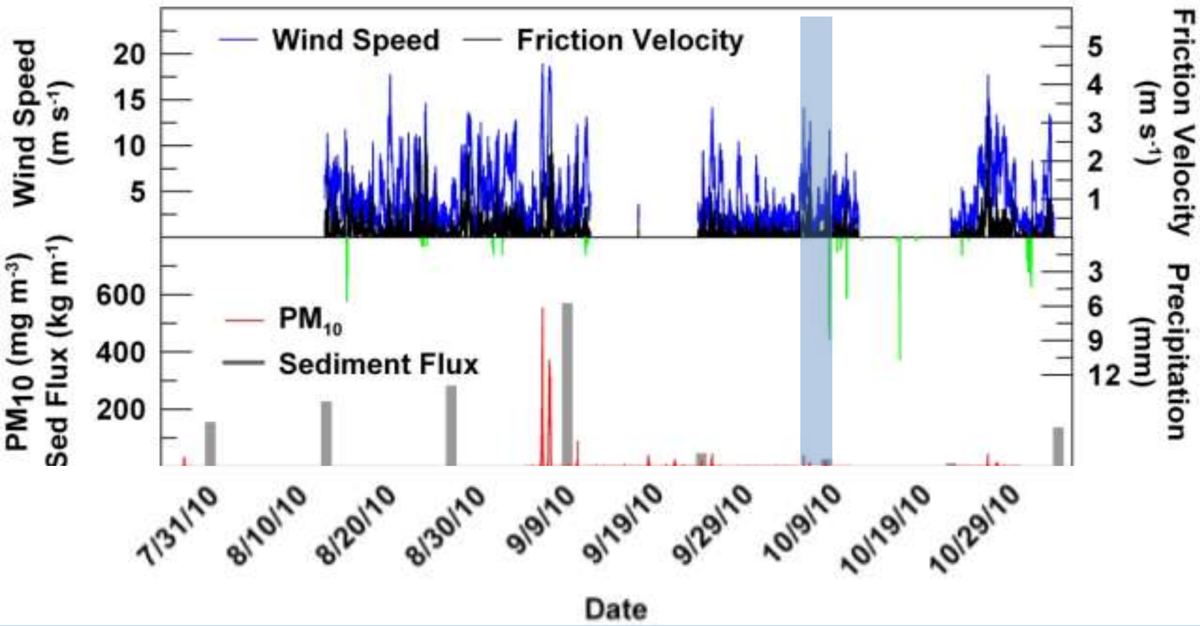




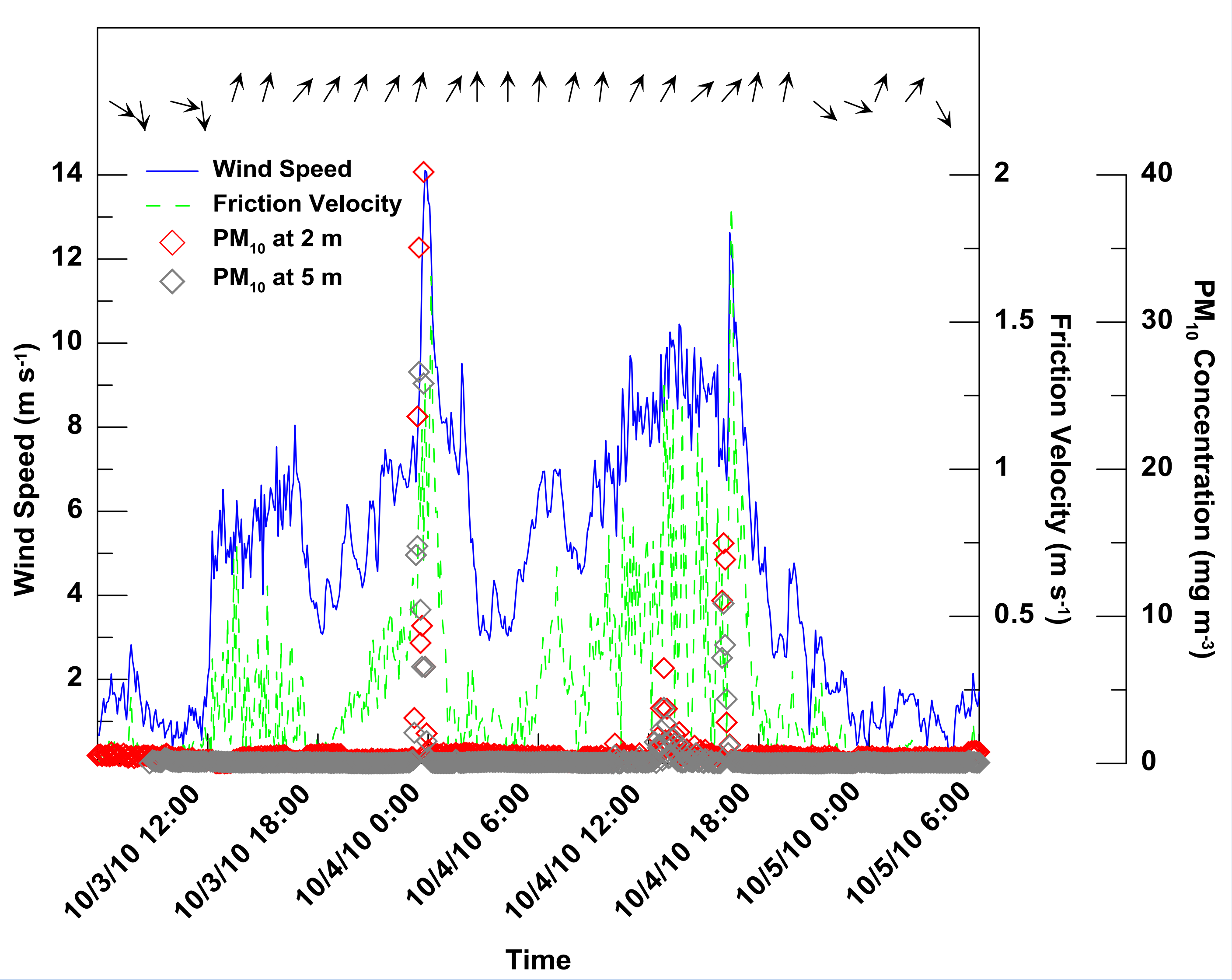
3-4 October: Sediment Flux

Horizontal sediment flux: 26 kg/m

More frequent precipitation after this event



3-4 October: PM_{10} Emissions



Horizontal Sediment Flux

Event	Interval (days)	Flux (Kg m^{-1})	Depth (m)
Netherlands *Riksen and Goosens, 2005*	7	2000	1
Kansas *Fryrear, 1995*	1	1236	2
Loess Plateau, China *Dong et al., 2010*	30	800	150
4-5 Sep	11	570*	1
Texas *Van Pelt et al., 2004*	1	626	1
Australia *Leys and McTainsh, 1996*	7	213	2.3
3-4 Oct	14	26	1
Columbia Plateau *Sharratt et al., 2007*	3	22	1.5
Mojave Desert *van Donk et al., 2003*	30	77	2

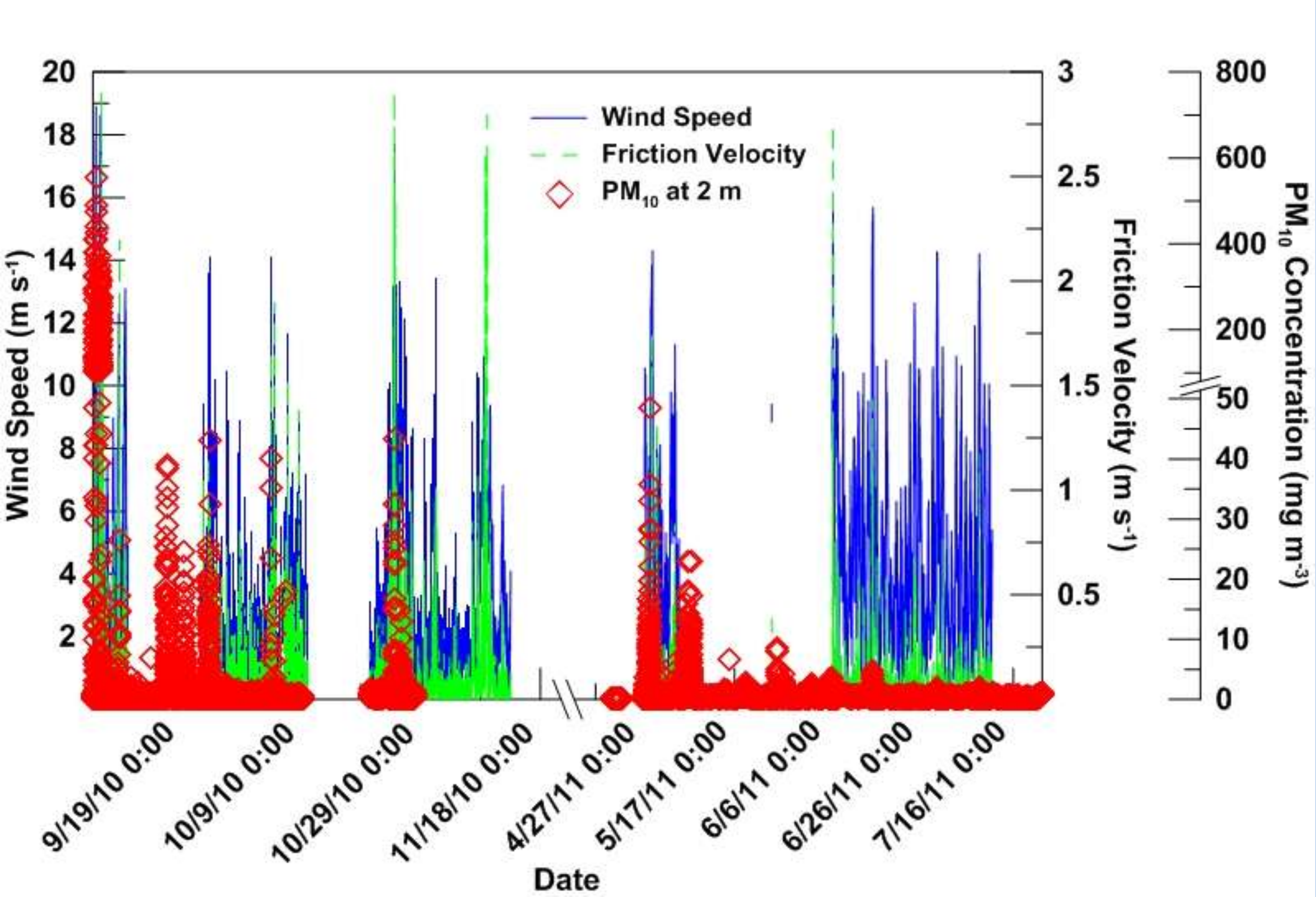
** Conservative estimate, sediment traps overfilled*

PM_{10} Concentration and Vertical Flux

Dust Event	Event Duration (hrs)	Max Concentration (µg m^3)	Max Vertical Flux (µg m^2 s^{-1})
4-5 Sep	28.5	690,000	-
3 Oct	1	40,000	4280
4 Oct	0.5	14,970	1090
Columbia Plateau *Sharratt et al., 2007*	14	8535	-
4 Oct	1.5	6480	1510
Columbia Plateau *Kjelgaard et al., 2004*	-	6000	258
Texas *Zobeck and Van Pelt, 2006*	2.5	200	400
Texas *Stout et al., 2001*	-	166	-

**E-Samplers (MetOne Instruments) were used to measure PM_{10} in this study; they were calibrated against an E-BAM (MetOne Instruments;US EPA Equivalent Method) for the soils at the burned site.*

Fall 2010 – Summer 2011: PM_{10} Emissions



Conclusions

- Fire can convert a wind erosion-resistant landscape into one that is highly erodible
  - Sediment fluxes on order of most erodible landscapes in US
  - Vertical fluxes of PM_{10} on the upper end of what has been reported in the literature
- Post-fire wind erosion poses risks both on-site and far downwind
- Dust emissions can persist for months after a fire

Other Questions

- Where is wind erosion a post-fire risk?
  - Ecotype, climate, terrain
- Erosion immediately post-fire
- Erosion mitigation
- Forecasting post-fire wind erosion events
- Impacts and interactions
  - Air quality
  - Deposition
  - Soil productivity
  - Aeolian-fluvial interactions


Thank You!
nwagenbrenner@fs.fed.us
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