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Observations of a Burning Bush as a Function of Wind and Moisture Content

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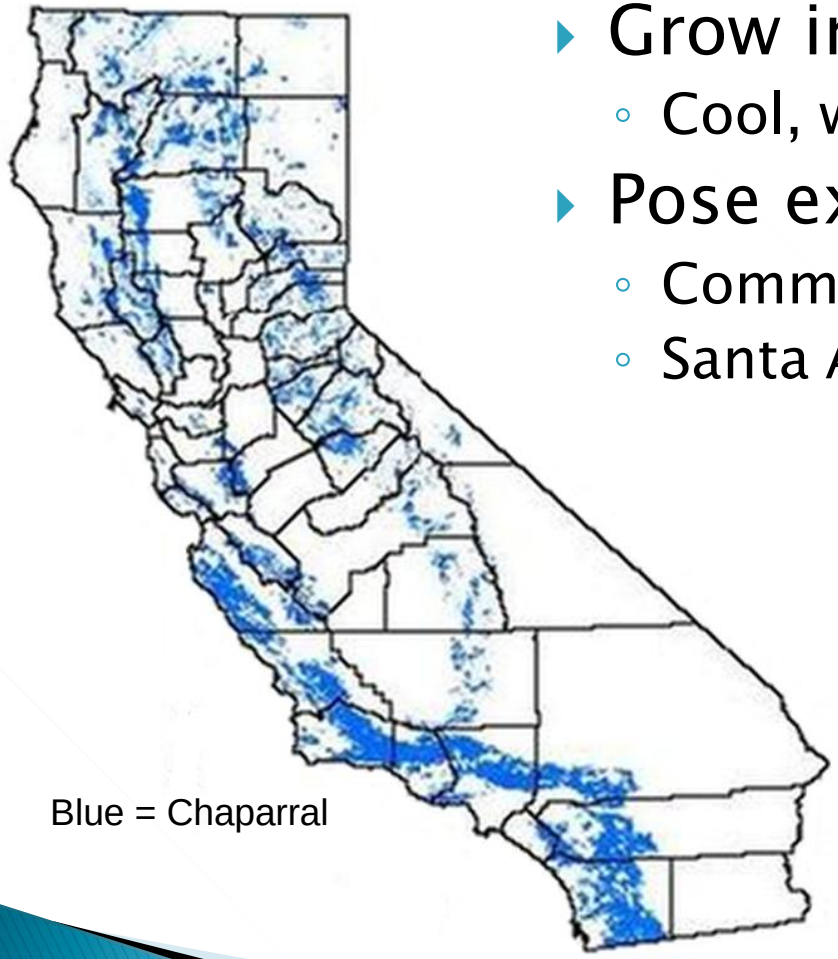
Introduction

- There is a need to predict fire spread in forest fuels
  - Prescribed burning
  - Safety of fire crews
- Observed difference between “live” and “dead” fuels
- Shrub model (Brandon Anderson, next)
  - Need a way to improve/validate model
  - First step in scaling up from single leaf experiments

Objectives

- Burn moist shrubs under well-controlled conditions
- Record behavior
  - Wind speed
  - Moisture content
  - Fuel type

California Chaparral



Blue = Chaparral

- Grow in Mediterranean climate
  - Cool, wet winters and hot, dry summers
- Pose extreme fire hazard
  - Common in Wildland-Urban Interface
  - Santa Ana Wind (>60 mph)

Old growth chaparral

Chaparral Species

Ceanothus[1]

Scrub Oak[1]

Chamise[1]

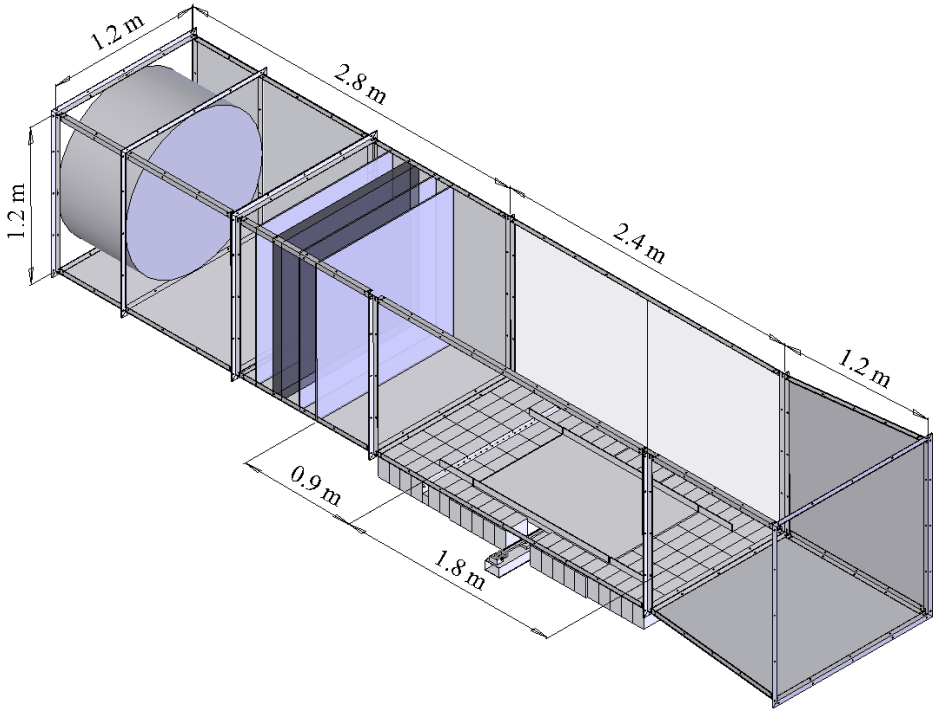
Mountain Mahogany[1]

Manzanita

Cleveland Sage[1]

[1]Images from http://www.sanelijo.org/chaparral.html, © 2001 Linda K. Hedlund

Experimental Apparatus



- Facilities provided by PSW Research Station in Riverside, CA
- Wind tunnel
  - Provided wind speeds of 0.45–1.08 m/s
- IR and video cameras

Preparing the Shrub

- Shrubs harvested from nearby regions
  - One week old
  - MC of 6-40%
- Shrubs were arranged in a wire mesh bed
- Shrubs were ignited using excelsior
  - Clump of excelsior (top image)
  - Bed of excelsior (bottom image)

Experiment Matrix

Run	Species	Moisture	Mass (g)	Wind (m/s)
1	Manz	40.0%	-	0.45
2	Manz	40.0%	-	0.45
3	Manz	6.0%/40.0%	-	0.45
4	Manz	6.0%/40.0%	-	0.45
5	Cham	~15%	-	0.45
6	Cham	~15%	-	0.69
7	Cham	~15%	-	0.69
8	Manz	23.8%	-	0.45/0.9
9	Manz	20.0%	780	0
10	Manz	20.0%	_	0.45
11	Manz	20.0%	697	1.08
12	Cham	6.7%	3040	0.69
13	Manz	27.1%	1111	0.69
14	Cham	13.2%	1311	0
15	Cham	13.2%	-	0
16	Cham	13.2%	934	0.69
17	Cham	13.2%	1338	1.08

Run Example (Excelsior Clump)

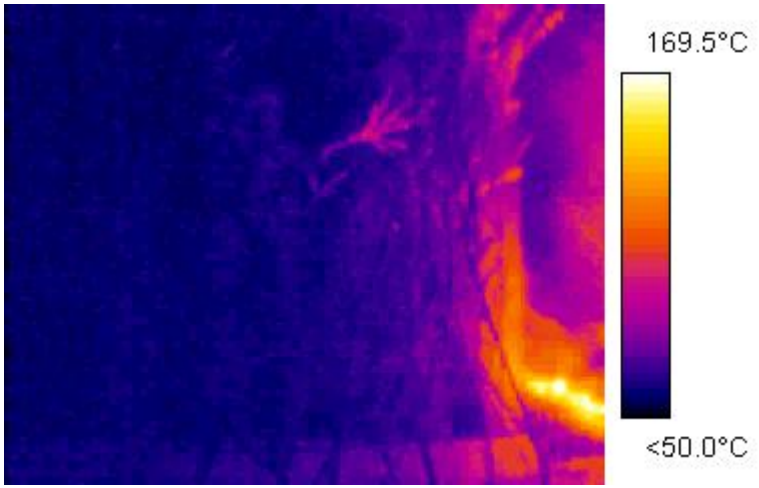
- Species = Manzanita
- MC = 20%
- Wind = 0.45 m/s
- Observations:
  - Different flame tilt angles in different parts of the shrub
  - Angled spread
    - Flame spreads upward to the left

Run Example (Excelsior Bed)

- Species = Chamise
- MC = 15%
- Wind = 0.69 m/s
- Observations:
  - Sustained flame contact necessary for ignition
  - Preheating from the surface fire accelerates the rate of spread in the shrub

Excelsior Bed (IR)

- Species = Chamise
- MC = 15%
- Wind = 0.69 m/s
- Observations:
  - Convective preheating dominates radiative preheating
  - Wind greatly increases the effects of convective preheating



Whole Shrub

- Species = Chamise
- MC = 6.7%
- Wind = 0.69 m/s
- Observations:
  - Flame tilt angle changes in transition from excelsior to shrub
  - Flame contact necessary for spread

Effects of Moisture Content

- Species = Manz
- MC = 40% & 6%
- Wind = 0.69 m/s
- Observations:
  - Flame will not propagate at high moisture content

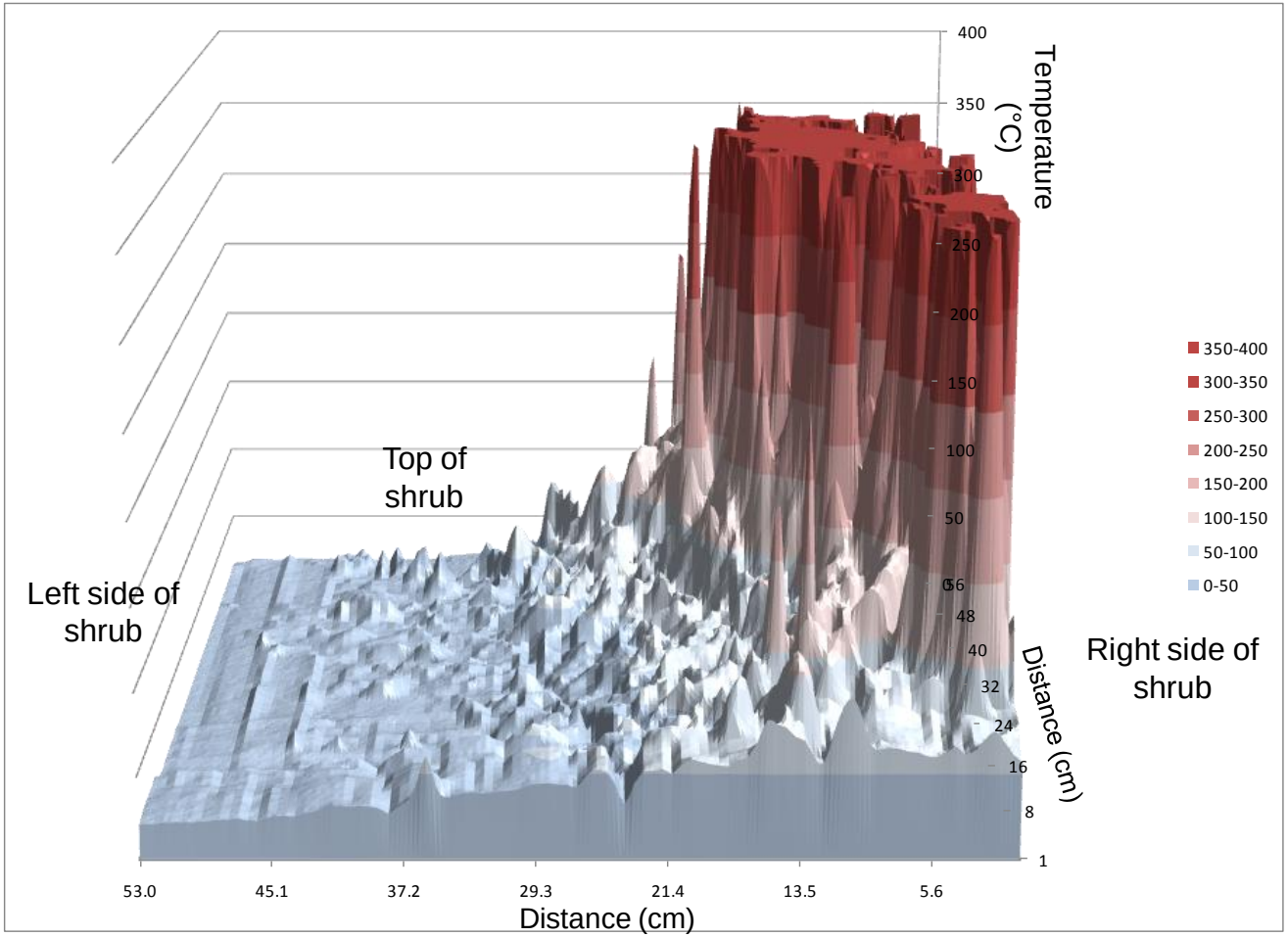
Wind Effects

1.08 m/s Wind

No Wind

MC = 13.8%

Preheating



Temperature Profile of a manzanita shrub at ~45s

MC = 20%

Wind = 0.45 m/s

Conclusions

- Flame tilt angles can be very different in different areas of a shrub
- Flame propagates upward at an angle
- Limited preheating when no wind is present
- Flame will not propagate at high MC
  - Propagation MC limit is a function of wind speed
- Rate of spread is a function of wind, species, and moisture content

Current/Future Work

- Continue video analysis, including more quantitative results
  - Flame height, flame length, flame tilt angle
  - Spread/no spread predictions
- Enhance the preheating analysis of the shrubs
- Implement results into the bush model