Patterns of Live Fuel Moisture in the Northern Great Basin

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Abstract

Live fuel moisture is an important component of wildfire behavior in fire-prone ecosystems. Fuel moisture content is a critical component in determining the probability of ignition, rate of forest fire spread, rate of energy release, and production of smoke by burning and smoldering fuel. Live fuel moisture content is in part dependent on soil moisture contents, as well as meteorological variables such as temperature and vapor pressure. Four sample sites across a precipitation gradient in central Oregon were instrumented with volumetric water moisture meters at 50cm and vegetation sampled for moisture content. Live fuels were sampled at each site every two weeks April through October between 2008 and 2013. Plant communities reflected the precipitation gradient. Live fuel moisture demonstrated that plant populations in the community peak in moisture content at different times. Annual moisture content patterns of both soil and fuels are highly variable and partly tied to timing and quantity of precipitation events. The degree of variability suggests that predicting live fuel moisture for real-time fire management, while a valuable tool, is a complex operation.

Introduction

- Live fuel moisture (LFM) impacts the probability of ignition rate of spread of wildfire, rate of energy release, smoke production, and conversion of surface fire to canopy fire
- Lower LFM typically results in larger fires (Fig. 1)
- LFM is a valuable input into models used by fire managers to predict fire behavior
- Fire models often applies a blanket value to LFM based on one species, which is a potential problem in regions with mixed vegetation and no dominant species
- High LFM can act as a heat sink and suppress fire; low LFM can be a heat source and increase fire intensity
- Accurate LFM can improve fire behavior modeling and threat assessment

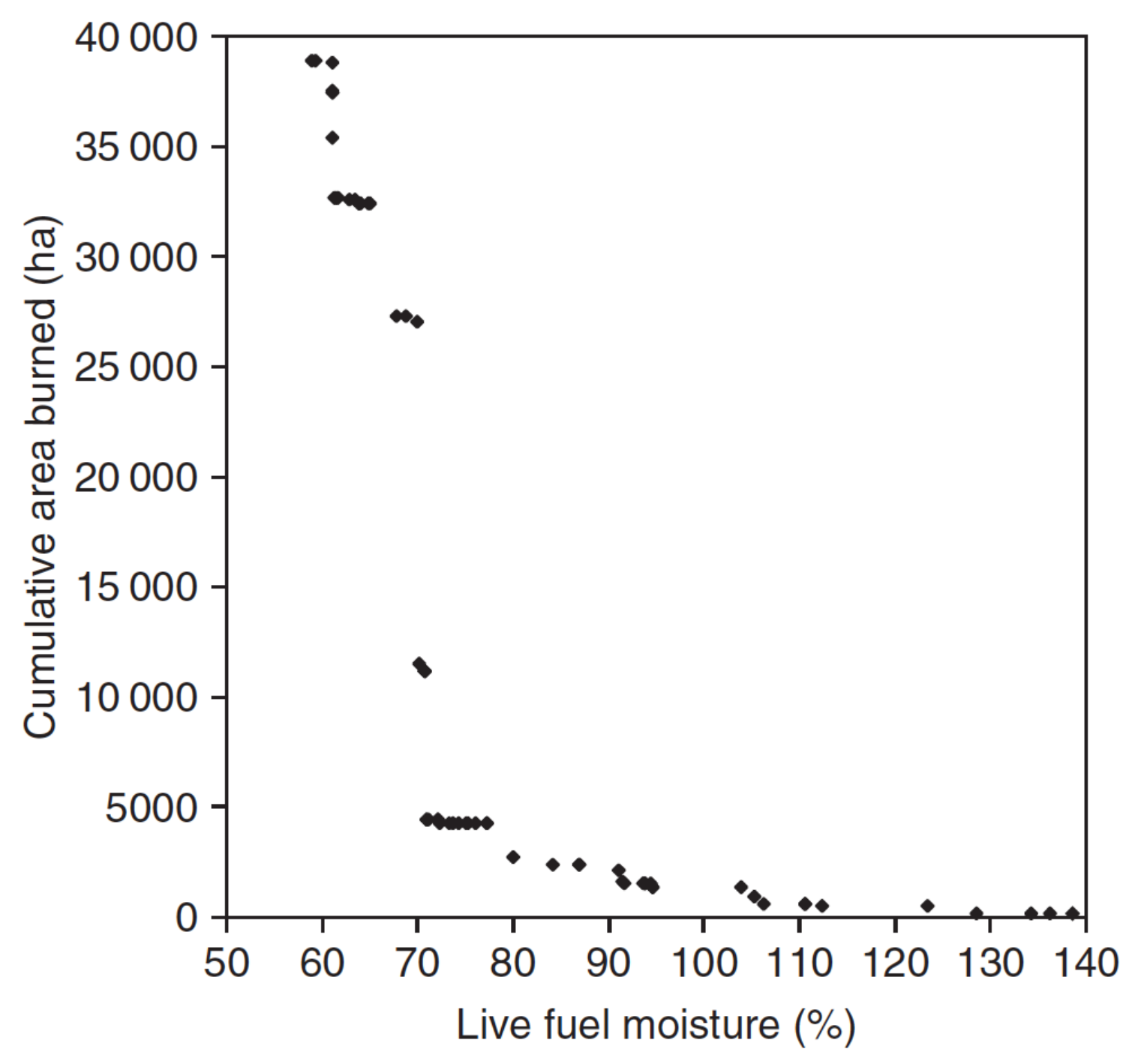


Figure 1: Relationship between Live Fuel Moisture and area burned for California Wildfires between 1984 and 2005. (From Dennison et al. 2008)

Purpose

- Develop baseline of LFM for multiple plant species in various climatic environments to help understand how to use LFM across climatic gradients with species variation
- Develop baseline of soil moisture which corresponds to live fuel moisture and species types

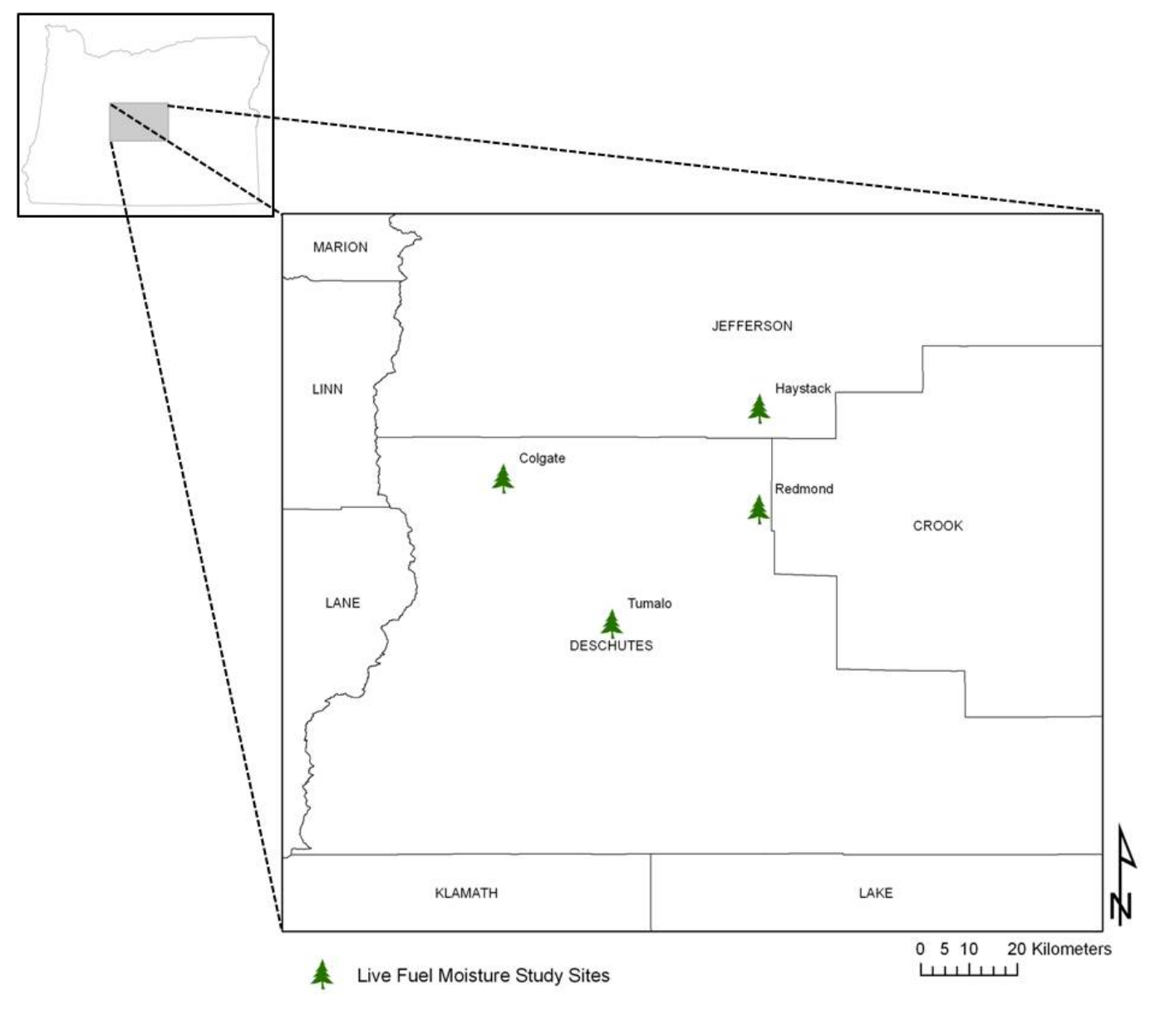
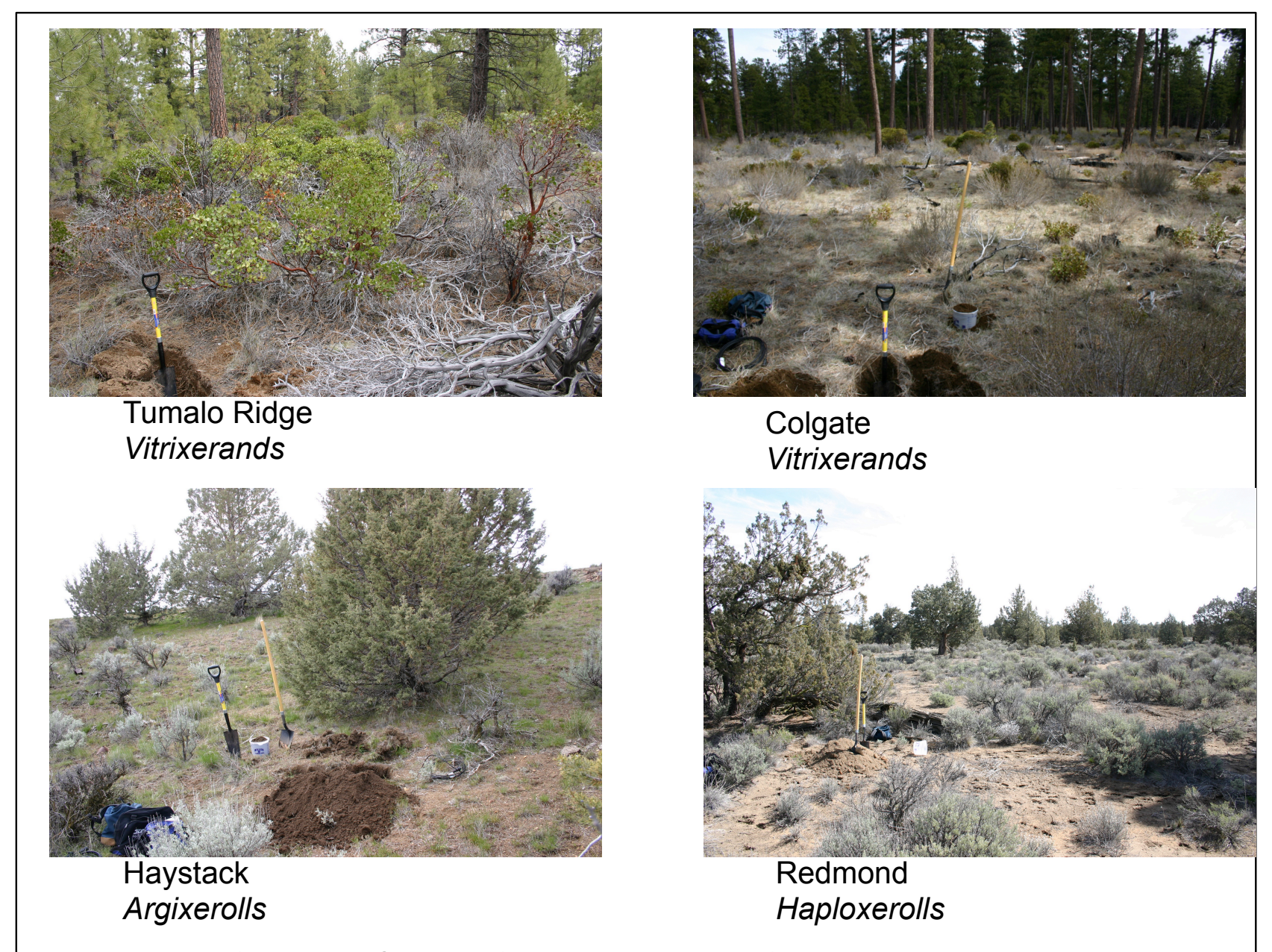


Figure 2: Site Locations in Oregon.


Tumalo Ridge
Vitrixerands

Colgate
Vitrixerands

Haystack
Argixerolls

Redmond
Haploxerolls

Figure 3: Photos of sample sites and soil great groups

Methods

- Four study sites in the Northern Great Basin were established adjacent to Remote Automated Weather Stations (RAWS) in four climatic zones (Fig. 2, 3)
- Site vegetation was characterized and major shrub species selected for LFM monitoring.
  - 5 samples per species per site, components of three plants per sample
  - New, old, leafy growth (Brown et. al, 2009)
  - Approximately every two weeks, weather dependent April – October
  - Same time of day for sampling
  - Dried for 24h at 75°C and LFM calculated (LFM = water loss/dry grams)
- Three Stevens Water Hydramon soil moisture/temperature probes installed at 50 cm at each site (Fig. 4)
- Soils characterized for
  - Texture @ 50 cm – hydrometer method
  - Coarse fragments by volume
  - Organic matter by loss on ignition

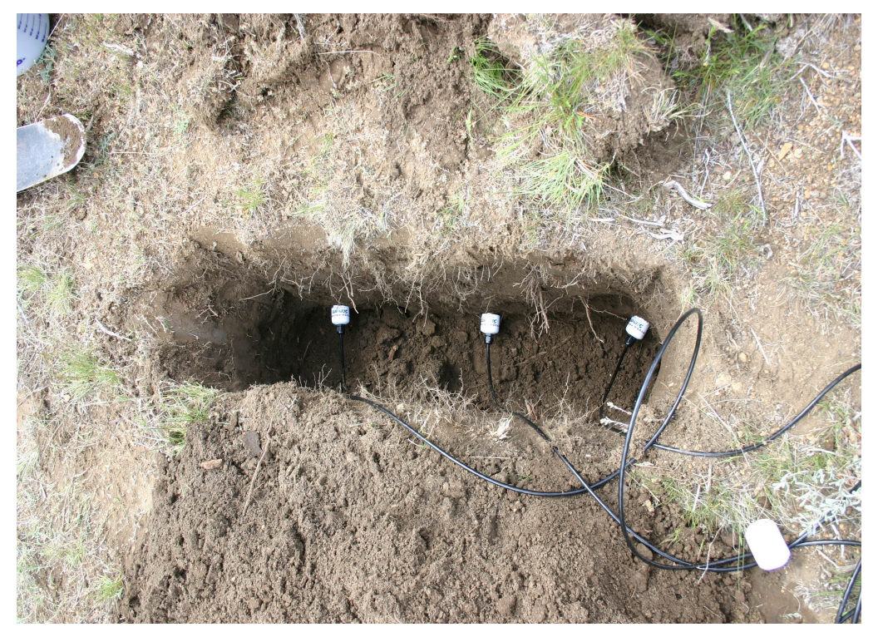


Figure 4: Placement of Stevens Hydramon probes at Tumalo site

Site	Soil Texture	% Clay	% Org. Carbon	Coarse Fragments	Mapped Soil Great Groups
Tumalo	Sandy Loam	16	4.4	8%	Vitrixerands
Colgate	Sandy Loam	8	3.5	30%	Vitrixerands
Haystack	Sandy Clay Loam	22	6.8	8%	Argixerolls
Redmond	Sandy Loam	11	3.1	5%	Haploxerolls

Table 2: Soil properties at 50 cm depth and mapped taxonomy.

Results

Site Characteristics

- Vegetation is mixed conifer on wetter sites (TUM and COL) and sagebrush-juniper at drier locations (HAY and RDM) (Table 1)
- Eastern sage-juniper sites experience higher temperatures during the growing season, where mixed conifer sites have similar temperature profiles (Fig. 5a)
- Study period precipitation (Apr-Oct) shows RDM is most limited where TUM and COL are similar. Excluding Sep and Oct data, which are the tail end of fire season, indicates that important wet-up can occur in those months compared to summer months (Fig. 5b & 5c)

Site	Component	Species	Component cover (%)
Tumalo Ridge Elev 1218 m	Overstory	Ponderosa pine (*Pinus ponderosa*)	50
		Western juniper (*Juniperus occidentalis*)	2
	Shrub	Green Manzanita (*Acrostaphylos patula*)	20
		Antelope bitterbrush (*Pershia tridentata*)	20
		Snowbrush (*Ceanothus velutinus*)	3
	Grass/Forb	Idaho fescue (*Festuca idahoensis*)	10
		Other	23
Colgate Elev 1006 m	Overstory	Ponderosa pine	30
		Western juniper	1
	Shrub	Green Manzanita	8
		Antelope bitterbrush	20
	Grasses/Forb	Idaho fescue	<1
		Blue wildrye (*Elymus glaucus*)	1
Haystack Elev 992 m	Overstory	Western juniper	10
	Shrub	Basin big sagebrush (*Artemisia tridentata* ssp *tridentata*)	30
		Rabbitbrush (*Chrysotahmnus* spp.)	35
	Grass/Forb	Crested wheatgrass (*Agropyron cristatum*)	8
		Other	22
Redmond* Elev 930 m	Overstory	Western juniper	15
	Shrub	Basin big sage	15
	Grass/forb	Idaho fescue	1

Table 1 Site Characteristics

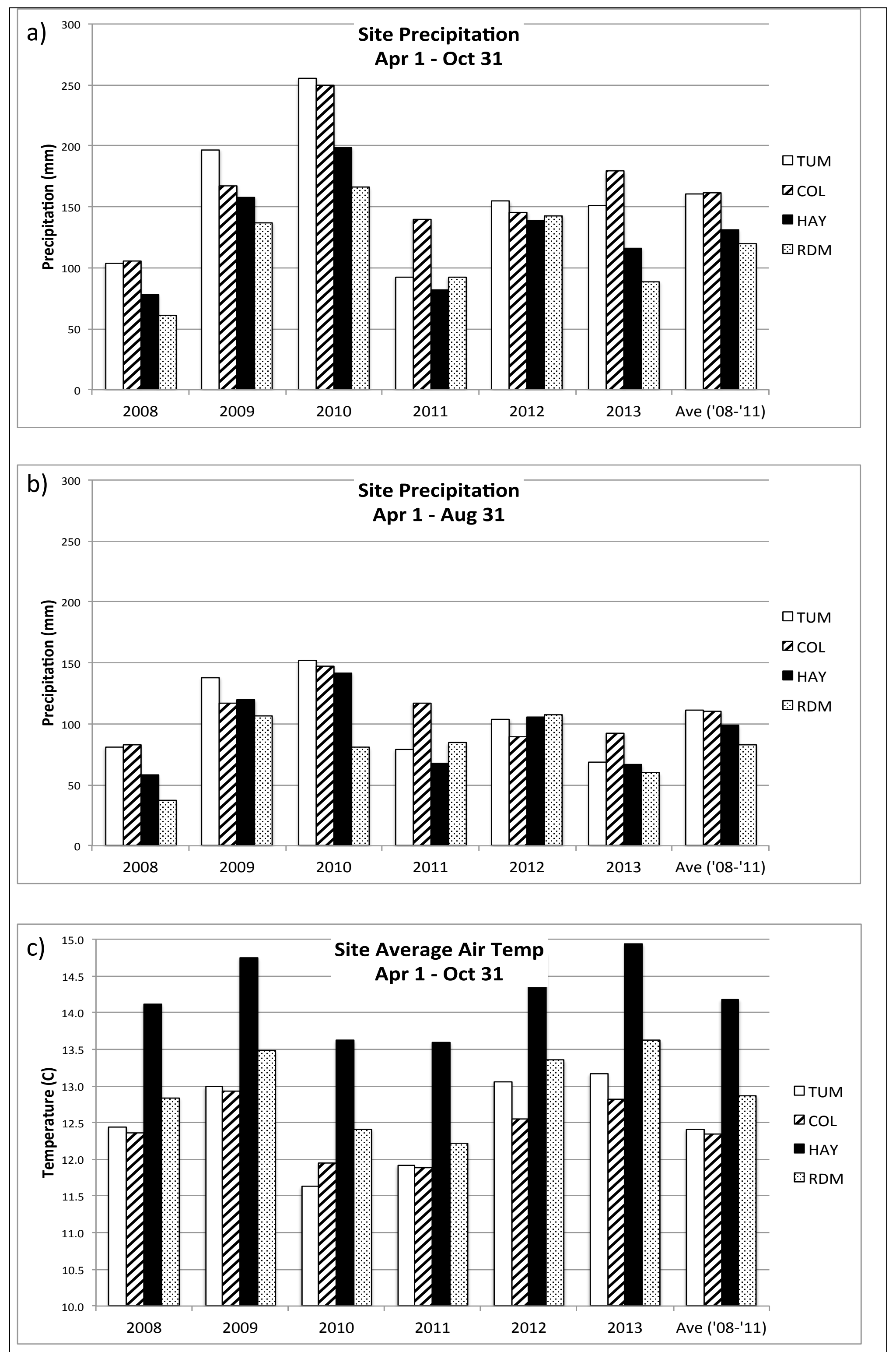


Figure 5: Annual site temperature and precipitation profiles and study period (208-2013) averages

- *Soil Moisture and Temperature*
  - Soil properties of texture and organic carbon (Table 2), as well as site elevation can explain some of the variations in soil temperature and moisture dynamics
  - Highest soil moisture contents are associated with both site precipitation (TUM) and highest soil clay and OC contents (HAY) (Fig. 6a&b)
  - Soil temperature associated with elevation, cooling with increasing elevation. Clay and organic carbon may also play a role.
  - LFM is variable by species and location (Fig 7 a&b). LFM does not have appear to be controlled by any one variable, Simple LFM modeling for fire may not capture the variability between species.

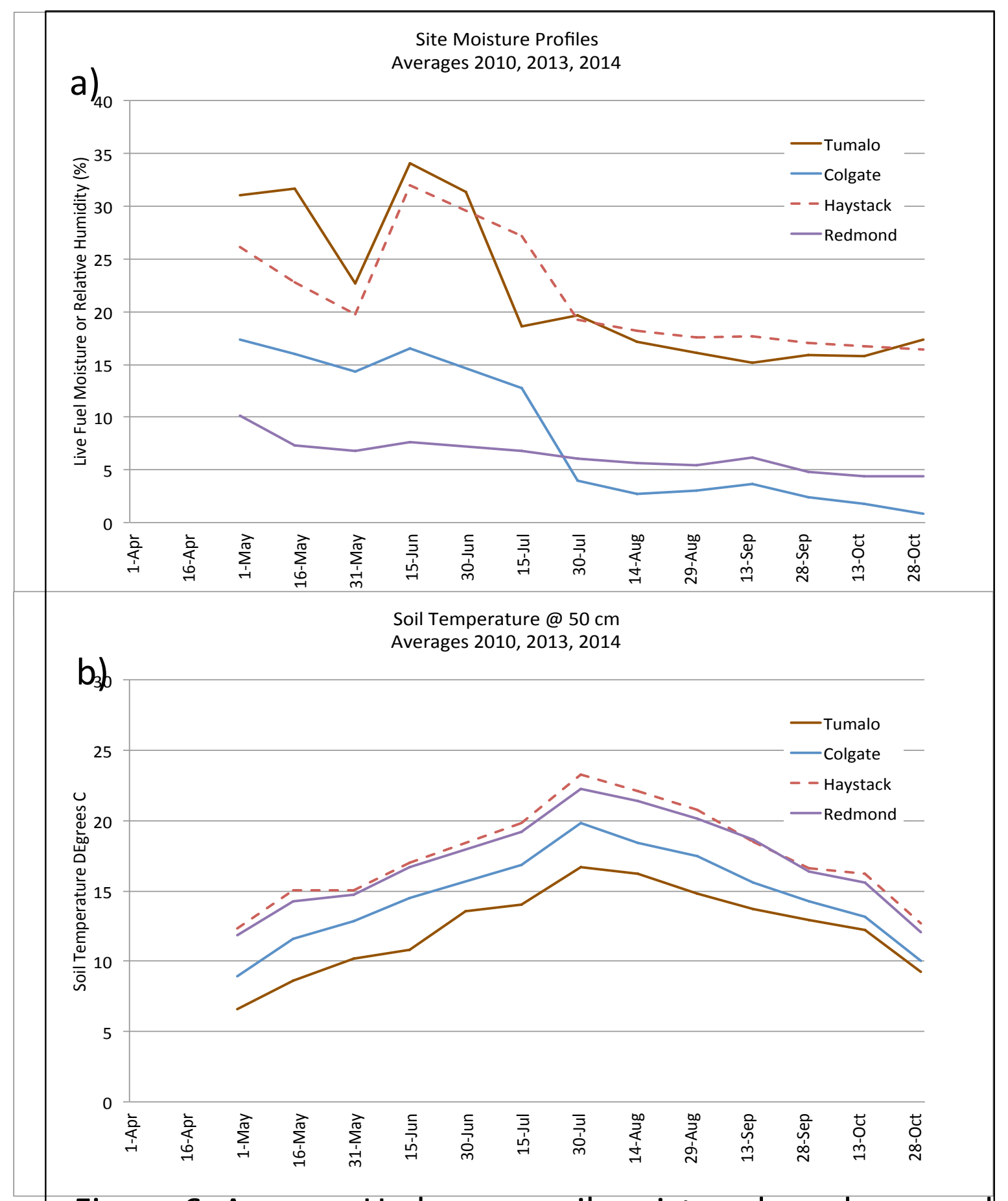


Figure 6: Average Hydramon soil moisture by volume and soil temperature at 50 cm depth.

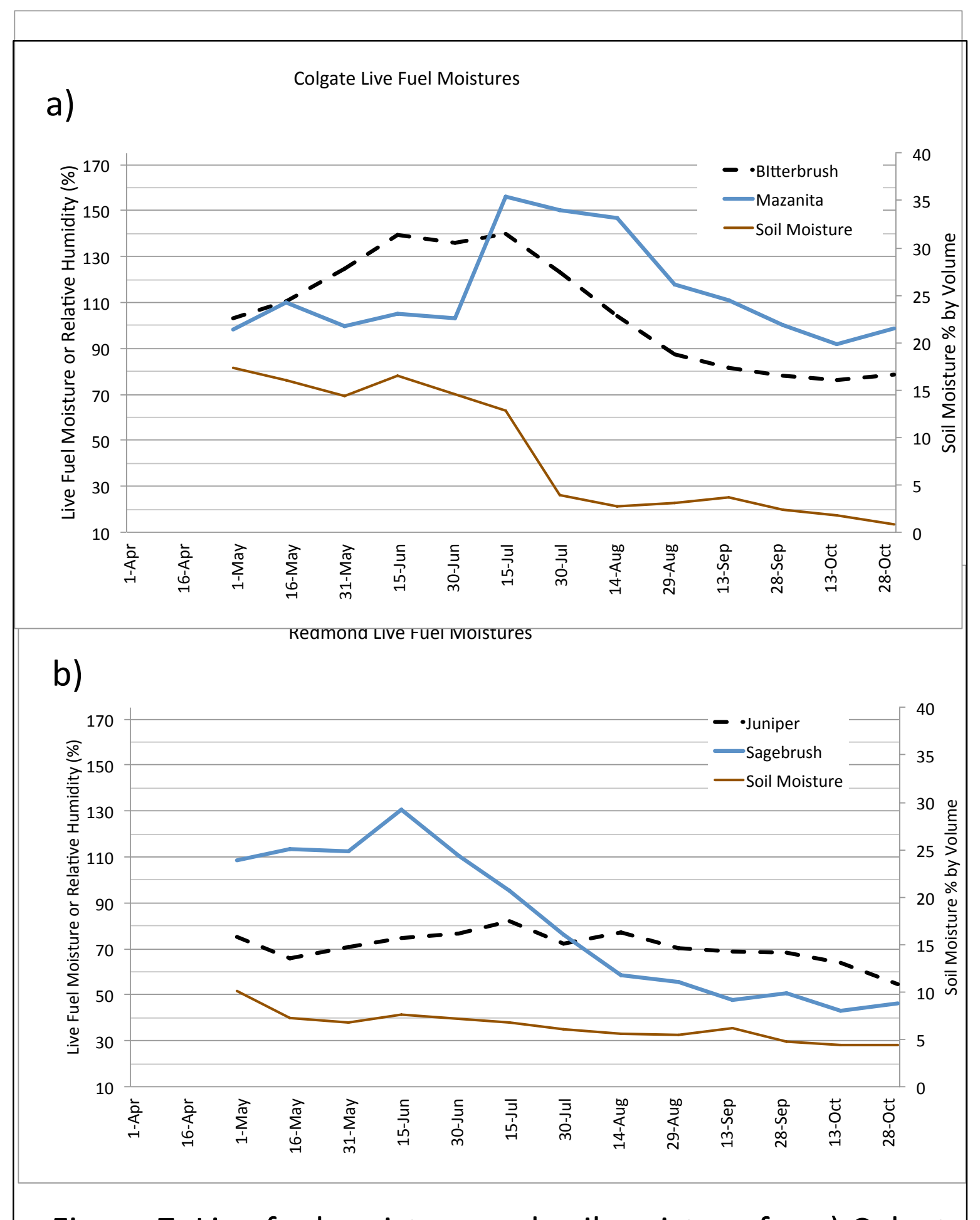


Figure 7: Live fuel moisture and soil moisture for a) Colgate and b) Redmond sites .

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Future work

- Investigate influence of volcanic ash on sensor moisture calibration
- Explore development of model to predict live fuel moisture from weather variables and soil moisture

References

- Brown, A., P.N. Omi, and J. Pollet. 2009. Live fuel moisture sampling methods: a comparison. Fire Management Today. 69 (4): 37-42.
- Dennison, PE, MA Mortiz, and RS Taylor. 2008. Evaluating predictive models of critical live fuel moisture in the Santa Monica Mountains, California. International Journal of Wildland Fire, 17:18-27.