Biomass consumption in big sagebrush ecosystems

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Abstract

Big sagebrush (*Artemisia tridentata*) ecosystems typically experience stand replacing fires during which some or all of the ignited biomass is consumed. Biomass consumption is an important fire effect as it is directly related to the emissions and energy released during the fire. Consumption of aboveground biomass (fuel) was evaluated for a series of operational prescribed fires in big sagebrush throughout the interior West. Pre-burn fuel characteristics (composition, amount, and structure), fuel conditions (live and dead fuel moisture content), and environmental conditions (weather and topography) affected fire behavior and subsequent fuel consumption. Total aboveground biomass consumption varied from 1.6 to 22.3 Mg ha^{-1} (18 to 99 %) among the 17 experimental areas. Multiple linear regression and generalized linear modeling techniques were used to develop equations for predicting fuel consumption during these prescribed fires. Pre-burn fuel loading, which is influenced by, among other things, season of burn, site productivity, time-since-last-fire, and grazing is the most important variable for predicting fuel consumption. Removal or reduction of big sagebrush is desirable for several reasons, including wildlife habitat improvement, livestock range improvement, fire hazard abatement, and ecosystem restoration.

Objectives

- Develop a model to predict consumption of big sagebrush
- Incorporate the model into the software package CONSUME 3.0
- Promote more effective and informed use of emission production, fire effects, fire behavior, and wildfire/prescribed fire tradeoff models
- Enable better wildland fire emissions and fire effects accounting and planning at local, state, regional, and national scales.

Methods

Field Measurements

- Sites within the boundaries of 9 prescribed burns in 4 western states
- Range of biomass, cover, height, and sub-species of sagebrush
- Grid of transects and destructive sample plots -- Fig. 1
  - Vegetation cover, height and biomass on transects and plots
  - ½ destructive plots sampled pre-burn and ½ post-burn
- Live and dead fuel moisture immediately prior to ignition
- Weather before and during fire (temperature, relative humidity, windspeed)

Analysis

- Multiple linear regressions to predict consumption of sagebrush biomass
- Model selection criteria -- parsimony and reasonable physical explanation
- Generalized linear model (GLM) using the same variables
- GLM programmed into CONSUME 3.0

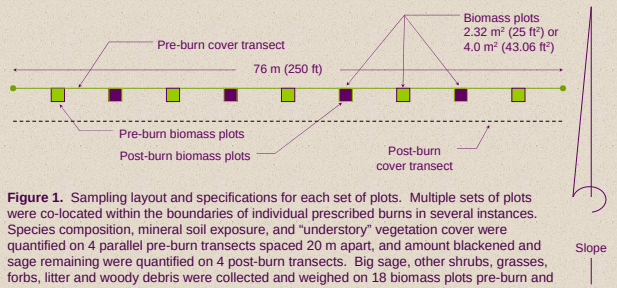

Figure 1. Sampling layout and specifications for each set of plots. Multiple sets of plots were co-located within the boundaries of individual prescribed burns in several instances. Species composition, mineral soil exposure, and "understory" vegetation cover were quantified on 4 parallel pre-burn transects spaced 20 m apart, and amount blackened and sage remaining were quantified on 4 post-burn transects. Big sage, other shrubs, grasses, forbs, litter and woody debris were collected and weighed on 18 biomass plots pre-burn and big sage was collected on 18 biomass plots post-burn. Big sage was separated into live and dead fractions during pre-burn sampling.

Results and Discussion

Total aboveground biomass consumption varied among the 17 experimental areas, with 15-100 percent of the experimental area experiencing fire. Fire spread was most limited in the single spring burn despite weather conditions similar to the fall burns. Five out of seven of the study sites where fire burned less than 40 percent of the experimental area had dead 10hr fuel moisture values in excess of eight percent.

Fuel loading, vegetation coverage, fuel moisture, weather (wind speed), and site characteristics (slope) were critical factors affecting fuel consumption (Fig. 2). It appears that dead 10hr fuel moisture must be below a certain value to allow combustion, fire spread and subsequent fuel consumption. Once fuel moisture has fallen below a critical value, weather conditions and fuel loading appear to be the controlling elements. Like fuel moisture, there appears to be a windspeed threshold. The effects of windspeed can be exacerbated to some degree by slope.

The ability to predict fire effects (i.e., fuel consumption) under varying environmental conditions will facilitate prescription development, planning and burn scheduling to most effectively apply fire to achieve desired levels of fuel consumption, fire effects and smoke production.

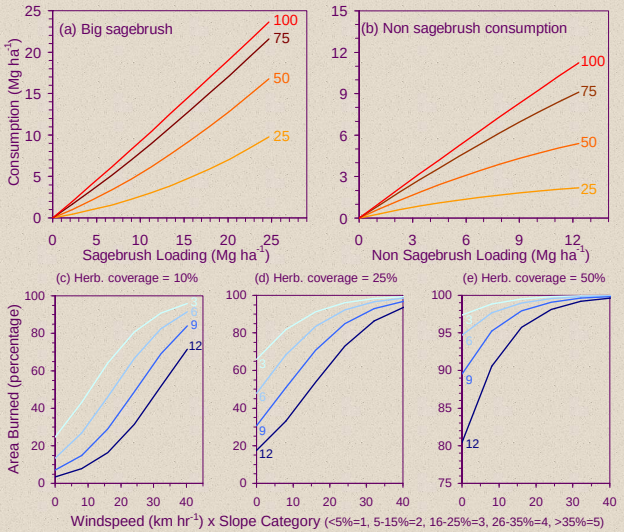

Figure 2. General linear models showing sagebrush (a) and non sagebrush (b) consumption as a function of loading at 25, 50, 75, and 100 percent of area burned, and area burned (c-e) as a function of windspeed x slope category at 3, 6, 9, and 12 percent 10hr fuel moisture content where herbaceous vegetation coverage is 10 percent (c), 25 percent (d), and 50 percent (e).

Acknowledgements

The following people were critical to the success of this project:

- Jeff Rose, Lance Okeson, and Russell Truman – BLM & USFS (Burns, OR)
- Andrew Goheen and Chris Farinetti – USFWS (Lakeview, OR)
- John Thompson – BLM (Cody, WY)
- Al Augustine – NPS (Lava Beds National Monument, CA)
- Field crew of the Fire & Environmental Research Applications Team