Ground measurements of fuel and fuel consumption from experimental and operational prescribed fires at Eglin Air Force Base, Florida

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Abstract: Ground-level measurements of fuel loading, fuel consumption, and fuel moisture content were collected on nine research burns conducted at Eglin Air Force Base, Florida in November, 2012. A grass or grass-shrub fuelbed dominated eight of the research blocks; the ninth was a managed longleaf pine (*Pinus palustrus*) forest. Fuel loading ranged from 1.7 Mg ha^{-1} on a sparsely vegetated grass site to 19.9 Mg ha^{-1} on the managed longleaf pine site. Fuel consumption followed suit and was lowest on the sparsely vegetated site (1.1 Mg ha^{-1}) and highest on the forested site (6.7 Mg ha^{-1}). A fuelbed selected from the fuelbed library of the Fuel Characteristic Classification System (FCCS) matched well with the forested site. Consume 3.0 and FOFEM 5.9 predicted total fuel consumption to within 0.5 Mg ha^{-1} of the measured total consumption in 4 of the 9 blocks randomly selected for comparison. This preliminary data analysis is part of the Joint Fire Science Program-supported project 'A Data Set for Fire and Smoke Model Development and Evaluation—the RxCADRE Project'. The entire dataset will be available in a globally accessible repository for testing and evaluation of fire and fuel models in 2014.

Additional keywords: fuel loading, fire effects

Introduction

The availability of an integrated, quality-assured fuels, fire, fire effects, and atmospheric parameter dataset for the development and evaluation of fuels, fire behavior, emissions, and fire effects models is limited (Cruz and Alexander 2010; Alexander and Cruz 2012). To develop such a dataset, the Joint Fire Science Program (JFSP) generously supported this study: 'A Data Set for Fire and Smoke Model Development and Evaluation – the RxCADRE Project' (JFSP 2012). The study focused on 6 disciplines: fuel characteristics and consumption, meteorology, fire behavior, fire mapping, emissions, and fire effects. This paper presents preliminary ground-based measurements of fuel loading, fuel moisture content, and fuel consumption, collected on nine research burns conducted at Eglin Air Force Base (Florida) as part of the this study. It also presents a simple comparison of the Fuel Characteristic Classification System (FCCS) (Ottmar *et al.* 2007), Consume v. 3.0 (Prichard *et al.* 2007), and the First Order Fire Effects Model v. 5.9 (FOFEM) Reinhardt *et al.* 1997) predictions with the measured data as an example of how this dataset can be used to evaluate current fire and fuel tools.

Methods

Ground-level measurements of fuel loading, consumption, and moisture content were taken from six 100x200-m (2 ha) replicate experimental blocks (S3, S4, S5, S7, S8, S9) and three 200-400 ha operational blocks (L1G, L2G, L2F) both before and after prescribed burning at Eglin Air Force Base in November 2012 (Fig. 1). A grass or grass-shrub fuelbed dominated eight of the research blocks while one block was a longleaf pine (*Pinus palustrus*) forest. Twenty-five pre- and twenty-five post-burn clip plots (1 m^{-2}) were established on the outside of each experimental burn block, and thirty pre- and thirty post-burn clip plots (1 m^{-2}) were established along 3 grid lines within the operational blocks L1G, L2G, and L2F. In addition, nine pre- and post-burn clip plots (0.25 m^{-2}) were established at each of three highly-instrumented plots (HIPS) located within blocks L1G and L2G. Twelve pre- and post-burn clip plots (0.25 m^{-2}) were established at the HIPS in L2F to account for the increased variability of the fuels in a forested site (Fig. 2). Fuel from within the clip plots was collected and categorized into 5 fuelbed categories (shrubs, grasses, down-and-dead wood, litter, and duff), dried in an oven, then weighed to determine pre- and post-burn loading. Consumption was calculated by subtracting the average preburn loading from average postburn loading, by fuelbed category, for each set of plots. Five to ten 6 L plastic bags of fuel moisture content samples representing shrubs (stems and leaves), grasses, small and large woody material, litter and duff, were collected immediately before each burn.

We assessed the usefulness of this dataset in evaluating fire models by comparing 1) measured fuel loading with the best fit fuelbed from the FCCS fuelbed library and 2) measured fuel consumption with predictions from Consume vs. 3.0 (Prichard *et al.* 2007), and the First Order Fire Effects Model 5.9 (FOFEM) (Reinhardt *et al.* 1997).

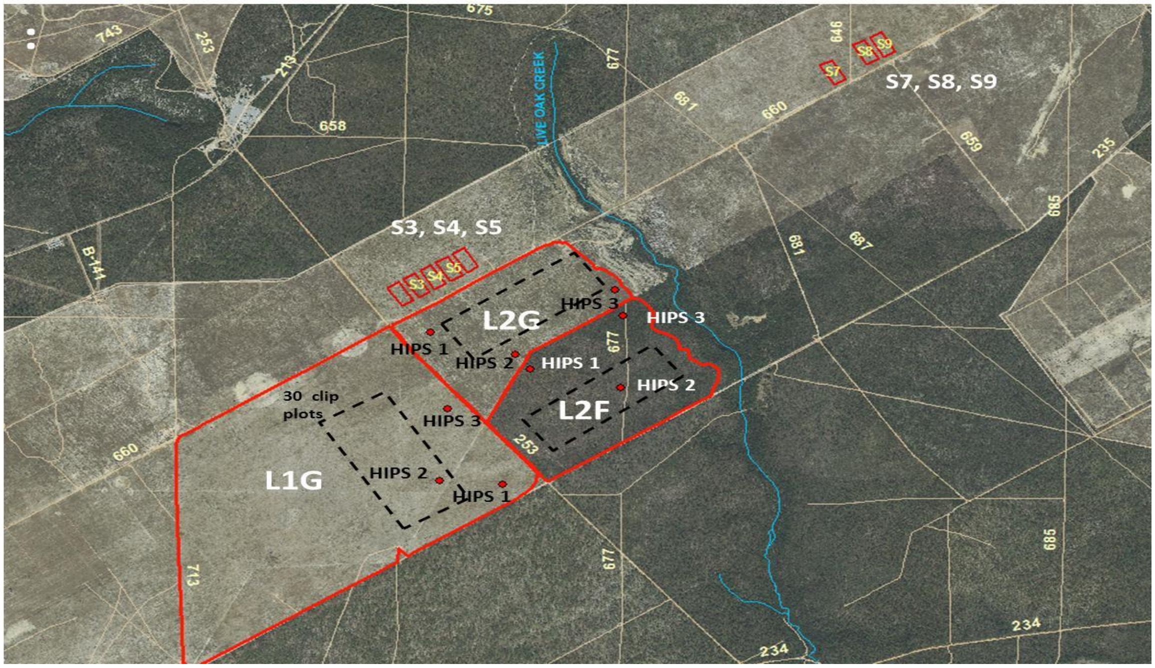


Fig. 1. Small replicate and larger burn blocks established for the November, 2012 RxCADRE research project located on the B70 bombing range at Eglin Air Force Base, Florida.

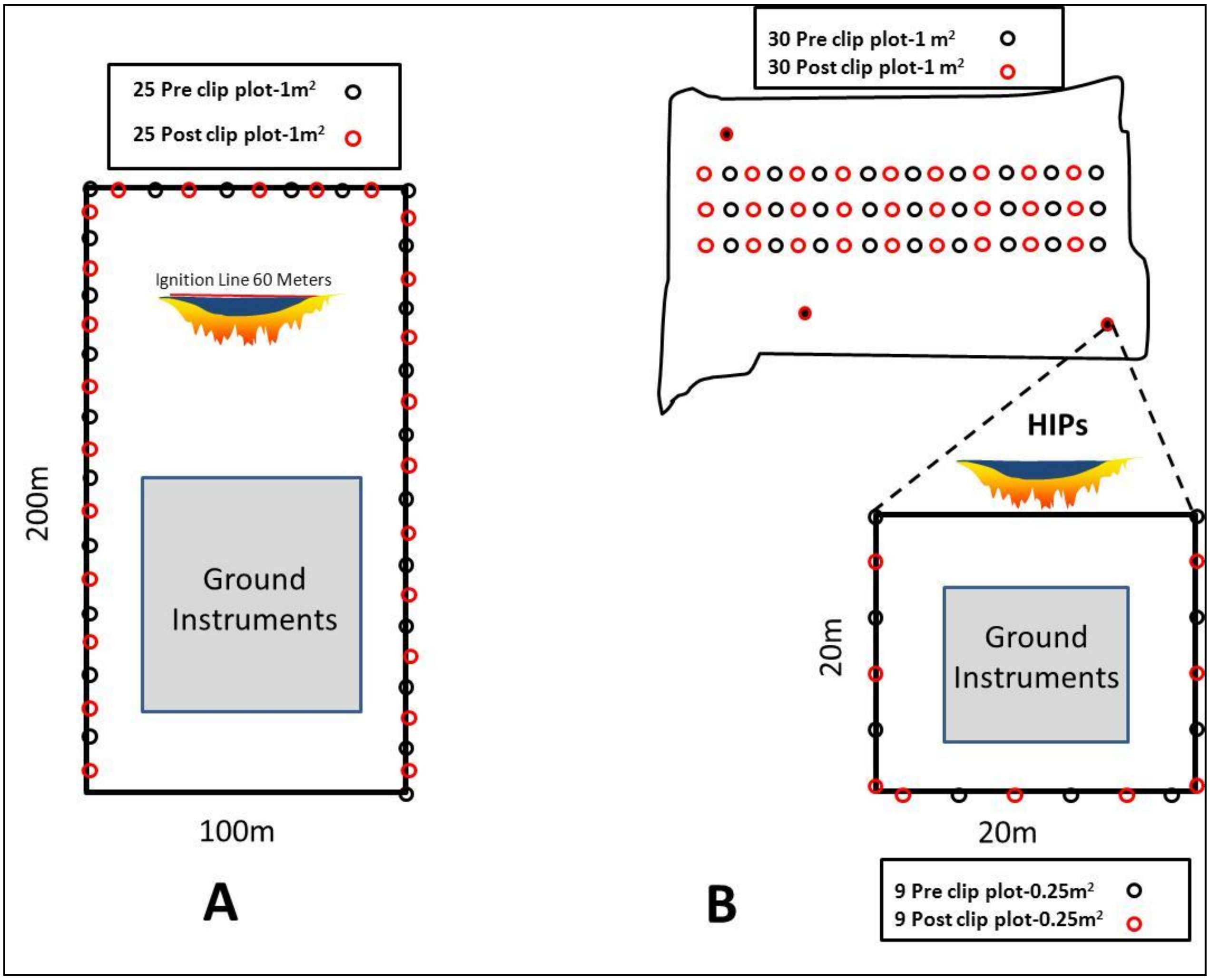


Fig. 2. Plot layout for (A) replicate small experimental burn blocks and, (b) large operational burn blocks.

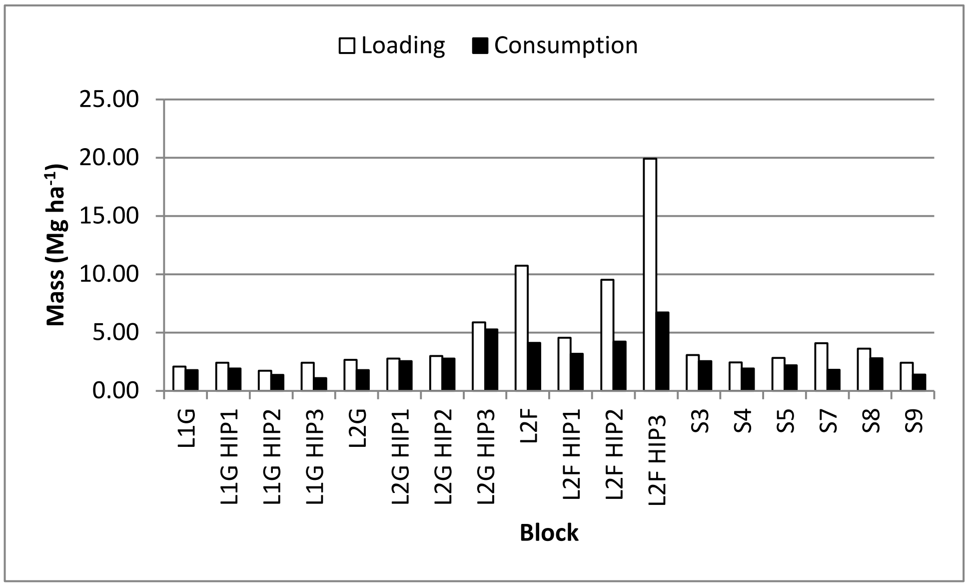
Results and Discussion

Fuel loading ranged from 1.7 Mg ha^{-1} on L1G-HIP2 to 19.9 Mg ha^{-1} on L2F-HIP3 (Fig. 3A). Block L1G was sparsely vegetated because it had been burned recently and treated with herbicide. L2F HIP 3 was more heavily vegetated since it was a forested site and contained more live and dead material than the grass and grass/shrub burn blocks.

Fuel consumption ranged from a low of 1.1 Mg ha^{-1} in L1G-HIP3 to 6.7 Mg ha^{-1} in L2F-HIP3 (Fig. 3A). The lowest fuel consumption corresponded to the block with the lowest loading; and the highest fuel consumption corresponded to the block with the highest fuel loading. Overall, fuel consumption may have been limited because a hard frost had not occurred and the shrub leaves and grasses were not cured. Furthermore, all blocks had been routinely burned every two to three years, reducing the total available fuel.

The day-of-burn fuel moisture content of the live vegetation (shrub, grass and forb) ranged from 108 percent in L2F to 129 percent in S4 (Fig. 3B). The moisture in surface fuels (litter) ranged from 2 percent on S9 to 17 percent on S4. The only block to contain down-and-dead woody material was L2F where the moisture contents were 12, 17, 26, and 40% respectively for the 1-hr, 10-hr, 100-hr, and 1000-hr woody fuel classes.

(A)



(B)

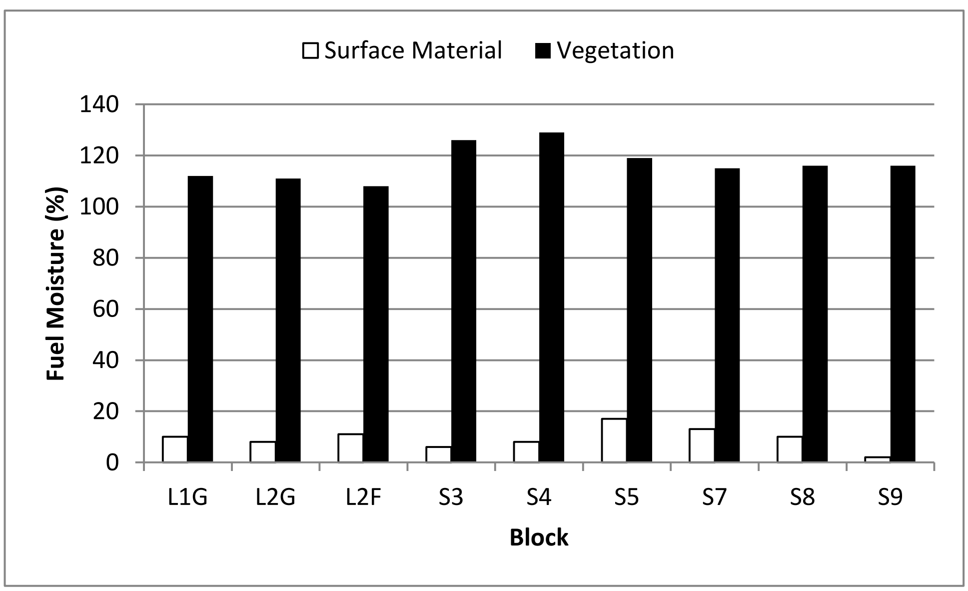


Fig. 3. (A) Measured fuel loading and fuel consumption and (B) measured fuel moisture content.

A search was made of the FCCS fuelbed library to find a fuelbed that closely matched the most complex fuelbed (L2F); fuelbed 191 was selected. This fuelbed is indicative of a longleaf pine forest that is burned every two to three years. It matched closely with data collected before the fire (Fig. 4A). Fuelbed 191 would have provided a reasonable fuelbed to initiate a customization. Additional comparisons will be conducted as we further analyze the data.

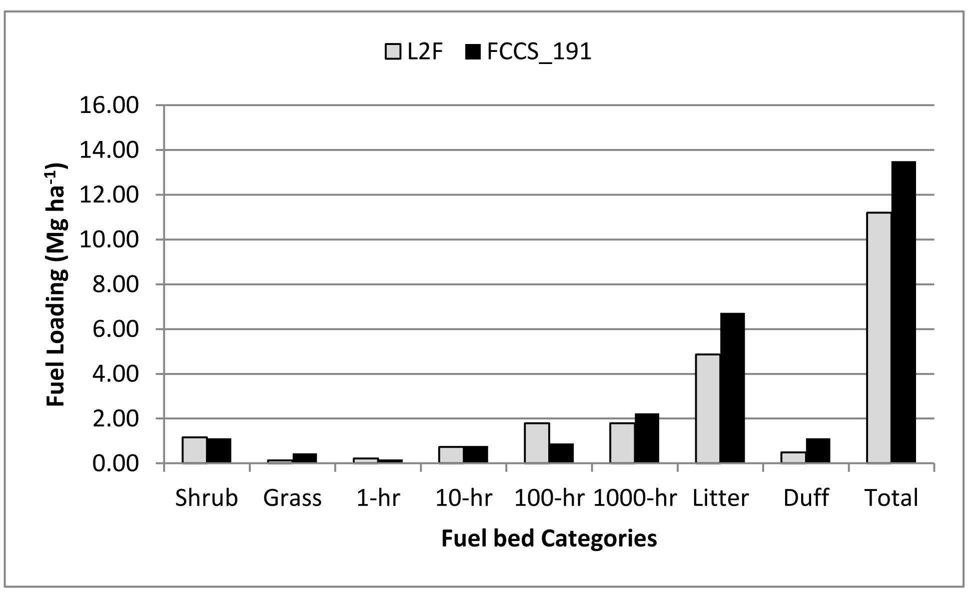
Consume and FOFEM both predicted the measured fuel consumption within 0.5 Mg ha^{-1} in all research blocks with the exception of block L2F (Fig. 4B). Here, Consume was within 0.5 Mg ha^{-1}, however, FOFEM over predicted total consumption by more than 3 Mg ha^{-1}. This is explained in part by the fact that FOFEM assumes all litter is consumed during a prescribed fire. In the case of block L2F, some litter was not consumed. Similar conclusions were reached by Reid *et al*. 2013).

Fuel loading, fuel moisture content, and fuel consumption data are expected to be used by those in other scientific disciplines to evaluate their results within the broader RxCADRE research effort. The data will also help to evaluate fuels, fire behavior, smoke, and fire effects models such as the Wildland-urban interface-Fire Dynamics Simulator (WFDS) (Mell *et al.* 2007), FIRETEC (Linn *et al.* 2002), FlamMap (Finney *et al.* 2006), BehavePlus (Heinsch and Andrews 2010), Consume, FOFEM, BlueSky Playground, CanFIRE, and BORFIRE (de Groot *et al*. 2007; de Groot *et al*. 2009).

Conclusion

This paper offers a preliminary review of a small portion of the ground-level data (fuel loading, moisture content, and fuel consumption) collected during the Joint Fire Science Program-supported RxCADRE field campaign at Eglin Air Force Base in Florida. We also assessed the usefulness of this dataset in evaluating fire models by comparing this data set with fuel loadings from the FCCS fuelbed library and fuel consumption predicted from Consume v. 3.0 and FOFEM v. 5.9. These data are one of several sets that will be available in an open repository in 2014 for the testing and evaluation of fire and fuel models. Further data reduction and analysis will be performed in the upcoming year.

A



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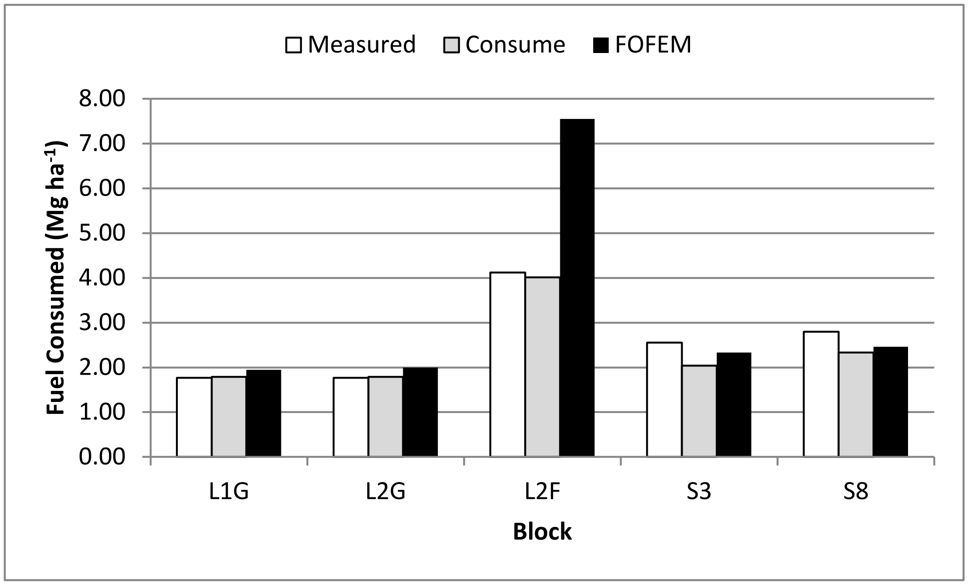

Fig. 4. (A) Measured fuel loading and fuel loading catalogued with FCCS fuelbed 191,and (B) comparison of total fuel consumption as measured and modeled by Consume and FOFEM.

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