# The new GLOBE Fire Fuel Protocol

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**Abstract:**
The GLOBE Fire Fuel Protocol is new to the collection of methods available in the GLOBE program. The Fire Fuel data collection techniques have been synthesized from existing recognized fuel sampling methods and are designed to estimate the amount of dead biomass by fuel size class. The biomass estimates provide the inputs needed for estimating fire behavior and fire effects in most ecosystems. An accurate estimate of fire behavior is used to determine fire hazard, which, when reduced, can help save lives, property, and ecosystems. While the methods may be time consuming, they are not difficult and are easy to understand. Beyond the use for fire effects and fire behavior estimation, data collect with these methods provide a current inventory of fire fuels, are an indicator of habitat and food sources for many animals and microorganisms, and provide a good estimate of total carbon reserves at a sample site. The methods presented in the Fire Fuel Protocol are also being used in national scale fuels science projects making the GLOBE data compatible with many other fuels datasets and a valuable additional data source. The Fire Fuel Protocol also makes an excellent compliment to the other protocols presented in the Land Cover/Biology section.

INTRODUCTION

For thousands of years, fires have shaped landscapes around the world (figure 1). As fire's importance to ecosystems has been recognized by many international scientists numerous studies have been undertaken to understand the relationship between fuels and fire behavior and fire effects. Development of fuels data collection methods has been an important facet of fire research in the last 50 years. Over time, fire scientists have been able to refine fuels sampling techniques in to successfully quantify and qualify fire fuels and understand the influence of fuels on fire.

**Figure 1--Fire in a subalpine fir forest of Idaho.**

Fuels are the aboveground organic biomass that can burn in a fire and are usually classified by size and whether they are live or dead, woody or herbaceous. Examples of woody material are twigs, branches, logs, and shrubs (figure 2). Grasses, mosses and lichens are typical herbaceous fuels. Fuels are often divided into surface and crown fuels with surface fuels being all biomass below six feet in height and crown fuels the biomass above six feet. The most important fuel measurement is the weight of the fuel per unit area (e.g., kg $m^{-2}$), called fuel loading by fire managers and researchers. Fuel loading is often stratified by each fuel type or component; for example, grasses, twigs, logs, and shrubs would each have a separate fuel loading estimate.

**Figure 2--Examples of woody fuels on forest floor.**

Fuels are the key factors to determine the behavior and effects of fires. Fire behavior describes how fast a fire travels or how hot a fire burns. Things like fire intensity, spread rate and flame length are common fire behavior measures. Smaller sized fuels like grasses and twigs usually burn rapidly and carry the flames so they determine fire spread. Fire effects describe consequences of the fire on ecosystems components. Tree mortality, soil heating, emissions, and plant succession are examples of fire effects. Any material that burns or smolders for a long time, such as logs or duff, can heat the soil and kill roots and soil organisms. The consumption of the fuel by fire will generate smoke that can enter the atmosphere and create health? problems for people.

There are an amazing variety of fuels in ecosystems worldwide but the importance of fuel types vary by ecosystems. For example, logs and twigs do not play a significant role in

**Figure 3--A prairie grass fire.**

fire behavior or effects when not part of the fuel complex, such as in prairies (figure 3). In some forests the lichens hanging from trees can move fire into tree crowns resulting in higher tree mortality and a fire that is more difficult to control. One interesting fuel component related to fire effects is duff – the highly decomposed plant material lying on top of the mineral soil. Duff is an exceptionally active layer, biologically. It is a source of nutrients and moisture that plants use thus many small roots are located in the duff layer. So, the consumption of duff by a fire can kill many plant parts and reduce microbial activity. These microbes are important for plant health because they are related to nutrient production and help supply the roots with nutrients and water.

Fire managers need an accurate description of the fuels to devise ways to save lives and protect homes and ecosystems. Historically, fuels data has been difficult to obtain because most fire programs do not have the resources for a fuels inventory program. However, it is vitally important that fire management has timely fuels data to implement strategies for reducing fuel hazard and fire risk. The GLOBE *Fire Fuel Protocol* provides students comprehensive methods to sample the most common and important fuels in a form that is useful to fire management. These methods have been synthesized from existing fuel sampling methods so that student surveys are complete and robust. The collected fuel information can be used to compute fire behavior and effects, and is directly valuable to fire managers.

THE GLOBE FIRE FUELS PROTOCOL

The sampling for the *Fire Fuel Protocol* is divided into two parts. First, a set of general stand measurements are made within a 30 x 30 meter "center plot". This information gives managers an idea of what the stand looks like, called structure. Stand structure can be important for determining fire behavior, especially risk of crown fire. Second, surface fuels are sampled with detailed measurements along sampling planes around the center plot (figure 4).

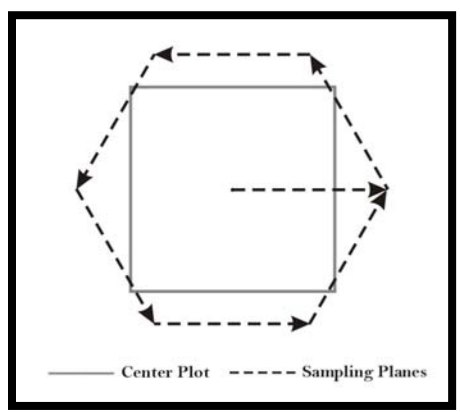


**Figure 4 --Layout of center plot and sampling planes.**

There are several classes of fuels sampled with this protocol (table 1). Down woody debris is typically divided into size classes based on the average length of time it takes to dry the wood.

**Table 1—Fuel types and size classes used in the GLOBE Fire Fuel protocol.**

| Fuel Type | Size (Fuel Diameter) | Description |
|---|---|---|
| Crown Foliage | Any | Living and dead crown foliage including needles and broad leaves |
| Crown Branch Wood | 0 to 3 cm | Live and dead crown woody branches |
| Shrub -- Live | Any | Living woody plants – trees and shrubs less than 2 meters tall |
| Shrub -- Dead | Any | Dead shrubby material suspended above ground. This includes trees and shrubs less than 2 meters tall. |
| Herbaceous - Live | Any | Live herbaceous plants including grasses, sedges, forbs, ferns, and lichen |
| Herbaceous -- Dead | Any | Dead herbaceous plant parts above ground |
| Litter | None | Recently fallen needles, leaves, cones, and bark |
| Duff | None | Partially decomposed organic material below the litter layer |
| Downed Wood | 0 to 1 cm | Takes 1 hour to dry woody twigs and branches |
| | 1 to 3 cm | Takes 10 hours to dry woody twigs and branches |
| | 3 to 8 cm | Takes 100 hours to dry woody branches |
| | 8 to 23 cm | Takes 1000 hours to dry branches and logs |
| | 23 + cm | Takes 10,000 hours to dry logs; coarse woody debris |

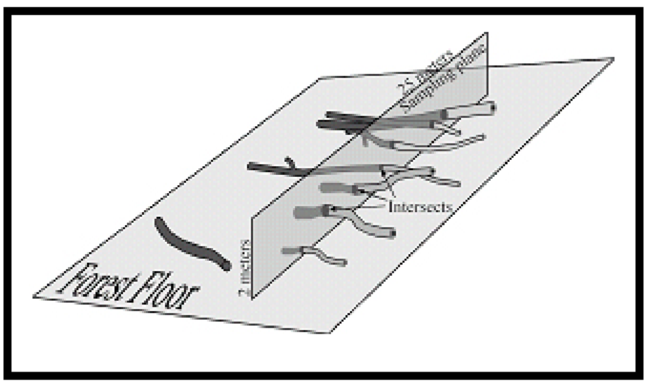

**Figure 5--The planar intersect technique.**

The majority of woody fuels in GLOBE protocols are sampled using a planar intersect sampling method. The sampling area is an imaginary plane rising vertically to a height of two meters above a measuring tape laid on the ground. All fuels that intersect that plane are counted (figure 5). The count of intersects by size class are used to compute fuel loading using published equations. This method is very quick and is easily taught, but it can sometimes be difficult especially when small woody fuels are numerous such as in slash piles or areas where trees have been cut for harvest (see figure 2).

The planar intersect method is not practical for sampling litter, duff, herbaceous, and shrubby material, so these fuel components are measured using a microplot method nested along the

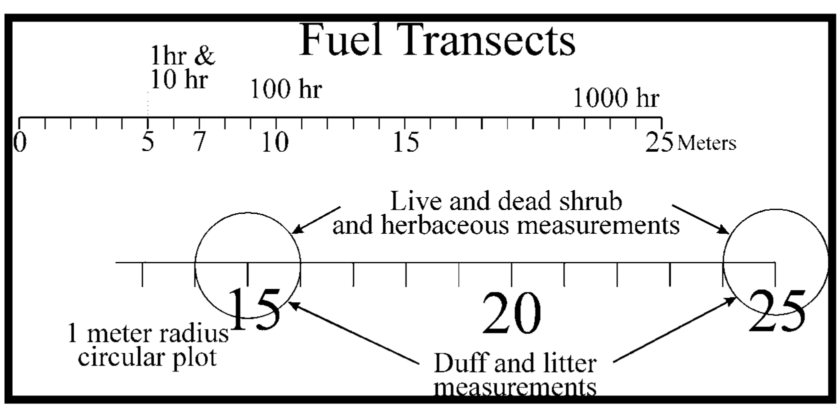

**Figure 6-- Sampling locations along the sampling plane.**

planar intercept transects. Canopy cover and plant height are estimated on two microplots at intervals along the transect. These are used to compute loading using standard volumetric equations. The depth of litter and duff are measured at the same points along the transect and this depth is used to compute loading by multiplying by a duff and litter bulk density constant (figure 6).

The Fire and Fuels Protocol should be applied in a homogeneous area that is at least 90 x 90 meters in size. Fuels are often correlated with the surrounding plant community and topographical setting so it is best to confine fuel sampling to an area with similar vegetation characteristics along with similar slope, aspect, and elevation.

SUMMARY

Fuels are very important to fire management because they are used to predict the characteristics of a wildfire. The amount and kinds of fuels can influence the ignition, spread, intensity, and severity of a fire. Fire behavior prediction models use fuels to calculate fire danger, hazard, and risk. In addition, fuel loading provides an estimation of the amount of dead and live biomass in a stand, which is extremely important for the calculation of carbon, water, and nutrient cycles. Because this methodology was designed to approximate the amount of biomass in nearly every compartment of a plant community, the data collected can be used to compute fire spread, smoke production and fuel consumption. These calculations allow fire managers to more effectively plan and implement prescribed burning projects. This could save lives, protect property, and improve fire management.

**Figure 7-- Collecting fuels using the GLOBE protocols.**