Methods for Characterizing Moisture Regimes for Assessing Fuel Availability Pocosin, Sand Hills and Appalachian Vegetation Communities

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Biographical sketches

Roberta A. Bartlette has assisted in studies and analysis of fuel and fuel bed properties, smoldering combustion, fire behavior of laboratory and wildland fires, large fire growth, and fire occurrence. She began working with studies in live fuel moisture and satellite remote sensing in 1988 and currently focuses on the use of satellite remote sensing to assess fire potential in wildland vegetation and live fuel moisture content. Her master's thesis project, completed in 1993, focused on identifying thresholds to sustained ignition in organic soils. Roberta is actively involved in Fire Danger Rating and Fire Behavior Prediction training and technology transfer to interagency wildland fire managers at both the regional and national level. She has developed and taught lessons and workshops in fuel moisture, drought, fire behavior prediction calibration, use of fire danger rating software, and interpretation of AVHRR NDVI imagery. She has developed self-study guides for displaying, interpreting and analyzing vegetation index imagery and self-paced lessons for software use and data interpretation designed for Internet posting. She has participated in long-range fire assessments within most of the geographic areas of the U.S. Roberta brings to the study her background in live and dead fuel measurement, combustion in live fuels and organic soils and remote sensing image analysis and interpretation. Roberta received her undergraduate degree in Zoology in 1970 and a Masters Degree in Forestry with fire management and soils emphasis in 1993, both from the University of Montana.

James J. Reardon has assisted in studies of smoldering combustion limits, vegetation characterization and moisture measurement in recent years at the Fire Sciences Laboratory. He has spent a number of years studying moisture and burning organic soils. He has developed and tested a number of moisture sensing devices. He has participated in a multiyear project in studying soils and fuels in North Carolina and brings to this project knowledge of the vegetation, potential sample sites, measurement techniques and equipment needed to carry out the proposed study. Jim received a B.S. degree in 1978 in Natural Resource Management: Forestry and Soils, from Rutgers University, New Brunswick, New Jersey.

Gary M. Curcio has been employed by the Division of Forest Resources for the past twenty years. For the last seven years his work experience has concentrated in the area of wildland fire special projects and the preparation of corresponding staff reports. The common denominator or theme throughout his work is wildland fire. He is currently responsible for the maintenance of the Division's RAWS network, is a leading Division Fire Behavior Analyst and represents the southeast as a state member on the National Advisory Group of Fire Danger Rating and Interagency Airtanker Board. Recently his research time has been devoted to Fire Danger and Aviation Projects is particularly making NFDRS more meaningful to fire fighters, review of adverse fire weather and its impact on near fatal misses, and the national standards for single engine airtankers and amphibious airtankers. Gary presented the idea of developing fire danger rating pocket cards for firefighter use to the National Advisory Group for Fire Danger Rating. The idea had been heartily endorsed. Gary brings to the study knowledge of fuels, fire and personnel and practices across agencies in North Carolina. Gary has earned a B.S. degree in earth sciences from Albright College and a M.F. degree in Forest Management and Pathology from Duke University.

Abstract

This paper discusses methods used to address local knowledge gaps in characterizing soil and live fuel moisture trends in North Carolina vegetation complexes that are of significant concern to fire management plan development and implementation. Compared to Western species, live fuels of the Southeastern region have received little attention and few historical short-term studies have illustrated moisture trends within Southeastern live fuel species. While recent studies have examined moisture and combustion limits within organic soils, multiple year moisture trends in the fuel/soil complex have not been described or linked to weather or satellite remotely sensed data. This field project is directly measuring moisture contents in live surface fuels, root mat and organic soils in coastal plain sites and in live surface fuels and organic and/or mineral soils of upland piedmont and mountain sites. Water table wells and moisture sensors are used quantify moisture gradients within deep organic soils. Daily weather and radiometric measurements are collected from representative weather stations and used to estimate midday dead fuel moisture contents and potential evapotranspiration. Vegetation greenness is directly measured and monitored using satellite remote sensing. Understanding yearly moisture trends in the live fuel/soil complex will identify fuel availability within these vegetation types. Linking identified combustion limits with estimated soil and leaf moistures will improve the effectiveness of prescribed fire use, fire preparedness planning and suppression by providing information not currently available in commonly used drought indices. The best methods for monitoring fuel availability will be discussed and preliminary data results will be displayed.

Materials and Methods

Sample sites have been selected within Atlantic Coastal Plain, long leaf pine/savannah sites and mountain locations that span North Carolina's geographic extent and vegetation community types. Cooperating agencies offered sample locations ranging from The Great Dismal Swamp National Wildlife Refuge at the northern extent of the study area to The Nature Conservancy's Green Swamp at the southern extent represent the Atlantic Coastal Plain. The Great Smoky Mountain National Park and the National Forests of North Carolina (NF or NC) offered sites with Appalachian Mountain vegetation communities to the west. The Department of Defense, the Carolina Sandhills National Wildlife Refuge and North Carolina state land management cooperators selected sites representing Coastal Plain and Piedmont/Sand hills vegetation. At least two widely separated sample sites have been established in each vegetation type. Within Atlantic Coastal Plain, pond pine (*Pinus serotina*) woodland, high pocosin, low pocosin and marsh grass vegetation communities will be sampled. Other types may be added depending on sampler availability. Longleaf pine (*Pinus palustris*) - savannah communities are sampled within the Piedmont and some Coastal Plain locations. Mountain laurel and rhododendron fuels will be sampled within Appalachian Mountain sites. Currently a total of twenty five sites are instrumented (11 pocosin, 7 mountain laurel, 3 rhododendron, and 4 longleaf pine).

Site descriptions include line transect estimates of vegetation and dead fuel cover. The most frequent species are cataloged and overstory tree cover is estimated. These values will be used to adjust vegetation indexes for the actual amount of surface area with vegetation. Notation of changing plant phenology accompanies periodic sampling.

Moisture content sampling – Sampling began slowly in 2004 as sites were established. Sampling will continue through August of 2007. The study teams and cooperators sample moisture content in live vegetation, 0 to ¼ inch diameter and ¼ to 1 inch diameter dead woody fuels, litter, and duff. The root mat, and muck soil is collected in communities with deep organic soils and mineral soil moisture is sampled at other sites. Samples are collected weekly to biweekly during the spring and fall fire seasons and during the growing season. Sampling is biweekly once leaves have matured and moisture stabilized. Winter sampling occurs as access to sites permits. Three composite samples are collected per visit of each sampled element of each identified sample species. One to three species have been selected per site representing dominant species of concern to fire managers. Sampled components for each species include new leaves of the year, mature leaves, and attached dead twigs less than ¼ “ in diameter. Each of the three samples of each sampled component is made up of material from several individual plants. Three composite samples of the root mat, the sapric muck soil layer below the root mat, or mineral soil in drier sites are collected. Moisture content is determined using standard oven-dry techniques and moisture content is expressed on a dry-weight basis.

Soil measurements – Each study site is equipped with a data logger to record hourly ground water level, soil moisture and soil temperature. Ground water levels are commonly used as an indictor of ground fire potential in the pocosin vegetation type. On 11 coastal plain sites automated ground water level measurements are made at hourly intervals using an ECOTONE ground water wells. These instruments use changes in the capacitance of a probe inserted in standard slotted well pipe to measure water level fluctuations at depths up to 48 inches beneath the soil surface. Manual water level measurements are made at weekly intervals at 4 pocosin sites.

Soil moisture is the basis of many drought indices that are used as a measure of fire danger. Duff and soil moisture are measured both destructively and non-destructively on all study sites. Campbell soil water content reflectometer probes measure the changes in soil conductivity due to soil moisture. Measurements are made at 0-6 inches and 0 – 12 inches of the soil profile. Measurements in the pocosin study sites are made in the muck (sapric material) beneath the root mat, and measurements in the laurel and rhododendron sites are made in mineral soil. The moisture distribution within the sapric muck layer will be predicted using published soil parameters Vegetation type specific calibration equations are also being developed.

Soil temperature is an important parameter affecting plant physiological processes and is also needed to correct the soil moisture calibrations. Soil moisture measurements are made with a thermister at 6 inches beneath the soil surface in the mineral soil sites and at the root mat/ muck interface in the pocosin study sites.

Weather data collection – Weather stations are maintained by cooperators in this study and weather observations are recorded in the Weather Information Management System. A solar radiometer added to each weather station will improve the estimate of the amount of sunlight at each station. This data will be used to calculate PET and estimate the moisture content of dead fuels by size classes (Nelson 2000).

Remotely sensed imagery – Currently, the EROS Data Center of the USGS provides AVHRR-NDVI data to the fire community on a weekly basis. This data will be used to monitor temporal and spatial differences in vegetation reflectance on a 1-km resolution. In 2002, the “Aqua” satellite with MODIS sensors will be launched. MODIS sensor data is available from the NASA “Aqua” and “Terra” satellites. This data will be used over 7 to 8-day composite periods, to offer higher resolution vegetation monitoring.

Fire behavior notes – Ultimately, land managers wish to be able to improve their ability to predict fire behavior in live fuels and organic soils, especially to be able to identify the threshold to sustained combustion. This project will not involve burning to identify and verify these thresholds, however, our cooperators are all actively involved in fire use and suppression. During the period of the study, they will provide feedback to the principal investigators noting date of burning and whether or not live fuels and/or organic fuels sustained burning. Identifying these critical thresholds can only be accomplished by linking fire behavior observations to weather and sample data.

Summary

Seasonal average and trends in live and dead fuel moisture content are important in fire prediction, planning and suppression. The leaf moisture content of plant foliage is an indicator of both the foliage ignition potential and a reflection of soil water availability. Predicted changes in soil moisture content are an integral component of a number of drought indices and soil moisture is an important consideration in burning organic soils where there is a risk of ground fire. This study is being conducted to collect base line data to evaluate live foliage and soil moisture as an indicator of both fire behavior and ground fire potential. Study methods, equipment and the special problems presented by climate and wildlife will be discussed. Preliminary trends from the first year of sampling will be presented to compare spatial and vegetation type differences within the study region.