Stereo Photo Series for Quantifying Natural Fuels in the Prairie Forest and Northwestern Great Plains

Final Report for JFSP Project #03-3-3-46
by
Roger D. Ottmar, Principal Investigator

Pacific Northwest Research Station

Fire and Environmental Applications Team

Pacific Wildland Fire Sciences Laboratory
Seattle, Washington

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Gary Kirpach (vice Mitch Maycox) and Roger Ottmar, Principal Investigators

Final Report to the Joint Fire Science Program (JFSP 0-3-3-46)

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December 31, 2006

ABSTRACT

The natural fuels stereo photo series is a collection of geo-referenced data and photographs that display a range of natural conditions, fuel loadings, and other fuelbed characteristics in a wide variety of forest-, woodland-, shrub-, and grass-dominated ecosystem types. The photo series are useful tools for quickly and inexpensively evaluating vegetation and fuel conditions in the field. The objectives of this project were to **continue the development of the Natural Fuels Photo Series to include a series that covers the Prairie Forest and Northwestern Great Plains region of eastern Montana.**

Discussions with the Bureau of Land Management and the USDA Forest Service concluded that a photo series volume needed to be developed and published that included two fuelbed types: (1) sagebrush with grass and (2) ponderosa pine-juniper. Eleven sagebrush and grass sites and twelve ponderosa pine and juniper types were located, photographed and inventoried in central and eastern Montana. Field data was reduced and analyzed. The major deliverable of this project, a camera-ready Natural Photos Series Volume X has been completed and has been sent to the printer. The photo series will be available for distribution from the Pacific Northwest Research Station free of charge by June 2007.

INTRODUCTION

Controlling wildfires, safely using prescribed fires, conducting management actions to enhance ecosystem health, and prioritizing treatment of hazardous fuels all require accurate quantitative information about fuelbeds. Most managers have fuels data of insufficient extent, detail, or resolution necessary for fire behavior and fire effects prediction, or for fuel treatment planning. Photo series provide a quick, easy, inexpensive means for quantifying and describing existing fuel properties for selected areas within a landscape. Federal, state, and private fuel and fire managers use the Natural Fuels Photo Series to help them quantify and assess fire severity and

hazard, air pollutant emissions, and other effects of fire. Photo series can reduce average field and fuel inventory time from 21 to 3 person-hours – a saving of $1,500 in inventory costs per unit sampled.

Although there are many published photo series (e.g., Maxwell and Ward 1976, 1980; Fischer 1981; Blonski and Schramel 1981; Ottmar et al. 1990), they are often limited in scope, contain single photographs, and generally do not fully characterize the entire fuelbed complex. Older photo series also lack the detail needed for validating remotely sensed data, developing Fuel Characteristic Class fuelbeds, and are often restricted to activity fuels in forested biomes. With the increase in prescribed burning in natural fuel types and in non-forested ecosystems, a study was commissioned by the Department of the Interior in January 1995 to develop a photo series for natural fuels that would improve the photo series coverage of several major fuel types common to Federal lands in the United States (phase I). Further photo series development was sponsored by the Joint Fire Science Program in 1998 (JFSP 98-1-1-05 Photo Series - phase II) and 2001 (JFSP 01-1-7-02). Some critical fuel types were not covered within the scope of phases I and II, because of funding and time limitations. Several of these critical fuel types were completed for this Joint Fire Science Program project.

OBJECTIVES

The objectives of this project were to:

(1) reassess the literature and the needs of land managers to identify a maximum of 6 fuelbed types and their associated fuel elements not covered by previous projects for further development of the Natural Fuels Photo Series.
(2) locate, photograph and field inventory a maximum of 20 sites within a fuelbed type that represents a range of fuel and vegetation conditions.
(3) produce a camera-ready manuscript and assist with the printing process.

METHODS

ASSESSMENT OF LITERATURE AND FUEL TYPE SELECTION

The principal investigators and local fuel authorities participated in two planning meetings and reconnaissance trips. This informal needs assessment resulted in selection of two fuelbed types for this JFSP-sponsored Natural Fuels Photo Series development project (table 1). The two fuelbed types included: (1) sagebrush with grass and (2) ponderosa pine-juniper (central and eastern Montana)

SITE SELECTION, DATA COLLECTION AND PHOTOGRAPHY

A total of 11 sites were selected for the sagebrush and grass fulebed type and 12 sites selected for the ponderosa pine and juniper fuelbed types (table 1). All sites were in Montana and selected from the Charles M. Russell National Wildlife refuge, Warhorse National Wildlife Refuge, and BLM lands near Lewistown, Montana.

Sites photographed for a fuelbed type are selected to show a range of conditions of various site attributes depending on the ecosystem type. For example, the sagebrush and grass sites represent a range of shrub coverage, species composition, and shrub size conditions and are ordered by total above ground biomass. The ponderosa pine-juniper sites show a range of woodland and forest stand conditions and are ordered by tree density. Photographs were taken and fuel loading, stand structure, and composition data were collected by using the procedures of Maxwell and Ward (1980) as a guide (fig. 1).

Table 1. Fuelbed types, location, number of sites, and photo series published for this project.

Fuelbed Type	Location	Sites	Photo Series Title
Sagebrush with grass	Montana,	11	Stereo Photo Series for Quantifying Natural Fuels Volume X: Sagebrush with grass and ponderosa pine-juniper types in central Montana (please see camera ready attachment).
Ponderosa pine-juniper	Montana	12	

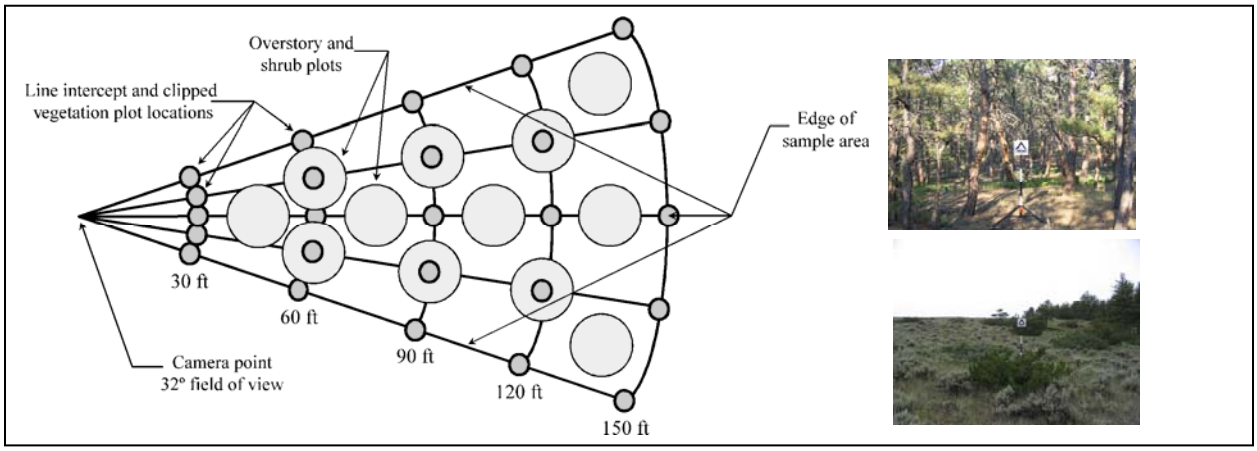

Figure 1. Photo series sampling layout. Forty random azimuth line transects (one at each point on the 30- and 150-foot arcs, and two at each point on the 60-, 90-, and 120-foot arcs) and 12 clipped vegetation plots (two to three per arc) were located within the sample area. Trees, shrubs, and seedlings were inventoried on 12 systematically located sample plots.

Single and stereo-pair photographs were included in each guide. The three-dimensional image obtained by viewing the photographs with a stereoscope will improve the ability of the land manager to appraise natural fuel, vegetation, and stand structure conditions. A larger, wide-angle photograph was included for additional comparisons. The summary data for each site relate to the field of view of the stereo-pair photographs.

PHOTOGRAPH AND INFORMATION ARRANGEMENT

The photographs and accompanying data summaries are presented as single sites organized into two series. Each site is arranged to occupy two facing pages. The upper page contains a wide-angle (50mm) photograph and general site and stand information. For the ponderosa pine - juniper series,

the upper page includes information on understory vegetation and dead and down woody material loading and density by size class. The lower page includes the stereo-pair photographs and summaries of the overstory tree, sapling, and shrub structure and composition. The sagebrush with grass series also includes vegetation, litter and woody material loading by size class. The ponderosa pine - juniper series also includes forest floor information along with juniper biomass and structure information.

SITE AND STAND INFORMATION

The camera point of each site was located with a global positioning system (GPS) receiver using the WGS-84 datum. Aspect and slope were measured with a compass and clinometer, respectively. Ecological community classification (to the association level; USGS 2006), an indicator of current vegetation composition, was assigned for all sites. In addition, Society of American Foresters (SAF; Eyre 1980) and Society for Range Management (SRM; Shiflet 1994) cover type, indicators of current vegetation composition were assigned for all ponderosa pine - juniper and sagebrush with grass sites, respectively. Shrub, forb, and graminoid species coverage along with mineral soil exposure, was estimated by using line intercept transects (Canfield 1941). The listing of understory species was not meant to be a complete vegetation inventory and may represent only a portion of the actual species richness of the sampled areas.

For the ponderosa pine - juniper series, tree and seedling species present at a site are listed in order of abundance. Crown closure was measured with a forest densitometer (95 systematically located points). Tree and seedling composition and density were determined either by a total inventory of the sample area, or estimated by using twelve 0.005-acre circular plots; all trees less than 4.5 feet tall were considered seedlings.

UNDERSTORY VEGETATION

Graminoid and forb heights were measured at 25 points located systematically throughout the sample area; shrub height was calculated as an average of all shrubs measured in 12 systematically located 0.005-acre circular plots. Understory vegetation biomass was determined by sampling 12 square, clipped vegetation plots (10.76 square feet each) located systematically throughout the sample area (fig. 1). All live and dead understory vegetation (except *Juniperus* spp.) within each square plot were clipped at ground level, separated, and returned to the laboratory for oven drying. Understory vegetation and other collected material was oven dried at a minimum of 158°F for at least 48 hours before weighing and determination of area loading. Where present, *Prunus virginiana* was considered a shrub and measured in twelve 0.005-acre circular plots; biomass was calculated from a growth-form-based allometric equation (tall shrubs; Brown 1976).

FOREST FLOOR INFORMATION

For the ponderosa pine - juniper series, litter and duff depth were calculated as the average of measurements taken every 5 feet between the 30- and 150-foot arcs of the three center transects for a total of 75 measurements (fig. 1). The depth of the litter and duff was calculated as an average of the depth only where litter or duff was encountered during sampling (null values, or points where litter or duff were absent, are not included in the average). Therefore, the depths reported for litter and duff are not unit-wide averages, and do not necessarily sum to total depth. Loading was calculated from depth and bulk density values derived from field measurements or

through collection of material in twelve 10.76 square foot plots.[1] Constancy, an indicator of how consistently the various forest floor components occur in the sample area, is expressed as a percentage of the total number of measurements. The amount of exposed mineral soil at each site for the ponderosa pine - juniper series can be estimated by subtracting the constancy of the total forest floor from 100 percent. For the sagebrush with grass series, litter loading was determined through collection of material in twelve 10.76 square foot plots.

SELECTED SHRUB AND TREE SPECIES

For the sagebrush with grass series, individual plants of selected shrub and tree species were measured in circular plots or, if shrub density was low, in the entire sample area. Selected tree and shrub species included *Pseudotsuga menziesii, Juniperus scopulorum, Artemisia tridentata,* and *Sarcobatus vermiculatus*. The density and percentage of all stems that were dead is based on the number of plants rooted in circular plots ranging from 0.0001-acre to 0.005-acre each (or in the entire sample area if shrub density was low). Crown area was calculated from crown breadth (i.e., the average of the maximum crown diameter, and the widest point perpendicular to the maximum crown diameter). Basal diameter was measured above the root collar. Height is given as the average and maximum height of all sampled individuals of a given species. Cover was estimated using line intercept transects (Canfield 1941). *Pseudotsuga menziesii* biomass was estimated using a species-specific allometric equations (Brown 1978) and includes the mass of foliage and branches less than three inches diameter. Shrub biomass was determined by sampling 12 square clipped vegetation plots located systematically throughout the sample area.

WOODY MATERIAL

Measurement techniques used for inventorying dead and down woody material were patterned after the planar intersect method outlined by Brown (1974) and described by Maxwell and Ward (1980). Forty transects of random azimuth starting at 25 systematically located points within the sample area were used to determine woody material loading and density (fig. 1). Woody material data are reported by size classes that correspond to timelag fuel classes used in fire behavior modeling (see, for example, Burgan and Rothermel 1984).[2] Woody material in 10-hour, and 100-hour-and-larger size classes was tallied on transects that were 10 feet and 30 feet long, respectively. The decay class and the actual diameter at the point of intersection were measured for all pieces >3 inches in diameter. All woody material less than or equal to three inches in diameter was considered sound. Woody material loading and woody material density were calculated from relationships that use number of pieces intersected and transect length (and wood specific gravity for loading) developed by Brown (1974) and Safranyik and Linton (1987), respectively. Woody material loading in the 1-hour size class (and the 10-hour and 100-hour size classes for many of the sites) was determined by collecting, oven drying, and weighing all pieces in twelve 10.76-square-foot plots. When woody material >3 inches in diameter was scarce, a total inventory within the sample area was conducted to determine loading and density estimates. Measurements were taken to determine log volume, and wood specific gravities were applied to the volume to calculate loading.

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[1]Forest floor bulk density values used for each material type appear under “Notes to Users” for each series.
[2]1-, 10-, 100- and 1000-hour timelag fuels are defined as woody material ≤0.25 inch, 0.26-1.0 inch, 1.1-3.0 inches, and >3.0 inches in diameter, respectively.

SAPLINGS AND TREES

Overstory tree and sapling composition and density were determined either by a total inventory of the sample area, or were estimated by using twelve 0.005-acre circular plots located systematically throughout the sample area (fig. 1). Tree measurement data were summarized by diameter at breast height (d.b.h.) [3] size class and by tree status (live, dead, or all trees). The two most abundant tree species for each size class are listed with their relative density. Height to crown base (reported as ladder fuel height in previous photo series volumes) was defined as the height of the lowest, continuous live or dead branch material of the tree canopy, and height to live crown was defined as the height of the lowest continuous live branches of the tree canopy. Live crown mass (branchwood and foliage) was calculated from species- and size-specific allometric equations (Brown 1978, Jenkins et al. 2003). *Juniperus scopulorum* with a single-stemmed form was considered a tree.

JUNIPER BIOMASS

Juniperus scopulorum and *Juniperus horizontalis* in the Missouri Breaks region of central Montana have a diverse morphology, from prostrate shrub to tree form, and are reported to hybridize (Fassett 1944, 1945), making them difficult to identify to the species level. Therefore, all juniper with a multi-stemmed form were combined, regardless of species, and characterized by height class to distinguish between the low stature juniper form (≤ 3 ft tall) and the more upright form (> 3 ft tall). Biomass was collected in six systematically located 10.76 square foot plots for each height class represented at each site. All juniper vegetation that occupied the space defined by a vertical projection of the plot edges was clipped, separated into live and dead components, and weighed. A sub-sample of plots was further separated into size classes including foliage and live and dead fine twigs less than or equal to 0.25 inch, 0.26-1.0 inch twigs, and greater than 1.0 inch diameter stem and branch material. Biomass for each height class was calculated by multiplying the square footage occupied by each size/status class and the average loading per square foot for that size/status class for each site.

DELIVERABLES

The primary deliverable product for the project was one volume of the Natural Fuels Photo Series, three progress reports, and a website (table 2). Two-thousand copies of the volume will be printed through the Pacific Northwest Research Station and distributed free of charge. Copies will be distributed to the JFSP. Additional products, updates to photo series tutorial (JFSP 04-4-1-19) and technology transfer has been completed that were beyond the scope of the project (table 3). Data collected for this photo series effort allowed the Fuel Characteristic Classification System (JFSP 98-1-1-06) to be more robust and include more fuelbeds in types that were historically data-poor.

[3] D.b.h. is measured 4.5 feet above the ground.

Table 2. Comparison of proposed and actual deliverables.

Proposed	Delivered	Status
Three progress reports	Three progress reports were completed for the JFSP	Done
One photo series volume	In print. Ottmar, Roger D.; Vihnanek, Robert E.; Wright, Clinton S. **2007**. Stereo photo series for quantifying natural fuels. Volume X: Sagebrush with grass and ponderosa pine-juniper types in central Montana. Gen. Tech. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Two-thousand copies of this Volume will be printed through the Pacific Northwest Research Station and be available free of charge by June 2007.	In print.
Publication describing inventory and photographic methodologies	None. The inventory and photographic methodologies are presented in each photo series publication.	
Web Page	http://www.fs.fed.us/pnw/fera/photoseries.html	Done

Table 3. Additional deliverables completed that were not included in the original proposal.

Additional Deliverables Completed But Not Originally Proposed
RX-410 and RX-310 Photo Series Training Package
Eight poster presentations and published abstracts.
Four presentations at various conferences and seminars.
35 photo series presentation and exercises at RX 410 (Smoke management), RX 300, (Burn Boss), and RX 310 (Fire Effects) national and regional training sessions.
Digital photographs and data provided for implementation into Digital Photo series project (JFSP- 04-4-1-02)
This photo series was included in the photo series tutorial project (JFSP-04-4-1-19)
This photo series was included in five Field Training Workshop project curriculum (JFSP-05-4-1-14) and two conference workshops.
This photo series was included in two conference workshops
This photo series was included in one Region 8 workshop.

WEB PAGE

A web page including project progress, citation and ordering information was established at www.fs.fed.us/pnw/fera/photoseries.html.

POSTERS, ABSTRACTS, AND PRESENTATIONS

Ottmar, R.D., R.E. Vihnanek and C.S. Wright. 2003. Stereo photo series for quantifying natural fuels in the Americas. Poster and extended abstract. In: Kush, John S. (ed.), Longleaf pine: a southern legacy rising from the ashes. Proceedings of the fourth longleaf alliance regional conference. November 17-20, 2002, Southern Pines, North Carolina. Longleaf Alliance Report No. 6.

Ottmar, R.D., R.E. Vihnanek and C.S. Wright. 2003. Stereo photo series for quantifying natural fuels in the Americas. Poster and extended abstract. Proceedings of the workshop: Using fire to control invasive plants: what's new, what works in the Northeast? January 24, 2003, Portsmouth, New Hampshire.

Ottmar, R.D., R.E. Vihnanek and C.S. Wright. 2003. Stereo photo series for quantifying natural fuels in the Americas. Presentation. Seminar on fire management and forest restoration. February 10, 2003, University of Guadalajara, Autlan, Jalisco, Mexico.

Ottmar, R.D., R.E. Vihnanek and C.S. Wright. 2003. Stereo photo series for quantifying natural fuels in the Americas. Poster and abstract. Society for Ecological Restoration, Northwest Chapter and the Pacific Northwest Chapter of the Society of Wetland Scientists "The Restoration Toolbox" Joint Regional Conference. March 24-28, 2003, Portland, Oregon.

Ottmar, R.D., R.E. Vihnanek and C.S. Wright. 2003. Stereo photo series for quantifying natural fuels in the Americas. Poster and extended abstract. 3rd International conference on wildland fire and international wildland fire summit. October 3-6, 2003, Sydney, Australia.

Ottmar, R.D., R.E. Vihnanek and C.S. Wright. 2003. Stereo photo series for quantifying natural fuels in the Americas. Presentation. 6th Congress of Mexican forest management. November 5-7, 2003, University of San Luis Potosi, San Luis Potosi, Mexico.

Ottmar, R.D., R.E. Vihnanek and C.S. Wright. 2003. Stereo photo series for quantifying natural fuels in the Americas. Poster. 5th Symposium on Fire and Forest Meteorology and the 2nd International Wildland Fire Ecology and Fire Management Congress. November 17-20, 2003, Orlando, Florida.

Ottmar, R.D., R.E. Vihnanek and C.S. Wright. 2003. Stereo photo series for quantifying natural fuels in the Americas. Presentation. 10th Symposium on research, natural resource development, and management. November 24-27, 2003, University of Guadalajara, Autlan, Jalisco, Mexico.

Ottmar, R.D., R.E. Vihnanek and C.S. Wright. 2004. Stereo photo series for quantifying natural fuels in the Americas. Presentation. 2nd Seminar on fire management and forest restoration. March 11, 2004, Independent Agricultural University Antonio Narro, Saltillo, Mexico.

Ottmar, R.D., R.E. Vihnanek and C.S. Wright. 2004. Stereo photo series for quantifying natural fuels in the Americas. Poster. First international symposium on forest fires and fire management. July 1-3, 2004, Zapopan, Mexico.

Ottmar, R.D., R.E. Vihnanek and C.S. Wright. 2004. Stereo photo series for quantifying natural fuels in the Americas. Poster. 16th Mexican botany congress. October 17-22, 2004, Oaxaca, Mexico.

Ottmar, R.D., R.E. Vihnanek and C.S. Wright. 2004. Stereo photo series for quantifying natural fuels in the Americas. Poster. The week of fire. October 19-21, 2004, Cancun, Mexico.

PUBLICATIONS (PRINTER READY DRAFT AT THE TIME OF THIS REPORT)

The camera-ready draft of one Natural Fuel Photo Series publications has been completed. The draft is being sent to the printers for publication. The publication will be distributed free of charge through the Pacific Northwest Research Station

Ottmar, Roger D.; Vihnanek, Robert E.; Wright, Clinton S. 2007. Stereo photo series for quantifying natural fuels. Volume X: Sagebrush with grass and ponderosa pine-juniper types in central Montana. Gen. Tech. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Will be printer through the Pacific Northwest Research Station.

WEB PAGE

A website link to the photo series project was established at http://www.fs.fed.us/pnw/fera/photoseries.html

DEMONSTRATIONS AND WORKSHOPS

Photo Series Demonstrations (JFSP 04-4-1-19)

- The 3-day train-the-trainer Southern Regional Fuels Workshop (November 7-9, 2005), Hawaii Regional Fuels Workshop (February 28-March 2, 2006), the Pacific Northwest Regional Fuels Workshop (May 14-16, 2006), Alaska Regional Fuels Workshop (August 15-17, 2006), and Ohio Regional Fuels Workshop (November 28-December 1) taught and demonstrated the photo series and digital photo series. The workshop consisted of a series of short presentations, question and answer sessions, an 8-hour field demonstration, and a hands-on practicum led by the principal investigator. Questions and comments were collected during the demonstration and were used to improve the photo series. Three additional workshops within the scope of this JFSP proposal in 2007 will also demonstrate the photo series. The final report will be submitted to the JFSP for this training project in June 2007.
- A 4-hour workshop that included a demonstration of the photo series was conducted at the 1st Fire Behavior and Fuels Conference on March 27, 2006, Portland, Oregon.
- A 2-hour photo series demonstration each of three days was conducted at the Region 8 prescribed fire workshop, October 17-19, 2006 in Johnson City, Tennessee.
- A 4 hour workshop that included a demonstration of the photo series was conducted at

the third fire effects Congress, November 13, 2006 San Diego, California.

CONSULTATIONS

The principle investigator consults with several land managers, regulators, and scientists each year with regard to photo series use and future development.

TUTORIAL

A web-based self-taught tutorial along with an instructor's guide and student workbook for the photo series has been developed (JFSP 04-4-1-19). The photo series tutorial can be accessed through a web-browser or down-loaded directly from http://www.fs.fed.us/pnw/fera/products/tutorials/. The final report for this project has been submitted to the JFSP.

LESSON PLANS AND TRAINING

A "how to use the photo series" lesson plan was developed and implemented in the Smoke Management Techniques RX- 410 National Training Curriculum. The lesson has since been incorporated into several regional training curricula, including: RX 310 Fire Effects and RX 300 Prescribed Fire Burn Boss. Finally, the training has been adapted by the University of Idaho in there 401 fuels management series and into the Technical Fire Management fuels module.

TRAINING

The principal Investigator has taught how to use the photo series approximately 35 times at both National and regional training sessions. In addition, photo series training was given to a group of Mexican fire management professionals at the Forestry Center in Cuidad Guzman, Mexico from February 21-March 2, 2005.

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