Research Note

CSIRO PUBLISHING

International Journal of Wildland Fire **2010**, *19*, 374–376

www.publish.csiro.au/journals/ijwf

Critique of Sikkink and Keane's comparison of surface fuel sampling techniques

Clinton S. Wright[A,B], *Roger D. Ottmar*[A] *and Robert E. Vihnanek*[A]

[A]USDA Forest Service, Pacific Northwest Research Station, Pacific Wildland Fire Sciences Laboratory, 400 North 34th, Suite 201, Seattle, WA 98103, USA.

[B]Corresponding author. Email: cwright@fs.fed.us

Abstract. The 2008 paper of Sikkink and Keane compared several methods to estimate surface fuel loading in western Montana: two widely used inventory techniques (planar intersect and fixed-area plot) and three methods that employ photographs as visual guides (photo load, photoload macroplot and photo series). We feel, however, that their study design was inadequate to evaluate the accuracy of these methods when measured against a series of reference sites. Incorrect use may have contributed to the authors' inferences that the photo series method was the least accurate in this case. Furthermore, sampling efficiency was not adequately taken into account when evaluating overall efficacy of the five methods studied.

Additional keywords: fuel inventory techniques, photo series.

Introduction

Land and fire managers have numerous reasons to estimate fuel loading in a variety of forest and range ecosystems, including predicting fire behaviour, wildland fire hazard, fuel consumption and smoke production; monitoring fuel treatment effectiveness and longevity; and evaluating carbon stocks and potential bioenergy sources. Sikkink and Keane (2008) compared five sampling techniques for estimating the biomass of surface fuels (shrubs, herbs, fine and coarse woody debris) in dry western Montana conifer forests. They compared the accuracy and efficiency of standard and well-documented inventory methods (planar intersect and fixed-area plot sampling) and techniques that use a photographic field guide as an assessment aid (pboto-load, photoload macroplot and photo series). Sikkink and Keane (2008) provided a concise annotated description of these and various other surface fuel sampling methodologies, so we will not revisit them here.

We applaud Sikkink and Keane (2008) for their attempt to evaluate the accuracy and efficiency of these different sampling methods, as such an evaluation could provide guidance for and justification of surface fuel sampling designs for future inventory and monitoring programs. However, designing and conducting statistically valid research in which the response variables are the results of human observations is challenging under the best of circumstances. It is our opinion that an inadequate study design was employed and insufficient data are presented in the article and supplemental table to clearly evaluate the precision, accuracy, bias, or efficiency of the methods tested, or the accuracy and precision of the shrub, herb and fine woody fuel reference values reported.

Study design shortcomings aside, we feel that Sikkink and Keane (2008) discounted the photo series for estimating surface fuel loading without adequate justification. Our primary issue as it relates to this critique concerns the manner in which the photo series was used and evaluated relative to the other tested methods. Photo series are useful tools for estimating surface fuel loading. Their relative ease of use and efficiency should be fully considered when selecting sampling methods, particularly for operational surveys when time, personnel, and funding are limiting.

In the interest of full disclosure, we have been involved with producing, further developing, and promoting photo series in one form or another for more than 20 years (R. D. Ottmar and R. E. Vihnanek) or have had a hand in data collection and preparation for all of the Natural Fuels Photo Series publications (C. S. Wright). We would like to point out that (1) photo series have changed and evolved to become more useful for a broader array of potential users; (2) correct usage of photo series is important for achieving the best results; and (3) efficiency is an important factor to consider when evaluating sampling methods, particularly when considering operational use.

Photo series evolution

For their time and intended use, early photo series, such as those published by Fischer (*1981a*, 1981b, 1981c), were useful tools for fire managers. As fire and fuel management has evolved, however, data requirements have increased in breadth and complexity. Whereas Fischer may have designed his photo series to support managers who were chiefly concerned with estimating or predicting fire spread and intensity, additional issues related to smoke management, fire effects, wildlife habitat, carbon accounting, and biomass extraction also concern contemporary fire and resource managers. For these reasons, photo series have evolved to include data that characterise the

10.1071/WF09084 1049-8001/10/030374

entire fuelbed (current examples can be found online at http://depts.washington.edu/nwfire/dps, accessed 11 December 2009).

As mentioned, early photo series (e.g. Fischer 1981a, 1981b, 1981c) were useful tools; however, more recent versions have improved in format. Current volumes of the Natural Fuels Photo Series include oblique stereo pairs, as well as larger photos of higher print quality. Stereoscopic photos help users get a better sense of stand and fuel structure by presenting a three-dimensional image of the stand from which the data were collected. Although these improvements may not entirely mitigate the problems associated with visually obscured surface fuels (Sikkink and Keane 2008, p. 375), large, high-quality images and stereo-pair photos are improvements that can help users achieve better results when estimating fuelbed characteristics such as surface fuel loading.

In addition to improvements in photo display, newer photo series also include a richer quantitative description of the entire fuelbed. Fischer (l98lb) included only data describing litter, duff, and woody surface fuels; therefore Sikkink and Keane (2008) were not able to evaluate the efficacy ofthis photo series for evaluating all aspects of the surface fuel stratum. The Natural Fuels Photo Series (e.g, Ottmar *et al.* 1995, 2007) include data describing all aboveground biomass, including shrub, forb, and grass quantities, species composition, and details that characterise the tree and shrub strata for forest and shrub-dominated types, respectively. Whereas Fischer (198lb) was meant primarily as a tool for assessing potential fire behaviour, the additional information presented in the Natural Fuels Photo Series can be used for assessments of other ecosystem and stand characteristics (e.g. crown fuels, stand structure, overstorey and understorey species composition, and wildlife habitat). To date, Natural Fuels Photo Series have been published in 15 geographically organised volumes for 39 different ecosystem types throughout the United States.

Proper use of photo series

Our biggest criticism of Sikkink and Keane (2008), concerning their evaluation of the photo series, is related to the manner in which it was used to assess surface fuels at their study sites. In fact, as described, the photoload macro technique actually closely resembles the photo series methods recommended by numerous authors (e.g. Maxwell and Ward 1976, 1980; Koski and Fischer 1979; Blonski and Schramel 1981; Fischer 1981a, 1981b, 1981c, 1981d; Ottmar *et al.* 1995, 2007; Wright *et al.* 2006) where they suggest that a fuelbed be visually decomposed into its component parts with each part assessed individually. Several different photos may be necessary to accurately estimate the loading of the different components that comprise the fuelbed. In addition, two photos may also be used to interpolate a value where they bracket an observed condition at a site. In Sikkink and Keane (2008), however, subjects were instructed 'to determine which of the oblique photos most closely matched the observed downed woody debris conditions. Loadings were assigned to each fuel component using summaries presented by Fischer (l98la) for each selected photo' (Sikkink and Keane 2008, p. 367). It is not clear from this description of sampling methods whether the procedures of Fischer (l98lb) were used. The authors' description of the methods for estimating fuel loading suggests that a single photo (and its accompanying woody fuel loading values) was selected to represent 1-, 10-, 100- and 1000-h size-class down woody debris rather than separate photos, or interpolations between bracketing photos, for each down woody debris category. Indications that it took ~5 min per site (Sikkink and Keane 2008, p. 375) tend to support our interpretation, because, in our experience, a more thorough category-by-category evaluation would have been more time-consuming. Regardless, it is possible that surface fuel loading can be more accurately estimated using the category-by-category and bracket-and-interpolate approach than the selection of a single photograph (and its accompanying data) to represent all surface fuel categories for a site.

Although simple in concept, we have found that most users require training and practice to become comfortable and confident in their abilities to use photo series to make accurate, precise, and efficient assessments. We base this statement on observations and feedback from 10 full-day workshops at which more than 200 fire, fuel, and air-quality managers with varying levels of experience in fuel assessment have been instructed in and practiced using the Natural Fuels Photo Series on inventoried reference sites scattered throughout the United States. It would appear that only minimal, if any, training in photo series use was provided to the subjects who participated in the Sikkink and Keane (2008) study, whereas one (Keane and Dickinson 2007, p, 11) or two (Sikkink and Keane 2008, p. 367) hours of training were provided on the photoload techniques. Relative to the other methods and to the reference values, results of the photo series estimates of woody fuel loading were very good for some sites and down woody debris categories despite lack of training, potentially incorrect usage, and much less time spent conducting assessments using the photo series.

Sampling efficiency

In order to minimise sampling time (i.e. maximise sampling efficiency), one must often sacrifice some data quality (i.e. accuracy and precision); the appropriate sampling method balances sampling time or efficiency with the quality of measurement required for the application of interest. In their discussion, Sikkink and Keane (2008) make reference to sampling times for the various methods (~5 min per site for the photo series, 6-7 min per site for the photo load macroplot, 100-180 min per site for the planar intersect, 125-190 min per site for the photoload, and 300-600 min per site for the fixed-area plot), but present no quantitative evaluation of these sample-time estimates. One of the stated objectives of their study was 'to evaluate how much time was required to complete sampling' (i.e. the efficiency) using the various sampling techniques; however, no quantitative comparisons of sampling time or efficiency were presented (cf Freese 1962; Husch *et al.* 1982). Adding the time necessary to establish a 10 x l0-m grid over a 0.25-ha site, which can be considerable in difficult terrain or dense vegetation, makes the methods that required systematic sampling (i.e. photoload, fixed-area plot, planar intersect) even more time-consuming and therefore less efficient. Significant differences in loading estimation could not be detected among the different sampling methods; however, the large differences in sampling time required (i.e. efficiency) were discounted in evaluations of the methods tested but should also be considered when judging efficacy.

Summary

In circumstances that call for a quick, inexpensive assessment of surface fuel loading, photo series are useful tools for land and fire managers. Photo series should not be dismissed in general based on the performance of one volume with admitted limitations that may have been used incorrectly. Improvements in photo display (larger, higher-resolution photo and stereo pairs) and data richness (data characterising the entire fuelbed, not just the litter, duff, and woody fuels) in more recent volumes of the photo series add functionality and address some of the deficiencies encountered by Sikkink and Keane (2008) when using the photo series of Fischer (198lb).

References

Blonski KS, Schrarnel JL (1981) Photo series for quantifying natural forest residues: southern Cascades, northern Sierra Nevada. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, General Technical Report PSW-S6. (Albany, CA)

Fischer WC (1981a) Photo guide for appraising downed woody fuels in Montana forests: grand fir-larch-Douglas-fir, western hemlock, western hemlock-western redcedar, and western redcedar cover types. USDA Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-96. (Ogden, UT)

Fischer WC (1981b) Photo guide for appraising downed woody fuels in Montana forests: interior ponderosa pine, ponderosa pine-larch-Douglas-fir, larch-Douglas-fir, and interior Douglas-fir cover types. USDA Forest Service, Intermountain Forest and Range Experiment Station General, Technical Report INT-97. (Ogden, UT)

Fischer WC (1981c) Photo guide for appraising downed woody fuels in Montana forests: lodgepole pine, and Engelmann spruce-subalpine fir cover types. USDA Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-98. (Ogden, UT)

Fischer WC (1981d) Photo guides for appraising downed woody fuels in Montana forests: how they were made. USDA Forest Service, Intermountain Forest and Range Experiment Station, Research Note INT-299. (Ogden, UT)

Freese F (1962) Elementary forest sampling. USDA Forest Service, Agriculture Handbook No. 232. (Washington, DC)

Husch B, Miller CI, Beers TW (1982) 'Forest Mensuration.' 3rd edn. (Wiley: New York)

Keane RE, Dickinson LJ (2007) Development and evaluation of the photoload sampling technique. USDA Forest Service, Rocky Mountain Research Station, Research Paper RMRS-RP-61CD. (Fort Collins, CO)

Koski WH, Fischer WC (1979) Photo series for appraising thinning slash in north Idaho: western hemlock, grand fir, and western redcedar timber types. USDA Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-46. (Ogden, UT)

Maxwell WG, Ward FR (1976) Photo series for quantifying forest residues in the ponderosa pine type, ponderosa pine and associated species type, and lodgepole pine type. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, General Technical Report PNW-52. (portland, OR)

Maxwell WG, Ward FR (1980) Photo series for quantifying natural forest residues in common vegetation types of the Pacific Northwest. USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, General Technical Report PNW-l05. (Portland, OR)

Ottmar RD, Vihnanek RE, Wright CS (1998) Stereo photo series for quantifying natural fuels. Volume I: mixed-conifer with mortality, western juniper, sagebrush, and grassland types in the interior Pacific Northwest. National Wildfire Coordinating Group, National Interagency Fire Center PMS 830. (Boise, ID)

Ottmar RD, Vihnanek RE, Wright CS (2007) Stereo photo series for quantifying natural fuels. Volume X: sagebrush with grass and ponderosa pine-juniper types in central Montana. USDA Forest Service, Pacific Northwest Research Station, General Technical Report PNW-GTR-719. (Portland, OR)

Sikkink PG, Keane RE (2008) A comparison of five sampling techniques to estimate surface fuel loading in montane forests. *International Journal of Wildland Fire* 17, 363-379. doi:10.1071/WF07003

Wright CS, Ottmar RD, Vihnanek RE (2006) Stereo photo series for quantifying natural fuels. Volume VIII: hardwood, pitch pine, and red spruce/alsam fir types in the north-eastern United States. National Wildfire Coordinating Group, National Interagency Fire Center PMS 840. (Boise, ID)

Manuscript received 29 July 2009, accepted 15 December 2009