Supplement of Biogeosciences Discuss., 12, 15737–15762, 2015
http://www.biogeosciences-discuss.net/12/15737/2015/
doi:10.5194/bgd-12-15737-2015-supplement

Biogeosciences
Discussions
Open Access

Supplement of

Vegetation structure and fire weather influence variation in burn severity and fuel consumption during peatland wildfires

G. M. Davies et al.

Correspondence to: G. M. Davies (davies.411@osu.edu)

Protocol for recording peatland Composite Burning Index (pCBI) plots

Introduction

This brief introduction is adapted from the full description of the original CBI method provided in Key & Benson (2006). We recommend readers are familiar with the background and details on the method they provide before proceeding. The Composite Burn Index is used to derive index values that summarize general fire effects within an area, that is, the average burn condition on a plot. It was designed for moderate-resolution remote sensing applications and to provide a landscape perspective of burned regions. As such, plots are fairly big and are generally be widely spaced (> 90 meters apart). However, there is no reason *per-se* why the technique could not be adapted for work at smaller spatial scales. The CBI is a provides a forensic approach to understanding fire severity in that it can be collected after the fact when monitoring of fire behaviour and severity at the time of the burn was not possible. Field data are quick to collect (about 30 minutes per plot) and rely mostly on visual estimation, qualitative judgments and comparison with pre-fire conditions or nearby unburnt areas where these are available. The primary task is to capture the range of variation found within burns, covering as many fire effects and biophysical settings as possible.

The CBI was designed to capture fire effects in forest ecosystems by gauging changes from pre-fire conditions. Assessment is made across two key vegetation strata: the crown (canopy and subcanopy) and understory (shrub and herb layers and soils/substrates). Visual ratings of fire effects included variables such as soil condition and colour, fuel consumption, evidence of post-fire resprouting newly colonizing species, etc. The CBI provides a continuous, though bounded, numeric value so that it can be analysed in the context of environmental variables fuel load or fire weather conditions. We have modified the CBI in order to apply it to British moorlands/peatlands. This includes accounting for the largely tree-less nature of these ecosystems, the importance of paying particular attention to peat-building *Sphagnum* species and the need to assess fire effects of peat substrates themselves (Table S1).

Table S1: Variables recorded during fire severity assessment using the peatland Composite Burn Index.

Substrate/ground fuel effects	**Surface fuel effects**
Litter/light fuel consumed	Proportion of plants top-killed
Area showing charred or consumed peat	Fine/Crown fuel consumed
Ash cover	Survival (%) of grass/sedge tussocks
Exposed mineral soil cover	Survival (%) of shrubs
Sphagnum damage (% loss of capitula)	Shrub resprout abundance
Moss scorch/consumption	Potential for new colonizing species
Sphagnum/moss survival	Potential changes in species composition

An important point to note regarding the pCBI methodology (and the CBI approach in general), is that it depends on the visual observation of fire-induced changes and subsequent assignment of fire effect scores. The final pCBI score is this highly dependent on the skill and experience of individual observers and substantial differences can occur between observers if significant efforts aren't made to cross-calibrate observations and train new observers. This fact also means that it can be difficult to directly compare the results CBI monitoring completed by different research team.

Equipment required

- Map of fire perimeter and/or general location
- 2 x 100 m tapes
- CBI field form
- Notebook
- Pencil
- Clipboard
- Compass
- Clinometer
- GPS
- Meter rule
- Camera
- Metal ID tags and die stamp set
- Pliers
- Rebar
- Plastic bags for soil/plant sample collection
- Indelible marker

Plot design

- Two types of plots can be recorded: 1) paired burnt-unburnt established across the fire perimeter; and 2) stand-alone burnt plots located in the interior or larger burns. Paired plots will facilitate comparison with pre-burn conditions but caution needs to be used in selecting appropriate locations. Fires can self-extinguish where fuel or abiotic conditions change and thus burnt and unburnt locations may not be comparable. Additionally prior land-use history means peatlands in the UK often contain a patchwork of vegetation stands at different times since fire. Observers should ensure burnt and unburnt areas are comparable by, for example, using pre-fire aerial photographs, liaising with local land-managers and comparing the densities and basal-diameters of *Calluna* stems on either side of the fireline. Researchers should preferably limit themselves to sections of the fireline known to have been actively extinguished.
- Plots consist of a 20 m circle, marked using two crossed 20 m tapes. One tape should be aligned North-South and the other West-East
- All transects run magnetic North- South
- Distance is always measured from North to South and West to East

Plot layout

For the burned-unburned paired plots the plot layout design is shown in Figure 1. Davies et al. also used such plots for destructive sampling of pre- and post-fire fuel load. To ensure burnt and unburnt subplots are comparable, burnt sub-plots must be placed no more than 30 m from the fire perimeter; unburned plots should be located within 5-25 m of the fire perimeter. It is undesirable to locate unburnt sub-plots closer to the fire line as they may have been disturbed during fire-fighting operations or by scorching from flames.

Stand-alone plots allow researchers to capture a wider range of fire severities that may not be evident at the perimeter. Their disadvantage is that is much more difficult to make confident judgements about changes from pre-fire conditions and direct comparisons with similar but unburnt areas is not possible.

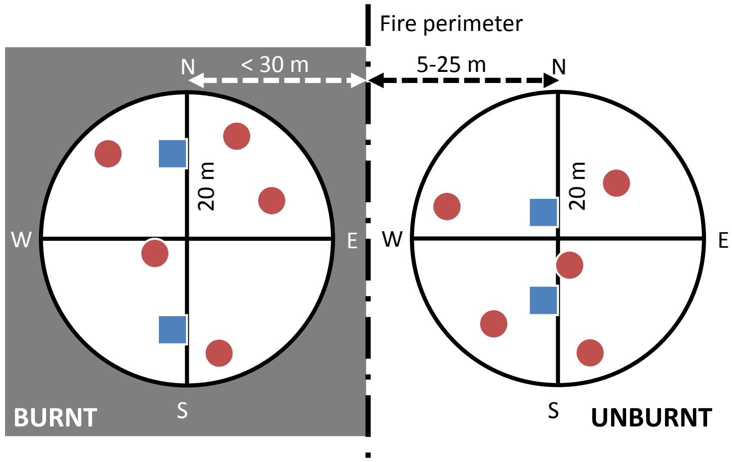

Fig. A1: Layout of monitoring plots. CBI plots= black circle. For Davies et al. (in review), two, 250 cm^2 fuel assessment quadrats (squares) were randomly located along the N-S axis of the plot. Fuel was also harvested within five, 19 cm diameter gas flux chambers (circles) located at random co-ordinates within each plot. We recommend at least five fuel samples are taken in each subplot.

Plot marking

- Where permanent plots are to be established we recommend marking them with rebar and a metal ID tag at the central point of the CBI plot, where N/S transect crosses the W/E transect.

Data collection

Filling the form

If any of the categories are not present or cannot be reliably scored at time of monitoring, write NA in the factor scores column and discount from calculation of stata and overall pCBI score.

General information

- ***Fire name.*** Name or code of the fire as assigned by local land-managers or fire-fighting agencies
- ***Examiners.*** Person/people who fills in the form.
- ***Field date.*** Date when the CBI plot is performed.
- ***Plot/sub-plot code.*** Plot code is normally composed of the first letter of the name of the fire, then B (from burned) or UB (from unburned) and finally the number of the CBI plot. For example for the first burned plot analysed at the Wainstalls fire assessed by Davies et al., the code given was WB1.
- ***Slope.*** In degrees measured with a clinometer.
- ***Aspect.*** In degrees measured with a compass.
- ***UTM zone.*** UTM zone recorded by the GPS.
- ***GPS error.*** Error of the position recorded by the GPS.
- ***UTM E plot centre and UTM N plot centre.*** The position of the plot will be recorded as the centre point of the plot.
- ***GPS location saved***. Save the position in the GPS as the name of plot code, and write it in the field form.

- ***Plot diameter***. The plot diameter is normally 20 m for pCBI plots. 30 m plots may be used in forested peatlands where effects on tree canopies are also recorded (not considered here)
- ***Photos ID.*** Write down the file name of the photos taken at each plot.

Strata 1 - Substrate ratings

Important note - do not count litter or fuels built-up after the fire

- ***Litter/light fuel consumed.*** Proportion of fallen leaves, needles, and deadwood < 3 inches (<7.6 cm) diameter consumed by the fire. Ignore new litter-fall which can be significant if shrubs/trees are scorched. Count litter/light fuel even if it occurs under living plants.
- ***Duff/Peat.*** Proportion of plot area showing signs of duff or peat charring or consumption. Where smoulder pans are visible make a specific note of their number and size.
- ***Ash cover.*** Note the proportion and colour of any ash found on the peat/ground surface. White or grey (5 to 10 %) or red (5-50% and more than 50%).
- ***Exposed mineral soil cover.*** Area of the plot over which mineral soil or rock has been exposed by the fire. Discount rocks and boulders that were exposed prior to the fire.
- ***Sphagnum damage*.** Proportion of *Sphagnum* shoots showing discolouration and/or capitula loss. Colour can be unchanged or discoloured to different degrees (30-50-75-100%). Capitula (the top of the plant) have compact clusters of young branches, and their loss is assessed by percentage (10-30-70-100%).
- ***Moss scorch/consumption.*** Proportion of any layers of pleurocarpous or acrocarpous mosses showing signs of scorching/discolouration (50-100%) or consumption (50-100%).
- ***Sphagnum/moss survival.*** Proportion of *Sphagnum* or moss likely to have survived the fire the fire. Assessment can be made by inspecting *Sphagnum* and /or moss shoots for evidence of areas remaining green or showing resprouting stems.

Strata 2 - Herbs and low shrubs

- ***Top-killed.*** Pre-fire living plants that have been consumed or fatally scorched by the fire.
- ***Fine/crown fuel consumption***. Proportion of fine shrub crown (leaves and twigs < 2.5 cm diameter) and herbaceous fuels consumed. If the top-plant was totally consumed then the fine/crown fuel consumed will also be 100%. Include any unburned patches within the plots.
- ***Frequency of grass/sedge/forb survival.*** Proportion of pre-fire graminoids and forbs that are still alive after the fire, based on number of resprouting tussocks and stems plot wide. Note this is survivorship, not cover, not new seedlings. Include any unburned patches within the plot and resprouting perennial herbs. Burned plants may need to be examined for viable growth points. Do not include new plants from regenerating from seed.
- ***Frequency of shrub survival***. Percentage of pre-fire shrubs that are still alive after fire, based on number plot wide; survivorship, not cover, not new seedlings. Include unburned as well as burned patches in the plot. Burnt plants may need to be examined for viable growth points. Do not include new plants from seed.
- ***Colonizers.*** Potential dominance 2-3 years post fire of new (native or exotic) plants, includes herbs and tree seedlings and nonvascular plats. Invasion of *Pteridium aquilinum* is a particular concern on some drier sites.
- ***Changing species composition.*** Potential for longer-term changes in species composition and/or relative abundance 2 to 3 years post-fire.
- ***Shrub frequency resprouting.*** Relative frequency of shrub resprouts taking account of time since fire.

Other observations

- ***Pre-fire fuel bed depth.*** In unburnt subplots take six measurements of the depth of the moss/litter layer, duff beneath the moss/litter and the overall depth of the fuel bed (i.e. from top of peat to top of tallest shoot touching the ruler. Take readings to the nearest cm every 3 m along the North-South transect
- ***Ericaceae and other seedling frequency***. This will be assessed qualitatively by the following categories: Unknown (No seeds have been found), Very infrequent, Infrequent, Occasional, Frequent and Very frequent.

Photographs

- Take a photograph (landscape format) looking along the N-S transect from north to a south
- Record the ID number of the image in the Photos ID box on the field form

Calculating the pCBI

- To calculate the pCBI score for a plot average the ratings within each strata and then sum the two strata averages together.

References

Davies, G.M., Domènech, R., Gray, A. and Johnson P.C.D. (in review): Vegetation structure and fire weather influence variation in burn severity and fuel consumption during moorland wildfires. Biogeosciences.

Key, C.H. and Benson, N.C. 2006. Landscape Assessment (LA) Sampling and Analysis Methods. General Technical Report RMRS-GTR-164-C. USDA Forest Service Rocky Mountain Research Station, Fort Collins, CO, USA. Available from: http://www.fs.fed.us/rm/pubs/rmrs_gtr164/rmrs_gtr164_13_land_assess.pdf [Accessed 23 March 2015].

PEATLAND COMPOSITE BURN INDEX

BURNED PLOT

Fire name:		Examiners:		Field date:	
Plot code:		Slope (degrees):		Aspect (degrees):	
UTM Zone:		GPS Error:		UTM E plot center:	
GPS Datum:		Plot elevation:		UTM N plot center:	
GPS Location saved:		Plot Diameter:			
Photos ID:					

% of plot area burnt =

STRATA RATING FACTORES		BURN SEVERITY SCALE							Factor Scores
		No Effect	Low		Moderate		High		
		0.0	0.5	1.0	1.5	2.0	2.5	3.0	
STRATA 1 - SUBSTRATES									
Litter/ light fuel consumed		unchanged	--	30% litter	--	60% litter	--	100%	
Duff/ Peat		unchanged	--	Light char	--	50% loss deep char	--	Consumed	
Exposed mineral soil cover		unchanged	--	+ 10% change	--	+ 40% change	--	>80% change	
Sphagnum damage	discoloured	unchanged	--	30%	--	50%	75%	100%	
	capit. loss	none	< 10%	--	30%	--	70%	100%	
Moss Scorch/ Consumption		unchanged	--	50% scorch	100% scorch	--	50% cons	100% cons	
Sphagnum / Moss survival		100%	--	90%	--	50%	<20%	None	
STRATA 2 - HERBS, LOW SHRUBS AND TREES LESS THAN 1 M									
Top-killed		unchanged	--	30%	--	80%	95%	100%+branch loss	
Fine/ Crown fuel consumed		unchanged	10%	--	30%	50%	90%	100%	
Frequency herb survival		100%		90%		50%	<20%	None	
Frequency of shrub survival		100%	--	90%	--	50%	<20%	None	
Colonizers		unchanged	--	Low	--	Moderate	High-Low	Low to None	
Changing species composition		unchanged	--	Little change	--	Moderate change	--	High change	
Shrub frequency resprouting		100%	--	90%	--	50%	<20%	None	
COMMENTS									
Frequency of Ericaceae seedlings			unknown	very infrequent	infrequent	ocasional	frequent	very frequent	
Frequency of other seedlings			unknown	very infrequent	infrequent	ocasional	frequent	very frequent	

UNBURNED PLOT

Fire name:		Examiners:		Field date:	
Plot code:		Slope (degrees):		Aspect (degrees):	
UTM Zone:		GPS Error:		UTM E plot center:	
GPS Datum:		Plot elevation:		UTM N plot center:	
GPS Location saved:		Plot Diameter:			
Photos ID:					
A. SUBSTRATES					
Pre-fire % cover: Litter= Duff= Soil/Rock=			**Pre-fire depth (cm): Moss/Litter= Duff= Fuel Bed=**		
B. HERBS, GRASSES, SEDGES, DWARF SHRUBS AND TREES LESS THAN 1 M					
Pre-fire % cover of each group:					

OBSERVATIONS

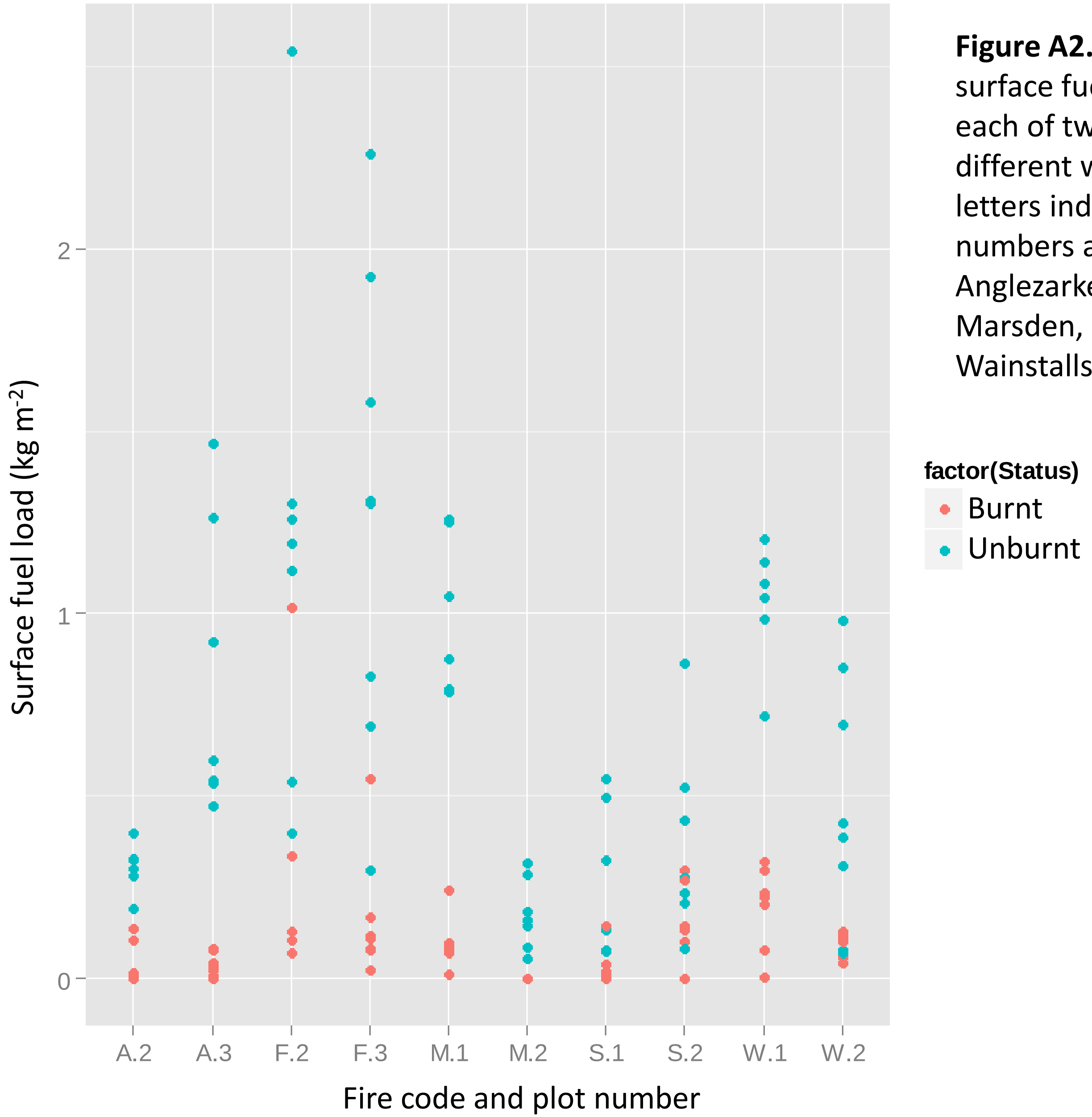

Figure A2.1: Distribution of surface fuel load data across each of two paired-plots in five different wildfires. On the x-axis letters indicate the wildfire and numbers are the plot ID. A = Anglezarke, F = Finzean, M = Marsden, S = Loch Doon, W = Wainstalls.

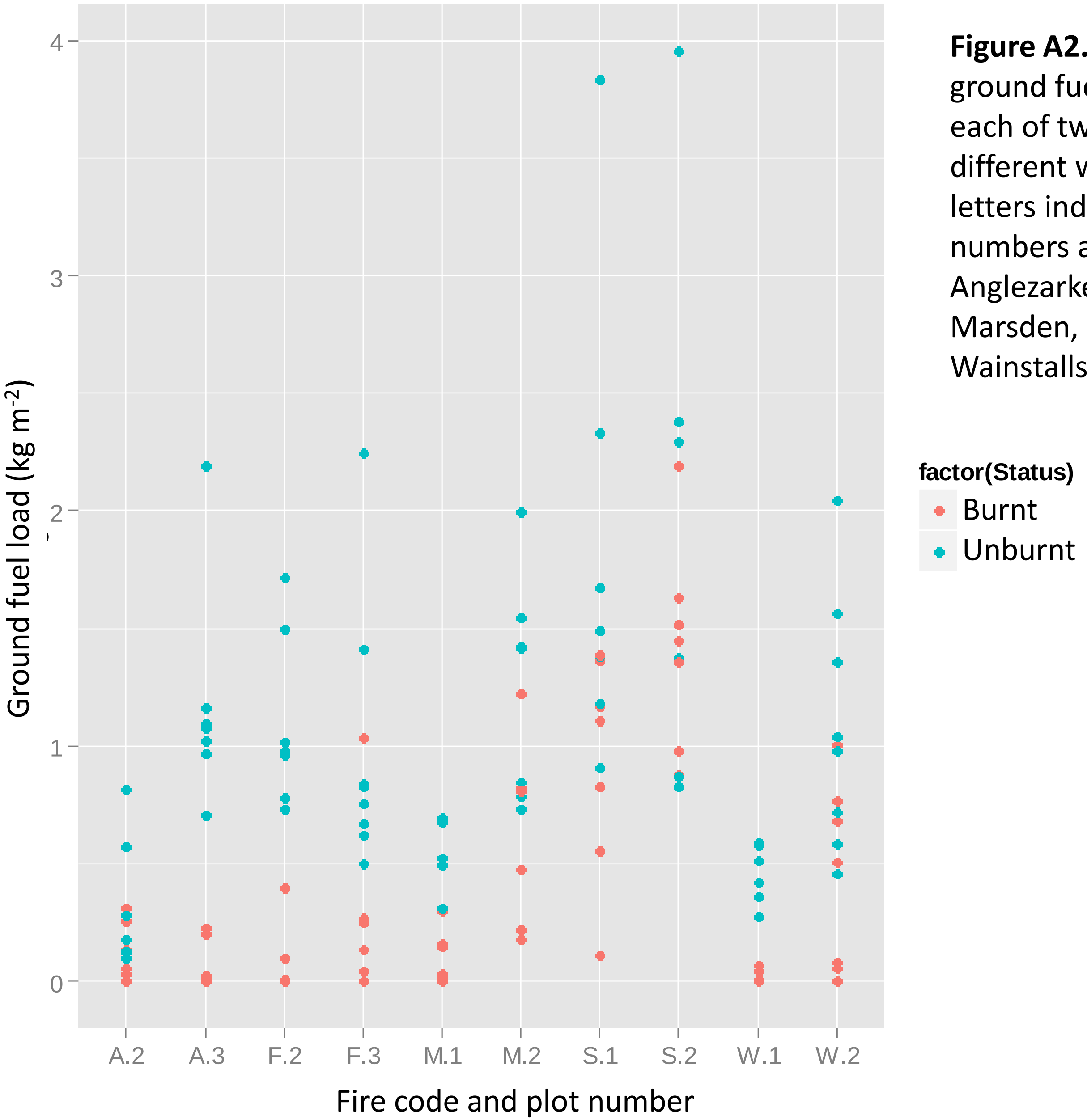

Figure A2.2: Distribution of ground fuel load data across each of two paired-plots in five different wildfires. On the x-axis letters indicate the wildfire and numbers are the plot ID. A = Anglezarke, F = Finzean, M = Marsden, S = Loch Doon, W = Wainstalls.