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Supplementary Material

A generic, empirical-based model for predicting rate of fire spread in shrublands

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Table S1. Summary of site characteristics, vegetation type, plot layout, fuel sampling methods and characteristics, weather and fire behaviour assessment methods for the South African dataset (van Wilgen 1982; 1984; van Wilgen et al. 1985)

Site location	Experimental fires conducted at two locations: Kogelberg (34°16'S; 19°00'E) and Cederberg (32°20'S; 19°03'E), in the Western Cape Province, South Africa. Fires conducted between 1976 and 1979 (Kogelberg) and 1983 and 1984 (Cederberg).
General topography	The Kogelberg site was approximately 110 m above sea level and located on level but rocky ground with shallow, sandy, well-drained and nutrient-poor soils derived from sandstone. The Cederberg site was approximately 470 m above sea level and located on a northeast facing slope, with inclinations varying from 6 to 15 degrees. Soils are gravelly and shallow.
Climate	Both sites characterised by Mediterranean-type climate, with warm, dry summers and cool wet winters. Mean annual rainfall 1015 mm at the Kogelberg site, and 664 mm at the Cederberg. July had the highest mean monthly rainfall at both sites (Kogelberg 204 mm; Cederberg 125 mm), and February had the lowest mean monthly rainfall at both sites (Kogelberg 37 mm; Cederberg 15 mm).
Vegetation type	Vegetation was a tall (1.8 m) open shrubland at both sites. The dominant shrub at the Kogelberg was *Leucadendron laureolum* (Proteaceae), and at the Cederberg the proteaceous shrubs included *L. pubescens*, *Paranomus bracteolaris* and *Protea laurifolia*. The understorey at both sites consisted of grasses or reed-like plants in the families Restionaceae,Cyperaceae and Poaceae, and fine-leaved shrubs in the families Asteraceae, Ericaceae and Fabaceae.
Plot layout	A total of 14 experimental plots of approximately 50 x 50 m.
Fuel assessment methods	The biomass of dominant shrubs was estimated using regression analysis for tall shrubs (relationships between stem diameter and total above-ground biomass, as well as biomass of plant parts with a diameter of < 6mm). See van Wilgen (1982) and van Wilgen and Richardson 1985 for methods. The understorey biomass was estimated by clipping, drying and weighing above-ground plant material on plots of 1 – 4 m^2. Plant material from these clip-plots was divided into shrubs, restioid plants, graminoid plants, other herbs, and litter (dead material).
Fuel description	Total above-ground plant biomass ranged from 0.969 to 3.415 kg/m^2, with a coefficient of variation of 36%. Most (around 80%) of the biomass was provided by understorey plants, and consisted of an erect mixture of herbaceous and fine-leaved shrubs, interspersed with erect dead material derived mainly from herbaceous plants, and a ground layer of leaf litter from overstorey shrubs. Both sites were mature, that is they had not been burnt for at least 15 years prior to biomass sampling.
Weather observations	Wet and dry-bulb temperatures measured using an Assmann aspirated psychrometer. The instrument was hand-held, about 50 m from the plots. Wind measured with anemometer at 1.8 m height positioned about 50m from the plot. All data logged at 1-minute intervals
Fuel moisture	Samples of the vegetation (< 6 mm in diameter) were clipped immediately prior to the fires. Two or three samples each of (1) dead material, (2) understorey shrubs, and (3) twigs and foliage of overstorey shrubs were sealed in air-tight glass bottles until each could be weighed and dried. Moisture contents were calculated as % of dry mass.

Rate of fire spread	Rate of spread was estimated from a grid of 16-20 points in each plot. Steel wires were tied to steel pegs with nylon line. The other end was tied to a numbered brick suspended over a frame outside of the plot. When the fire reached the peg, the nylon melted, the brick fell, and the time lapsed between ignition and fall was noted (fires were ignited as headfires (with the wind) along one boundary of the plot). Fire isolines were constructed after the burns were completed to estimate rate of spread (the mean rate between points in the path of the headfire).

Table S2. Summary of site characteristics, vegetation type, plot layout, fuel sampling methods and characteristics, weather and fire behaviour assessment methods for the Southern NSW dataset (Catchpole 1987)

Site location	Experimental fires at Deua National Park (35° 44'S, 149° 39'E; Australia, burns conducted in Dec 1984) and Nadgee Nature Reserve (37° 18'S, 149° 56'E; Australia, burns conducted in Nov 1986).
General topography	The experimental site at Deua National Park was approximately 800 m above sea level and located on the Great Divide in southern NSW. The experimental site at Nadgee Nature Reserve was approximately 50 m above sea level and located on the coast near the NSW/Victoria border.
Climate	The Deua National Park site had a Montane climate with annual rainfall is 690 mm, mean minimum temperature 6°C, and mean maximum temperature 19°C. The Nadgee Nature Reserve site had a coastal climate with annual rainfall is 745 mm, mean minimum temperature 12.5°C, and mean maximum temperature 18.2°C.
Vegetation type	The Deua National Park site had vegetation dominated by *Allocasuarina Nana* (almost the only species) with interspersed grass 3% of the fuel load. The vegetation at the Nadgee Nature Reserve site was a mix of shrubland and sedges.
Plot layout	Experimental plot sizes varied between 30 and 50 m width by 100 m length.
Fuel assessment methods	Fuel load and structure were described using a combination of line intersect and destructive sampling methods. Destructive sampling was used to estimate fuel load in each layer (litter and elevated), height, bulk density and proportion of dead fuel.
Fuel description	Overall fuel cover was about 90% at the two sties. For the Deua NP fuel height was 0.7m, the total fuel load comprised litter and shrubs with some grass. Fine fuel load (dead leaves and live twigs and leaves with diameter <3 mm) was 2.5 kg m^{-2}. For the Nadgee NR fuel height varied between 0.25 and 0.5 m; the total fuel load comprised shrubs and sedge vegetation. There was very little litter fuel. Fine fuel load (dead leaves and live twigs and leaves with diameter <3 mm) was 0.9-1.5 kg m^{-2}.
Weather observations	Air temperature and relative humidity were measured at 1.5 m above ground within 2 km of the experimental plots. A tower with anemometers positioned at 0.75m, 2m and 2.5m were placed 50 to 75 m in the windward side of the ignition line centre.
Fuel moisture	Moisture content of dead fine fuels was measured by destructive sampling. Samples were collected from litter, elevated dead and live fuels.
Rate of fire spread	In low intensity fires the observers mapped the fire perimeters at 1-minute intervals using numbered metal discs.

Table S3. Summary of site characteristics, vegetation type, plot layout, fuel sampling methods and characteristics, weather and fire behaviour assessment methods referent to the NSW data (Bradstock and Auld 1995)

Site location	Experimental fires at Kur-ing-gai Chase NP and Blue Mountains NP, Australia. Burns conducted spring 1990 and autumn 1991.
General topography	Flat or gently sloping (i.e. < 5 degrees) ridge-tops
Climate	Warm temperate, rainfall aseasonal.
Vegetation type	Kur-ing-gai Chase NP: low open woodland or low open forest of *Eucalyptus gummifera, E. haemastona, Angophora costa.* Shrubs: *Petrophile pulchella, Banksia ericafolia, Hakea dactyloides, Grevillia speciosa, Boronia pinnata*. Legumes: *Acacia suaveolens, A. ulicifolia, Bossiaea obcordata, B. scolopopendra, Dillwynia retorta, Phyllota phylicoideas, Pultenaea elliptica.* Blue Mountains NP: low open forest of *Angophora costa, Eucalyptus piperita, E. oblonga, E. haemastona.* Shrubs: *Lamberta Formosa, Leptospermum attenuatum, Hakea dactyloides.* Legumes: *Acacia terminalis, A. ulicifolia, Daviesia corymbosa, Putenaea scabra.*
Plot layout	Two plots within each of 3 experimental sites of varied size with minimum size length of 100m and maximum of 200m
Fuel assessment methods	Pre- and post-fire destructive sampling with circular rings (area 0.25m2) to a height of 2.5m. Fuel split into fine surface, fine aerial and coarse surface components. Fuel sorted by size classes.
Fuel description	Pre-fire data has disappeared into the mists of time unfortunately.
Weather observations	A portable weather station was used at each site, with Stevenson screen and various sensors plus anemometer (2 m height from memory).
Fuel moisture	Moisture content of dead fine fuels was measured by destructive sampling.
Rate of fire spread	Timed photographs of when fire arrived at fixed points. Rates of spread obtained from distance and time between standards.

Table S4. Summary of site characteristics, vegetation type, plot layout, fuel sampling methods and characteristics, weather and fire behaviour assessment methods referent to the Tasmania dataset (unpublished data with Jon Marsden-Smedley)

Site location	Fire INT was a wildfire on the northern part of Tasmania's west coast, fires RCH3 to RCH5 were planned burns in Rocky Cape national Park, fires FRY11, FRY12 and FRY14 were planned burns in Freycinet National Park and fires WILHe1 to WILHe5 were planned burns in Mt William National Park. Fires conducted between 1991 and 1998.
General topography	All sites fires were conducted in relatively flat sites.
Climate	The INT and RCH fires were conducted in sites with high year round rainfall. The FRY and WIL fires were conducted in sites with cool moist winters and dry summers.
Vegetation type	The INT fire was conducted in *Leptospermum scoparium* heathland. The RCH fires were conducted in *Banksia serata* and *L. scoparium* heathland. The FRY fires were conducted in *Leptospermum glaucescens* heathland which had a sparse overstorey of *Eucalyptus amygdalina*. The WIL fires were conducted in *Leptospermum scoparium* and *Xanthorrhoea* heathland with a sparse *E. amygdalina* overstorey. A ground layer of mixed grasses and sedges was also present.
Plot layout	The INT fire was in excess of 10 000 ha when measured. The other fires were lit along fire breaks and the fires measured within the blocks. All fires had fireline lengths in excess of 100 m.
Fuel assessment methods	Fuel characteristics were assessed visually.
Fuel description	Not available
Weather observations	All weather parameters were recorded at the fire ground within 100 m using hand held instruments.
Fuel moisture	Fuel moistures were measured as the oven dry weight from fuel samples collected in the field.
Rate of fire spread	Rate of spread was determined by recording the location of the fire front at different times.

Table S5. Summary of site characteristics, vegetation type, plot layout, fuel sampling methods and characteristics, weather and fire behaviour assessment methods referent to the Northern Spain dataset (unpublished data on file at Forestry Research Center of Lourizan, Galicia, Spain)

Site location	Six experimental sites in western Galicia, Spain (Pontevedra and Lugo, 31 fires) and one in northwestern Castilla –Leon (42^0 9'N, 6^0 14'W 13 fires), Spain. Burns conducted between 1993 and 2003.
Climate	Western Galicia has a mild temperate climate with Atlantic influence. Annual precipitation ranging from 1000 to 1400 mm. The experimental site in Castilla-León is characterized by a Mediterranean climate with a continental influence.
Vegetation type	Fires were conducted in (1) gorse (*Ulex sp.)* dominated communities, *(2)* mixed heathland of *Erica australis- Pterospartum tridentatum* heathlands, (3) tall temperate and humid mixed-heathlands with *Erica australis* and *Ulex sp*. as dominant species and (4) mixed- low heathlands with *Erica umbellata, Pterospartum tridentatum* and *Ulex sp.* Species.
Plot layout	Experimental plots with different sizes and shapes, varying between square from 20 x 20- m to 200 x 200 -m, rectangular from 20 x 25 –m to 80 x 54-m, to hexagonal (30 m side), surrounded by 5-10 m width fuel breaks.
Fuel assessment methods	Pre-fire fuel load and structure data were obtained by combining point intersect measurements and destructive sampling. Fuel was sorted by species, condition (live and dead) and size class (< 6mm and > 6mm, respectively) and dried in a fan forced oven to 105 º C for 48 hours to determine fuel weights on dry basis.
Fuel description	Overall fuel cover averaged 96% (range 78-100%). Fuel bed height varied between 0.32 and 1.5 m. The total fuel load comprising litter, suspended dead fuels and live shrub canopy components with diameter <6 mm) varied between 0.77 kg m^{-2} and 5.97 kg m^{-2}.
Weather observations	Air temperature, relative humidity and wind direction and wind speed (at 2-m and 6-m above the ground) were recorded by an automatic meteorological station located approximately 50 m upwind from the experimental plot an area with an undisturbed fuel structure, representative of the fuel to be burned. Data recorded at 1 Hz and averaged over 1-min periods.
Fuel moisture	Moisture content of dead suspended fine fuels, litter and live foliage was measured by destructive sampling. Five to 10 samples of dead fuel component were collected along a transect 15 to 30 min prior to each ignition. Live fuels were typicaly collected the day before each burn. Samples were sealed in tins and taken to a laboratory to determine the oven dry weight (dried at 100ºC for 24h).
Rate of fire spread	Fire rate of spread was measured by two observers by timing when the fire front reached pre-placed posts within each experimental plot. Generally, a grid of posts was established prior fire. Grid spacing varied between 5- 25, depending of the plot size and the expected fire rate of spread.

Table S6. Summary of site characteristics, vegetation type, plot layout, fuel sampling methods and characteristics, weather and fire behaviour assessment methods for the Portuguese dataset (Fernandes 2001; Vega *et al*. 2006)

Site location	Different locations in Portugal but mostly in the northern part of the country (lat. 39ºN to 42ºN, long. 7ºW to 9ºW). Burns conducted between 1994 and 2003.
General topography	Mountains and plateaus. Elevation generally above 400 m, often above 700 m. Soils derived from granite, schist or limestone.
Climate	Mediterranean with an oceanic influence. Annual precipitation and mean annual temperature vary in the ranges of 600-1500 mm and 10-16 ºC.
Vegetation type	Mediterranean-type shrubland or heathland of variable physiognomy and composition. Dominant species: *Ulex europaeus*; *Erica umbellata* and *Chamaespartium tridentatum*; *Erica australis* and *Chamaespartium tridentatum*
Plot layout	Plot size varying between approximately 50 x 50 m and 150 x 100 m.
Fuel assessment methods	Shrub cover and height measured along linear transects or in microplots. Biomass data from destructive sampling in quadrats was combined with stand structure data to estimate fuel loadings (by size class and live or dead condition) and bulk density. Fuel loadings in the prescribed burning plots were estimated non-destructively using published equations.
Fuel description	Shrub cover and height varied between 60 and 100% and 0.2 and 1.8 m, respectively. Elevated fine (<6 mm diameter) load varied between 0.48 kg m^{-2} and 3.66 kg m^{-2}, of which 8 to 38% was dead fuel.
Weather observations	At two meters in the open by a meteorological station near the burn plot, or measured upwind with hand-held instruments.
Fuel moisture	Moisture content of fine fuels was obtained from destructive sampling, individualizing elevated live, elevated dead and, for some fires, litter.
Rate of fire spread	Fire spread rates were determined by timing the head fire front arrival to pre-placed poles or other pre-defined reference points.

Table S7. Summary of site characteristics, vegetation type, plot layout, fuel sampling methods and characteristics, weather and fire behaviour assessment methods referent to the South Australian heath data (Cruz *et al*. 2010)

Site location	Experimental fires at the Ngarkat Conservation Park (35° 45'S, 140° 51'E), South Australia, Australia. Burns conducted between 2006 and 2008.
General topography,	The experimental site was approximately 130 m above sea level and located in a characteristic dune and swale system comprising large flat areas with relatively small dunes intermixed. Soils were aeolian sands of varying depth, overlying deep alluvial soils of the old River Murray delta (Specht and Rayson, 1957).
Climate	Semi-arid climate. Annual rainfall of the area is 473 mm with a distinct annual cycle with a maximum of 63 mm in August and a minimum of 18 mm in February.
Vegetation type	Vegetation was characterized as open woodland with *Eucalyptus calycogona*, *E. diversifolia*, *E. incrassata* and *E. leptophylla* as dominant overstorey species and an understorey *of Astroloma conostephioides*, *Adenanthos terminalis*, *Babingtonia behrii*, *Calytrix involucrata* and *C. tetragona*. A ground layer of mixed grasses and sedges was also present
Plot layout	A total of 10 experimental plots were prepared with size approximately 250 x 250 m.
Fuel assessment methods	Fuel load and structure were described using a combination of point intersect and destructive sampling methods. Destructive sampling was used to estimate fuel load in each layer (litter, near-surface, elevated and overstorey), height, bulk density and proportion of dead fuels.
Fuel description	Overall fuel cover varied between 46 and 83%. The total fuel load comprised of litter, understorey shrubs and overstorey canopy fine fuels (leaves and live twigs with diameter <3 mm) varied between 0.38 kg m^{-2} (in a 7-year old stand) and 1.48 kg/m^2 (in a 21-year old stand).
Weather observations	Air temperature and relative humidity were measured at 1.5 m above ground within 2 km of the experimental plots. For the SA experiments a primary 10-m tower with anemometers at 2- and 10-m height was placed 50 to 75 m along the side of the burn plot. A secondary back-up tower with a sole anemometer at 2-m was placed 50 to 75 m in the windward side of the ignition line centre. For each burn the wind towers were located in areas with a fuel structure representative of the experimental fire
Fuel moisture	Moisture content of dead fine fuels was measured by destructive sampling. Two types of samples were collected. Surface litter was collected from the top 10 mm of the litter layer. At locations where the litter layer was less than 10 mm deep, the entire layer was sampled. Suspended dead fuel samples were taken from between 0.1 and 1.0 m height, depending on the vertical distribution of fuel at each sampling location.
Rate of fire spread	Rate of spread was determined from measurements of the time of fire arrival at grid points within each experimental plot. Grid spacing varied between 25 and 50 m, depending on the expected rate of fire spread. In low intensity fires the observers mapped the fire perimeters at 2-minute intervals using numbered metal tags

Table S8. Summary of site characteristics, vegetation type, plot layout, fuel sampling methods and characteristics, weather and fire behaviour assessment methods for the New Zealand dataset (unpublished data on file with Scion; as illustrated in Anderson, 2009, after NZ Fire Research, 2000)

Site location	Experimental fires in manuka heath/scrub and gorse scrub from 7 sites across New Zealand. Burns were conducted between 1993 and 1997. What: manuka heath, Whatuwhiwhi, Northland, 34.85°S, 173.39°E. Jurl: manuka heath, Jurlina, Northland, 34.99°S, 173.36°E. Tokb: manuka scrub, Tokerau Beach, Northland, 34.88°S, 173.38°S. Ngat: manuka scrub, Ngatea, Waikato, 37.30°S, 175.45°E. Kawh: pakihi wetland, Kawhaka, West Coast, 42.75°S, 171.20°E. Wain: gorse scrub, Wainuiomata, Wellington, 41.31°S, 174.93°E. Hima: gorse scrub, Himatangi, Manawatu, 40.43°S, 175.28°E
General topography	The 3 Northland experimental sites (What, Jurl & Tokb) were located close to the coast on flats and ridges originating from sand dunes or gumlands, <40 m above sea level. The Ngat site was an inland peat swamp about 5 m asl. The Kawh site was a flat native wetland (pakihi) on outwash gravels about 150 m asl, caused by impeded drainage and an impervious soil horizon. The Wain gorse site was on a gravel terrace adjacent to a braided river, and the Hima gorse site on gently undulating old sand dune plains surrounded by improved pastureland, both <30 m asl.
Climate	Climate for the sites varied from subtropical oceanic with warm humid summers and mild wet winters in Northland, to warm temperate in the lower North Island (Hima, Wain), to cool temperate for the West Coast (Kawh). Annual rainfall averages around 1000-1500 mm for the North Island sites, up to 3000 mm for Kawh near Hokitika on the South Island's West Coast.
Vegetation type	Manuka sites included closed native heath or shrubland (Z3, Z4 or S3; after Specht, 1979) of varying height comprising *Leptospermum scoparium*, sometimes intermixed with kanuka (*Kunzea ericoides*). Heath sites included a sedge understorey (*Shoenus* or *Baumea* spp.), and occasional prickly hakea (*Hakea sericea*). The Kawh pakihi was open shrub wetland (Z3G; after Specht, 1979) comprising mixed native low heath (*L. scoparium*), ferns (*Gleichenia dicarpa*), and rushes dominated by *Machaerina teretifolia* and *Empodisma minus*. Gorse sites were closed scrub (Z4; after Specht, 1979) of *Ulex europaeus* L. with continuous or near-continuous canopy cover, generally no understorey, and deep surface and elevated gorse litter.
Plot layout	A total of 29 experimental plots were burnt across the 7 sites, with plot sizes of 100 x 100 m, and in a two cases (at Whatu) of 50 x 50 m.
Fuel assessment methods	Pre- and post-burn fuel load and structure were described using destructive sampling methods (Pearce et al., 2010). Destructive sampling was used to estimate fuel load in each layer (duff, litter, understorey and overstorey), height, bulk density and proportion of dead fuels.
Fuel description	Overall shrub cover and height varied from 47-48% and 0.4-0.5 m for pakihi wetland, to 43-83% and 0.6-4.8 m for 3-10 year old manuka heath/shrubland, to 58-92% and 2.2-3.1 m in gorse. The total above-ground available fuel load comprising litter, understorey and overstorey canopy fine fuels (leaves and live twigs with diameter <2 mm) (Pearce et al., 2010) varied from 0.64 kg m^{-2} in pakihi up to 3.82 kg m^{-2} for manuka and 4.81 kg m^{-2} for gorse. Elevated percent dead

	ranged from around 80% in pakihi, to 50-61% in gorse and 3-43% in manuka. Fuel consumption (based on pre- and post-burn measurements) ranged from 0.64-0.77 kg m^{-2} in pakihi, to 1.03-5.71 kg m^{-2} in manuka and 4.47-6.67 kg m^{-2} in gorse.
Weather observations	A portable automatic weather station was used to measure air temperature, relative humidity, 2-m wind speed & direction, and rainfall at each site. These were averaged over the duration of each fire run, and also used to determine Fire Weather Index codes and indices for correlation with observed fire behaviour.
Fuel moisture	In practically all cases, moisture content of dead and live fine fuels for all fuel layers present (duff, litter, understorey and overstorey) was measured by destructive sampling (in one case, only composite elevated moisture content was measured, so dead %MC has been estimated from a model for manuka heath). Elevated dead %MCs ranged from 14-29% in manuka, to 19-22% in pakihi, to 12-17% in gorse.
Rate of fire spread	Rate of spread was determined from measurements of the time the fire front reached marked grid points within each experimental plot. Grid spacing varied between 5 and 20 m, depending on plot size.

Table S9. Summary of site characteristics, vegetation type, plot layout, fuel sampling methods and characteristics, weather and fire behaviour assessment methods for Western Australia wildfires (unpublished data on file at Department of Parks and Wildlife, Manjimup WA Australia)

Site location	Wildfire observations from Leeuwin Naturaliste National Park (34° S, 115° E), south-west Western Australia. Contos fire occurred on 6 April 2006. Ellen Brook fire occurred on 23 November 20111..
General topography	Gently undulating coastal terrain within 5 km of the ocean, consisting of limestone ridges and consolidated calcareous sand dunes. Elevation 60 to 100 m above sea level. Occasional deeply incised erosion gullies running westwards to the coast.
Climate	Mediterranean. Annual rainfall of 1000 mm with a winter maximum. Light coastal showers may occur at any time of the year within 10 km of the coast. Strong (>30 km h^{-1}) southerly sea breezes are a regular feature during the summer months from December to March.
Vegetation type	Vegetation was characterized as Tall shrubland with 30-70% foliage cover for the talent plant layer (ST3 in the framework Australian fuel classifification). Characteristic tall shrub species include *Agonis flexulosa*, *Banksia grandis*, *Banksia sessilis*, *Xanthorrhoea preissi*. Fuel ages ranged from 15 to 25 years for both fires.
Plot layout	Not applicable. wildfires
Fuel assessment methods	Fuels not measured in detail. Photographs were used to estimate vegetation height, density and species composition.
Fuel description	Overall fuel cover varied has been estimated at 80% as an average value in mature fuels unburnt for 15 to years.
Weather observations	10 m wind observations from the Bureau of Meteorology automatic weather station at Witchcliffe, located 9 km inland from the Indian Ocean. The Witchcliffe AWS is within 15 km of both fire grounds. Jeff Keppert has done high resolution (400 m grid cell) modelling of the winds associated with the 2011 Ellen Brook fire. Air temperature and relative humidity observations used from the Bureau of Meteorology automatic weather station at Witchcliffe.
Fuel moisture	Not measured. Moisture content estimated using a moisture prediction model. In both case studies there was no significant effect of recent precipitation on dead fuel moisture content.
Rate of fire spread	Rate of spread was determined from fire spread reconstructions prepared by L McCaw based on witness statements and time stamped photographs. The reconstructed spread is considered to be moderately reliable for the Contos fire, and highly reliable for the Ellen Brook fire. Contos fire spread was estimated for the period 1900 h to 2400 h on 6 April 2006. Ellen Brook fire spread was estimated for the period 11.45 h to 13.45 h on 23 November 2011.
Supporting documents	Contos fire McCaw L and Round-Turner R (2007) Blackwood District Fire 29 Leeuwin Naturaliste National Park 6 & 7 April 2006. Fire narrative. Department of Environment and Conservation, WA. Ellen Brook fire GHD Pty Ltd (2012) Prescribed burn incident 9BS520 – Ellenbrook) – 23 November 2011 Operational Review. Prepared for the WA State Solicitors Office by Paul de Mar, GHD Pty Ltd. Bureau of Meteorology (2012) Meteorological aspects of the Margaret River fires 23 and 24 November 2011. Australian Government.

Keppert J, Fawcett R and Peace M (2012) Meteorological aspects of the margaret River fires on 23 November 2011. Bushfire CRC poster presented at the AFAC conference in Perth.
McCaw L (2012) Re-construction of the spread of Fire 8 Ellen Brook. Prepared 30 March 2012. This map was included as Figure 1 in the Post-Incident Analysis Report prepared by Noetic Solutions.

Table S10. Summary of site characteristics, vegetation type, plot layout, fuel sampling methods and characteristics, weather and fire behaviour assessment methods for Gippland (Vic) prescribed burns (unpublished data on file with Parks Victoria, VIC, Australia)

Site location	Old Burn Track Ecological Burn, 11th December 2012, Yanakie Isthmus Wilsons Promontory National Park (38°54'38.76"S, 146°14'22.12"E), Victoria, Australia. Fire behaviour observations of ecological burn in Coast Tea-tree invaded Calcareous Swale Grassland and Calcarenite Dune Woodland on the 11th December 2012.
General topography	The topography of the Yanakie Isthmus consists of a jumble of dunes generally aligned in an east-west direction, rising to 10 – 20m above the coastal plain (20-60 m above sea level). A range of slopes and aspects are present within the burn with north east and south west aspects predominating. Dunes in the area are subject to movement and there are a number of large areas of bare sand present within the burn boundary, particularly where the burn adjoins Waratah Bay.
Climate	Not provided
Vegetation type	Coastal Alkaline Scrub (EVC 859) is the dominant EVC and occupies the ridge tops and slopes of the dunes that occur across the Yanakie Isthmus. Calcareous Swale Grassland (EVC 309) is found on the large swales between calcareous dunes. Generally it consists of a tall shrubland 2-4m tall, typically with a medium shrub layer, small shrub layer and sedges, grasses and herbs in the ground layer. Dominant species are Drooping Sheoak *Allocasuarina verticillata,* Coast Tea-tree *Leptospermum laevigatum,* Sweet Bursaria *Bursaria spinosa ssp. Macrophylla* and Coast Wattle *Acacia longifolia ssp. Sophorae* and Coast Beard-heath *Leucopogon parviflorus*. Long term absence of fire has allowed Coast Tea-tree and Coast Wattle to invade these areas forming a dense canopy with limited surface fuels.
Plot layout	Plot size varying between approximately 50 x 50 m and 150 x 100 m.
Fuel assessment methods	Fuels assessment from report on the Yanakie Isthmus Coastal Grassy Woodland Adaptive Experimental Management (AEM) program
Fuel description	Areas invaded by Coast Tea-tree form a tall closed scrub between 2 and 4m in height with sparse surface fuels, total fuel load of approximately 12t/ha, large % of dead material within elevated fuels.
Weather observations	Wind recorded by Yanakie Parks Victoria Office (approximately 5km to the N of the burn) supplemented by field observations with handheld kestrel. Temperature, relative humidity and dew point recorded by Yanakie Parks Victoria Office (approximately 5km to the N of the burn) supplemented by field observations with handheld kestrel.
Fuel moisture	Fuel moistures were sampled on the morning of the burn. (Elevated 11.6%, Bark 13.2%)
Rate of fire spread	Rate of spread was determined from observations of the fire front by air observers and measurements of the time taken for the fire to spread between known points.

Table S11. Summary of site characteristics, vegetation type, plot layout, fuel sampling methods and characteristics, weather and fire behaviour assessment methods for model development data and controlled burn evaluation data collected in Buttongrass moorlands in Tasmania (see Marsden-Smedley and Catchpole 1995a, b)

Site location	Tasmania: 3 sites on the Gordon River Road. 3 sites on the Lyell Highway, Cape Sorell, and King River (see Marsden-Smedley and Catchpole 1995a)
General topography	Generally flat sites.
Climate	Cool temperate maritime climate. Annual rainfall is 2500 mm. Mean minimum temperature 2°C, mean maximum temperature 20°C.
Vegetation type	Buttongrass moorland (*Gymnoschoenus sphaerocephalus*) with some heath species and restiods.
Plot layout	Experimental plots of size 0.25 or 1ha (ignition lines 50m or 100m). Hazard-reduction burns had fireline lengths greater than 100.
Fuel assessment methods	Fuels assessment from report on the Yanakie Isthmus Coastal Grassy Woodland Adaptive Experimental Management (AEM) program
Fuel description	Mean overall fuel cover was about 80%. Fuel height was 0.2-1.5m. The total fuel load comprised mainly buttongrass. There was no litter fuel but sometimes a layer of dead fuel from previous burns. Fine fuel load was 0.9-3 kg m^{-2}
Weather observations	Air temperature and relative humidity were measured with AWS within 250 of the experimental plots for experimental burns and using hand-held instruments for hazard-reduction burns. Experimental fires had AWS (wind speed 10m and 1.7m) within 250m of burn ad parallel or upwind of burn. For hazard-reduction burns a hand-held anemometer was used.
Fuel moisture	Moisture content of dead fine fuels was measured by destructive sampling. Samples were collected from elevated dead and live fuels.
Rate of fire spread	Numbered metal tags for low-intensity fires. For other fires timing when fire reached either numbered posts or noticeable features.

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