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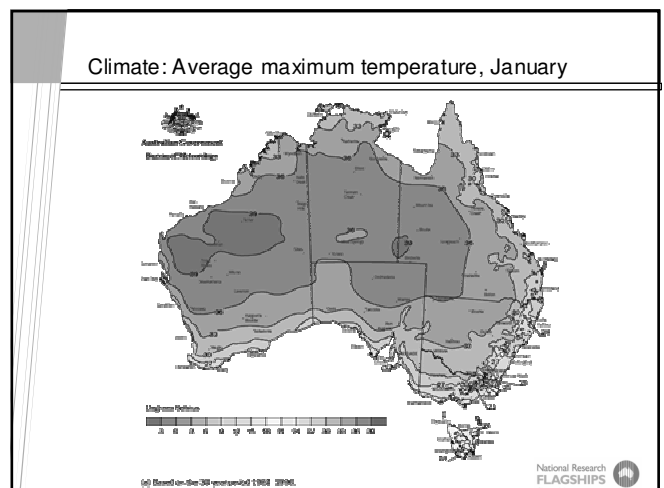
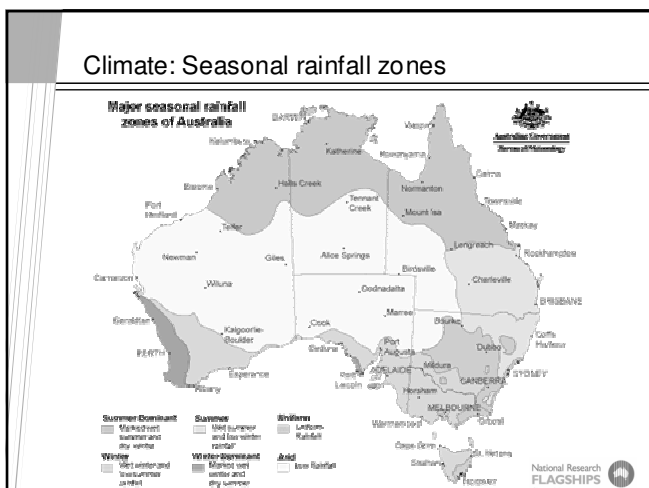
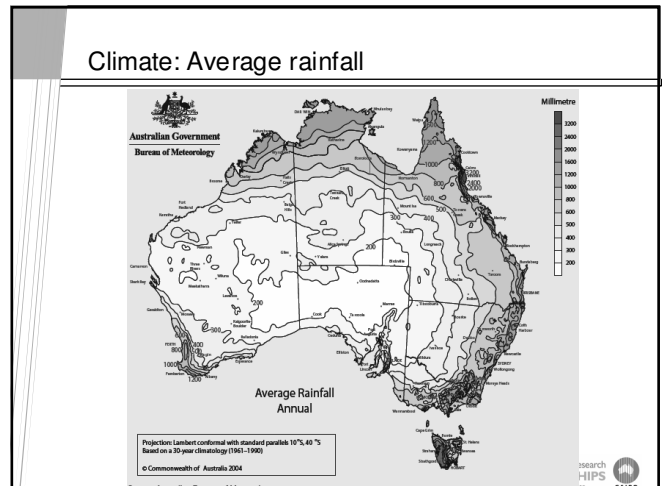
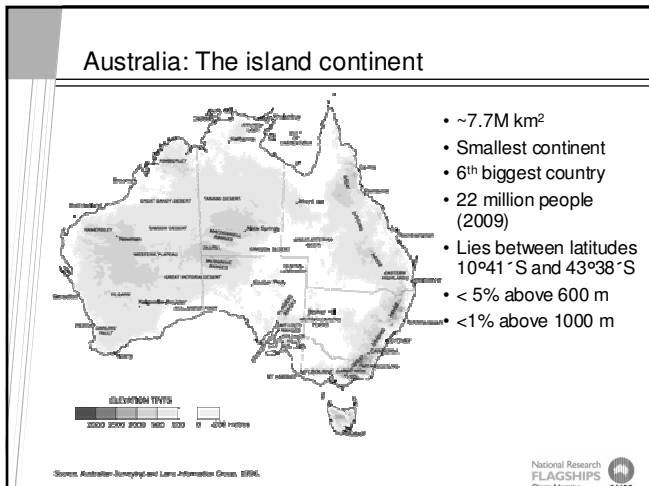
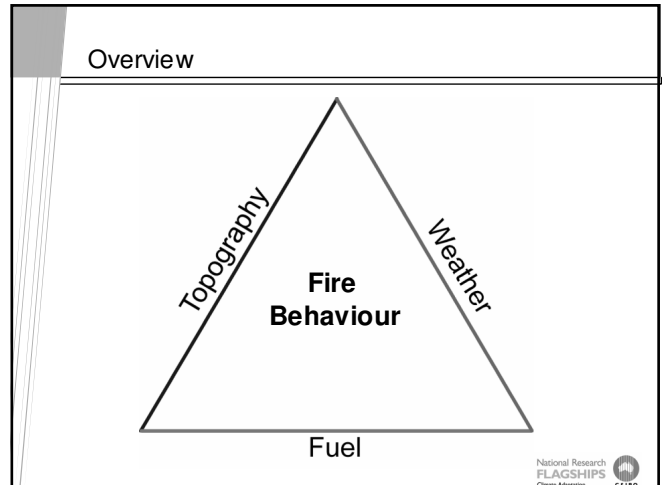
Bushfire Behaviour: An Australian Perspective

Climate Adaptation Flagship

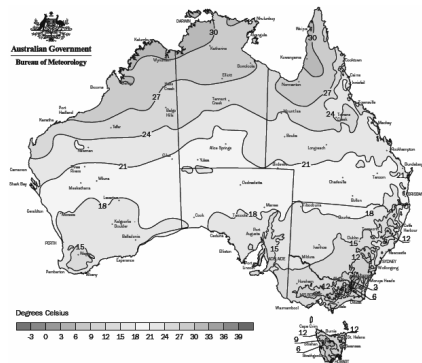
Andrew Sullivan
Senior Research Scientist
14 October 2009

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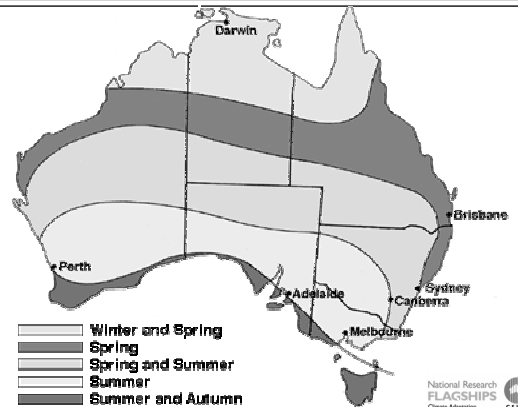
Climate: Average maximum temperature, July



(a) Based on the 30-year period 1961-1990.
Source: Australian Bureau of Meteorology.

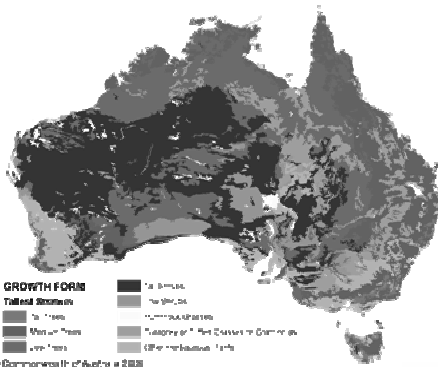
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Bushfire seasons in Australia



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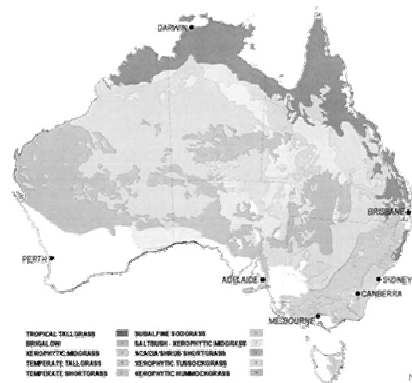
Vegetation: Growth forms



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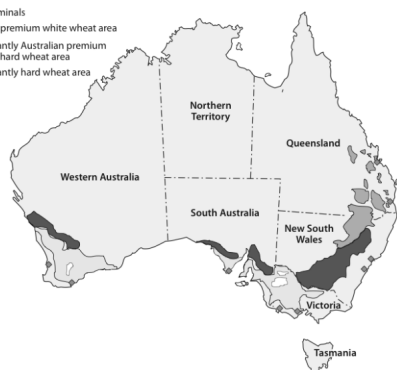
Vegetation: Grasslands



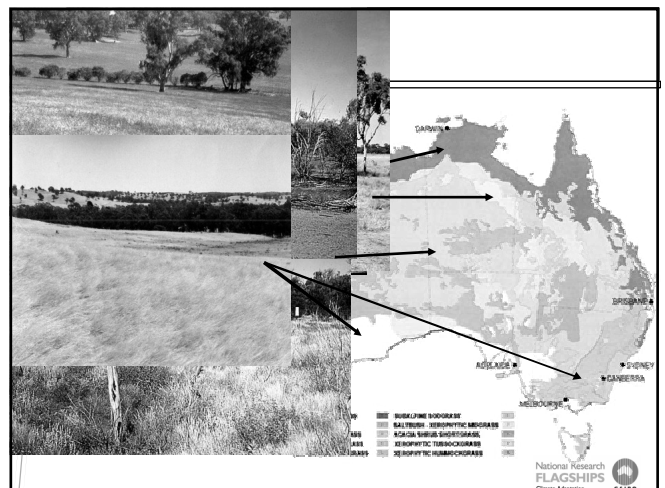
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Vegetation: Agriculture (Crops)

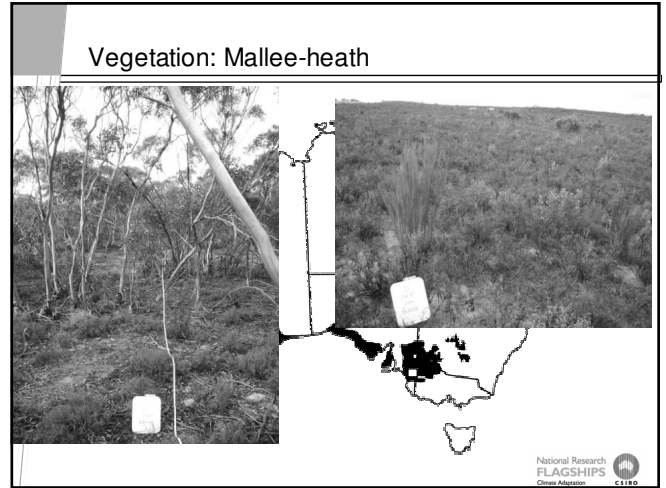
- ♦ Wheat terminals
- Australian premium white wheat area
- Predominantly Australian premium white and hard wheat area
- Predominantly hard wheat area



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Plantations, farm forestry and fire risk

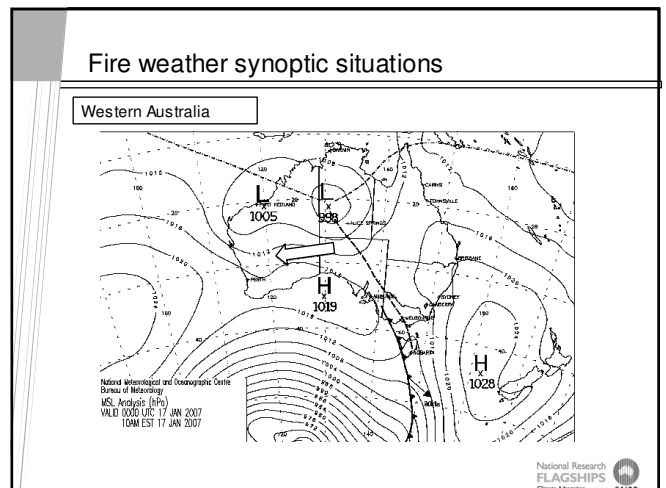
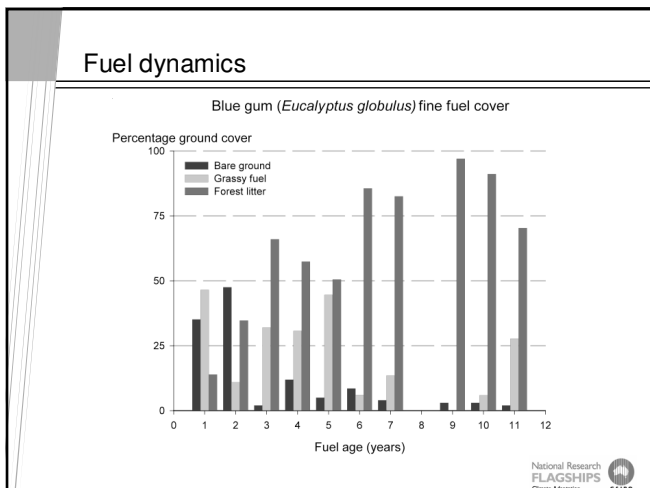
- Often established on cleared agriculture land
 - *Pinus radiata*
 - Blue gum (*E. globulus*)
- Recent increase in number and area of plantations
- Limited skill base in forest fire fighting
 - Decreasing rural populations
 - Increasing expectations by communities
 - Reliance on insurance by corporations

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Plantation fuels

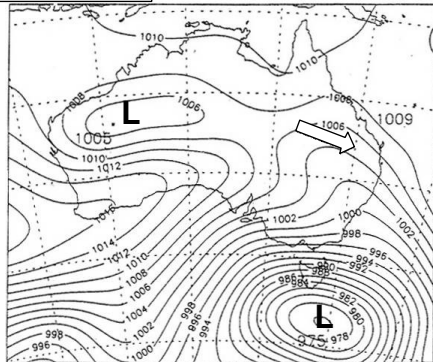
- Trees extremely sensitive to damage by fire, particularly early on.
- Arrangement of fuel changes rapidly throughout the rotation.
- If managed for saw logs or greater than 10 year rotation significant potential for substantial build-up of fuel.

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Fire weather synoptic situations

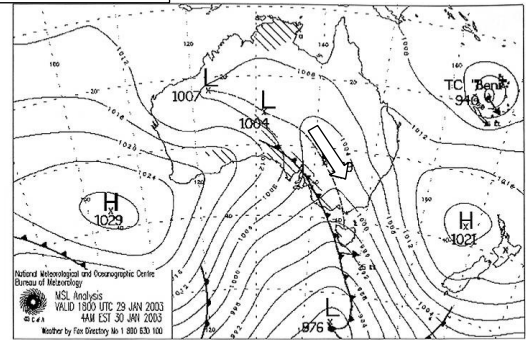
Eastern Australia



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Fire weather synoptic situations

South-eastern Australia

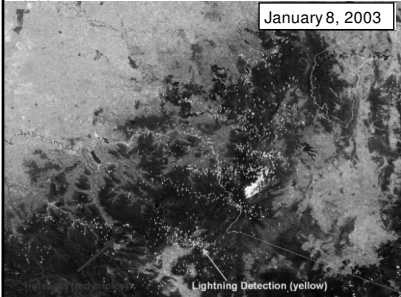


National Meteorological and Oceanographic Centre
Bureau of Meteorology
MSL Analysis
VALID 1500 UTC 29 JAN 2003
44M EST 30 JAN 2003
Weather by Fax Directory No 1 800 830 100

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Ignitions

January 8, 2003



Lightning Detection (yellow)

- Lightning predominant source
 - Associated with dry thunderstorms
 - Common during summer in south, late dry season in north
- Arson
- Unintentional ignitions
 - Welding, grinding
 - Powerlines
- Escaped fire (agricultural burning off)
- Pre-existing fires
 - Controlled, contained, mop-up, blacked-out

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Bushfires: Main classifications

Grassfires



Forest fires

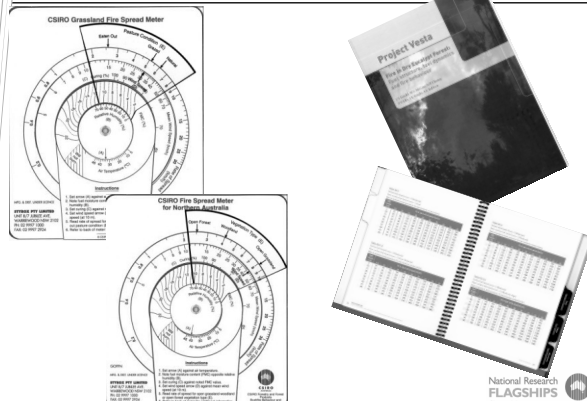
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Fire Danger Rating Systems



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Fire Behaviour Prediction Systems



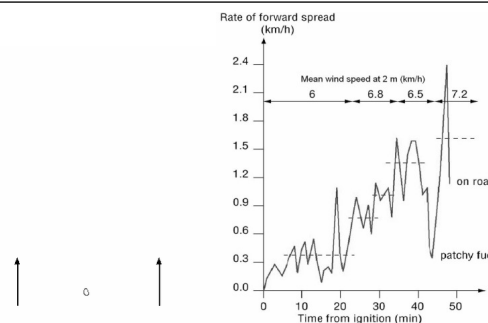
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Grassfire behaviour characteristics



- Fuel burns out quickly
 - 5-10 sec
- Fires build up very rapidly
- Very fast
 - $>20 \text{ km h}^{-1}$
- Can burn more than 100,000 ha in one day
- Very responsive to changes in wind
- Relatively low flames: 1-8 m

Grassland fire spread



Suppression difficulty

Grass fires



Fire Danger	Max flame height (m)	Suppression Options
Low	0.5	Easy. Stopped by tracks.
Moderate	1.0	Easy with water.
High	3.0	Difficult with water.
Very High	4.0	Possible only light fuels and favourable topography.
Extreme	6.0+	Impossible at the head. Possible on flanks.

Forest fire behaviour characteristics



- Fuel burns out slowly
 - fine fuel: 2-5 min
 - logs: 1 hr +
- Fires develop slowly (hours)
- Max. speed $\sim 10\text{-}12 \text{ km h}^{-1}$
- High flames
 - up to 2-3 canopy height
- Firebrands and spot fires
- Large range of intensity
 - $50 - 100,000 \text{ kW m}^{-1}$
- Available fuel increases with drying and fire intensity






Dry sclerophyll forest fire – 16 year old fuel



Mallee-heath fire – 22 year old fuel



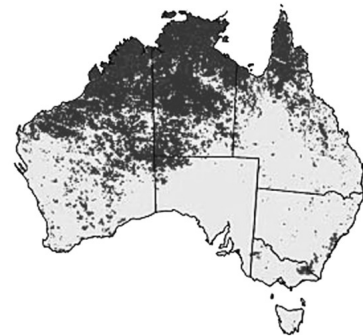
Suppression difficulty

Forest fires	Fire Danger	Max flame height (m)	Suppression Options
	Low	1.5	Easy. Hand tools.
	Moderate	6.0	Upper limit for bulldozers, air tankers
	High	15.0	Possible in light fuels and on lee slopes.
	Very High	15.0 +	Possible only as fire starts (i.e. very small).
	Extreme	30.0 +	Impossible.

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Extent of fire in Australia

Fire history 1997-2003



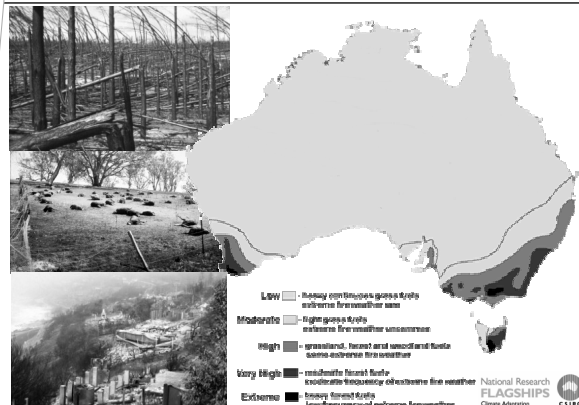
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Fire management responsibilities

- States and Territories
 - Public lands
 - State land management agencies
 - Fuel management, planning, response
 - Aircraft
 - Private lands
 - State fire services—response and co-ordination
 - Volunteer bushfire brigades (~300,000 volunteers)
 - Plantations—Industry bushfire brigades
- Commonwealth
 - Bureau of Meteorology
 - Fire weather forecasts, fire danger warnings
 - Emergency Management Australia
 - Coordinates emergency response – military
 - National Aerial Firefighting Centre
 - Coordinates additional aircraft across nation

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Potential for bushfire disasters



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Bushfire disasters

"5% of fires cause 95% of the loss and damage"



Fatalities

2009	173
2005	9
2003	4
1998	9
1983	76
1967	62

House losses

2008/09	2000+
2004/05	100+
2002/03	550+
2001/02	106+
1993/94	300+
1982/83	2500+
1966/67	1300+



Bushfire mitigation: Fuel management





Hazard reduction burning in forests

- Reduces fuels
 - Height
 - Structure
 - Amount
- Reduces potential for spotting through consumption of bark
- Increases potential for control under wider range of weather conditions
- Decreases intensity of fires
 - Reduced impact on ecology and biodiversity
- Changes in fire frequency
 - Possible deleterious impacts on ecology and biodiversity




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Bushfire mitigation: Fuel management



- Hazard reduction burning in grasslands
 - Common only in northern Australian
 - Historically indigenous/cultural burning
- Used to
 - Reduce fuels to reduce extent of late dry season wildfires
 - Create safe passage regions
 - Create and protect green pick for small mammals
- Recently used in greenhouse gas abatement programs
 - Reduce fuels early in dry season
 - Reduce occurrence and extent of high intensity late season wildfires
- Change in fire regime—possible deleterious impacts on ecology and biodiversity?

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- ## Hazard reduction burning in grasslands
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 - Recently used in greenhouse gas abatement programs
 - Reduce fuels early in dry season
 - Reduce occurrence and extent of high intensity late season wildfires
 - Change in fire regime--possible deleterious impacts on ecology and biodiversity?


Bushfire mitigation: Suppression



- Firefighter safety paramount
- Initial attack is key under severe fire weather
 - Rapid detection
 - Rapid initial attack
 - Good access
 - Maintenance of tracks and fuel breaks
- Right tactics for specific conditions
- Right equipment for tactic employed
- Training critical
 - Fire behaviour
 - Safety
- Weather forecasts and planning
- Aircraft (VLATs)

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Coastal Adaptation



- Firefighter safety paramount
 - Initial attack is key under severe fire weather
 - Rapid detection
 - Rapid initial attack
 - Good access
 - Maintenance of tracks and fuel breaks
 - Right tactics for specific conditions
 - Right equipment for tactic employed
 - Training critical
 - Fire behaviour
 - Safety
 - Weather forecasts and planning
 - Aircraft (VLATs)
- National Research 

Black Saturday: long-term drought

deciles 1 July 2001 to 30 June 2007

Australian Government
Bureau of Meteorology

- Significant rainfall deficit since 1970s in south-west WA
- Drought in eastern Australia shows correlation with ENSO
- Significant rainfall deficit in south-east over last 10 years

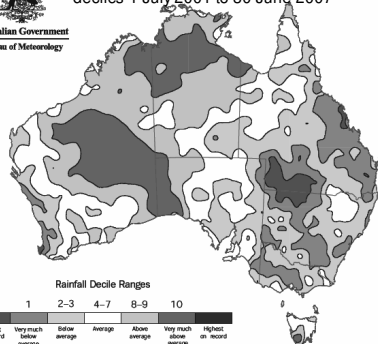
Rainfall Decile Ranges

1	2-3	4-7	8-9	10
Lowest on record	Below average	Average	Above average	Highest on record

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Climate Australia




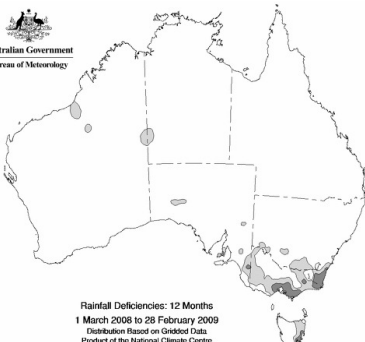
deciles 1 July 2001 to 30 June 2007



- Significant rainfall deficit since 1970s in south-west WA
- Drought in eastern Australia shows correlation with ENSO
- Significant rainfall deficit in south-east over last 10 years

Black Saturday: Short-term drought


Australian Government
Bureau of Meteorology



Rainfall Percentile Ranking


10
5
0

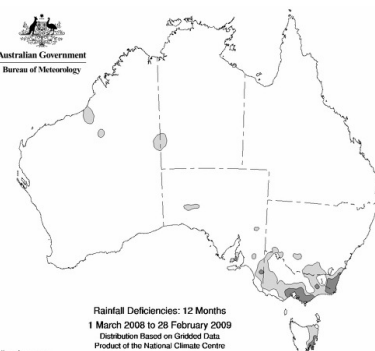
Serious Deficiency
Severe Deficiency
Lowest on Record

Rainfall Deficiencies: 12 Months
1 March 2008 to 28 February 2009
Distribution Based on Gridded Data
Product of the National Climate Centre

<http://www.bom.gov.au>

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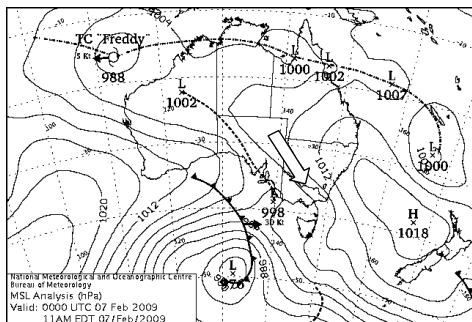


Rainfall Deficiencies: 12 Months
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Product of the National Climate Centre

Black Saturday: Synoptic conditions

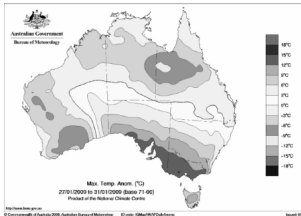
transiting weather system of the tropical cyclone centre
Bureau of Meteorology
MSL Analysis (hPa)
Valid: 0000 UTC 07 Feb 2009
11 AM EDT 07 Feb 2009

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Black Saturday: Weather and fires

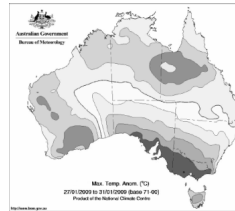
- Heatwave 27-31 January
 - 3 consecutive days above 43°C.
 - 374 deaths above the normal death rate.
- February 7
 - Max. temp: 46.1°C
 - Min. RH: 3-4%
 - Mean w ind speeds: 50-70 km h⁻¹
 - 592 bushfire outbreaks (including 20 pre-existing)
 - 47 fires with potential to become severe
 - 14 fires became 'major' fires
 - Fatalities in 5 fires



Map of Australia showing maximum temperature anomalies (Max. Temp. Anom. (°C)) for the period 27th January to 31st March 2009 (Black '09). The map is shaded in various tones of gray, indicating temperature ranges from -10°C to 10°C. The legend on the right shows the temperature scale: -10°C, -5°C, 0°C, 5°C, 10°C, 15°C, 20°C, 25°C, 30°C, 35°C, 40°C, 45°C, 50°C, 55°C, 60°C, 65°C, 70°C, 75°C, 80°C, 85°C, 90°C, 95°C, 100°C, 105°C, 110°C, 115°C, 120°C, 125°C, 130°C, 135°C, 140°C, 145°C, 150°C, 155°C, 160°C, 165°C, 170°C, 175°C, 180°C, 185°C, 190°C, 195°C, 200°C, 205°C, 210°C, 215°C, 220°C, 225°C, 230°C, 235°C, 240°C, 245°C, 250°C, 255°C, 260°C, 265°C, 270°C, 275°C, 280°C, 285°C, 290°C, 295°C, 300°C, 305°C, 310°C, 315°C, 320°C, 325°C, 330°C, 335°C, 340°C, 345°C, 350°C, 355°C, 360°C, 365°C, 370°C, 375°C, 380°C, 385°C, 390°C, 395°C, 400°C, 405°C, 410°C, 415°C, 420°C, 425°C, 430°C, 435°C, 440°C, 445°C, 450°C, 455°C, 460°C, 465°C, 470°C, 475°C, 480°C, 485°C, 490°C, 495°C, 500°C, 505°C, 510°C, 515°C, 520°C, 525°C, 530°C, 535°C, 540°C, 545°C, 550°C, 555°C, 560°C, 565°C, 570°C, 575°C, 580°C, 585°C, 590°C, 595°C, 600°C, 605°C, 610°C, 615°C, 620°C, 625°C, 630°C, 635°C, 640°C, 645°C, 650°C, 655°C, 660°C, 665°C, 670°C, 675°C, 680°C, 685°C, 690°C, 695°C, 700°C, 705°C, 710°C, 715°C, 720°C, 725°C, 730°C, 735°C, 740°C, 745°C, 750°C, 755°C, 760°C, 765°C, 770°C, 775°C, 780°C, 785°C, 790°C, 795°C, 800°C, 805°C, 810°C, 815°C, 820°C, 825°C, 830°C, 835°C, 840°C, 845°C, 850°C, 855°C, 860°C, 865°C, 870°C, 875°C, 880°C, 885°C, 890°C, 895°C, 900°C, 905°C, 910°C, 915°C, 920°C, 925°C, 930°C, 935°C, 940°C, 945°C, 950°C, 955°C, 960°C, 965°C, 970°C, 975°C, 980°C, 985°C, 990°C, 995°C, 1000°C.

Source: National Research Flagships, CSIRO

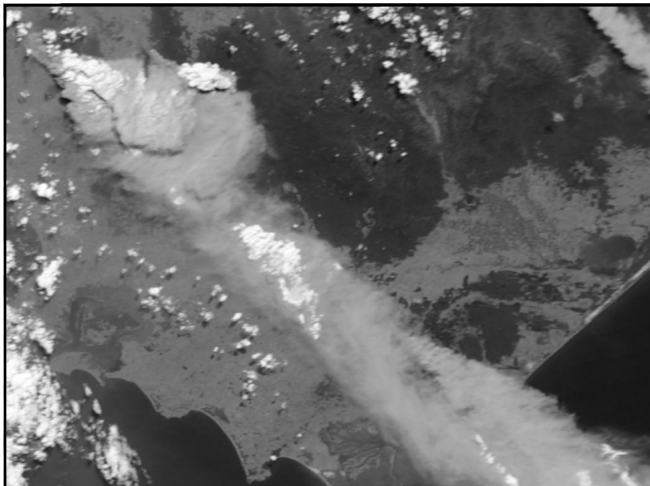
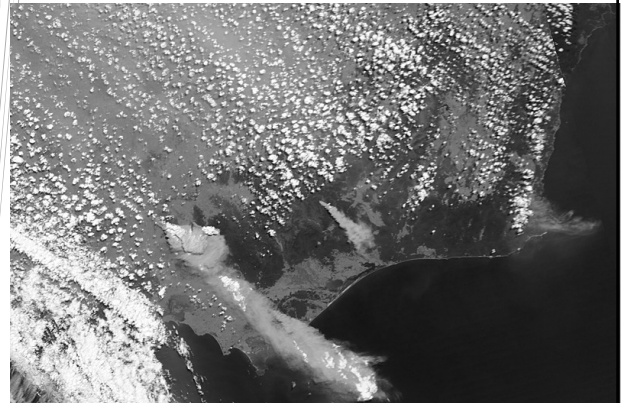
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Black Saturday: Major fires

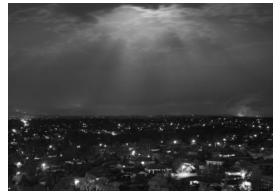


Black Saturday: Major fires

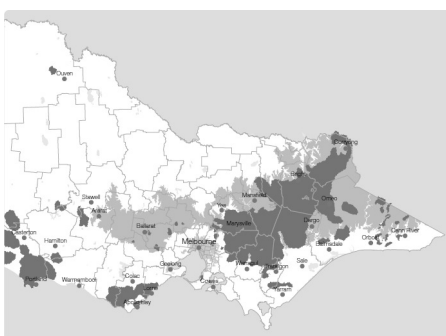


Black Saturday: Impacts

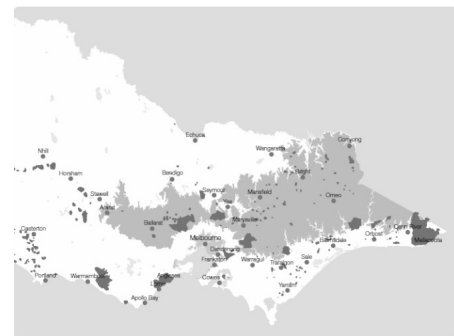
- 173 people killed
- 2059 houses destroyed
- 78 townships destroyed or seriously affected
- Thousands of people displaced
- 22,500 people registered for assistance



1938-1939 fires



1982-1983



2002/2003



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Australian Bushfire Behaviour: Summary



- All of Australia prone to the occurrence of bushfires of some type at some time of the year.
- Periodic, extended and extensive drought common throughout Australia.
- Most of the native flora has adapted to frequent bushfire
- Native forests
 - Abundant build-up of litter--slow to decay
 - Bark--firebrands, spotting

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Australian Bushfire Behaviour: Summary



- Frequent occurrence of bad 'fire weather'
 - Synoptic patterns that bring hot, dry winds from centre of continent
- Widespread potential for ignition from dry lightning during fire season
- Annual widespread wildfires in tropical north during late dry season.
- Less frequent but potentially more disastrous fires in temperate south

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Australian Bushfire Behaviour: Summary



- Exclusion of fire from daily life
- Loss of experience of fire
- Restrictions on hazard reduction burning
- Increased community reliance on agencies
- Expectation of warnings and fire trucks
- Loss of experience in agencies
- Shift toward response rather than responsibility
 - A\$100 million on aircraft (NSW, 2007)
 - +A\$20 million on fuel management (Vic, 2009)

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CSIRO Sustainable Ecosystems

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Senior Research Scientist

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Web: www.csiro.au/org/BushfiresOverview.html

Thank you

Contact Us

Phone: 1300 363 400 or +61 3 9545 2176

Email: Enquiries@csiro.au Web: www.csiro.au

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