Post-wildfire recovery of vegetation and water yield: A case study of the summer 2001/2002 Sydney Basin wildfire.

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Project overview

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Surface water balance equation can be expressed as:

$$\Delta\langle S\rangle = \langle P\rangle - \langle ET\rangle - \langle Q\rangle - \langle R\rangle \qquad (1)$$

where $\Delta\langle S\rangle$ is the change in spatially averaged catchment water storage, $\langle P\rangle$ is the spatially averaged precipitation, $\langle ET\rangle$ is the spatially averaged evapotranspiration, $\langle Q\rangle$ is the spatially averaged catchment surface-water runoff, and $\langle R\rangle$ is the spatially averaged catchment recharge.

Project overview

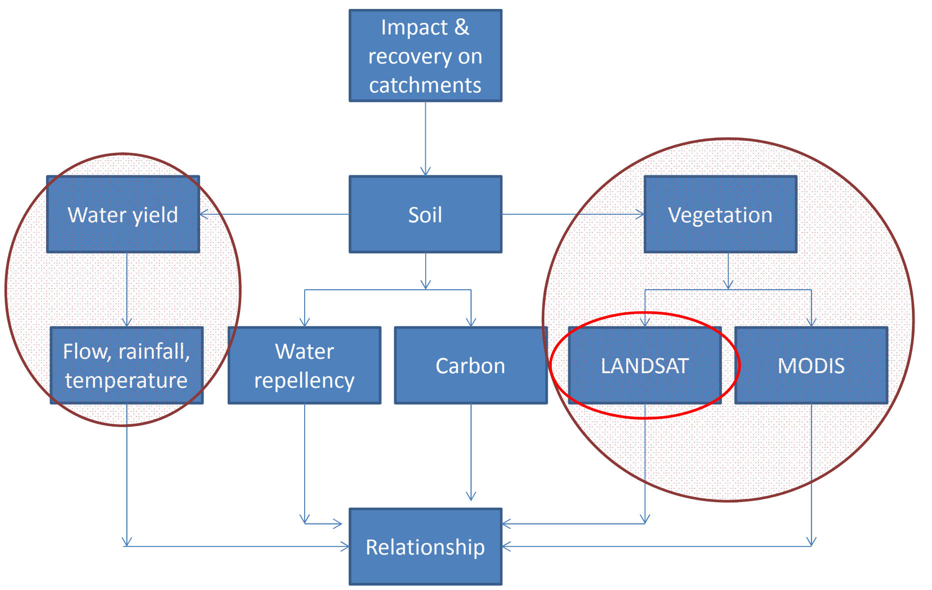
Groundwater discharges are often thought to be small and are difficult to quantify.

The equation is then simplified as:

$$\boldsymbol{Q = \langle P \rangle - \langle ET \rangle - \Delta\langle S \rangle} \qquad \textbf{(2)}$$

where $\langle Q \rangle$ is the spatially averaged catchment surface-water runoff, $\langle P \rangle$ is the spatially averaged precipitation, $\langle ET \rangle$ is the spatially averaged evapotranspiration and $\Delta\langle S \rangle$ is the change in spatially averaged catchment water storage.

Project overview



Why?

•Response by vegetation communities

•Obligate resprouters vs. seeders

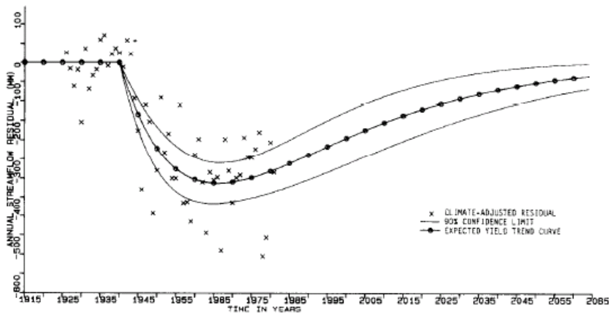
•Impact on a catchment’s hydrology

•Initial decline of water yield

•Recovery of water yield to pre-wildfire conditions

Why?

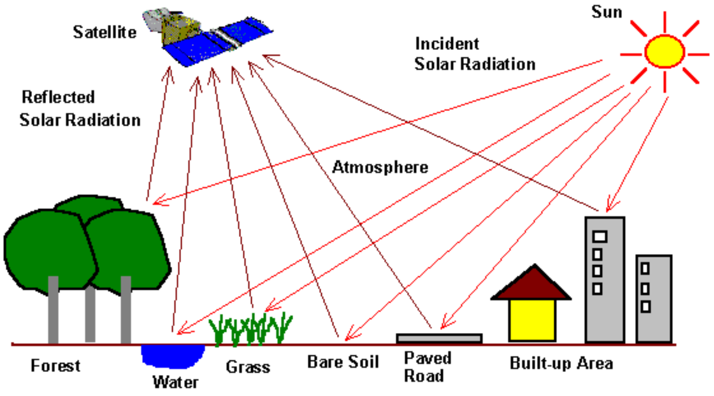
Kuczera curve



A Satellite's perspective

•Remote Sensing- Vital source for modern day research.

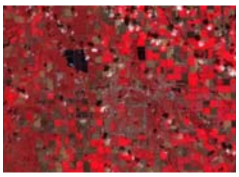
•Acquire information from object without physical contact.



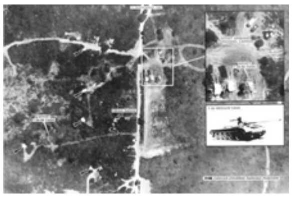
From CRISP, 2001

Remote sensing

•Environmental studies:
agriculture, vegetation change, urban development, climate change etc.



•Other uses: military operations, emergency response, disaster relief etc.

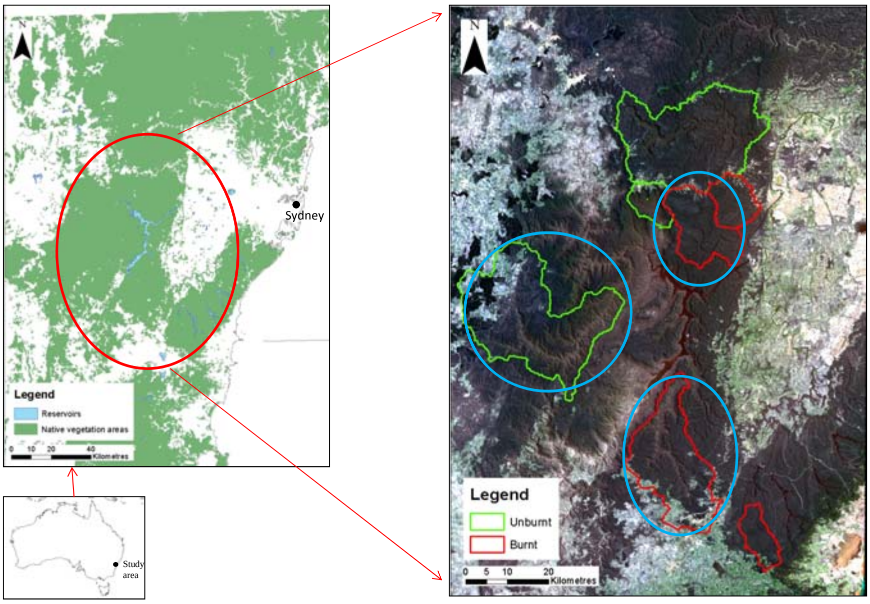


Project aims

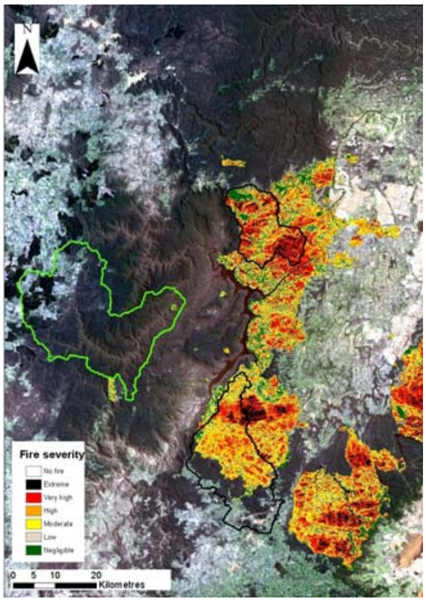
•Determine if vegetation and water yield recover within 8 years post-wildfire.

•Establish of there is a relationship between vegetation recovery and water yield recovery.

Study sites



Methods



•Create fire severity map based of Landsat data (based from Chafer et al. 2004).

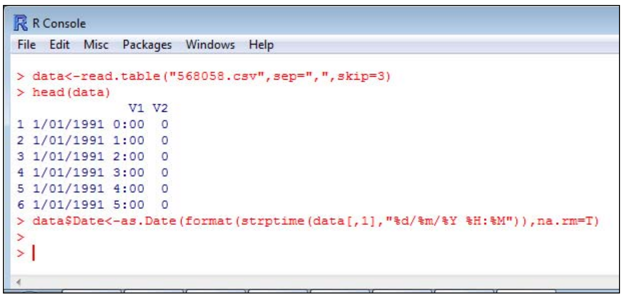
•Determine subcatchments based on location of hydrometric station

Methods

WATER YIELD- processing

•Obtain hourly water yield and rainfall data, plus daily maximum temperature data from 1991-2010

•Process data into weekly data.




```
> data<-read.table("568058.csv",sep=",",skip=3)
> head(data)
              V1 V2
1 1/01/1991 0:00  0
2 1/01/1991 1:00  0
3 1/01/1991 2:00  0
4 1/01/1991 3:00  0
5 1/01/1991 4:00  0
6 1/01/1991 5:00  0
> data$Date<-as.Date(format(strptime(data[,1],"%d/%m/%Y %H:%M")),na.rm=T)
>
> |
```

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Methods

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WATER YIELD cont.- model

•A log normal model (Eq. 1) using thin plate splines were used (Wood, 2003). The smoothing parameters were selected using restricted maximum likelihood (REML).

$$\log(y) = \beta_0 + \sum_{i=1}^{n} s_i(X_i) \qquad \textbf{(3)}$$

where β_0 is the parameter vector, s_i is the i^{th} thin plate smoothing spline, X_i is the i^{th} covariate.

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WATER YIELD cont.

•**Goodness-of-fit :** Nash-Sutcliffe coefficient (NSE) and modified Nash-Sutcliffe coefficient (mNSE).

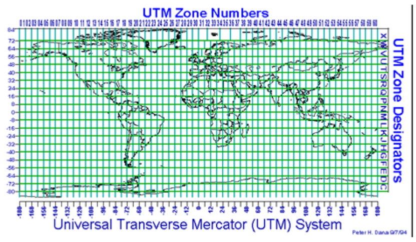
E= < 0	E= 0	E= 1
Observed mean is a better predictor than the model	Model predictions are as accurate as the mean of the observed data	Perfect match of modeled discharge to the observed data

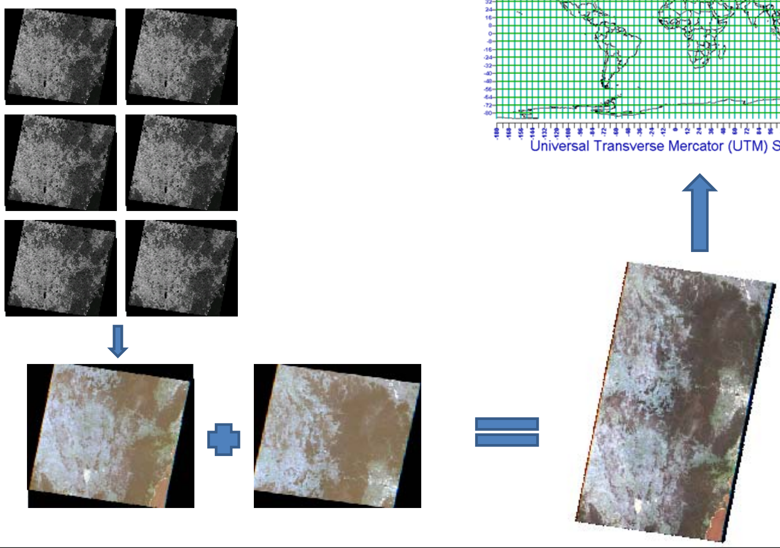
•**Change detection:** Error plots are the observed data-predicted data. If there is change will resemble the Kuczera curve.

•Looking at long term recovery so only interested in mean error values.

Methods

Vegetation-processing





Methods

VEGETATION

•Top of atmosphere (ToA) correction:

1. Digital number (DNs) values to spectral values (Eq. 2)

$$L = \alpha D_n + \beta \qquad (4)$$

where L = spectral radiance values, α is the gain and β is the recalled bias

2. Radiance to ToA reflectance (Eq. 3)

$$\rho_0 = \pi * L_0 * d^2 / E_0 * \cos \vartheta_z \qquad (5)$$

where ρ_0 = Unitless plantary reflectance, L_0= spectral radiance, d = Earth-Sun distance in astronmoical units, E_0 = mean solar exoatmospheric irradiances and θ_z = solar zenith angle.

Methods

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VEGETATION- indices (range from -1 to 1)

•**Normalized Difference Vegetation Index (NDVI)**

$$NDVI = \frac{near\ IR - red}{near\ IR + red}$$

•**Corrected Normalized Difference Vegetation Index (NDVIc)**

$$NDVI_c = \frac{near\ IR - red}{near\ IR + red} * (1 - \frac{mIR - mIR_{min}}{mIR_{max} - mIR_{min}})$$

where mIR refers to the middle-infrared band 5

•**Normalized Burn Ratio**

$$NBR = \frac{(NIR - MIR)}{(NIR + MIR))}$$

where MIR refers to band 7

Band	Spectral Ranges (μm)	
1	Blue	0.45 to 0.52
2	Green	0.52 to 0.6
3	Red	0.63 to 0.69
4	Near-IR	0.76 to 0.90
5	Mid-IR1	1.55 to 1.75
6	Thermal-IR	10.4 to 12.5
7	Mid-IR2	2.08 to 2.35

Expected Outcomes

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Control catchment:

1) Goodness-of-fit values: Extensively higher than burnt catchments post-wildfire if there is a change in water yield.

2)Error plots: No pattern in data, should have a flat smooth line

3) Vegetation: Vegetation indices should remain higher than burnt catchments during post-wildfire period unless affected by external factors i.e. climate

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Results

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Goodness-of-fit

Subcatchment	Pre- NSE	Pre- mNSE	Post- NSE	Post- mNSE
Erskine Creek	0.61	0.58	0.37	0.52
Nattai River	0.76	0.60	0.69	0.53
Kowmung River	0.59	0.53	0.63	0.40

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Results

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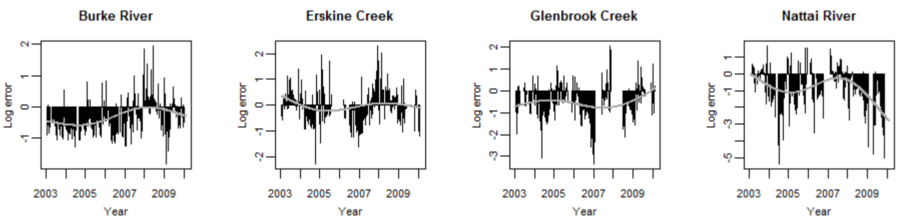
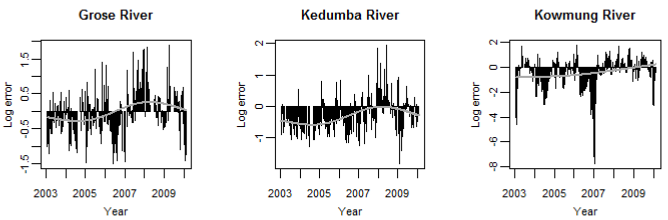
Error Plots





Subcatchment	Mean error	Mean exponent
Burke	-0.59	0.56
Erskine	-0.02	0.98
Glenbrook	-0.53	0.59
Nattai	-0.86	0.42
Grose	-0.03	0.97
Kedumba	-0.31	0.73
Kowmung	-0.46	0.63

Results

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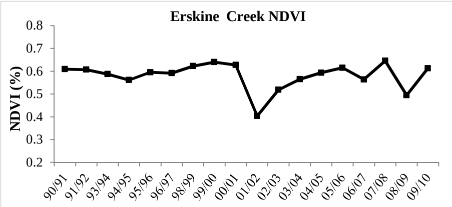
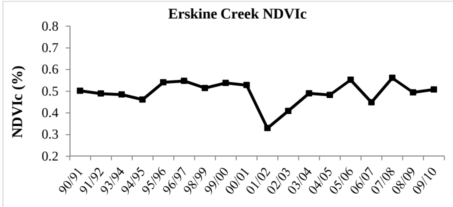
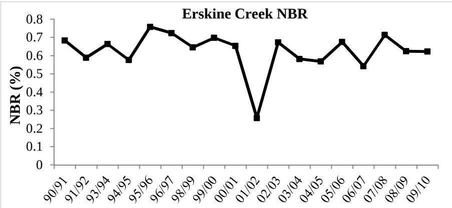
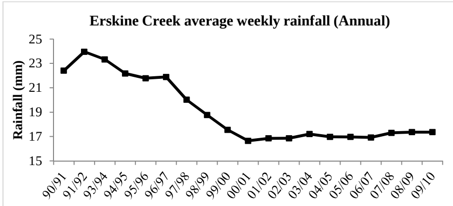
Vegetation indices- Erskine Creek









Results

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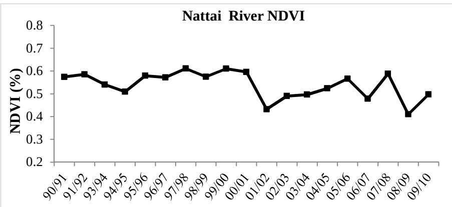
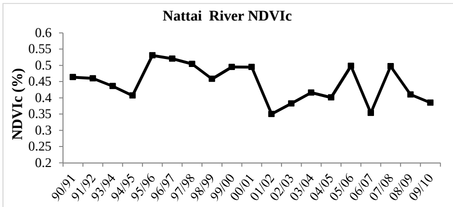
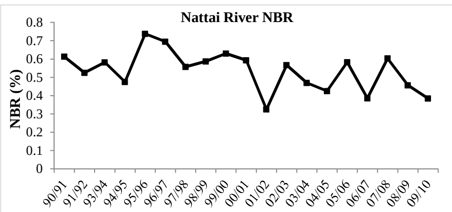
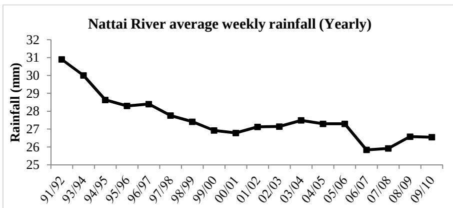
Vegetation indices- Nattai River









Results

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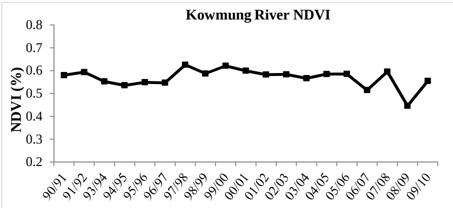
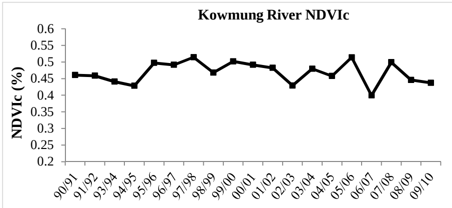
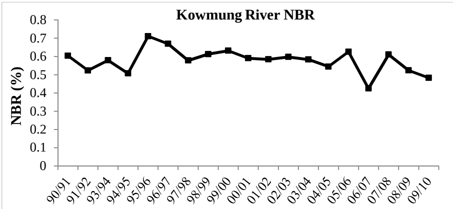
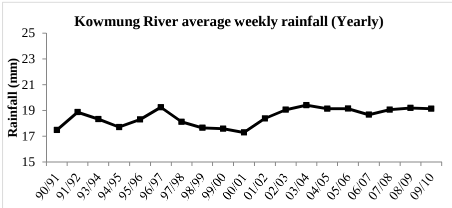
Vegetation indices- Kowmung River









Results

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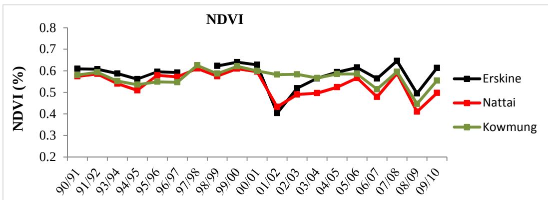

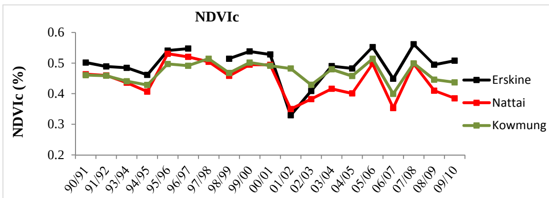

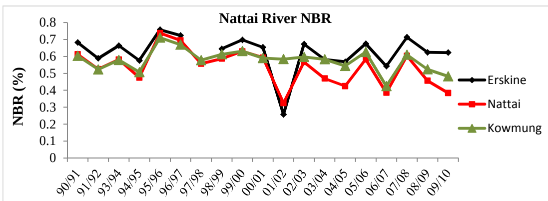

Discussion

Water yield + vegetation

•GAM: Limitations i.e. Climate >El Nino post-wildfire until 2007.

•Kuczera: Vegetation regrowth = decline in water yield-Not in this study!

•Vegetation shrub layer which accounts for 80% of fuel would have began recovering within months post-wildfire (Chafer et al., 2004).

Discussion

Water yield + vegetation

•El Nino to La Nina mid-spring 2007 (10 month process).

•2007-2008 above average rainfall

•El Nino mid-2009: Australia serious rainfall deficiencies which is obvious in the vegetation recovery graphs = over estimating water yield during this period.

Conclusion

- No pattern in smooth curves resembling the Kuczera curve.
- Water yield and vegetation recover within 2-5 years post-wildfire in the outer Sydney Basin.
- Sydney Basin subcatchments have a faster recovery rate than Melbourne catchments.
- GAM models and remote sensing can help develop new strategies for wildfire events.
- Use Moderate Resolution Imaging Spectroradiometer (MODIS) imagery to assess same period.

References

Chafer, C.J., Noonan, M., Macnaught, E., 2004. The post-fire measurement of fire severity and intensity in the Christmas 2001 Sydney wildfires International Journal of Wildland Fire 13, 227-240.

CRISP (2001) What is Remote Sensing? http://www.crisp.nus.edu.sg/~research/tutorial/intro.htm. Accessed 23rd July, 2012.

Kuczera, G., 1987. Prediction of water yield reductions following a bushfire in ash-mixed species eucalypt forest. Journal of Hydrology, Netherlands 94, 215-236.

THANK YOU!!!