Post-fire Biomass Recovery Monitoring by Remote Sensing
Factsheet v1 October 2023

Background

Remote sensing scientists from the Department of Planning and Environment's Science, Economics and Insights Division have developed a new approach to mapping post-fire biomass recovery by monitoring annual post-fire change in spectral reflectance indices based on sentinel 2 satellite imagery (https://doi.org/10.1016/j.rse.2022.113151). The method can be used to monitor change in the amount and greenness of vegetation cover. Research and development of the method was initially supported by the Natural Resources Commission, as part of their Forest Monitoring Improvement Program's Foundational Priority Projects.

Method

The NSW post-fire biomass recovery monitoring system is based on the concept that a disturbed system state will be reflected by high rates of system change, while undisturbed or recovered system states are characterised by near-zero rates of change. This reflects the typical pattern of diminishing rates of spectral change in post-fire recovery trajectories, as the burnt area initially shows post-fire changes until it eventually returns to a stable state (Fig 1).

This method overcomes major limitation of other approaches that attempt to estimate post-fire recovery in comparison to a defined pre-fire state. These approaches are strongly influenced by the methods used to define the pre-fire state and are likely to be confounded by climatic fluctuations over various timeframes. Our novel approach tracks recovery dynamics over space and time in the post-fire environment, without reference to pre-fire conditions. By comparing standardised measures of the magnitude of change in vegetation cover and greenness within burnt and surrounding unburnt areas, patterns of recovery can be compared between fires across the landscape. Compilation of sequential annual maps over the longer term can indicate when the burnt area has reached a stable state. A stable state may be indicated when post-fire recovery values represent little to no change, and where all fire severity classes are synchronised with surrounding unburnt areas over multiple consecutive years. This may indicate either recovery to the pre-fire state, or an alternative stable state, but the distinction cannot be determined from this remote sensing method.
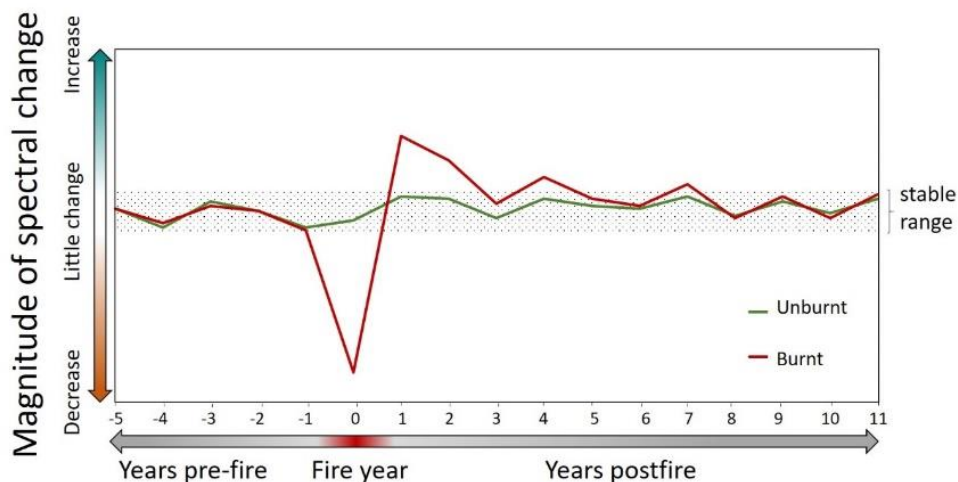

Figure 1. Conceptual diagram of typical patterns of spectral change in post-fire timeseries.

Development and testing

In developing the NSW post-fire biomass recovery monitoring method, we tested various spectral indices and found that the Normalised Burn Ratio 2 (NBR2) performed best in monitoring post-fire change. NBR 2 modifies the widely used Normalised Burn Ratio (NBR), describing relationships between reflectance values within two short wave infra-red spectral bands, and has been found to be particularly useful in post-fire recovery monitoring. The index was tested across ten case study fires in NSW and was found to differentiate between severity classes and correlate to field-based measures of recovery such as foliage cover and tree resprouting characteristics at one-year post-fire.

Outputs

The method can be applied annually to monitor the change in vegetation cover and greenness across fires previously mapped through the NSW RFS/DPE Fire Extent and Severity Mapping (FESM) system. Annual monitoring has been undertaken for each of the three years following the 2019-20 wildfires.

Annual monitoring compares the difference in the NBR2 index between the target recovery year relative to one year previous, on a pixel-by-pixel basis. In each annual timestep, the best available cloud-free Sentinel 2 imagery closest to the fire end date is used to minimise seasonal impacts on the Index. Raw index values are classified into standardised categories for ease of interpretation. This standardised classification indicates the relative magnitude of increase or decrease in vegetation cover, with high and low values representing increases and decreases respectively, and values around 7 indicating little to no change between years (Table 1).

Post-fire recovery dynamics may be examined by analysing the post-fire biomass recovery values across fire severity classes over time (Fig 3). Ecological system stability is suggested when index values within the fire footprint remain close to the stable range and/or there is little difference between fire severity classes and surrounding unburnt areas over multiple consecutive years.

Table 1. NSW Post-fire Biomass Recovery standardised classification

Pixel value	Post-fire Recovery Class	Index values
1	extreme decrease	< -500
2	very large decrease	-400 to -500
3	large decrease	-300 to -400
4	moderate decrease	-200 to -300
5	small decrease	-100 to -200
6	very small decrease	-50 to -100
7	little to no change	-50 to 50
8	very small increase	50 to 100
9	small increase	100 to 200
10	moderate increase	200 to 300
11	large increase	300 to 400
12	very large increase	400 to 500
13	extreme increase	> 500

Technical Information

File Naming Convention

What			Where	When	Processing		Options	Suffix
cv	ms	re	NSW	20192020	ak6	l0		img
satellite	instrument	product	location	date	stage	projection	N/A	format
Example: cvmsre_frfs0310199_20190115_ak2m6.img								

Codes	Description
cv	Sentinel 2
ms	Sentinel 2 multispectral imager (MSI)
re	Reflective - used for all multispectral instruments.
NSW	NSW statewide mosaic
yyyyyyyy	Post-fire recovery image year 1 and year 2
ak6	ak6 = Quality assured standardised classified post-fire stability product.
l0	GDA94 NSW Lambert 3308

Image details
Data type: Raster
Pixel size: 10m (Sentinel 2)
Base Imagery: Sentinel 2 (2016/17-ongoing)
Datum: GDA 94 NSW Lambert (EPSG: 3308)

Acknowledgements
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- Natural Resources Commission
- NSW Rural Fire Service
- NSW Bushfire Research Hub
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- Joint Remote Sensing Research Program

Data access
Annual statewide mosaics for 1, 2 and 3 years following the 2019-20 fires are currently available via the SEED portal. Post-fire recovery of other fires mapped through the NSW FESM program can be made available on request, given appropriate resourcing.