

DPIE Fire Extent and Severity Mapping FESMv3 Factsheet (December 2020)

Background

In collaboration with the NSW Rural Fire Service (RFS), DPIE Remote Sensing & Regulatory Mapping team has developed a semi-automated approach to mapping fire extent and severity through a machine learning framework based on sentinel 2 satellite imagery (<https://doi.org/10.1016/j.rse.2020.111702>). The product is designed to estimate fire severity, which is a metric of the loss of biomass caused by fire, using cover as a surrogate for biomass. Fire severity differs from fire intensity, which is the energy output of the fire. While severity and intensity may be correlated, factors such as climate, weather conditions, topography and vegetation community composition strongly influence how fire intensity is translated into fire severity.

In FESMv1 (January 2018-April 2019), we trained and tested a random forest algorithm on a set of case study fires from the 2017/18 and 2018/19 fire years. The modelling produced strong predictive power for mapping new fires and was accepted by RFS as a baseline to begin development of an automated system. Further funding has been committed from RFS and the NSW Natural Resources Commission to support further research for model refinements and testing the operational processing system. Significant improvements have been made with an update to the model in December 2019 (FESMv2). Following the black summer of 2019/20, several wildfires had high resolution post-fire aerial photography captured within 4-6 weeks post-fire. These were used to enhance the FESM training dataset to update the model in July 2020 (FESMv3). Further updated versions are expected with ongoing development and enhanced training data.

Prior to finalised operational testing of the NSW RFS/DPIE FESM automated system, the prototype FESM system was deployed in December 2019 to provide rapid response severity mapping to support DPIE operations. The interim data was progressively refined through the fire season but was limited by not having access to input data of the minimum standard the system was built to tolerate (spatial location within 2km accuracy and fire start and end dates). An interim state-wide mosaic for the 2019-20 fire season was produced on 20 April 2020.

In July 2020, the operational automated system went live. From this date on, fires recorded as 'out' in the RFS ICON system are automatically uploaded to the FESM request bucket (AWS S3). This is monitored by the DPIE Remote Sensing & Regulatory Mapping team and ingested into the semi-automated FESM processing workflow on the DPIE super-compute facility (SDC), using the recently updated FESMv3 algorithm. The FESM products are delivered back to the FESM response bucket in near real time, depending on availability of cloud free sentinel 2 imagery. In addition to mapping the current 2020/21 fire season (wildfires and hazard reduction burns), back-dated processing of the 2019/20, 2018/19 and 2017/18 fire years commenced for wildfires >100ha. Statewide mosaics will routinely be made available as soon as possible following each fire season.

Method

Random forest is an ensemble learning algorithm, with an iterative nature ensuring a convergence approach to classification problems. Random forest models were trained and tested using sampling data derived from high resolution aerial photograph interpretation (API) of fire severity classes from a set of 8 case study fires (Table 1), with corresponding spectral data derived from a suite of candidate severity indices. Training data of low to extreme severity was generated for 2 wildfires from 2017/18,

6 wildfires from 2018/19, and a further 8 wildfires from 2019/20. Unburnt training data is automatically extracted from a buffered zone around a given estimated fire boundary, and visually QA'd, before being combined with the burnt training data and applied in the random forest algorithm to produce the FESM map.

Table 1 Fire severity classification ruleset based on high resolution aerial photo interpretation.

| Pixel Value | Severity class | Description | % foliage fire affected |
|-------------|----------------|--|---|
| 0 | Unburnt | Unburnt surface with green canopy | 0% canopy and understory burnt |
| 1* | Reserved Class | Experimental burnt grassland class. Operationally at a statewide scale, this requires further development. | |
| 2 | Low | Burnt understory with unburnt canopy | >10% burnt understory >90% green canopy |
| 3 | Moderate | Partial canopy scorch | 20-90% canopy scorch |
| 4 | High | Complete canopy scorch (+/- partial canopy consumption) | >90% canopy scorched, <50% canopy consumed |
| 5 | Extreme | Complete canopy consumption | >50% canopy biomass consumed |

*This class is reserved for future development. The DPIE FESM Interim Statewide Mosaic dated 19 April 2020 includes Class 1 as 'Non-FESM burnt area' as a precautionary approach, as not all fires were processed and there were significant limitations due to smoke and cloud during as the fires were still burning. In future versions this class may represent burnt grassland, currently in development.

Accuracy Assessment

Based on independent API cross-validation assessment (predicting severity classification of new fires not used to train the model), the FESMv3 accuracy statistics range from 85-95% for unburnt and extreme severity, and between 60-85% for low, moderate and high severity. The average API validation accuracy statistics are show in Table 2. The range of vegetation types and area of the landscape tested in the FESMv3 accuracy assessment is much greater than in FESMv2. Furthermore, post-fire field validation assessments were collated from numerous surveys shortly following the 2019/20 season. The accuracy statistics from the field validation data assessed so far appear to have a similar range as the API-based validation statistics. More detailed assessments of the performance of the modelling across vegetation type, terrain and climatic regions using high resolution aerial photography interpretation and post-fire field assessments are ongoing.

Table 2 Balanced accuracy statistics comparing the FESMv2 and FESMv3 model using aerial photo interpretation (API) and post-fire severity field assessments. The FESM classification ruleset (Table 1) was used to assess a minimum plot size of 30 x 30m with homogenous severity.

| Severity Class | FESMv2 (April 2020) | | FESMv3 (December 2020) | |
|------------------|---------------------|------------------|------------------------|------------------|
| | API Validation | Field Validation | API Validation | Field Validation |
| unburnt | 0.99 | 0.98 | 0.93 | 0.97 |
| low | 0.73 | 0.63 | 0.81 | 0.76 |
| moderate | 0.68 | 0.65 | 0.76 | 0.73 |
| high | 0.64 | 0.57 | 0.79 | 0.84 |
| extreme | 0.85 | NA | 0.90 | NA |
| Overall accuracy | 0.60 | 0.54 | 0.76 | 0.68 |

Technical Information

File Naming Convention

| What | | | Where | When | Processing | | Options | Suffix |
|--|--|---------|---------------|----------|------------|------------|---------|--------|
| cv | ms | re | fnpw0000012 | 20191127 | ag1 | m6 | | img |
| satellite | instrument | product | FESM scene id | date | stage | projection | N/A | format |
| Example: cvmsre_frfs0310199_20190115_ag1m5.img | | | | | | | | |
| Codes | Description | | | | | | | |
| cv | Sentinel 2 | | | | | | | |
| ms | Sentinel 2 multispectral imager (MSI) | | | | | | | |
| re | Reflective - used for all multispectral instruments. | | | | | | | |
| fnpw0000012 | FESM scene identifier. 'f' - FESM, 'nfw' - agency, '0000012' - 7 character number. | | | | | | | |
| yyyymmdd | Fire end date - date by year, month, day | | | | | | | |
| ag1 | FESM products: ag1 = severity raster. ag5 = burnt area shapefile. ag6 = index image. ag4 = training data used to train the fire severity map (csv). Ag8 = unburnt training index image | | | | | | | |
| m4 | MGA Zone 54 (m4), 55 (m5) or 56 (m6) | | | | | | | |

Image details Available for requested fires. Input data is required from customer, including estimated spatial extent (~2km accuracy) and fire start and end dates.

Data type: Raster (severity) and vector (burnt area – amalgamated severity classes).

Pixel size 10m

Base Imagery Sentinel 2 (2016-ongoing)

Image pixel values (Fire Severity Classes)

| Pixel Value | Severity class |
|-------------|----------------|
| 0 | Unburnt |
| 1* | Reserved Class |
| 2 | Low |
| 3 | Moderate |
| 4 | High |
| 5 | Extreme |

*This class is reserved for future development.

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- NSW Rural Fire Service
- NSW Bushfire Research Hub
- Sentinel 2 data courtesy of the Australasian Copernicus Hub
- Staff from the Joint Remote Sensing Research Program

Data access

State-wide mosaics of wildfires are produced at the end of each fire season and delivered through the SEED portal. Fire severity maps for individual wildfires and hazard reduction burns (post-2017/18) can be requested from DPIE through the data broker data.broker@environment.nsw.gov.au