Frequently Asked Questions:

Burnt Area Mapping on NAFI

August 2024

Contents

What burnt areas are mapped?

Burnt area mapping refers to the coloured patches you see on the NAFI map display that are areas previously burnt by fire. These are distinct from the hotpots which show the point locations of actively burning fires. The NAFI service displays two types of burnt area (or fire scar) mapping.

250m per pixel moderate resolution burnt area mapping

This is the regular burnt area mapping that is displayed as coloured patches along with the hotspots when you enter the NAFI site. Each pixel of mapping is 250m across on the ground – around the size of a large sports stadium. This mapping is largely based on imagery from polar-orbiting satellites such as the *Terra* satellite with its 250m per pixel MODIS sensor. For more information on the satellites used see *FAQs Hotspots Mapping on NAFI* in the NAFI help menu.

This mapping is regularly updated throughout the year across the open savanna and rangelands landscapes of Australia as shown below. In the frequently burnt areas of the far north, it is updated around once a week during the northern fire season.

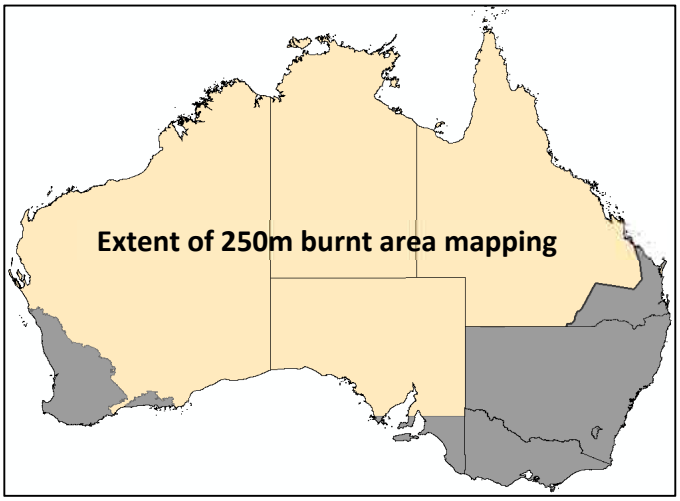

Figure 1: the extent of the moderate resolution 250m burnt area mapping displayed by the NAFI service.

The 250m burnt area mapping is used to help estimate fuel levels and its multi-year fire histories are used for planning and assessing fire management across large areas and properties. It is also used to help estimate emissions from fires across the far north.

20m/10m per pixel higher resolution mapping

The NAFI site also display mapping with a higher spatial resolution of 10 or 20m per pixel – so each pixel represents an area around the size of a basketball court. This mapping is sourced from the Multi Spectral Imager carried on the Sentinel 2 satellites

which produces images with spatial resolutions of 10m or 20 depending on the wavelength bands used.

As all the burnt area mapping displayed on NAFI is manually edited in one way or another, it takes significantly more work to produce accurate higher-resolution burnt area mapping and so this is currently done only for the areas shown in Figure 2.

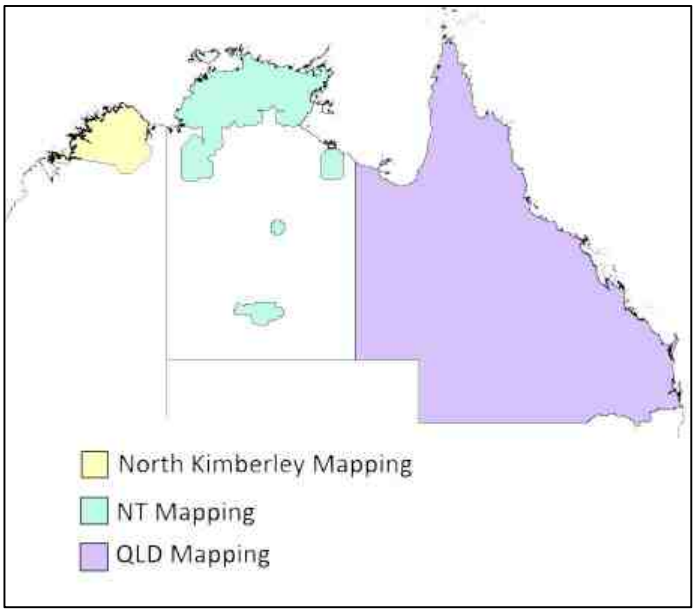

Figure 2: the extent of the higher resolution 10-20m burnt area mapping displayed by the NAFI service.

The higher res 20m mapping for the North Kimberley is updated every three months. The 20m mapping for the NT is updated every week or two throughout the northern fire season. The 10m mapping for Qld is updated every month throughout the year, usually 3-4 weeks after the month of mapping.

The Kimberley and NT higher res mapping is produced by NAFI and the Qld higher res mapping is sourced from the Qld Government Department of Environment and Science.

The 10m/20m higher resolution mapping is used in fire operations e.g. where the details of gaps in fire breaks need to be known. As this is only available for a few years there are no multi-year fire histories as of mid 2024.

Both 250m and 10/20m burnt area mapping are classed as “moderate resolution” mapping by remote-sensing specialists – “high resolution” mapping involves pixels a few metres or less across. For the large areas of country NAFI deals with, however, the 20m/20m mapping is a significantly higher resolution than the regular 250m mapping with distinct applications, so we refer to it as “Hi Res” for short.

How are burnt areas mapped?

The 250m burnt area mapping

The 250m resolution burnt areas on the NAFI site are mapped using images from a range of satellite sensors. The main source of imagery is from the MODIS sensor (carried on *Terra* and *Aqua* satellites) and the VIIRS sensor (carried on *NPP* and *JPSS* satellites) – see box on next page. This imagery is frequently updated – around an image a day for any location from each satellite – which allows the fire scar maps to be updated frequently. MODIS images have a resolution of 250m per pixel and the VIIRS images 375m. Two images with different dates are used to map fire affected areas (burnt areas), in the absence of cloud cover (Figs 3a and 3b).

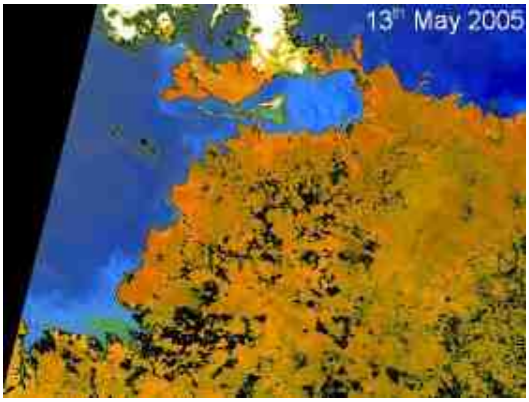

Figure 3a. Initial Image

Figure 3b. Later Image

Fire affected areas are visually identified by creating a new "difference" image that highlights changes from one time to the next. Fire affected areas are red and previously burnt areas are dark green (Fig 4).

Figure 4. Image of new burns

Object-oriented AI software is then used to "segment" the combined difference image. This means that pixels with similar values and that sit in the same area are clumped together into polygons (Fig 5).

The resultant polygons are classified and manually edited to accurately incorporate all fire affected areas (Fig 6).

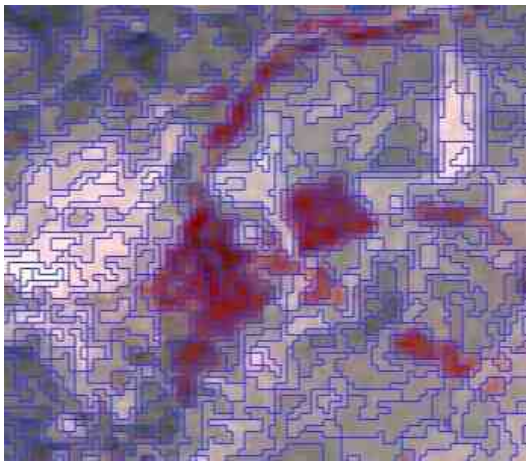

Figure 5. Polygons of new burnt areas

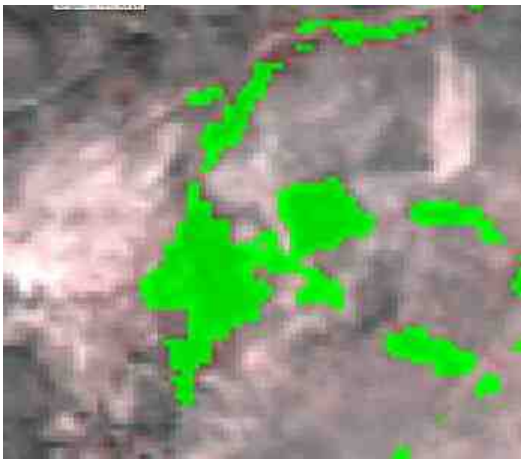

Figure 6. Final burnt area mapping

Additionally, higher-resolution imagery from the Sentinel-2 satellite is used to help map fainter, more patch burnt areas. This imagery is updated less frequently, around once every five days for a given location.

As each mapping period is completed, the resulting maps are uploaded to the NAFI site updating the current burnt areas that appear on the standard display (Fig 7).

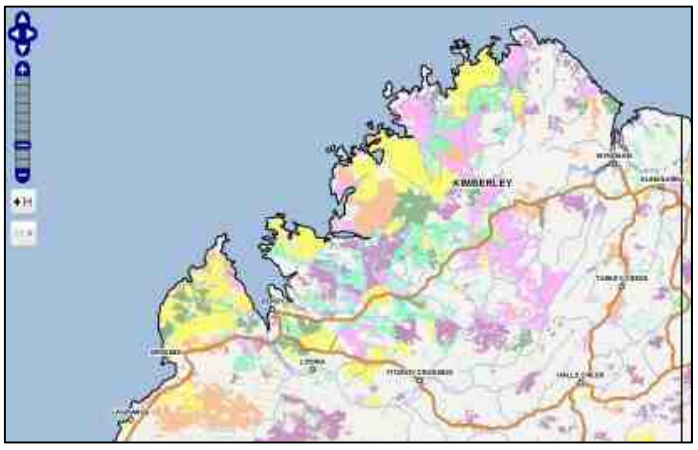

Figure 7 All burnt areas for the year to date on NAFI

Sensor Terms
The MODIS (Moderate Resolution Imaging Spectroradiometer) the VIIRS (Visible Infrared Imaging Radiometer Suite) and the Multi Spectral Imager (MSI) are all satellite-based sensors designed to capture images of the earth in the visible and infrared wavelengths so visible features along with heat sources can be identified.

The 10m/20m burnt area mapping

The higher resolution burnt area mapping is mapped by NAFI staff in basically the same way as the 250m mapping, except the imagery is sourced from the Multi Spectral Imager (MSI) carried on the Sentinel 2 satellites. The mapping process takes significantly longer for a given area than the 250m mapping as there are many more pixels to inspect and edit.

The Queensland 10m burnt area mapping (see Fig. 2 above) uses a more advanced AI process to produce burnt area mapping for the entire state, and this is then manually edited before being released.

Whether imagery sourced from the MSI sensor has 10m or 20m resolution depends on the mix of wavelengths chosen – if you want to focus on the visible wavelength features then 10m resolution can be used, but of you also want to see heat features then 20m resolution imagery must be used to include the infrared wavelengths.

How accurately are burnt areas mapped?

There are three types of accuracy that affect fire management:

- Spatial accuracy – how well the location, size and shape of the mapped burnt area matches that of the actual burnt area. This is important, for example, for fire breaks created by early dry season burning. You will want the mapped break to be accurate in its location, size and shape so you can effectively work out how it will pull up wildfires.
- Temporal accuracy – how well the date of the mapped burnt area matches that of the actual burnt area. While not as critical as the date and time of an active fire (hotspot) the date of a burnt area is useful in estimating the fuel level of that burnt area, so you want it to be accurate to within a week or two and in the case of measuring emissions you want the accuracy of the July/August cut-off date between the Early and Late dry seasons to be as accurate as possible.
- Radiometric accuracy – how well the images themselves capture the different features of the land detected by using a range of wavelengths. For example, the 10m/20m MSI sensor on the Sentinel 2 satellites can detect more features of a burnt landscape than the 250m MODIS sensor as it can capture more wavelengths. This means it can identify burnt areas that are more faded than the MODIS sensor can.

The spatial accuracy of the 250m burnt area mapping

Mapped burnt areas are a more comprehensive and spatially accurate record of burning than the record of hotspots. However, these maps are not 100% spatially accurate as, for example, cloud cover can make mapping difficult and the resolution will place a limit on the accuracy achieved.

As an example of the accuracy of the burnt area mapping, the MODIS satellite image (Figure 8), from October 2004, shows a large fire spreading on a number of fronts to the west of Lake Woods (the white area) in the Barkly region of the NT. This fire eventually spread much further and can be seen on the NAFI site as a very large fire scar (Figure 9).

You can see from the shape of the unburnt areas within the original fire scar (outlined in the map) that the fire scar mapping is reasonably accurate – often to within 250m. The hotspots are only accurate to around a kilometer or so.

Figure 8. Satellite image (MODIS) of a large fire

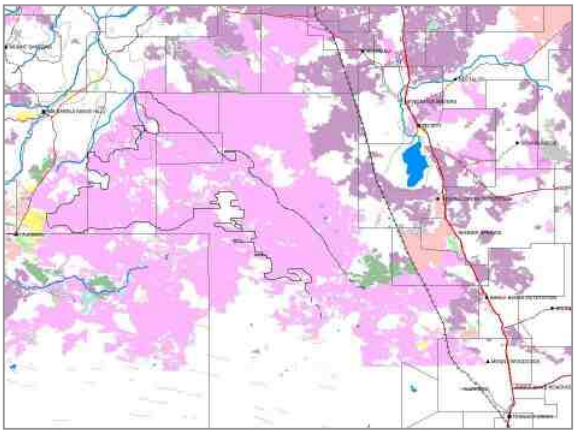

Figure 9. Final mapping display on NAFI

However, as the map above shows, the NAFI site often does not clearly identify the area burnt by an individual fire – but rather the extent burnt in each month. If a fire burns out a particular area, and then another fire burns out an adjoining area in the same month – the NAFI site might map this as a single scar of the same colour. Similarly, if a fire burns for many days from one month into the next it is likely to be mapped as a burnt area of two colours. However, the colour of a fire scar does not always change exactly at the end of a month (see ***How accurately are burnt areas dated*?** below).

250m mapping spatial accuracy: validation and reviews

To ensure the NAFI burnt area mapping is as accurate as possible, the mapping is reviewed by a separate mapper at the end of the early dry season and at the end of the year. This review picks up and adds any burnt areas that may have been missed by persistent cloud cover and double-checks the existing mapping.

This reviewed mapping is then validated against aerial surveys and high-resolution satellite imagery at six sample areas across the northern savannas in both the early and late dry seasons. The validation is required across the northern savannas to ensure the burnt areas are at least 80% accurate for the Savanna Burning emissions reduction program that uses the NAFI burnt areas. In practice, the NAFI burnt area mapping is mostly more than 90% spatially accurate.

Figure 10. Validating 250m NAFI fire scar mapping by helicopter.

The spatial accuracy of the 10m/20m burnt area mapping

At 10/20m resolution per pixel this burnt area mapping is generally more spatially accurate that the 250m mapping – particularly when each burnt area is checked during a manual editing process. This higher spatial accuracy makes the hi-res mapping more useful for fire operations: the gaps between fine-scale fire breaks are often of the order of a few 10s of metres which can be picked up by the hi-res mapping but not the 250m mapping (Fig 11). Being aware of these gaps can be important where extensive networks of strategic breaks are being used.

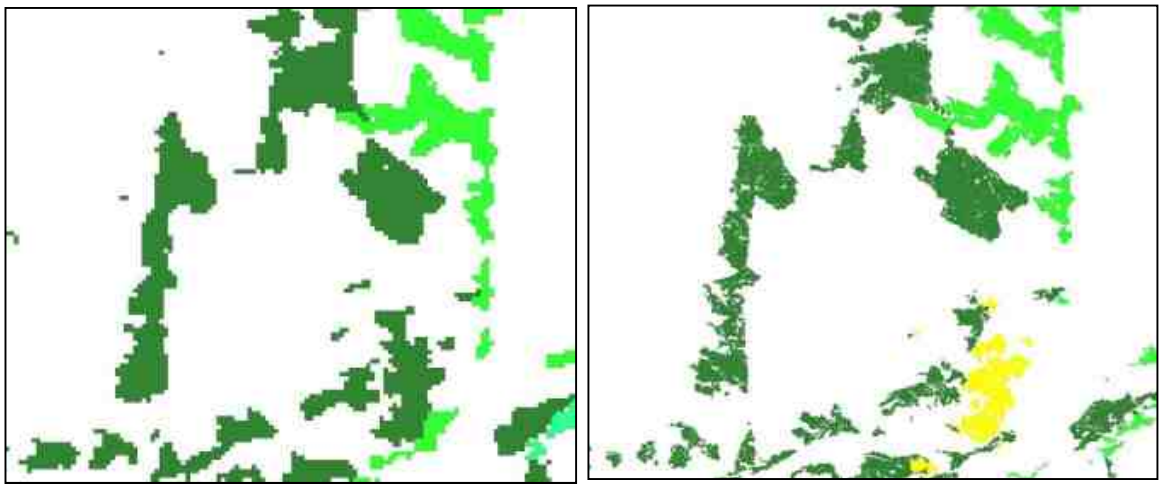

Figure 11. The same fire scar maps based on 250m imagery (left) vs. 10m imagery (right)

This accuracy advantage of the hi-res burnt area mapping, however, may not hold in landscapes and at times of year that have more cloud cover. This is because the time between overpasses of the two Sentinel 2 satellites, that are used for the hi-res imagery, is around 5 days, compared to the much shorter time between overpasses of the 250m satellites (from a day to a few hours). In persistently cloudy weather the Sentinel 2 passes can end up missing a clear view of some ground areas for weeks at a time and if there has been a burn in those areas it can have faded away by the time the Sentinel satellites get a clear view. So for these cloud-prone landscapes, such as northern Cape York Peninsula, the hi-res mapping can miss burnt areas, reducing spatial accuracy.

Note that some of the burnt areas in the hi-res mapping in Fig 11 are coloured differently than the equivalent 250m burnt area. They are dated with a later month than the one in which they were actually burnt and this dating issue for Hi res mapping is dealt with in the next section.

Using the higher radiometric resolution of the Sentinel 2 imagery

The multiple wavelength bands and higher radiometric resolution of the MSI sensor means that the 10m/20m imagery is better at identifying faded burnt areas and burnt areas with more complex appearances such as those in sandy desert landscapes. The higher spatial resolution also helps here. Consequently the 10m/20m imagery is often used to map burnt areas in more difficult to map landscapes and then incorporated into the 250m burnt area mapping – after being re-sampled to 250m.

How accurately are burnt areas dated?

The dating accuracy of the 250m burnt area mapping

The satellites used for the 250m mapping pass overhead a few times a day, allowing burnt area mapping across northern Australia to be updated from every few days to every week or two during the fire season depending on the fire activity. In the more arid areas where fire activity is more variable, fire scar mapping is carried out when required depending on the fire activity.

Burnt areas are mapped by comparing two images of the same locations taken several days apart - from different passes of the satellite (see Figs, 3a and 3b above). Because burnt areas are mapped by comparing an image with a past image, the time the fire actually occurred can only be ascribed to any time within that interval – say within the last week. If that week was mostly in a given month then the fire scar colour is assigned to that month. However, it is possible that a fire occurred on say the 2nd of November but its fire scar was detected by comparing an image from the 3rd of November with an image from a week earlier – the 27th of October. As we cannot tell exactly when the fire occurred and as the period in which the fire could have occurred is mostly in October, the fire scar would be allocated to October (pink). So, the colour (and implied date) of a

fire scar should be taken only as an approximate guide near the end or beginning of a month. The exception to this rule is the July and August burnt areas where, because this is the demarcation between the early and late dry seasons under the Savanna Burning emission methods, care is taken to date the division between July and August scars as close as possible to the end of July / start of August.

You can see the two bounding dates for any of the burnt areas in the shapefile of the completed annual fire histories downloaded from the NAFI site. It is in the "Map Period" attribute.

The dating accuracy of the 10m/20m burnt area mapping

The time between overpasses of the two Sentinel 2 satellites, that are used for the hi-res imagery, is around 5 days. If an overpass is obscured by clouds, then the time between updates for a given location on the ground can be measured in weeks. This makes it harder to accurately date burnt areas detected using the hi-res satellite imagery. Using the imagery alone, burnt areas can be detected a month after they actually occurred in cloudy areas. For this reason, hi-res burnt area mapping in places like Arnhem Land are dated using the more temporally-accurate hotpots data. Generally, the dating of Hi-res mapping should be treated with more caution that the dating of the 250m mapping.

How are the burnt areas displayed on the NAFI site?

The burnt areas are displayed in various combinations on the NAFI site to suit different purposes.

250m burnt area mapping displays

Current Year Burnt areas

The standard display when you enter the NAFI map viewer shows hotpots up to a week old against a background of the current year's 250m burnt areas colour coded by the month in which they were detected as being burnt. This is to give an idea of the fuel conditions that surround active fires.

Recent Years Burnt areas

Many people find viewing the last two or three years of 250m fire history useful as a guide to fuel levels and you can do this by going to the "Track Fires" (or "Fire History") tab and then "Recently burnt areas" in the left-hand menu. Then choose how many years of recent fire history in your area you want to view. For more information go to the "Help" tab and "Using NAFI" and select "Help on viewing current fires".

Past Years Burnt areas

Once the calendar year has ended, the 250m burnt area map for that year is kept so we have each year of burnt areas from 2000 available for display on NAFI. Users can then check out the months burnt in past years. All these maps are available under the "Fire History" tab, under "Burnt areas by Month" in the left-hand menu, which displays each month of the year in a different colour as for the current burnt areas. This can be useful to see what areas burnt early and late in past years in your area. The same fire scar data is also displayed under "Burnt areas by Year" layers in which each year's burnt areas are displayed in a single colour. This can be useful for estimating fuel levels.

Fire Histories

As well as displaying individual years of burnt areas, the NAFI site also displays "Fire History" maps that profile the complete history of 250m burnt areas from 2000 in various ways. Three types of fire histories are displayed: the number of years burnt in an area (fire frequency); the number of years burnt by late dry season fires in an area; and the time since an area was last burnt.

10/20m hi res burnt area mapping displays

The 10/20m hi res burnt area mapping has only a few years of mapping produced in selected areas (see Fig 2) and so is not yet available in multi-year fire histories. Also as CDU does not own some of this mapping we would need the owner's permission to display fire histories when they are developed.

Current Year Hi Res Burnt Area mapping

As for the 250m mapping, this displays the current year's 10/20m burnt area mapping using the same monthly colours. The extent is shown in Fig 2 above.

Recent Years Burnt areas

The last few years of fire history are useful as a guide to fuel levels and you can do this by going to the "Track Fires" (or "Fire History") tab and then "Recent HiRes Fire Scars" (or "HiRes Fire Histories") in the left-hand menu. This display the same areas as the current year display.

Why does the hi-res burnt area mapping not cover more areas and years ?

As shown in Fig. 2 on page 2, the hi-res burnt area mapping only covers certain areas of northern Australia. The main reason for the limited extent is cost and time: creating burnt area maps from high-resolution imagery using an editing process for accuracy involves looking at many more images and pixels for a given area (around 150 times as many pixels for 20m vs 250m imagery) than using the 250m imagery. So, it takes a lot longer and costs a lot more for a mapper to map a given area of burnt areas.

The hi-res mapping that does cover large areas such as the Qld mapping uses AI algorithms to do most of the mapping. The problem here is that the automated mapping is not uniformly accurate and does not map some types of landscape as well as others and is prone to miss burnt areas in cloud-prone areas. There is also the issue of late dating with the hi-res imagery (see *How accurately are burnt areas dated?* above). This means you cannot produce reliable fire histories from this broad-scale fire scar mapping of the sort that are required for regional planning and emissions measurement.

Where does the Cloud data come from?

Figure 12. The cloud image on NAFI

The cloud viewing option is available in the "Track Fires > Check Conditions". The "Smoke and Clouds" image layer is a Himawari satellite image sourced on-demand as a map service from Geoscience Australia. Himawari is a geostationary satellite sitting just to the north of Australia and can provide a regular stream of continually updated satellite images of the continent every 10 minutes or so. The images are coarser than those used to map the burnt areas and hotspots, but they can show the latest cloud cover and will show smoke plumes from larger fires.

What other data are displayed on the NAFI site?

Apart from the hotspots and burnt areas shown when you enter the NAFI site, and the fire histories described above, a number of other useful layers are available for display on maps:

- The background maps available by clicking the buttons at the top of the layer list, use various data
  - The line maps are made up of various data layers from Geoscience Australia as well as the Cadastral (property boundaries) layer from the respective State and Territory agencies.
  - The 250K Topographic maps come from Geoscience Australia
  - A high-resolution satellite image layer sourced from Google.

- The Parks and Reserves boundaries are from the respective State and Territory agencies.

- For the NT only, NAFI also displays a regularly updated map of vegetation curing (dryness) based on satellite-sourced Normalised Difference Vegetation Index (NDVI) imagery. The imagery is sourced from Landgate WA and colour coded to suit NT conditions.

What are the Google Earth and WMS options about?

You might like to view fire data in other map viewers such as *Google Earth* with its familiar controls and high-resolution background images, or you may want to view the data in your own mapping system such as ArcGIS, QGIS or an in-house mapping interface, in which case you can use a Web Map Service (WMS) to bring NAFI data into these other map viewers.

Viewing NAFI data on Google Earth

If you have *Google Earth* installed (it is free to install) you can select the “Data” tab on NAFI and then “for Google Earth” in the left hand menu and choose from three options (Current fire data, Past year’s burnt areas and Fire History data) to download these data as .kmz files. A kmz file is a zipped version of a kml – or keyhole markup language – file, which are the files used to display spatial data on *Google Earth*. A display of NAFI burnt areas and hotspots on *Google Earth* is shown below. Not all current hotspots are available in this view to avoid overloading our servers, but most current hotspots are, as well as burnt areas and fire histories.

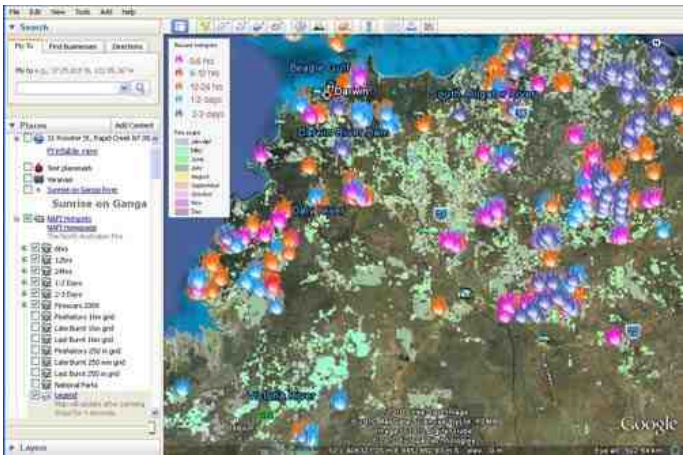

Figure 13. NAFI hotspots and burnt areas displayed on Google Earth

Viewing NAFI data on other mapping software using WMS

You can also access some of the main NAFI data as a Web Map Service (WMS) which can deliver the map images of hotspots, burnt areas and some fire histories as a data feed that can be used by ArcGIS, QGIS and other mapping programs. The burnt areas are delivered as images so you cannot query them for their attributes – instead you need to rely on the NAFI legend. To download NAFI data as WMS, choose the "Tools" menu and "Google Earth, WMS" in the left-hand menu and the "View as WMS service" link.

Viewing NAFI data on other mapping software using the QGIS Plug-in

If you have the free mapping software QGIS, you can install a NAFI "plug-in" which provides a convenient way to view the NAFI WMS data in QGIS. You can find out more from the "Help on Installing the QGIS NAFI plug-in" link under Help > Using NAFI (PDF).

Figure 14. Using the QGIS plug-in the various NAFI WMS map layers are made easily accessible with clear menus.

What are the Reports all about?

A reporting tool is available under the “Reports” tab above the map. This tool allows you to select an area of interest – either from a drop-down menu of pre-set areas like Properties, Parks and Reserves or Indigenous Protected Areas, or by drawing your own boundary on the NAFI maps with the mouse. You can then choose from a range of reports on fire activity in that selected area:

- Burnt areas by year – quantifies the areas burnt for each month in that area for a given year back to 2000.

- Fire History - generates reports on the fire frequency, late fire frequency and time since last burnt in your selected area across a choice of three time periods: the full record of fire history back to 2000; the earliest 10-year period on record (2000-2009) and the most recent 10 years on record.

These reports are then produced as a pdf as shown below.

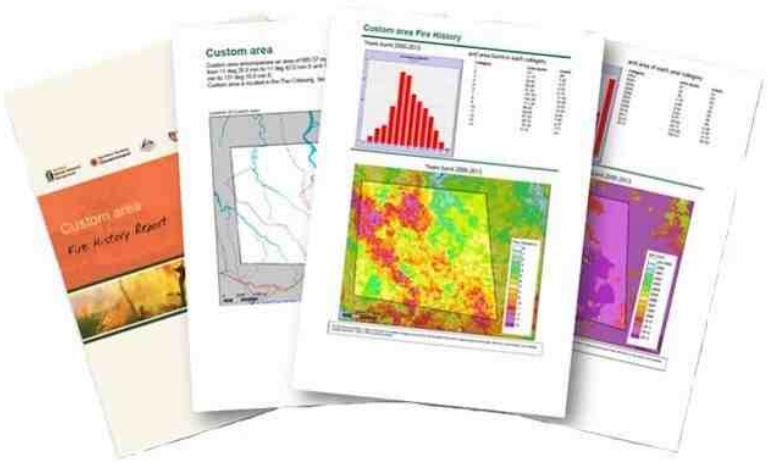

Figure 15. Sample pages from the Report tool

The graphs and tables in these reports are based on an analysis of the 250m burnt area data displayed on the NAFI website – and they rely on the uniform accuracy of these data. For more information go to the “Help” tab and “Using NAFI” and select “Help on fire reports”.

How do I find out more?

If you need more information you can:

- Read the NAFI help pages on Using NAFI under the “Help” tab
- Get in touch with the relevant contact person by clicking the “Contact Us” link on the NAFI home page.