NAFI North Australian and Rangelands Fire Information

Frequently Asked Questions:

Data and Mapping

November 2021

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How are the fires on the NAFI site detected?

All "hotspots", the red, blue and pink spots that mark active fires, are initially detected by heat or brightness sensors mounted on orbiting satellites. These sensors create electronic heat images of the land which can be beamed down to receiving stations on the ground (see below).

A computer then examines each of these images and detects fires by checking each of the small elements or "pixels" that make up the image (you can think of these pixels as being like the small squares that make up a television image). Pixels that are much brighter than neighbouring pixels and that have some other heat characteristics are identified as fires (see *How accurately do hotspots show the location of a fire?* page 4).

The latitudes and longitudes of these bright spots or hotspots are then sent to the NAFI website and displayed as suspected fires on maps.

How often is a fire monitored – and what satellites are used?

You may have noticed that sometimes the location of a fire hotspot on the website is updated a few times in a few hours and at other times there are longer gaps between updates.

Much of this can be explained by the orbits of the satellites that monitor the fires. In late 2021 the NAFI website was receiving fire data from six satellites:

- two minibus-sized satellites operated by NASA: *Terra* and *Aqua*,
- The slightly smaller European meteorological satellite Metop C (*NOAA-23*[1])
- The small satellite operated by the US National Oceanic and Atmospheric Administration (NOAA): *NOAA-19*
- two satellites operated jointly by NASA and NOAA: the *Suomi NPP* satellite and the *JPSS-1 (NOAA-20)* satellite.

Figure 1. from left to right: NASA's Terra satellite, NOAA-19 and JPSS-1 (Images from NASA and NOAA)

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[1] This name is used as Metop C was part of a joint US/European initiative that involved NOAA, but in the future NOAA-23 will be a successor to the JPSS-1 satellite.

The satellites move in orbits designed to monitor the entire globe – roughly north-south paths that pass close to the poles and are synchronised with the rotation of the earth (Figure 2). As the satellites follow these paths at around 20,000 kilometres an hour, on-board sensors continually generate images of the earth below in strips 2,300-2,400km wide depending on the satellite. As the images are created they are beamed down to receiving stations.

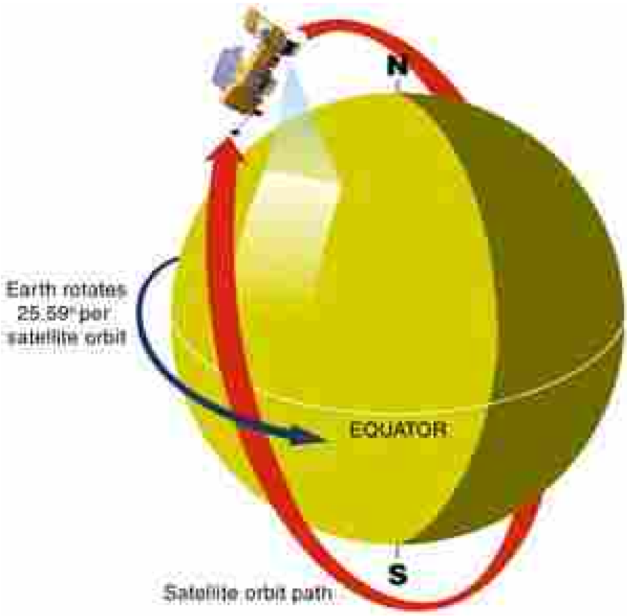

Figure 2. The polar orbits of the satellites used by the NAFI website

These orbits allow the satellites to see almost the entire globe in daylight and pass over a given point at roughly the same angle to the sun each day (so images from different days are lit by the sun in the same way and can be more easily compared). To do this they actually see most points twice day – once on the daylight side and once on the night side of the earth 12 hours later. As fires can be detected at night this means most fires in Australia could be seen twice a day by each of the five satellites that feed the NAFI site – i.e. ten times on a good day.

In practice, the coverage is not nearly as good as this because often a fire will be obscured by clouds, smoke or haze or it may not be large enough or hot enough to be detected, particularly if it lies near the edge of a satellite view. The NOAA-19 and NOAA-23 satellites do not always produce hotspots on their passes.

In the fire season a large fire in north Australia is typically detected perhaps two to four times in daylight hours and two or three times at night. However, for a given region on the ground the satellite passes are not evenly spaced through the day – there may be an overpass from the *NOAA19* satellite between 6 and 8am but more likely not, leaving a significant gap in overpasses until the *Terra* satellite in the late morning, with the *Aqua* going overhead in the early afternoon and the *NPP* and *JPSS-1* satellites overpassing in the early to mid- afternoon. Then there will be another gap until *NOAA-19* between 6 and 8pm the *Terra* satellite returns before midnight, together with a *NOAA-23* (*Metop C)* pass around midnight with *Aqua*, *NPP* and *JPSS-1* in the early – mid morning.

As outlined below, given it takes between 30 minutes and two hours for the hotpots to reach the NAFI site once they've been detected, you have to add this time to the times above to get an idea of when NAFI is updated.

Websites:
Terra Satellite: http://terra.nasa.gov
Aqua Satellite: http://aqua.nasa.gov
NOAA-JPSS Satellites: https://www.nesdis.noaa.gov/content/our-satellites

How accurately do hotspots show the location of a fire?

Whether or not a fire is detected and the accuracy with which it is mapped is partly related to the satellites' sensors. Three types of sensors are used to detect fires: the NASA *Terra* and *Aqua* satellites use a MODIS or "Moderate Resolution Imaging Spectroradiometer" and the *NPP* and *JPSS-1* satellites use a VIIRS or "Visible Infrared Imaging Radiometer Suite". Both these sensors take digital images of the earth's surface using a number of different wavelengths or spectral bands. Images in some of these bands are pretty good for picking out burning fires in the landscape, and they rely largely on the heat signals given off by the fires rather than how visually bright they are (see Figure 4, next page).

The NOAA and Metop C satellites use a similar instrument of older vintage – the "Advanced Very High Resolution Radiometer" (AVHRR) which was presumably an apt description when it was designed in the 1970s. The AVHRR uses less spectral bands and has a lower resolution than MODIS/VIIRS but also detects fires by their heat.

The fire data from the sensors will be picked up by a number of ground stations across Australia. Landgate in Perth and Geosciences Australia in Canberra will then process the data to create the satellite images. All the images in the key thermal bands are then analysed by computers to detect the tell-tale heat signals of burning fires. Once detected, the latitude and longitude of the fires – the "hotspots" – are then sent to fire-tracking websites including the NAFI site.

Given that the satellites orbit 700 - 800km above the earth, the fires need to be reasonably hot compared to their surroundings to be detected in this way. Nevertheless quite small "fires" can be picked up – for example the heat signals from the top of the stacks in Mt Isa are detected despite being only a few metres across. While other islands of heat such as warm water in dams and hot rock outcrops can sometimes register as fires, the great majority of hotspots appear to be real fires.

Detecting fires with these sensors is one thing, accurately locating them is quite another. The picture below left shows a satellite photo of a fire inland from Port Douglas, to the right is the same fire from a MODIS image in the thermal wavelengths used to detect the heat signals of fires. Note that while the thermal image has starkly highlighted the fire, because the image is made up of pixels a kilometer or more across, the boundaries of such fires can't be narrowed down to within a kilometer or so. This is the case for images from the MODIS and AVHRR sensors. The VIIRS sensor, however, allows hotspots to be located within 375m or so.

Figure 3. Satellite photo of a scene 45km across, showing a fire just left of centre – with grey smoke streaming to the left

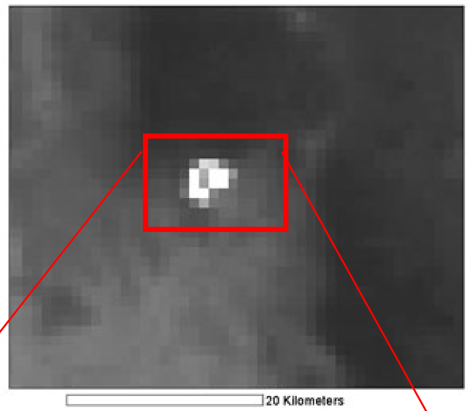

Figure 4. Lower resolution thermal MODIS image showing same fire

Figure 5. The same fire as shown on the NAFI site with hotspot symbols when zoomed in. The area shown is only around 10km across.

Because of these limits on accurately locating hotspots, the hotspot data received from Landgate are plotted with a precision of one hundredths of a degree of latitude or longitude (a little over 1km in north Australia), whereas hotspot locations received from GeoScience Australia have a precision of a thousandth of a degree (a little over 100m) although these hotspots are also only accurate to around 400m - 1 km. So when you zoom right in on a hotspot on the NAFI site as shown in Figure 5 you can get a false impression of precision because the hotspot symbols can end up being a lot smaller than a kilometer across. There is a warning about this imprecision on the NAFI site.

Some of these limitations can be got around by tweaking the computer programs that analyse the satellite images, but most improvements will come from changes such as using geo-stationary satellites that can see the ground continuously and using more sensitive sensors (although this is not easy to achieve – see below).

Why can't fire hotspots be tracked more frequently?

We hear a lot about advances in satellite technology so it may come as a surprise that we still have gaps of many hours during the day when we can't track fires by satellite. It turns out very frequent tracking of burning fires with satellites is difficult:

- There are around 2,000 active satellites orbiting earth but the great majority are not scientific satellites set up to observe the earth's surface. To frequently track natural processes like fires across the entire globe, the satellites need to have appropriate orbits such as the polar obits, described above, that allow the satellite to pass over every point of the earth's surface within a day. They also need to have the appropriate sensors that can detect burning fires. There are not many of these satellites – but still quite a number launched by countries like the USA, China and India. However, it is only the NASA, NOAA and Metop satellite systems, and the satellites above, that have been set up with the appropriate hotspot detection algorithms and distribution processes that then make this data freely available for agencies around the world to use.

- What about using Geostationary satellites that are positioned over Australia? Geostationary satellites can generate almost continuous images of the earth so, in theory, they should be able to generate a continuous record of fires. There are a number of Geostationary weather satellites with sensors that can detect fire hotspots, and one of these, a Japanese weather satellite, *Himawari 8,* is positioned over Australia. *Himawari 8* needs a very high orbit of around 35,000 km in order to be geostationary and while it has a very sensitive sensor, it still has a relatively low resolution of a few km (compared to 1km or less for the NASA/NOAA satellites above) which makes it difficult to detect a lot of smaller fires. However, the *Himawari 8* imagery can be very useful for checking hotspots – this imagery can be viewed on the Landgate *Firewatch* site listed at the bottom of page 7.

- What about the new constellations of micro- and nano-satellites or "cubesats" being launched? Groups like Planet have now launched hundreds of these tiny satellites into low earth orbit and the sheer number of these satellites means

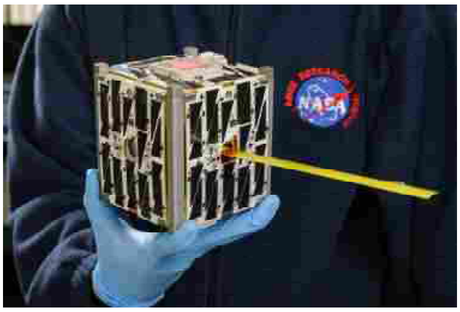

Figure 6. A NASA Cubesat

that in theory they can combine high resolution imagery with frequent updates of fire activity for a given location. Planet imagery is already being used to assist fire management in Australia. However, Planet are a commercial operation and currently there is no system set up involving hotspot detection and free distribution equivalent to the NASA and NOAA satellites. But there are many other cubesats being launched and this technology could be used more broadly for hotspot detection in the future.

Who creates the hotpot data?

The NAFI website receives the decoded hotspots from two agencies in Australia: Landgate WA which receives images from the five satellites described above from various ground stations such as Perth, Darwin, Hobart and Brisbane; and Geoscience Australia, based in Canberra, which receives hotspots from these satellites via a ground station in Alice Springs. The NAFI site receives the hotspot data over the internet and automatically updates as soon as the hotspots are available.

Two different computer programs or algorithms are used to detect hotspots from MODIS satellite images from the NASA satellites.

- The "MOD-14" algorithm has been developed by NASA to detect a broad range of heat signals – not just fires – and this can be used to detect fires from day and night time passes. Both Geoscience Australia and Landgate use the MOD-14 algorithm to produce hotspots from the NASA satellite images they receive.
- Landgate's Satellite Remote Sensing Services have also developed their own "SRSS" algorithm which is tailored to detecting fires from MODIS night-time passes. So the night time passes analysed by Landgate produce two sets of hotspots one from the MOD-14 algorithm and one from the SRSS algorithm.

Landgate and Geoscience Australia have also developed similar algorithms for producing hotpots from the VIIRS sensor on the *NPP* and *JPSS-1* satellites.

WA Landgate also process passes from *NOAA-19* and *NOAA-23* satellites with another algorithm tailored to these passes. Daytime *NOAA-19* and *NOAA-23* passes may not be processed because of the unreliability of the AVHRR sensor in detecting fires in daylight.

Websites:

Landgate: https://firewatch-pro.landgate.wa.gov.au (This site also has a lot of useful data on it for managing fires)
Geoscience Australia: https://sentinel.ga.gov.au

How long does it take between detection by the satellite and hotspots appearing on the NAFI website?

The delay is usually between 30 minutes and two hours.

- Once the satellites have completed their pass the thermal image is transmitted to a receiving station where the hotspots are identified by computer programs (see *How accurately do hotspots show the location of a fire?* page 4)

- Then, the latitude and longitude of the hotspots detected are calculated and delivered via the internet to the NAFI site where they are immediately uploaded to the database and become visible to users in the web-map. However, because of the chain of events involved in getting hotpots to the website various delays can occur (see *What can delay the hotspot data getting to the NAFI site?* below) Also there are various reasons the satellites may not detect a fire soon after it ignites, so it can be several hours between the ignition of a fire and its appearance on the NAFI site. (see *How often is a fire monitored – and what satellites are used?* page 2).

What can delay the hotspot data getting to the NAFI site?

Because the hotpots signals are relayed from an orbiting satellite to a ground station, to a computer and then through a complex internet network to the NAFI site, any problems in this long series of events can prevent the hotpots from reaching the website (see Figure 7, next page).

Occasionally there are technical problems with the satellites or the receiving stations. The most common problems, however, are faults and delays in the internet network that connects the receiving stations and agencies with the NAFI site.

When things are working as they should, it can still take between 30 minutes and two hours for an image signal to be sent from the satellite to the various ground stations around Australia, decoded into hotspots and then sent through the network to the NAFI site.

Some hotspots processed by Landgate are based on satellite images that have to be imported from downlink stations in Alice Springs and Hobart via the internet and this can produce delays of a few hours before the spots reach the NAFI website.

Accidental damage to Telstra cables, power failures, and network issues are just a few of the reasons why hotspot signals may not reach the NAFI site as scheduled and may take several hours instead. If you need information on a fire at short notice, these long delays are effectively the same as missed fires. However, the vast majority of hotspots are processed and displayed without any problems.

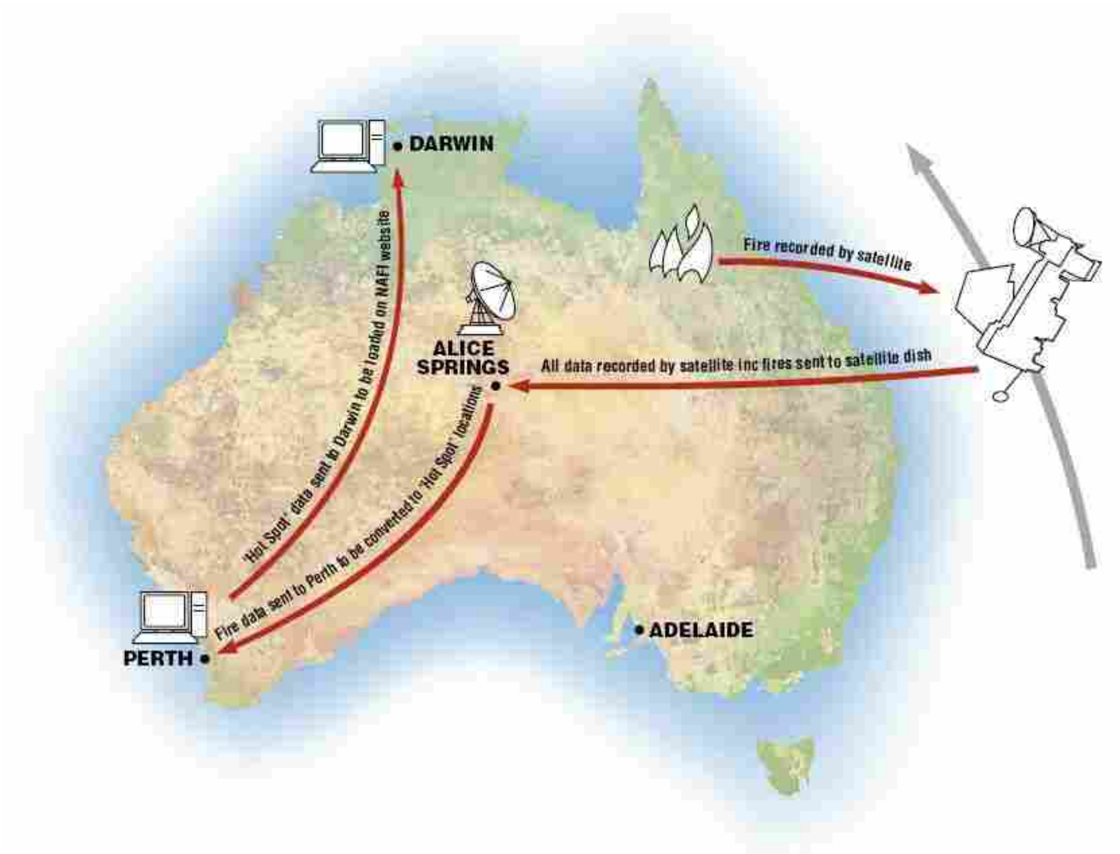

Figure 7. The path from detection to website – in this case via Landgate in Perth.

Do all burning fires show up as hotspots?

Although most major fires are detected by the satellites, for various reasons not all fires may be detected. The main reasons are:

- *The fire is too small or too low in intensity*. The satellite sensor detects fires through the radiant heat they give off, so fires that give off intense heat signals will be more easily detected than low intensity fires. Thus, the larger more intense fires towards the end of year will be more easily detected than the cooler, patchy fires in the early dry season. This also means that fires may need to grow in size before they are detected, and may be difficult to detect on cool mornings. However, even very small fires that are sufficiently intense will be detected – for example the chimney emissions from Mt Isa are usually picked up.

- *The fire is obscured by clouds or smoke*. The satellite sensors are not good at seeing through clouds, thick smoke or haze. This means that when there are large fires that produce thick smoke, other fires downwind under the smoke plume may not be detected. So at times when many fires are active and there is a thick smoke haze across the landscape, more fires than usual may not be detected. Cloud cover can be a problem in northern Australia from October to December when there may still be quite a few fires on the ground.

- *There is no satellite in view when the fire is burning* This can occur for short-lived fires (see *How often is a fire monitored – and what satellites are used?* page 2)

Are all hotspots shown on the map actually fires?

Evidence to date indicates that the great majority of hotspots are actual fires; however, this will depend on the satellite instrument used. The MODIS and VIIRS instruments used on satellites rarely register heat signals in the landscape as fires when they are actually not fires.

The AVHRR instrument on the NOAA-19 satellite, however, can occasionally generate a line of false fires running along the path of the satellite pass – often along the edge of the sensor image from the south-east to the north-west. At other times very high ground temperatures can create false hotpots when they are visible to the AVHRR sensor as small gaps through cooler cloud cover. Even the MODIS and VIIRS sensors can produce false hotpots as a result of very high temperatures producing anomalous patches of heat in some landscapes or as a result of interaction with cloud edges.

We make efforts to remove these errors as soon as they are detected, to ensure that the NAFI hotspot dataset is as accurate as possible.

These issues underscore the fact that the hotspots should always be viewed with a measure of caution, particularly if they are isolated and not part of an established fire – and if they have only been detected by one satellite pass. You can see which satellite pass (and hence which instrument) was used to detect a hotspot by going to the “Tools” tab and using the “Query hotspots” tool at the bottom of the “Map Layers” menu on the left. For more information go to the “Help” tab and “Using NAFI” and select “Help on viewing current fires”.

How are fire scars mapped?

Fire scars on the NAFI site are mapped using images from a range of satellite sensors. The main source of imagery is from the MODIS sensor (*Terra* and *Aqua* satellites) and the VIIRS sensor (*NPP* and *JPSS-1* satellites). This imagery is frequently updated with 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 (fire scars), in the absence of cloud cover (Figs 8a and 8b).

Figure 8a.

Figure 8b.

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 9).

Figure 9.

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 10).

The resultant polygons are classified and manually edited to accurately incorporate all fire affected areas (Fig 11).

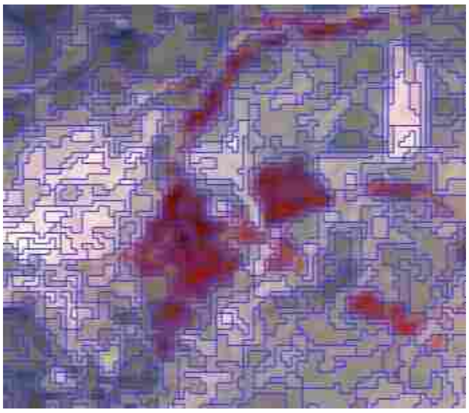

Figure 10.

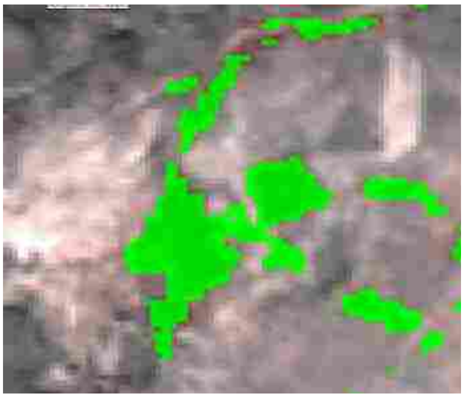

Figure 11.

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 fire scars that appear on the standard display (Fig 12).

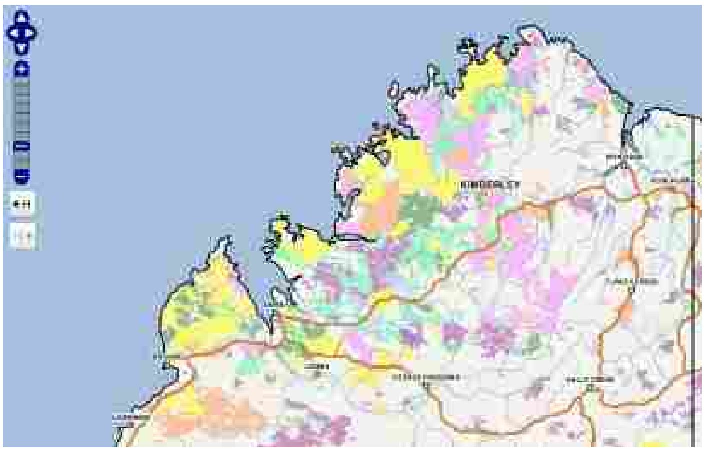

Figure 12

Land managers across northern Australia and the rangeland use these maps as monitoring and planning aids throughout the fire season. The information can help identify unburnt gaps in strategic fire control lines and can be used to assess fire risk, develop a burning history for individual paddocks, or construct a fire history of fire-sensitive and surrounding vegetation types on a conservation reserve. The fire scars are also used to help calculate the emissions from fire as part of the Savanna Burning emission reduction methods. In 2021 these fire scar maps cover most of the Australian rangelands – only excluding western NSW (Figure 13)

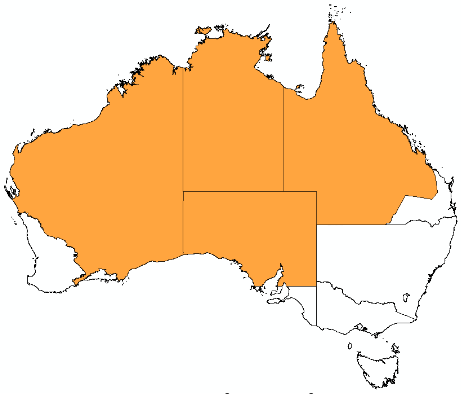

Figure 13   extent of NAFI fire scar mapping

How accurately are fire scars mapped?

The mapped fire scars are a more comprehensive and accurate record of burning than the record of hotspots. However, these scar maps are not always 100% accurate as, for example, cloud cover can make mapping difficult.

As an example of the accuracy of the fire scar mapping, the MODIS image (Figure 14), 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.

Figure 14.

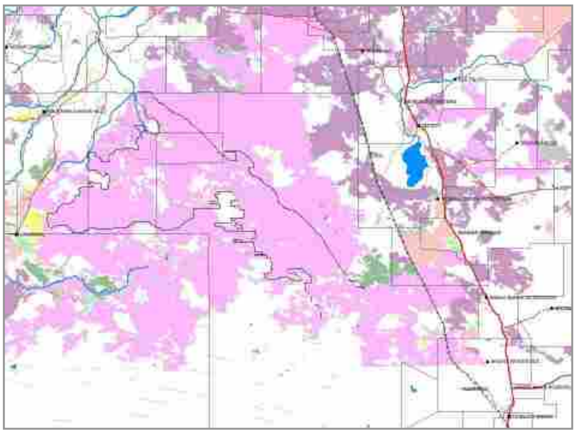

Figure 15.

This fire eventually spread much further and can be seen on the NAFI site as a very large fire scar (Figure 15).

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. These fire scar maps provide a more accurate guide to fire history than the hotspots which are only accurate to around a kilometer or so.

However, as the map above shows, the NAFI site often does not clearly identify scars from individual fires – 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 scar of two colours. However, the colour of a fire scar does not always change exactly at the end of a month (see *How regularly are fire scars updated and how accurately are they dated*? below).

Validation and Reviews

To ensure the NAFI fire scar mapping is as accurate as possible, the mapping is reviewed by an independent mapper at the end of the early dry season and at the end of the year. This review picks up and adds any scars 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 fire scars are at least 80% accurate for the Savanna Burning emissions reduction program that uses the NAFI fire scars. In practice, the NAFI fire scar mapping is mostly more than 90% accurate.

Figure 16. Validating NAFI fire scar mapping by helicopter.

When are fire scars updated and how are they dated?

The fire scar mapping across northern Australia is updated 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.

Fire scars are mapped by comparing two images of the same locations taken several days apart - from different passes of the satellite (see *How are fire scars mapped?* page 10). Because fire scars 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 fire scars 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 fire scars on the NAFI site by selecting the "Tools" tab, selecting the "Query active layer" tool in the left-hand menu and then clicking inside the fire scar of interest.

How are the fire scars displayed on the NAFI site?

The fire scars are displayed in various combinations on the NAFI site to suit different purposes.

Current Year Fire Scars

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 fire scars 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 Fire Scars

Many people find viewing the last two or three years of 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 Fire Scars

Once the calendar year has ended, the fire scar map for that year is kept as a map layer on the NAFI site – so we have each year of fire scars from 2000 available for display so users can check out the months burnt in past years. All these maps are available under the "Fire History" tab, under "Fire Scars by Month" in the left-hand menu, which displays each month of the year in a different colour as for the current fire scars. 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 “Fire Scars by Year” layers which can be useful for estimating fuel levels.

Fire Histories

As well as displaying individual years of fire scars, the NAFI site also displays “Fire History” maps that profile the complete history of fire activity 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. These three types of fire history are available at two scales:

- 250m scale maps which are based on the MODIS fire scar mapping described above. They are available under the “Fire History” tab. These fire histories can also be downloaded from the NAFI site as images, and in some cases as shapefiles. For more information go to the “Help” tab and “Using NAFI” and select “Help on viewing fire histories and downloading data”.

- There are also limited 1km scale maps which are based on AVHRR fire scar mapping (sourced from NOAA satellites) produced by Landgate WA. These maps cover the whole of Australia, but only for the years 1997-2010. They can be accessed under the “Tools” tab and “Map Layers” in the left-hand menu. Look for “Histories 97-10 (1K)”.

For more information go to the “Help” tab and “Using NAFI” and select “Help on viewing fire histories and downloading data”.

What is the role of Higher-resolution fire scar maps?

Fire scar mapping based on higher-resolution satellite imagery can offer significant advantages. For example, the Sentinel-2 satellites provide regular images of fire scars at 10-20m resolution per pixel – much finer scale than the 250m resolution of the MODIS imagery as shown below:

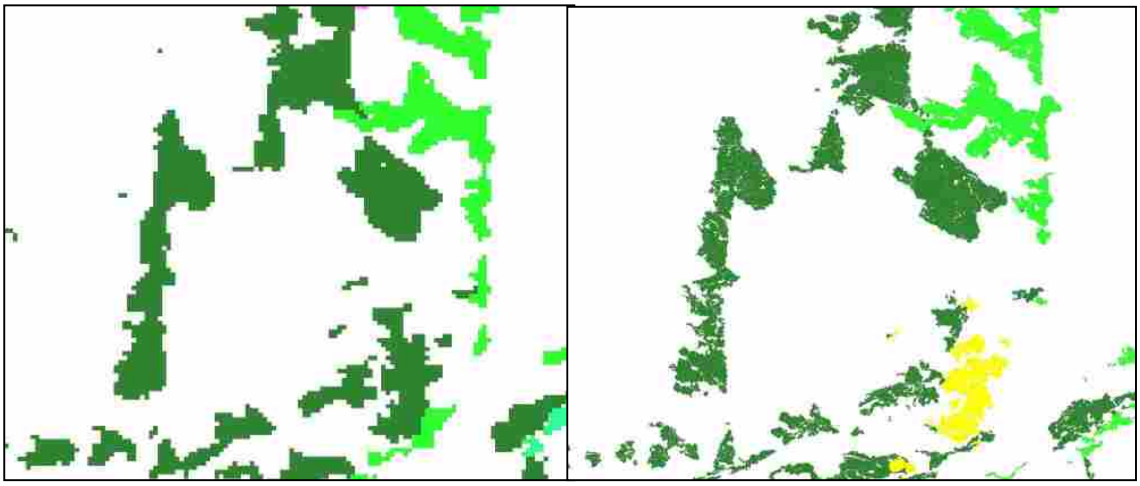

Figure 17. The same fire scar maps based on MODIS (left) vs. Sentinel-2 (right) imagery

You can see that the high-resolution Sentinel 2-based fire scar mapping picks up the fine details of the scars much better than the MODIS mapping. So why isn't it used for mapping fire scars across the rangelands?

- The main reason is cost and time: creating fire scar 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 MODIS/VIIRS imagery. So, it takes a lot longer and costs a lot more for a mapper to map a given area of fire scars.

- While the fire scars based on Sentinel-2 or Landsat imagery have high spatial resolution they have low temporal resolution: i.e. it is difficult to date the scars accurately because the gap between satellite overpasses is measured in days rather than hours for the MODIS and VIIRS-based fire scars. This also means that while the MODIS scars can be updated every few days if needed, the Sentinel scars, because of the fewer overpasses and because it takes longer to map, can only be updated every few weeks and then only for a regional area. This makes the MODIS scars more useful for generating a rapid assessment of the area burnt by a large moving fire.

There are, however, algorithms being developed that produce fully-automated high-resolution fire scar maps. The image on the right above is produced by one such algorithm with some editing. So, it is possible to produce reasonably accurate, high resolution fire scar maps.

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 fire scars in cloud-prone areas. You can also see from Figure 17 that the dating of the fully automated fire scars can be too late because of the larger gaps between satellite overpasses: e.g. there are July scars that have been dated as August scars. This means you cannot produce reliable fire histories from fully automated high-resolution fire scar mapping of the sort that are required for regional planning and emissions measurement.

But the high-resolution fire scar mapping can be very useful:

- Manually-edited high-resolution fire scar mapping can be produced at less frequent intervals for particular regions. The reliable and accurate maps can be used for regional planning and fire operations. The high-resolution mapping can be important for managing late season wildfires that are threatening fire breaks implemented earlier in the fire season (e.g. those shown in Figure 17) as the gaps in the breaks are more clearly shown than in the MODIS-based fire scars. This allows a better assessment of risk in the face of the approaching wildfires.

  Such regional maps are displayed on NAFI in the Kimberley, Darwin and Arnhem land-Kakadu regions.

- In landscapes where the fully-automated mapping works well, this mapping could be used for operational fire management by fire managers who know their country and can spot any errors in the automated mapping.

Various groups are working to improve the automated high-resolution fire scar mapping and by combing this with some editing a product useful across large areas that can be updated with a reasonable frequency might be possible in the near future.

What happens when the satellites fail?

The NAFI fire scar mapping and hotspot data depend upon satellites with limited lifetimes. Since NAFI started operations in 2003 a number of NOAA satellites used for hotspot data have been retired or have failed. The *Terra* satellite that is currently used for much of the MODIS fire scar mapping is due to fail sometime in 2021, if not before, as both the *Aqua* and *Terra* satellites are now well beyond their planned operational lifetimes.

These satellites should be replaced by successor satellites and we already have two newer satellites – the *Suomi NPP* and the *JPSS-1* satellites that can be used as replacements for *Terra* and *Aqua*, with a third satellite in the series, *JPSS-2*, due for launch in 2022 with *JPSS-3* (2026) and *JPSS-4* (2031) to follow. However, these satellites aren't exact replacements for *Terra* and *Aqua*. Firstly, their VIIRS sensors produce 375m resolution images which are slightly coarser that the 250m images produced by the MODIS sensors carried by the older satellites. This should be fine for mapping the area of fires typically found in the savannas but there could be issues if the fire scars become much finer and patchy under a transformed fire management in the future.

The other issue is that all the newer satellites have orbits that see them passing over locations on earth in the afternoon (local time), but often the best time for mapping burnt areas in tropical north Australia is the morning as there tends to be less cloud cover and smoke haze. The *Terra* satellite has a morning pass and consequently is used for most of the fire scar mapping. The likely solution here is to use the newer *Sentinel 3* satellites that produce 300m resolution images and have a morning pass every couple of days together with the increasing number of *JPSS* satellites.

Where do the Cloud and Lightning data come from?

These two viewing options are available in the "Track Fires > Check Conditions" menu

- 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.

- The lightning data is sourced by Landgate in WA from DTN in the US and is based on cloud-to-ground data from the Earth Networks Total Lightning Networks (ENTLN).

What other data are displayed on the NAFI site?

Apart from the hotspots and fire scars 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 and the 1M Topographic maps are World Aeronautical Charts from Airservices 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 or in-house mapping interface, in which case you can use a Web Map Service or WMS to bring NAFI data into these other map viewers.

Viewing NAFI fire scars and hotspots 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 fire scars 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 fire scars 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 fire scars and fire histories.

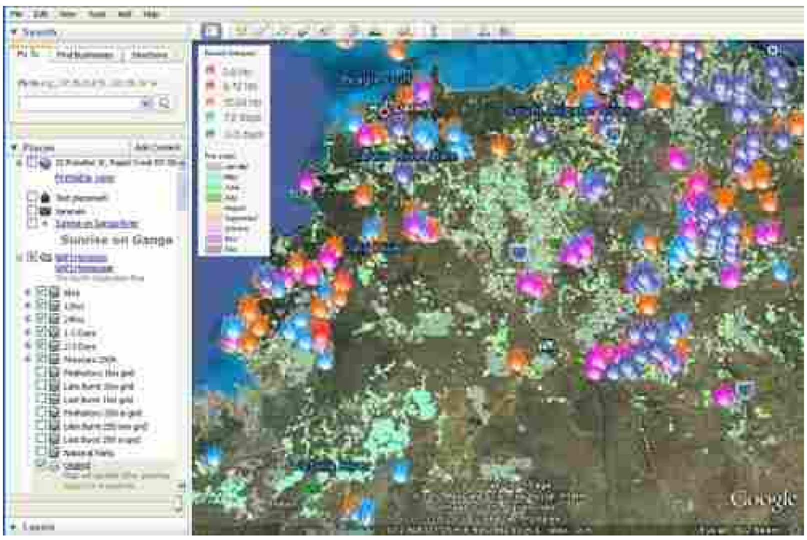

Figure 17. NAFI hostpots and fire scars displayed on Google Earth

You can also access some of the main NAFI data as a Web Map Service (WMS) which can deliver the map images of hotspots, fire scars and some fire histories as a data feed that can be used by ArcGIS and other mapping programs. The fire scars 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.

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:

- <u>Fire scars by year</u> – shows the area of fires scars for each month in that area for a given year back to 2000.

- <u>Fire History</u> - 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.

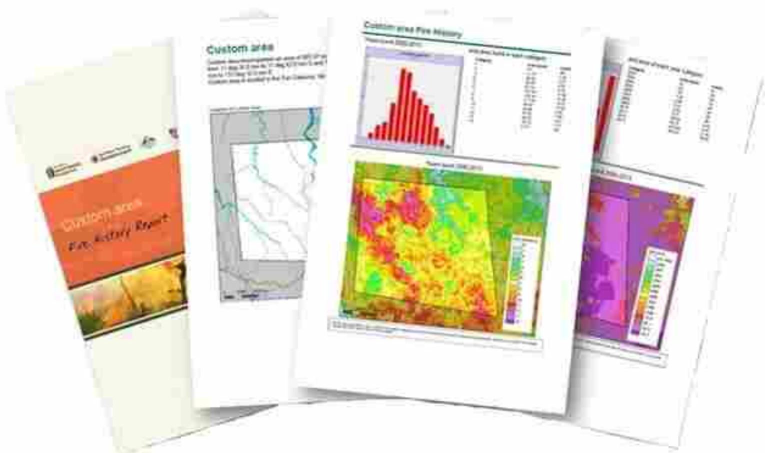

Figure 18. Sample pages from the Report tool

The graphs and tables in these reports are based on an analysis of the fire scar 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.