Frequently Asked Questions:

Data and Mapping

September 2010

How are the fires on the NAFI site detected?

All "hotspots", the red, blue and pink spots that mark fires, are initially detected by heat 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 *How often is a fire monitored – and what satellites are used?* – 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 5).

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 2010 the NAFI website was receiving fire data from four satellites: two minibus-sized satellites operated by NASA: *Terra* and *Aqua*, and two slightly smaller satellites operated by the US National Oceanic and Atmospheric Administration (NOAA): *NOAA-18* and *NOAA-19*.

Figure 1. NASA's Terra and Aqua Satellites are the size of a small bus (NASA Image)

Figure 2. A slightly smaller NOAA satellite (NOAA Image)

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 3). 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.
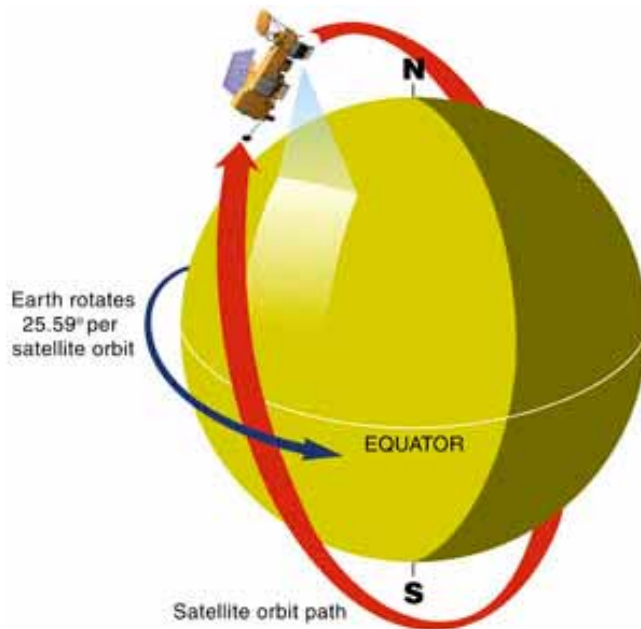

Figure 3. The polar orbits of the satellites used by the NAFI website

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 four satellites that feed the NAFI site – i.e. eight 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. Also the daytime passes of NOAA satellite are not used as their sensors are not well tuned to reliably detecting fires in daylight.

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, the satellite passes are not evenly spaced through the day – during the day hotspot updates tend to be clustered around the two daytime passes of the NASA satellites: in the late morning and the early afternoon. There is a noticeable gap from around 4am to 10am.

Websites:
Terra Satellite: http://terra.nasa.gov
Aqua Satellite: http://aqua.nasa.gov
NOAA Satellites: www.oso.noaa.gov/poes/

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. Two types of sensors are used to detect fires: the NASA satellites use a MODIS or "Moderate Resolution Imaging Spectroradiometer". It is the size of a small fridge and takes 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 3, next page).

The NOAA 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 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 (Formerly the WA Department of Land Information) 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 both the MODIS and AVHRR sensors.

Figure 4. Satellite photo of a scene 45km across, showing a fire just left of centre – with grey smoke streaming to the left
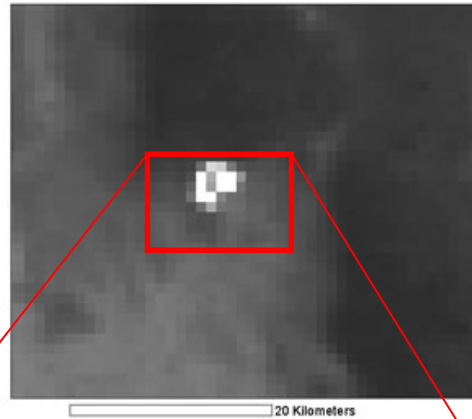
Figure 5. Lower resolution thermal MODIS image showing same fire

Figure 6. 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 1 km. So when you zoom right in on a hotspot on the NAFI site as shown in Figure 6 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. In the meantime we will continue to improve the NAFI site to make the information it does display easier to use.

Who creates the hotpots once the satellite images are received, and what difference does this make?

The NAFI website receives the decoded hotspots from two agencies in Australia – Landgate WA (formerly the Western Australian Department of Land Information) which receives images from both NASA and NOAA satellites from various ground stations such as Perth, Darwin, Hobart and Brisbane – and Geoscience Australia, based in Canberra, which receives hotspots from NASA 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 (Sentinel) 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 are now processing MODIS images from GeoScience Australia's downlink site at Alice Springs and sending the hotspots from these images to the NAFI site – although they are somewhat delayed.

WA Landgate also process night-time passes from NOAA satellites with another algorithm tailored to these passes. Daytime NOAA passes are not processed because of the unreliability of the AVHRR sensor in detecting fires in daylight.

To summarise, the NAFI site receives hotpots from a range of satellites, which have been processed in a range of ways:
- Night-time passes of NOAA satellites sourced from a range of downlink sites across Australia and processed by Landgate

- Day and night time passes from NASA satellites sourced from a range of downlink sites across Australia and processed by Landgate and Geoscience Australia

How long does it take between detection and hotspots appearing on the 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 5)
- 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 3).

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, computer viruses and new security measures that block email traffic 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.

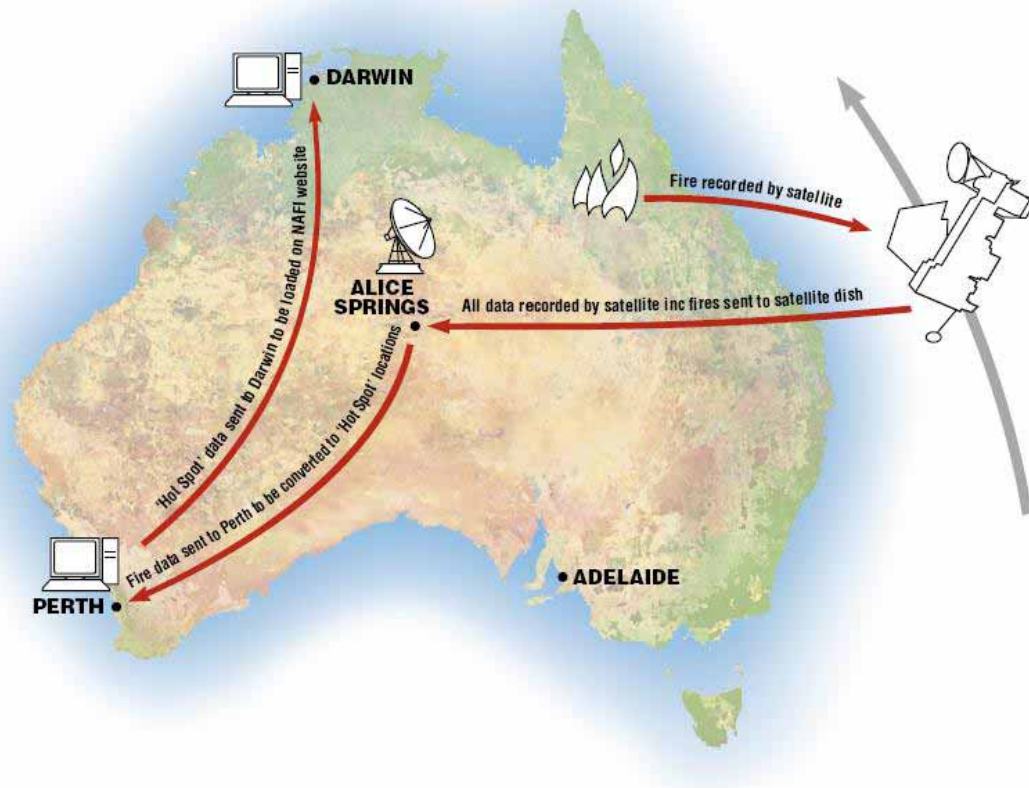Even so, the great majority of spots reach the site on schedule.

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*. Neither the MODIS nor AVHRR fire sensor is very 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 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 3)

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 instrument used on the Terra and Aqua satellites rarely registers heat signals in the landscape as fires when they are actually not fires. The AVHRR instrument on the NOAA satellites, however, can sometimes register things like hot rocks as fires particularly in more southerly latitudes in hotter weather. Occasionally this instrument will also 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. You can see which satellite (and hence which instrument) was used to detect a hotspot by using the "i" tool.

How are fire scars mapped?

Fire scars on the NAFI site are mapped using images from the MODIS instrument carried by NASA's Terra satellite. These images have a resolution of 250m, see http://www.ga.gov.au/acres/prod_ser/modisdata.jsp . Two images with different dates are used to map fire affected areas (fire scars), in the absence of cloud cover (Figs 8a and 8b).
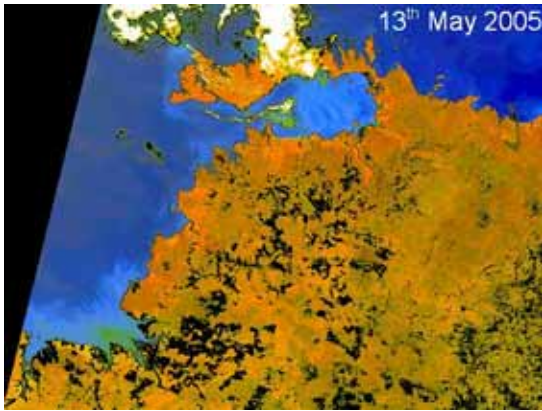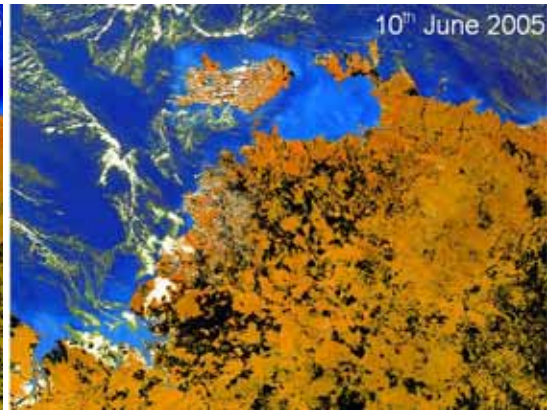
Figure 8a.   Figure 8b.

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.

A remote sensing application from Definiens (see http://www.definiens.com/definiens-professional_11_7_9.html) is used to "segment" the combined MODIS difference image. This means that pixels with similar values and that sit in the same area are clumped together into polygons (Fig 10).
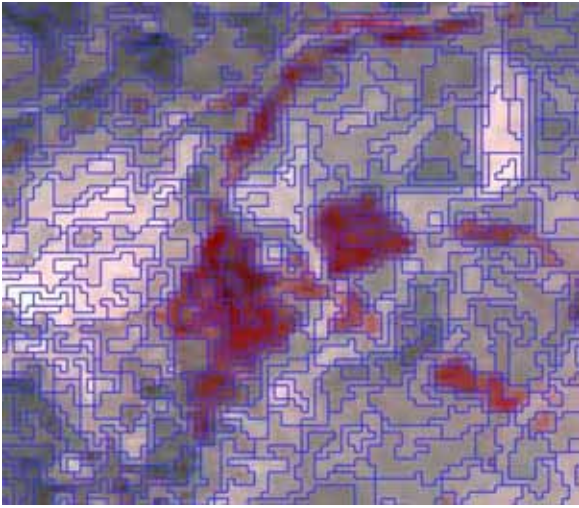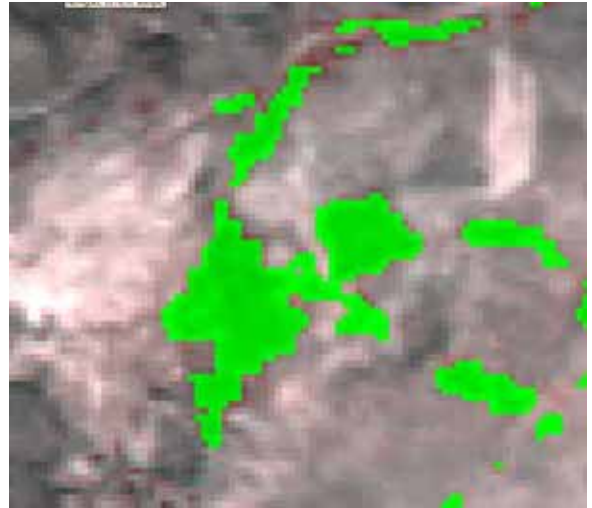
Figure 10.

Figure 11.

The resultant polygons are classified using the Definiens software and manually edited to accurately incorporate all fire affected areas (Fig 11). Note that before 2007 Queensland fire scars were mapped using different software that achieves a similar result.

As each mapping period is completed, the resulting maps are uploaded to the NAFI site as a tiff file which is automatically added to the NAFI map background (Fig 12).
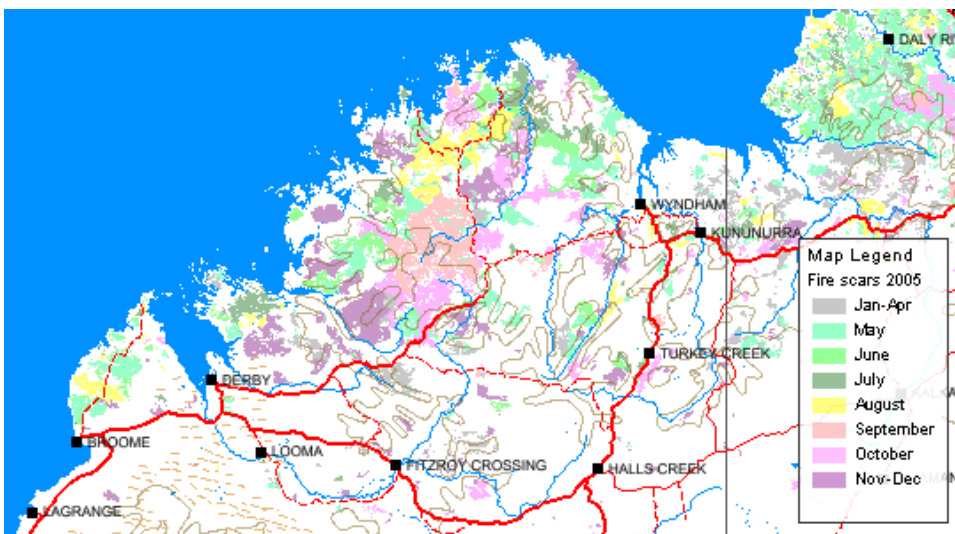

Figure 12.

Land managers across northern Australia 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 by land managers 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.

In 2008 these maps covered the NT and WA down to around 20 degrees S and for all of Queensland outside the populated south east. In 2009 and 2010 the fire scar mapping was extended to cover all of the NT.

How accurately are fire scars mapped?

The mapped fire scars are usually a more comprehensive and accurate record of burning than the record of hotspots. However, these scar maps are not always 100% accurate as wetlands and other dark features can be mistaken for fire damage and cloud cover can make mapping difficult.

The MODIS image on the next page, 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.
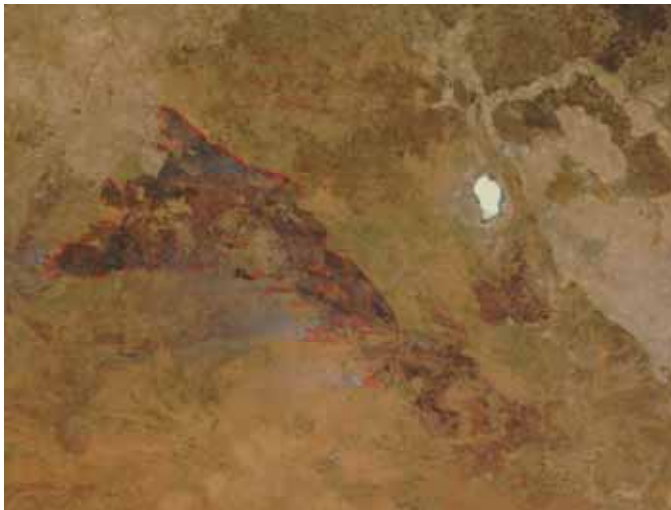

Figure 13.

This fire eventually spread much further and can be seen on the NAFI site as a very large fire scar (below).
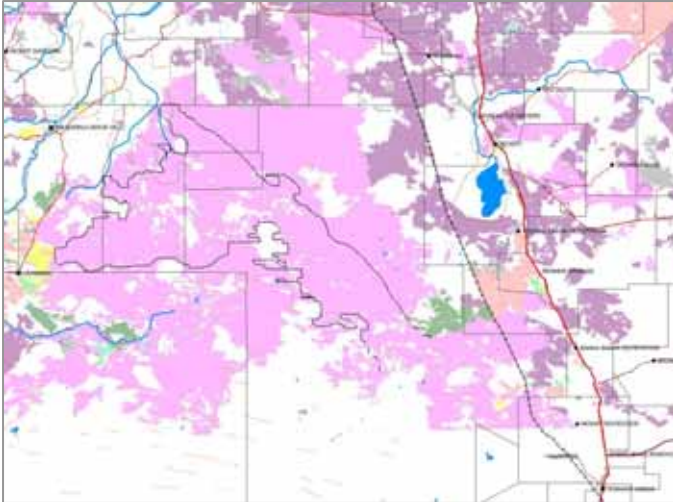
Figure 14.

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 generally 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 change exactly at the end of a month (see *How regularly are fire scars updated and how accurately are they dated*? below).

Before September 2004, fire scars in the Kimberley were mapped by Landgate using a more automated process based on images from the AVHRR instrument on NOAA satellites. This instrument provides lower resolution images, hence these older fire scars appear "blockier" on the WA maps.

How regularly are fire scars updated and how accurately are they dated?

Since 2007 we update fire scars maps for the Kimberley region and the northern NT every week during the fire season. In the Kimberley fire scars are mapped down to about 19 or 20 degrees south latitude and from 2009, fire scar mapping cover all of the NT. Fire scars from Queensland are also mapped by the Cape York Peninsula Sustainable Futures every week if possible and are mapped for all of rural and remote Queensland outside the south-east.

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). The comparison between images is best made when the satellite images are illuminated by the same sun angle – i.e. when their satellite paths follow the same line at the same time of day. For the NASA Terra satellite this occurs every 16 days or so for a given location. So the best way to map fire scars is to wait 16 days between passes over a given area and then compare the images. However a reliable map can also be generated each week for most locations.

Because fire scars are mapped by comparing an image with a past image, the time the fire actually occurred can only be ascribed to some 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.

You can see the two bounding dates for any of the 2005 to 2008 fire scars on the NAFI site by selecting them as the active layer with the layer tool and then using the "i" tool to query a fire scar. To see the dates for 2004 fire scars you will need to have some GIS software and download shape-files from the NAFI site (go to DOWNLOAD DATA → Fire scar data).

What other fire scars are displayed on the NAFI site?

Automated fire scar maps
As well as the manually mapped scars, the NAFI site displays 250m MODIS fire scars that have been automatically generated, sourced from WA Landgate. Only the last 10 days or so of these scars are displayed in a single colour as shown below. These scars are updated every day or two and can provide a more timely update on the progress of a fire – however the automated scars are also subject to more errors that the manually mapped scars, particularly in wetter landscapes and at wetter times of year when moist soils can trigger false mapping of fire scars.
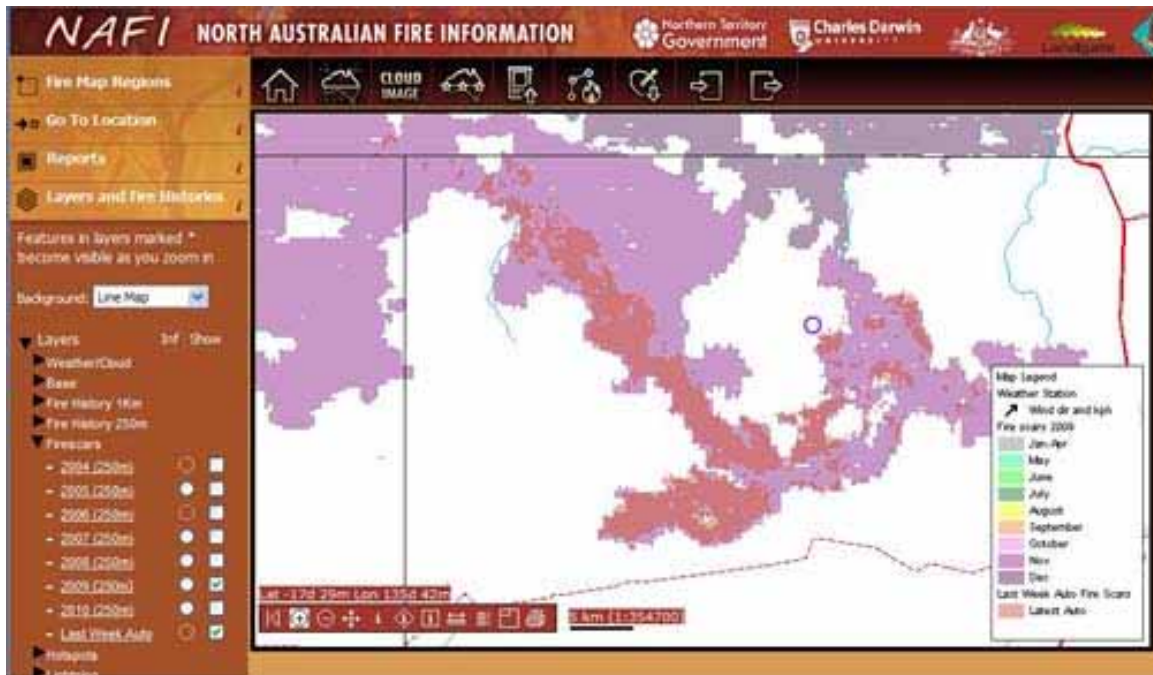
Figure 15. The darker areas show the automated fire scars

Past Year 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 2004 available for display so users can check out the months burnt in past years. All these maps are available under the heading "Firescars" in the Layers and Fire Histories menu.

Last Two Year Fire Scars

One problem with the past year fire scar layers is that they can be confusing if displayed together if you want to build up a picture of multiple years' fire activity to estimate the fuel burnt in an area. So the NAFI site also displays the most recent two past years' fire scars as a transparent striped layer that can be viewed together with the current fire scars (2 Yr Scars) as shown below.
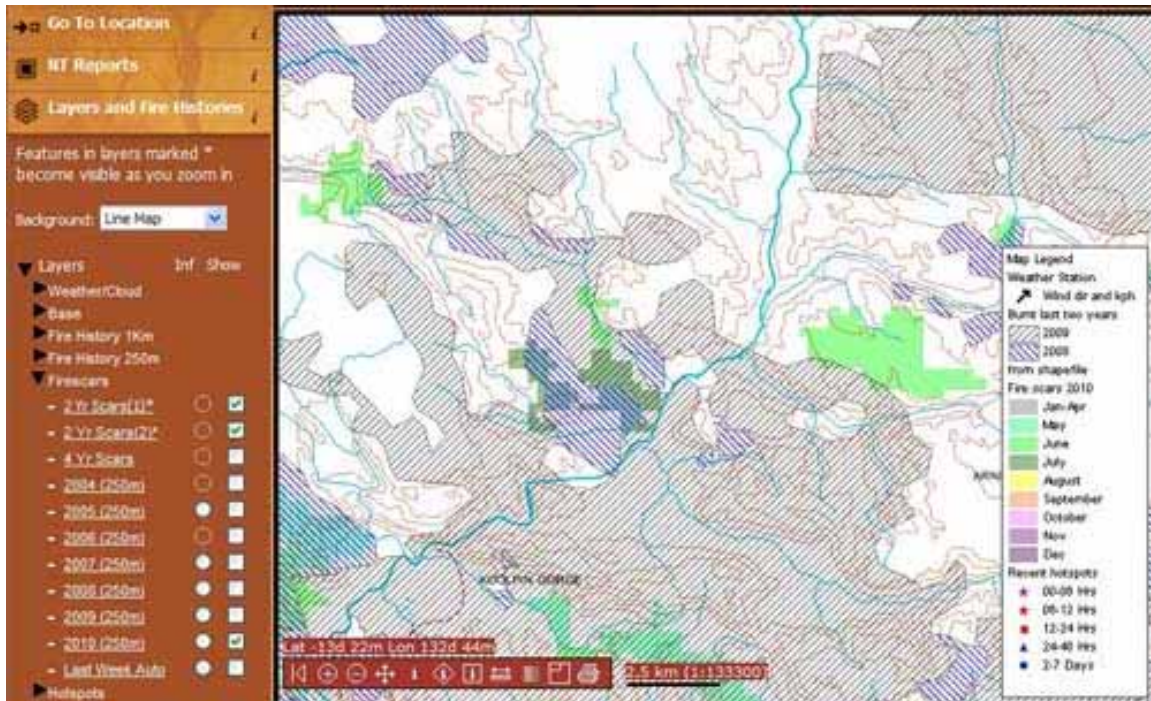
Figure 16. The display of the 2 Yr fire scars with the current fire scars

Note that the display consists of two layers – with a more detailed one that becomes visible as you zoom in. This display is useful for fire managers in the far north who use it to get a better idea of fuel loads.

What fire histories are available?

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 2004-2009 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 produced at two scales:

- 250m scale maps which are based on the MODIS fire scar mapping described above. For all but the most recent years, these maps cover the same extent as the fire scars the NT and WA down to around 20 degrees S and further south in Queensland.
- 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.

These fire histories can also be downloaded from the NAFI site as images, and in some cases as shapefiles.

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

- The cloud image layer is a MODIS satellite image sourced on-demand as a map service from Geoscience Australia. This is the same image that appears on the sentinel site and is at a lower resolution than the 250m resolution MODIS image used to create fire scars. It is displayed with the line map layers on top for easier orientation of image features.

- The weather layer features fire-related weather data such as temperature and windspeed which are sourced from the Bureau of Meteorology website. These data are updated regularly throughout the day.

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

- All Sentinel hotspots – ie all the hotpots as shown on the Geoscience Australia Sentinel website (http://sentinel.ga.gov.au). This layer is also provided on-demand as a map service from Geoscience Australia, so unlike the other hotpots, the NAFI site receives this information as a map image, not as data. The NAFI site already displays MODIS hotspots from the Sentinel website, but this layer also shows NOAA-AVHRR hostpots (which may be different from the NOAA-AVHRR hotspots already on the NAFI site as they are processed with a different algorithm by Sentinel). This layer also shows hotspots from the most recent passes.

- The lightning data is sourced by Landgate in WA from http://webflash.ess.washington.edu/ and forwarded on to us every 24 hours.

What is the "Using Other Viewers" option 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. You can do this by selecting the "Using Other Viewers" option in the left hand menu where you can choose from two options:

- Google Earth – if you have *Google Earth* installed you can go here and to access the NAFI fire data as a .kmz file which can be viewed in *Google Earth* as 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.
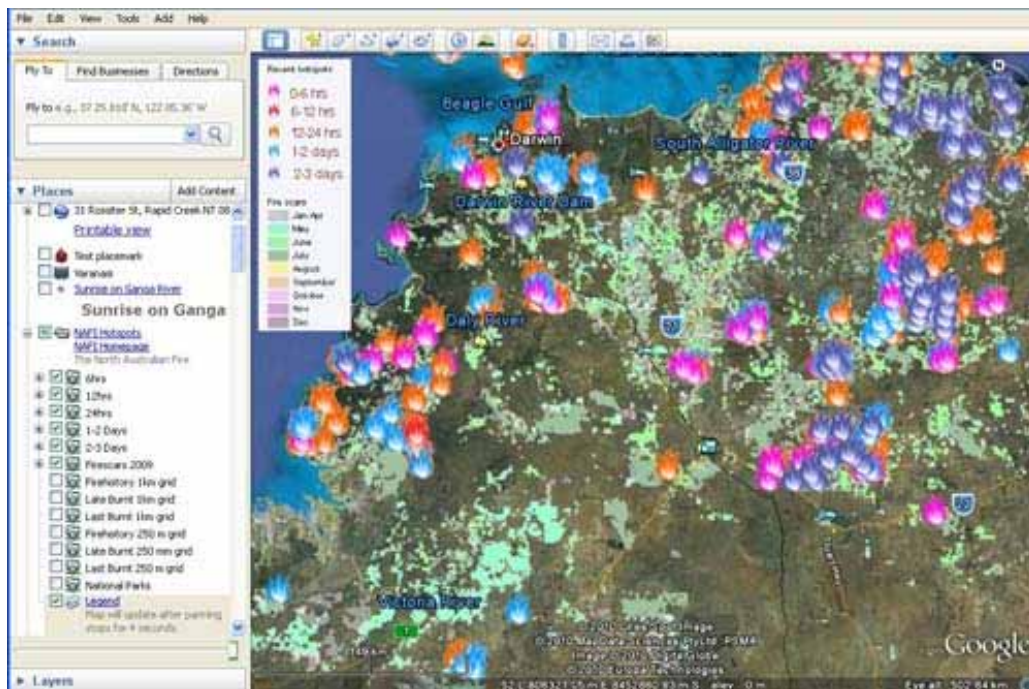

Figure 17. NAFI hostpots and fire scars displayed on Google Earth

- 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, fire scars and some fire histories as a data feed that can be used by ArcGIS and other mapping programs. These are delivered as images so you cannot query them for their attributes – instead you need to rely on the NAFI legend.

What are the NT Reports all about?

A new feature of the website in 2010 is the "NT Reports" available in the menu on the left. To cut down the load on the website, these are only available if you are logged in.

You can log in by clicking on the ⬒ icon in the upper tool bar and then using your email address and giving yourself a password. As the name implies, these reports are only available for NT areas at the moment.

This tool allows you to select an area of interest – either from a drop-down menu of pre-set areas like Parks and Reserves or Indigenous Protected Areas, or by drawing your won boundary on the NAFI maps with the mouse. You can then choose from a range of reports on fire activity:

- Fire history by year - shows how your fire patterns have changed over the last six years
- Fire frequency -shows the frequency of fire over the last six years across your area
- Late Fire frequency - shows the frequency of fire after July 31 over the last six years across your area
- Year last burnt - shows the number of years since parts of your selected area were last burnt

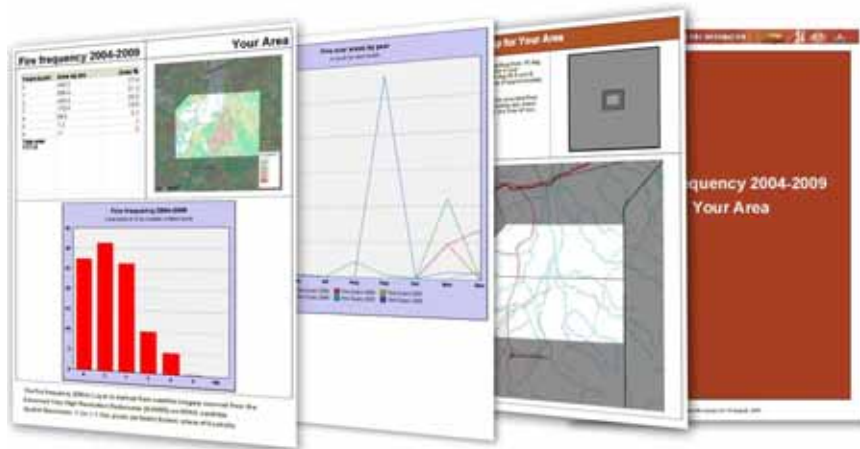These reports are then produced as a pdf as shown below.

Figure 18. Sample pages from the NT Report tool

The graphs and tables in these reports are based on an analysis of the fire scar data displayed on the NAFI website. For more information go to:

http://www.firenorth.org.au/nafi2/help/report_guide.pdf

How can I speed up my map viewing?

The performance of the map viewer is dependent to some extent on the server and database behind the scenes. We do our best to maintain and tune these to provide optimal performance for users. However, there are some aspects of performance that are in your hands. These can make a significant difference to your map viewing if you do not have a fast (broadband) connection to the web.

- Select "Line Map" as the background: the line map images are less than half the size of the scanned map images
- Reduce the size of your browser window: a smaller window means smaller images to download. You can increase the size of the window when you have homed in on an area of interest.
- Navigate the list of contents by clicking on the arrow icons rather than the text. The arrow icons will expand the list without downloading any pages. Click on the text only when you want to view a page or map.

How do I find out more?

If you need more information you can:

- Read the help pages on this site
- Follow the links to related sites
- Get in touch with the contact person for your state (see About NAFI in the tool bar above the map)