Field Trip Report
Queen Victoria Springs and Plumridge Lakes Nature Reserves
7-14 May 2006

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Purpose:

- To observe operational aerial prescribed burning conducted by Goldfields Region.
- To quantify fuels and make weather observations.
- Validate satellite cover indices as a measure of vegetation cover.
- To conduct experimental fires to validate the spinifex fire spread model.
- To make suggestions about fire management for nature conservation in spinifex-dominated vegetation communities in the Great Victoria Desert.

Observations of operational burns

We were unable to access the burn cells on the ground to properly appreciate extent of aero-burning but could observe the smoke plumes, which indicated that some patches burnt reasonably well while others (most?) did not. However, it was encouraging that most of the fires appeared to have extinguished over night, with some exceptions. By the second day after ignition, little or no smoke was evident. My observations are that under the mild conditions (max. temps. 24-25° C, min. o/nite min. temps. 2-5°C, min. RH 24%, max. RH 77%), especially low-wind conditions (4-7 kph @ 2m – calm o/nite), only the oldest/heaviest fuels sustained ignition and even then, fires were probably patchy and relatively small, which is a good result.

These observations are confirmed by the fire model predictions (see below). However, the full picture will be known after interpreting Landsat TM imagery (MODIS too coarse). Burning under mild, low wind conditions in May appears to be a good option for regulating fire size and intensity in older spinifex-dominated fuels.

Fuel Measurements

A disturbing observation was the extent of relatively recent wildfire in the reserves and the Great Victoria Desert generally. Based on satellite imagery and proportions of tracks and roads traversed, I estimated some 85% of the flammable vegetation (spinifex-dominated vegetation) of the reserves has been burned by wildfire in the last 5 years or so. Individual fires, or multiple fires at or about the same time, have resulted in very large and contiguous areas being reduced to the same or similar seral stage. Thus, the scale and frequency of fires has resulted in loss of habitat heterogeneity/diversity. Many fires appear to be high intensity, resulting in significant physical damage to the tree and mallee overstorey and structural simplification of the vegetation. We also 'cleaned' charcoal from a grass tree stem to see whether we could use *X. thorntoni*, which is prevalent throughout the GVD, to reconstruct fire history over the last 200-300 years (Ward *et al.*) – no luck - no 'fire makers' (black bands) were found on the stem; this requires further investigation.

Biomass (fuel weight) and fuel moisture content measurements were made along the fuel structural transects installed by Ryan Butler in QVSNR (Table 1). Additional transects were installed in PLNR. [illegible]lly, spinifex cover varied with time since last fire (to be expected) and the density of the [illegible]eucalypt overstorey. For example, fuel on transects 7 & 8 are about 25 yrs old, but spinifex [illegible]d biomass is low – the cover of mallee is relatively high. In hindsight, we should have [illegible]d the eucalypt overstorey/basal area, because it appears that there is a weak but significant [illegible]relationship between overstorey cover and spinifex/ground cover – possibly competition for [illegible]e or alleleopathy limiting spinifex development under dense malle/eucalypt canopies – a job [illegible] time. This variability of overstorey cover will limit the utility of remote sensing as an effective tool for measuring ground cover, but knowledge of sparse spinifex cover could be used to control fire spread under marginal burning conditions.

It was encouraging to note that the predicted and measured spinifex fuel weights were reasonably similar (Table 1). Predictions were made by Ryan Butler using the formulae of Burrows *et al.* (1996):

FF = 0.25(CV) + 0.04(HT) - 3.2

Where:

FF = fuel factor (a surrogate for fuel quantity)
CV = fuel (spinifex) cover (%)
HT = mean hummock height (cm)

Fuel quantity (FQ) and fuel factor (FF) are related by the equation:

FQ = 0.98(FF) - 0.08

Table 1: Fuel characteristics summary – QVSNR fuel transects. Spread Index (SI) calculated using mean wind speed @ 2m above ground (1400 hrs 9 May 2006) = 7.3 km/hr. If SI<0, then sustained fire spread is unlikely.

Fuel sample line transects	Estimated fuel age - yrs (tree ring counts)	[1]Mean fuel wt measured (t/ha)	Mean fuel wt predicted (t/ha)	Mean spinifex cover (%)	Mean spinifex ht (cm)	Mean spinifex patch size (m)	Mean bare patch size (m)	[2]Patch size ratio (fuel:bare)	[3]Profile moisture content (%)	Fire Spread Index (SI)
1&2	? not sampled	3.4	3.2	15.8	24.5	0.57	1.65	0.34	24.3	**-10.2** (fire will not spread)
3&4	3-4	5.0	4.5	13.9	25.5	0.73	1.09	0.67	26.5	**-9.5** (fire will not spread)
5&6	40-45	8.4	8.9	31.7	32.5	0.93	1.76	0.53	15.4	**-1.6** (fire unlikely to spread)
7&8	24-26	4.6	6.05	18.4	41.3	1.67	3.24	0.51	14.3	**-4.9** (fire will not spread)

[1] Oven dry weight
[2] The lower the ratio, the less continuous the spinifex/surface fuel cover.
[3] Cross section through a spinifex clump - % oven dry wt.

Experimental Fire - Plumridge Lakes NR:

Date: 11 May 2006
Time: 10:40 – 11:40 hrs
Ignition: Single Point Ignition

Weather
Temp. 24.3-25.2 °C
RH: 27.7-25.7 %
Wind: Mean ENE @ 6.1 kph @ 2 m above ground, gusts to 11 kph. (i.e. wind light and variable)

Fuels

- Mature spinifex and mallee approx. 40-45 yrs old based on ring counting of mallee and mulga stems.

- Mean spinifex Profile Moisture Content: 15.6%
- Mean fuel dry weight: measured = 8.1 t/ha; predicted fuel wt = 9.4 t/ha
- Mean fuel (ground) cover 34.4%
- Mean height spinifex: 25.3 cm
- Mean fuel patch size: 1.39m
- Mean bare patch size: 1.87m
- Fuel ratio (fuel patch:bare patch): 0.743

Predicted Fire Behaviour

Fire Spread Index (SI): $\mathbf{SI_{FQ} = 0.57(Wind) + 0.96(Fuel\ wt) - 0.42(PMC) - 7.42}$

$$\mathbf{SI_{FQ} = 0.57(6.1) + 0.96(8.1) - 0.42(15.6) - 7.42 = -2.73}$$

An SI of -2.73 suggests a very low likelihood of sustained fire spread (see Table 2). The model suggests wind speed needs to be > 10 kph for sustained spread under these conditions.

Table 2: The likelihood of sustained fire spread (spread index - SI) determined from Equations and potential rates of spread.

SI	Likelihood of fire spread and potential ROS (m h^{-1})
SI < -2	Very low - fire highly unlikely to spread (ROS = 0)
-2 < SI < 0	Low – fire could spread (ROS < 500)
0 < SI < 2	Moderate – fire will spread (ROS: 500 –1,000)
2 < SI < 4	High – fire will spread (ROS: 1000 – 2,000 m/hr)
4 < SI < 6	Very High – fire will spread (ROS: 2,000 – 3,000 m/hr)
6 < SI < 10	Extreme – fire will spread (ROS: 3,000 – 4,000 m/hr)
SI > 10	Very Extreme – fire will spread (ROS > 4,000 m/hr)

Observed Fire Behaviour

- Rate of spread:
  - Mean: 102 m/hr but not sustained
  - Range: 90-120 m/hr
- Spread not maintained after 54 minutes of burning. Stopped by broken/separated fuels, wind speed too low.
  - Fire shape: Approx. 92 m long x 25 m wide at widest point.
  - Perimeter burning: No backfire, ~15% of flank burning (occasional clumps), headfire fragmented.
- Flame heights: mostly 1.5-2.5m, flaring to 4m.
- Occasional spotting from mallees (bark) to 10 m.

Comments:

Because of the low and variable wind speeds, conditions for sustained fire spread in this fuel complex were marginal. The fire maintained spread for almost 1 hour before self-extinguishing. Although the model predicted a low probability of fire spread, it burnt for longer than I expected for these wind conditions. This may have been due to the significant proportion of dry leaf litter beneath the mallees and occasional spotting, which assisted with fire spread. Due to the consistency of weather conditions during the field trip, especially the light and variable winds, we decided not to conduct further experimental burns. There was also a dearth of 'mature' spinifex to burn (that was accessible from the tracks).

While I was unable to observe conditions of fuel and fire behaviour during the recent aerial burns (cells inaccessible), it was evident from the smoke plumes that some parts of both the PLNR and the

QVSNR burnt quite well, whereas other parts did not. I suggest that the older, heavy, more continuous vegetation/fuels burnt under these mild conditions. Based on the visibility of the plumes, most fires appeared to burn out on the first night after ignition, although some patches continued to burn into the following day. Landsat TM imagery will reveal the full extent of the burning.

Concluding observations & suggestions

Burning under mild weather (especially low wind) conditions in May has the advantage that only the heavier, more contiguous fuels are likely to burn, and even then, the burns will probably be relatively small, patchy and low intensity based on the plumes (perhaps several hundred ha). This is a good result – to be confirmed by Landsat imagery. Burning in spring (around September) when conditions are warmer, and winds are usually a stronger (the windiest month), should result in more of the landscape burning. Because so much of the reserves and the surrounding UCL has been burned by wildfire over the last 3-6 years, there is little chance of major fire escapes from prescribed burning in spring. On the other hand, because there appears to be so little mature/late seral stage vegetation left, we need to show some restraint in targeting these fuels.

Currently, the diversity of seral stages is low and the grain size coarse – some 85% of the flammable vegetation in both reserves (and most of the western portion of the GVD) being in the early seral (post-fire stage). In the absence of definitive knowledge of the best mix of seral stages, or of 'functional habitats' for biodiversity, we should aim for a negative exponential distribution of age classes – this is a fire-stable distribution and is the theoretical distribution likely to result from random ignitions in fire-prone environments (see the considerable literature on this). The literature provides techniques for paramatising the negative exponential distribution based on plant vital attributes such as juvenile periods and longevity. An example for a spinifex community is shown in Figure 1 below.

This model suggests that we should aim to have about 30% of the landscape in the early post-fire stage (<=6 yrs), about 35% in the intermediate post-fire seral stage (7-18 yrs) and about 35% in the late post-fire seral stage (19-45 years). Research into traditional Aboriginal burning in the Great Sandy Desert (Burrows and Christensen 1994) offers some support for this in that it showed that about 22-25% of the landscape was recently burnt (last 5-6 years). The spatial distribution of these seral stages should be as diverse as we can manage, with patch sizes mostly in the order of hundreds of hectares, but ranging up to several thousand ha. on occasion. This contrasts with the current situation in the reserves (and elsewhere) where burn patch sizes, or contiguous patches of the same or similar seral stage, whether created by one or more ignitions, are in the order of tens of thousands of ha.

Constructing the distribution of seral stages (proportion of area in each stage/time since last fire) and determining patch mosaics (mean, median) burnt patch size from Landsat imagery is necessary so that we can monitor and report on the consequences/outcomes of proactively managing fire in these environments. This measure of fire-induced habitat diversity will be a surrogate for biodiversity. Taking an adaptive management approach, and if resources permit, it would be most worthwhile re-activating Dr David Pearson's study site, and perhaps establishing replicates/reference sites in other representative areas, including areas where we do not manage fire (see below), to directly monitor biodiversity response to proactive fire management.

An important issue, and it underlines the instability of the current vegetation/fuel age distribution, is that most of the reserve(s) will not currently carry fire because vegetation is too immature (as a fuel), but in the next 5-7 years or so, the situation will reverse such that all of these areas (most of the reserve) will again be available to burn.

Rather than targeting the remaining (few?) patches of long unburnt vegetation, which appears to be in short supply (unless there are some very large tracts that I am unaware of), I suggest annual/biennial? flights over the younger areas in May and September in an attempt to break up the vegetation before it reaches a point of being able to sustain large summer conflagrations; the inevitable cycle if we are not proactive.

Being proactive will move the landscape towards a more desirable seral stage structure as shown in Figure 1, reducing the incidence of large, severe wildfires. Because of the nature of the younger fuels, burning will need to be carried out under windier conditions (minimum 15-20 km/hr @ 2m) to have the desired result – this will mean avoiding older fuels, which will burn too fiercely under these conditions.

In the interests of adaptive management, it would be worthwhile and informative to identify a reasonably large tract of land (say 200,000 ha) between the QVSNR and the PLNR and NOT introducing fire to this tract – allow the unplanned fires to dictate the fire regime and the fire mosaic. Then contrast and compare this with a similar tract(s) of land where we DO introduce fire, as suggested above. Monitor both sites via satellite imagery (Landsat TM –although more expensive, it is much higher resolution (30m) than MODIS (1 km)). This should be best done as an operational adaptive management project in collaboration with Science Division and IMB through Graeme Behn (remote sensing).

I am of the view that it is important to 'baseline' the current fire regime condition of all of the major spinifex-dominated (desert) nature reserves – QVSNR, PLNR, Neale Junction NR, Yeo Lake NR, Great Victoria Desert NR and Gibson Desert NR using Landsat TM imagery with assistance from the above team and setting up a fire history database.