Fire and TEK Burning Trial

Preliminary Results

Using Fire as a Tool for Managing Native Grasses:

An Indigenous Perspective

Wodonga region, North East Victoria

Project partnership between:

North East Catchment Management Authority and Kiewa Catchment Landcare Groups

DRAFT V 2.0

January 2015

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This report has been developed with the involvement and cooperation of a range of stakeholders, but individual stakeholders have not necessarily committed to undertaking specific actions. The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification due to changes in knowledge.

Citation:

Foreman, P.W. (2015). Fire and TEK Burning Trial; Preliminary Results. Using Fire as a Tool for Managing Native Grasses: An Indigenous Perspective; Wodonga region, North East Victoria. Report prepared by Blue Devil Consulting for North East Catchment Management Authority and Kiewa Catchment Landcare Groups, Wodonga.

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Foreword

'Using Fire as a Tool for Managing Native Grasses: An Indigenous Perspective' is a project partnership between the North East Catchment Management Authority (CMA) and Kiewa Catchment Landcare Groups. Funding was obtained (commencing in the 2013/14 FY) under the Caring for our Country (CfOC) Sustainable Environment and Sustainable Agriculture stream.

The project will examine the use of fire as a management tool and how it could be applied to achieving sustainable native pasture management in North East Victoria in partnership with Traditional Owners (TOs) to help incorporate an understanding of the traditional uses of fire (a form of Traditional Ecological Knowledge or TEK).

The project is structured around:

1. An initial forum (held in Albury in November 2013);
2. Demonstration trial plots/sites; and
3. Two associated field days.

The outcomes (of the demonstration trial plots) will be measured using indicators of both biodiversity and productivity.

It is intended that those who participate in the project will gain an:

- Increased awareness of the value and benefits of native pastures and how management practices can either degrade or enhance native pastures;
- Increased understanding of how fire can be used to manage native pastures;
- Increased capacity and skills to sustainably manage native pastures; and
- Increased appreciation of and respect for Indigenous TEK.

The demonstration trial plots and assessment results will also provide important initial data on the use of fire in temperate zones, and could act as a catalyst for further trials and research. And finally, it is hoped, the project will have a longer term impact in terms of improved grassland and grassy woodland management through the use of fire–based TEK.

Summary

This project is a CfOC funded collaboration between the NE CMA, Kiewa Catchment Landcare Groups and Traditional Owners (TOs), examining the traditional use of fire (a form Traditional Ecological Knowledge or TEK) for improving sustainable native pasture management in North East Victoria. Via an initial forum, demonstration trials and field days, it is hoped participants will improve their awareness and understanding of, and skills and capacity in how to use TEK–based burning to improve native pastures in terms of biodiversity and pastoral values. In particular it is hoped the demonstration trial will help catalyse further investigation into the use of fire for improving temperate native pastures and grassy ecosystems.

Preliminary investigations show there is a sound basis for pursuing collaborations between TOs, pastoralists and scientists that combine science with TEK in order to create new knowledge around using fire to achieve productivity and biodiversity outcomes in these ecosystems. While drawing on the experience of TOs in Cape York will be useful in attempting to revive traditional burning in south–east Australia, caution is advised to acknowledge ecological differences between tropical vs. temperate ecosystems, as well as the much higher level of landscape change and dispossession in Victoria.

Although further research is needed, it is assumed traditional use of fire involved cool season burns – patchy at an intermediate scale as limited by natural barriers – aimed to stimulate fresh plant growth including staple foods, attract macropods for hunting and reduce potentially destructive, hot summer fires.

Based on what we know about the native pasture management and the ecology and function of these ecosystems, there is great scope to use TEK–based burning (in combination with other tools like grazing management, fertilisers, weed control, managing total grazing pressure, and soil and pasture monitoring) to boost both biodiversity values and pasture productivity by increasing the abundance and function of native species, but especially promoting a diversity of native grasses, at the expense of annual exotics.

Three freehold sites were selected for the demonstration trial in the Wodonga and Talgarno regions of North East Victoria. The properties where representative of the native pastures and modified grassy woodlands typical of farms on the lower slopes of the region – with a range of native diversity and composition and a long history of grazing and fertiliser application. Enough indigenous elements remain at these sites – but especially native grasses – to expect all would benefit from the careful use of TEK–based burning under existing land uses, including rotational grazing.

One of the more effectively burnt sections (but still inadequate) of Doyle's Kangaroo Grass dominated grassy woodland near Wodonga (Photo: May 2014).

Lush Weeping Grass regrowth in an area previously dominated by annual exotic grasses following a 'hot' fuel reduction surrounding the Doyle's hill top home near Wodonga (Photo: May 2014).

A total of 30, 20x20m plots laid out in transects or grids, comprising: three replicates of four treatments (unburnt/ungrazed, unburnt/grazed, burnt/grazed, and burnt/ungrazed) at two sites; and two treatments (unburnt/ungrazed and burnt/ungrazed) at the remaining site, were established in January 2014.

Given project objectives and constraints, the trial design represented a trade–off between the technical rigour typically associated with research experiments (i.e. level of replication and precise measurement methods etc.) and the need to meaningfully engage with the needs and expectations of key partners.

Burning was applied in the cool season as soon as possible following the Autumn break; grazing was applied as per rotational systems typical of regional farms; and data was collected on vegetation composition and structure, soil characteristics, and pasture values at various times throughout the year.

The burning attempted in May 2014 proved to be unsuccessful at the two pastoral sites (Hayes and Sinclair's) and of limited success but inadequate at the other site – Doyle's, managed as a conservation area – due to operational delays following an unexpectedly early autumn break. The burn at Doyle's was considered inadequate because it was not 'hot' enough to consume a significant coverage and depth of litter/fuel and standing foliage, due to high moisture levels on the day. However, despite this, the initial results for Doyle's showed some evidence of the potential benefits of burning expected under this trial – namely (non–significant) trends towards increased native species diversity and a reduction in the richness and abundance of mostly annual grassy weeds.

Especially for the two pastoral sites (Hayes and Sinclair's), which were 'under grazed' in 2014, the results here can be effectively considered a baseline assessment against which properly implemented grazing and burning treatments in 2015 can be compared. In this context, preliminary analysis showed the potential lack of replication and the coarseness of the %Cover estimation method – both recognised project risks that would be most readily improved by increasing the level of replication and/or changes to the %Cover estimation method. Any significant increase in the level of replication or any shift to measuring %Cover using more precise but time–consuming methods, is considered unfeasible.

The feed test results showed the two pastoral sites at the lower end of pastoral value – adequate to maintain dry stock – and the conservation site, a step lower due to the complete absence of either grazing or burning. And as expected at Doyle's, burning served to boost pastoral metrics such as digestibility, metabolisable energy and crude protein by stimulating new growth leaves that were notably less coarse (than unburnt grass) and more typical of grazed pasture. It is speculated other pastoral value differences between sites (especially the two pastoral sites) could be accounted for by differences in fertiliser (superphosphate) application, with the highest rates likely applied at Hayes where there were more acid soils.

Having established a good baseline through 2014, it is critical to the success of this project that grazing and burning is adequately implemented as soon as possible in 2015. There should be no delay in delivering the burns as soon as possible after any obvious autumn break, and in the event of a dry autumn, the burn should be undertaken prior to June when it is safe to do so. Grazing should be commenced as conditions allow following the implementation of burning, and if grazing is required before this, stocking levels should remain low over summer and/or autumn to ensure adequate dry fuel remains to carry the planned autumn burn.

Background and Preliminary Conceptual Framework

Traditional burning practices

The traditional (pre–colonisation) use of fire and its impact on the environment has been widely discussed and debated for some time. Early explorers, pioneering pastoralists and, more recently, ecologists and historians have all recounted and interpreted the use of fire by Aborigines and its impact on the landscape.

Some examples include:

- Major Thomas Mitchell's conclusion that "*Fire is necessary to burn the grass, and form those open forests*";
- Edward Curr's often quoted assertion that "*almost every part of New Holland was swept over by fierce fire, on average, once every five years*";
- Tim Flannery, recounting Professor Rhys Jones' vision (from the latter's paper 'Fire–stick Farming') of "*Aborigines… farming the land, albeit through the use of fire*"; and, most recently
- Historian Bill Gammage, perhaps going a step further and using evidence principally from early colonial art work, testimony and journals, and other historical sources to argue that, Aborigines were responsible for a complex system of land management using fire that reshaped the landscape towards greater service of their needs.

While there is much ongoing debate about the nature, extent and impact of traditional burning practices (especially as it likely varied across the continent's diverse biogeography; plus the relative impact of 'natural' fires – more widespread from about 10 MY due to climate driven aridity (Hill 1994)), there is more–or–less consensus that fire was socially and ecologically very important pre–colonisation. The question more appears to be around whether Aborigines manipulated the natural burning patterns or significantly appropriated them, and changed and extended the impact of fire over large areas causing widespread transformative change in relatively recent geological time? Clearly addressing this question is beyond the scope of this project, but it provides useful context for considering incorporation of TEK–based burning into this project.

One way of approaching this question is to look to more intact regions – such as the Cape York northern tropical savannahs where traditional burning is still practised – as a kind of template for attempting a 'reconstruction' or 're–assembly' of Barraja region traditional burning practices in North East Victoria. The Cape York experience would help show what traditional burning looks like and how it is integrated with cultural and social practices and systems, including how it is practised. However, some caution is required when translating the northern experience to the south–east: firstly there are differences in the ecology of temperate vs. tropical ecosystems; secondly, the level of landscape change and fragmentation is much greater in the south–east; and thirdly, the likely very different traditional customs and practices in the south–east, ceased following widespread dispossession shortly after colonisation.

Conceptually, it is important any reconstruction aims for a proper synergistic partnership between TEK and science whereby 'new knowledge' emerges. The following excerpt from Sacred Ecology (Berkes 2012) explains this well:

> "*Scholars have wasted…. too much time and effort on a science vs. traditional knowledge debate; we should reframe it instead as a science and traditional knowledge dialogue and partnership. Here we are not referring to somehow synthesizing science and traditional knowledge, but rather the generation of* ***new knowledge*** *through the synergy of combining what is already known to science and to local and traditional knowledge*." (my highlight)

In fact, it could be argued this project aims to go further: envisaging a tripartite partnership between TOs (and TEK), science and private land holders. Either way the same synergistic pathway to *new knowledge* applies and is necessarily a long–term and on–going process.

Quite rightly the emphasis of this project is on establishing this process by initiating collaborations that: improve awareness, understanding and appreciation; builds capacity and skills; and catalyses ecological research. While as far as possible the demonstration trial should be robustly designed, it is entirely consistent with project objectives to trade–off some of the technical rigour typical of scientific research to embrace and incorporate the important pragmatic conventions of pastoralists and the perspective of the local Barraja (and Cape York) TOs.

In this context, planning for the demonstration trial has been based on the following preliminary assumptions and broad understandings of the traditional use of fire:

1. The often cited (traditional use of fire) objective to stimulate fresh plant growth including staple foods and encourage 'fresh' grass growth to attract wildlife for hunting would mean burning in the cooler seasons – typically from late autumn to early spring – whereby useful plants would be encouraged and potentially destructive 'hot' fires would be avoided (amongst other things). Happily this period is coincident with the non–fire danger period when there are fewer statutory restrictions on the use of fire. This approach is also consistent with the recent shift in the northern tropical savannahs back to 'cooler' burns earlier in the season – often immediately following the wet – based on traditional practices (Baker 1993);
2. As stated, above, burning encouraged macropods for hunting purposes – both kangaroos and many medium–weight–range species that are now locally/absolutely extinct – which would have exerted a significant impact on ecosystems. Today even kangaroo grazing pressure is often absent or low, and despite the differences, stock could be seen here as an effective 'replacement' for macropods and managed accordingly – in particular, rotational grazing regimes and relatively low stocking rates, both likely indicative of occasionally burnt areas in pre–colonisation landscapes; and
3. It is likely cool season burning would have created significant burnt patch areas, but limited by local natural barriers such as rock outcrops, bare areas, animal tracks, springs, creeks and 'green' riparian zones, and of course other recently burnt patches (amongst other things). In attempting to mimic this pattern today, burning should be conducted over a significant proportion of paddocks (or indeed whole paddocks depending on the terrain) rather than highly structured, small–scale plots typical of scientific research. For example, say up to hectares or tens of hectares in multiple patches across single paddocks. While natural fire barriers should be exploited today as far as possible for this purpose, it may be more practical to use existing or new tracks, roads and other fire breaks.

Note: it is likely additional points will emerge with further investigation and consultation, and aspects of those above may need further research.

Native Pastures

Native pastures are a natural feature across the south–east Australian temperate pastoral region, but especially the inland slopes, that can offer pastoralists a range of benefits. However the pro's and con's of native pastures must be well understood and practised if these benefits are to be realised. Improved awareness, skills and capacity is needed to ensure native pastures are not degraded, but sustainably managed and enhanced – including through the use of fire and TEK.

A summary of the benefits of native grasses and pastures include (DEPI 2011):

- Native grasses are mostly naturally adapted perennials able to persist well in the Australian environment under a wide range of extreme conditions such as drought, flood, fire, heavy rain, frost and snow;
- They are also tolerant of low fertility, acid soils, water stress and are more resistant to disease;
- Many widespread native grasses (such as Wallaby Grasses, Red Leg Grass, Weeping Grass and Kangaroo Grass) have similar nutritional characteristics to introduced species;
- The mix of both warm and cool season species in many native pastures provides the potential for year–round green feed; and
- Their structural and growth characteristics also serve to maintain soil stability – reducing soil erosion and nutrient loss – and boost productivity through increased soil moisture use.

It should be noted that one of the often cited limitations of native grasses – that wild species have diverse genetic traits resulting in less predictable and commercial characteristics (DEPI 2011) – is the product of their long evolutionary history in Australia's unique environment; and the very basis of the numerous benefits listed above. And furthermore, because native pastures represent the residual elements of formerly extensive and highly productive grassy ecosystems, they retain greater biodiversity values and, importantly, the potential for ready enhancement under appropriate management.

However, under conditions where improved pasture species perform adequately, the agronomic and environmental benefits of native grasses have been underrated (DEPI 2011). They are typically viewed through the prism of 'low input' pastures; residual on less productive and more challenging terrain that is often less well managed. Part of the objective of this demonstration trial is to show how these extensive and often dominant areas might be better managed to serve both productivity and biodiversity ends using tools such as grazing management (including rotational and deferred grazing), fertiliser application, weed control, managing total grazing pressure, soil and pasture monitoring, and the use of fire and TEK.

It is assumed productivity will be boosted by an increase in the abundance of perennials (natives) and increased feed value of the pasture as measured by metrics like: digestibility, crude protein, detergent fibre and metabolisable energy (Appendix 7).

"*Digestibility is a measure of the proportion of a grass that can be utilised by an animal, and is strongly influenced by the plants stage of growth. Grasses that are green, leafy and actively growing will have a higher digestibility than those that are in head or have hayed off.*" (www.dpi.nsw.gov.au)

Demonstration trial aims

Typically long term deferred grazing is needed to raise the abundance of native grasses as well as allowing natural regeneration of shrubs and trees for shelter and other biodiversity benefits. The demonstration trial aims to show that TEK–based burning can be used to encourage native grasses at the expense of exotic annuals, and improve both productivity and biodiversity values in the context of routine rotational grazing, especially where native grass cover is relatively low.

Currently fire is rarely used in the region, with grazing – based on 'traditional' post–colonisation farm practices – dominating the landscape, including in conservation reserves. A managed change in stock grazing practices towards lower stocking rates and rotational regimes, and replacement with burning as appropriate, could result in significant environmental improvements. The significant challenge, however, is demonstrating the benefits without raising people's concerns about fire risk, and compromising farm productivity. To this end, a well–structured demonstration trial would be extremely useful in building the case for change.

In order for the demonstration trial to provide important initial data on the use of fire–based TEK for: sustainably managing and enhancing native pastures; and/or improving the biodiversity values of remnant grasslands and grassy woodlands, it will be designed/structured around the following key questions:

- Does TEK–based burning of rotationally grazed native pastures and/or native grassland/grassy woodland improve condition (biodiversity values) and productivity (i.e. native grass diversity and abundance, plus forage quality value); and
- Does the timing of the burn and grazing affect the response?

It is assumed increasing the diversity and abundance of native grass species, will result in increased:

1. Biodiversity values (e.g. species diversity and structural complexity – especially increased forbs and shrubs);
2. Pasture resilience (buffering against drought, preventing soil loss especially from summer storms); and
3. Grazing flexibility, extending productive growing seasons in response to summer rain.

And the key mechanism for these improvements would be reduced weed competition, and the creation of space for native species regeneration and recruitment from a soil seed bank – possibly stimulated by fire – and/or wind and bird dispersal processes; and fire stimulating a short term spike in grass growth rates, flowering and seed production.

With early burning it is expected some exotic seed would be destroyed and that which survives would more–or–less immediately germinate with growth slower in the cooler conditions. Under cool season rotational grazing, the exotic cohort would be preferentially grazed possibly resulting in a greater reduction in exotic abundance compared to control.

With the late season burning it is expected some flowering/early seeding annual exotics and part of the soil seed bank would be destroyed by the heat and there would be little subsequent germination because of increasing temperatures. Under later season (spring) grazing the native grasses would be preferentially grazed possibly reducing germination and recruitment compared to control.

Methods

Experimental design elements and assumptions

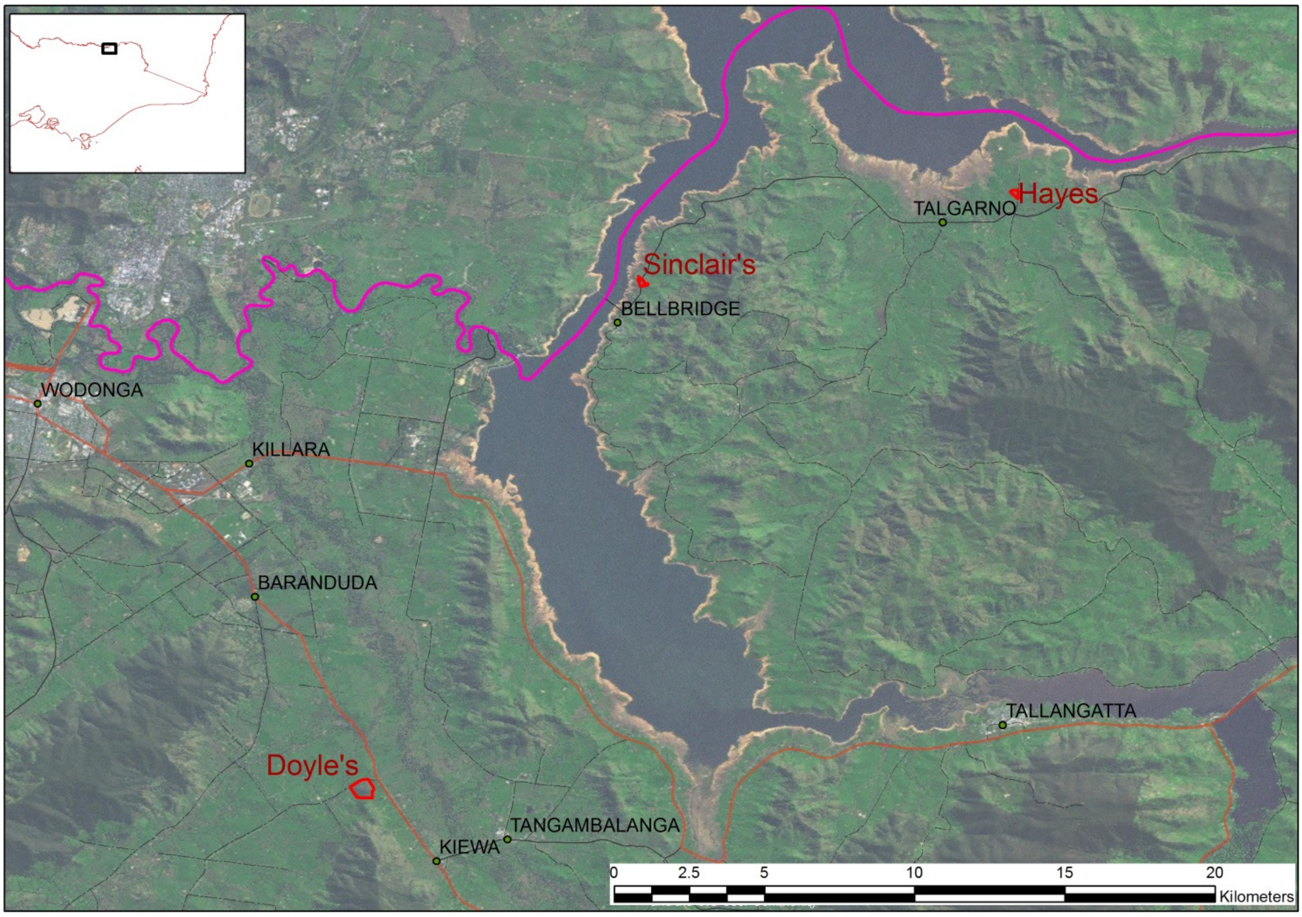
Three trial sites where short listed from a range of candidate private properties supporting remnant disclimax (i.e. modified) grassy woodland located in and around the Talgarno and Wodonga regions, North East Victoria. These were properties owned and managed by:

- Rhonda Sinclair, Murray River Road, Bellbridge (Sinclair's Farm);
- Grey Hayes, Hores Road, Talgarno (Hayes Farm); and
- Bridget Doyle, Kiewa – Lindsey Road, Kiewa (Doyle's Conservation Area).

All three sites were located on exposed, sloping terrain ~210 m ASL on the widespread Omeo Metamorphic Complex uplands, with the Sinclair and Hayes properties entirely cleared of trees and currently part of commercial pastoral farms, and the Doyle property a destocked conservation block with a high cover of remnant eucalypts such as Blakely's Red Gum. The sites represent a range in the richness and abundance of native grasses and forbs, and exotic species.

All sites have: a long history of cattle and/or sheep grazing; variable superphosphate application history; not been recently sown to exotic perennial pastures such as Phalaris or Cocksfoot; and not been burnt or very infrequently. There is also little grazing pressure from either macropods or rabbits at all sites, both of which are actively controlled or excluded by the landholders. And there is no control for serious invasive environmental weeds such as Sweet Vernal Grass, Fog Grass, Phalaris or Cocksfoot.

Figure 1: *Location of trial sites in the Wodonga and Talgarno region, North East Victoria.*



In total, 30 plots comprising four treatments vs. three replicates were established at the three sites: Sinclair's (12 plots); Hayes (12 plots) and Doyle's (6 plots) (Figure 2). The burning comprised an early season treatment (from late autumn to early winter depending on conditions – April to June) and the grazing comprised a typical rotational system based on cattle (Hayes) and sheep (Sinclair's) stocking rates, with resting over spring to early summer, depending on conditions. The 'ungrazed' treatments where achieved with stock exclusion fencing (ring lock or electric wires) in grazed paddocks. The plots were laid out in transects or grids over similar patch types to allow ready treatment implementation, access and reassessment (Appendices 1–3).

Grazing was not applied at Doyle's because this site is being managed as a conservation area. Grazing levels were maintained low at Sinclair's and Hayes in 2014 to retain adequate litter/fuel to allow burning proposed for 2015. Due to seasonal conditions, cool–season burning was not possible at Sinclair's and Hayes in 2014, and burning was inadequate at Doyle's (Figure 2).

Figure 2: *Treatment and replication allocation across the three trial sites. * = Burning treatment not applied in 2014; # = burning treatment inadequate in 2014; and @ = 'under grazed' in 2014.*

Site	*(1) Control; unburnt/ungrazed*	*(2) Burnt/ Ungrazed*	*(3) Burnt/ @grazed*	*(4) Status–quo: unburnt/@grazed*	*Total*
Sinclair's, Bellbridge	3	*3	*3	3	12
Hayes, Talgarno	3	*3	*3	3	12
Doyle's, Kiewa	3	#3	–	–	6
Total	**9**	**9**	**6**	**6**	**30**

For logistic reasons burning was not possible until May 4, 2014 – well after the Autumn Break, which occurred in the beginning of April (~113 mm was recorded at the Wodonga BOM weather station between April 3 and 11). All burning was conducted as a collaboration between the local CFA brigades, landholders and TOs (esp. Rod Mason – a regional TO with extensive experience and skills with traditional burning practices in south–east Australia) using small vehicle–mounted water tanks, pumps and drip torches. Attempts at Doyle's on May 4 where only partially successful but inadequate; and over the subsequent days attempts at the remaining two sites were unsuccessful due to high moisture levels and new grass growth (Figures 3 & 4).

Figure 3: *Attempted burning at Doyle's, May 4, 2014 lead by Rod Mason (LHS) with assistance from the local CFA brigade. Only partially successful and inadequate for demonstration trial.*

Figure 4: *Burning at Sinclair's and Hayes on May 7 unsuccessful due to advanced growth of annual exotic vegetation (bright green).*

Each plot comprised 20 x 20 m treatment areas marked with a steel post in each corner within which a single 10 x 10 m sub–plot was located (with a 5 m surrounding buffer zone) for vegetation evaluation purposes in January and November 2014. As the fencing occurred before burning, minor fire breaks were established with water prior to burning to avoid damaging fences. Where possible, burning was extended beyond the plots over a larger area (≥1 ha) to replicate assumed traditional practices.

Monitoring and evaluation – biodiversity values

An initial, pre–treatment assessment of biodiversity values (baseline) occurred concurrently with trial establishment in January 2014, and the first post–treatment assessment occurred in November 2014. However, given burning was unsuccessful or inadequate at each site, and the Hayes and Sinclair's sites were 'under–grazed', treatment implementation has been effectively postponed until 2015, and thus the November 2014 assessment provided additional baseline data.

Biodiversity values assessment comprised measurements or estimates of a number of plot–scale vegetation metrics, including: composition, richness and cover–abundance of all indigenous and exotic vascular plant taxa, and lifeform and substrate categories. The lifeform categories included: geophytes; large, medium and small tussock grasses; non–tussock grasses; all graminoids; ground ferns; large, medium and small forbs; all forbs and other herbs; trees, mistletoes, aquatics; and cryptogams (mosses, liverworts and lichens). The substrate categories included: rocks, logs, branches, litter, bare ground and water.

Cover/abundance categories were based on standard methods used by the Department of Environment and Primary Industries (DEPI) and its predecessors (see Muir *et al.* 1995), namely:

- \+ <1% Projected Foliage Cover (PFC), few individuals;
1. <1% PFC, many individuals;
2. 1 to 5% PFC, any number of individuals;
3. 6 to 25% PFC, any number of individuals;
4. 26 to 50% PFC, any number of individuals; and
5. >50% PFC, any number of individuals.

Search time ranged from 20 to 30 minutes and while the lists are thorough, additions could be made with further searching. All plant taxonomy follows Walsh and Entwistle (1994, 1996 and 1999) and Walsh and Stajsic (2007). All spatial information was entered into ArcGIS 10.2 for preparation of maps and exported to MS EXCEL for tabular presentation and simple analyses.

The flora for the three sites combined comprised 95 taxa, including 47 exotics (see associated MS EXCEL spreadsheet 'Fire & TEK Jan & Nov 2014 Results').

All spatial information was projected in the Projected Coordinate System (PCS) GDA94_MGA_zone_55 using ESRI ArcGIS 10.2. Satellite imagery was sourced from the ESRI online global coverage. All other geographic data such as topography, hydrology, cadastre and roads etc. were obtained from the DEPI corporate library (www.data.vic.gov.au). Additional spatial data (waypoints and tracks) were created using a GARMIN GPSmap62sc GPS – with data downloaded using Garmin BaseCamp Version 4.2.5 software.

Hierarchical Cluster Analysis and Ordination graphs were performed using the Sorensen (Bray–Curtis – group average) co–efficient at the six–group level. All analyses were conducted using PC–ORD Version 6.08 (McCune and Mefford 2011).

For this preliminary assessment of results, likelihood of significant difference between treatments (various metrics) was indicated with standard deviation data only. It is expected future analyses will include t–tests using non–parametric Mann–Whitney U–tests and related statistical analyses with tools developed by McDonald (2009).

Monitoring and evaluation – pasture productivity

Fresh 50 gram pasture samples were collected from each plot at each site (Hayes = 12; Doyle's = 6 plus two extra for Microlaena; only 5 of the 12 from Sinclair's) on October 22 and 23, 2014 and analysed for eight standard feed test metrics by Australian Wool Testing Authority Ltd (Trading as Agrifood Technology Pty Ltd or 'Feed Test' based in Werribee).

The standard pasture productivity or 'feed test' metrics include:

1. Dry Matter (%);
2. Moisture (%);
3. Crude Protein (% of dry matter);
4. Acid Detergent Fibre (% of dry matter);
5. Neutral Detergent Fibre (% of dry matter);
6. Digestibility (DMD) (% of dry matter);
7. Digestibility (DOMD) (Calculated) (% of dry matter); and
8. Est. Metabolisable Energy (Calculated) (MJ/kg DM).

Soil structure and nutrient analysis was conducted by Soil & Plant Analysis Laboratory Limited from surface soil (0–10 cm) samples taken at Hayes and Doyle's in November 2014. Metrics included: Gravel %; Texture ; Ammonium Nitrogen mg/Kg; Nitrate Nitrogen mg/Kg; Phosphorus Colwell mg/Kg; Potassium Colwell mg/Kg; Sulphur mg/Kg; Organic Carbon %; Conductivity dS/m; pH Level (CaCl2) pH; pH Level (H2O) pH; DTPA Copper mg/Kg; DTPA Iron mg/Kg; DTPA Manganese mg/Kg; DTPA Zinc mg/Kg; Exc. Aluminium meq/100g; Exc. Calcium meq/100g; Exc. Magnesium meq/100g; Exc. Potassium meq/100g; Exc. Sodium meq/100g; Boron Hot CaCl2 mg/Kg; and PBI (Phosphorus Buffering Index).

MS EXCEL was used for tabular presentation and simple analyses. For this preliminary assessment of results, likelihood of significant differences between treatments was indicated with standard deviation data only. It is expected future analyses will include t–tests using non–parametric Mann–Whitney U–tests and related statistical analyses with tools developed by McDonald (2009).

Results and discussion

Biodiversity values – site condition and composition

One of the aims of site selection was to sample a range of condition; spanning both species–poor and species–rich sites – sampling variation in weediness, and the richness and abundance of indigenous grasses, forbs and shrubs. The results suggest this has been achieved, but to a limited extent. Reflecting a long history of pastoral land use, both Hayes and Sinclair's were classed low compared to Victorian Riverina grassland references sites (see Foreman 1996) and the relevant grassy woodland EVC benchmark (www.depi.vic.gov.au), and Doyle's was generally medium with the exception of low classification for both shrubs and forbs (Figure 5).

The %Cover of indigenous grasses at Hayes and Doyle's was unexpectedly high; the latter accounted for by the dominance of Kangaroo Grass. Although Doyle's is currently being managed for conservation, the dominance of thick swards of Kangaroo Grass, the low presence of forbs and complete absence of shrubs, reflects a long history of grazing, from which recovery without intervention will be very slow. The benchmark and reference site comparisons point out the three sites are significantly modified, but variously retain indigenous values that have potential to improve with interventions such as fire, within the context of current land use (Figure 5). In other words, these sites are good candidates for the demonstration trial.

Although Hayes and Sinclair's are similar in terms of relative site condition, composition analysis of the January and November 2014 data pooled reveal they were discretely different and that overall, floristic variation was much greater between sites than within sites – even factoring in seasonal variation. Presumably this reflects the distance between sites, differences in terrain and substrate (aspect, soil and slope) and again land use history, especially variation in the application of fertiliser (Appendices 4 & 5).

Figure 5: *Overview of relative site condition (Biodiversity values). Key: green = high; orange = medium; red = low; grey = absent. Note: Site values do not need to add to 100%.*

Key biodiversity metrics (mean per plot; Jan 14)	*Species–poor (two sites)*		*Species–rich (one site)*	*GLD ref. sites (N=70)#*	*Benchmark GWL**
	Hayes	**Sinclair's**	**Doyle's**		
Indigenous richness	5.4	7.8	13.5	28.0	43
Indigenous grass richness	3.8	5.7	10.5	8.8	19
Indigenous grass %Cover	37.2%	12.1%	51.6%	45.6%	46%
Exotic richness	8.7	12.8	12.3	14.0	N/A
Exotic %Cover	87.0%	78.5%	60.5%	55.2%	<5%
Indigenous forb richness	0.7	0.8	1.2	17.7	18
Indigenous forb %Cover	0.2%	0.3%	2.6%	73.1%	30%
Indigenous shrub richness	0.0	0.0	0.0	1.5	6
Indigenous shrub %Cover	0.0%	0.0%	0.0%	3.2%	21%

*EVC_175_62: Rainshadow Grassy Woodland – Northern Inland Slopes bioregion;
– Quadrats ≥35 species per 10x10 m area (see Foreman 1996)

Biodiversity values – impact of burning

Despite attempts, moisture levels and exotic grass growth was too advanced at both Hayes and Sinclair's by the first week of May (approx. one month after the autumn break) for any significant ignition. Limited burning was only achieved at Doyle's primarily due to the dominance of Kangaroo Grass, although here – again due to excessive moisture levels – the burn was considered too 'cool' to be adequate. Coverage was very patchy and there was little combustion of the deeper litter layer that would have destroyed exotic annual weed seed and opened up the grassy sward to encourage indigenous perennial re–sprouting, flowering, seeding and recruitment (Figures 3 & 4).

Consistent with this analysis, the results of the Doyle assessment in November 2014 showed only minor (likely not significant) trends in the direction expected – an increase in the richness of indigenous species, a decrease in the richness of exotics (mostly annual grasses), and a decrease in the %Cover of both exotics and indigenous plants (Figures 6 & 7). Any improvements in the %Cover of indigenous plants would only be expected in the second year following an immediate reduction in the %Cover of all plants post–burn. Any increase in the abundance of indigenous plants post–burn could be the result of a combination of interstitial recruitment (especially if this period coincides with spring) and increased visibility of plants with the removal of litter and exposure of the soil surface.

Analysis of the November 2014 data at Hayes and Sinclair's, including plots planned for burning in 2015 (with and without grazing) showed evidence of a lack of replication and the low precision and high variability of the %Cover estimates. Improvements in the 2015 assessment could be introduced by increasing the number of replicates and/or increasing the number of %Cover categories. Much more precise measurement of %Cover (using point quadrats for instance) is considered too time consuming and unfeasible for this demonstration trial (Appendix 6).

Figure 6: *Impact of burning at Doyle's on mean plot indigenous and exotic richness*

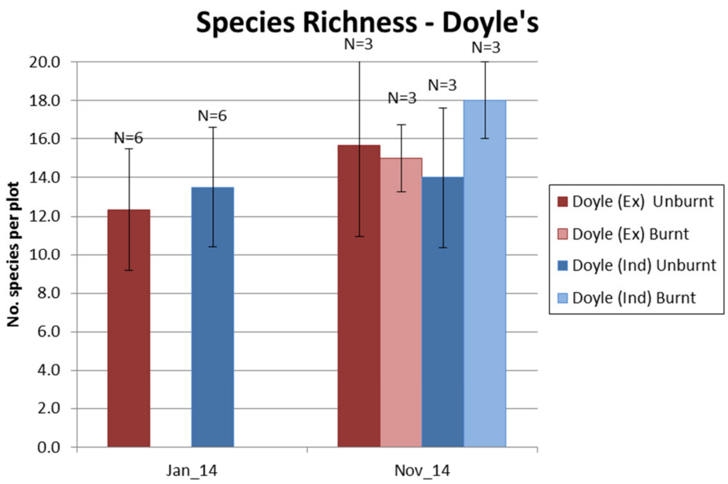
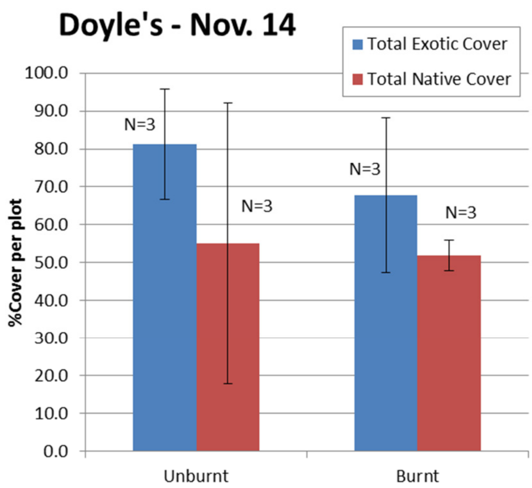


Figure 7: *Impact of burning at Doyle's on mean plot indigenous and exotic %Cover*



Biodiversity values – impact of grazing

It was noted earlier that both Hayes and Sinclair's were 'under–grazed' in 2014. While grazing data is not available, visual assessment of these sites suggested a negligible impact at Hayes and a slight impact at Sinclair's. Analysis of the impact of grazing on composition well illustrates these relative impacts with no separation between treatments on the Ordination graph at Hayes and a slight separation emerging at Sinclair's (Appendix 5).

Given the burning wasn't successful at these sites, analysis of pooled data (unburnt and 'to be burnt' in 2015; N=6) showed no possible significant difference for any of the 14 metrics considered (Appendix 7). Analysis of non–pooled data (N=3) showed evidence, as reported earlier, of a lack of replication and the low precision and high variability of the %Cover estimates, especially at Hayes. This has always been a recognised risk for this project, but could be improved by increasing the number of %Cover categories as discussed under impact of burning. And also clearly the landholders will need to ensure greater levels of grazing are implemented in 2015.

Pasture productivity values

All three sites were at the lower end of the productive range (55–60%) where digestibility is adequate to maintain dry stock. Only the unburnt plots at Doyle's were the exception, with notably lower levels of digestibility (~51%) due to the absence of recent grazing or any other major disturbance. As expected at Doyle's, digestibility increased when sampled five months following the limited burning in May 2014 as the dominant Kangaroo Grass was clearly at an early regrowth stage with noticeably less coarse leaves. The relatively higher values at Hayes and Sinclair's were presumably due to the effect of routine stock grazing.

A similar effect was seen with metabolisable energy and crude protein – the latter an estimate of the total protein present in a grass, positively related to digestibility and with livestock performance (www.dpi.nsw.gov.au). Presumably the fresh growth following the burn also explains the spike in these metrics at Doyle's. However, both crude protein and metabolisable energy levels were consistently highest at Hayes, with Sinclair's generally in between. This gradient may be accounted for by differences in fertiliser (superphosphate) application. Soil tests revealed much higher nutrient levels at Hayes compared with Doyle's where fertiliser has never been applied or at least not for some decades. Phosphorus levels were 315% higher, along with consistently higher levels of Organic Carbon and Conductivity, plus Potassium, Sulphur and Calcium, as well as a range of heavy metals – Iron, Zinc, Aluminium and Boron (Appendix 8). The more acidic soil at Hayes is a further indication of fertiliser use, and although the soils at Sinclair's were not tested, it is assumed Sinclair's practice a somewhat intermediate fertiliser regime to Hayes.

Finally, there was no grazing feed value effect at Hayes or Sinclair's as expected because of the early stage of the demonstration trial and given both sites where 'under–grazed' in 2014. And as burning was not successful at these two sites in 2014, no assessment of the impact of burning on feed value was possible.

Recommendations and conclusions

Preliminary investigations show there is a sound basis for pursuing collaborations between TOs, pastoralists and scientists that combine science with TEK in order to create new knowledge around using fire to achieve productivity and biodiversity outcomes in grassy ecosystems. While drawing on the experience of TOs in Cape York will be useful in attempting to revive traditional burning in south–east Australia, caution is advised to acknowledge differences in the ecology of tropical vs. temperate ecosystems, as well as Victoria's much higher levels of landscape change and dispossession.

Although further research is needed, it is assumed that traditional use of fire involved cool season burns – patchy at an intermediate scale as limited by natural barriers – aimed at stimulating fresh plant growth including staple foods, attracting macropods for hunting and reducing potentially destructive hot, summer fires.

And based what we know about native pasture management and the ecology and function of temperate grassy ecosystems, there is great scope to use fire (in combination with other tools) to boost both biodiversity values and pasture productivity by increasing the abundance and function of native species, but especially a diversity of native grasses.

The three sites selected for the demonstration trial near Wodonga in North East Victoria, where highly modified grazed and fertilised grassy woodland remnants with enough indigenous elements (esp. native grasses but also trees at one site) remaining to benefit from careful use of fire under existing land uses.

Attempted burning in May 2014 proved to be unsuccessful at the two pastoral sites (Hayes and Sinclair's) and limited but inadequate at the other site – Doyle's, managed as a conservation area – due to operational delays following an unexpectedly early autumn break. The burn at Doyle's was considered inadequate because it was not hot enough to consume a significant coverage and depth of litter and standing foliage, due to high moisture levels on the day. However, despite this, the initial results showed some evidence of the potential benefits of burning expected under this trial – namely (non–significant) trends towards increased native species diversity, and a reduction in the richness and abundance of weeds.

Especially for the two pastoral sites (Hayes and Sinclair's), which were 'under grazed' in 2014, both the January and November results can be effectively considered a baseline assessment against which properly implemented grazing and burning treatments in 2015 can be compared. In this context, preliminary analysis showed the potential lack of replication and the coarseness of the %Cover estimation method – both recognised project risks that would be most readily improved by increasing the level of replication and/or changes to the %Cover estimation method.

The feed test results showed the two pastoral sites at the lower end of pastoral value – adequate to maintain dry stock – and the conservation site, a step lower due to the complete absence of disturbance. And as expected at Doyle's, burning served to boost pastoral metrics such as digestibility by stimulating new growth leaves, more typical of grazed pasture. It is speculated other pastoral value differences between sites (especially the two pastoral sites) could be accounted for by differences in fertiliser (superphosphate) application, with the highest rates likely applied at Hayes where there was more acid soils.

Having established a good baseline through 2014, it is critical to the success of this project that grazing and burning is adequately implemented as soon as possible in 2015. There should be no delay in delivering the burns as soon as possible after any obvious autumn break, and in the event of a dry autumn, burning should occur prior to June when it is safe to do so. Grazing should be commenced as conditions allow following the implementation of burns, and if required before this, stocking levels should remain low over summer or autumn to ensure adequate dry litter/fuel remains to carry the planned autumn burn.

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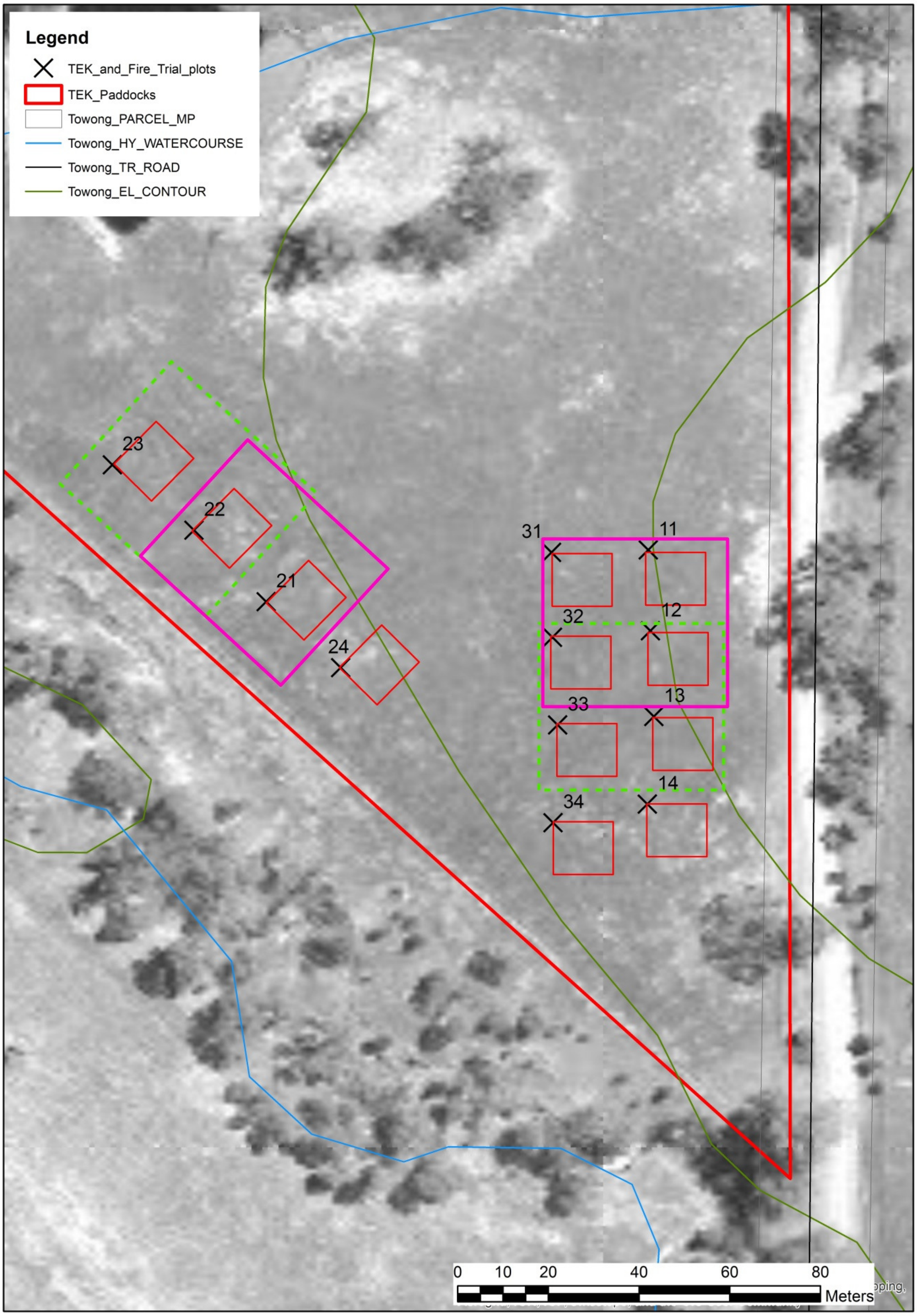
Appendices

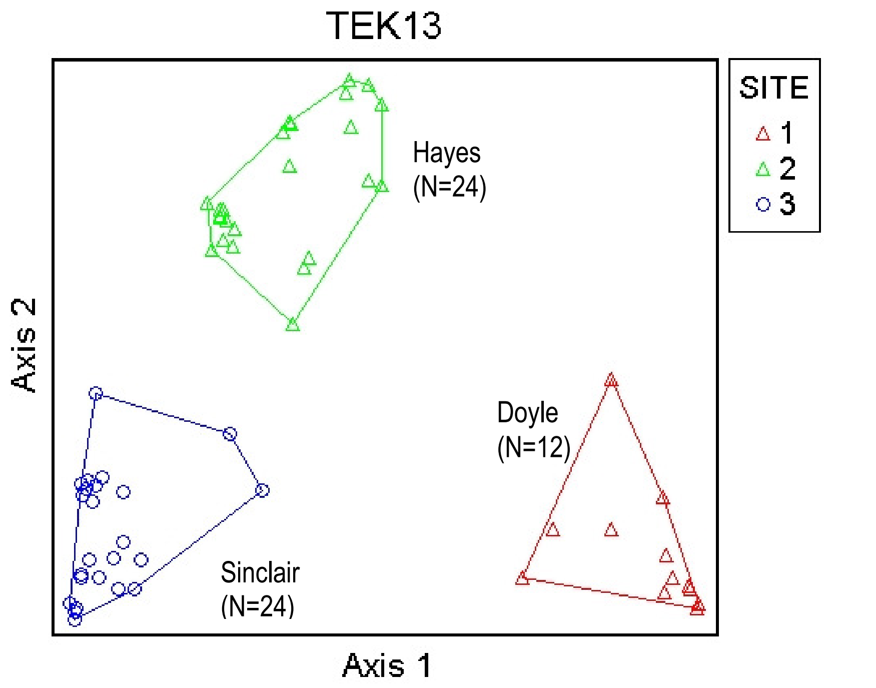
Appendix 1: Burning trial plots at Doyle's

Appendix 2: Burning trial plots at Sinclair's

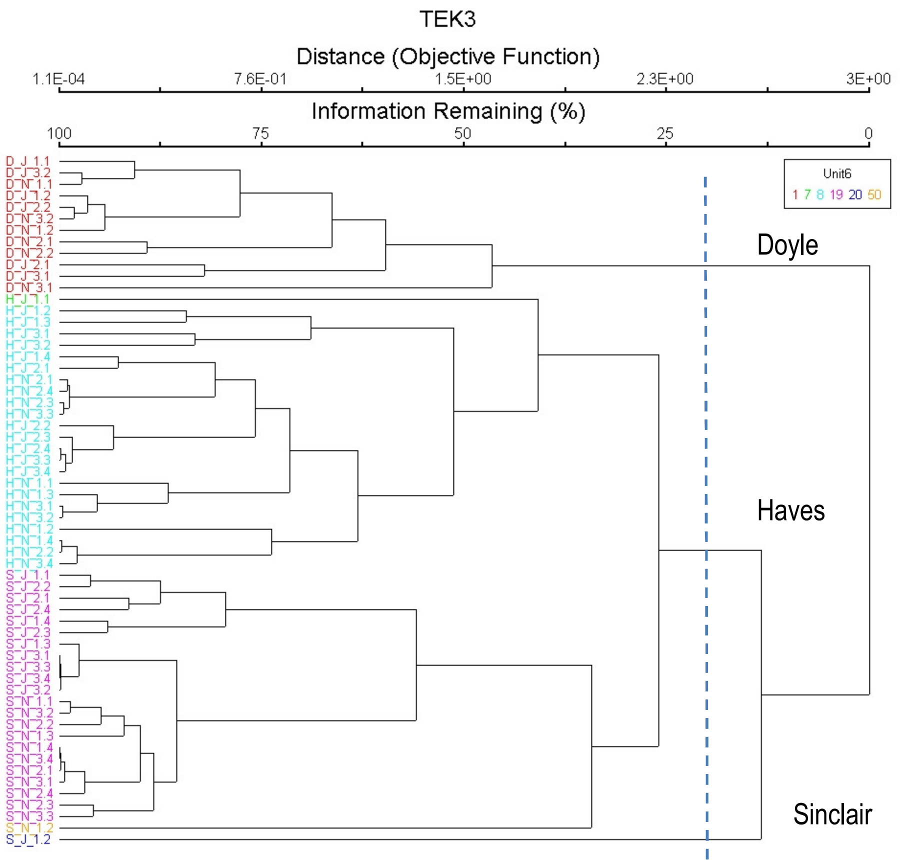
Appendix 3: Burning trial plots at Hayes



Appendix 4: Ordination Graph and Cluster dendrogram; January & November pooled



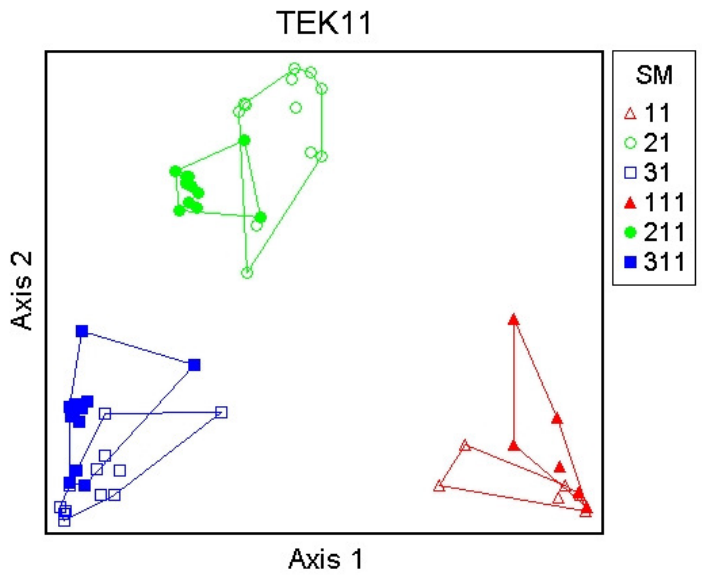
Note: All three sites very different florsitically, reflecting differences in geographic separation, physical attributes and land use history



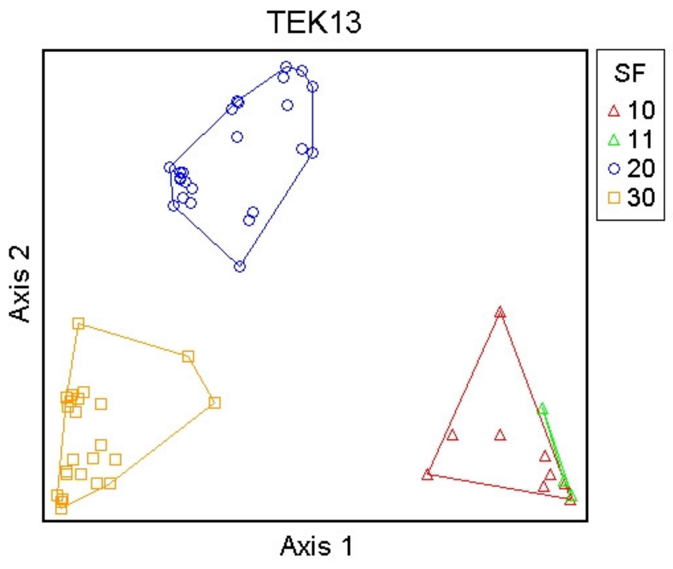
Note: plot 1.2 at Sinclair's, containing a small spring soak supporting semi–aquatic species at the time of both assessments, was very different different to all other plots and may need to be excluded from future analysis to reduce variation.

Appendix 5: Ordination Graphs showing effect of season, burning & grazing, plus outliers

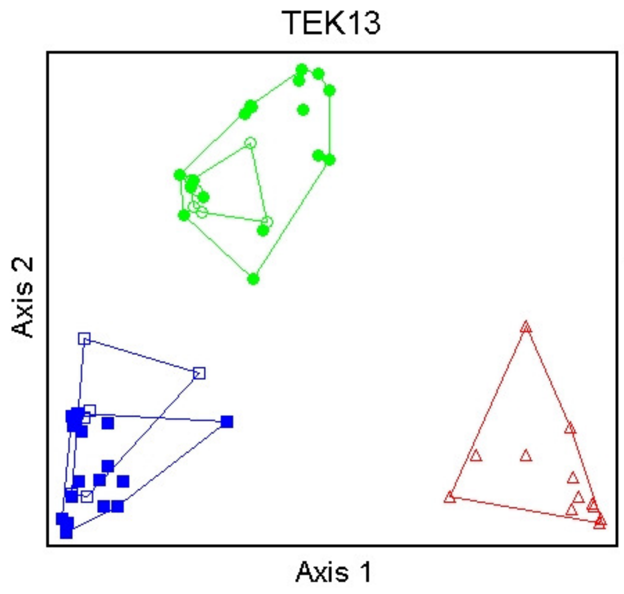
Season



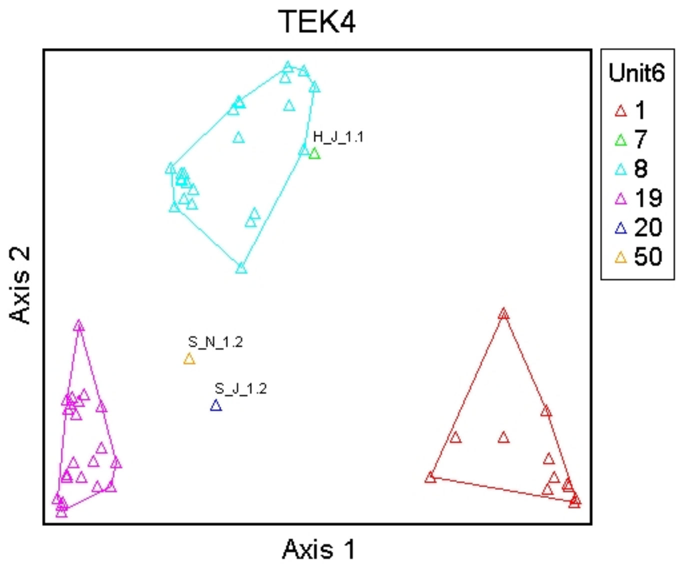
Burning



Grazing



Outliers



Appendix 6: November 2014 impact of burning results

Highlight denotes possible significant difference; TB Burnt = to be burnt in 2015; STD = standard deviation

Metric (Nov. 2014)	*Unit*	*Doyle's*				*Hayes*								*Sinclair's*							
		Ungrazed				Ungrazed				Grazed				Ungrazed				Grazed			
		Unburnt	STD	Burnt	STD	Unburnt	STD	TB Burnt	STD	Unburnt	STD	TB Burnt	STD	Unburnt	STD	TB Burnt	STD	Unburnt	STD	TB Burnt	STD
	Replicates	N=3		N=3		N=3		N=3		N=3		N=3		N=3		N=3		N=3		N=3	
Exotic Total Richness	No. spp.	15.7	4.7	15.0	1.7	9.7	0.6	8.7	1.2	9.0	1.0	8.7	0.6	11.3	3.2	16.3	2.1	10.0	2.0	13.7	3.1
Ind. Total Richness	No. spp.	14.0	3.6	18.0	2.0	6.0	1.7	6.3	3.1	3.3	0.6	4.7	1.5	6.0	1.0	8.3	3.8	8.0	2.0	8.7	1.2
Total Richness	No. spp.	29.7	8.1	33.0	1.0	15.7	1.5	15.0	3.5	12.3	0.6	13.3	2.1	17.3	3.2	24.7	5.8	18.0	2.0	22.3	3.1
Sum %Cover	%Cover	136.3	26.7	119.7	24.3	140.3	27.6	147.0	30.5	192.0	18.0	171.5	31.6	124.9	16.5	143.6	29.0	121.3	13.7	118.2	6.8
Ind. Graminoids	%Cover	52.7	35.9	50.4	4.4	29.4	9.8	62.5	25.3	63.7	19.7	32.6	9.6	20.5	18.8	9.4	7.0	24.5	9.1	18.2	9.3
Ind. forbs & other herbs	%Cover	1.1	1.8	0.3	0.2	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.1	0.0	0.1	0.4	0.6	0.1	0.1	0.1	0.1
Total Ind.	%Cover	55.0	37.2	52.0	4.0	29.4	9.8	62.6	25.3	63.8	19.7	32.7	9.7	20.6	18.7	9.8	6.9	24.5	9.1	18.3	9.2
Ex. Graminoids	%Cover	78.1	15.2	63.8	20.7	83.3	29.1	64.9	39.5	101.2	21.9	119.4	21.1	90.5	9.4	104.2	25.3	90.3	6.5	90.0	6.6
Ex. forbs & other herbs	%Cover	3.2	0.8	4.0	0.4	27.6	8.0	19.5	11.0	27.0	12.6	19.4	12.0	13.9	6.2	29.5	7.1	6.5	2.5	9.9	7.9
Total Ex.	%Cover	81.3	14.6	67.8	20.4	110.9	22.6	84.4	39.8	128.2	23.7	138.8	23.0	104.4	8.5	133.8	29.0	96.8	4.9	99.9	7.2
Ex. Annual Herbs	%Cover	1.3	1.5	0.4	0.1	6.4	7.6	1.5	1.3	18.7	17.8	7.1	6.9	11.2	6.8	15.5	0.3	3.0	0.1	7.2	7.1
Ex. Perennial Herbs	%Cover	1.9	1.5	3.6	0.5	21.2	15.3	18.0	12.0	8.3	8.4	12.3	7.8	2.7	1.4	14.0	6.9	3.5	2.5	2.7	1.4
Ex. Annual Gram	%Cover	26.0	18.3	24.8	20.9	82.7	29.0	63.7	39.2	99.5	20.3	119.0	21.2	89.6	9.6	76.1	19.2	88.4	7.1	88.6	6.9
Ex. Perennial Gram	%Cover	52.1	21.3	38.9	0.2	0.6	0.1	1.2	1.6	1.7	1.6	0.4	0.2	0.9	0.3	28.1	43.7	1.9	1.4	1.4	0.5

Appendix 7: November 2014 impact of grazing results

STD = standard deviation

Metric (Nov. 2014)	*Unit*	*Hayes*				*Sinclair's*			
		Ungrazed		Grazed		Ungrazed		Grazed	
	Replicates	N=6	STD	N=6	STD	N=6	STD	N=6	STD
Exotic Total Richness	No. spp.	9.2	1.0	8.8	0.8	13.8	3.7	11.8	3.1
Ind. Total Richness	No. spp.	6.2	2.2	4.0	1.3	7.2	2.8	8.3	1.5
Total Richness	No. spp.	15.3	2.4	12.8	1.5	21.0	5.8	20.2	3.3
Sum %Cover	%Cover	143.7	26.3	181.7	25.6	134.3	23.4	119.8	9.8
Ind. Graminoids	%Cover	45.9	25.0	48.2	21.9	15.0	14.1	21.3	8.9
Ind. Forbs & other herbs	%Cover	0.1	0.1	0.1	0.1	0.2	0.4	0.1	0.1
Total Ind.	%Cover	46.0	25.0	48.2	22.0	15.2	13.9	21.4	8.9
Ex. Graminoids	%Cover	74.1	32.6	110.3	21.7	97.4	18.6	90.2	5.9
Ex. Forbs & other herbs	%Cover	23.6	9.7	23.2	11.8	21.7	10.5	8.2	5.6
Total Ex.	%Cover	97.7	32.4	133.5	21.7	119.1	25.0	98.4	5.7
Ex. Annual Herbs	%Cover	4.0	5.6	12.9	13.6	13.4	4.9	5.1	5.0
Ex. Perennial Herbs	%Cover	19.6	12.4	10.3	7.5	8.3	7.7	3.1	1.9
Ex. Annual Gram	%Cover	73.2	32.5	109.3	21.4	82.9	15.4	88.5	6.3
Ex. Perennial Gram	%Cover	0.9	1.1	1.0	1.3	14.5	31.4	1.6	1.0

Appendix 8: Summary of Feed Test (Pasture productivity) results

Highlight denotes possible significant difference; STD = standard deviation

Metrics (Oct. 2014)		*Unit*	*Doyle*				*Hayes*				*Sinclair*			
			Unburnt		Burnt		Ungrazed		Grazed		Ungrazed		Grazed	
			N=3	STD	N=3	STD	N=6	STD	N=6	STD	N=2	STD	N=3	STD
Dry Matter	DM	(%)	91.23	0.25	91.70	0.56	90.58	0.73	90.75	0.83	91.45	0.21	91.53	0.25
Moisture	Moist	(%)	8.77	0.25	8.30	0.56	9.42	0.73	9.25	0.83	8.55	0.21	8.47	0.25
Crude Protein	CP	(% of dry matter)	8.53	0.74	11.00	0.70	12.28	1.13	12.80	0.45	9.80	1.98	9.00	1.30
Acid Detergent Fibre	ADF	(% of dry matter)	35.43	1.31	33.47	1.01	31.18	0.90	30.88	0.56	33.35	3.18	35.17	2.65
Neutral Detergent Fibre	NDF	(% of dry matter)	65.83	1.72	63.97	1.12	61.82	0.74	61.02	0.69	64.55	4.17	66.13	3.60
Digestibility (DMD)	DMD	(% of dry matter)	51.53	1.38	55.87	2.05	62.42	1.10	62.63	0.80	60.55	1.06	58.53	1.45
Digestibility (DOMD) (Cal.)	DOMD	(% of dry matter)	50.47	1.17	54.17	1.70	59.68	0.96	59.90	0.70	58.15	0.92	56.40	1.20
Est. Metabolisable Energy (Cal.)	EME	(MJ/kg DM)	7.27	0.21	8.00	0.35	9.12	0.16	9.15	0.15	8.80	0.14	8.47	0.25

Appendix 9: Summary of soil analysis results

Highlight denotes possible significant difference; STD = standard deviation

Metric (18/11/2014)	*Hayes 1.1 – 1.4*		*Doyle's (all)*		*Inc. at Hayes*
	N=4	STD	N=6	STD	
Gravel %	3.13	3.75	5.00	0.00	–37.50%
Texture	1.13	0.25	1.42	0.20	–20.59%
Ammonium Nitrogen mg/Kg	6.50	2.38	5.00	2.45	30.00%
Nitrate Nitrogen mg/Kg	<1	0.00	1.50	0.71	N/A
Phosphorus Colwell mg/Kg	18.00	1.41	4.33	1.03	315.38%
Potassium Colwell mg/Kg	275.75	77.34	146.00	35.71	88.87%
Sulphur mg/Kg	3.35	0.13	2.10	0.28	59.52%
Organic Carbon %	3.14	0.23	1.80	0.35	74.79%
Conductivity dS/m	0.02	0.01	0.02	0.00	48.42%
pH Level (CaCl2) pH	4.00	0.08	4.35	0.10	–8.05%
pH Level (H2O) pH	4.80	0.08	5.27	0.14	–8.86%
DTPA Copper mg/Kg	0.48	0.06	0.58	0.11	–17.29%
DTPA Iron mg/Kg	229.97	12.26	141.72	36.30	62.28%
DTPA Manganese mg/Kg	14.83	5.03	13.29	6.06	11.58%
DTPA Zinc mg/Kg	1.01	0.28	0.58	0.10	74.21%
Exc. Aluminium meq/100g	2.54	0.30	0.89	0.23	184.68%
Exc. Calcium meq/100g	2.69	0.53	1.61	0.55	66.91%
Exc. Magnesium meq/100g	0.81	0.21	0.84	0.26	–3.95%
Exc. Potassium meq/100g	0.41	0.14	0.34	0.09	23.13%
Exc. Sodium meq/100g	0.03	0.01	0.04	0.02	–21.74%
Boron Hot CaCl2 mg/Kg	0.24	0.03	0.17	0.03	46.97%
PBI (Phosphorus Buffering Index)	113.20	8.80	77.73	11.67	45.63%