Fire Patterns of South Eastern Queensland in a Global Context: A Review

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Abstract—*Fire is an important driver in ecosystem evolution, composition, structure and distribution, and is vital for maintaining ecosystems of the Great Sandy Region (GSR). Charcoal records for the area dating back over 40, 000 years provide evidence of the great changes in vegetation composition, distribution and abundance in the region over time as a result of fire. Fires have shaped landscapes and ecosystems, creating fire-dependencies and fire disturbance-adapted flora and fauna with traits to survive fire, such as resprouting post-fire and serotiny of cones and fruit. However such traits are not necessarily only developed as a result of fire as a process of natural selection, other factors may play a role in such trait development within plants. Paleo-records and modern observations show a definitive link between fire and climate (temperature and precipitation), with an increase in fire with increasing temperatures. This has serious implications in a warmer world there will be an increase of wildfire risk. Of importance is the understanding of the interactions between multiple drivers of fire regimes from the past and present. This is critical for developing fire regime management protocols for the Great Sandy Region and other similar fire-prone regions into the future.*

Keywords: *Fire regime, vegetation dynamics, evolution, fire dependency, wildfires, paleofire*

Introduction

The Great Sandy Region (GSR) of South East Queensland is an iconic landscape, including the largest sand island in the world (Fraser Island), as well as the significant mainland Cooloola sand mass. The importance of this region has been highlighted by a number of Queensland, Australian, and international environmental protection agreements, including World Heritage and the Convention on Wetlands of International Importance (Ramsar) listings for Fraser Island, protection for the Great Sandy Strait between Fraser Island and the northern parts of the Cooloola region and National Park status for most of the GSR (Figure 1).

This paper provides a review of the global, Australian, and local context for changing fire regimes for the GSR. This will provide important contextual information into undergoing research on the fire regimes for the past, present and future that will be vital for sustainable fire management plans for this significant region. Paleofire history of the earth in general and changes to fire regimes over time and space as well as linking these to changes and fluctuations in the climate to the present are discussed with a view to focus on Australia and the GSR locality. The focus of this paper is on shifts in fire regime over space and time and impacts that changes in climate have had on fire regime history. Linking past with present fire regimes being an integral part of the discussion, with an overarching view to look at possible drivers and changes to future fire regimes with a shifting tropical belt that is an important driver for future climate change, particularly fire management protocols

Climate and Wildfire

There is strong evidence that the atmosphere is warming and that there is an increase in warm El Niño Southern Oscillation (ENSO) years with a weakening of the Walker circulation over the past decades (Knopf and Petoukhov, 2007; Meng and others. 2012). Present data show that there has been an increase in width of the tropical belt of between 2º to 4.8º latitude north/south over the past 30 years (Seidel and Randel, 2007; Grassi and others. 2012; Davis and Rosenlof, 2012; Allen and others, 2012a b). This expansion has seen the shift in the subtropical subsidence, leading to an enhanced mid-latitude tropospheric warming and poleward shift of the subtropical dry zone, jet streams, and storm tracks, which is expected to contribute to an increased frequency of mid-latitude droughts in both hemispheres (Seidel and others, 2008; Grassi and others, 2012; Wilcox and others, 2012; Allen and others 2012a; Cai and others. 2012).

Evidence of fire has been recorded in charcoal deposits dating back to 440 million years ago (mya) when the first stomata-bearing plants evolved (Pausas and Keeley, 2009). These fires were thought to have been low intensity fires, probably due to the limited biomass available to burn and reduced atmospheric oxygen. However according to Pausas and Keeley (2009), charcoal deposits increased substantially around 345 mya during the Carboniferous Period, which correlates with the increase in atmospheric oxygen levels of the oxygen maxima through to around 2.5 mya when

In: Keane, Robert E.; Jolly, Matt; Parsons, Russell; Riley, Karin. 2015. Proceedings of the large wildland fires conference; May 19-23, 2014; Missoula, MT. Proc. RMRS-P-73. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 345 p.

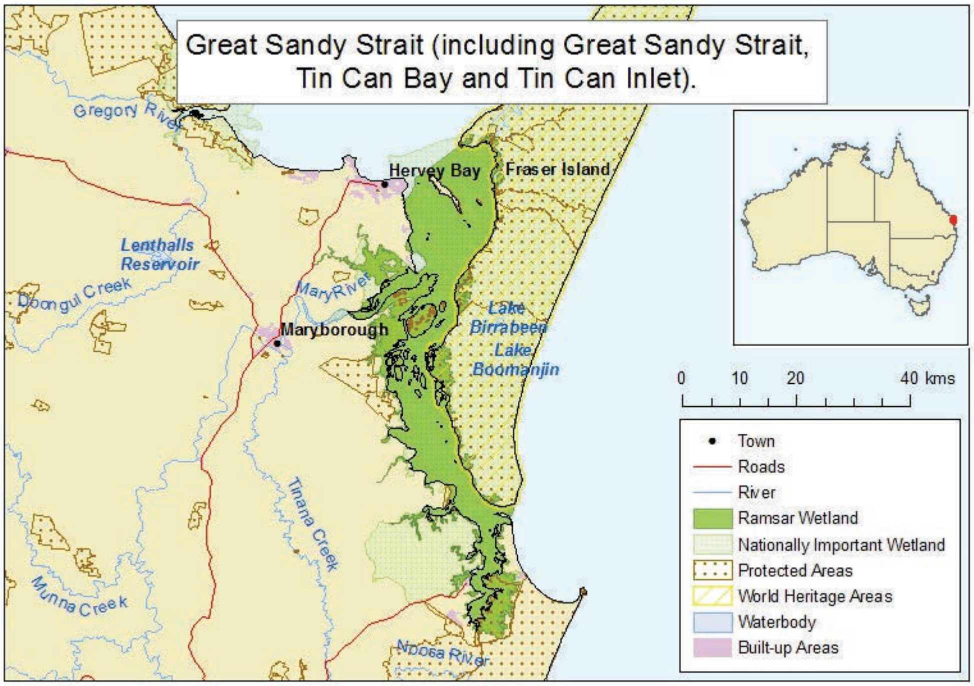

Figure 1—Map of the Great Sandy Strait Region, showing the major protected areas (i.e., Fraser Island National Park and Cooloola Recreation Area), Ramsar listed wetlands and World Heritage listed areas (Fraser Island). Source: http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=51.

early hominids started evolving and using fire. In northeast Queensland, records of Aboriginal fire have been recorded between 45 and 43 thousand years ago up until the arrival of Europeans approximately 200 years ago when charcoal deposits possibly increased due to land clearing and modification of the landscape (Turney and others 2001; Rule and others 2012).

The south eastern Queensland region of eastern Australia (incorporating the GSR) has had limited research into past fire regimes and the links to human occupation. Direct archaeological evidence traces human occupation to around 20,000 years ago at the Wallen Wallen Creek site on North Stradbroke Island (Neal and Stock 1986) and longer charcoal records (extending back to 45,000 years) from North Stradbroke Island suggests a complex fire history (Moss and others 2013). The Native Companion Lagoon site, located on the west coast of the island and within 5 km of the Wallen-Wallen site, suggests higher fire frequencies from 45,000 to 40,000 years ago, which may be analogous to the North Queensland findings. However, a similar aged record from the high dunes of the island at Tortoise Lagoon, finds no evidence of increased burning during this time, with charcoal peaks apparently related to dry climatic phases in the record. This suggests that site characteristics and local to sub-regional factors may play a key role in charcoal records and multiple sites may be required to fully understand past fire regimes for a region (Moss and others, 2013). More recent charcoal records from North Stradbroke Island at Myora Springs may reflect the influence of climate change and people on past fire regimes (Moss and others, 2013). With a shift to a warm ENSO period from between 800 to 500 years ago caused dryer conditions to prevail on the island, resulting in drought and higher anthropogenic fire frequency during this period. This was followed by cooler, wetter conditions developing around 500 years ago which correlates with a decline in charcoal deposits (Moss and other 2011). With the arrival of Europeans fire regimes once again changed around 200 years ago, resulting in more frequent fires and burn-offs for agricultural, residential and industrial purposes. These changes led to changes in the landscape to fire-tolerant vegetation, *Eucalyptus* forest and *Melaleuca* swamp paperbark at the expense of less fire-tolerant species like Casuarinaceae (Moss and others 2011). According to Haberle and others (2010), “No single driver can explain past fire patterns and many events may be the result of multiple drivers interacting on differing temporal and spatial scales” (p. 80). Of critical importance is an understanding of these interactions between multiple drivers of fire regimes from the past and present which is critical for developing fire regime management protocols for Australia in the future (Haberle and others 2010).

According to Seidel and others (2007) an unequivocal sign of climate change has been the warming of the atmosphere and oceans, with the thawing of land and melting of ice at the poles, and the expansion of the tropical belt. Several studies (Hu and Fu 2007; Seidel and others 2008; Lu and others 2009) have looked at the expansion of the tropical belt and poleward migration of the divergent air of the Hadley cell, which has important implications for subtropical populations due to possible changes in the global climate. This suggests that a shift in precipitation in the temperate regions of the planet will have profound impacts on fire regimes, ecosystems, plant communities, crop production and agriculture (Spratt and Sutton, 2008; Nitschke and Innes. 2013). Further, Lucas and others (2014) state that recent decadal observations suggest changes in the hydro-climate with an increase in the frequency of droughts and reduced precipitation as has been observed in southern portions of Australia. This is supported by research undertaken by Moss and others (2012a) suggesting that natural climate factors can significantly alter fire frequency and intensity, such as increased climate variability associated with the ENSO phenomenon that dramatically impacts fire regimes.

Wildfires have increased in size and intensity over recent decades that may be linked to extreme weather events such as extended droughts (Liu and others. 2013; Westerling and others. 2006) and where frequent low intensity surface fires in forest ecosystems have transitioned to severe fire behaviour due to climate change (Bigio, 2013). These recent increases in large fires globally have caused concern about the influence climate change and humans may have on future fire regimes, with predictions of shifts to climatically driven fire for the 21st century (Pechony and Shindell, 2010). Pastro and others (2011) states that more intense and frequent wildfires are predicted in the future due to climate change. A better understanding of climate and wildfire interactions will be required to mitigate impacts of future fire regimes.

Collins (2014) shows a trend for a strong increase in the occurrence of high to extreme fire weather since the mid 1990's across the northern Sierra Nevada, USA. In addition to this De Groote and others (2013) reviewed recent studies using several General Circulation Models that show a general increase in future fire weather severity with increased fire season in many regions around the globe. Added to this is the suggestion by McKenzie and others (2014) that smoke from wildfires in the future may be more intense and widespread, further increasing the effects of greenhouse gases in the atmosphere by exerting positive radiative forcing within the short term (Simmonds and others, 2005; McKenzie and others, 2014).

Present forecasts of climate change indicate an increase in temperatures, with warmer springs and earlier runoff and longer fire seasons (Westerling and others, 2006; Flannigan and others, 2013). Any increase in wildfire extent and intensity would affect human safety, livelihoods, landscape biodiversity and vegetation communities (Litschert and others 2012; Rogstad and others 2012). Measuring the rates of change (changes in frequency, intensity, season and sequence) in wildland fire and understanding the mechanisms responsible for such changes are important research goals (Hessl 2011). A number of modeling studies project increases in wildfire activity in future decades; however few empirical studies have documented change in modern fire regimes. Identifying generalised pathways through which climate change may alter fire regimes is a critical next step for understanding wildland fire under a changing climate (Hessl, 2011).

In a study by Nitschke and Innes (2013) a statistically significant increase in mean fire (increase in the average size of wildfire) size was predicted to occur along with an increase in maximum fire size and decrease in the mean fire interval. Changes in fire regimes will have direct implications for ecosystem management as the combination of large, flammable fuel types and fire-prone climatic conditions increase the risk of larger more frequent fires (Nitschke and Innes 2013; Loepfe, 2012), with greater impacts on biodiversity and plant communities with increasing wildfire intensities (Beck and others 2011; Bigio 2013).

Fire History and Evolutionary Response

Originally climate and soil were thought to control the distribution of ecosystems with fire only playing a limited role (Pausas and Keeley 2009). However fire is and has been an important driver in ecosystem evolution, composition and distribution through its impact on biota (Bond and others 2005; Pausas and Keeley 2009; Coneder and others 2009; Bowman and others 2011; Batllori and others 2013). Fire has played a key role in the evolution of plant community composition, distribution and abundance within ecosystems from around 440 million years ago (mya) when the first stomata plants evolved on the planet (Glasspool and others 2004; Bond and Keeley 2005; Pausas and Keeley 2009) to present. Further charcoal records show that there has been continuous fire activity from the late Silurian to present, a period of approximately 400 million years according to Bowman and others (2011).

Fire-modified ecosystems has resulted over time and space in biomes becoming fire dependent (Bond and others 2005; Conedera and others 2009) where fire is a major evolutionary force creating fire disturbance-adapted ecosystems. Bowman and others (2011) state that fire has been an important factor in plant evolution, shaping some biomes such as the flammable savanna communities of the late Cenozoic Era. Ecosystem response and adaptation to fire has been shown to evolve over short evolutionary timescales as suggested by Litsios and others (2014) with fire response traits impacting plant evolution (Wells 1969) resulting in diversity increase. However Litsios and others (2014) state that this is still controversial, providing examples where rates of diversification are not associated with fire response traits for five plant genre found in fire prone habitats.

According to Conedera, and others (2009) wildfire is a key factor in changing the climate as it affects the chemistry of the atmosphere and carbon cycle. Pausas and Keeley (2009) suggest that due to the importance of fire as an ecosystem modifier, plants developed traits to survive fire, such as resprouting post-fire and serotiny of cones and fruit. However such traits are not necessarily only developed through fire as a process of natural selection, other factors may play a role in such trait development within plants (Bowman and others 2009).

According to Power and others (2008) fire has varied globally on a continuous basis since the last glacial maximum (LGM) between 22-19 thousand years BP (Adams-Hosking and others 2011) in response to changes in climate, vegetation and human land use (Bowman and others 2011). Fuel availability and weather conditions are important drivers of wildfire and can be both directly and indirectly linked to climate (Duguy and others, 2013) vegetation type and human activity. Further, with the domestication of fire, humans substantially changed the natural fire regimes (Conedera and others 2009), which in turn has changed ecosystem constituent species. Originally anthropogenic burning was thought to have created the flammable biomes, and to a certain extent this is true, however natural fires occurred millions of years before humans existed on the planet (Bond and Keeley 2005). At the biome level the variation in fire regime and biomass burnt changes with a changing climate, fuels and ignition sources (Pyne and others 1996; Power and others 2008).

Daniau and others (2012) state that paleo-records and modern observations show a definitive link between fire and climate (temperature and precipitation) with an increase in fire with increasing temperatures. This has serious implications as in a warmer world there will be an increase in wildfire risk (Daniau and others 2012). Daniau and others (2012) further suggest that increases in wildfire due to increased temperature can be off-set by precipitation; however, this will depend on whether or not there is an increase or decrease in precipitation at a regional level.

Fuel-limited regions of today could see increased wildfire with increased precipitation, especially with the expansion of the tropical belt and monsoons associated with future warming (Meehl and others 2007; Daniau and others 2012). Associated with the expansion of the tropical belt are increases in drought in the shifting subtropical dry regions (Seidel and Randel 2007) and enhanced risk of wildfire. However according to Daniau and others (2012) any increase in fire due to increases in temperature for example maybe offset by changes in fuel dynamics due to changes in precipitation. The global incidence of wildfire decreased during the twentieth century despite increasing temperatures, which could be linked to landscape fragmentation and fire exclusion (Marlon and others 2008; Daniau and others 2012; Marlon and others 2013; McWethy and others 2013; Buma and others 2013). However it has been suggested that the level of landscape fragmentation is no longer an effective means of wildfire suppression due to the evidence of an increase in wildfire due to natural and anthropogenic change (Mickler and others 2013) and in particular the increases in wildfire being linked to global warming (Daniau and others 2012).

It is well documented that wildfire regimes have been affected by climate change in the past and that future fire regimes will be driven by changes in future climates, with longer wildfire seasons, more frequent, severe and larger wildfires (Duguy and others 2013; Brotons and others 2013). According to Power and others (2008) regional climate change has directly affected ignition and fire spread while indirectly affecting vegetation composition and structure and available fuel loads. Pechony and others, (2010) state that there has been an increase in concern about the influence of climate change and human activity on future wildfire and that comparatively little is actually known about the importance of these factors on wildfire. Such changes would have significant impacts on species abundance, distribution, ecosystem dynamics, and on both atmospheric and biogeochemical cycles, impacting the climate (Zinck and others 2011).

Fire regime and an understanding of organism response to wildfire is essential for ecological management of any natural system and the conservation of biodiversity as changes to the natural cycle of wildfires can negatively impact constituent species structure, abundance, distribution and density (Driscoll and others 2010; Farnsworth and others 2014). This brings into question whether pyrodiversity begets biodiversity, as Farnsworth and others (2014) argue the importance of scale when burning for biodiversity.

Fire regimes comprise of fire interval, intensity, season, frequency, sequence of fires and the temporal, spatial fire history and patch mosaic dynamics (Parr and Andersen 2006). Fire regimes are used to manage ecosystems to achieve conservation goals by focusing on the landscape scale to maintain spatially heterogeneous patches of different fire history (Kelly and others 2012). According to Barrett and others (2013) an understanding of the patterns of the spatially heterogeneity is important for predicting future fire regime shifts at regional scales. Within this context any inappropriate fire regimes would negatively impact organisms within the fire prone ecosystem on the landscape scale (Avitabile and others 2013) and act as a key threatening process to some of the ecosystems organisms (Avitabile and others 2013).

Wildfire regimes have changed over time for any given climate or vegetation group due to human influence (Martin and Sapsis 1991) and are expected to change (Thonicke and others 2013) unexpectedly and rapidly in response to future climate change. This change will impact all fire prone ecosystems on the planet changing the complex spatiotemporal patterns of vegetation biomass, composition, and structure (McKenzie and others 2011).

Australian Fire Regimes

Fire is an essential process in the Australian landscape and its ecosystems, playing a vital role in plant evolution, distribution, and adaptation (Watson and others 2004). Cary and others (2012) state that fire has been evident in Australia from charcoal records since the Paleogene Period (65 mya) and throughout the Neogene period to present. According to Lynch and others (2007) fires have been a consistent feature within the Australian landscape, increasing in importance with the evolution of the sclerophyll vegetation and in determining the distribution of fire sensitive vegetation such as rain forest communities (Bowman 1998; Enright and Thomas 2008). Natural fire regimes created self-sustaining eucalypt ecosystems, an important evolutionary driver of the Australian landscape, creating a dynamic equilibrium (Jurskis 2005b) maintaining eucalypts and other sclerophyll taxa as the dominate species. It is also suggested that fires may increase within periods of climate warming, which is supported by the close relationship between fire and ENSO (Lynch and others 2007; Cary and others 2012). Mooney and others (2011) suggests that the important evolutionary role of fire in Australia led to the development of plant responses to fire with morphological and reproductive adaptations to fire such as resprouting and obligate seeders. The palaeoenvironmental records show a consistent response to climate change by fire and that this response is rapid, where there are fewer fires under colder climates compared with warmer climate with a greater number of fires (Mooney and others 2012).

Enright and Thomas (2008) suggest that almost all fire ignitions prior to the arrival of people on the Australian continent would have been the result of lightning strikes and that the frequency of ground flash lightning shows a strong north to south gradient. This is in agreement with Murphy and others (2013) in that Australian fire regimes are related to the latitudinal gradient in the summer monsoon, where frequent low intensity fires occur in the tropical rainfall regions of the north with infrequent high intensity fires in the temperate southern regions (Murphy and others 2013). The latitudinal gradient is postulated as the main driver of fire regime on the continental scale by Murphy and others (2013) and not biomass accumulation. Further Murphy and others (2013) states that Australian fire regimes are relatively frequent surface fires of grasses and herbage in the different vegetation types of the continent. The spatial arrangement of fire regimes and the influence on the viability of species is poorly understood in an Australian context (Driscoll and others 2010).

Collins and others, (2013) found that precipitation regimes play an important role within wildfire regimes including spatial fire severity. Future fire management strategies will need to be adaptable to spatial variation in mean annual precipitation with changes in future climates. In support of Driscoll and others (2010), Haberle and others (2010) state that "current severe drought and plant mortalities are increasing fire hazard and raising concerns about the trajectory of post-fire vegetation change and future fire regimes" (p. 80) in Australia, indicating further research is required to answer what possible changes to vegetation may arise and what are possible future fire regimes.

Bowman and others (2012) say that there is mounting concern that wildfire frequency and intensity could increase with climate change. Fire regimes are affected by fire weather and fuel characteristics, and there is evidence of an increase in fire weather in southern Australia. Dunlop and Brown (2008) question as to how we should respond to the changing fire regimes. They suggest that we manage the consequences of a changing fire regime, ensuring habitat survival for sensitive species and human infrastructure.

Fire regime on the landscape scale level involves a range of spatiotemporal disturbance variables which has led to the belief that diversity in fire regime would promote biodiversity (Faivre and others 2011). According to Pastro and others, (2011) there is evidence that ecosystem heterogeneity created by burning patches of vegetation can increase biodiversity; an example is the spinifex grasslands of central Australia where fire heterogeneity increases mammal and reptile diversity. However it must be pointed out that fauna and flora in Australia are resilient to fire and therefore there is little if any differentiation between assemblages found in unburnt and burnt habitats (Pastro and others 2011). The ecological balance in many Australian eucalypt ecosystems has been upset through changes in fire regimes with the exclusion of fire by Europeans, which has resulted in a decline in both the abundance and health of these systems (Attiwill 1994; Jurkis 2005a; Jurkis 2005b).

The Great Sandy Region

In Queensland fire has been recorded from charcoal taken from sediment core samples as early as 130 000 years ago as a result of dry conditions at the end of the penultimate glacial period in combination with the phase of high ENSO activity (Moss and Kershaw 2007). Evidence of anthropogenic fires first date to around 45 000 years ago with the advent of Aboriginal occupation and fire stick practises (Fensham 1997; Turney and others 2001; Moss and Kershaw 2007; Moss 2008). Aboriginal burning continued until the settlement of Europeans in the 1800s, when there was a shift in fire regimes with an increase in anthropogenic fires (Haberle and others 2010) supported by an increase in charcoal deposits during that period.

The GSR is dominated by eucalyptus woodlands, mangrove forests, peat swamps and coastal heath plant communities (Figure 2) that are fire promoting and highly flammable (Moss and others 2012) and rainforest. Fraser Island has important mycorrhizal fungi occurring naturally in the sand providing nutrients for the diverse plant community occurring on the island (Kurtböke and others 2007). In the GSR fire history records have been collected and are well documented using radio-carbon dating and charcoal records. Moss and others (2013) state that there are "three records of vegetation and burning from North Stradbroke Island provide the first continuous records extending past the Last Glacial Maxima" (p. 270) to around 47000 years BP. According to Moss and others (2011) research undertaken at Myora Springs on North Stradbroke Island indicates a link between a warm ENSO and drought between 800 to 500 years ago that promoted an increase in burning and flammable vegetation such as open eucalyptus forests and Melaleuca paperbark swamp.

Research undertaken by Longmore (1997) shows that the GSR, and in particular Fraser Island, has undergone substantial changes in vegetation community structure over time from climax through to advanced retrogressive stages. The vegetation has changed from a predominantly rain forest with *Araucaria* sp. to a dryer rainforest with *Podocarpus* sp. between 600ka to 350ka to more sclerophyllous forest until before the Last Glacial Maximum (LGM). This change in the plant community was primarily driven by climate change and accelerated by increased burning. According to Longmore and Heijnis (1999) evidence of fire is low at the start of the record, but increases from around 350ka to the LGM, thereafter increasing with frequent fire records during the Holocene. Changes to the island's vegetation are thought to have been through succession, fire and climatic change (Longmore and Heijnis (1999). Around 500 years ago a cool ENSO persisted and the vegetation shifted once again to a fire sensitive Casuarinaceae dominated landscape (Moss and others 2011). According to Moss and others (2012b), there was a regional shift in fire regimes of the Sand Masses associated with European settlement, with a decline in burning and an expansion in eucalyptus and corresponding decline in Casuarinaceae, which needs

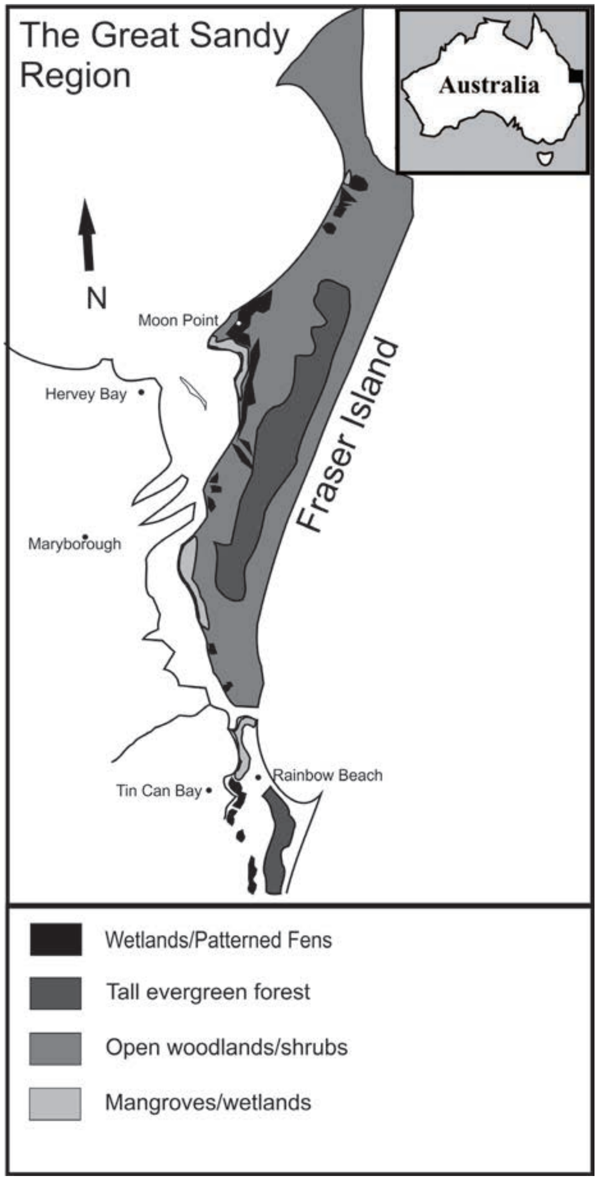

Figure 2—Map showing the location of the Great Sandy Region in relation to the Australia east coast and the four dominant vegetation communities of the region showing the location of rain forest or tall evergreen forest, mangrove swamp and wetlands, open eucalyptus woodlands and the peat swamp or patterned fens.

further investigation as to why there was a decline in fire sensitive plants (Moss personnel communication).

Late Quaternary fire regimes of the Sand Masses of south east Queensland are extremely complex according to Moss, and others (2012b); site location could be a factor in determining the dominance of either anthropogenic or climate factors as the control (Moss and others 2012b). Questions resulting from this research asked by Moss and others (2012b) include what are the long-term ecological impacts of altered fire regimes on biodiversity, what are the vegetation shifts across the region and what factors are behind the higher fire regimes of the pre-European arrival to the region?

According to Jurskis (2005b) fires were ignited by lightning and Aborigines over time and space; however, the extent of these fires were governed by climatic and edaphic conditions. Research by Fensham (1997) shows that Aboriginal burning during the initial contact with Europeans was prevalent along the coast of Queensland with high frequency of fires occurring compared with infrequent burning undertaken inland and with limited fires being lit in the summer and spring months.

Present fire regimes of the region are managed by the Queensland Government's Department of National Parks, Recreation, Sport and Racing through prescribed burning and wildfire management. Fire is managed according to fire protection policy, biodiversity conservation and through fuel reduction activities. According to Hocking (1998) monitoring the impacts of fire on Fraser Island vegetation consists of two elements, fixed point photography of before and after (fire events) and fixed plots using the standard Braun-Blanquet method. Prescribed burning is undertaken for ecological burning, hazard reduction burning, wildfire suppression activities, or burning for weed control and site rehabilitation for the purpose of the protection of life and property, and to ensure the maintenance of biodiversity through continued natural processes (Queensland Government 1994).

Conclusion

Fire has been recorded since the advent of the first vascular plants, and fire regimes have shifted with changing climatic and atmospheric oxygen levels (Pausas and Keeley. 2009) driving evolutionary processes of ecosystems such as distribution and composition of species. These shifts in fire regime continued and were modified by humans through migration, settlements, and land clearing practices over the millennia further impacting ecosystem dynamics and composition. Aboriginal and European settlers in Australia have had a substantial impact on natural fire regimes altering natural ecosystems to and from fire tolerant species depending on the fire regimes at that time.

According to Driscoll and others (2010) quantification of fire regimes is still unknown and in its infancy and how species are influenced by the spatial arrangement and temporal sequences of fires. Parr and Andersen (2005) suggest that the "ecological significance of different burning patterns is still unknown and has led to fire-management plans being based on pyrodiversity rhetoric that lacks substance in terms of operational guidelines and capacity for meaningful evaluation" (p. 1610).

Further unknown factors are how herbivory, predation, fragmentation, invasive species and weather interact with fire to alter species responses to fire directly, or via changes to the fire regime (Driscoll and others 2010). Lastly what are the long-term ecological impacts of an altered fire regime for the conservation of south-east Queensland's biodiversity (Moss and others 2012b). The answers to these questions are paramount to successful management of future fire regimes of the region.

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The content of this paper reflects the views of the authors, who are responsible for the facts and accuracy of the information presented herein.