

# **FIRE IN COASTAL WETLANDS – IMPLICATIONS FOR MANAGEMENT**

**G Schneider<sup>1</sup> & S Sutherland<sup>1</sup>**

<sup>1</sup>NSW Land and Property Management Authority

## **Abstract**

With climate change and urban expansion on the coastal fringe impacting on local communities and their environment, the biodiversity requirements and management strategies to deal with bushfire in coastal ecosystems are increasingly critical.

Coastal wetlands identified by State Environmental Planning Policy No. 14 (SEPP 14) occur in conjunction with a range of coastal vegetation types particularly Endangered Ecological Communities. Although the majority of these vegetation types are fire adapted, patterns of NSW coastal development have placed urban areas in proximity to approximately 35,000ha of SEPP 14 posing a serious risk of bushfire impacting on human life and property.

Wildfire frequency, intensity and associated suppression activities may adversely affect environmental and cultural values of wetlands. Prescribed burning, in combination with planning and implementation of a suite of bushfire hazard reduction activities is preferred and necessary to reduce fire-induced damage to biodiversity, human life, property and cultural values.

There are complicated and sometimes conflicting issues associated with any hazard reduction activity including burns, maintenance of asset protection zones and fire trails. Life and property considerations are balanced with environmental impacts. The majority of hazard reduction activities in NSW are now carried out using streamlined environmental approval processes. However, areas identified as SEPP 14 require an Environmental Impact Statement, and Local and State Government approval for non-exempt activities including hazard reduction.

Land managers, fire authorities and their communities are faced with a high level of bushfire risk in coastal wetland areas due to climate change, the cost and complexity of both obtaining approval, planning, assessing and physically implementing the works. A case study and a number of scenarios and proposals are investigated where integrated management solutions can achieve appropriate bushfire risk management and biodiversity outcomes.

## **Climate change, fire weather & intensity**

Peak research organisations including the Commonwealth Science and Industrial Research Organisation (CSIRO) and the Bushfire Cooperative Research Centre (CRC) have reported that there will be impacts of climate change on fire weather on the NSW coastal fringe. The CSIRO undertook fire weather modelling under a number of climate change scenarios in south eastern Australia for 2020 and 2050 and found that (Bushfire CRC, 2006a):

- The number of very high and extreme fire weather days could increase between 4-25 percent by 2020 and 15-70 percent by 2050 across parts of south eastern Australia.
- The changes would be greatest in the inland and relatively less along the coast and in Tasmania.
- Higher fire weather risk in spring, summer and autumn will shift periods suitable for prescribed burning more towards winter.

The Bushfire CRC report by Hennessy *et al* (2006) stated:

“The south-east region of Australia is particularly vulnerable to bushfire - along with southern California and southern France it is identified as one of the three most fire-prone areas in the world. It is therefore critical that we prepare for the potential of increased fire risk associated with the hotter and drier years we may experience in the future.”

The above scenarios indicate to the NSW land manager that in areas occupying or adjacent coastal wetlands, bushfire frequency and intensity will increase. With this increase, it is inevitable that the risk to adjoining life and property assets (including environmental and cultural assets) will also increase. Similarly, the possibility that conditions in current bushfire-prone areas may become hotter, drier, and/or windier or that such areas may experience more frequent extreme ‘fire weather’ days, must be factored into future planning particularly by government, researchers, fire authorities, land managers and the community.

It is also worth noting other impacts to, or arising from any projected increase in fire occurrence within and adjacent coastal wetlands. For example, the increased frequency and/or intensity of aeolian dust and fire-borne particulates predicted by increased fire and associated wind can affect coastal productivity and promote blooms (DPI, undated). Additionally, any efforts and economic arrangements for the State of NSW associated with reducing greenhouse gas emissions associated with bushfire or sequestering carbon through vegetation sinks will depend on managing the impacts of bushfire.

There are also consequences for the distribution of coastal wetlands as a result of projected sea level rise caused by climate change. For example, it is predicted that the saltwater/freshwater interface will move further inland; existing wetlands will be flooded more regularly and to a greater depth (they will become wetland lagoons); new wetlands will develop in low lying areas along estuaries; and the changes to water and salinity levels will change the distribution of aquatic and terrestrial flora and fauna along the estuary, with existing habitats and ecosystems tending to migrate inland (DNR, undated). One can speculate that this shift will bring wetland fires closer to the doorstep of coastal development.

## **Ecological requirements for fire in wetlands**

Designated State Environmental Planning Policy No. 14 (SEPP 14) wetlands occur in conjunction with a range of coastal vegetation types particularly Endangered Ecological Communities (EECs). In the criteria used by Adam *et al* (1985) these designated wetlands are mapped into seven broad types: Mangroves; Sedgelands; Saltmarsh; Melaleuca Forests; Casuarina Forests; Brackish and Freshwater Swamps; and Wet Meadows.

These wetland types have been interpreted utilising descriptions by authors such as Winning (1991) and categorised into the following Keith (2004) vegetation formations and biodiversity fire intervals for Strategic Fire Advantage Zones (SFAZ) and Land Management Zones (LMZ) as described by the NSW Rural Fire Service (RFS (2006)):

Broad wetland type#	Interpreted / estimated equivalent Vegetation Formation*	Minimum fire interval for SFAZ (years)*	Minimum Fire Interval for LMZ (years)*	Maximum Fire Interval for SFAZ & LMZ (years)##
Mangroves & Saltmarsh	Saline wetlands	No burning permitted	No burning permitted	No burning permitted
Sedgeland; Brackish & Freshwater Swamps; Wet Meadows	Freshwater wetlands	7	10	35
Melaleuca & Casuarina Forests	Forested wetlands	7	10	35

# (as described by Adam *et al* (1985))

\* (interpreted / estimated equivalent Keith (2004) Vegetation Formation);

## (as described by Bush Fire Research Group (2002) based on (Keith 2002)).

Of the above listed equivalent vegetation formations identified by Keith (2004), the following Coastal Floodplain EECs, listed under the *NSW Threatened Species Conservation Act 1995* are considered to occur within these vegetation formations within the NSW North Coast, Sydney Basin and South East Corner bioregions:

- **Swamp oak floodplain forest;**
- **Freshwater wetlands on coastal floodplains;**
- **Swamp sclerophyll forest;**
- **Coastal saltmarsh;**
- **River-flat Eucalypt forest; #**
- **Sub-tropical Eucalypt forest on coastal floodplains #;** (Only occurs in the NSW North Coast Bioregion)

# excluded from SEPP 14 mapping

The majority of these vegetation types are fire adapted, with most of the flora species within these vegetation types exhibiting two main strategies for survival: they are either 'seeders' or 'sprouters'.

Minimum fire intervals for vegetation types are based on the minimum maturity requirements of species sensitive to extinction under frequent fire regimes. Therefore the minimum interval is the length of inter-fire-interval that should avoid any local species extinctions. The maximum fire interval indicates the time since fire at which it may be expected that species may be lost from the community due to senescence and is largely based on assumptions and generalisation for lifespan and seed bank longevity. If the fire history of a reserve is such that over 50% of any one vegetation formation falls outside of the appropriate domain, serious conservation consequences are predicted. (National Parks & Wildlife Service (NPWS) 2002)

The fire regime, as determined by fire frequency, intensity and seasonal pattern differentiation, is the pattern of multiple fires over time (Department of Environment and Climate Change (DECC) 2007). The combination of varying fire regimes within a landscape creates a mosaic enabling a more diverse range of native flora and fauna species to exist within this landscape. We can therefore assume that if our wetland areas containing vegetation requiring fire for the maintenance of ecological integrity are not exposed to appropriate fire regimes, then the long term ecological integrity of our freshwater and forested wetlands are under threat. This is extensive given the association of coastal wetlands with the expanding urban interface and the associated problems with conducting prescribed burning activities, especially within SEPP 14 as discussed below.

## **SEPP 14 Coastal Wetlands and the urban interface**

Over 80% of the Australian population lives in the coastal zone, with significant recent non-metropolitan population growth (Harvey and Caton, (2003) in Hennessey *et al* (2007)). A significant portion of this population is located along the eastern coastline, where Chen and McAneney (2006) in Hennessey *et al* (2007) suggest that more than 426,000 New South Wales and Queensland addresses (from the National Geo-coded Address File) at that time were within 3km of the coast and less than 6m above sea level.

A coarse Geographic Information System (GIS) intersection analysis was recently undertaken to provide an indication of the area of SEPP 14 mapping that occurs within proximity to urban areas in NSW. A spatial data set of urban areas from the NSW Land and Property Management Authority's Spatial Data Warehouse was used with a 120 metre wide buffer on its perimeter. It enabled the application of distance from unmanaged vegetation to these urban areas where the mechanics bushfire attack illustrate wildfire has the most impact on built assets. Spatial data from the NSW Department of Planning (DoP) of SEPP 14 mapping (DoP 2006 in CANRI 2009) was then selected where it intersected with the buffered area of the urban dataset.

This analysis identified an area of almost 35,000 hectares or 360 separate mapped wetland areas within close proximity to urban areas. A number of shortfalls are recognised in this analysis including the currency of the data, omission of rural residential type developments and the identification of SEPP 14 areas of low flammability vegetation types such as saltmarsh. However it does give an indication of the magnitude of the issue that can be refined with more defined data sets and analysis. It is also worth noting that SEPP 14 wetland areas usually occur across the landscape in conjunction with a variety of other fire adapted and ecologically distinct vegetation communities including coastal heaths.

## **SEPP 14 and its impact on fire management activities**

There are more than 1,578 (or 96,650 hectares, (DoP 2006 in CANRI 2009) of coastal wetlands of State significance that are mapped under SEPP 14. Areas mapped as designated wetlands by the original 1985 mapping extend along the entire NSW coastline (and up to 30kms inland), however they exclude the coastline associated with greater Sydney, between the Hawkesbury River to the north through to Wollongong in the south ((CANRI 2009).

SEPP 14 areas were identified through aerial photograph interpretation at a scale of 1:25,000 (Adam *et al* 1985). To the bush fire management practitioner, this is a coarse scale when trying to implement works at a property boundary and urban interface level. Given that the legal definition of SEPP 14 is the outer edge of the area depicted on the survey mapping performed by Adam *et al* (1985), the boundaries of SEPP 14 are often inaccurate with the width of the line being approximately 25m (Winning 1991, and CANRI 2009). This has wider implications for undertaking bushfire hazard reduction activities, particularly associated with mechanical works such as the construction and maintenance of bush fire Asset Protection Zones (APZs) and fire trails where defensible space is less than 25 m and fire trails are around 6m wide.

Coastal wetlands identified by SEPP 14 have defined planning and development controls for activities proposed in them under the *NSW Environmental Planning and Assessment Act 1979*. The SEPP identifies any activities involving clearing defined as “the destruction, or removal in any manner of native plants growing on the land” and requires development consent from local council and concurrence of the Director General of Department of Planning and must be accompanied by an Environmental Impact Statement (EIS) as designated development (CANRI 2009). The only exemptions are for the removal of noxious weeds, boundary fencing and surveying. There are no exemptions identified for fire management activities such as burning or provision of APZs and fire trails.

Resource strapped land managers and fire authorities are often unwilling or unable to deal with the cost and complexities of attempting to prepare an EIS and carry out the assessment for proposed activities. As a result many developed areas that are at significant risk under extreme fire conditions are left in the ‘too hard basket’. An interesting scenario occurs when a National Park (where the SEPP does not apply) adjoining mapped SEPP 14 areas on other tenure types are subject to different processes of approval, in Park a Certificate or REF as opposed to an EIS elsewhere. This increases the complexity of managing fire at a supposedly tenure blind landscape level as is rightfully promoted contemporarily.

For extended periods of any season or climatic event wetland areas are often too wet and inaccessible to achieve any sort of fire management activities. There exists a narrow window of opportunity to implement any fire management activities while conditions are appropriate and do not become volatile or ineffective. There is also a very poor understanding of the ecological requirements of various vegetation formations’ response to fire amongst land managers, the scientific community and other decision makers.

## **Wildfire, prescribed burning and its complexity**

Wildfire frequency, intensity and associated suppression activities may adversely affect environmental and cultural values of wetlands. They are not carried out with regard to environmental values. They are regularly as a result of arson occurring in the early afternoon, on weekends, or during school holidays. To compound the inappropriate fire regime that wildfire causes, these fires are often underway during high and extreme fire weather days, resulting in high intensity fires that can burn through to the canopy and dramatically deplete ground seed stores of fire tolerant flora species. In these conditions fire authorities are often left with little choice other than to implement physical construction of fire breaks with earthmoving machinery or back burning operations often creating undesirable impacts on wetlands. The use of machinery and heavy fire fighting vehicles also has the potential to expose acid sulphate soils with additional downstream impacts.

Prescribed burning, in combination with planning and implementation of a suite of bushfire hazard reduction activities is preferred and necessary to reduce fire-induced damage to biodiversity, human life, property and cultural values. Although high intensity fires can provide for fire heterogeneity, frequent high intensity wildfire that may be associated with wetlands along the urban interface reduce biodiversity by promoting species that favour these conditions over more fire sensitive species. Other areas are too long without fire and are at risk of being underburnt. The balancing act is to maintain a variability of fire regimes across fragments of landscape intersected by human development.

## **The complex nature of bushfire management activities**

There are complex and often conflicting issues associated with any bushfire management activity including burns, maintenance of APZs and fire trails. Life and property considerations are balanced with diverse social and environmental impacts and benefits. Interface bushland areas can be both highly valued and feared by adjoining residents, it is not uncommon to have completely polarised views and opinions in one street regarding fire management and individual perceptions of risk. Implementing fire management activities could be likened to waiting for all planets to align before hazard reduction works can proceed.

The following is a list of some of the main considerations and issues that should be considered when planning for hazard reduction burns in wetland areas. It also includes just some of the considerations prior to undertaking fire trail or APZ maintenance:

1. Application of the appropriate fire regime, including prescribing and identifying the appropriate frequency, and fire season conditions to achieve the desired intensity; requires monitoring of fuel loads and moisture content to ensure that a burn can be implemented as prescribed and to provide intelligence on expected fire intensity contours;
2. Appropriate weather conditions: temperature, relative humidity, wind speed and direction, atmospheric stability and rainfall are significant factors which will influence the way fires behave, spread and therefore influence the ease or otherwise of the fire suppression task (RFS, undated). Finding the appropriate weather conditions can dramatically reduce the opportunity to undertake prescribed burns;
3. Ensuring that the fire regime, is appropriate for the vegetation formations including the fire interval threshold for any threatened flora and fauna species and EECs known or likely to occur onsite;
4. Ensuring that Aboriginal and other cultural heritage issues are identified and addressed. This may include undertaking fee for service cultural heritage assessments;
5. Addressing peat soils. This is generally unique to coastal wetlands as they are often associated with peat soils that under drier conditions can ignite and continue to burn underground until waterlogging occurs. Prescription burns in coastal wetlands should therefore be undertaken when the ground is sufficiently waterlogged to prevent ignition of the peat soil profile;
6. Addressing community health and safety issues. It is common to find retirement villages and medical centres located on the coastal fringe adjacent bushland / wetland areas. Consideration of community health and safety, particularly in

- relation to the frail or elderly can require extended notification and additional prescribed burn planning responsibilities;
7. Notifying and liaising with stakeholder groups and neighbouring landholders. This is often a difficult task due to sometime conflicting agendas and the difficulty in contacting these groups. For example, the local koala rescue group may need to be involved to undertake site surveys prior to and directly after the prescribed burn in known koala colony forested wetland habitat. These volunteers are important in locating koalas and if necessary assisting to plan fire ignitions to minimise risk from prescribed burn activities.
  8. Access management issues associated with implementing burns on the fringes of reserves on the urban interface are a major consideration in the larger populated centres along the NSW coastline. Access points from the urban fringe into coastal bushland areas are often facilitated by the removal of vegetation following prescribed burning. Additionally, the clearing required for the APZs and fire trails utilised for managing bushfire at the urban interface will facilitate public access into these reserves. Unfortunately, if access management such as appropriate gating, fencing / bollards and signage is not in place, then these areas are also more vulnerable to arson and associated activities such as the dumping of stolen vehicles and rubbish;
  9. Assessing the surrounding landscape to identify if the prescribed burn activity is also suitable for the transitional vegetation formations and adjacent areas inhabited by threatened species. For example, heath and coastal woodlands can often be associated with coastal wetlands, yet have different fire intensity and fire frequency interval requirements. Heath burns often in high intensity fires which may not always be appropriate given the proximity of urban development adjacent the wetland;
  10. Ensuring that the bushfire control lines have been identified and are installed and operational. This may include upgrade and maintenance of APZs, fire trails, mechanical or manual control lines. These are important in ensuring that the burn doesn't escape to adjacent areas of bushland or property assets that are inappropriate to burn;
  11. Ensuring the availability of resources for undertaking prescribed burning activities – including the provision of fire control units and their staffing (RFS volunteers often only available evenings and weekends); funding for operational expenses such as food / refreshments, fuels for vehicles and equipment and occasionally funding for aircraft use, such as for dropping aerial incendiaries and reconnaissance.

### ***Case Study***

#### ***Fire Management within Belmont Wetlands State Park***

Belmont Wetlands was established in 2006 as the 10th State Park in NSW covering 514 hectares of former BHP land located between the suburbs of Redhead and Belmont on the east coast of Lake Macquarie City Council Local Government Area within the Hunter Region. The site was proclaimed by the NSW Government on 3 March 2006 as Crown Reserve No.1011388 for Public Recreation, Coastal Environmental Protection and Tourist Facilities and Services.

Belmont Wetlands State Park (BWSP) has significant natural and cultural heritage values and its local and regional significance is considerable as it forms part of the largest remaining coastal wetland system in the Lake Macquarie LGA and occupies approximately 4.5km of beach frontage. The wetlands and coastal areas of BWSP have links to

Aboriginal culture and mythology; for example Belmont Lagoon has cultural significance to Aboriginal people as a gathering area and is the subject of a Dreamtime creation legend about *The Night the Moon Cried*. (Andrews Neil Urban Design Group 2009)

A Plan of Management for BWSP is currently on exhibition detailing among numerous things the land management issues of the site. This site has historically been, and in some instances continues to be subject to such problems as arson attack, rubbish dumping, anti-social behaviour, unauthorised car and motorbike activity, and extensive infestations of weeds and feral animals. Much of the site had been sand mined; however a significant complex of freshwater wetlands and lagoons of varying integrity exist within the State Park.

Bushfire management strategies within the State Park have been evolving since its proclamation. They include the establishment of bushfire APZs, SFAZs, and fire trails to protect the neighbours from arson induced fire emanating from the State Park and vice versa. As it is a requirement of the *NSW Rural Fires Act 1997* that landowners implement appropriate bushfire mitigation measures to prevent fire escaping and impacting on adjoining properties, the establishment of APZs and repair of fire trails were seen as a priority.

Many of the fire trails have existed for well over 20 years and in many cases longer. As part of the bushfire management planning for the site, the fire trail complex has been rationalised, with only the most *Important* and *Essential* trails (as defined in the Bush Fire Coordinating Committee Policy No 2/2007) to be kept as registered fire trails on the Lake Macquarie Bush Fire Management Committee Fire Trail Register.

These fire trails are critical for compartmentalisation and safe implementation of prescribed burns by fire fighting personnel and for the efficient operation of their equipment. The fire trails within the State Park are also critical for assisting in controlling bushfire initiated by regular arson attack that has resulted in some vegetation formations being burnt below their minimum fire interval threshold.

Several of these trails have existed for decades within the mapped SEPP14. The actual boundary of the SEPP 14 clearly does not reflect the true wetland boundary on the ground. However as these trails dissect, or in some cases merely skim the SEPP 14, an EIS is required for simply trittering encroaching vegetation or environmental weeds from the trail verges, or grading / draining / filling the trail surface. Therefore the overriding benefits of having the fire trail maintained to reduce arson and inappropriate fire regimes in some parts of the State Park are impeded by the requirement to undertake an EIS for these minimal maintenance requirements. To complicate matters, SEPP 14 requirements for an EIS extend to the maintenance of APZs (critical for the protection of human life and property); and prescribed burning activities, even though the fire may be important for the ecological integrity of the wetland through weed control and keeping below the maximum fire frequency threshold of the vegetation.

## **Existing bushfire planning instruments**

To assist with some of the considerations outlined above, the majority of bushfire hazard reduction activities in NSW are now carried out using streamlined environmental approval processes.

The Infrastructure SEPP 2007 identifies a range of bushfire management activities that are exempt from consent as long as they are consistent with a bushfire risk management plan applicable to the land but it excludes SEPP 14 areas. The Infrastructure SEPP, and the Bush Fire Environmental Assessment Code (the 'Code') prepared by the RFS (2006), provide streamlined environmental approval processes for identified and arguably essential bushfire hazard reduction works. In many cases it can be argued that the higher level of environmental review from an EIS produces a very similar outcome to a Review of Environmental Factors (REF) when alternative options and scenarios are considered.

For most public and private land in NSW, the Code provides a streamlined environmental assessment process for use by issuing authorities and certifying authorities in determining bushfire hazard reduction certificates ('Certificates') for prescribed burning and the maintenance of APZs. The Code is prepared pursuant to sections 100J to 100N of the *Rural Fires Act 1997* and only covers works carried out in accordance with a bushfire risk management plan that applies to that land within APZs, SFAZs and LMZs.

Although there are some limitations to which the Code applies, it provides comprehensive guidance and standards on most of the environmental issues that would otherwise make it extremely difficult to implement mechanical hazard reduction works and prescribed burning hazard reduction works. Such guidance and standards within the Code (RFS 2006) include:

- Standards to prevent soil erosion and instability;
- Standards for the protection of riparian buffers;
- Standards for the protection of native vegetation;
- Standards for the protection of biodiversity, including threatened species, Endangered Ecological Communities, fire regimes and fire interval thresholds;
- Standards for the protection of Aboriginal heritage;
- Standards for the protection of other cultural heritage;
- Standards for the protection of significant environmental protection areas;
- Standards relating to weeds;
- Type of burn (burn intensity and situation);
- Construction of control lines;
- Fire permits;
- Notification of fire fighting authorities;
- No burn days;
- Standards relating to the effects of smoke;

However under section 100A of the *Rural Fires Act 1997*, a Certificate cannot be issued for bushfire hazard reduction activities on that land under this Code to which SEPP 14 applies. Similarly, a Certificate cannot be issued under the code, except where works involve only the manual removal of noxious or environmental weeds in saline wetlands and coastal freshwater lagoon vegetation formations. Nor can Certificates be issued for the construction or maintenance of fire trails, or burning for bush regeneration or ecological purposes. (RFS 2006)

Many of the transitional and surrounding vegetation formations within proximity of SEPP 14 can have bushfire hazard reduction activities carried out under the Code or Infrastructure SEPP. However as there is a legal requirement to provide an EIS for any works within the areas mapped as SEPP 14, including maintenance of existing control lines and fire trails, control lines are being installed by some land managers on the outside perimeter of SEPP 14 to overcome the need to undertake an EIS for prescribed burning and associated containment activities. Unfortunately, the installation of control lines

around SEPP 14 are often detrimental to the adjacent vegetation, disturbing the ground surface and opening up opportunity for undesirable impacts such as human and vehicle access, and weed invasion.

## **Conclusion**

Forecast impacts of climate change and fire weather demonstrate the need for improved fire management practices on the NSW coastal fringe. The cost and complexity of obtaining approval, planning, assessing and physically implementing fire management activities, are currently impeding works in wetland areas including SEPP 14.

The requirement for an EIS to carry out essential fire management works in SEPP 14 areas has the potential to impact on coastal wetland ecology and integrity and place adjoining communities at elevated risk from wildfire impacts. Resource strapped land managers and fire authorities are often unwilling or unable to tackle the cost and complexities of attempting to prepare an EIS and carry out the assessment for proposed activities. As a result many developed areas at significant risk under extreme fire conditions are left in the 'too hard basket'. While the acceptance of 'residual risk' may be appropriate in extenuating circumstances it must be demonstrated that viable alternatives have been considered.

Land managers, fire authorities and communities are currently faced with a high level of bushfire risk in coastal wetland areas where forested wetlands occur on the urban interface particularly those identified by SEPP 14. There are options whereby integrated management solutions can assist with overcoming outdated and / or inappropriate constraints that reduce the effectiveness of bushfire management activities. The following proposed recommendations may provide some options to assist in making our coastal communities safer and our wetlands healthier:

## ***Recommendations***

1. All planning for coastal development must take into account the need for adequate buffers around wetland areas, and in particular SEPP 14. These buffers need to consider the edge effects that the development has on the wetland, including the provision for bush fire management strategies that are required for ongoing management of the wetland, such as APZs and fire trails. The edge effects of APZs and fire trails must also be considered in the planning and should be contained where appropriate within the proponents land and not impact adjoining wetland areas;
2. Re-assessment of SEPP 14 boundaries is required with improved aerial photography and understanding of vegetation formations to include eucalypt component wetlands;
3. Provision for a Review of Environmental Factors (REF) type assessment process to establish at least a minimum defendable space and APZs adjacent existing developed areas where life and property is at imminent extreme risk of bushfire
4. Fire tolerant wetland vegetation formations identified by SEPP 14 should be able to be assessed under their relevant EEC conditions under the Code for implementation of prescribed burning activities;

5. Existing registered fire trails on Bush Fire Management Committee registers should be assessed for routine maintenance activities under the Infrastructure SEPP 2007, and be exempt under SEPP 14;
6. Utilise integrated bushfire management solutions to achieve appropriate bushfire risk management and biodiversity outcomes, including the establishment and implementation of APZs, SFAZs, LMZs, registered fire trails and control lines. Indirect strategies are also critical, including community education and engagement; access management and signage;

## References

Adam, P., Unwin, N., Weiner, P. & Sim, I. (1985) *Coastal wetlands of New South Wales: A survey and report prepared for the Coastal Council of New South Wales*. Coastal Council of NSW, Sydney.

Andrews Neil Urban Design Group (2009) *Draft Plan of Management (PoM) Belmont Wetlands State Park, September 2009*. Final Draft PoM released for public exhibition. Belmont Wetlands State Park Trust and NSW Land and Property Management Authority.

Bush Fire Research Group (2002) *Fire Interval Guidelines for Broad Vegetation Types*. Biodiversity Strategy funded project 'Development of Guidelines for Ecologically Sustainable Fire Management' (Biodiversity Strategy Priority Action 43: Manage fire in accordance with ESD principles). NSW National Parks & Wildlife Service.

Bushfire CRC (Cooperative Research Centre) (2006a) *Climate change impacts on fire. Bushfire CRC Update 1*, Bushfire CRC, East Melbourne, Victoria. Accessed 30.9.09 at: <http://www.bushfirecrc.com/publications/downloads/Update%201.pdf>

Bush Fire Coordinating Committee Policy No. 3/2007 – Fire Trails.

CANRI 2009 – Community Access to Natural Resource Information 2009 Coastal Wetlands (State Environment Planning Policy No. 14) – SEPP 14. Accessed 01.10.2009 at: Also  
<http://www.canri.nsw.gov.au/nrdd/records/ANZNS0157000002.html>

Chen, K. and McAneney, J. (2006) *High-resolution estimates of Australia's coastal population with validations of global population, shoreline and elevation datasets*. Geophys. Res. Lett., 33, L16601. doi:10.1029/2006GL026981.

Department of Environment and Climate Change (2007) *Fire in the NSW Environment*. Department of Environment and Climate Change NSW, Sydney South.

DNR (NSW Department of Natural Resources) (undated). *Estuaries Fact Sheets: Human Impacts*. Accessed 30.9.09 at: [http://www.dnr.nsw.gov.au/estuaries/factsheets/humanimpacts/climate\\_change.shtml](http://www.dnr.nsw.gov.au/estuaries/factsheets/humanimpacts/climate_change.shtml)

DoP (NSW Department of Planning) (undated) *State Environment Planning Policies*. Accessed 04.10.2009 at:

(<http://www.planning.nsw.gov.au/PlanningSystem/Legislationandplanninginstruments/ListofStatePolicies/tabid/78/Default.aspx>;) )

DPI (NSW Department of Primary Industries) (undated) *Projected impacts of climate changes on fishing and aquaculture*. Accessed 30.9.09 at:

<http://www.dpi.nsw.gov.au/research/topics/climate-change/fishing-and-aquaculture>

Harvey, N. and Caton, B. (2003) *Coastal Management in Australia*. Oxford University Press, Melbourne, 342 pp.

Hennessy, K, Fitzharris, B., Bates, BC., Harvey, N., Howden, SM., Hughes, L., Salinger J. & Warrick, R. (2007) *Australia and New Zealand. Climate change 2007: impacts, adaptation and vulnerability: contribution of Working Group II to the fourth assessment report of the Intergovernmental Panel on Climate Change*, ML Parry, OF Canziani, JP Palutikof, PJ van der Linden and CE Hanson, (Eds), Cambridge University Press, Cambridge, UK, pp. 507-540.

Hennessy, K., Lucas, C., Nicholls, N., Bathols, J., Suppiah, R., and Ricketts, J. (2005) *Climate change impacts on fire-weather in south-east Australia*. CSIRO Marine and Atmospheric Research, Aspendale, Victoria, 34 pp.

Keith, D. (2004) *Ocean Shores to Desert Dunes: the native vegetation of NSW and the ACT*. DIPNR (NSW) and NSW NPWS (DEC).

Keith, D. (2002) *A compilation map of native vegetation for New South Wales*, Version 1.1. NSW Biodiversity Strategy, NSW Government.

NPWS (2002). *Fire interval guidelines for broad vegetation types*. NSW National Parks & Wildlife Service. Unpublished.

RFS (NSW Rural Fire Service) (undated) *The Effects of Weather on Bushfires*. Accessed 30.9.09 at [http://www.rfs.nsw.gov.au/dsp\\_content.cfm?cat\\_id=516](http://www.rfs.nsw.gov.au/dsp_content.cfm?cat_id=516) NSW Rural Fire Service.

RFS (2006) *Bush Fire Environmental Assessment Code for New South Wales*. NSW Rural Fire Service.

RFS & NSW Department of Planning (2006) *Planning for Bush Fire Protection. A guide for Councils, Planners, Fire Authorities and Developers*. NSW Rural Fire Service.

*State Environment Planning Policy No 14 – Coastal Wetlands*. NSW Legislation. Accessed 04.10.2009 at:

<http://www.legislation.nsw.gov.au/viewtop/inforce/epi%2B532%2B1985%2BFIRST%2B0%2BN/?fullquery=%28%28%28;>)

Winning, G. (1991) *Some problems in determining the boundaries of SEPP 14 Wetlands*. Wetlands (Aust) vol 11, no. 1, pp 10-20.