Australian Government

Department of Sustainability, Environment, Water, Population and Communities

Ginini Flats Wetland Complex

Ramsar Site

Ecological Character Description

Image credits: David Whitfield, Anita Wild, DSEWPaC

Ginini Flats Wetland Complex
Ramsar site

Ecological Character Description

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Anita Wild, Entura, Hobart.

Introductory Note

This Ecological Character Description (ECD Publication) has been prepared in accordance with the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* (National Framework) (Department of the Environment, Water, Heritage and the Arts, 2008).

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) prohibits actions that are likely to have a significant impact on the ecological character of a Ramsar wetland unless the Commonwealth Environment Minister has approved the taking of the action, or some other provision in the EPBC Act allows the action to be taken. The information in this ECD Publication does not indicate any commitment to a particular course of action, policy position or decision. Further, it does not provide assessment of any particular action within the meaning of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), nor replace the role of the Minister or his delegate in making an informed decision to approve an action.

The *Water Act 2007* requires that in preparing the [Murray-Darling] Basin Plan, the Murray Darling Basin Authority (MDBA) must take into account Ecological Character Descriptions of declared Ramsar wetlands prepared in accordance with the National Framework.

This ECD Publication is provided without prejudice to any final decision by the Administrative Authority for Ramsar in Australia on change in ecological character in accordance with the requirements of Article 3.2 of the Ramsar Convention.

Note: There may be differences in the type of information contained in this ECD publication, to those of other Ramsar wetlands.

Executive summary

The Ginini Flats Wetland Complex is a composite of subalpine sphagnum bogs and associated wet heath and wet grassland habitats occupying a series of interconnected wetlands known as West Ginini, Ginini Flats, Cheyenne Flats and Morass Flats within Namadgi National Park in the ACT, Australia. The site is situated at the northern extreme of the climatic range for sphagnum bog wetlands in the Australian Alps and is one of the largest such complexes. The 'Alpine Sphagnum Bogs and Associated Fens' ecological community and the northern corroboree frog (*Pseudophryne pengilleyi*) population at the site are recognised as being nationally significant and are listed under the *Environment Protection and Biodiversity Conservation Act*. The Ginini Flats Wetland Complex incorporates one wetland type as defined by the Ramsar Classification System for Wetland Type (Ramsar Convention, 2008): U – Nonforested peatlands which includes shrub or open bogs, swamps, fens.

This ecological character description (ECD) of Ginini Flats Wetland Complex provides a description of the wetland at the time of Ramsar listing (1996). The Ramsar Convention has defined ecological character as "the combination of the ecosystem components, processes and benefits/services that characterise the wetlands at a given point in time" (Australian Government Department of Environment, Water Heritage and the Arts (DEWHA), 2008). As part of this ECD, critical services, components and processes for the site have been identified along with their interactions through the use of conceptual diagrams.

This ECD also addresses changes in the ecological character of the Ramsar wetland since the time of listing. The convention has defined the "change in ecological character" as "the human induced adverse alteration of any ecosystem component, process and/or ecosystem benefit/service" (DEWHA, 2008). Included in the ECD is a description of key threats to the ecological character (since time of listing), identification of limits of acceptable changes, key knowledge gaps and recommended monitoring, and assessment of the current condition of the site, including known changes in ecological character since the time of listing.

Ramsar criteria

A wetland has to meet at least one of the 'Criteria for Identifying Wetlands of International Importance' to be designated a Wetland of International Importance. The original Ramsar Information Sheet (RIS) for Ginini Flats Wetland Complex (ACT Parks and Conservation Service, 1995) identified that the wetland met four Criteria for Identifying Wetlands of International Importance:

Criterion 1: *A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near natural wetland type found within the appropriate biogeographic region.*

Criterion 2: *A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.*

Criterion 3: *A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.*

Criterion 4: *A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.*

Reassessment against the current Ramsar criteria for the state of the wetland in 2009 identified that the Ginini Flat Wetland Complex continued to fulfil all criteria met at the time of listing in 1996 and an additional criterion first introduced in 2005. The criteria met in 2009 include:

Criterion 1: This criterion was claimed as met in the original RIS (ACT Parks and Conservation Service, 1995) because alpine sphagnum bogs and associated fens have a limited geographic distribution nationally. Ginini Flats Wetland Complex is recognised as a significant example of this wetland type because it is situated at the northern extreme of the climatic range for sphagnum bog wetlands within the Murray–Darling Drainage Division.

Criterion 2: This criterion was claimed as met in the original RIS (ACT Parks and Conservation Service, 1995) because Ginini Flats Wetland Complex is known to have recognised presence of threatened species or communities. This criterion is still met at Ginini Flats Wetland Complex due to a nationally listed ecological community (Alpine Sphagnum Bogs and Associated Fens) and threatened fauna species (northern corroboree frog).

Criterion 3: This criterion was claimed as met in the original RIS (ACT Parks and Conservation Service, 1995) based on the presence of regionally significant species and nationally significant vegetation communities and flora species. The Ginini Flats Wetland Complex is at the northern biophysical limit of this habitat type within the Murray–Darling Drainage Division and is of importance in maintaining the genetic and ecological diversity of a number of endemic and restricted species found in subalpine wet heaths and bogs. Sites with extensive bog development dominated by *Sphagnum* are uncommon on the mainland of Australia. Significant plant species associated with the wetlands include the peat moss (*Sphagnum cristatum*), alpine plum pine (*Podocarpus lawrencei*), alpine ballart (*Exocarpos nanus*), dwarf buttercup (*Ranunculus millanii*), silver caraway (*Oreomyrrhis argentea*), and *Craspedia* sp. F. (Helman and Gilmour, 1985).

Criterion 4: This criterion was claimed as met in the original RIS (ACT Parks and Conservation Service, 1995) based on the provision of critical habitat provided for breeding cycles of the northern corroboree frog. The northern corroboree frog relies on the availability of small ponds in the wetlands for nests; with suitable ponds formed by a high water table accompanied by suitable hydrological conditions such as low flow rates. This criterion is still met.

Criteria 5–8: These criteria were not assessed as being met at the time of designation in 1996 and reassessment of these criteria confirm that they are not met at this site as the site does not support large populations of waterbirds, nor is it a significant wetland for fish species.

Criterion 9 '*A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species':* This criterion was first included as part of the 2005 criteria. This criterion is newly claimed based on the presence of the greater than one percent of individuals in the wild of the northern corroboree frog.

Key components, processes and ecosystem processes and interactions

The Ramsar ECD process also requires identification of the critical components and processes influencing the ecological character of Ginini Flats Wetland Complex. A summary of these key processes at time of listing are provided in the table below.

Key components and process at the time of listing for Ginini Flats Wetland Complex

Component/ Process	**Summary Description**
Biophysical setting	The geology underlying Ginini flats consists of intensively deformed granitic rocks of Silurian age that are overlain by Ordovician aged metasediments, which are extensively folded and composed of quartz arenite, siltstone and slate, with occasional hornfels beds. Water flowing through interstitial spaces over the granitoids is forced closer to the surface at the edge of the metasediments, resulting in seepages and spring lines. The combination of these processes results in conditions suitable for the continuous growth of *Sphagnum* and other wetland plants that have been recognised as significant in this subalpine environment.
Hydrology	Ginini Flats Wetland Complex is located at the headwaters of the Ginini Creek which forms the base of a small catchment of 410 ha that rises from 1520 mASL to a maximum elevation at the summit of Mt Ginini of 1762 mASL. Ginini Flats Wetland Complex has relatively high rainfall (circa 1250 mm/yr).
Peat formation	Peatlands form in areas with cool temperatures, positive water balance and usually more than 500 mm annual precipitation and are characterised by production of organic matter in excess of decomposition resulting in net accumulation. The development of peat layers result in alteration of surface and ground water inflows and outflows. This peat is comprised of two main layers, the surface, living Acrotelm that experiences fluctuations in water levels and the lower, anaerobic Catotelm which is typically saturated.
Vegetation	The peatland development at the site has been extensive, both in the drainage basin and on the slopes, providing a variety of vegetation types within the wetland complex including sphagnum bogs, wet heath and wet grassland (or fen). On top of the living *Sphagnum* layer there is substantial variation in vegetation composition in the bog complex, including a mosaic of bog, wet heath, wet herbfield, sedgeland, dry heath and tall wet heath along a gradient of reducing water availability, surrounded by subalpine woodland.
Water quality	The surface water within the Ginini Flats Wetland Complex is unpolluted and slightly acidic, and has low conductivity and very low turbidity. Limited amounts of sediment are likely to be transported to the Ginini Flats Wetland Complex as the result of disturbance of the surrounding catchment. There is the potential for some erosion through slope retreat on the steeper slopes, however this is a small area of the catchment for the wetlands.
Frogs	At the time of Ramsar designation in 1996, the northern corroboree frog (*Pseudophryne pengilleyi*) was recognised to be an important value of Ginini Flats Wetland Complex and the site was believed to hold one of the largest known populations of this species. Currently, *P. pengilleyi* is listed as Vulnerable on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, Vulnerable on Schedule 2 of the NSW Threatened Species Conservation Act 1995, and Endangered on the IUCN Red List.

Mammals, birds and reptiles	At the time of listing in 1996, the Ginini Flats Wetland Complex supported a range of wetland habitats including sphagnum bog, wet herbfield and wet heath. Vertebrate fauna species that have been recorded in the area, are wetland dependent and are expected to have been present around the time of listing include broad-toothed rat, Latham's snipe, alpine water skink and mountain swamp skink.
Fish	The native mountain Galaxias (Galaxias olidus) inhabits the small streams that bisect the Ginini Flats Wetland Complex. There is no evidence that exotic fish species have colonised aquatic habitat within Ginini Flats Wetland Complex.
Invertebrates	Ginini Flats Wetland Complex contains a number of habitats that support invertebrates. There is a lack of baseline ecological information on macroinvertebrates associated with Ginini Flats Wetland Complex, although the body of research suggests that the invertebrate fauna of bog environments in Australia is highly diverse given the heterogeneity of habitats found within them.

Key ecosystem services

Ecosystem services have been defined under the Ramsar Convention (Ramsar, 2005) covering benefits to humanity from wetlands. A number of key services including regulating, cultural and supporting services are provided by Ginini Flats Wetland Complex and are summarised in the table below.

Key ecosystem services provided by Ginini Flats Wetland Complex

Ecosystem service or benefit category	**Description**
Provisioning services – products obtained from the ecosystem such as food, fuel and fresh water	
Wetland products	The wetland complex is part of the Cotter River Catchment, which is the primary water supply source for Canberra the capital city of Australia.
Regulating services – benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation	
Climate regulation	Peat may be a significant carbon sink depending on climatic and hydrological conditions (Lawrence et al., 2009). However, peat can also act as a carbon source under warmer conditions, which promote peat decline. Predictions by Whinam and Chilcott (2002) suggest that such decline is likely.
Maintenance of hydrological regimes	Localised flattening of hydrological curve through the retention and slow release of moisture over a period of days (Western et al., 2009).
Erosion protection	Protection of soil surface from frost heave and accelerated erosion processes.
Water quality maintenance	Filtration of water, buffering of nutrients and sediments.
Hazard reduction	Flood control through limited flattening of the hydrological curve (as outlined above)

Ecosystem service or benefit category	Description
Supporting services – services necessary for the production of all other ecosystem services such as water cycling, nutrient cycling and habitat for biota. These services will generally have an indirect benefit to humans or a direct benefit over a long period of time.	
Biodiversity	Supports a significant sub-set of regional flora species and an ecologically-significant vegetation community.
	Supports a number of regionally significant and, nationally and internationally threatened species and vegetation communities.
	Supports a significant population of a threatened amphibian species (northern corroboree frog).
Soil formation	Supports peat soil formation and the accumulation of organic matter.
Nutrient cycling	Provides buffer capacity and removal or conversion of up to 90 per cent of nitrates (Silvester, 2009).
Cultural services – benefits people obtain through spiritual enrichment, recreation, education and aesthetics	
Recreation and tourism	Winter skiing in the surrounding grassland and woodland areas, summer walking and spring wildflower viewing.
Spiritual and inspirational	The wetland is likely to have been used on-route to traditional harvest sites (Mt Gingera) for Bogong moths by Aborigines.
Scientific and educational	Scientific studies on the northern corroboree frog and provision of eggs for captive breeding program.
	Numerous paleological studies of vegetation, climate and fire histories in peat sediments.
	Medium-term monitoring of restoration trials of post-fire recovery techniques in sphagnum bogs.

Threats to the Ramsar site

Ginini Flats Wetland Complex is within a National Park and at the top of the catchment and is therefore protected from many developmental and upper catchment impacts. However, major threatening activities exist and include:

- long term alterations in climate
- increases in intensity or frequency of fires
- changes to the hydrological regime from long-term climate change
- feral animal (particularly pigs) activity
- changes or increase in upper catchment infrastructure
- weed invasion
- chytrid fungus disease impacts on the northern corroboree frog.

Limits of acceptable change[1]

Following the identification of services and threats, limits of acceptable change were identified and are summarised in the table below.

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1. Limits of Acceptable Change are a tool by which ecological change can be measured. However, Ecological Character Descriptions are not management plans and Limits of Acceptable Change do not constitute a management regime for the Ramsar site.
2. Exceeding or not meeting Limits of Acceptable Change does not necessarily indicate that there has been a change in ecological character within the meaning of the Ramsar Convention. However, exceeding or not meeting Limits of Acceptable Change may require investigation to determine whether there has been a change in ecological character.
3. While the best available information has been used to prepare this Ecological Character Description and define Limits of Acceptable Change for the site, a comprehensive understanding of site character may not be possible as in many cases only limited information and data is available for these purposes. The Limits of Acceptable Change may not accurately represent the variability of the critical components, processes, benefits or services under the management regime and natural conditions that prevailed at the time the site was listed as a Ramsar wetland.
4. Users should exercise their own skill and care with respect to their use of the information in this Ecological Character Description and carefully evaluate the suitability of the information for their own purposes.
5. Limits of Acceptable Change can be updated as new information becomes available to ensure they more accurately reflect the natural variability (or normal range for artificial sites) of critical components, processes, benefits or services of the Ramsar wetland.

Limits of acceptable change identified at Ginini Flats Wetland Complex

Theme component/ Process	Nomination criteria	Supporting baseline data	Limits of acceptable change to ecological character	Qualifying statement	Confidence level
Abiotic					
Hydrology	1,2,3,4 and 9	Observational evidence of functioning including presence of pools and wetted peat layers.	LAC 1 Qualitative evidence of reductions in functionality of hydrology such as breaking of pools, development and persistence of erosion pavements or hydrophobic peat surfaces following fire disturbance for a period of greater than five years.	No data were available for the time of listing meaning that site specific data are of insufficient quality and quantity to determine statistically supported LACs. Therefore, this LAC is set to be qualitative and judgement based. The five year threshold for lack of recovery is based on recovery observations following the 1998 and 2003 fires in numerous Victorian peatlands documented by Tolsma and Shannon (2007).	Low
Nutrient and Carbon Recycling	1, 2 and 3	Peat extent mapping and some depth mapping	LAC 2 Greater than 20% change in extent (9.8 +/– 0.5 ha) of peat surfaces and evidence of oxidation.	No data were available on peat extent or depth at the time of listing. The baseline extent of approximately 50ha mapped in 1999 by Hope et al., 2009 was used in lieu of other data. However, site specific extent and temporal change data remain of insufficient quality and quantity to determine a statistically supported LAC. The 20% change level is an arbitrary figure based on mapping error tolerances and the precautionary principle.	Low
Biotic					
Vegetation/ *Sphagnum* and Peat Accumulation	1, 2 and 3	Short-term extent and depth mapping	LAC 3 Greater than 20% change in extent (9.8 +/– 0.5 ha) and a lack of recovery five years following disturbance (e.g. fire) that removes Arcotelm or Acrotelm and Catotelm LAC 4 Peat accumulation of less than 3.5cm per century or growth of *Sphagnum* spp. less than 30cm/yr. Loss of *Sphagnum* spp. propagules for recruitment following a large disturbance event ongoing for a period of five years.	No data were available on *Sphagnum*, vegetation or peat accumulation rates at the time of listing. The baseline extent of approximately 50ha mapped in 1999 by Hope et al., 2009 was used in lieu of other data. Site specific data is of insufficient quality and quantity to determine a statistically supported LAC. The 20% change level is an arbitrary figure based on mapping error tolerances and the precautionary principle. Peat accumulation and *Sphagnum* spp. has been recorded for Ginini and other bogs (Clark, 2003). The peat accumulation figure is difficult to measure with sufficient precision in the short-term; therefore more focus should be placed on the *Sphagnum* growth figure. It should be noted that this growth figure is based on pre-compressed *Sphagnum*.	Low

Theme component/ Process	Nomination criteria	Supporting baseline data	Limits of acceptable change to ecological character	Qualifying statement	Confidence level
Vegetation/ *Sphagnum*	1, 2 and 3	Floristic surveys of 'keystone[2]' species. However, these data are short-term and there are too few data points to capture long-term variability.	LAC 5 Loss, or extended (> 2 seasons) absence of keystone including (but not restricted to): *Sphagnum cristatum, Empodisma minus, Richea continentis, Epacris paludosa, Baloskion australe, Baeckea gunniana, Carex gaudichaudiana, Myriophyllum pedunculatum* and *Poa costiniana* from Ginini Flats Wetland Complex. LAC 6 Reduction or absence of recruitment of new individuals or ramets for these species.	No data were available for the time of listing meaning that site specific data are of insufficient quality and quantity to determine statistically supported LACs. However, ongoing monitoring and analysis may facilitate future determination of a LAC for relative abundance of keystone species identified by Hope et al., 2009.	Low
Vegetation/ *Sphagnum* and Peat Accumulation	1, 2 and 3	Inferred fire history fo r the site showing an average interval around 25–30 years	LAC 7 An increase in fire frequency greater than 25 years or inferred increase in intensity.	There are data on the frequency of fire events in adjacent woodland at Mt Ginini (Zylstra, 2006). It is not certain if Ginini Flats Wetland Complex burnt during all these events and, if so, the severity or extent. However, it is evident that the community can recover from fire events over time. There are no data on past fire intensity or quantitative information for this community in general. Therefore, there is no baseline provided for this variable.	Low
Northern corroboree frog	4 and 9	Abundance Occurrence, pattern and extent of *Sphagnum* pools for breeding	LAC 8 Absence of calling males in two successive monitoring seasons LAC 9 Evidence of stochastic declines due to disease or limited breeding site availability LAC 10 Evidence of no suitable habitat due to closing of pools or collapse of system.	Due to the very low numbers of frogs at the site and the difficulties in measuring and detecting differences (Evans 2009 *pers.comm*., August 12) these population LACs are qualitative and should be interpreted with caution. Site specific quantitative data on habitat is of insufficient longevity to determine natural variability and determine a statistically supported LAC.	Low

[2] Keystone species are those which control the structure and functioning of the peatland or bog community, are always present and influence some aspect of the critical processes (Hope et al. 2000)

Changes since listing

There has not been a significant alteration in ecological character of Ginini Flats Wetland Complex since the initial listing in 1996. However, there has been a substantial natural disturbance (2003 fire), a significant decline in the population of the northern corroboree frog and potential ongoing, incremental changes of the functioning of the peatland system (ongoing climate alteration).

The three sphagnum bogs which comprise the Ginini Flats Wetland Complex were all burnt in the landscape scale fires of 2003 in which most ACT mountain bogs had between 55 and 100 per cent of the surface burnt (Hope et al*.,* 2003; Carey et al*.,* 2003) with up to 30 centimetres of peat destroyed in some parts and severe damage to a large proportion of the *Sphagnum*. Around 45 per cent of the surface of Ginini west and east bogs were badly burnt in the fires with around 50 per cent (22 ha) of the sphagnum bog as a whole burnt.

Ginini Flats Wetland Complex was burnt twice in the 2003 fires with the main damage along the stream channel where high shrub densities occurred. Peat fires also burnt into the trench dug in the 1940s but otherwise the fibrous surface was generally retained in the centre of the bog and the residual moisture in the peat had prevented burning of the peat at depth. Where the peat did burn to between 5 and 20 cm a sterile, often hydrophobic ash surface remained, with a neutral pH unlike the normally acidic bogs. These areas were also susceptible to frost heave and erosion after being burnt. In the deeper bog areas the loss of hummock forming *Sphagnum cristatum,* which is critical to bog function and hydrology, was considered to be a serious impact that may have long-term effects on the wetlands.

Observations in 2009 showed that some areas where *Sphagnum* retreated following the 2003 fires were recolonised by *Empodisma minus* fen, while others remain bare. Some of the fringing peat surface has been exposed and this area is likely to continue to oxidise and erode due to the lack of vegetation cover and loss of moisture. In April 2009, field observations showed a persistence of some ruderal weeds such as sheep's sorrel (*Rumex acetosella*), thistles (*Carduus* spp.) and cats ear (*Hypochoeris* sp.) which were also recorded immediately following the fires. Whilst these have persisted they are expected to decline as regeneration of native species continues.

Following the extensive fires in 2003, concerns were raised about the long term health and recovery of the bog system from ongoing damaging processes such as accelerated runoff and subsequent stream entrenchment. Observations at Ginini Flats Wetland Complex showed there to be active peat tunnelling, which is the incision and erosion of the peat dams that could lead to long term impacts and slow recovery. Restoration works have focussed on techniques which restore hydrological functionality to the bogs to enable recovery of the key bog species—*Sphagnum*, *Empodisma* and *Carex*—and to increase the residence time and infiltration of surface water by slowing flow rates.

Water quality declined following the January 2003 bushfires. It was particularly impacted by large rain events in February and March of 2003, which led to large scale erosion of the denuded slopes of the catchment. Data from nearby catchments indicates that water quality in sub-catchments of the Australian Alps affected by the 2003 fires has returned to the high water quality previously considered representative of these environments and it is expected that the water quality in Ginini Flats Wetland Complex has followed a similar trend.

Since the unexplained decline in all populations of the northern corroboree frog around 1987, there has been concern for the long-term viability of populations. There is also concern for other frog species. The fires of 2003 had direct and immediate as well as indirect, long term impacts on the already low frog populations. The fires occurred at the time of the 2003 breeding season which is likely to have reduced overall numbers through direct mortality and subsequent influence on the longer term population viability. Indirect impacts include changes in habitat, as all known corroboree frog over-wintering habitat was burnt by moderate to high severity fires.

Key knowledge gaps and monitoring

Key knowledge gaps and monitoring recommendations were identified to fully describe the ecological character of the site and to set meaningful limits of acceptable change – these are summarised in the table below.

Key knowledge gaps and monitoring recommendations for Ginini Flats Wetland Complex

Component/ Process	**Knowledge gap**	**Monitoring Purpose**
Abiotic		
Hydrology	Magnitude, duration and seasonality of inflows and outflows	To determine the water balance of the site and establish limits of acceptable change parameters
Water quality	Magnitude, duration and seasonality of water quality parameters	Determine if there are changes in water quality parameters
Nutrient and carbon cycling	Status of the system – whether the system is accumulating or eroding	To determine if peat levels are increasing, stabilising or decreasing
Biota		
Amphibians	Ongoing suitability of the site for breeding	To continue current monitoring program to determine status of the population
Sphagnum	Status of recovery of the *Sphagnum* and maintenance of positive feedback services	Establish baseline for *Sphagnum* recovery
Vegetation	Dynamics of vegetation communities	Baseline and set limits of acceptable change
Macroinvertebrates	Available biomass and population structure	Establish baseline data and set limits of acceptable change at the next review.
Fish	The presence of *G. olidus* within the Ginini Flats Wetland Complex is documented; however, it is unknown as to whether the 2003 fires have affected this population.	Determine status/persistence of *G. olidus* populations in the Upper Cotter Catchment.
Birds	Presence of threatened or migratory species	Species abundance and composition
Feral Pigs	-	Continue baseline data collection and detect population changes

Recommendations for monitoring variables and critical components are provided to assist with the assessment of the Limits of Acceptable Change, to reduce knowledge gaps and detect potential changes in ecological character.

Communication and education messages

Under the Ramsar Convention a Program of Communication, Education, Participation and Awareness (CEPA) was established to help raise awareness of wetland values and functions. The Ramsar Convention encourages that communication, education, participation and awareness are used effectively at all levels, from local to international, to promote the value of wetlands.

A comprehensive CEPA program for an individual Ramsar site is beyond the scope of an ECD, but key communication messages and CEPA actions, such as a community education program, can be used as a component of a management plan.

Key messages for the Ginini Flats Wetland Complex Ramsar site arising from this ECD, which should be promoted through the CEPA program relate to the importance of the vegetation communities and the northern corroborree frog.

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Abbreviations and acronyms

ACT	Australian Capital Territory
ACTEW	ACTEW Corporation Limited – ACT Government-owned utility company; previously ACT Electricity and Water
ANZECC	Australia New Zealand Environment and Conservation Council
ANU	Australian National University
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BIOCLIM	A bioclimatic prediction system which uses surrogate terms (bioclimatic parameters) derived from mean monthly climate estimates, to approximate energy and water balances at a given location.
BoM	Bureau of Meteorology
CAMBA	China–Australia Migratory Bird Agreement
CEPA	Communication, Education, Participation and Awareness – program under the Ramsar convention to help raise awareness of wetland values
Cth	Commonwealth
DEWHA	Australian Government Department of Environment, Water Heritage and the Arts
EC	Electrical Conductivity
ECD	Ecological Character Description
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
ha	Hectare
IBRA	Interim Biogeographic Regionalisation for Australia
IUCN	International Union for Conservation of Nature
JAMBA	Japan–Australia Migratory Bird Agreement
LAC	Limits of Acceptable Change Framework (following Stankey et al., 1985)
mASL	Metres above sea level
N_2	Nitrogen
n.d.	No date
NH_3	Ammonia
NH_4^+	Ammonium
NO	Nitrous oxide
NO_x	Nitrogen oxides include the gases nitrous oxide (NO) and nitrogen dioxide (NO_2)
NO_3^-	Nitrate

NTU	Nephelometric Turbidity Unit – a measure of water turbidity
NWI	National Water Initiative
PCL	Parks, Conservation and Lands (PCL), a branch within the Environment and Recreation network of the ACT Government Department of Territory and Municipal Services (TAMS)
PO_4	Phosphate
RIS	Ramsar Information Sheet
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
SEH	South Eastern Highlands
SO_4^-	Sulphate
TAMS	ACT Government Department of Territory and Municipal Services
TN	Total nitrogen
TP	Total phosphorous

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1. Introduction

1.1 Structure of the document

This document has the following structure:

- A description of the Ramsar Convention and other relevant legislation
- A site description
- Descriptions of how the Ginini Flats Wetland Complex fulfils criteria under the Ramsar Convention
- An account of ecosystem services, components and processes at the time of listing (1996)
- Information outlining critical components, services and processes of the site
- From this, threats to ecological character of the site are identified
- Limits of acceptable change
- A description of current ecological character.

1.2 The Ramsar Convention and Ginini Flats Wetland Complex

The Ramsar Convention was initially ratified in Ramsar, Iran, in 1971 and was specifically focused on the preservation of waterfowl habitat, hence the name: 'Ramsar Convention on Wetlands, especially as waterfowl habitat'. Subsequent revisions have expanded the Convention to include recognition of a wider set of values.

The Convention has many parts to it. 'Articles' address the obligations of the Contracting Parties, while wetlands are assessed against 'criteria' for listing as an internationally important wetland. Under the Convention various wetland types are listed.

When Australia ratified the Convention in 1971, it became one of 153 countries known as Contracting Parties. This implies acceptance of a number of obligations regarding management of listed wetlands. These obligations include management of wetlands that promotes both sustainable use and conservation of natural features of the extant ecosystems (Convention Article 3.1) and maintaining the site's ecological character (Convention Article 3.2).

The Ginini Flats Wetland Complex was designated as a 'Wetland of International Importance' under the Ramsar Convention on Wetlands in 1996.

As part of the original nomination for Ginini Flats Wetland Complex in 1996, a Ramsar Information Sheet (RIS) was prepared in 1995 that described crucial elements of the site. This RIS was updated in 1999 and as part of the current ECD. A summary of RIS elements is provided in Table 1-1.

Table 1-1 Site details and listing elements for the Ginini Flats Wetland Complex

Site Parameter	**Detail**
Name	Ginini Flats Wetland Complex
Location	Latitude: 35°31'S Longitude:148°46'E
General Location	Near Mt Ginini, Namadgi National Park, Australian Capital Territory. The nearest urban area is the city of Canberra.
Area	Ramsar site area: 368 ha Wetland complex: 50 ha Open Flats: 75 ha Total Catchment: 410 ha
Altitude (mASL)	Ginini Flats 1520–1600 mASL Cheyenne Flats 1520–1540 mASL
Date of Ramsar site designation	11 March 1996
Ramsar criteria met	1, 2, 3, 4 and 9
Management authority for the site	ACT Parks, Conservation and Lands, GPO Box 158 Canberra ACT 2601, Australia
Date the ECD applies	1996
Status of description	This is the first Ecological Character Description (ECD) for Ginini Flats Wetland Complex Ramsar site.
Date of compilation	April 2010
Compiled by	Anita Wild, Simon Roberts, Brad Smith, Dax Noble and Ray Brereton
RIS Reference	Ramsar Information Sheet: 5AU045, 1995. Updated in November 1999 by Mr Mark Lintermans, Wildlife Research and Monitoring, Environment ACT and available at: http://www.environment.gov.au/cgi-bin/wetlands/ramsardetails.pl?refcode=45#
References to the Management Plan	ACT Government (2001) *Ginini Flats Wetlands Ramsar Site Plan of Management 2001*.Conservation Series No. 18 (Environment ACT, Department of Urban Services, Canberra, available at: http://www.tams.act.gov.au/play/parks_conservation_and_lands/about_pcl/publications_and_forms/strategies,plans_and_reviews/ginini_flats_wetlands_ramsar_site

1.3 Purpose of the ecological character description

The Ramsar Information Sheet (RIS) is a major component of the documentation provided when proposing a site for Ramsar listing. A RIS must be prepared for each Ramsar site at the time of listing and should be updated every six years if necessary (Ramsar Convention 1996, Resolution VI.1 paragraph 2.3). Subsequent updates incorporate key information from the ecological character description.

This ecological character description (ECD) of the Ginini Flats Wetland Complex Ramsar site provides a baseline description of the wetland at the time of listing (1996). The Ramsar Convention has defined ecological character as "the combination of the ecosystem components, processes, benefits and services that characterise the wetlands at a given point in time" (Ramsar Convention, 2005, Resolution IX.1 Annex A). The ECD forms a baseline to assess changes in the ecological character of the Ramsar wetland. The convention has defined the "change in ecological character" as "the human-induced adverse alteration of any ecosystem component, process and/or ecosystem benefit or service" (Ramsar Convention, 2005, Resolution IX.1 Annex A). The ECD can also be used as the reference for:

- the development and implementation of a management plan designed to maintain the ecological character of the site
- the design of a monitoring program to detect changes in ecological character
- the regular evaluation of the results of the monitoring program to assist onsite management
- the assessment of the likely impact on ecological character of proposed actions as required under the *Environment Protection and Biodiversity Conservation Act 1999*, including environmental impact assessments
- reporting to the Australian Government and the Ramsar Convention about any changes in the ecological character of the Ramsar site.

The aims of an ECD for Ramsar wetlands are (DEWHA, 2008):

1. To assist in implementing Australia's obligations under the Ramsar Convention, as stated in Schedule 6 (Managing wetlands of international importance) of the *Environment Protection and Biodiversity Conservation Regulations 2000* (Cth):
   - (a) to describe and maintain the ecological character of declared Ramsar wetlands in Australia, and
   - (b) to formulate and implement planning that promotes:
     - (i) conservation of the wetland, and
     - (ii) wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem.

2. To assist in fulfilling Australia's obligation under the Ramsar Convention to "arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the Ramsar List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference."

3. To supplement the description of the ecological character contained in the Ramsar Information Sheet submitted under the Ramsar Convention for each listed wetland and, collectively, form an official record of the ecological character of the site.

4. To assist the administration of the Commonwealth *Environment Protection and Biodiversity Conservation* (EPBC) Act 1999, particularly:

    (a) to determine whether an action has, will have, or is likely to have a significant impact on a declared Ramsar wetland, in contravention of sections 16 and 17B of the EPBC Act, or

    (b) to assess the impacts that actions referred to the Minister under Part 7 of the EPBC Act have had, will have, or are likely to have on a declared Ramsar wetland.

5. To assist any person considering taking an action that may impact on a declared Ramsar wetland to determine whether to refer the action to the Minister, under Part 7 of the EPBC Act, for assessment and approval.

6. To inform members of the public who are interested generally in declared Ramsar wetlands to understand and value the wetlands.

1.4 Relevant treaties, legislation, regulations and policies

The following treaties, legislation, regulations and policies are relevant to the management of the Ginini Flats Wetland Complex. This list shows a hierarchy of legislation from International Treaties, such as the Ramsar Convention, to supporting Commonwealth and Territory Legislation.

1.4.1 International

- the *Convention on Wetlands*, signed in Ramsar, Iran, in 1971
- the *Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment* (JAMBA), formed in 1974
- the *Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment* (CAMBA), formed in 1986

- the *Agreement between the Government of Australia and the Republic of Korea for the Protection of Migratory Birds and their Environment* (ROKAMBA), signed in 2007
- the *Convention on the Conservation of Migratory species of Wild Animals* (the Bonn Convention), signed in 1991

1.4.2 National

1.4.2.1 Legislation

- *Environment Protection and Biodiversity Conservation Act 1999*

  The Commonwealth's *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) contains national provisions relating to protection and management of Ramsar Wetlands and listed threatened and migratory species. The Act:

  - recognises that Ramsar Wetlands of International Importance (and listed threatened and migratory species) are matters of National Environmental Significance
  - introduces an environmental assessment and approval regime for actions that are likely to have a significant impact on Ramsar wetlands (and listed threatened and migratory species)
  - provides for improved management of Ramsar wetlands.

  Any action which has, or is likely to have, a significant impact on the ecological character of the Ginini Flats Wetland Complex Ramsar Site should be referred to the Australian Government Environment Minister to determine whether the action is subject to the EPBC Act. Details on the Act and its provisions can be obtained from the Australian Government Department of Sustainability, Environment, Water, Population and Communities (www.environment.gov.au/epbc)
- Approved Conservation Advice for the Alpine Sphagnum Bogs and Associated Fens ecological community (Approved conservation advice under s266B of the *Environment Protection and Biodiversity Conservation Act 1999*) (Australian Government, 2008)
- National Water Initiative (NWI) (Australian Government, 2004)

1.4.2.2 Guidelines and policies

- *National Framework and Guidance for Describing the Ecological Character of Australian Ramsar Wetlands.* Module 2 of the National Guidelines for Ramsar Wetlands (Department of Environment, Water, Heritage and the Arts (DEWHA), 2008)

- The Wetlands Policy of the Australian Government (Biodiversity Group of Environment Australia,1997)
- *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000)

1.4.2.3 Strategies and plans

- *Threat Abatement Plan for Predation, Habitat Degradation, Competition and disease Transmission by Feral Pigs* (Department of the Environment and Heritage, 2005)

1.4.3 Territory

1.4.3.1 Legislation

The following Australian Capital Territory Acts and their associated regulations apply to the Ginini Flats Wetland Complex Ramsar site and will have to be considered where applicable when implementing management actions at the site:

- *Nature Conservation Act 1980* - This Act provides the main legislative backing for the ACT Government's management of reserved lands, covering the protection and conservation of native plants and animals. In so doing, the Act confers powers on the Conservator to control activities on reserved land. For Ramsar Wetlands, this is managed through the ACT Department of Territory and Municipal Services (TaMS) with Parks, Conservation and Lands (PCL) as the direct management agency.
- *Environment Protection Act 1997*
- *Heritage Act 2004*
- *National Environment Protection Council Act 1994*
- *Planning and Development Act 2007*
- *Plant Diseases Act 2002*
- *Pest Plants and Animals Act 2005*
- *Roads and Public Places Act 1937*
- *Water Resources Act 2007.*

1.4.3.2 Guidelines and policies

There are no Territory guidelines or policies relevant to the Ginini Flats Wetland Complex Ramsar site.

1.4.3.3 Strategies and plans

- *Namadgi National Park Revised Draft Plan of Management* (ACT Government, 2007a)
- *Strategic Bushfire Management Plan for the ACT* (ACT Government, 2009)
- *Threatened species Action Plan No. 6 for the corroboree frog* (Pseudophryne corroboree). (NSW National Parks and Wildlife Service, 2001). The ACT Flora and Fauna Committee has recommended this plan be revoked and instead declare *Pseudophryne pengilleyi* a vulnerable species.
- Namadgi National Park Feral Horse Management Plan 2007 (ACT Parks, Conservation and Lands, 2007)
- Interim Recreation Strategy (Mackay, 2004)
- National Capital Plan (Commonwealth of Australia, 1990)
- ACT Nature Conservation Strategy (ACT Government,1997a)
- Willow Management Strategy for the Upper Murrumbidgee Catchment (ACT Government, 1997b)
- ACT Natural Resource Management Plan 2004 – 2014 (ACT Government, 2004)
- Lower Cotter Catchment Strategic Management Plan (ACT Government, 2007b)
- Territory Plan (ACT Government, 2008)
- The ACT Integrated Catchment Management Framework in the Murray–Darling Basin 2001–2010 (Murray–Darling Basin Commission, 2001)

2. Site description

2.1 Overview

The Ginini Flats Wetland Complex consists of a composite of subalpine sphagnum bogs and associated wet heath and wet grassland habitats occupying a series of interconnected wetlands known as West Ginini, Ginini Flats, Cheyenne Flats and Morass Flats within Namadgi National Park in the Australian Capital Territory (ACT), Australia. The site is situated at the northern extreme of the climatic range for sphagnum bog wetlands in the Australian Alps. The ‘Alpine Sphagnum Bogs and Associated Fens’ ecological community and the northern corroboree frog (*Pseudophryne pengilleyi*) community on site are nationally significant. The Ginini Flats Wetland Complex is in the upper reaches of the Cotter River catchment in the Murrumbidgee River Drainage Basin in south-eastern Australia. The site is also of hydrological importance due to the role the wetlands play in maintaining water quality and, to a lesser extent, moderating runoff. The Cotter River catchment is the primary water source for Canberra, in the ACT, the capital city of Australia.

2.2 Site location

The Ginini Flats Wetland Complex is located near Mt Ginini in the upper reaches of the Cotter River catchment in the Brindabella Range within the Namadgi National Park, 40 kilometres south west of Canberra, in the ACT (Figure 2-1). The area is relatively undisturbed. The Cotter River catchment is the primary water supply for Canberra. The total catchment area is 410 ha, including 50 hectares of wetland complex and 75 hectares of open flats. Elevation of Ginini Flats Wetland Complex ranges from 1520–1600 mASL.

2.2.1 Drainage division

The Ginini Flats Wetland Complex is in the upper reaches of the Cotter River catchment, which is within the Murrumbidgee River Drainage Basin in south-eastern Australia. This catchment in turn is a component of Australia’s largest river system, the Murray Darling Drainage Division (Bureau of Meteorology (BoM), 2009; Figure 2-2). The Drainage Division extends from north of Roma in Queensland to Goolwa in South Australia and includes three quarters of New South Wales and half of Victoria. It covers 1 060 000 square kilometres and is the third largest in Australia after the Western Plateau (2 450 000 square kilometres) and Lake Eyre (1 170 000 square kilometres) (Murray–Darling Basin Commission, 2005).

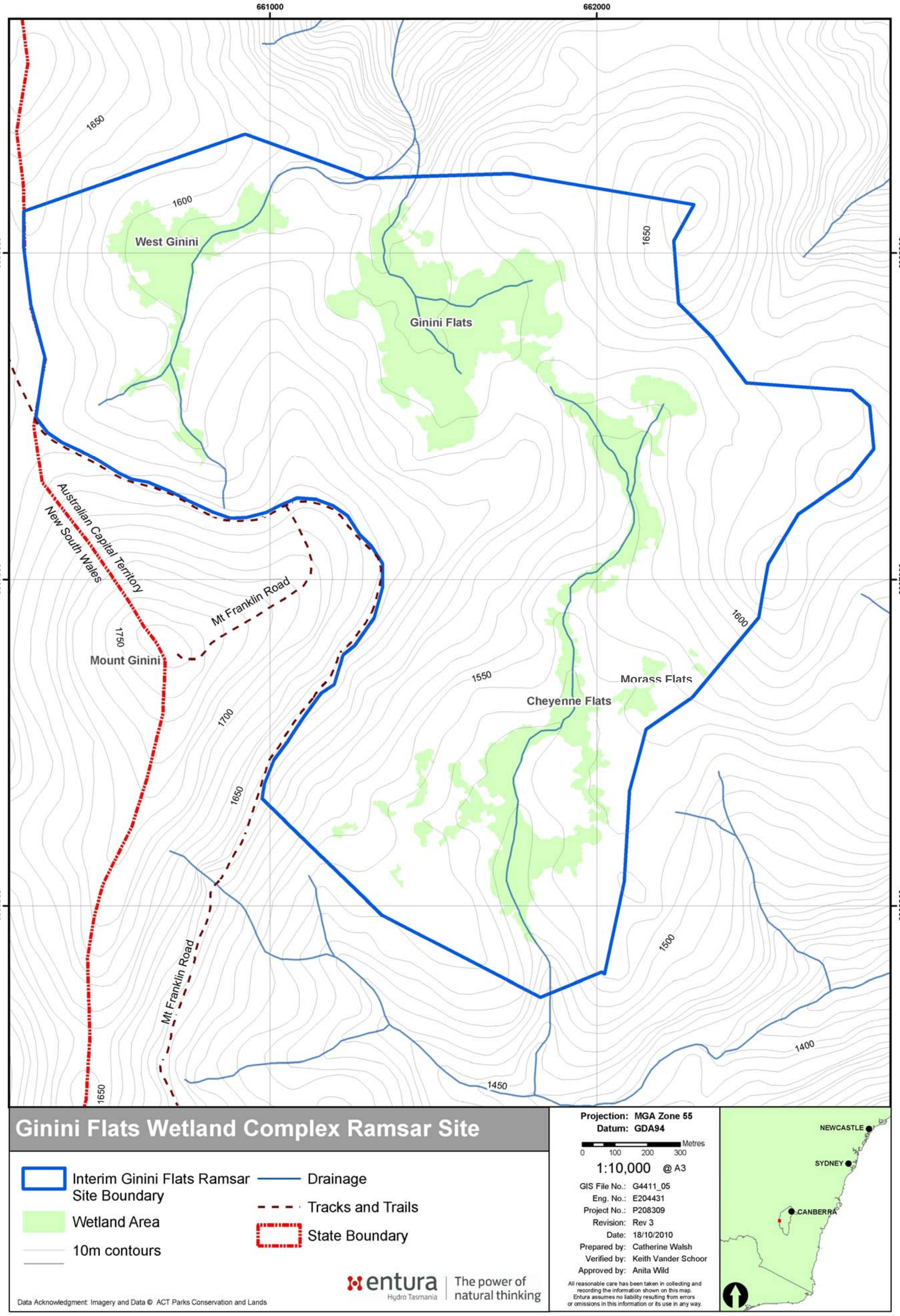

Figure 2-1 Location of the Ginini Flats Wetland Complex Ramsar Site in the ACT showing the Ramsar site boundary, wetland area and drainage lines.

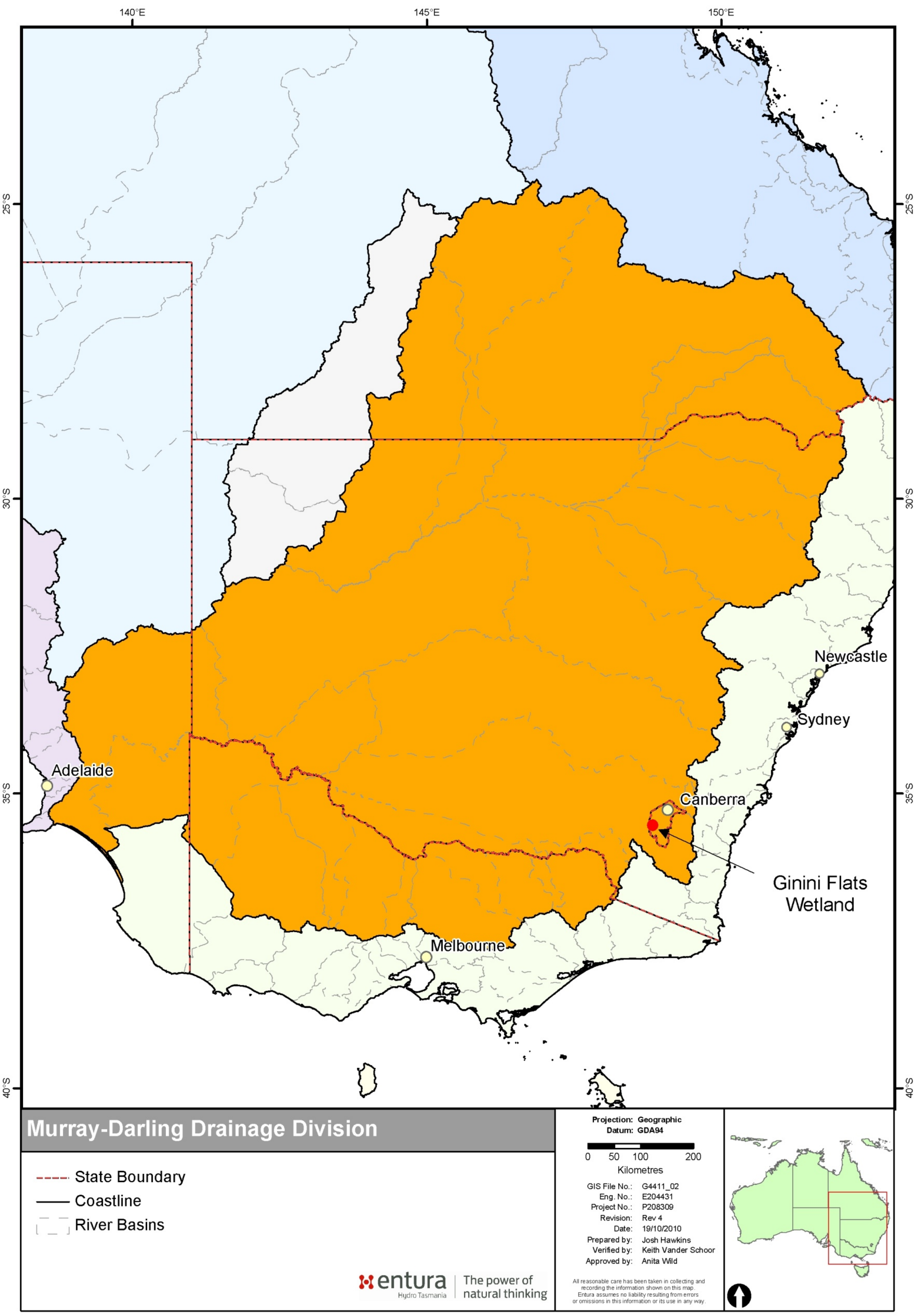

Figure 2-2 Ginini Flats Wetland Complex in relation to Drainage Divisions

The drainage division classification has been further divided into biogeographic regions following the Interim Biogeographic Regionalisation for Australia (IBRA) which identifies geographically distinct areas of similar climate, geology, landform, vegetation and animal communities. It divides the Australian land mass into 85 bioregions and 403 subregions (IBRA 6.1; Commonwealth of Australia, 2005). Ginini Flats Wetland Complex falls within the Australian Alps IBRA bioregion, which is characterised by a series of high elevation plateaux capping the South Eastern Highlands (Region SEH) and the southern tablelands in New South Wales (NSW) and ACT (DEWHA, 2000). The geology of this bioregion consists predominantly of granitic and basaltic rocks. Vegetation is dominated by alpine herbfields and other treeless communities, snow gum woodlands, and montane forests dominated by alpine ash (DEWHA, 2000).

2.2.2 Climate

Climate data for the site are interpolated from a meteorological site at Mt Ginini that has incomplete records dating from 2004 onwards. This weather station is located at 1760 mASL, between 160 and 200 metres above the wetland. General temperature lapse rates of a 6.5 °C drop in ambient air temperature for every 1000 metres (Nunez and Colhoun, 1980), suggest that the wetland site is likely to be slightly warmer than the monitoring station, particularly in winter, due to the exposed nature of the weather station. However, cold air drainage patterns associated with the bog will also act to reduce temperatures; therefore these data from Mt Ginini provide a good overall approximation of temperatures at the site.

The climate of Ginini Flats Wetland Complex is characterised as subalpine, with average diurnal temperatures ranging from a minimum in July of 2.0 °C to a maximum in January of 21.0 °C (Figure 2–3). The mean annual maximum temperature is 11.7 °C. Mean minimum temperatures were lowest in July at –2.7 °C and highest in January at 10.0 °C, with a mean annual minimum of 3.4 °C (BoM 2009). The diurnal range of winter temperatures is generally about half that of summer due to the passage of cold fronts and the greater extent of radiation cooling on the more frequent clear nights. Extremes in both maximum and minimum temperatures occur, including heat wave periods in summer when sequences of days over 35 °C have been recorded, particularly in January or February (BoM 2009).

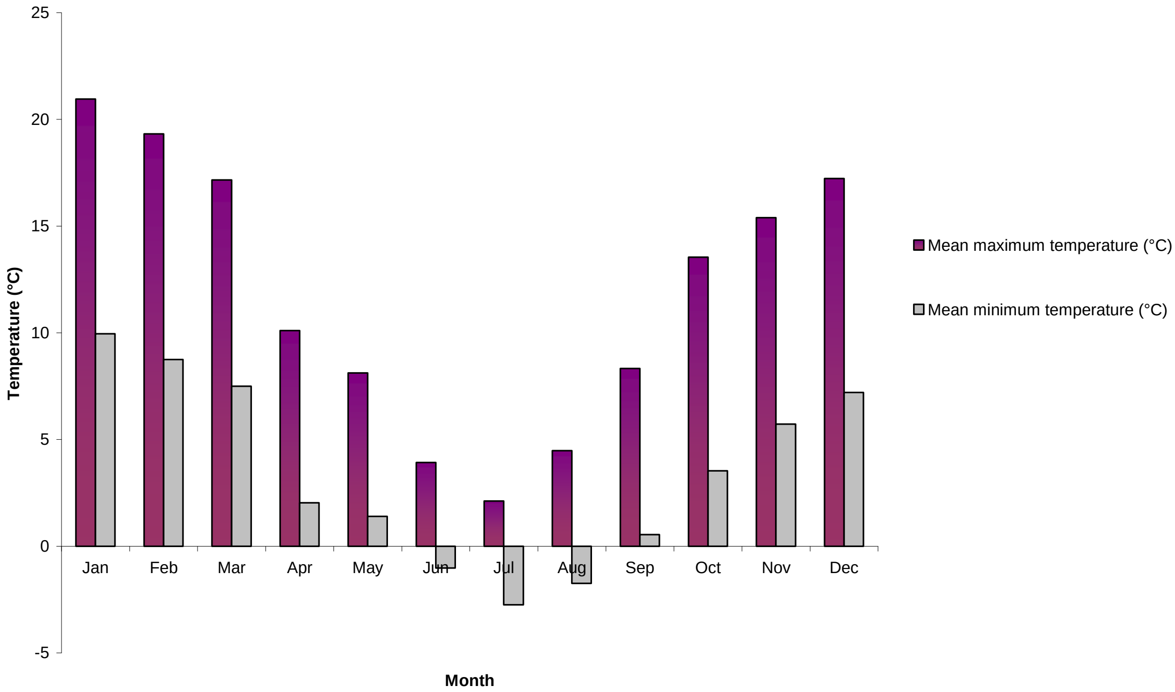

Figure 2-3
Mean maximum and mean minimum monthly temperatures at Mt Ginini based on observations since 2004 (BoM 2009)

The Mt Ginini meteorological data for precipitation is restricted to a short period of time and is not reliable. Rainfall interpretation from climatic maps undertaken by Osborne (1990) concluded that average annual rainfall is in the vicinity of 1250 mm; around half of the rainfall of many other sphagnum bog sites in the Australian Alps.

This rainfall also includes snowfall events which occur between June and September; although snow can fall outside these months. The area is subject to south-westerly and westerly weather systems, which frequently result in blizzard-like conditions to the mountain range and are the most common snow-producing systems in Australia (Davis, 1998). Cold southerly patterns occur infrequently and are associated with very heavy snow falls (Davis, 1998). These weather systems deposit snow on the predominantly easterly and south easterly slopes at Ginini and Cheyenne Flats which, as lee slopes, are areas of snow accumulation and slow thaw (Billings and Mooney, 1968). West Ginini has a more westerly aspect so snow cover is likely to be of shorter duration. Within these areas snow depth patterns and persistence also vary depending on the ground conditions. For example, rocks and shrubs can result in irregular distribution of snow and uneven melting, contributing to differences in microclimatic conditions such as the length of growing season, soil microclimate, patterns of snow thaw and water availability, and exposure to wind and frosts (Billings and Mooney, 1968; Mark and Bliss, 1970). The lack of persistent snow cover leads to harsh conditions as snow provides substantial insulation for vegetation in the colder periods (Billings and Mooney, 1968). This lack of insulating snow cover also leads to a high prevalence of frost heave. Frost heave occurs when soil moisture freezes, forming needle ice that can heave seedlings out of the soil, leading to vegetation loss and the erosion of soil surfaces. If moisture is present, temperatures only need to cool to as little as –2 °C for frost heave to develop in some clay soils (Lawler, 1989). Data recorded by McPherson (cited in ACT Government, 2001) showed average ground temperature at Mt Ginini to be –0.5 °C in July, indicating that the incidence of frost heave is likely to be high in winter and spring.

2.3 Land tenure

Ginini Flats Wetland Complex is encompassed within the Namadgi National Park in the ACT, which is managed by Parks, Conservation and Lands (PCL), a branch within the ACT Government Department of Territory and Municipal Services (TAMS). The western edge of the site extends close to the boundary between the ACT and NSW. Bimberi Nature Reserve is located on the NSW side of the border, offering similar protection to that of a national park. All of the upper and middle sub-catchments of the Ginini Flats Wetland Complex are protected in Namadgi National Park.

As designated under the Namadgi National Park Draft Management Plan (*ACT Government, 2007a*), Ginini Flats is designated as part of the Remote Area Zone, which has the primary purpose of core conservation and catchment area maintenance. This zoning requires that recreation is limited to low-impact activities (*ACT Government, 2007a*).

2.4 Site history and past land use

Within the wetland system there is little evidence that Ginini Flats were used by Australian Aboriginals; however there is considerable evidence that Australian Aboriginals used the nearby Mt Gingera area, 6 kilometres south of the wetland complex (Flood, 1980). Therefore, it is likely that the open flats would have been traversed by people *en route* to the high peaks during the annual Bogong moth (*Agrotis infusa*) harvest (Clark, 1980). Archaeological evidence exists for campsites 4 kilometres south of the flats (Flood, 1980).

European use of the area has been recorded since the early 1830s, when stock were moved to high country pastures in the summer. However, given the lack of extensive grasslands or heathlands in the immediate vicinity, this use is likely to have been intermittent outside serious drought periods. Following acquisition of the land by the Australian Government in 1909, grazing was officially ceased in 1913 although one short period of grazing was allowed for drought relief in the 1920s (ACT Government, 2001). The site was included in the reserve system when the Namadgi National Park was declared in 1984.

Other than the impacts from feral animals (horses, pigs and rabbits), disturbances within the catchment and the wetland complex have been limited. In 1938 a two metre deep, 50 metre long trench was cut in West Ginini Flat by the Australian Forestry School for a study of peat profiles. This trench has not fully recovered and is still evident today, with some local impacts to hydrology and subsequent changes in vegetation community. In the 1940s, *Sphagnum* from West Ginini Flat was cut for use as filters in vehicle gas production during World War II. These areas were recorded to burn in 2003 to a greater degree than surrounding areas that had not been mined and show slower recovery (Macdonald, 2009).

In 1936 members of the Canberra Alpine Club assessed Ginini Flats as a potential site for the development of a ski lodge in their endeavour to develop the area into a major ski centre for the population of Canberra (Higgins 1994). Due to the good shelter from the westerly and southerly winds and abundant clean water supply, it was considered very desirable. However, the Mt Franklin site was eventually chosen due to the absence of timber at Ginini Flats for the construction of a lodge. In the 1960s ski development on the Kosciuszko Range, where conditions for skiing were more reliable, led to reduced use of the area and the facilities at Mt Franklin were demolished in 1969 (ACT Government 2001) with the exception of the Chalet that was destroyed in the 2003 bushfires. Evidence of past skiing use remains (see Figure 2-4); outside the wetland area trees have been cleared to form a ski run on the eastern slope of Mt Ginini, upslope of the wetlands, allowing access to the wetland in winter.

Figure 2-4 The cleared ski run in open *Eucalyptus pauciflora* woodland between Mt Franklin Road car park and Ginini Flats, looking west towards Mt Ginini (Photograph: Anita Wild, April 2009).

Current human activity is generally limited to the pursuit of low-impact recreational activities; bushwalking, cross-country skiing and nature observation. However, the wetland complex is an important area for scientific study and investigation, with most recent visits recorded in the National Parks logbook being by researchers (ACT Territory and Municipal Services unpublished data). However, greater public visitation is expected to occur as the area recovers from the impact of the 2003 fires.

Vehicular access to the Ginini Flats area is via the gravel Mt Franklin Road along the Brindabella Range to Mt Ginini. The road is closed at Mt Ginini, making it the terminus for vehicular access and a focal point for many visitors to the area, as well as allowing car access to within 300 metres of the wetland complex. The public road is closed during high fire risk times and high snow cover. The road and the car park pass through the catchment of the wetlands; beyond the car park, the road is closed to the public by locked gates, with the track beyond providing vehicular access for management and a walking route for bushwalkers. The cleared track doubles as a low use ski-run during the winter months. A closed four wheel drive vehicle management trail crosses parts of Cheyenne Flats, originally providing access to the (now burnt) arboretum; this trail is only used by walkers and is naturally revegetating.

Within the catchment there is a Civil Aviation Authority air navigation facility, a Bureau of Meteorology weather station, and communications radio relay station on the summit of Mt Ginini that has been operating since 2004. A gravel road is maintained to this facility with a large fire break around the facility, along part of the ridgeline and along the access trail.

2.4.1 Fire history

Prior to the Ramsar listing in 1996, the last severe wildfire event to burn through the Ginini Flats area was in 1939 and is recorded to have burnt much of the wetland area. Other significant bushfire events occurred in the Ginini Flats area in 1851, 1875, 1899, 1918, 1925 and 1944 (Banks cited in Clark 1980). It is not known how much of the wetland complex was burnt in these fire events because ash and other deposits do not remain evenly in the strata. However, it is likely that edges of the bog were impacted.

In 2003, bushfires were lit by lightning along the Brindabella Range and severely burnt 90 percent of Namadgi National Park including the Ginini Flats Wetland Complex. This fire was preceded by drought conditions which would have resulted in drier conditions in the bogs that predisposed them to fire impacts. The drier condition of the peat adjacent to a trench also led to greater impacts (Hope et al*.,* 2003). The impact of this fire has been considered further below and has been taken into consideration during the discussion of current ecological condition and discussion of Ramsar threats (Section 5.1).

2.5 Ramsar criteria

2.5.1 Ramsar criteria fulfilled at time of designation

A wetland has to meet at least one of the 'Criteria for Identifying Wetlands of International Importance' to be designated a Wetland of International Importance. The original Ramsar Information Sheet (RIS) for Ginini Flats Wetland Complex which was completed in 1995 and updated in June 1999 records that the wetland met four Criteria for Identifying Wetlands of International Importance. These criteria are:

Criterion 1: *A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near natural wetland type found within the appropriate biogeographic region.*

[Justification against former Criterion 1(a) under the Pre-1999 Criteria]

In 1996, the Ginini Flats Wetland Complex was recognised as one of the largest, deepest, and least disturbed subalpine sphagnum bogs in mainland south-eastern Australia. Such wetlands have a very limited distribution in the Australian Alps.

Criterion 2: *A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.*

[Justification against former Criterion 2(a) under the Pre-1999 Criteria]

The wetland complex has a diverse assemblage of subalpine flora and fauna that were restricted to this wetland type.

Criterion 3: *A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.*

[Justification against former Criterion 2(b) under the Pre-1999 Criteria]

The Ginini Flats Wetland Complex was recognised as being at the northern biophysical limit of this habitat type, and was of importance in maintaining the genetic and ecological diversity of a number of endemic and restricted species found in subalpine wet heaths and bogs.

Criterion 4: *A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.*

[Justification against former Criterion 2(c) under the Pre-1999 Criteria]

The Ginini Flats Wetland Complex provided important breeding habitat for the vulnerable corroboree frog (*Pseudophryne corroboree*[3]); a rare species confined to the Southern Highlands of New South Wales and the Australian Capital Territory (subsequently reclassified). The area supported the largest population of this species in the Brindabella Range.

2.5.2 Current situation and additional criteria met in this reassessment

Criteria for Identifying Wetlands of International Importance were first adopted by the Ramsar Convention in 1974 and have subsequently been revised in 1990, 1996, 1999 and 2005, when the current criteria were adopted (see Table 2-1). The site has been re-assessed against the 2005 criteria as part of completing the Ecological Character Description and updating the Ramsar Information Sheet.

Table 2-1 Criteria for Identifying Wetlands of International Importance as adopted by the Ramsar Convention Conference of Contracting Parties (Criteria pertinent to Ginini Flats Wetland Complex are highlighted in blue).

Group A of the Criteria. Sites containing representative, rare or unique wetland types	
Criterion 1:	A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region[4]
Group B of the Criteria. Sites of international importance for conserving biological diversity	
Criteria based on species and ecological communities	
Criterion 2:	A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
Criterion 3:	A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.
Criterion 4:	A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.
Specific criteria based on waterbirds	
Criterion 5:	A wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds.
Criterion 6:	A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.
Specific criteria based on fish	

[3] This species has subsequently been reclassified as *Pseudophryne pengilleyi*

[4] The Australian Government considers that the appropriate biogeographic region for the assessment of the Ramsar criteria is the drainage division (BoM 2009). Note that this is a change from the IBRA regions which were used the 1995 and 1999 RIS and which are on a much finer geographic scale (see Section 2.2.1).

Criterion 7:	A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
Criterion 8:	A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
Specific criteria based on other taxa	
Criterion 9:	A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.

This assessment of Ginini Flats Wetland Complex against the 2005 criteria is described below.

Criterion 1: This criterion was claimed as met in the original RIS (ACT Parks and Conservation Service, 1995) because alpine sphagnum bogs and associated fens have a limited geographic distribution nationally.

Ginini Flats Wetland Complex is recognised as a significant example of this wetland type because it is situated at the northern extreme of the climatic range for sphagnum bog wetlands within the Murray–Darling Drainage Division. The sphagnum bog component of Ginini Flats has previously been recognised as one of the largest in Australia (Costin, 1954) and this is likely to remain the case if the areas burnt in the 2003 fires return to a bog community.

Ginini Flats Wetland Complex is also of local-scale hydrological importance (under Article 2 of the Convention) due to the role the wetlands play in maintaining water quality and, to a lesser extent, moderating runoff (see discussion in hydrology section – Section 3.1.2).

This criterion was met at designation in 1996 and continues to be met.

Criterion 2: This criterion was claimed as met in the original RIS (ACT Parks and Conservation Service, 1995) because Ginini Flats Wetland Complex is known to have recognised presence of threatened species or communities. This criterion is met at Ginini Flats Wetland Complex due to a nationally listed ecological community and threatened fauna species.

Ginini Flats Wetland Complex is predominantly comprised of an ecological community complex that is listed as Endangered on the Commonwealth EPBC Act and is a significant example in the Murray–Darling Drainage Division. The 'Alpine Sphagnum Bogs and Associated Fens' ecological community is acknowledged to be of restricted geographical distribution and thus at increased likelihood that the action of a threatening process could cause it to be lost in the near future. It has also suffered severe decline of functionally important species in this vegetation community across its geographic range, to the extent that restoration of the entire community is not likely to be possible in the near future. The community has also suffered a reduction in community integrity across most of its geographic distribution, such that regeneration is unlikely to occur in the near future even with positive human intervention.

The Ginini Flats Wetland Complex also provides important breeding habitat for the vulnerable northern corroboree frog (*Pseudophryne pengilleyi*), a species listed as Vulnerable in the EPBC Act. Whilst this species has experienced a major population decline in the past 20 years, the population at Ginini continues to be one of the largest in the wild, providing eggs for the captive breeding program

(M Evans 2009, pers. comm., 12 August). It has a significant proportion of one of the four genetically distinct populations (Morgan et al., 2008).

This criterion was met at designation in 1996 and continues to be met.

Criterion 3: This criterion was claimed as met in the original RIS (ACT Parks and Conservation Service, 1995) based on the presence of regionally significant species and nationally significant vegetation communities and flora species. The Ginini Flats Wetland Complex is at the northern biophysical limit of this habitat type within the Murray–Darling Drainage Division and is of importance in maintaining the genetic and ecological diversity of a number of endemic and restricted species found in subalpine wet heaths and bogs. Sites with extensive bog development dominated by *Sphagnum* are uncommon on the mainland of Australia. Significant plant species associated with the wetlands include the peat moss (*Sphagnum cristatum*), alpine plum pine (*Podocarpus lawrencei*), alpine ballart (*Exocarpos nanus*), dwarf buttercup (*Ranunculus millanii*), silver caraway (*Oreomyrrhis argentea*), and *Craspedia* sp. F. (Helman and Gilmour, 1985).

In addition, Ginini Flats Wetland Complex provides important breeding habitat for the vulnerable northern corroboree frog (*Pseudophryne pengilleyi*), a species listed as Vulnerable in the EPBC Act. Whilst this species has experienced a major population decline in the past 20 years, the population at Ginini continues to be one of the largest in the wild, providing eggs for the captive breeding program (M. Evans 2009 *pers. comm.*). It has a significant proportion of one of only four genetically distinct populations (Morgan et al., 2008).

This criterion was met at designation in 1996 and continues to be met.

Criterion 4: This criterion was claimed as met in the original RIS (ACT Parks and Conservation Service, 1995) based on the provision of critical habitat provided for breeding cycles of the northern corroboree frog. The northern corroboree frog relies on the availability of small ponds in the wetlands for nests; with suitable ponds formed by a high water table accompanied by suitable hydrological conditions such as low flow rates. Females briefly enter the bogs to lay approximately 25 eggs. The eggs are laid above the water line in nests in the vegetation. The eggs continue to develop in the nest over a two month period until a phase of suspended development is triggered. Tadpoles of the northern corroboree frog can hatch in autumn if there is sufficient rainfall and the young develop in the pools over winter. After hatching and moving to a nearby pool in the bog they feed on small amounts of organic detritus and, later, small invertebrates including black ants (Carey et al., 2003). The frogs later metamorphose and move from the bog communities to shelter in ground litter and organic matter in surrounding woodland over the summer. The fires of 2003 had direct and immediate as well as indirect, long term impacts on the already low frog populations. The fires occurred at the time of the 2003 breeding season which is likely to have reduced overall numbers through direct mortality with subsequent influence on the longer term population viability (Carey et al., 2003). Indirect impacts include changes in habitat—all known corroboree frog over-wintering habitat was burnt by moderate to high severity fires (Carey et al., 2003).

This criterion was met at designation in 1996 and continues to be met.

Criteria 5–8: These criteria were not assessed as being met at the time of designation in 1996 and reassessment of these criteria confirm that they are not met at this site as the site does not support large populations of waterbirds, nor is it a significant wetland for fish species.

These criteria were not met at designation in 1996 and continue not to be met.

Criterion 9: This criterion was first included as part of the 2005 criteria. This criterion is newly claimed based on the presence of the greater than one percent of individuals in the wild of the northern corroboree frog. At the time of the last survey in February 2009, the Ginini Flats wetland population, despite its low numbers, would represent nearly 50 per cent of the higher elevation population of northern corroboree frogs at known breeding sites (M Evans 2009, pers. comm., 12 August). This criterion is claimed irrespective of the impacts of the 2003 fires because monitoring showed there to be some individuals present. Despite the low numbers this population is still considered significant for this species that has very low population numbers overall.

This criterion was not available in 1996 and this criterion is newly claimed as being met in the 2009 Ecological Character Description and RIS.

2.6 Wetland types

The Ramsar Classification System for Wetland Type (Ramsar Convention, 2008) lists different wetland types. While Ginini Flats Wetland Complex has numerous vegetation communities that define its ecological character, there is however only one Ramsar designated wetland type within the Inland Wetlands category relevant to the site:

- U – **Non-forested peatlands**; includes shrub or open bogs, swamps, fens.

This wetland type is composed of the following vegetation communities: sphagnum bog, sedgeland, wet herbfield, wet heath, and tall wet health (Hope et al*.,* 2009).

3. Components, ecosystem processes and services at the time of listing (1996)

3.1 Components and ecosystem processes of Ginini Flats Wetland Complex in 1996

3.1.1 Biophysical setting

The geology underlying Ginini flats consists of intensively deformed granitic rocks of Silurian age that are overlain by Ordovician aged metasediments, which are extensively folded and composed of quartz arenite, siltstone and slate, with occasional hornfels beds. The geology is significant as the combination of fractures combined with the alternating impervious and semi-impervious metasediments causes a down-welling of surface waters into the massive underlying granitoids. Water flowing through interstitial spaces over the granitoids is forced closer to the surface at the edge of the metasediments, resulting in seepages and spring lines. The combination of these processes results in conditions suitable for the continuous growth of *Sphagnum* and other wetland plants that have been recognised as significant in this subalpine environment (ACT Government, 2001).

Slope retreat occurs on the steeper slopes comprised of metasediments and is accelerated by fire which removes the protective vegetative cover, and by frost-heave during subsequent winters. Closer to the slopes of Mt Ginini, periglacial processes have led to the lateral and vertical movement of superficial boulders and metasediments, along with an inversion of clay and humic soil layers. This process enables surface waters to easily penetrate deep into the soil profile; however, due to the active surface profile, such processes also make it difficult for plants to establish on bare ground (Wild, 2008). Such areas often have a high degree of subsurface water flow, although this flow decreases sharply with depth; surface flows are typically flashier and deliver less quantity than these subsurface flows (Fritz, 2006; Grover, 2006). The combination of subsurface flows and high degree of water infiltration delays the peak hydrograph, resulting in peak run-off being retained by the *Sphagnum* for up to a day following a rain event in some cases (Grover, 2006). It should be noted that the influence of bogs on hydrology at a catchment scale is likely to have been overstated in the past (Western et al., 2009).

Local surface water interactions at the Ginini Flats Wetland Complex may be significant due to the extent and depth of the bog (see Section 3.1.4). The transfer of water over and through these systems is generally limited in sediment supply, as sediment loads would result in gully formation and deep incision into the peat, causing catastrophic stripping of the peat and bog material down to the basal layers. Fluvial activity through these types of systems is frequently at bank-full stage, with the surrounding low-lying *Sphagnum* seen as the floodplain (Nanson, 2009).

Channel formation in peatlands tends to be similar in morphology to alluvial channels, typically with a large degree of sinuosity (Nanson, 2009), but peatland rivers do tend to diverge from alluvial channel morphologies in that there are sharp bends with long straight reaches and irregular side channel pools (Watters and Stanley, 2007). In a study of upland fen-dominated systems, Watters and Stanley (2007) found sediment input was extremely low due to a lack in upstream sediment sources. Sediment supply is likely to be similarly limited for the upland bog system of the Ginini Flats Wetland Complex due to the limited upstream catchment area. The sediment that is found in these types of systems is generally plant derived and, coupled with factors discussed above and low slope, generally presents little opportunity for erosion to occur (Watters and Stanley, 2007). Drainage and harvesting of these systems has, however, led to channel formation through erosion triggered events from mass soil or substrate failure (Huang, 2002).

Channel morphology in the Ginini Flats Wetland Complex is governed by biological accretion, which can grow back, thus physically altering the stream morphology, in some cases through a type of oblique accretion normally found in alluvial settings (Nanson, 2009; Watters and Stanley, 2007; Page et al., 2003). In order to understand the geomorphology of peatland type systems the normal physical processes need to be extended to include biological and ecological processes that may enact a greater influence over these systems.

3.1.2 Hydrology

On a regional scale, Ginini Flats Wetland Complex is located at the headwaters of the Ginini Creek, part of the Middle Cotter Catchment within the Cotter River Catchment (the primary water supply for the city of Canberra). The Cotter River Catchment extends over 481 square kilometres and includes three sub-catchments: the Upper Cotter (Corin Dam Catchment), Middle Cotter (Bendora Dam Catchment to Corin Dam) and the Lower Cotter (Cotter Dam Catchment to Bendora Dam). Ginini Creek forms the base of a small catchment of 410 hectares that rises from 1520 mASL to a maximum elevation at the summit of Mt Ginini of 1762 mASL.

3.1.3 Water quality

Ginini Flats Wetland Complex has relatively high rainfall (around 1250 mm/yr) and has freely draining alpine humus soils that are typical of much of the Australian Alps subalpine areas. There is a well developed cover of snow gum woodland with a grassy ground cover or shrubby understorey on the upper slopes. The general topography of the area ranges from gently undulating to moderate slopes. There is the potential for some erosion through slope retreat on the steeper slopes (ACT Government, 2001), however this is a small area of the catchment and only limited amounts of sediment are likely to be transported to the Ginini Flats Wetland Complex (Watters and Stanley, 2007).

Precipitation is likely to be close to chemically pristine as the Australian Alpine watershed is some distance from major industrial influences. The waters within the Ginini Flats Wetland Complex are reported to be unpolluted and slightly acidic, and to have low conductivity and very low turbidity (Osborne, 1991).

Although there has been little direct monitoring of water quality within Ginini Flats Wetland Complex or Ginini Creek, information on water quality from the larger catchment of the Cotter River is collected as part of the management of the drinking water supply by ACTEW. These data are presented here to provide context for the catchment as a whole and to show the overall impact of the large-scale fires on the catchment in the absence of long-term, accredited monitoring at Ginini Flats Wetland Complex.

The nearest downstream water quality station to Ginini Creek that is regularly monitored is at the Cotter River inlet end of the Bendora Reservoir. This site represents water from most of the upper Cotter River catchment, an area of approximately 290 square kilometres. Water quality from the upper Cotter River was considered to be exceptional quality for drinking water purposes at the time of listing.

Surface (0.3 m) water quality data (NH_3, NO_x, total nitrogen (TN), PO_4, total phosphorus (TP), pH, electrical conductivity (EC) and turbidity) has been collected from the Bendora Reservoir since 1994 by ACTEW Corporation. The effects of the January 2003 fire on all these parameters (other than pH) are evident as a clear increase in concentrations after the fires (Figure 3-1). All of these parameters appear to have returned to close to pre-2003 levels by 2009. It is clear that, for the data set as a whole, water quality from 1994 to 2002 was considerably better than from 2003 to the present.

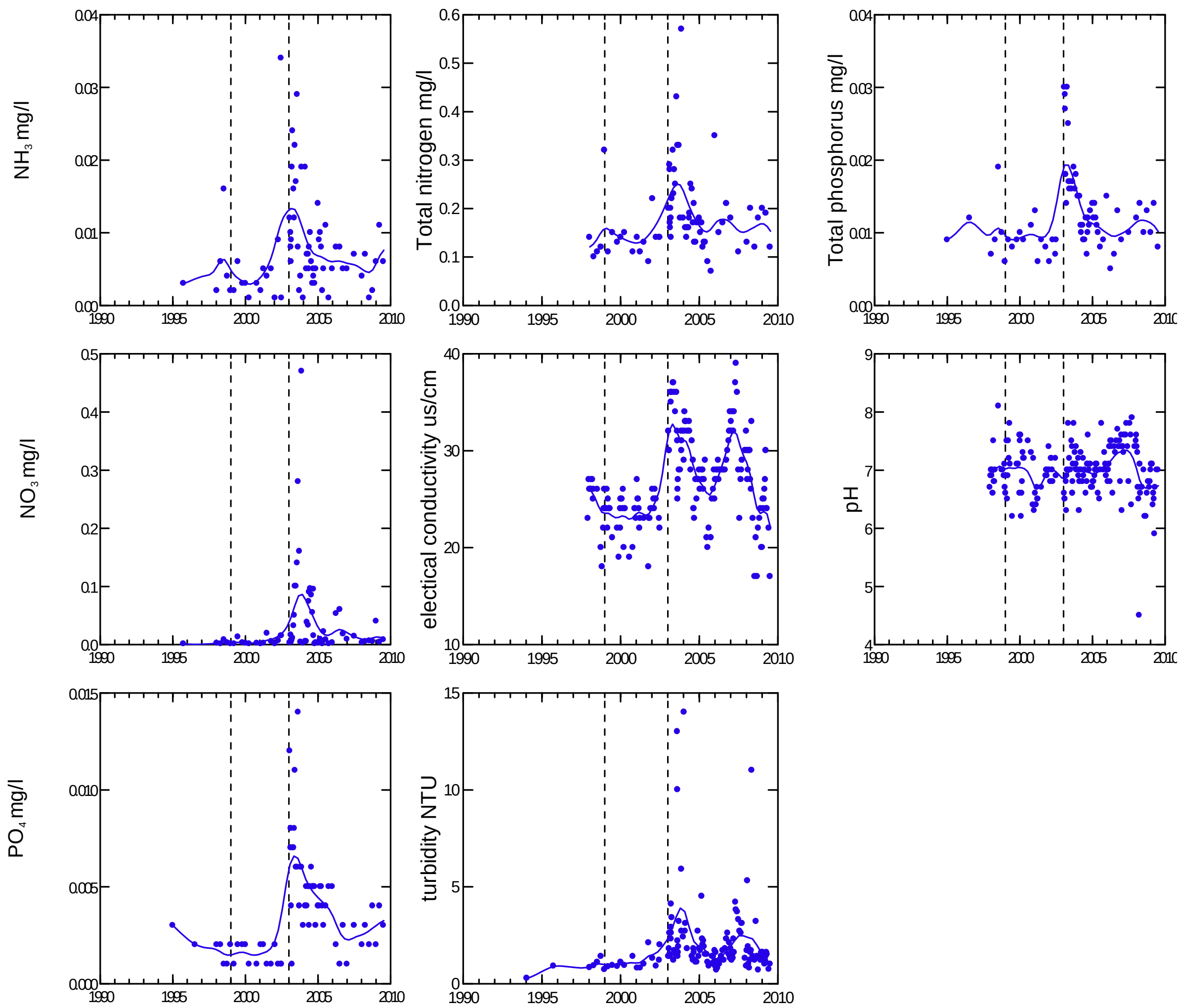

Figure 3-1 Water quality at Bendora Reservoir from 1994 to 2009 (data from ACTEW). Smoothing line is distance weighted least squares fit. The two vertical lines indicate the time of listing (1996) and the 2003 fires, respectively.

Statistical analyses of available data for surface water quality of the upper reach of Bendora Dam are presented in Table 3-1 along with values from the ANZECC and ARMCANZ Guidelines (2000) for upland rivers in the ACT region. All of the water quality parameters that have defined guideline values fall outside the guideline values at some time. Although EC and turbidity exhibit lower than guideline values this is likely to reflect higher quality water from the catchment than expected for these types of waters. The exceedance of the nutrient parameters (NO_x, TP, TN) for any significant period of time would indicate that eutrophication of the system may be occurring relative to an undisturbed environment.

Table 3-1 Surface water quality in the upper reach of Bendora Dam between 1994 and 2009 (source ACTEW). Pink cells indicate values above; blue cells values below and non-shaded cells indicate values within the ANZECC guideline values (ANZECC and ARMCANZ 2000).

Measure and unit	NH_3 mg/l	NO_x mg/l	TN mg/l	PO_4 mg/l	TP mg/l	PH	EC us/cm	Turbidity NTU
ANZECC guideline	–	<0.015	<0.25	–	<0.02	6.5–9	30–350	2–25
Number of cases	71	71	72	72	72	187	187	138
Minimum	0.002	0.002	0.070	0.002	0.005	4.5	17	0.3
Maximum	0.034	0.470	0.570	0.014	0.030	8.1	39	14.0
Arithmetic mean	0.008	0.033	0.184	0.004	0.013	7.0	27	2.0
20th percentile	0.003	0.002	0.130	0.002	0.009	6.7	24	1.0
50th percentile	0.006	0.006	0.165	0.003	0.011	7.0	26	1.5
80th percentile	0.011	0.051	0.221	0.005	0.016	7.4	31	2.4

3.1.4 Vegetation

Naturally poor drainage conditions at the site have resulted in the development of extensive sphagnum bogs, wet heath and wet grassland (or fen) in recent history (Hope and Southern, 1983) as conditions became more suited to vegetation development, with cooler and moister summer conditions occurring around 3 200 years ago (McPhail and Hope, 1985). This coincides with studies that indicate the Ginini Flats bog community is around 3 380 (+/– 70) years old (Costin, 1972), verified by Hope (2003). It persists to an average depth of 85 cm, although this varies greatly and depths of up to two metres have been recorded in the past (Clark, 1980). The bog development has been extensive, both in the drainage basin and on the slopes, providing a variety of sphagnum bog types within the wetland complex. Three classifications of bogs, based on their topographic setting, occur within the Ginini Flats Wetland Complex:

1. slope bog and fens are found at breaks of slope on valley slopes indicating groundwater supply;
2. headwater bogs occur at the head of small streams, often surrounded by heath of woolly tea-tree (*Leptospermum lanigerum*) and other shrubs; and
3. valley floor bogs and fens occur on the floor of valleys, often with meandering incised streams dammed by peat ponds (Hope et al*.,* 2003).

All three types of sphagnum bogs at Ginini Flats are dominated by large hummock forming mosses, predominantly *Sphagnum cristatum*, and other water-loving, oligotrophic plants including a covering of shrubs and restiads. These sphagnum bogs develop in areas of reliable water availability because, like other mosses, *Sphagnum* lacks a vascular system to transport water and nutrients (van Breemen 1995, Moore and Bellamy, 1974). *Sphagnum* spp. is a slow growing moss species that forms extensive wetland communities and has been recorded to increase in length by up to 30 cm in a growing season at Ginini Flats (before compression from snow pack) (Clark, 1980). This growth pattern has resulted in a linear accumulation of peat of 0.7–3.3 cm/100 years (Hope, 2003).

On top of the *Sphagnum* layer there is substantial variation in vegetation composition in the bog complex, including a mosaic of bog, wet heath, wet herbfield, sedgeland, dry heath and tall wet heath along a gradient of reducing water availability, surrounded by subalpine woodland. The vegetation at Ginini Flats Wetland Complex was described by Clark (1980) and classified by Helman and Gilmour (1985), providing the communities described in Table 3-2 and the mapping classifications presented in Figure 3-2 follow Hope et al. (2009). Classification of *Sphagnum* communities in NSW and ACT into nine floristic groups based on species presence and absence showed Ginini Flats to be included in the shrubby-sedgey sphagnum peatland group (Whinam and Chilcott, 2002). These communities are characterised and differentiated by the shrub *Baeckea gunniana* and include many sedges such as *Empodisma minus, Baloskion australe, Luzula* spp. and the grass *Poa costiniana* in drier areas.

Table 3-2 Vegetation communities and dominant species which comprise the Ginini Flats Wetland Complex Ramsar site

Vegetation community (Helman and Gilmour, 1985)	**Mapping unit (Hope et al., 2009)**	**Mapped extent [5] (ha)**	**Dominant species**
Bog	Sphagnum bog	44.4	*Sphagnum cristatum, Richea continentis* and *Baloskion australe*
Wet herbfield	Poa	19.4	*Poa costiniana, P. clivicola* and *Arthropodium milleflorum*
Wet heath	Shrub bog	0.2	*Epacris paludosa, Baeckea gunniana* and *Callistemon pityoides*
Sedgeland	Carex fen	0.03	*Carex gaudichaudiana* and *Ranunculus* spp.
Tall wet heath	Shrubs	1	*Leptospermum lanigerum* and *Sphagnum cristatum*
Dry heath	Not mapped	Approx 345	*Bossiaea foliosa, Oxylobium alpestre* and *Helipterum anthemoides*
Snow gum woodland	n/a		*Eucalyptus pauciflora* ssp. *debeuzevillei*

The predominant vegetation community within the Ramsar site boundary (which follows catchment boundaries) is snow gum (*Eucalyptus pauciflora* ssp. *pauciflora* and ssp. *debeuzevillei*) woodland with a grassy ground cover (*Poa* spp.) or a shrubby understorey dominated by *Bossiaea foliosa, Oxylobium ellipticum* and *Daviesia ulicifolia* (Figure 3-2). The woodland structure is indicative of past fire events (1939 and 1944), displaying relatively even-aged mallee habits where trees have re-sprouted from lignotubers. The understorey varies from low shrubs to grassy areas. This community occurs on alpine humus soils on the well-drained surrounding slopes of the catchment that drain into the wetland proper. There are also pockets of snow gum woodland within the wetland, with one such patch between west Ginini Flats and east Ginini Flats having an understorey of *Tasmania xerophila* and *Poa* spp.

[5] Note: these areas have been calculated on flat, mapped extents and do not take into account slopes or elevations (Digital Terrain Model), therefore these calculations are likely to underestimate the total area on steeper slopes compared with flat areas. Mapping precision and interpretation details are presented in Hope et al. (2009).

The interface of wetland communities and the open woodland is characterised by dry heaths of *Bossiaea foliosa* and *Oxylobium alpestre*, which may represent the edge of cold air drainage pools where mean temperatures reduce primary productivity and the development of sufficient woody tissue to support snow gums (Bell and Bliss, 1980) resulting in an 'inverted tree line'. Wetter areas and gullies have tall wet heath communities dominated by dense stands of *Leptospermum lanigerum*, which may have an understorey of *Sphagnum*.

Wet herbfield communities, which may also be classified as grasslands, also occur on the periphery of the bog communities at Ginini Flats. This community includes *Poa* tussock grasses (*Poa costiniana*, and *P. clivicola*) and small epacrid shrubs (*Epacris microphylla* and *E. brevifolia*).

Sedgeland communities are dominated by the rhizomatous sedge *Carex gaudichaudiana* on peat to alpine humus soils and can be viewed as an alternative state community where, at the time, *Sphagnum* cannot grow. These communities are more correctly classified as fens because the water table is, on average, at the soil surface (Whinam and Hope, 2006). This results in open pools supporting *Gonocarpus micranthus* and the aquatic milfoil *Myriophyllum pedunculatum*. This community is viewed as inseparable to sphagnum bogs in the EPBC Act (1999) listing which are incorporated into the Endangered Alpine Sphagnum Bogs and Associated Fens community (DEWHA, 2009a).

The sphagnum bog complex and wet heath communities form a mosaic, which includes the shrub species *Richea continentis, Epacris paludosa*, *Baeckea gunniana, Callistemon pityoides* and *Grevillea australis* growing on hummocks and hollows of *Sphagnum*. Stands of *Richea continentis* are extensive and were considered of value by Costin (1972) in his survey of that time. The restiads *Empodisma minus* and *Baloskion australe* intergrow between and over the *Sphagnum* hummocks, which are around 50 cm higher than adjacent hollows, resulting in a variable surface appearance of the bog. *Empodisma minus* fen occurs on the drier edges and shrub growth (particularly of the myrtaceous shrubs *Baeckea* and *Leptospermum*) often concentrates along drainage channels.

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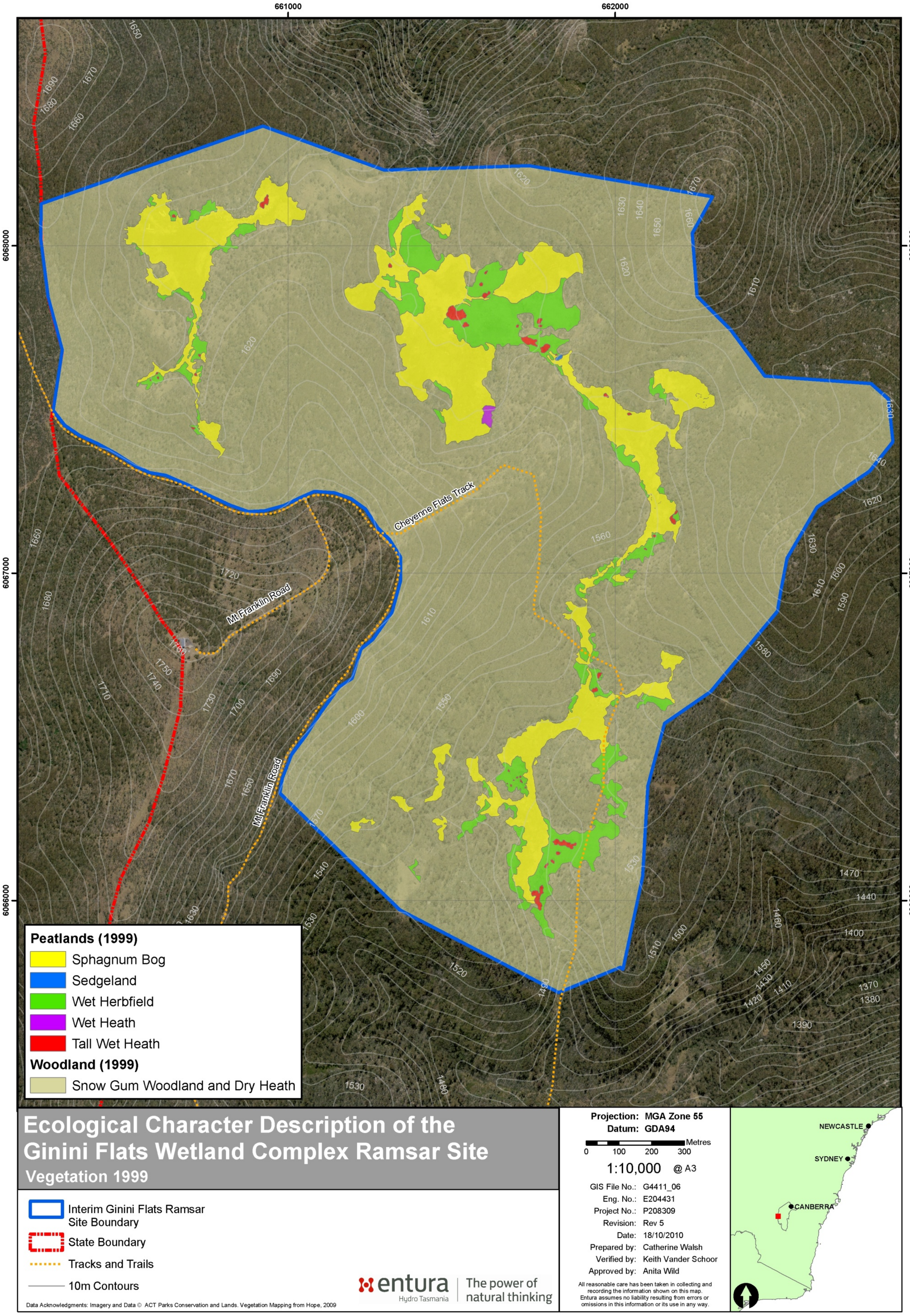

Figure 3-2 Distribution of vegetation communities at Ginini Flats Wetland Complex (data from Hope et al., 2009)

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3.1.4.1 Exotic plant species

At the time of listing there was little evidence of weeds in the wetlands themselves, although some peripheral weed invasion was noted associated with disturbed areas such as roads. There are now a number of 'naturalised' ruderal weeds in alpine and subalpine areas including sheep's sorrel (*Rumex acetosa*).

3.1.5 Peat formation

Peatlands form in areas with cool temperatures, positive water balance and usually more than 500 mm annual precipitation (Gignic and Vitt, 1994, cited in Halsey et al*.,* 2000). They are the product of complex interactions between biotic factors (growth rate, decomposition, exclusion of other plants) and abiotic conditions (water supply, temperature, topography). These interactions often develop over many thousands of years (over 3 000 years for Ginini Flats Wetland Complex), with hydrological conditions being considered one of the fundamental driving forces in both the formation and degradation of peatlands. Water flow and storage changes as peatlands develop (Price et al*.,* 2003). In developed peatlands the accumulating dead peat beds become the predominant substrate for water flow through wetland. Similarly, the living peat plants form an open structure that allows the passage of excess water.

A positive water balance is the primary requirement for peatland growth and maintenance. Influx or recharge of water can come from precipitation, surface runoff from the catchment or groundwater sources. Efflux, or discharge of water, is usually through runoff downstream, seepage to groundwater or evapotranspiration (Charman, 2002). Overall, for peatlands to function there needs to be a net balance of influx and efflux that maintains waterlogged conditions within the peat. Peatlands retain large amounts of water, with peat being more than 95 per cent water by weight. Accumulated peat, therefore, represents a net storage of water in the landscape, although only a small proportion of this is ever available to downstream communities.

Developing peatlands are characterised by the production of organic matter in excess of decomposition that leads to a net accumulation of plant-derived organic matter (Watters and Stanley, 2007). A consistent water supply that provides a net positive water balance in the beds is a prerequisite for the accumulation of peat, as decomposition processes are accelerated when peat beds become exposed (Charman, 2002). The maintenance of waterlogged conditions also provides conditions beneficial for the net production of peatland plants (Grosvernier et al*.,* 1997). *Sphagnum* spp. in particular have no root system and must obtain water through direct exposure to free water. *Sphagnum* spp. also have the ability to actively create conditions that give them a competitive advantage over other plants through the creation of acidic, cold and anoxic peat bogs (van Breemen, 1995). Peat formation has been measured at Ginini Flats, revealing a linear accumulation of peat of 0.7–3.3 cm / 100years (Hope, 2003).

3.1.6 Amphibians

Like other wetlands, Ginini Flats Wetland Complex provides habitat for amphibian species including frogs. Three frog species have been recorded within, or near the wetlands. The common eastern toadlet (*Crinia signifera*) and southern toadlet (*Pseudophryne dendyi*) have been recorded in the adjacent subalpine woodlands. The threatened northern corroboree frog is considered in further detail below.

3.1.6.1 Corroboree frog

Studies of genetic structure of *Pseudophryne* populations revealed that the geographic and altitudinal differences between populations were reflected in their genetic structure. This resulted in the classification of two separate species: *P. pengilleyi* (northern corroboree frog), and *P. corroboree* (southern corroboree frog) (Osborne and Norman, 1991). *Pseudophryne pengilleyi* is confined to the alpine and subalpine regions of the ACT and the adjacent Fiery Range and Bogong Mountains in NSW, whereas *P. corroboree* is found only in the Snowy Mountains in NSW (Osborne, 1989). Populations within both species are likely to be independent due to their slow moving nature, potentially limited dispersal abilities and barriers to dispersal (Osborne and Hunter, unpublished data cited in Morgan et al*.,* 2008).

At the time of Ramsar designation in 1996, the northern corroboree frog was recognised to be an important value of Ginini Flats Wetland Complex and the site was believed to hold one of the largest known populations of this species. Currently, *P. pengilleyi* is listed as Vulnerable on the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, Vulnerable on Schedule 2 of the NSW *Threatened Species Conservation Act 1995*, and Endangered on the IUCN Red List.

The species life history descriptions are based on the work of Osborne (1989) who studied and compared the corroboree frog forms. *Pseudophryne pengilleyi* is a small, distinctive frog, with adults reaching approximately 2.5–3 cm in body length at maturity. This species has black and yellow dorsal stripes that look similar to the ochre body paint of some Aboriginal people during corroborees and other festivals, leading to its common name. The bright colouring of the frog is believed to be an adaptation to act as both camouflage and predator deterrent, as many highly coloured frog species are known to be toxic to predators. The marking patterns of *P. pengilleyi* differ from *P. corroboree*, and the species can also be distinguished by their advertisement calls.

Frogs use different habitats within and surrounding the wetland complex depending on season and breeding status (Pengilley, 1966 cited in DEWHA, 2009b). During the early summer breeding period males move into the sphagnum bogs, wet tussock grasslands (mapped as wet herbfield in Figure 3-2) and wet heath from the surrounding snow gum woodland to establish nests and begin calling to females. The frogs rely on the availability of small ponds in the wetlands for nests; with suitable ponds formed by a high water table accompanied by suitable hydrological conditions such as low flow rates. Females briefly enter the bogs to lay eggs. Approximately 25 eggs are laid above the water line in these nests, and the eggs continue to develop in the nest over a two month period until a phase of suspended development is triggered. Tadpoles of the northern corroboree frog can hatch in autumn if there is sufficient rainfall and the young develop in the pools over winter. After hatching and moving to a nearby pool in the bog they feed on small amounts of organic detritus and, later, small invertebrates including black ants (Carey et al*.,* 2003). The frogs later metamorphose and move from the bog communities to shelter in ground litter and organic matter in surrounding woodland over the summer.

Northern corroboree frogs can take up to four years to reach sexual maturity (one year as an embryo/tadpole and two years as a juvenile/sub-adult), resulting in a time lag in recruitment following disturbances such as fires or drought. The populations have been impacted in the past by natural phenomena such as drought because of the lowering of the water table in the sphagnum bogs and the subsequent reduction in the number and size of breeding pools (Pengilley, 1973).

The population of northern corroboree frogs has declined significantly since the 1980s across its entire range. At Ginini Flats Wetland Complex, the frog was once estimated to be the largest vertebrate biomass (Osborne, 1990) and had the largest aggregations of the species in its range. By

1992, populations of northern corroboree frogs in the ACT had declined significantly, with less than 10 per cent of the population size of the early 1980s, and have continued to be at very low levels since (Figure 3-3). This low population size was the state of *P. pengilleyi* at the time of listing of Ginini Flats Wetland Complex, with less than 15 calling males being recorded at this location (M. Evans 2009 pers. comm.).

The decline in numbers is believed to be due to chytridomycosis, a disease caused by infection with the Amphibian Chytrid Fungus (Hunter, 2007 cited in Morgan et al*.,* 2008), a pathogen that may have been carried to the site by another frog species, *Crinia* spp. (DEWHA, 2006). Hunter (2007) found that 14 per cent of the population of *P. pengilleyi* were infected with the fungus, lower than the 44–59 per cent in *P.corroboree* populations sampled. The decline to the current critically low population size has prompted the initiation of a captive husbandry program, with the population at Ginini Flats providing valuable eggs for this program.

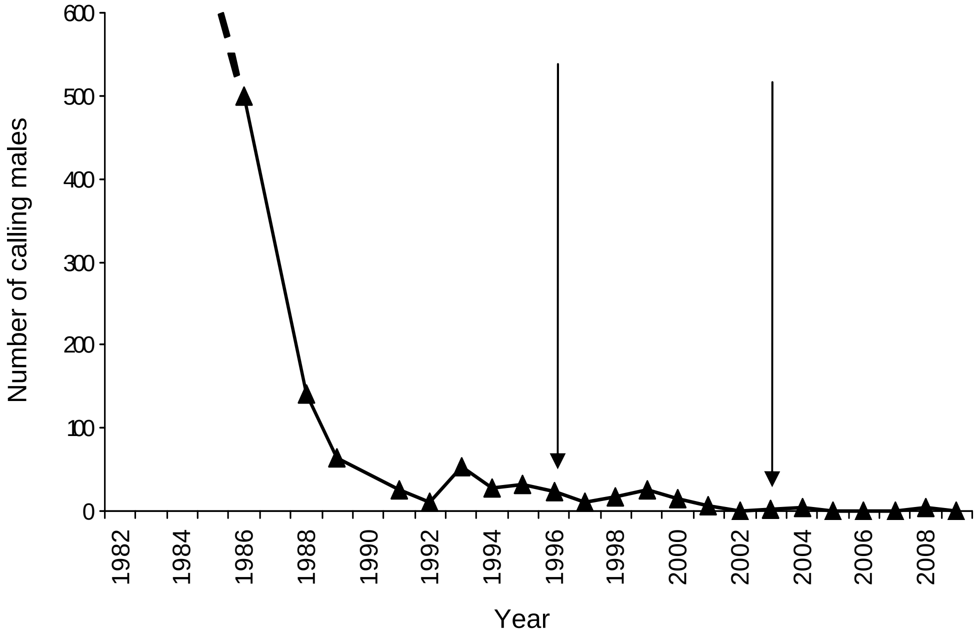

Figure 3-3 Population numbers of *P. pengilleyi* calling males recorded at Ginini Flats (data from M. Evans 2009). The first arrow indicates time of listing (1996) and the second arrow a major fire event (2003).

3.1.7 Mammals, birds and reptiles

At the time of listing in 1996, the Ginini Flats Wetland Complex supported a range of wetland habitats including sphagnum bog, wet herbfield and wet heath. The location and extent of these habitats are shown in Figure 3-2. These wetland habitats support fauna species that are restricted to subalpine wetlands across the Australian Alps, with the Ginini Flats Wetland Complex forming the northern extent for many of these species. Vertebrate fauna species that have been recorded in the area (ACT Government, 2001) are wetland dependent and are expected to have been present around the time of listing include:

- broad-toothed rat (*Mastacomys fuscus*)
- Latham's snipe (*Gallinago hardwickii*)
- alpine water skink (*Eulamprus kosciusko*)

- mountain swamp skink (*Niveoscincus rawlinsoni*).

These species are discussed further below.

3.1.7.1 Broad-toothed rat

The broad-toothed rat occurs in a range of habitats where there is dense vegetation cover (Green and Osborne, 1994), including wet herbfield and wet heath habitats at the Ginini Flats Wetland Complex, although there is little available data on the abundance of broad-toothed rats at the site. The broad-toothed rat is herbivorous and feeds mainly on grasses but does also eat the leaves of herbs, seeds and fungi (Green and Osborne, 1994).

3.1.7.2 Latham's snipe

Latham's snipe is listed as a migratory species protected under international agreements (JAMBA, CAMBA, ROKAMBA, Bonn) as well as a marine species under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Latham's snipe breeds in Japan and migrates to Australia for the spring and summer months. It forages in mud for aquatic invertebrates. The sphagnum bog, wet herbfield and wet heath habitats within the Ginini Flats Wetland Complex are likely to be suitable for Latham's snipe, particularly where there are open mud areas for foraging and dense low vegetation for shelter.

Latham's snipe have been recorded in five out of the sixty-six surveys that have been carried out within 10 kilometres of the Ginini Flats Wetland Complex between 1998 and 2006. All five records of Latham's snipe are from late January and early February in 2002, when a total of seven birds were observed through three sightings of single birds and two sightings of two birds (Source: http://www.birdata.com.au/homecontent.do accessed 29 July 2009).

3.1.7.3 Alpine water skink

Eulamprus kosciuskoi is a moderately large skink that grows to 20 cm and is widespread in the Australian Alps. They are confined to areas of sphagnum bog, wet heath and, to a lesser extent, wet herbfield (Green and Osborne, 1994). Alpine water skinks have been observed to shelter in burrows made by freshwater crayfish (*Euastacus* species) (Green and Osborne, 1994). They feed on small invertebrates (for example flies, grasshoppers, spiders and moths) and are viviparous, with females giving birth to between two and five live young in late summer (Green and Osborne, 1994). This species is believed to occur within or adjacent to Ginini Flats Wetland Complex although there has been little research undertaken (ACT Government, 2001).

3.1.7.4 Mountain water skink

Pseudemoia rawlinsoni (referred to in the RIS and previous Management Plan for the site as *Niveoscincus rawlinsoni* and *Leiolopisma rawlinsoni*) is a small skink, approximately 100 mm long, with glossy olive scales (Green and Osborne, 1994). These skinks are locally common in swampy habitats including sphagnum bog, wet heath and wet herbfield (Green and Osborne, 1994). The bog swamp skink feeds on small invertebrates. The species is viviparous with a litter size of four to eight young born in late summer (Hutchinson and Donnellan, 1988). This species is believed to occur within or adjacent to Ginini Flats Wetland Complex although there has been little research undertaken on reptiles in the area (ACT Government, 2001).

3.1.8 Fish

The native mountain Galaxias (*Galaxias olidus*) inhabits the small streams that bisect the Ginini Flats Wetland Complex (ACT Government, 2001). This species and the two spine blackfish (Gadopsis *bispinosis*) are the few native fish known to occur above the snowline in the Snowy Mountains region. *Galaxias olidus* feeds on both terrestrial and aquatic invertebrates and may itself be predated on by alpine water skinks (Green and Osborne, 1994).

There is no evidence that exotic fish species have colonised aquatic habitat within Ginini Flats Wetland Complex. ACT Government (2007) explains that the Cotter River catchment (for which the Ginini Flats Wetland Complex is part of the headwaters) is one of a few south-east draining catchments that do not support a number of exotic fish species. Carp and redfin are excluded due to the fish barrier created by the Cotter Dam and brown trout are excluded from the mid and upper catchment by the fish barrier created by the Bendora Dam. Rainbow trout are not excluded by these barriers and occur upstream of the dam. Therefore, the Ginini Flats Wetland Complex contributes to providing important habitat for *G. olidus* in the associated creek systems. Given the lack of brown trout and other invasive species in the wetland, the persistence of *G. olidus* suggests that the fish community was in a natural, undisturbed condition at the time of listing.

3.1.9 Invertebrates

Ginini Flats Wetland Complex contains a number of habitats that support invertebrates. Bog habitats, including streams that bisect the flats and shallow pools with woody debris substrates, support aquatic invertebrate fauna (Australian Nature Conservation Agency, 1996). Terrestrial insects commonly utilise the flats as feeding and breeding habitat, especially those species whose life histories involve an aquatic larval stage. It is thought that the majority of invertebrates within bog environments are of terrestrial origin, as completely aquatic habitats are transitory, disappearing when the peat rises above the water table (Batzer and Wissinger, 1996).

There is a lack of baseline ecological information on macroinvertebrates associated with Ginini Flats Wetland Complex, although the body of research suggests that the invertebrate fauna of bog environments is highly diverse given the heterogeneity of habitats found within bog environments. For example, Los (2005) demonstrated that the composition of aquatic invertebrate communities within shallow pools associated with bog environments vary between different vegetation types in the Bogong High Plains in Victoria.

The invertebrate fauna of the Australian Alps is believed to be highly diverse and highly endemic amongst the fauna that are restricted to montane and subalpine regions, but they are poorly understood (*ACT Government, 2007a*; Green, 1998). Osborne (1984) recorded 840 species of insects and arachnids within the nearby Kosciuszko National Park in all habitat types. Lambkin et al*.,* (2002) recorded 163 species from 31 families in the order Diptera. Suter et al*.,* (2002) collected 112 invertebrate taxa from streams in the Mt. Kosciusko area, including insects and non insects, with caddisfly larvae being the most diverse (36 species in 13 families). It is also likely that many species remain undescribed (Osborne, 1984) and it is understood that this is the case for the Ginini Flats Wetland Complex macro-invertebrate fauna. Further to this, Kirkpatrick (1994) suggests that the biodiversity in the alpine invertebrate fauna alone may fulfil the World Heritage Area criteria for nomination. A full description of common Australian alpine invertebrate fauna is provided by Green and Osborne (1994), Campbell et al*.,* (1986), and Green (2002).

A number of notable invertebrate species have been recorded within Ginini Flats Wetland Complex. Of the terrestrial species, *Polyzosteria virridisma* (metallic bog cockroach) is confined to the Snowy Mountains and Brindabella Ranges alpine areas, and has been observed in Ginini Flats (Australian

Nature Conservation Agency 1996; Green and Osborne, 1994). Osborne (1984) notes that a number of species, whilst reasonably common to the Australian alpine environment, are at their most northern limit at the Ginini Flats Wetland Complex, within somewhat isolated populations. Species include: *Acripeza reticulate* (mountain grasshopper), *Yeelanna* sp. (spotted grasshopper), *Kosciuscola tristis* (alpine chameleon grasshopper) and various species of *Lycosa* (alpine wolf spiders).

Of the aquatic species, the Namadgi National Park Draft Management Plan (*ACT Government, 2007a*) states that the spiny freshwater crayfish (*Euastacus rieki*) is present within the Namadgi National Park alpine areas, including bog environments. Given the shallow pools with woody debris substrates and streams with overgrown woody shrubs, it is possible that this species occurs within the Ginini Flats Wetland Complex, although this requires confirmation.

Despite the potential for a wide range of invertebrate species, given the lack of data specific to the site the actual ecological condition of invertebrate fauna at the time of listing is not known. Despite this lack of knowledge on ecological condition, it is acknowledged that the invertebrate fauna of the Ginini Flats Wetland Complex form an important food source for *Pseudophryne pengilleyi* (northern corroboree frog), *Galaxias olidus* (mountain galaxid) and other invertebrates such as *Lycosa* sp. (alpine wolf spiders) (Carey et al*.,* 2003; Cadwallader et al*.,* 1980; Green and Osborne, 1994; Murkin and Batt, 1987).

3.1.10 Feral animals

Past disturbance to the site include livestock grazing (Clark, 1980). Livestock grazing has been minimal with the last official grazing in the area occurring in 1909, and possibly during a period of drought in 1920 (Clark, 1980).

Feral pigs have been observed in the Ginini Flats Wetland Complex. Feral pigs disturb large areas of herbfield in their search for food such as insect larvae and tubers (Alexiou, 1983). Pigs also wallow in bog pools and can disturb the breeding pools used by the corroboree frogs that breed in the area.

Foxes (*Vulpes vulpes)* are found in the area and pose a threat to vulnerable species in the wetlands such as the broad-toothed rat and Latham's snipe. Feral horses are a potential threat as they have impacted the Mt Bimberi *Sphagnum* bog in the south of Namadgi National Park, but are currently being managed by a control program. Rabbits and European wasps are also found at the wetlands. Feral deer are an emerging threat as they have been observed within the park.

3.2 Ecosystem services

The Millennium Ecosystem Assessment provided an assessment of the current state of the world ecosystems and the services they provide to humans (Millennium Ecosystem Assessment, 2005). This assessment resulted in a list of recognised services various wetland types may provide, and form the basis of assessments for Ramsar listed wetlands. Four main categories of ecosystem services are described in the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005) including:

1. provisioning services – the products obtained from the ecosystem, such as food, fuel and fresh water
2. regulating services – the benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard reduction

3. cultural services – the benefits people obtain through spiritual enrichment, recreation, education and aesthetics

4. supporting services – the services necessary for the production of all other ecosystem services, such as water cycling, nutrient cycling and habitat for biota. These services will generally have an indirect benefit to humans or a direct benefit over a long period of time.

The key ecosystem services and benefits provided by the Ginini Flats Wetland Complex at the time of listing are outlined in Table 3-3. Critical components and processes underpinning these services are detailed further in Section 4.

Table 3-3 Ecosystem services and benefits provided by the Ginini Flats Wetland Complex

Ecosystem service or benefit category	**Description**
Provisioning services – products obtained from the ecosystem such as food, fuel and fresh water	
Wetland products	The wetland complex is part of the Cotter Catchment, the primary water supply source for Canberra, capital city of Australia.
Regulating services – benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation	
Climate regulation	Peat may be a significant carbon sink depending on climatic and hydrological conditions (Lawrence et al., 2009). However, peat can also act as a carbon source under warmer conditions which promote peat decline. Predictions by Whinam and Chilcott (2002) suggest that such decline is likely.
Maintenance of hydrological regimes	Localised flattening of hydrological curve through the retention and slow release of moisture over a period of days (Western et al., 2009).
Erosion protection	Protection of soil surface from frost heave and accelerated erosion processes.
Water quality maintenance	Filtration of water, buffering of nutrients and sediments.
Hazard reduction	Flood control through flattening of the hydrological curve (as outlined above).
Supporting services – services necessary for the production of all other ecosystem services such as water cycling, nutrient cycling and habitat for biota. These services will generally have an indirect benefit to humans or a direct benefit over a long period of time.	
Biodiversity	Supports a significant sub-set of regional flora species and an ecologically-significant vegetation community.
	Supports a number of regionally significant and, nationally and internationally threatened species and vegetation communities.
	Supports a significant population of a threatened amphibian species (northern corroboree frog).
Soil formation	Supports peat soil formation and the accumulation of organic matter.
Nutrient cycling	Provides buffer capacity and removal or conversion of up to 90% nitrate (Silvester, 2009).
Cultural services – benefits people obtain through spiritual enrichment, recreation, education and aesthetics	
Recreation and tourism	Winter skiing, summer walking and spring wildflower viewing.

Ecosystem service or benefit category	**Description**
Spiritual and inspirational	Wetland is likely to have been used on-route to traditional harvest sites (Mt Gingera) for Bogong moths by Aborigines.
Scientific and educational	Scientific studies on the northern corroboree frog and provision of eggs for captive breeding program.
	Supports numerous Paleological studies of vegetation, climate and fire histories in peat sediments.
	Medium-term monitoring of rehabilitation trials of post-fire recovery of sphagnum bogs.

4. Critical components, ecosystem processes and system interactions

Critical ecological components and processes underpinning the ecological services described in this ecological character description (see Section 3.2) are detailed below. Functioning of these critical components and processes is also described in the conceptual models which follow.

4.1 Hydrology

4.1.1 Peatlands

Peatlands behave in significantly different ways to mineral soils in the way they transmit and store water. Ingram (1978) considers peat to have two layers that have different hydrological properties:

1. the surface layer (Acrotelm), which contains an oscillating water table with variable water content and is subject to periodic air entry, has high hydraulic conductivity and is rich in microbes
2. the lower layer (Catotelm), which is constantly saturated and has no air entry, poor hydraulic conductivity and is poor in microbes (Figure 4-1).

The Acrotelm consists of growing or recently dead plant material. This layer is generally between 0 and 50 cm thick, and typically encompasses the full range of water table fluctuation within the bog (Price et al., 2003). The lower layer, or Catotelm, consists of successively more decomposed plant material with depth, and can be many metres thick. It is typically saturated. The transition from the Acrotelm to the Catotelm is often distinct with a rapid change in the density of the substrate (Charman, 2002).

In sphagnum bogs the Acrotelm is considered highly permeable and while the hydraulic conductivity is generally high, it rapidly declines with depth. Hydraulic conductivity can decrease in the Acrotelm by as much as four orders of magnitude over 50 cm depth (Boelter, 1965 cited in Price et al., 2003). In many peatlands, surface runoff is the major route of efflux from the system and is often strongly correlated to fluctuations in water level (Charman, 2002). The decrease in hydraulic conductivity within the Acrotelm leads to a level of self-regulation in the relationship between flow and water level that constrains water table fluctuations within a small range. When the water table is high, flow is through the higher layers of the Acrotelm where hydraulic conductivity is also high; as the water table falls so too does hydraulic conductivity, leading to a longer retention of water in the bog system (Bay, 1969 cited in Price et al., 2003). All of the Catotelm (at least in sphagnum bogs) has low hydraulic conductivities. Like the Acrotelm, there is often also a decline in hydraulic conductivity with depth in the Catotelm (Charman, 2002; Grover, 2006).

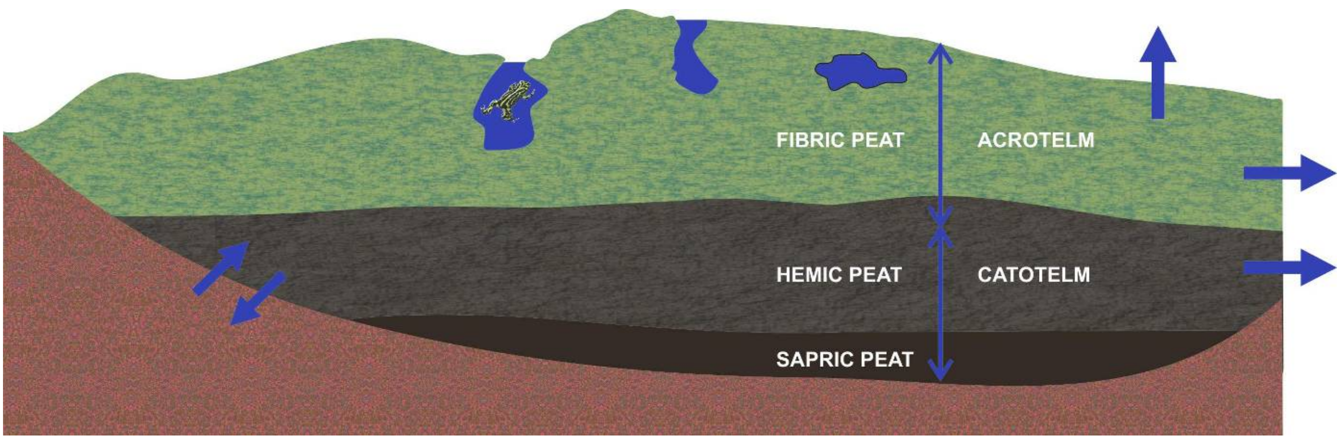

Figure 4-1 Conceptual model of the structure of Ginini Flats Wetland Complex showing the peat layers and hydrological inflows of the system

The water retention capacities of the Acrotelm and Catotelm are also very different. The proportion of water released when they are allowed to drain by gravity (defined as the specific yield) can effect both the survival of bog plants and the amount of water delivered downstream. The Acrotelm shows a decrease in specific yield with depth, typically starting at 0.5 (50 per cent of water released) at the surface and decreasing to 0.1 (10 per cent of water released) at 50 cm depth (Boelter, 1965 cited in Price et al., 2003). Average specific yields in the Catotelm are considered to be approximately 0.2 (20 per cent of water released). Like the Acrotelm, the Catotelm typically exhibits decreases in specific yield with depth, and this is thought to be the consequence of the increasing level of decomposition of the peat over time, which produces increasingly smaller pore sizes between the organic particles. The specific yield of the Catotelm is considered inconsequential to downstream flow or yield, as this part of the bog is constantly saturated and the water contained within it remains a constant volume.

The decrease in specific yield of the Acrotelm with depth does have consequences for the long term retention of water in the bog, in particular after a period of dry weather. During base flow conditions between rain events, the influx of water will slowly diminish from surface and groundwater sources and the Acrotelm will reduce in storage capacity as the water table drops. The response in stream flow below the bog when a major rainfall event occurs will then depend on the available storage capacity of the Acrotelm, with longer periods between events more likely to lead to reduced yields downstream. When spare storage capacity is available in the Acrotelm, a delay in runoff compared to mineral soils will occur in the receiving waters; this delay has been demonstrated to be as great as 22 hours in a Scottish peatland that had not received rain for 50 days (Smit et al., 1999 cited in Western et al., 2009).

The lower specific yield of the Acrotelm at depth decreases the rate of decline in water level within the bog when flow is reducing. Overall, although the physical cross-section of the Acrotelm appears to be wide and shallow, its hydraulic cross section is more akin to a V shaped weir, where increased flows lead to a smaller relative response in water table depth.

4.1.2 Water balance

A net positive water balance, on the scale of seasons, is considered an essential component in the functional integrity of peatlands and is one of the factors limiting development of extensive sphagnum bogs north of Ginini Flats Wetland Complex, with Barrington Tops in New South Wales being an exception due to local conditions and altitude (Nanson, 2009). Direct measurements of water balance in wetland systems are rare, as many of the components of the water cycle are difficult to measure directly on the scale of a natural system. No water balance measurements are known for Ginini Flats; however estimations can be calculated using a combination of both direct and modelled data, as Western et al., (2009) did for the comparable Bogong High Plains system.

The water balance of five small catchments (183–2000 ha) on the Bogong High Plains that contained between 13 and 18 per cent peatlands was calculated. This proportion of peat is comparable to that of the Ginini Flats Wetland Complex. The Bogong High Plains have average annual rainfalls of 2070 to 2496 mm, with runoff being 63 per cent to 80 per cent of rainfall. The difference between rainfall and runoff is primarily loss through evapotranspiration (a loss of 504 to 878 mm per annum). These calculations assumed that evapotranspiration did not occur during times of snow cover (generally 4–5 months of the year). These rates of evapotranspiration are high by Australian standards, representing the generally wet nature of the environment, and are about 85 per cent of the potential evaporation that would occur from a similar area of open water (Western et al., 2009).

Partitioning of the evapotranspiration rates between peatlands and the rest of the catchment in the Bogong High Plains indicated that peatlands loose significantly less water than the catchment as a whole. Peatlands water loss due to evapotranspiration was found to be about 30 per cent less on average than the surrounding catchment (Western et al., 2009). Whilst the rainfall figures for the Bogong High Plains are substantially higher than for Ginini Flats Wetland Complex (approx 1250 mm), the underlying mechanisms are likely to be similar.

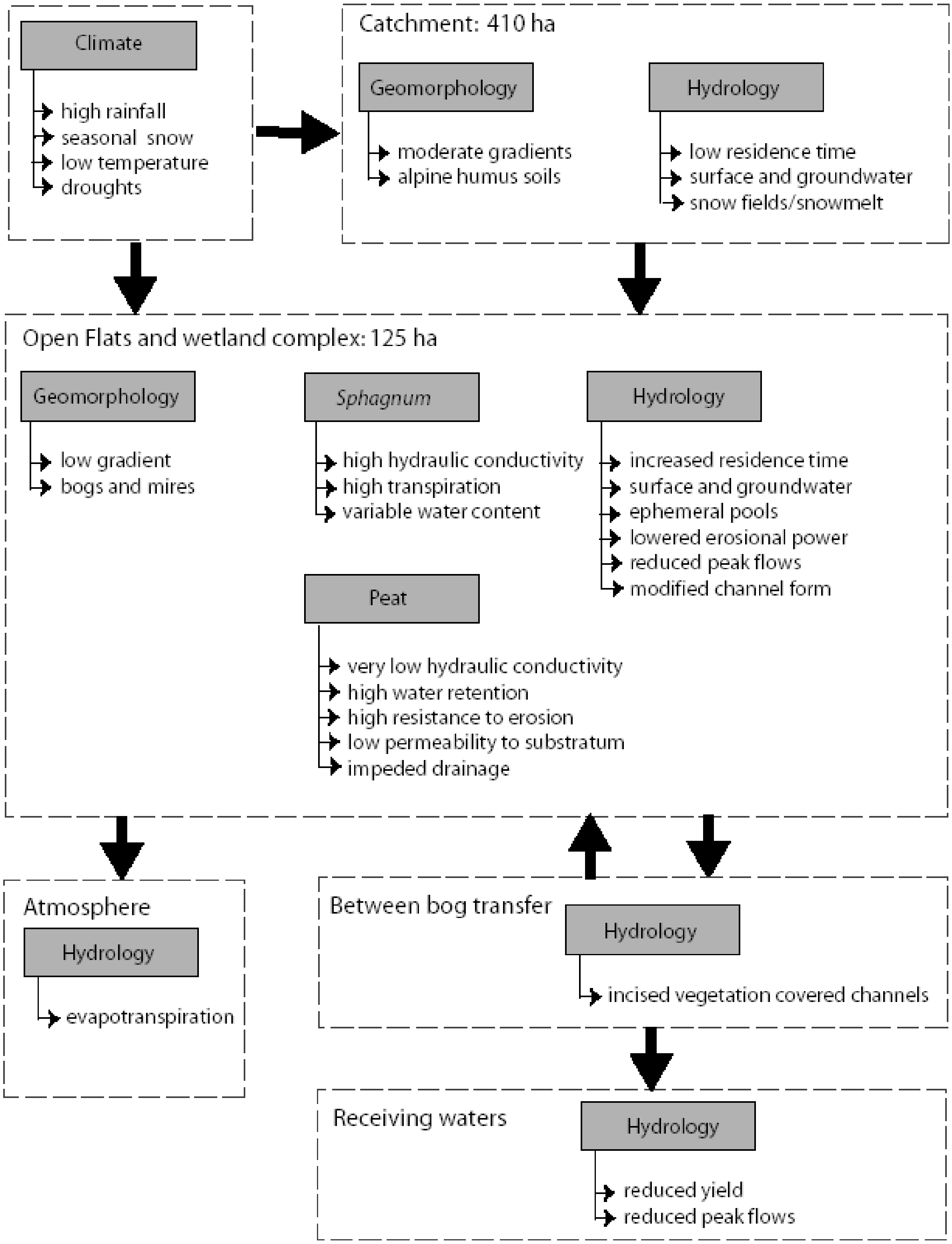

Figure 4-2
Relationships between catchment factors (climate, geomorphology and hydrology) on the Ginini Flats Wetland Complex

Water balance at the Ginini Flats Wetland Complex will depend on the relative influx and efflux rates of water over time (Figure 4-2). The current understanding of hydrology in the subalpine areas of south-eastern Australia considers that stream flow in the summer months is maintained by strong base flows, and that runoff from the catchment is strongly damped by retention in both snow and groundwater processes (Western et al., 2009). Recharge of groundwater during periods of high precipitation can maintain base flow surface water for several weeks after the event. Storage in groundwater is therefore likely to be an important component in maintaining net positive water balance in Australian subalpine bogs that are recharged by groundwater or surface flow.

4.2 Nutrient dynamics and carbon cycling

Peat bogs such as Ginini Flats can be important components of aquatic and terrestrial systems as they are able to influence ecosystem function by storage of organic matter, alteration of hydrology and interception or transformation of nutrients. As they commonly form as valley peatlands they can be influential on the water quality of downstream aquatic environments and represent a long term water storage zone that would not otherwise occur if the area was composed of the native mineral soil. A commonly considered aspect of peatlands is their role in global carbon storage over millennia, and the potential for release of some of this store under a changing climate. This storage of carbon is the product of the slow accumulation of dead plant material through time, with *Sphagnum* peat on average being >50 per cent carbon by weight (Charman, 2002).

In turn, sphagnum bogs have a direct influence on water chemistry within the bog by producing large stores of carbon and exchange sites for cations, as well as the uptake and sequestration of nutrients. These processes lead to anoxic, low redox and acidic conditions within the peat and, to a variable extent, in water exiting these systems. Anoxic, low redox conditions lead to transformations in the redox state of many elements that can fundamentally affect their availability to biota, leading to their long term storage or loss from the system. Such conditions lead to decreased rates of microbial decomposition, with a consequent reduction in nutrient cycling rates. The stored peat biomass also represents long-term storage of both micro-nutrients (metals) and macro-nutrients (carbon, nitrogen and phosphorous).

In general, sphagnum bogs occur in areas with low nutrient input, with some bogs in the northern hemisphere becoming completely disconnected from ground or surface flows and relying on nutrients delivered by atmospheric deposition or nutrient recycling within the bog. *Sphagnum* is also particularly efficient at assimilating soluble nitrogen (NH_4^+ and NO_3^-), leading to a competitive advantage over vascular plants under nitrogen-limiting conditions (Turetsky, 2003). Due to the presence of both oxic and anoxic conditions in peatlands, denitrification may occur where soluble NH_4^+ is chemically reduced to nitrous oxide (NO) or nitrogen (N_2) gases, leading to a net loss of nitrogen from the system (Charman, 2002). Most freshwater aquatic systems are considered to be phosphorous limited although a number of recent studies show that nitrogen limitation is more common than previously thought. In low nutrient environments such as bogs there is rarely a large excess of either nitrogen or phosphorous (Charman, 2002). Should one element become more abundant the other is likely to become limiting (Charman, 2002).

Recent studies of the effect of sphagnum bogs on water quality on the Bogong High Plains showed a large effect on ionic composition (Silvester, 2009). This study recorded an increase in magnesium and calcium concentrations and a decrease in nitrate (NO_3^-) and sulphate (SO_4^-). Nitrate removal was almost complete, with >90 per cent of nitrate entering the system retained or removed during transit through the bog. Evapotranspiration, in conjunction with nitrate and sulphate reduction, also led to a net increase in the acid neutralising capacity of the exit water (Silvester, 2009). This study suggested that peatlands are likely to increase the pH buffering capacity of headwater streams (Silvester, 2009).

4.2.1 Carbon cycling

Most work done on nutrient dynamics of peat bogs relates to their gross productivity and relative decomposition rates, with carbon being the primary component of interest. Physical loss of carbon stores through erosion or transport of soluble organic compounds is minor and is usually not important in determining the carbon balance.

Measurements of primary productivity are generally based on production of new plant biomass over time. Methods of assessing net primary production commonly use changes in the height of the bog (although this is confounded by expansion and compression of the plants) or measurement of changes in living plant length or mass. Decomposition rates have been measured using mass loss in mesh bags or measurement of CO_2 flux from cores or the surface of the bog. Net primary production of new plant material must be in excess of carbon losses (through decomposition of historic dead plant material) for peat to accumulate.

4.3 Vegetation and peat formation

The distinct hydrological functioning and carbon cycling of the Ginini Flats Wetland Complex results in conditions well suited to growth of the dominant bog species, *Sphagnum critstatum*. In turn, this species modifies local conditions to give it a competitive advantage over other plants, making the bog environment acidic, nutrient poor, cool and anoxic (van Breemen, 1995). Bogs thus become a place where *Sphagnum* can out-compete other plants, enforced by some positive feedback mechanisms including the production of chemical compounds (Figure 4-3).

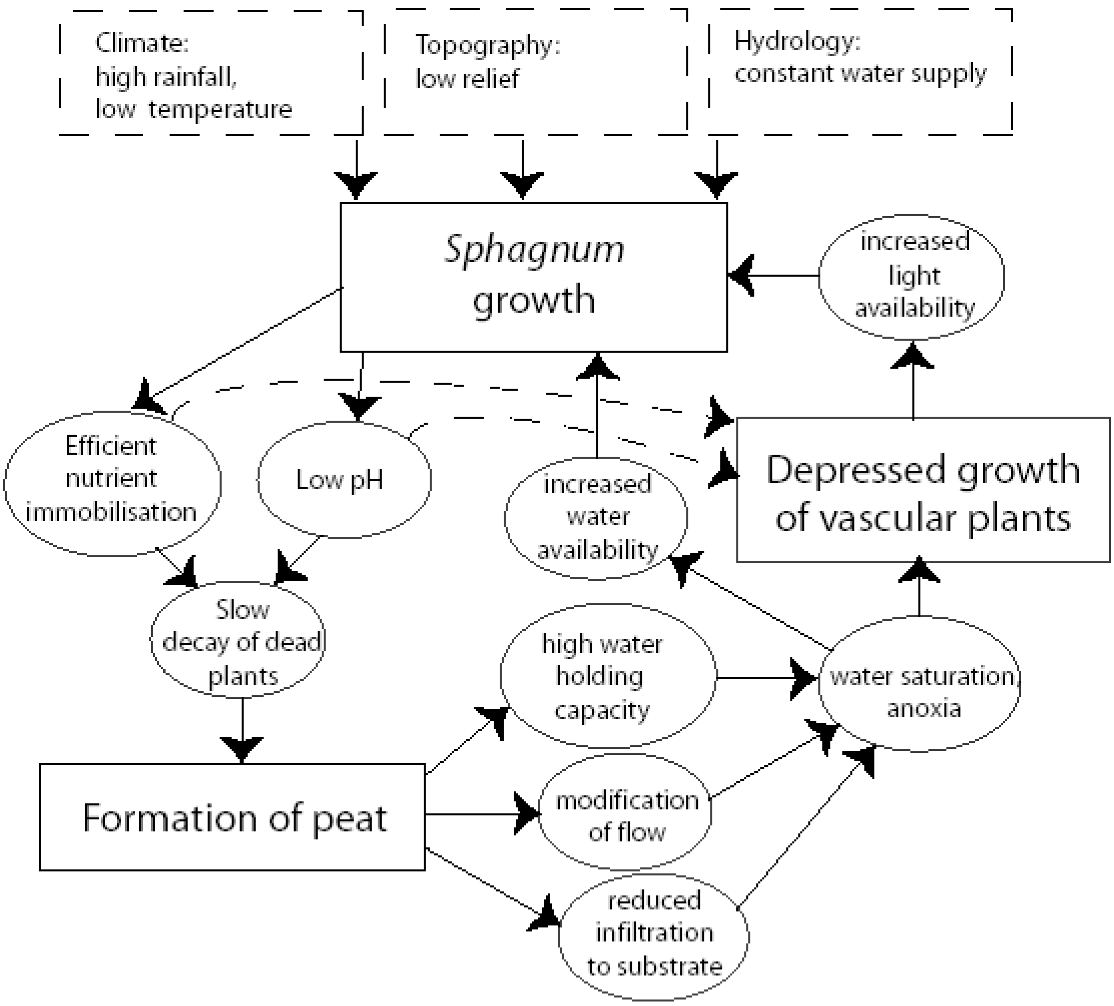

Figure 4-3 Conceptual model of sphagnum bog and peat formation (solid lines) and positive feedbacks favouring the growth of *Sphagnum* (dashed lines) (adapted from van Breemen, 1995)

Sphagnum bogs produce organic material that in the right environment is resistant to decomposition over time. The growth of *Sphagnum* and the accretion of peat also produce conditions that reduce decomposition rates. Low decomposition rates of *Sphagnum* have been attributed to its low nitrogen content, as well as the inhibition of microbial activity through the production of phenolic compounds that are particularly resistant to decay. Phenolics from *Sphagnum* have also been postulated to have antibiotic properties; the production of cation exchange sites on the plants cells may sequester essential metals required by microbes, in addition to producing acidic conditions that limit microbial activity. The maintenance of saturated water conditions in bogs also reduces the amount of aerobic decomposition that can occur.

Accumulation of peat is a long-term process, with only a very small percentage of total production of peatland plants retained over time. Measurements of accumulation rates over seasons-to-years indicate that there is a large variation in the net accumulation rate expressed as carbon (or as biomass) retained or lost per area. Net productivity can also be estimated from extrapolation of the age of peat in a vertical profile using isotopic methods. These types of estimates can be expressed as an average accumulation rate, resulting in a linear accumulation of peat of 0.7–3.3 cm / 100 years (Hope, 2003). Stem elongation of *Sphagnum* at Ginini Flats Wetland Complex was measured at up to 30 cm per annum by Clark (1980). The difference between *Sphagnum* development and peat development depth displays the compressed nature of the peat over time.

5. Threats to ecological character

The Ginini Flats Wetland Complex is protected within a National Park, limiting potential human threats to the site such as development and upper catchment impacts. Threats to the ecological character of Ginini Flats Wetland Complex include climate change, fire, feral animals, weeds, chytrid fungus, alteration of its hydrological regime and changes to catchment infrastructure. Each of these threats is detailed further in Table 5-1 along with the likelihood of threat occurring, potential consequences to the ecological character of the wetland and associated risk level (including expected timeframe of the risk). A brief outline of each threat is provided below.

Climate change

Ginini Flats Wetland Complex is situated at the northern extreme of the climatic range for sphagnum bog wetlands in the Australian Alps. Given the wetland is already at the limit of climatic tolerance, the greatest threat to it relates to the global-scale process of climate change and the myriad impacts and potential positive feedback mechanisms that can occur. Climate change has the potential to alter all critical components and processes (for example hydrology, peat formation, vegetation, habitat availability, water quality, groundwater recharge, see Table 5-1 for further detail), and thus the services that characterise the ecological character of the wetland.

Fire

Fire is acknowledged to be a natural, though sporadic, disturbance of subalpine and alpine areas (Banks, 1989). The fire history of the surrounding snow gum woodland has been determined by dendrochronological evidence by Banks (1989) and shows a high frequency of events of moderate to high intensity (Zlystra, 2006) with an increase in frequency between 1850 and 1950 with up to ten fires per decade recorded in the woodland. This frequency has subsequently declined post 1970 with around two fires per decade in that period. Significant bushfire events that are believed to have occurred within the wetland complex itself occurred in 1851, 1875, 1899, 1918, 1925 and 1944 (Banks, 1989 cited in Clark, 1980). It is not known to what extent the wetland complex was burnt in these fire events because ash and other deposits do not remain evenly in the strata. However, given general fire behaviour in bogs burning the drier areas (Carey et al*.,* 2003) it is likely that edges of the bog were impacted in these past fires.

The three sphagnum bogs which comprise the Ginini Flats Wetland Complex were all burnt in the landscape scale fires of 2003 in which most ACT mountain bogs had between 55 and 100 per cent of the surface burnt (Hope et al*.,* 2003; Carey et al*.,* 2003) with up to 30 centimetres of peat destroyed in some parts and severe damage to a large proportion of the *Sphagnum*. Around 45 per cent of the surface of Ginini west and east bogs were badly burnt in the fires with around 50 per cent (22 ha) of the sphagnum bog as a whole burnt. In some areas the fire-sterilised peats have not regenerated with bog species and they have remained dry with water passing under the peat (Hope et al*.,* 2009)

Fire results in changes to vegetation, peat formation, hydrology and water quality (see Table 5-1 for further detail). Whilst some impacts are short term (for example water quality) many are medium term (for example decades) and have the potential to significantly affect the ecological character of the wetland.

Altered hydrological regime

Changes in the hydrological regime due to drought, climate change, fires or changes in the catchment (for example clearing for infrastructure, groundwater extraction, drainage works) have the potential to influence water table levels and water balance within the wetland, and hence the peatlands and vegetation communities. In 1938 a two metre deep trench some 50 metres in length was dug through a large area of peat at Ginini Flats by researchers from the Department of Forestry at the Australian National University, and this may have altered the hydrology of a small area of the wetlands nearby.

Feral animals

Past disturbances to the site include livestock grazing (Clark 1980). Livestock grazing has been minimal with the last official grazing in the area occurring in 1909, and possibly during a period of drought in 1920 (Clark, 1980).

Feral pigs have been observed in the Ginini Flats Wetland Complex. Feral pigs disturb large areas of herbfield in their search for food such as insect larvae and tubers (Alexiou, 1983). Pigs also wallow in bog pools and can disturb the breeding pools used by the corroboree frogs which breed in this area.

In contrast, there is no evidence that exotic fish species have colonised aquatic habitat within Ginini Flats Wetland Complex. The Cotter River catchment (for which the Ginini Flats Wetland Complex is part of the headwaters) is one of a few south-east draining catchments that do not support a number of exotic fish species (*ACT Government, 2007a*). Carp and redfin are excluded due to the fish barrier created by the Cotter Dam and brown trout are excluded from the mid and upper catchment by the fish barrier created by the Bendora Dam.

Changes to catchment infrastructure

Existing, development and/or use of catchment infrastructure such as roads has the potential to impact the ecological character of the wetland through altered hydrology (increased runoff) and changes to water quality (for example increased sediments and turbidity, introduction of pollutants such as oil) (see Table 5-1 for further detail). Such impacts have the potential to impact peat formation, vegetation and habitat availability within the wetland.

Existing catchment development includes the ski run on the eastern side of Mt. Ginini, where trees have been removed upslope of the wetlands (now disused), the Mt Franklin Road and Car park and the weather monitoring infrastructure on the summit of Mt Ginini.

Weeds

The Ginini Flats wetlands remain relatively undisturbed and free of weed invasion. At the time of listing, some peripheral weed invasion was noted on disturbed areas such as roads. In April 2009, field observations showed a persistence of some ruderal weeds such as sheep's sorrel (*Rumex acetosella*), thistles (*Carduus* spp.) and cats ear (*Hypochoeris* sp.) which were also recorded immediately following the fires (Hope et al*.,* 2003). Whilst these have persisted they are expected to decline in abundance as regeneration of native species occurs.

Chytrid Fungus

At Ginini Flats Wetland Complex, the northern corroboree frog (*Pseudophryne pengilleyi*) was once estimated to be the largest vertebrate biomass (Osborne, 1990) and had the largest aggregations of the species in its range. By 1992, populations of northern corroboree frogs in the ACT had declined significantly, with less than 10 per cent of the population size of the early 1980s, and have continued to be at very low levels since. The decline in numbers is believed to be due to chytridiomycosis, a disease caused by infection with the Amphibian Chytrid Fungus (Hunter, 2007), a pathogen that may have been carried to the site by another frog species (*Crinia* spp.) or a human vector (DEWHA, 2006). Hunter (2007) found that 14 per cent of the population of the *P. pengilleyi* population was infected with the fungus.

5.1 Key threats

Table 5-1 Potential impacts and the likelihood of occurrence and consequence for key threats to the Ginini Flats Wetland Complex

Actual or likely threat/threatening activities	Potential impact(s) to wetland components, processes and/or services	Likelihood	Consequence	Risk	Timing of threat
T1. Long term alterations in climate	Changes in hydrology, such as lowering of the water table, will influence available water and primary productivity of the ecosystem (Grover, 2006), which may lead to system imbalance and potential decline of peat creation and storage mechanisms. Changes in stream flow levels and seasonality may impact on breeding habitat for frogs (Hazell, 2003). Changes in hydrology may lead to reduction of oligotrophic species such as *Sphagnum*, and allow other plants to invade. Increased CO_2 levels may result in increased primary productivity of *Sphagnum*. Increases in ambient temperature will result in increased peat oxidation and decomposition (Charman, 2002). Increases in soil temperature may increase evapotranspiration decreasing available soil moisture (Grover, 2006). Changes in snow cover depth, duration and melt patterns may result in a reduced snow pack, which will impact water availability in drought and decrease pools for frog breeding (Osborne and Green, 1998). Reduced snow cover which reduces insulation and protection from harsh winter conditions for fauna. Changes in snow melt may be reducing groundwater levels and recharge for the bog. Changes in temperature may reduce the frost hollow effect, permitting growth of woody species. Reduction in snow depth and persistence leading to increased impacts of cold, frost conditions on flora and fauna, potentially including:	Currently occurring	Moderate to high	High	Long-term

Actual or likely threat/threatening activities	Potential impact(s) to wetland components, processes and/or services	Likelihood	Consequence	Risk	Timing of threat
	• freezing surfaces of breeding pools inhabited by corroboree frog tadpoles (Green and Osborne, 1994) • increasing frost events reducing the potential for recovery from past disturbances (Wild, 2008) • a reduced snow pack, resulting in less-compacted *Sphagnum* (Clark, 1980), may change hydrological and growth characteristics of the bog Acrotelm.				
T2. Fire – increase in intensity or frequency	Vegetation changes favouring fire-tolerant rhizomatous sedges over *Sphagnum* (Whinam, 1995) and resultant changes in hydrological processes. Reduced peatbog area and increased dried peat or alpine humus soil area, resulting in variations in hydrology, nutrient fluxes, acidity and primary productivity (Grover, 2006). Impacts to adjacent woodland communities. Increased sedimentation from surface runoff of bare areas (Smith and Dragovich, 2008). Altered hydrology from channelisation. Change in floristics to more fire-tolerant species.	High – greater risk to raised bogs compared with valley bogs	Moderate if frequency is not too high	Moderate	Medium-term
T3. Altered hydrological regime	Fluctuating water table levels and cycles of wetting and drying, resulting in decomposition of peats (Grover, 2006). Lower water table conditions, which are less favourable for *Sphagnum* development (Grover, 2006).	Moderate (based on modelling)	Moderate to high	Moderate	Medium-term
T4. Feral animal activity	Changes in hydrological regime due to pig (and potentially deer) wallowing in pools. Potential disturbance of corroboree frog breeding pools, egg nests and non-breeding habitat by pigs (Osborne, 1991).	Currently occurring	Low to moderate	Low	Short-term, ongoing

Actual or likely threat/threatening activities	**Potential impact(s) to wetland components, processes and/or services**	**Likelihood**	**Consequence**	**Risk**	**Timing of threat**
	Creation of bare areas in herbfields due to pigs rooting for tubers (Alexiou, 1983). Channelling of bogs, altering hydrology (Whinam and Chilcott, 2002).				
T5. Changes in upper catchment infrastructure	Existing road infrastructure may cause sediment and turbid water run-off from the Mt Franklin road. The creation of additional infrastructure or upgrading works may exacerbate these impacts. Winter vehicular access to Mt Ginini may exacerbate road impacts.	High	Moderate to high	Low	Long term
T6. Weed invasion (conifers) from (previously) nearby arboretum Invasion of other weed species (e.g. apples, willows)	Competition and exclusion of native flora. Blackberry invasion may alter frog breeding habitat (Osborne, 1991).	Conifer risk is moderate if seed bank has persisted following fires. The risk for other species is moderate.	Low to moderate	Low	Medium-term
T7. Chytrid fungus	Decline in population and/or loss of the northern corroboree frog (*Pseudophryne pengilleyi*).	High – already occurs within wetland	High – has already resulting in a decline in population since 1992	High	Ongoing

5.2 Risk assessment

The risks identified in Table 5-1 show the greatest risks with the most severe consequences are associated with climate change. Increased temperatures and altered rainfall regimes have been predicted for the Australian Alps under climate change scenario modelling (Hennessy et al., 2003) which may in turn affect the carbon and water cycle processes in the wetlands. The impact of increased temperatures may be both positive and negative, with increased vegetation growth rates likely. Increased rates of evapotranspiration and decay of peat surfaces are also likely. Whinam et al., (in press) consider that future higher temperatures and altered rainfall patterns may result in the demise of *Sphagnum* bogs at the hottest and driest margins of their Australian distribution. This at-risk distribution will almost certainly include the Ginini Flats Wetland Complex.

Modelled climate change impacts predict increased frequency and intensity of precipitation events that may alter the overall hydrology of peatlands (Hennessy et al., 2003). This may result in the reduction of peatbog area or increased erosion of disturbed peat surfaces (Grover et al., 2005). Such processes may lead to a series of positive feedback mechanisms altering the state of the peat retention, and to the hydrological cycling of the system, placing pressure on the bogs' long term persistence.

Other identified risks are less severe but may contribute to changes in character in the longer term when associated with climate change impacts. These include impacts from feral animals (Figure 5-1) and weeds which, although not currently resulting in large-scale changes in the case of weeds, may do so in a drier, less acidic bog system.

Figure 5-1 A pig wallow - evidence of feral pig activity on the edge of Ginini Flats Wetland Complex

6. Limits of acceptable change

Limits of acceptable change (LAC) is a wilderness planning framework which has been applied to the management of Ramsar Sites to assist in detecting changes to ecological character (Davis and Brock, 2008). The framework uses existing data to quantify the natural variability in the systems against which future changes can be assessed. This approach requires an understanding of the critical components of the system (see Section 4) and quantitative measures of these components. This ECD has found that there are many knowledge gaps for these critical components and processes (see Section 8), making setting such limits challenging. Due to this lack of baseline data and an understanding of the natural variability of critical components at Ginini Flats Wetland Complex and the associated difficulties with setting quantifiable limits of acceptable change, the LACs in this section have been qualified with a measure of confidence. Qualitative indicators of hysteresis, or points where an adverse change cannot be remedied have also been included to provide additional indicators. These are presented in Table 6-1.

Many of the ecosystems services identified for Ginini are interrelated, with the supporting services influencing regulating services upon which the provisioning services depend (Figure 6-1). In addition, the supporting services underpin the cultural services. In many ways, the supporting services act as drivers in the system as the sphagnum bog provides conditions suitable for regulating services such as climate regulation, maintenance of hydrological regime and hazard reduction. As such, the LACs identified in Table 6-1 relate primarily to supporting services.

Limits of Acceptable Change – Explanatory Note

1. Limits of Acceptable Change are a tool by which ecological change can be measured. However, Ecological Character Descriptions are not management plans and Limits of Acceptable Change do not constitute a management regime for the Ramsar site.
2. Exceeding or not meeting Limits of Acceptable Change does not necessarily indicate that there has been a change in ecological character within the meaning of the Ramsar Convention. However, exceeding or not meeting Limits of Acceptable Change may require investigation to determine whether there has been a change in ecological character.
3. While the best available information has been used to prepare this Ecological Character Description and define Limits of Acceptable Change for the site, a comprehensive understanding of site character may not be possible as in many cases only limited information and data is available for these purposes. The Limits of Acceptable Change may not accurately represent the variability of the critical components, processes, benefits or services under the management regime and natural conditions that prevailed at the time the site was listed as a Ramsar wetland.
4. Users should exercise their own skill and care with respect to their use of the information in this Ecological Character Description and carefully evaluate the suitability of the information for their own purposes.
5. Limits of Acceptable Change can be updated as new information becomes available to ensure they more accurately reflect the natural variability (or normal range for artificial sites) of critical components, processes, benefits or services of the Ramsar wetland.

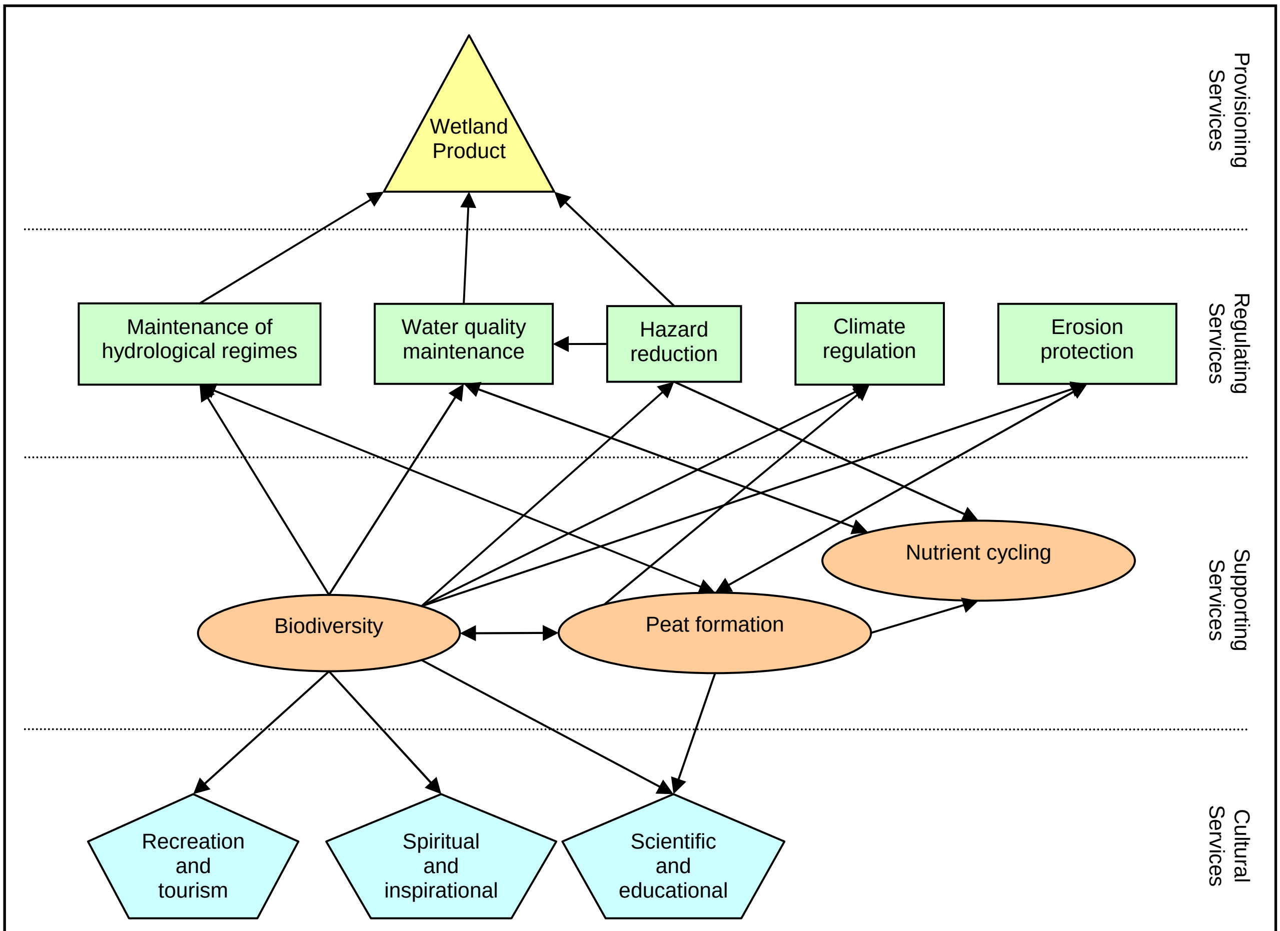

Figure 6-1 Interrelationships between ecosystem services identified for Ginini Flats Wetland Complex

Table 6-1 Baseline data, natural variability and limits of acceptable change for critical components of ecological character at Ginini Flats Wetland Complex

Theme component/ Process	Nomination criteria	Supporting baseline data	Limits of acceptable change to ecological character	Qualifying statement	Confidence level
Abiotic					
Hydrology	1,2,3,4 and 9	Observational evidence of functioning including presence of pools and wetted peat layers.	LAC 1 Qualitative evidence of reductions in functionality of hydrology such as breaking of pools, development and persistence of erosion pavements or hydrophobic peat surfaces following fire disturbance for a period of greater than five years.	No data were available for the time of listing meaning that site specific data are of insufficient quality and quantity to determine statistically supported LACs. Therefore, this LAC is set to be qualitative and judgement based. The five year threshold for lack of recovery is based on recovery observations following the 1998 and 2003 fires in numerous Victorian peatlands documented by Tolsma and Shannon (2007).	Low
Nutrient and Carbon Recycling	1, 2 and 3	Peat extent mapping and some depth mapping	LAC 2 Greater than 20% change in extent (9.8 +/– 0.5 ha) of peat surfaces and evidence of oxidation.	No data were available on peat extent or depth at the time of listing. The baseline extent of approximately 50ha mapped in 1999 by Hope et al., 2009 was used in lieu of other data. However, site specific extent and temporal change data remain of insufficient quality and quantity to determine a statistically supported LAC. The 20% change level is an arbitrary figure based on mapping error tolerances and the precautionary principle.	Low
Biotic					
Vegetation/ *Sphagnum* and Peat Accumulation	1, 2 and 3	Short-term extent and depth mapping	LAC 3 Greater than 20% change in extent (9.8 +/– 0.5 ha) and a lack of recovery five years following disturbance (e.g. fire) that removes Arcotelm or Acrotelm and Catotelm LAC 4 Peat accumulation of less than 3.5cm per century or growth of *Sphagnum* spp. less than 30cm/yr. Loss of *Sphagnum* spp. propagules for recruitment following a large disturbance event ongoing for a period of five years.	No data were available on *Sphagnum*, vegetation or peat accumulation rates at the time of listing. The baseline extent of approximately 50ha mapped in 1999 by Hope et al., 2009 was used in lieu of other data. Site specific data is of insufficient quality and quantity to determine a statistically supported LAC. The 20% change level is an arbitrary figure based on mapping error tolerances and the precautionary principle. Peat accumulation and *Sphagnum* spp. has been recorded for Ginini and other bogs (Clark, 2003). The peat accumulation figure is difficult to measure with sufficient precision in the short-term ; therefore more focus should be placed on the *Sphagnum* growth figure. It should be noted that this growth figure is based on pre-compressed *Sphagnum*.	Low

Theme component/ Process	Nomination criteria	Supporting baseline data	Limits of acceptable change to ecological character	Qualifying statement	Confidence level
Vegetation/ *Sphagnum*	1, 2 and 3	Floristic surveys of 'keystone[6]' species. However, these data are short-term and there are too few data points to capture long-term variability.	LAC 5 Loss, or extended (> 2 seasons) absence of keystone including (but not restricted to): *Sphagnum cristatum, Empodisma minus, Richea continentis, Epacris paludosa, Baloskion australe, Baeckea gunniana, Carex gaudichaudiana, Myriophyllum pedunculatum* and *Poa costiniana* from Ginini Flats Wetland Complex. LAC 6 Reduction or absence of recruitment of new individuals or ramets for these species.	No data were available for the time of listing meaning that site specific data are of insufficient quality and quantity to determine statistically supported LACs. However, ongoing monitoring and analysis may facilitate future determination of a LAC for relative abundance of keystone species identified by Hope et al., 2009.	Low
Vegetation/ *Sphagnum* and Peat Accumulation	1, 2 and 3	Inferred fire history for the site showing an average interval around 25–30 years	LAC 7 An increase in fire frequency greater than 25 years or inferred increase in intensity.	There are data on the frequency of fire events in adjacent woodland at Mt Ginini (Zylstra, 2006). It is not certain if Ginini Flats Wetland Complex burnt during all these events and, if so, the severity or extent. However, it is evident that the community can recover from fire events over time. There are no data on past fire intensity or quantitative information for this community in general. Therefore, there is no baseline provided for this variable.	Low
Northern corroboree frog	4 and 9	Abundance Occurrence, pattern and extent of *Sphagnum* pools for breeding	LAC 8 Absence of calling males in two successive monitoring seasons LAC 9 Evidence of stochastic declines due to disease or limited breeding site availability LAC 10 Evidence of no suitable habitat due to closing of pools or collapse of system.	Due to the very low numbers of frogs at the site and the difficulties in measuring and detecting differences (Evans *pers.comm*. 2009) these population LACs are qualitative and should be interpreted with caution. Site specific quantitative data on habitat is of insufficient longevity to determine natural variability and determine a statistically supported LAC.	Low

[6] Keystone species are those which control the structure and functioning of the peatland or bog community, are always present and influence some aspect of the critical processes (Hope et al. 2000)

7. Current ecological character (2009)

There has not been a significant alteration in ecological character of Ginini Flats Wetland Complex since the initial listing in 1996. However, there has been a substantial natural disturbance (2003 fire), a significant decline in the population of the northern corroboree frog and potential ongoing, incremental changes of the functioning of the peatland system (ongoing climate alteration).

The three sphagnum bogs which comprise the Ginini Flats Wetland Complex were all burnt in the landscape scale fires of 2003 in which most ACT mountain bogs had between 55 and 100 per cent of the surface burnt (Hope et al., 2003; Carey et al., 2003) with up to 30 centimetres of peat destroyed in some parts and severe damage to a large proportion of the *Sphagnum*. Around 45 per cent of the surface of Ginini west and east bogs were badly burnt in the fires with around 50 per cent (22 ha) of the sphagnum bog as a whole burnt.

7.1 Hydrology

Due to the ongoing impacts of the 2003 fires, it is expected that surface runoff has increased (Hope et al., 2003) and sediment entrainment from slopes above the bog complex has also occurred (Smith and Dragovich, 2008). However, other impacts include increased uptake by re-establishing vegetation in the catchment.

7.2 Water quality

Water quality in the upper Cotter Catchment was significantly affected by the bushfires in 2003. In order to estimate the water quality in the catchment prior to the fires (that will be more representative of the time of listing), the data from the Bendora Reservoir has been partitioned into post and pre fire, and presented as percentage exceedence distribution plots (Figure 7-1). Prior to the 2003 fires all the water quality parameters only rarely exceeded the ANZECC and ARMCANZ Guidelines (2000) for upland rivers and all the nutrient parameters were well below the guideline values for the vast majority of the time, indicting that the catchment was producing high quality water.

Water quality following the January 2003 bushfires declined and was particularly impacted by large rain events in February and March 2003 that lead to large scale erosion of the denuded slopes of the catchment (White et al., 2006). The longer term and potential future impact of fires on water quality in the upper Cotter catchment has lead to the construction of a water filtration plant to service Bendora Dam in order to secure a more reliable supply of drinking water from this source (White et al., 2006).

Since the 2003 fires the nitrogen and phosphorus concentrations have exceed the guideline values for a significant proportion of the time and the generally higher values for most of the nutrients in comparison to pre 2003 values indicates that for total nitrogen and total phosphorous concentrations may not have returned to pre fire levels by 2009. How much of this longer term change in water quality is the result of processes in the catchment compared to within the reservoirs (that would have been a trap for nutrients and sediment) is unclear. If rates of nutrient supply from the catchment have remained greater than pre 2003 this may not reflect similar conditions at the site of the Ginini Flats Wetland Complex as this part of the catchment has low gradients and would be likely to retain eroded material more efficiently.

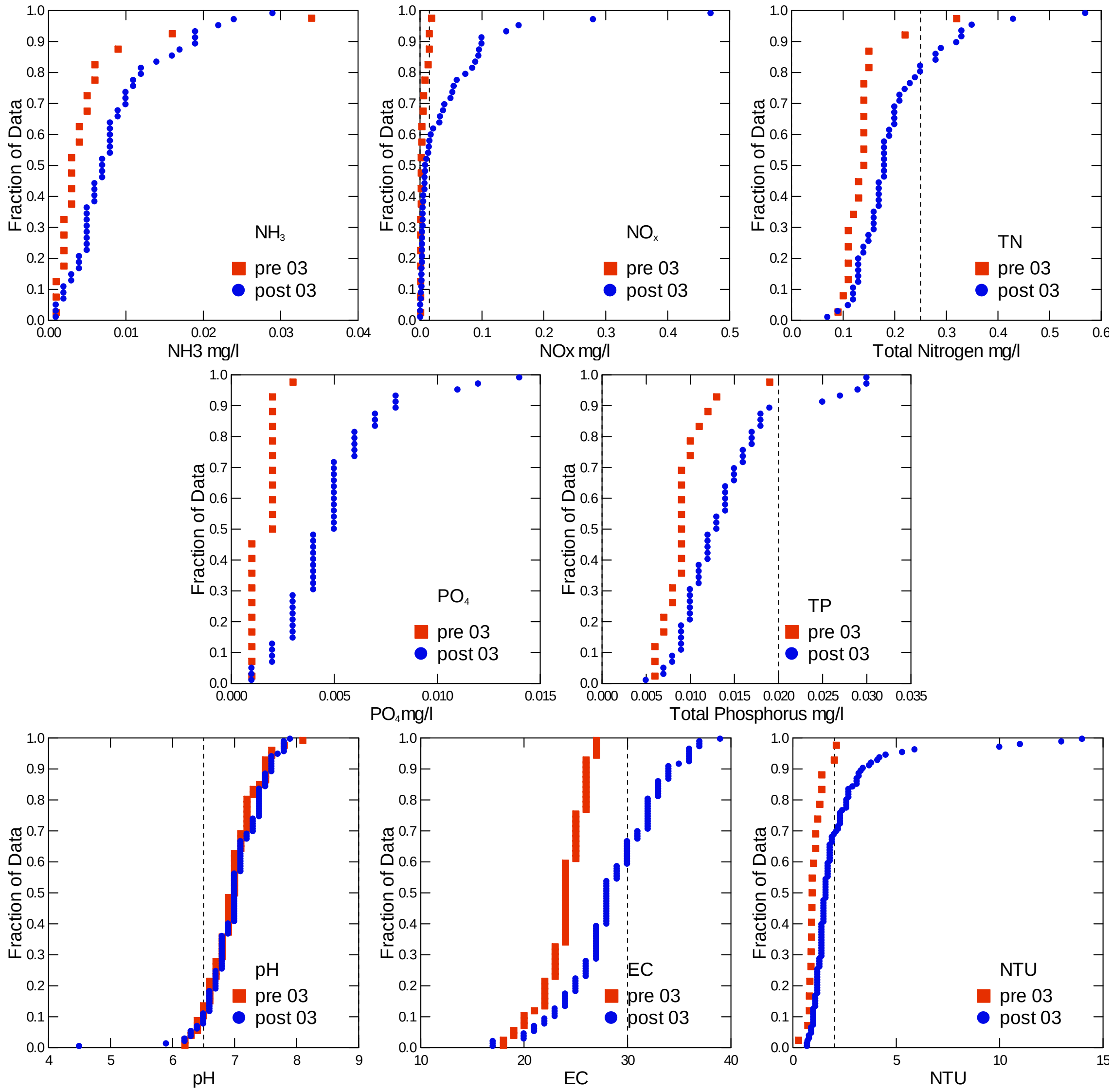

Figure 7-1 Exceedance plots for water quality data collect form the upper reach of the Bendora reservoir for the period before the January 2003 fires (1994–2003 red squares) and after the 2003 fires to June 2009 (blue circles). Vertical lines represent the ANZECC and ARMCANZ Guidelines (2000) for upland rivers where applicable.

A recent survey of river health in relation to environmental flows has sampled water quality in three tributaries (Cooleman Ck, Bull flat Ck and Bramina Ck) of the Goodradigbee River on the northern side of the Brindabella Range (White and Norris, 2007) which have similar aspect and habitat to the Ginini Creek, and were also extensively affected by the 2003 fires. Sample sites for these tributaries were all between 630 and 680 mASL and represent the majority of the tributaries in the catchment. Sampling was only carried out in spring of 2007 and all water quality parameters were well below ANZECC and ARMCANZ Guidelines (2000), other than TP which was slightly raised in one of the creeks. Turbidity was below the minimum value of the guidelines range in all cases (less than the detection limit of 2 NTU). This data, although sparse, indicates that water quality in the sub-catchments of the Australian Alps affected by the 2003 fires may have returned to the high water quality previously considered representative of these environments and it is expected that the water quality in Ginini Flats Wetland Complex would have followed a similar trend.

7.3 Vegetation and peat

Ginini Flats Wetland Complex was burnt twice in the 2003 fires with the main damage along the stream channel where high shrub densities occurred (Hope et al., 2003). Peat fires also burnt into the trench dug in the 1940s (see Section 2.4) but otherwise the fibrous surface was generally retained in the centre of the bog (Hope et al., 2003) and the residual moisture in the peat had prevented burning of the peat at depth (Whinam et al., in press). Where the peat did burn to 5–20 cm a sterile, often hydrophobic ash surface, remained with a neutral pH unlike the normally acidic bogs (Figure 7-2; Whinam et al., in press). These areas were also susceptible to frost heave and erosion. In the deeper bogs areas the loss of areas of hummock forming *Sphagnum cristatum* which is critical to bog function and hydrology was considered by Carey et al., (2003) to be a serious impact that may have long-term effects on the wetlands. Figure 7-3 shows the distribution of vegetation communities in Ginini Flats Wetland Complex following the 2003 fires.

Figure 7-2 Burnt grassland and woodland interface at Ginini Flats Wetland Complex showing a hydrophobic peat soil

In 2009, in areas where *Sphagnum* has retreated following the fires, *Empodisma minus* fen has recolonised many of these areas and others remain bare (Carey et al., 2003). Some of the fringing peat surface has been exposed and this area is likely to continue to oxidise and erode due to the lack of vegetation cover and loss of moisture (Hope et al., 2003). In April 2009, field observations showed a persistence of some ruderal weeds such as sheep's sorrel (*Rumex acetosella*), thistles (*Carduus* spp.) and cats ear (*Hypochoeris* sp.) which were also recorded immediately following the fires (Hope et al., 2003). Whilst these have persisted they are expected to decline as regeneration of native species occurs.

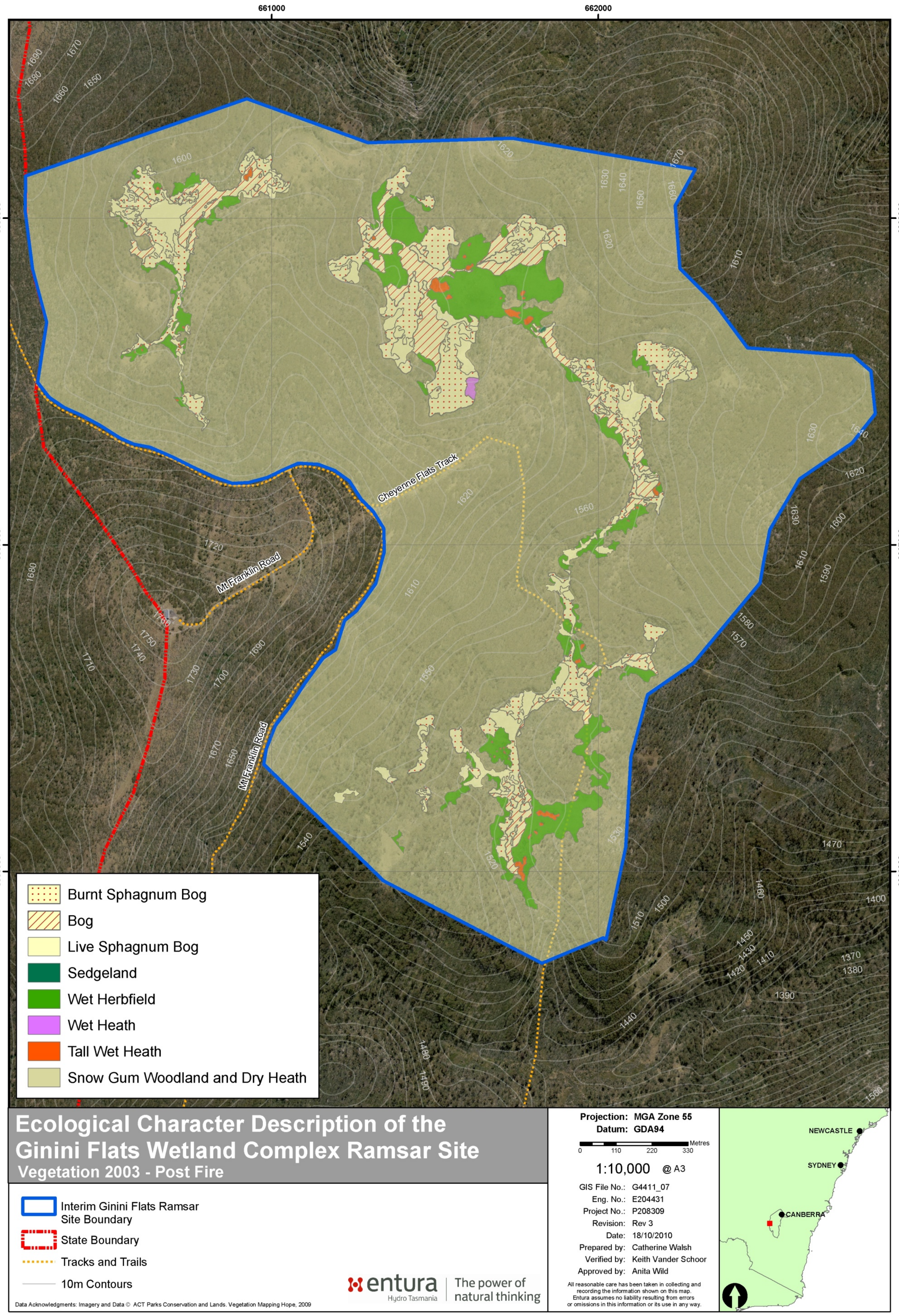

Figure 7-3 Distribution of vegetation communities at Ginini Flats Wetland Complex following the 2003 fires (data from Hope et al., 2009)

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7.3.1 Restoration programs at Ginini Flats Wetland Complex following the 2003 fires

Following the extensive fires in 2003, concerns were raised about the long term health and recovery of the bog system from ongoing damaging processes such as accelerated runoff and subsequent stream entrenchment (Good*,* 2009). Observations at Ginini Flats Wetland Complex showed there to be active peat tunnelling, incision and erosion of the peat dams that could lead to long term impacts and slow recovery.

Restoration works focussed on rehabilitation techniques which would restore hydrological functionality to the bogs to enable recovery of the key bog species—*Sphagnum*, *Empodisma* and *Carex*—and to increase the residence time and infiltration of surface water by slowing flow rates (Good*,* 2009). Bog restoration works in all areas of the Australian Alps focused on four core areas: water spreading and diversion to bogs and fens, pool creation and flow control, subsurface dams to maintain pools and vegetation treatments (Whinam et al.*,* in press). At Ginini Flats Wetland Complex, the maintenance of water to the peat surfaces was seen as a priority in these programs to prevent the peat dehydrating and becoming hydrophobic. Natural biodegradable materials such as coir logs and sterilised straw bales have been used to create pools and promote spreading of water over the surface (Figure 7-4).

Figure 7-4 Restoration works at Ginini Flats Wetland Complex showing a coir log used to dam a small stream

At west Ginini experimental works included tests of the effectiveness of shading to reduce evapo-transpiration and reduce wind velocities over the remaining vegetation were also initiated and early results indicate that *Sphagnum* growth is enhanced from this protection (Whinam et al., in press). These plots are also part of an ongoing monitoring program to determine the long-term effectiveness of restoration measures.

7.3.2 Impact of the fires on the current ecological character and long-term outlook

The 2003 fires burnt an extensive area of Ginini Flats Wetland Complex. Fortunately, the fires in 2003 did not destroy the fibrous peat surface nor result in major changes to hydrology. Impacts were more severe in the previously-disturbed trench area, emphasising the importance of maintaining a positive water balance or saturation of peat in these communities. Given the past recovery, recent recovery patterns noted by Whinam et al., (in press) and history of (albeit) slow recovery at other sites, Ginini Flats Wetland Complex is very likely to retain the characteristics that fulfil the criteria for Ramsar listing. The wetland will continue to contain a representative example of the *Sphagnum* community (Criteria 1, 2 and 3).

Whilst fire in these communities is not common, it is certain that the wetland complex has been burnt in the past (see Section 2.4.1), possibly at intervals as short as seven years, but more usually in the order of 25 years if the wetland was burnt along with the surrounding area. The edges of the system are most likely to have been impacted and there is conjecture that the extent of the bog has reduced over time in response to fire amongst other factors such as extended drying cycles.

However, if the frequency or intensity of fire is too great, this is likely to lead to a change in ecological character. Coupled with the ongoing risks associated with climate change, ongoing drought and drying and reduced groundwater recharge it is likely that the system could fall into a state of positive feedback whereby fire reduces the mass of peat layers that hold water and protect it against fire. Subsequent drying can make the area more susceptible to fire and a destructive cycle that is unable to be broken is initiated. These risks are dealt with more comprehensively in Section 5.1.

7.4 Amphibians

Since the unexplained decline in all populations of the northern corroboree frog around 1987, there has been concern for the long-term viability of these populations (Osborne et al., 1996); there is also concern for other frog species (Morgan et al., 2008). The fires of 2003 had direct and immediate, as well as indirect, long term impacts on the already small frog populations. The fires occurred at the time of the 2003 breeding season which is likely to have reduced overall numbers through direct mortality and subsequent influence on the longer term population viability (Carey et al., 2003). Indirect impacts include changes in habitat—all known corroboree frog over-wintering habitat was burnt by moderate to high severity fires (Carey et al., 2003). Damage to other habitat areas may take in the order of decades to recover. Ongoing alteration in the structure of the shallow breeding pools within the *Sphagnum* mass and local hydrology is likely to have occurred as a result of the fires in the medium term. Whether or not there has been continued seepage of water into these pools is also of concern.

Immediately following the fires, monitoring of the impacts on the frogs at Ginini Flats Wetland Complex was undertaken. However, due to the very low population numbers at the site (<15 calling males) it is difficult to determine whether there has been any trend (either positive or negative) in frog numbers since the time of Ramsar listing. At the time of the last survey in February 2009, the Ginini Flats wetland population, despite its low numbers, would represent nearly 50 per cent of the higher elevation population of northern corroboree frogs at the known breeding sites (Murray Evans pers. comm.).

7.5 Fish

High turbidity from runoff can affect fish populations and such conditions would have been expected immediately following the fires with subsequent erosion of bare soils (Smith and Dragovich, 2008). However, sampling undertaken by Carey et al., (2003) indicates a healthy population of *G. olidus* in Kangaroo Creek (Upper Cotter Catchment) following the 2003 bushfires, suggesting that this species has survived this event and remains in a natural condition. However, G. *olidus* would need to be surveyed in the Ginini Flats Wetland Complex to confirm this.

7.6 Invertebrates

Given the lack of data, a change or otherwise in ecological condition of the invertebrate fauna since listing cannot be accurately ascertained. However, given the 2003 fires it is likely that there have been some changes in the invertebrate community. Carey et al., (2003) suggest that the grasshopper fauna from the genus *Kosciuscola* is probably at the highest risk from fire, whilst ants seem to recover well given their ability to seek refuge in underground nests. However, they suggest that these observations would need to be confirmed with field sampling.

8. Knowledge gaps

Past baseline monitoring and quantitative data collection at Ginini Flats Wetland Complex has been limited to select disciplines: palaeobotanical studies, vegetation studies and frog population studies. However there has been a considerable increase in effort following the 2003 fires with a focus on rehabilitation (Carey et al., 2003). These data have provided a better understanding of the system processes but data are still lacking and preclude development of quantitative limits of acceptable change for the site. Without such knowledge, it is very difficult to detect critical changes in ecological character.

Key knowledge gaps for each component or process of Ginini Flats Wetland Complex are summarised below (Table 8-1). Following this, Table 8-2 outlines the linkages/relationships between ecological services and key threats (T; Section 5), limits of acceptable change (LAC; Section 6) and knowledge gaps (KG) that have been identified during preparation of the this ecological character description. Linkages with recommended monitoring are also provided.

It is recommended that the focus of addressing knowledge gaps be on obtaining data to identify changes in ecological character (and impacts of known/potential threats), thus allowing meaningful limits of acceptable change to be developed. Table 8-1 is not an exhaustive list of knowledge gaps and many questions for this site remain. Further, the information priorities of scientists and natural resource managers may be different to those necessary to describe and/or evaluate changes to ecological character.

Table 8-1 Summary of knowledge gaps for components and processes and the recommended measured variable

Theme component/process	Knowledge gap	Measurable variable or ecological component variables
Abiotic		
Hydrology	KG 1: Magnitude, duration and seasonality of inflows and outflows	Surface flows and groundwater seepages
Water quality	KG 2:Magnitude, duration and seasonality of water quality parameters	Water quality parameters
Nutrient and carbon cycling	KG 3:Status of the system – whether the system is accumulating or eroding	Depth of both Acrotelm and Catotelm peat layers and emissions associated with oxidating peats
Biota		
corroboree frog	KG 4:Ongoing suitability of the site for breeding	Habitat assessment of site – availability of pools and structure of *Sphagnum*.
Sphagnum	KG 5:Status of recovery of the *Sphagnum* and maintenance/reinstatement of positive feedback services	*Sphagnum* depth and extent, status of water table and level of saturation.
Vegetation	KG 6:Dynamics of vegetation communities	Long-term, fine-scale vegetation composition and abundance measures Ongoing recruitment of keystone species
Macro-invertebrates	KG 7:Available biomass and population structure	Abundance and composition of populations Status of community against benchmark such as AUSRIVAS
Fish	KG 8:The presence of *G. olidus* within the Ginini Flats Wetland Complex is documented; however, it is unknown as to whether the 2003 fires have affected this population.	Abundance and composition of populations
Birds	KG 9:Presence of threatened or migratory species	Abundance and composition of populations

Table 8-2 Relationship between ecosystem services and key threats (T), limits of acceptable change (LAC), key knowledge gaps (KG) and recommended monitoring (M)

Ecosystem service or benefit category	Key Threats	LAC	Key Knowledge Gaps	Monitoring
Provisioning services				
Wetland products	T1 - 5	-	KG 1	M 1
Regulating services				
Climate regulation	T1 - 2, T5	-	KG 3, KG 5	M 3
Maintenance of hydrological regimes	T1 - 5	LAC 1	KG 1	M 1, M 7
Erosion protection	T1 - 2, T4 - 5	-	KG 3	M 3, M 7
Water quality maintenance	T1 - 5	-	KG 2	M 2, M 7
Hazard reduction	T1 -5	-	KG 1	M 1, M 7
Supporting services				
Biodiversity	T1 - 7	LAC 3 - 10	KG 4 -9	M 4 - 10
Soil formation	T1 - 4, T6	LAC 2, LAC 7	KG 3, KG 5	M 3, M 7
Nutrient cycling	T1 - 2	-	KG 2 - 3	M 2 - 3
Cultural services				
Recreation and tourism	T1 - 2, T5 - 6	-	-	-
Spiritual and inspirational	-	-	-	-
Scientific and educational	T1 - 3, T5, T7	-	KG 4	-

9. Monitoring ecological character of Ginini Flats Wetland Complex

Recommendations for monitoring variables and critical components are provided in Table 9-1 to assist with the assessment of the Limits of Acceptable Change, to reduce Knowledge Gaps and detect potential changes in ecological character. This table has been prepared with reference to the Ramsar framework for monitoring wetlands which provides identification of key site monitoring needs. Linkages between monitoring and LACs/key knowledge gaps are provided in Table 9-1, whilst the relationship between the recommended monitoring and ecological services and threats is provided in Table 8-2.

Table 9-1 Monitoring needs for Ginini Flats Wetland Complex

Theme component	Component/process	Objective	Indicator or variable for measurement	Frequency	Priority	LAC and/or Key Knowledge Gap
Hydrology	Magnitude, duration and seasonality of inflows and outflows	M 1: To determine the water balance of the site and establish limits of acceptable change parameters	Surface and groundwater inflows and outflows through Catotelm and Acrotelm	Seasonally	Medium	LAC 1 KG 1
Water quality	Magnitude, duration and seasonality of water quality parameters	M 2: Determine if there are changes in water quality parameters	TP,TN, pH, turbidity	Seasonally	Medium	KG 2
Nutrient and carbon cycling	Peat formation and retention	M 3: To determine if peat levels are increasing, stabilising or decreasing	Depth of peat, emissions of oxidating peats	Bi-annually	Medium	LAC 2 KG 3
Biota	Amphibians	M 4: To continue current monitoring program to determine status of the population	Total numbers of calling males and habitat parameters (availability of pools)	Annually during breeding season	High	LAC 8 – 10 KG 4
	Sphagnum	M 9: Establish baseline for *Sphagnum* recovery	Plot based following Clark (1980)	Five yearly	Medium	LAC 3 – 4. LAC 7 KG 9
	Vegetation	M 8: Baseline and set limits of acceptable change	Extent and condition of vegetation communities (aerial photography)	Bi-annual or disturbance event based	Medium	LAC 5 – 6 KG 8

Theme component	Component/process	Objective	Indicator or variable for measurement	Frequency	Priority	LAC and/or Key Knowledge Gap
Biota (cont.)	Macro-invertebrates [7]	M 5: Establish baseline data and set limits of acceptable change	Number of taxa Presence/absence of families (Compare with Suter et al., 2002 for reference)	Annually in spring and autumn	Medium	KG 5
	Fish	M 6: Determine status/persistence of *G. olidus* populations in the Upper Cotter Catchment.	Abundance (or presence/absence) of *G. olidus*	Bi-annual to annual	Medium	KG 6
	Birds	M 10: Species abundance and composition	Presence of threatened or migratory species	Bi-annual or event based	Medium	KG 10
	Feral pigs	M 7: Continue baseline data collection and detect population changes	Total abundance of animals Evidence-based counts of disturbance impacts (e.g. number of rootings per ha)	Bi-annual or event based	Medium	KG 7

[7] Given the sensitivity of the Ginini Flats, monitoring methods that have minimal impact are recommended, for example the use of artificial substrates used by Los (2005). Monitoring the pools and streams could employ more traditional methods such as sweep netting edge water and pool habitats.

10. Communication and education messages

Under the Ramsar Convention a Program of Communication, Education, Participation and Awareness (CEPA) was established to help raise awareness of wetland values and functions. At the Conference of Contracting Parties in Korea in 2008, a resolution was made to continue the CEPA program in its third iteration for the next two triennia (2009 – 2015).

The vision of the Ramsar Convention's CEPA Program is: "People taking action for the wise use of wetlands." To achieve this vision, three guiding principles have been developed:

a) The CEPA Program offers tools to help people understand the values of wetlands so that they are motivated to become advocates for wetland conservation and wise use and may act to become involved in relevant policy formulation, planning and management.

b) The CEPA Program fosters the production of effective CEPA tools and expertise to engage major stakeholders' participation in the wise use of wetlands and to convey appropriate messages in order to promote the wise use principle throughout society.

c) The Ramsar Convention believes that CEPA should form a central part of implementing the Convention by each Contracting Party. Investment in CEPA will increase the number of informed advocates, actors and networks involved in wetland issues and build an informed decision-making and public constituency.

The Ramsar Convention encourages that communication, education, participation and awareness are used effectively at all levels, from local to international, to promote the value of wetlands.

A comprehensive CEPA program for an individual Ramsar site is beyond the scope of an ECD, but key communication messages and CEPA actions, such as a community education program, can be used as a component of a management plan.

Given the undisturbed nature of Ginini Flats Wetland Complex, susceptibility to disturbances such as trampling, and inclusion of this area in the remote zoning in the Namadgi National Park Draft Management Plan, large scale, on-ground CEPA activities at the Ramsar site are not compatible with the values of the wetlands and would require installation of infrastructure to prevent impacts (Hope, 2006). However, there are opportunities for smaller scale and low impact activities for raising awareness of the values of Ginini Flats Wetland Complex.

Key messages for the Ginini Flats Wetland Complex Ramsar site arising from this ECD, which should be promoted through the CEPA program include:

- the status of this wetland as a Ramsar listed wetland based on fulfilment of internationally established criteria
- the large-scale northerly extent of a nationally listed threatened sphagnum bogs and associated fens vegetation community
- the provision of habitat and captive breeding stock for the endangered northern corroboree frog

- the genetic and ecological diversity of a number of endemic and restricted flora species found in this vegetation community [specifically peat moss (*Sphagnum cristatum*), alpine plum pine (*Podocarpus lawrencei*), alpine ballart (*Exocarpos nanus*), dwarf buttercup (*Ranunculus millanii*), silver caraway (*Oreomyrrhis argentea*)]
- the distinctive processes of peat formation, *Sphagnum* growth and hydrological interactions in peatland systems
- the carbon capture and cycling in peatland systems and their valuable role worldwide in carbon dioxide sequestration and storage and the interaction with climate change. Comparisons of net carbon capture of peatlands and rainforest systems would provide perspective on relative value of these systems
- the threats from climate change to these systems and the concept of positive feedback whereby release of carbon dioxide may be sped up if climate change increases temperature, changes hydrology and results in oxidation of peat
- the overall concept of ecosystem service provisioning from wetland systems
- the ability for depositional systems such as sphagnum bogs and peatlands to provide stratigraphic layers to allow investigation of historical changes such as pollen analysis following on from substantial investigations already completed at Australian National University (ANU).

11. Glossary

Term	Explanation
Frost heave	The freezing of water-saturated soil that causes the deformation and upward thrust of the ground surface. Moist, fine-grained soil at cool to cold temperatures is most susceptible to frost heaving.
Hydrophobic	Used to describe soils or peat that has become water shedding where water infiltration does not occur.
Lignotuber	A woody growth containing bud present in many *Eucalyptus* species which can resprout following disturbance
Naturalised	A process that describes where a non-native organism has spread into the environment and the population has become self sustaining.
Oligotrophic	An ecosystem with few nutrients available to sustain primary productivity. A generalisation made about peatland and *Sphagnum* dominated ecosystems worldwide (van Breemen, 1995). Used as a relative term for Australian systems.
Redox	A redox measurement determines the reduction-oxidation status of a solution indicating the electron activity in the solution. This is comparable to a pH measurement which gives an indication of the acid/base status (or hydrogen ion activity) in the solution.
Restiads	A group of monocotyledonous plants in the family Restionaceae including *Restio* spp. *Baloskion* spp. and *Empodisma minus* in this instance.
Ruderal weeds	Describing flora species, specifically ones with relatively short life cycles and the ability to reproduce quickly and can colonise disturbed areas.
Specific yield	The volume of water that a unit volume of saturated permeable material will yield when drained by gravity expressed as a ratio (in this document).

12. References

ACT Government (1997a) A nature conservation strategy for the A.C.T.: draft. Environment ACT. Conservation Series No. 13. Environment ACT, ACT Parks and Conservation Service, Canberra.

ACT Government (1997b) Willow Management Strategy for the Upper Murrumbidgee Catchment. Environment ACT, Department of Territory and Municipal Services, Canberra.

ACT Government (2001) *Ginini Flats Wetlands Ramsar Site Plan of Management 2001*. Conservation Series No. 18 Environment ACT, Department of Urban Services, Canberra.

ACT Government (2004) ACT Natural Resource Management Plan 2004–2014. ACT Natural Resources Management Board, ACT Government.

ACT Government (2007a) *Namadgi National Park Revised Draft Plan of Management*, Environment and Recreation, Department of Territory and Municipal Services, Canberra.

ACT Government (2007b) Lower Cotter Catchment Strategic Management Plan (final) January 2007. Australian Capital Territory Government, Canberra.

ACT Government, 2008 *Territory Plan.* Available from: http://www.legislation.act.gov.au/ni/

ACT Government, 2009 – *Strategic Bushfire Management Plan for the ACT,* Draft for Community Comment. Publishing Services for the Emergency Services Agency, Canberra.

ACT Parks, Conservation and Lands, 2007– Feral Horse Management Plan. ACT Parks, Conservation and Lands, Canberra.

ACT Parks and Conservation Service (1995) *Information Sheet on Ramsar Wetlands Site 45 - Ginini Flats Subalpine Bog Complex.*

Alexiou P.N. (1983) Effects of feral pigs (*Sus scrofa*) on subalpine vegetation at Smokers Gap, A.C.T. *Proceedings Ecological Society of Australia* **12,** 135–142.

Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council. (2000).

Australian Government (2008) *Approved Conservation Advice for the Alpine Sphagnum Bogs and Associated Fens ecological community*.
http://www.environment.gov.au/biodiversity/threatened/communities/pubs/29-conservation-advice.pdf

Australian Nature Conservation Agency (1996) *A Directory of Important Wetlands in Australia*, Second Edition, ANCA, Canberra.

Banks J.C. (1989) A history of forest fire in the Australian Alps. In: The Scientific Significance of the Australian Alps. (ed R. Good) pp. 265–280. Australian Alps National Parks Liaison Committee/Australian Academy of Science, Canberra.

Batzer, D.P. and Wissinger, S.A. (1996) Ecology of insect communities in nontidal wetlands, *Annual Review of Entomology*, **41**:75–100.

Bell, K. and Bliss, L. (1980) Plant reproduction in a high arctic environment. *Arctic and Alpine Research* **12,** 1-10.

Billings, W. and Mooney, H. (1968) The ecology of arctic and alpine plants. *Biological Reviews* **43,** 481–529.

Biodiversity Group of Environment Australia (1997) *The Wetlands Policy of the Australian Government*. Environment Australia, Canberra.

Bureau of Meteorology (BoM) (2009) *Australian Drainage Divisions and River Basin Boundaries*. http://www.bom.gov.au/hydro/wr/basins/index.shtml

Cadwallader, P.L., Eden, A.K. and Hook, R.A. (1980) Role of Streamside Vegetation as a Food Source for *Galaxias olidus* Gunther (Pisces: Galaxidae), *Australian Journal of Marine and Freshwater Research,* **31**:257–262.

Campbell, I.C., McKaige, M.E. and Lake, P.S. (1986) 'The Fauna of Australian High Mountain Streams: Ecology, Zoogeography and Evolution', in Barlow, B.A. (ed.) *Flora and Fauna of Alpine Australasia: Ages and Origins*, CSIRO, Melbourne.

Carey, A., Evans, M., Hann, P., Lintermans, M., Macdonald, T., Ormay, P., Sharp, S., Shorthouse, D. and Webb, N. (2003) *Technical Report 17 Wildfires in the ACT 2003: Report on initial impacts on natural ecosystems.* Environment ACT, Canberra.

Charman, D. (2002) Chapter 3 Peatland Hydrology and Ecology. *Peatlands and Environmental Change*. J. W. Sons: 41–72.

Clark, R.L. (1980) *Sphagnum Growth on Ginini Flats, ACT*. Report to NSW National Parks and Wildlife Service.

Commonwealth of Australia (1990) National Capital Plan. National Capital Authority, Australian Government, Canberra.

Commonwealth of Australia (2005) *Interim Biogeographic Regionalisation for Australia, Version 6.1.* Available from: http://www.environment.gov.au/parks/nrs/science/pubs/map9.pdf

Costin, A.B. (1954) *A study of the ecosystems of the Monaro Region of New South Wales*. Soil Conservation Service of NSW, Sydney

Costin, A.B. (1972) Carbon 14 dates from the Snowy Mountains area, south-eastern Australia, and their interpretation. *Quaternary Research* **2**; 579–590.

Davis, C.J. (1998) Meteorological Aspects of Snow in Green, K. (ed.) *Snow a natural history; an uncertain future*. Australian Alps Liaison Committee, Canberra. Surrey, Beatty and Sons, Chipping Norton.

Davis, J. and Brock, M. (2008) Detecting unacceptable change in the ecological character of Ramsar Wetlands. *Ecological Management and Restoration* **9**: 26–32.

Department of the Environment and Heritage, 2005 *Threat Abatement Plan for Predation, Habitat Degradation, Competition and disease Transmission by Feral Pigs.* Available from:

http://environment.gov.au/biodiversity/threatened/publications/tap/pubs/feral-pig-tap.pdf

Department of the Environment, Water, Heritage and the Arts (DEWHA) (2000) *Revision of the Interim Biogeographic Regionalisation of Australia (IBRA) and development of Version 5, Summary Report*, Environment Australia, Canberra.

DEWHA (2006) *Threat Abatement Plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis*. Available from: http://www.environment.gov.au/biodiversity/threatened/publications/tap/chytrid.html

DEWHA (2008) *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands*. Module 2 of the National Guidelines for Ramsar Wetlands—Implementing the Ramsar Convention in Australia. Australian Government Department of the Environment, Water, Heritage and the Arts, Canberra.

DEWHA (2009a) *Alpine Sphagnum Bogs and Associated Fens* in Community and Species Profile and Threats Database, Department of the Environment, Water, Heritage and the Arts, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=29

DEWHA (2009b) *Pseudophryne pengilleyi* in Species Profile and Threats Database, Department of the Environment, Water, Heritage and the Arts, Canberra. Available from: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=66670

Evans, M. (2009) – personal communications

Flood, J.M. (1980) *'The Moth Hunters: Aboriginal Prehistory of the Australian Alps*.' Australian Institute of Aboriginal Studies: Canberra

Fritz, C. (2006) *Surface Oscillation in Peatlands: How Variable and Important is it?* 'Master of Philosophy, The University of Waikato.

Good, R. (2009) *Restoration of Mires (Bogs and Fens) in the Australian Alps Following Domestic Stock Grazing and the Impacts of the 2003 Wildfires*. Report prepared on behalf of the Mire Restoration and Research Group - Australian Alps Liaison Committee.

Green, K. (1998) *Snow Defining Character of the Alpine/Subalpine Fauna*, abstract of a paper presented at: The Global Threats to the Australian Snow Country Conference held at the Australian Institute of Alpine Studies, Jindabyne, Australia. 17–19 February 1998.

Green, K. and Osborne, W. (1994) *Wildlife of the Australian Snow Country*, National Library of Australia, Canberra.

Green, K. ed. (2002) *Biodiversity in the Snowy Mountains*. Australian Institute of Alpine Studies, Jindabyne, NSW.

Grosvernier, P., Matthey, Y. and Buttler, A. (1997) Growth Potential of Three *Sphagnum* Species in Relation to Water Table Level and Peat Properties with Implications for Their Restoration in Cut-Over Bogs. *Journal of Applied Ecology* **34(2):** 471–483.

Grover, S.P.P. (2006) *Carbon and water dynamics of peat soils in the Australian Alps*. Unpublished PhD Thesis. Centre for applied Alpine Ecology. Melbourne, La Trobe University.

Grover, S.P.P., McKenzie B.M., Baldock, J.A. and Papst, W.A. (2005) Chemical characterisation of bog peat and dried peat of the Australian Alps. *Australian Journal of Soil Research* **43**: 963–971.

Halsey, L.A., Vitt, D.H., and Gignac L.D. (2000) *Sphagnum*-Dominated Peatlands in North America since the Last Glacial Maximum: Their Occurrence and Extent. *The Bryologist* **103(2):** 334–352.

Hazell, D. (2003) Frog ecology in modified Australian landscapes: a review. *Wildlife Research* **30**: 193–205.

Helman, C.E., and Gilmour, P.M. (1985) *Treeless vegetation above 100 metres altitude in the ACT. A report to the Conservation Council of the Southeast Region and Canberra.* Canberra

Hennessy, K., Whetton, P., Smith, I., Bathols, J., Hutchinson, M. and Sharples, J. (2003) *The Impact of Climate Change on Snow Conditions in Mainland Australia*. CSIRO Atmospheric Research, Melbourne.

Higgins, M. (1994) *Skis on the Brindabellas*. Tabletop Press, O'Connor, ACT.

Hope, G. (2003) The mountain mires of southern New South Wales and the Australian Capital Territory: their history and future. In: J. Mackay (Ed). *Celebrating Mountains. Proceedings of the International Year of Mountains* (2002) *Conference*. Jindabyne Australia pp 67–79.

Hope, G. (2006) Histories of wetlands in the Australian Capital Territory and the bog recovery program. *Proceedings of the ACT NPA Symposium Caring for Namadgi – Science and People*. NPA Canberra.

Hope, G. and Southern, W. (1983) *Organic deposits of the Southern Tablelands region, New South Wales*, Report prepared for NSW National Parks and Wildlife Service, Sydney.

Hope, G., Nanson, R. and Flett, I. (2009) Technical Report 19. *The peat-forming mires of the Australian Capital Territory.* Territory and Municipal Services, Canberra.

Hope, G., Wade, A. and Whinam, J. (2003) *A report on the state of the mountain mires of the Australian Capital Territory after fires 14–22 January 2003*. Unpublished report for the ACT Recovery Group: Natural Resources and Wildlife Programs. ACT Environment and Conservation Branch, Namadgi National Park.

Huang, C.C. (2002) Holocene landscape development and human impact in the Connemara Uplands, Western Ireland. *Journal of Biogeography* **29**, 153–165.

Hunter, D. (2007) *Conservation Management of Two Threatened Frog Species in South-Eastern New South Wales, Australia*. Unpublished PhD Thesis, Institute for Applied Ecology, University of Canberra.

Hutchinson, M.N., and Donnellan, S.C. (1988) 'A new species of Scincid lizard related to Leilopisma entrecasteauxii, from south-eastern Australia.' *Transactions of the Royal Society of South Australia* **112**:143–151.

Ingram, H.A.P. (1978) soil layers in mires: function and terminology. *Journal of Soil Science* 29, 224–227.

Kirkpatrick, J.B. (1994) *'The International Significance of the Natural Values of the Australian Alps: A Report to the Australian Alps Liaison Committee*.' University of Tasmania, Hobart, Tas.

Lambkin, C.L., Power, N. and Starick, N.T. (2002) 'Mt Kosciusko: Biodiversity of Flies (Diptera)', in Green, K. (ed), *Biodiversity in the Snowy Mountains*, Australian Institute of Alpine Studies.

Lawler, D. (1989) Some observations on needle ice. *Weather* **44,** 406–409.

Lawrence, R., Rutherfurd, I., Ghadirian, P., White, M., Coates, F. and Thomas, I. (2009) *The geography and hydrology of high country peatlands in Victoria. Part 1 Geography and Classification.* Unpublished report. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria.

Los, S.M. (2005) *Association of Aquatic Macroinvertebrate Communities with Alpine Peatland Pool vegetation of Watchbed Ck, Bogong High Plains*, Victoria, BSc thesis, Latrobe University.

Macdonald, T. (2009) Technical Report 20 Sphagnum Bog Mapping and Recovery Plan. ACT Climate Change Strategy Action Plan 2007–2011. Project Report – Action 35. Territory and Municipal Services, Canberra.

Mackay, J. (2004) Interim recreation strategy for the natural areas of the ACT. Environment ACT, Department of Urban Services, Canberra. Electronic Copy http://www.tams.act.gov.au/__data/assets/pdf_file/0020/145244/interimrecreationstrategy0804.pdf Accessed June 2009.

Mark, A.F., and Bliss, L.C. (1970) The high-alpine vegetation of Central Otago, New Zealand. New *Zealand Journal of Botany* **8,** 381–451.

McPhail, M.K., and Hope, G. (1985) Late Holocene mire development in montane south-eastern Australia: a sensitive climatic indicator. *Search* **15,** 344–348.

Millennium Ecosystem Assessment (2005) *Ecosystems and human well-being: Wetlands and water synthesis.* World Resources Institute, Washington, DC

Moore, P.D. and Bellamy, D.J. (1974) '*Peatlands*.' (Elek Science: London)

Morgan, M.J., Hunter, D., Pietsch, R., Osborne, W. and Keogh, J.S. (2008) Assessment of genetic diversity in the critically endangered Australian corroborate frogs, *Pseudophyrne corroboree* and *Pseudophyrne pengilleyi*, identifies four evolutionarily significant units for conservation*. Molecular Ecology* **17**: 3448–3463.

Murkin, H.R. and Batt, B.D.J. (1987) The interactions of vertebrates and invertebrates in peatlands and marshes, *Memoirs of the Entomological Society of Canada*. **119(140**): 15–30

Murray–Darling Basin Commission (2005) *Murray Darling e-Resources 2005: Chapter 1 Surface Water Resources*. Available from: http://www.mdbc.gov.au/subs/eResource_book/chapter1/p1.htm

Murray–Darling Basin Commission (2001) Integrated catchment management in the Murray–Darling Basin 2001–2010: delivering a sustainable future: a statement of commitment by community and governments on future management of the natural resources of the Murray–Darling Basin. Murray - Darling Basin Ministerial Council, Canberra.

Nanson, R.A. (2009) The Evolution of Peat-Swamp Channels and Organic Floodplains, Barrington Tops, New South Wales, Australia. *Geographical Research*. **47(4):** 434 – 448.

NSW National Parks and Wildlife Service, 2001 *Threatened species Action Plan No. 6 for the corroboree frog* (Pseudophryne corroboree), NSW National Parks and Wildlife Service, Sydney.

Nunez, M. and Colhoun, E.A. (1980) A note on air temperature lapse rates on Mount Wellington, Tasmania. *Papers and Proceedings of the Royal Society of Tasmania*. 120:11–15

Osborne, W.S. (1984) *A Survey of the Distribution and Habitats of corroboree frogs (Pseudophryne corroboree) in Kosciusko National Park: with Reference to Ski Resort Development*. Report to NSW National Parks and Wildlife Service, Kosciusko District,

Osborne, W.S. (1989) Distribution, relative abundance and conservation status of Corroboree Frogs, *Pseudophryne corroboree* (Anura: Myobatrachidae). *Australian Wildlife Research*. **16**:537–547.

Osborne, W.S. (1990) *The Conservation Biology of* Pseudophryne corroboree *Moore (Anura: Myobatrachidae): A Study of Insular Populations*. PhD thesis, Australian National University, Canberra

Osborne, W.S. (1991) *The Biology and Management of the Corroboree Frog (*Pseudophryne corroboree*) in NSW.* Species Management Report No. 8. NPWS, Hurtsville, NSW.

Osborne W. S., Davis, M.S. & Green K. 1998. Temporal and spatial variation in snow cover. In '*Snow: A Natural History; an Uncertain Future*'. (Ed. K. Green) pp 56–68. (Australian Alps Liaison Committee, Canberra).

Osborne, W.S. and J.A. Norman (1991) Conservation Genetics of Corroboree Frogs *Pseudophryne corroboree* Moore (Anura: Myobatrachidae): population subdivision and genetic divergence. *Australian Journal of Zoology*. **39**:285–297.

Osborne, W.S., Zentelis, R.A. and Lau, M. (1996) Geographical variation in corroboree frogs, *Pseudophryne corroboree* Moore (Anura: Myobatrachidae): a reappraisal supports recognition of *P. pengilleyi* Wells and Wellington. *Australian Journal of Zoology* **44**:569–587.

Page, K.J., Nanson, G.C. and Frazier, P.S. (2003) Floodplain formation and sediment stratigraphy resulting from oblique accretion on the Murrumbidgee River, Australia. *Sedimentary Geology*. **13(1):** 5–14.

Pengilley, R.K. (1973) Breeding biology of some species of Pseudophryne (Anura: Leptodactylidae) of the Southern Highlands, New South Wales. Australian Zoologist. 18:15–30.

Price, J.S., Heathwaite, A.L. and Baird, A. (2003) Hydrological processes in abandoned and restored peatlands: An overview of management approaches. *Wetlands Ecology and Management* **11**: 65–83.

Ramsar Convention (2008) Annex B: Ramsar Classification System for Wetland Type. In Strategic Framework and guidelines for the future development of the List of Wetlands of International Importance of the Convention on Wetlands (Ramsar, Iran, 1971). Third edition, as adopted by Resolution VII.11 (COP7, 1999) and amended by Resolutions VII.13 (1999), VIII.11 and VIII.33 (COP8, 2002), IX.1 Annexes A and B (COP9, 2005), and X.20 (COP10, 2008). Available from: http://www.ramsar.org/pdf/key_guide_list2009_e.pdf

Silvester, E. (2009) Ionic regulation in an alpine peatland in the Bogong High Plains, Victoria, Australia. *Environmental Chemistry*. **6(5):** 424–431

Smith, H.G. and Dragovich, D. (2008) Post-fire hill slope erosion response in a subalpine environment, south-eastern Australia. *Catena* **73**: 274–285.

Stankey, G.H., Cole, D.N., Lucas, R.C., Petersen, M.E. and Frissel, S.S. (1985) *The Limits of Acceptable Change (LAC) System for Wilderness Planning*. General Technical Report INT–176, Intermountain Forest and Range Experiment Station, Ogden, UT. United States Department of Agriculture.

Suter, P.J., St. Clair, R.M., Hawking J.H. and Bryce, C. (2002) Aquatic Macroinvertebrates from Streams in the Mt Kosciusko Area, in Green, K. (ed.), *Biodiversity in the Snowy Mountains*, Australian Institute of Alpine Studies.

Tolsma, A. and Shannon, J. (2007) Evaluating the rehabilitation needs of mossbeds in the alpine and Mt Buffalo National Parks after the 2006/2007 fires. Unpublished report to Parks Victoria, Department of Sustainability and Environment.

Turetsky, M.R. (2003) The role of bryophytes in carbon and nitrogen cycling. *The Bryologist* **106(3):** 395–409.

van Breemen, N. (1995) How sphagnum bogs drown other plants. *Trends in Ecological Evolution* **10(7):** 270–276.

Watters, J.R. and E.H. Stanley (2007) Stream channels in peatlands: The role of biological processes in controlling channel form. *Geomorphology* **89**: 97–110.

Western, A., Rutherfurd, I., Sirawardena, R., Lawrence, R., Ghadirian, P., Coates, F. and White, M. (2009) *The Geography and Hydrology of High Country Peatlands in Victoria. Part 2. The Influence of Peatlands on Catchment Hydrology.* Unpublished report. Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Heidelberg, Victoria.

Whinam, J. (1995) Effects of fire on Tasmanian *Sphagnum* peatlands. *Bushfire '95. Australian Bushfire Conference, September 1995*. Presented papers.

Whinam, J. and Chilcott, N. (2002) Floristic description and environmental relationships of *Sphagnum* communities in NSW and ACT and their conservation and management. *Cunninghamia* **7 (3)**: 463–500.

Whinam, J. and Hope, G. (2006) *The Peatlands of the Australasian Region*. (Ed. G.M. Steiner) pp. 397–434. (Stapfia 85: Zugleich Kataloge der Oberösterreichische n Landsmuseen)

Whinam, J., Hope, G., Good, R. and Wright, G. (in press) *Post fire experimental trials of vegetation restoration techniques in the peatlands of Namadgi (ACT) and Kosciuszko National Parks (NSW), Australia*.

White, H. and Norris, R. (2007) '*The Biological Condition of the Cotter River*.' Institute of Applied Ecology, University of Canberra, ACT.

White, I., Wade, A., Worthy, M., Mueller, N., Daniell, T. and Wasson, R. (2006) The vulnerability of water supply catchments to bushfires: impacts of the January 2003 wildfires on the Australian Capital Territory. *Australian Journal of Water Resources* **10(2)**: 179–194.

Wild, A.S. (2008) *Vegetation recovery following disturbance in alpine and subalpine plant communities in Tasmania's Wilderness World Heritage Area*. Unpublished PhD Thesis, University of Tasmania.

Zylstra, P. (2006) *Fire history of the Australian Alps. Prehistory to 2003*. Australian Alps Liaison Committee, Canberra.

Appendices

A List of community assemblages for the site

<table>
<tr><th>Vegetation community (Helman and Gilmour, 1985)</th><th>Mapping unit (Hope et al., 2009)</th><th>Mapped extent (ha)</th><th>Dominant species</th></tr>
<tr><td>Bog</td><td>Sphagnum bog</td><td>44.4</td><td>Sphagnum cristatum, Richea continentis and Baloskion australe</td></tr>
<tr><td>Wet herbfield</td><td>Poa</td><td>19.4</td><td>Poa costiniana, P. clivicola and Arthropodium milleflorum</td></tr>
<tr><td>Wet heath</td><td>Shrub bog</td><td>0.2</td><td>Epacris paludosa, Baeckea gunniana and Callistemon pityoides</td></tr>
<tr><td>Sedgeland</td><td>Carex fen</td><td>0.03</td><td>Carex gaudichaudiana and Ranunculus spp.</td></tr>
<tr><td>Tall wet heath</td><td>Shrubs</td><td>1</td><td>Leptospermum lanigerum and Sphagnum cristatum</td></tr>
<tr><td>Dry heath</td><td>Not mapped</td><td rowspan="2">Approx 345</td><td>Bossiaea foliosa, Oxylobium alpestre and Helipterum anthemoides</td></tr>
<tr><td>Snow gum woodland</td><td>n/a</td><td>Eucalyptus pauciflora ssp. debeuzevillei</td></tr>
</table>

B Methods used to compile the description

The ECD for Ginini Flats Wetland Complex was compiled based on the outcomes of the inception meeting, a literature review, a field visit, consultation with relevant experts/stakeholders and development of relevant conceptual models. Information provided by each component is outlined below.

1. Inception meeting:

- Discussions and suggestions on the methods to deal with the change in ecological character in the ECD and RIS following the 2003 fires
- Identification and provision of relevant information held by the key stakeholders (e.g. reports, Geographic Information System layers, files)
- Identification of additional stakeholders for further consultation

2. Literature review and consultation

- The existing 1996 Ramsar Information Sheet and Management Plan for the site
- Information provided by key stakeholders
- Available literature (see Section 0), databases (EPBC protected matters, BioNet), spreadsheets, GIS layers and other information relevant to the ecological character of the Ramsar site (as defined by its boundaries)
- Available literature for peatland systems in other areas including the Victorian and NSW Alps, Tasmania and northern hemisphere areas
- Consultation with relevant experts/stakeholders, research institutions (Monash University, Australian National University, La Trobe University, University of Tasmania & Arthur Rylah Institute) and government agencies
- Key references for hydrology and water management, including papers and reports that specifically address the wetland and any available modelling and/or flow/rainfall data
- Experience and knowledge of the project team including independent PhD and honours research

3. Field visit and ecological assessment

- Clarification of the ecological character of the site based on the information gained from review of the literature, available data, and the general understanding of stakeholders

- Undertaken by Anita Wild from HTC on 27–29 April 2009 who used the opportunity to meet with local stakeholders and liaise with local ecologists

4. Conceptual models

- Developed by the project team following completion of the literature review and field assessment

5. Reporting

- Based on the guidelines for describing the ecological character of Australian Ramsar wetlands (DEWHA 2008)

C Curricula vitae for authors

Dr Anita Wild

Anita is a Senior Ecologist with Entura with over 15 years of assessment, restoration ecology and sustainable resource management experience. Anita has a PhD investigating natural recovery in alpine and subalpine vegetation communities in Tasmania and an honours degree investigating grazing impacts in alpine Victoria. She has worked extensively in alpine regions, undertaking vegetation surveys, quantitative ecological surveys, developing restoration plans in accordance with the International Society for Ecological Restoration Guidelines, implementing restoration plans and ecological assessment following fire and other disturbances. Anita has recently completed an assessment of hydrological disturbance of peatlands in alpine Victoria incorporating current and future climate change scenario hydrological modelling of individual peatlands to develop restoration priorities and treatments.

Anita's work also includes detailed quantitative plant ecology studies in other ecosystems including estuarine and fresh water systems. She is the lead vegetation specialist for the Gordon River Basslink Implementation Studies, investigating impacts of changes in regulated flow regimes on riparian vegetation in Tasmania's World Heritage Area. This project includes the design of a statistically and scientifically rigorous monitoring program, data collection at permanent impact and reference plots, statistical analysis of data and preparation of a report for review by an independent Scientific Reference Committee. Anita also has experience undertaking flora and fauna habitat surveys, vegetation management, environmental impact assessment and mitigation program design for wind farms, dams and other infrastructure in Tasmania, Victoria, Queensland and South Australia.

Simon Roberts

Simon is a Senior Aquatic Scientist at Entura and has over fifteen years experience in aquatic ecology, nutrient dynamics and impact assessments. Simon has worked on diverse range of water management issues from ecological impacts of developments on rivers to targeted investigations of ecological function in lakes and wetlands. He worked on systems ranging from small headwater streams to large coastal embayment's. He has also been a member of expert panels considering the long term impacts of climate change on estuarine and wetland communities. Simon's particular expertise is based around the role of micro algae, macro algae and macrophytes in nutrient cycling and ecosystem function in aquatic environments. He has designed and managed a number of programs investigating the role of sediments and autotrophs in relation to ecosystem 'health'. He has been involved in developing conceptual models of ecosystem function (both physical and biological) in wetlands and lakes. A key strength of this research has been the incorporation of the effects of physical forcing (flow and water level variation) on ecosystem function at spatial scales relevant to habitat management.

Brad Smith

Brad is an Environmental Scientist and is responsible for Aquatic Ecology including aquatic macroinvertebrates taxonomy and ecology, low lake level management and assessing the impacts of development on the aquatic environment. This role requires Brad to undertake scientific investigations into impact assessments and conduct surveys and monitoring of the aquatic environment. Brad also provides advice on the mitigation and monitoring of the aquatic environment as a result of past and recent developments. Brad has over five years professional experience in water management, field logistics, stakeholder liaison and lab processing. Brad currently participates and manages various projects within Hydro Tasmania's Aquatic Environment Program and has published a paper on the 'Changes in benthic macroinvertebrate communities in upper catchment streams in Tasmania across a gradient of catchment forest operation history' in a respected, peer reviewed journal.

Dax Noble

Dax is an Environmental Scientist with Entura and is responsible for carrying out environmental impact assessments, preparing environmental management plans and seeking environmental approvals for infrastructure development. This role requires Dax to carry out contaminated site assessments and field investigations including site selection and analysis. Dax has five years of experience in coastal and fluvial geomorphology, environmental/land and water management. Dax has worked both overseas and within Australia on varying projects including participating in an exchange program in the Netherlands undertaking field work on fen meadows focusing on water quality, ground water, ecohydrology and disturbed area restoration.

Dax has completed a masters degree in applied fluvial geomorphology and presented the 'Transition from Study to Work - Over three years of Reflection' to the 'Industry Connect Seminar Series' in New Zealand at the Environment Institute of Australia and New Zealand.

Raymond Brereton

Raymond is a Senior Ecologist for Entura with expertise in performing environmental assessments and approvals and assessing the impacts of developments on fauna, flora and their habitats, providing advice on policy and prescriptions for fauna and flora conservation and providing guidance and training on fauna and flora conservation and management. Raymond has over twenty years of experience working for natural resource management agencies in the field of fauna and flora conservation, addressing the impacts of developments on fauna, flora and their habitats; providing advice on policy and prescriptions for fauna and flora conservation; providing guidance and training on fauna and flora conservation and management; monitoring implementation of management prescriptions; and supervising fauna research projects. Raymond has continuing research interests in bird utilisation at wind farm sites and monitoring butterfly populations and is a member of the Tasmanian Forest Practices Tribunal (Fauna Specialist).