

## SUPPLEMENTARY MATERIAL

Appendix 1: The Australian Alps National Parks Co-operative Management Program encompasses 1.6 million ha of protected areas managed by three state government agencies with the collaboration of a federal government agency who are all parties to the Memorandum of Understanding (Australian Alps 2012)

The Australian Alps national parks are listed as National Heritage (Commonwealth of Australia, 2008) for the following values: (1) *The unique natural environment*: The outstanding landscape value of the high altitude peaks and plateaus, glacial lakes, alpine and sub-alpine ecosystems and the endemic and characteristic cold climate plants and animals are an important chapter in the evolutionary story of Australia's biodiversity; (2) *Longstanding human interaction*: The historical large scale Aboriginal social gatherings based on moth feasting were unique to the Alps, followed by over 150 years of transhumant alpine grazing, development of snow based alpine resorts and the use of alpine waters for irrigation, electricity production and domestic water supply; and (3) *Scientific significance*: The long history of scientific research and endeavour in the Alps, documenting the area's geology, botany and Aboriginal societies; (Australian Government, 2015a).

<i>State</i>	<i>Agency</i>	<i>Protected Area</i>	<i>Size (ha<sup>-1</sup>)</i>
Victoria	Parks Victoria	Alpine National Park	660,550
		Snowy River National Park	98,100
		Avon Wilderness	39,650
		Mount Buffalo National Park	31,000
		Baw Baw National Park	13,300
New South Wales	Office of Environment and Heritage; National Parks and Wildlife Service	Kosciuszko National Park	690,425
		Brindabella National Park	18,472
		Scabby Range Nature Reserve	4,982
		Bimberi Nature Reserve	10,886
Australian Capital Territory	Department of Urban Services; ACT Parks and Conservation Service)	Namadgi National Park	105,900
		Tidbinbilla Nature Reserve	5,450
National	Parks Australia	The Australian Government is not a land manager in the Alps Network but collaborates in co-operative cross border management.	

Appendix 2: Results from the surveys of (a) Alps Natural Icons and (b) Alps Invasive Species Threats where '1' is highest ranking and '9' is lowest ranking' and values are the number and percentage of votes for each rank class

	1		2		3		4		5		6		7		8		9			
(a) Alps icons	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	Total	Score
Alpine peaks (and high ridges)	51	14	18	5	3	1	3	1	3	1	7	2	7	2	3	1	0	0	27	7.4
Alpine peatlands (bogs)	18	5	29	8	29	8	3	1	14	4	3	1	0	0	0	0	0	0	27	7.2
Treeless high plains and frost hollows	11	3	29	8	25	7	11	3	7	2	3	1	3	1	3	1	3	1	27	6.6
Heritage / wild rivers	7	2	0	0	7	2	7	2	14	4	22	6	7	2	11	3	22	6	27	3.9
Mountain pygmy possum	7	2	3	1	7	2	18	5	0	0	7	2	11	3	29	8	14	4	27	3.9
Tall wet forest (E. delegatensis dominated)	3	1	3	1	7	2	11	3	11	3	18	5	25	7	7	2	11	3	27	4.1
Sub alpine woodland	0	0	14	4	3	1	37	10	18	5	22	6	0	0	3	1	0	0	27	5.6
Rain shadow woodlands (White box/Callitris pine)	0	0	0	0	3	1	0	0	18	5	11	3	25	7	18	5	22	6	27	3
Corroboree frog	0	0	0	0	11	3	7	2	11	3	3	1	18	5	25	7	22	6	27	3.2

	1		2		3		4		5		6		7		8		9			
(b) Alps Invasive Species	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	%	no.	Total	Score
Wild horses	64	18	14	4	0	0	0	0	0	0	10	3	3	1	7	2	0	0	28	7.6
Hawkweed spp	21	6	25	7	7	2	3	1	14	4	17	5	4	1	7	2	0	0	28	6.3
Blackberry spp	7	2	0	0	21	4	14	4	7	2	7	2	0	0	21	6	21	6	28	4.3
Wallow spp	3	1	3	1	14	4	10	3	14	4	7	2	17	5	7	2	21	6	28	4.1
Ox eye daisy	3	1	7	2	14	4	14	4	10	3	14	4	14	4	10	3	10	3	28	4.6
Wild pigs	0	0	3	1	7	2	21	6	10	3	7	2	17	5	14	4	17	5	28	3.9
Foxes	0	0	10	3	7	2	0	0	7	2	10	3	21	6	17	5	25	7	28	3.4
Deer spp	0	0	17	5	10	3	17	5	14	4	17	5	14	4	7	2	0	0	28	5.2
Broom spp	0	0	17	5	17	5	17	5	21	4	7	2	7	2	7	2	3	1	28	5.5

### Appendix 3: Descriptions of key invasive species threats

Invasive species	Description and threat
<p>Feral Horses</p> <p><i>Equus caballus</i></p>	<p>Feral Horses are considered a significant threat to the natural values of the Australian Alps (Coyne, 2001) through serious catchment and environmental impacts caused by soil loss, compaction and erosion, trampling of vegetation and damage to alpine Peatland habitat and water bodies (Nimmo and Miller, 2007 &amp; Australian Alps, 2010), in particular on streams and stream banks (Prober and Thiele, 2007; Dyring, 1990). It is estimated there are over 10,000 feral Horse in the Alps Network (Australian Alps, 2014). Degradation and loss of habitats caused by feral horses is listed as a potentially threatening process in Victoria (Victorian Government, 1988).</p>
<p>Hawkweed species</p> <p>Orange Hawkweed</p> <p><i>Hieranicum aurantiacum</i></p> <p>Mouse Ear Hawkweed</p> <p><i>Hieranicum pilosella</i></p> <p>King Devil Hawkweed</p> <p><i>Hieranicum praealtum</i></p>	<p>Hawkweed species can alter ecosystems and dominate and control natural landscapes. (NSW Government, 2015). Hawkweeds aggressively invade alpine treeless areas competing with native herbs and grasses and are a major threat to biodiversity in the Australian Alps network. Hawkweeds are a State Prohibited Weed in NSW (NSW Government, 2015a) and in Victoria (Victorian Government, 1994).</p>
<p>Broom Species*</p> <p>Scotch/English Broom</p> <p><i>Cytisus scoparius</i></p> <p>Cape Broom</p> <p><i>Genista montepessulana</i></p>	<p>Brooms are capable of totally transforming invaded habitats. They simplify the structure and diversity of the ground flora, and crowd or shade shrubs and tree seedlings, eventually preventing over storey regeneration. Dense stands seriously impede movement and act as harbour for feral animals such as pigs. (NSW Government, 2012). Broom invasion may also affect native animals, contributing to changes in species diversity and density (Australian Government, 2013). Brooms are declared as 'Must be suppressed/prohibited' in the ACT (ACT Government, 2009).</p>
<p>Deer Species</p> <p>Sambar Deer</p> <p><i>Rusa unicolor</i></p> <p>Fallow Deer</p> <p><i>Dama dama</i></p> <p>Red Deer</p> <p><i>Cervus elaphus</i></p>	<p>Sambar Deer populations are widespread and growing throughout the Alps network, their impact includes browsing, grazing, pugging, wallowing and antler rubbing. Deer impacts on Alpine Wetlands are a particular concern (Parks Victoria, 2014). The impact of Sambar deer on biodiversity is a threatening process in NSW (NSW Government, 2012) and in Victoria (Victorian Government, 1988).</p>
<p>Ox eye daisy</p> <p><i>Leucanthemum vulgare</i></p>	<p>Ox-eye Daisy (<i>Leucanthemum vulgare</i>) invades lowland grassland and grassy woodlands, damp sclerophyll forests, riparian vegetation, alpine and subalpine vegetation (Carr et al., 1992) and can threaten the integrity of native vegetation. It grows so densely that it can exclude almost all other vegetation (NSW Government, 2012). While most commonly</p>

	observed in disturbed areas such as roadsides and cleared land, of most concern is the species aggressively invading undisturbed subalpine grasslands, snowgum woodlands and wetlands (NSW Government 2015b).
Blackberries* <i>Rubus fruticosus</i> aggregate	Blackberries are widespread throughout the Alps networks present in most moist gullies and Riparian areas. It forms impenetrable thickets and is regarded as one of the worst weeds in Australia because of its invasiveness, potential to spread and environmental impact (Australian Government, 2015b). Invasion of native vegetation by Blackberry is a potentially threatening process in Victoria (Victorian Government, 1988). Blackberry is declared as 'Must be suppressed/prohibited' in the ACT (ACT Government, 2009).
Willow spp* Crack Willow <i>Salix Fragilis</i> Grey Sallow <i>Willow Salix cinerea</i>	There are a number of willow species invading riparian areas and wetlands. Willows damage stream health and habitat through slowing the flow of water, reducing aeration and changing watercourses through the capture of enormous amounts of sediment (Australian Government, 2015b & NSW Government, 2012). Willows are a particular concern for their propensity to invade alpine and sub-alpine wetlands, particularly following fire. These Willows are declared as 'Must be suppressed/prohibited' in the ACT (ACT Government, 2009).
Pigs <i>Sus scrofa</i>	Feral pigs present a significant threat to native species and ecological communities as a result of their behaviour and feeding habits and occur in a range of ecosystems. The impacts on native ecosystems in the Alps Network comes from rooting wallowing and trampling of treeless flats and wetlands, tusking or rubbing trees, and consumption of water, animals, plants and soil organisms. (Australian Government, 2013a), with presumed adverse impacts on wetland hydrology and abundance of plants and animals, including threatened species (ACT Government, 2012). Predation, habitat degradation, competition and disease transmission by feral pigs has been declared a threatening process nationally (Australian Government, 1999) and in NSW (NSW Government, 2012).
Red Fox <i>Vulpes vulpes</i>	Foxes occur throughout the Alps network and are a major threat to the survival of native fauna. They have a significant impact on ground dwelling mammals and birds, particularly on mid weight range native mammals such as Long Footed Potoroo, Quoll and Long nosed Bandicoot as well as the threatened Mountain Pygmy Possum, Broad Toothed Rat and Brush tailed Rock Wallaby. (Parks Victoria, 2014 and NSW Government, 2012). Predation by Foxes is a threatening process nationally (Australian Government, 1999) in NSW (NSW Government 2012) and in Victoria (Victorian Government, 1988).
* Weed of National significance; (Australian Government 2015c)	

#### Appendix 4: Data sources for the identified natural icons

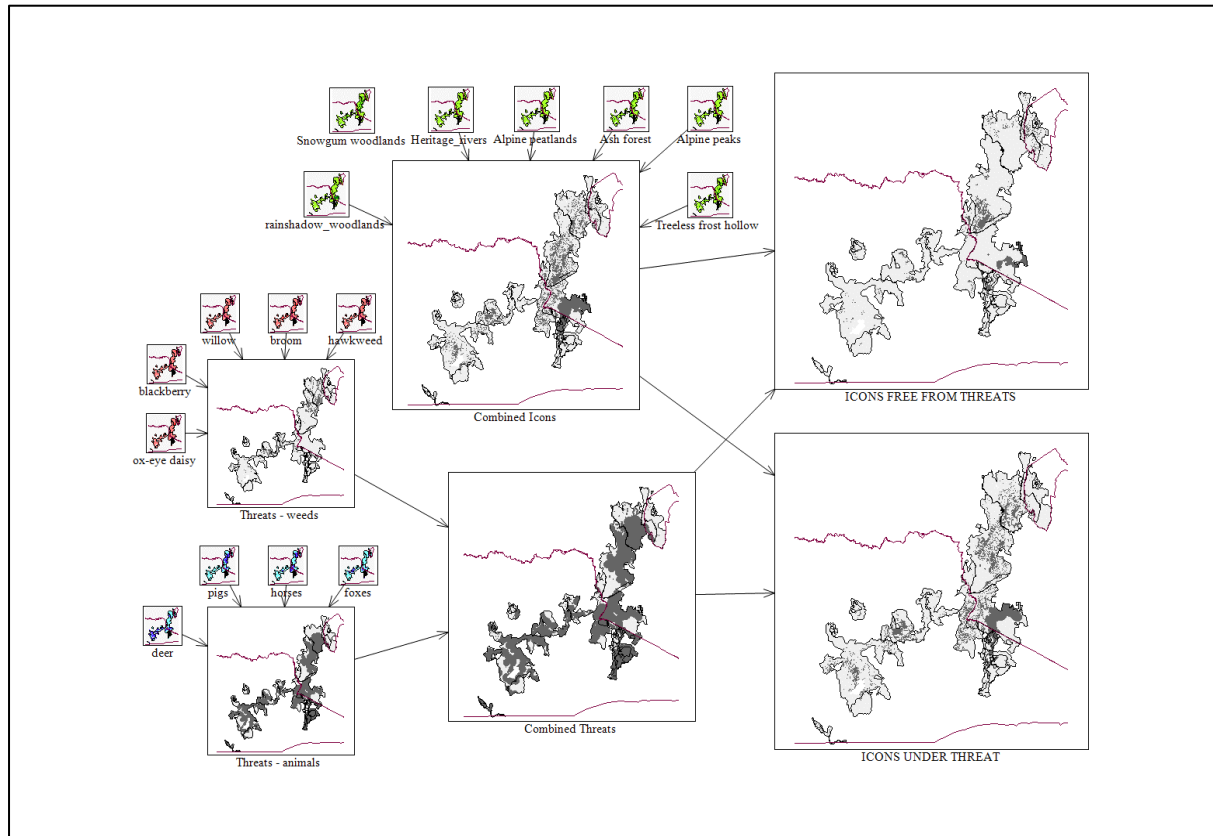
Natural Icon	Data source
Alpine Peaks	Manual mapping to identify the treeless peaks and high ridges prominent in the landscape, using a regionally distinct elevation rule then verifying qualitatively.
Treeless High Plains and Frost Hollows	Ecological Vegetation Classes (EVC) and Groups that identify these distinctive treeless areas. In Victoria: EVC's 41, 42, 44, 156, 170, 184, 192, 202, 204, 206, 208, 239, 317, 318, 905, 913, 1001, 1002, 1003, 1004, 1005, 1012, 1013, 1014, 1105 (DSE 2015). In NSW and ACT: Vegetation groups; 36, 123, 125, 126, 129, 131, 132, 147, 204, 205, 206, 207 (Gellie, 2005).
Alpine Wetlands	Australian Alps Bogs mapping layer (NSW Government (2012, and ARI, 2008), incorporating Ecological Vegetation Classes (Victoria) 210, 171, 288-61, 288-62, 1011, 211, and Vegetation group (NSW and ACT) 133 (Gellie, 2005).
Snow Gum Woodlands	Ecological Vegetation Classes (EVC) and Groups that identify these distinctive snow gum dominated areas. In Victoria, EVC's: 43, 977, 978 (DSE, 2015). In NSW and ACT: Vegetation groups; 37, 99, 127, 128, 130, 146 (Gellie, 2005).
Tall Wet Forests	Ecological Vegetation Classes (EVC) and Groups that identify these distinctive forests dominated by Alpine and Mountain Ash. In Victoria, EVC's: 29, 30, 35, 38, 39, 201 (DSE, 2015). In NSW and ACT: Vegetation groups; 86, 87 (Gellie, 2005).
Rain-Shadow Woodlands	A broad area geographically mapped but based on the Ecological Vegetation Classes and Groups that identify these distinctive woodlands. In Victoria EVC's 24, 27, 72, 175 (DSE, 2015). In NSW and ACT, Vegetation groups 35, 38, 41, 77, 78, 116 (Gellie, 2005).
Heritage Rivers	Victoria's Heritage River classification (Victorian Government, 1992) and in NSW and the ACT major rivers have been mapped directly from the IBRA Rivers data-layer (Australian Government, 2015) and (Bureau of Meteorology).

# Appendix new 5: Data sources for the spatial models of invasive species threats

Invasive species	Data Source	Data format
Feral horses ( <i>Equus caballus</i> )	Parks Victoria Environmental Information System; management records (Parks Victoria, 2014a)	Polygon
	Parks Victoria Environmental Information System: presence records (Parks Victoria, 2014b)	Polygon
	Parks Victoria Wild Horse distribution and density map (Parks Victoria, 2013)	Polygon
	NSW National Parks and Wildlife Service Invasive species database (NPWS, 2014)	Buffered point data
Hawkweed species	NSW National Parks and Wildlife Service Invasive species database (NPWS, 2014)	Buffered point data
Orange hawkweed ( <i>Hieranicum aurantiacum</i> )	Parks Victoria Environmental Information System; management records (Parks Victoria, 2014a)	Polygon
Mouse Ear Hawkweed ( <i>Hieranicum pilosella</i> )	Parks Victoria Environmental Information System: presence records (Parks Victoria, 2014b)	Polygon
King Devil Hawkweed ( <i>Hieranicum praealtum</i> )	ACT Weeds Geodatabase (ACT Government, 2014).	Polygon
Broom species	NSW National Parks and Wildlife Service Invasive species database (NPWS, 2014)	Buffered point data
Scotch/English broom ( <i>Cytisus scoparius</i> )	Parks Victoria Environmental Information System; management records (Parks Victoria, 2014a)	Polygon
Cape broom ( <i>Genista montpessulana</i> )	Parks Victoria Environmental Information System: presence records(Parks Victoria, 2014b)	Polygon
	ACT Weeds Geodatabase (ACT Government, 2014)	Polygon
Deer	NSW National Parks and Wildlife Service Invasive species database (NPWS, 2014)	Buffered point data
Sambar deer ( <i>Rusa unicolor</i> )	Parks Victoria Environmental Information System: presence records (Parks Victoria, 2014b)	Polygon
Fallow deer ( <i>Dama dama</i> )		
Red deer ( <i>Cervus elaphus</i> )		

Ox eye daisy ( <i>Leucanthemum vulgare</i> )	Parks Victoria Environmental Information System; management records (Parks Victoria, 2014a)  NSW National Parks and Wildlife Service Invasive species database (NPWS, 2014)  ACT Weeds Geodatabase (ACT Government, 2014)	Polygon  Buffered point data  Polygon
Blackberries( <i>Rubus fruticosus</i> ) aggregate	Parks Victoria Environmental Information System; management records (Parks Victoria, 2014a)  NSW National Parks and Wildlife Service Invasive species database (NPWS, 2014)  ACT Weeds Geodatabase (ACT Government, 2014)	Polygon  Buffered point data  Polygon
Willow spp* Crack willow ( <i>Salix Fragilis</i> ) Grey sallow ( <i>Willow Salix cinerea</i> )	NSW National Parks and Wildlife Service Invasive species database (NPWS, 2014)  Parks Victoria Environmental Information System; management records (Parks Victoria, 2014a)  Parks Victoria Environmental Information System: presence records (Parks Victoria, 2014b)  ACT Weeds Geodatabase (ACT Government, 2014)	Buffered point data  Polygon  Polygon  Polygon
Pigs ( <i>Sus scrofa</i> )	NSW National Parks and Wildlife Service Invasive species database (NPWS, 2014)  Parks Victoria Environmental Information System; management records (Parks Victoria, 2014a)	Buffered point data  Polygon
Foxes Red fox ( <i>Vulpes vulpes</i> )	NSW National Parks and Wildlife Service Invasive species database (NPWS, 2014)  Parks Victoria Environmental Information System; management records (Parks Victoria, 2014a)	Buffered point data  Polygon

Appendix 6: A screen shot of the MCAS-S window showing the sequence in which the data layers were combined to generate the combined icon and threat layers. Simple raster based map algebra was used to combine the primary data and then to calculate the area of icons free from threats and the area under threat. MCAS-S enables the data layers to be interactively manipulated and combined in different ways by decision makers





Appendix 7: Current approaches to identification of vegetation and landscape features and focal targets in Alps Network Management Plans and affinities where they are apparent.  
(N/A= no affinity)

<i>Victoria: Natural Ecosystems</i>	<i>NSW: Vegetation features (NF) and Areas of Outstanding Natural and Cultural Significance (AONCS)</i>	<i>ACT: Special Protection and Management.</i>
Alps	Alpine flora (NF)	Natural Temperate Grassland of the Southern Tablelands of NSW and the ACT
Alps	Subalpine inverted treelines (NF)	Montane and Subalpine Bog
Alps	Subalpine treeless flats and valleys (NF)	N/A
Alps	Subalpine woodlands (NF)	N/A
Alps	Upper slope treelines , (NF)	N/A
Alps	Podocarpus heaths and sphagnum bogs (NF)	N/A
Alps	Massed seasonal displays of alpine wildflowers (NF)	N/A
Alps	The alpine landscapes of the Main Range (AONCS)	N/A
Dry Forest and Woodlands	White box ( <i>E. albens</i> )–white cypress pine ( <i>Callitris glaucophylla</i> ) (box–pine) ecosystems of the lower Snowy River valley and Byadbo country , (NF)	Black Cypress Pine Tableland Open Forest
N/A	Yarrangobilly karst catchment (AONCS)	N/A
N/A	Cooleman Plain karst catchment . (AONCS)	N/A
N/A	The dominance of a single genus, <i>Eucalyptus</i> (NF)	N/A
Inland Waters and Wetlands	N/A	N/A
Wet Forest and Rainforest	N/A	N/A
Heathland	N/A	N/A

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(Citations not listed here can be found in the reference section of the main text)

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