IVG Forest Conservation Report 7A

Report for the Independent Verification Group of the Tasmanian Forests Intergovernmental Agreement (IGA) on the distribution of carnivore refugia within the proposed ENGO forest conservation areas: Distribution of large marsupial carnivores - locations of core habitat and population strongholds for the Tasmanian devil, spotted-tailed quoll and eastern quoll in Tasmania.

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Aims:

We were asked by the Independent Verification Group to provide information on the distribution and population strongholds of the three species of large marsupial carnivores in Tasmania, in a form that would allow the identification of priority areas for conservation of these species. The species are:

- Tasmanian devil *Sarcophilus harrisii*
- Spotted-tailed quoll *Dasyurus maculatus*
- Eastern quoll *Dasyurus viverrinus*

Background:

Tasmania is globally significant for the largest and most intact guild of marsupial carnivores, a currently species poor evolutionary radiation with ecomorphological counterparts in the placental carnivore faunas elsewhere in the world (Jones 2003). With the demise of the thylacine, there are three species in this size structured guild. The Tasmanian devil (6 - 14 kg), now positioned as the apex predator is the largest remaining marsupial carnivore is a predator and specialist scavenger. Now restricted to Tasmania, it was extirpated on the mainland by introduced dingoes 4000-5000 years ago. With recent severe disease-induced decline it is now listed as Endangered at State (Threatened Species Protection Act 1995), Federal (EPBC Act 1999) and International (IUCN) levels. The spotted-tailed quoll (2.5 – 6 kg) is also found in a patchy distribution along the Great Dividing Range to far north Queensland and is classified as Vulnerable nationally (EPBC Act 1999) and Rare in Tasmania (Threatened Species Protection Act 1995). It once occurred much further west into the semi-arid zone but has disappeared from all but the wettest parts of its mainland range. The eastern quoll (0.7 – 1.5 kg), a carnivore/insectivore, disappeared from mainland Australia between the 1930s and the 1960s. Foxes are implicated as a major factor in its extinction. It is listed as Near Threatened (IUCN).

Until recently, all these species' status was secure in Tasmania, despite the presence of feral cats in Tasmania since the 1800s. The devil and the eastern quoll are now under threat. The evolution and emergence of an unusual contagious cancer restricted to Tasmanian devils is threatening the extinction of this species. Broadscale population decline of Tasmanian devils is leading to competitive release of mesopredators and feral cats are increasing in numbers (Hollings et al. submitted). The trophic cascade that will occur with the loss of the top predator is not yet not fully appreciated. High cat abundance is, however, associated with higher prevalence of toxoplasmosis (Hollings, Jones & McCallum in prep.), a blood parasite that has both lethal and sublethal effects of wildlife. In addition to higher levels of predation of small mammals and birds, it is thought that cats are competitively superior to and will suppress spotted-tailed quoll populations – the latter species is not increasing as would be predicted from mesopredator release as devil populations decline. The eastern quoll has been in severe decline for the last 10 years. The reasons are not yet well understood but its decline is associated with both devil decline and drought and it is possible that increased predation and disease from increased cat populations play a role. In addition to these threats, the widespread presence of foxes in the state is of great concern for the persistence of all medium-sized mammals.

Positioned at a high trophic level, carnivores have an influential ecological role in top down structuring of ecosystems. They can protect smaller species through suppressing populations of invasive mesopredators such as feral cats and foxes. Habitat loss is also a significant threat to carnivore populations (Jones et al. 2003). Carnivores have generally large spatial requirements and so are particularly vulnerable to threats such as habitat loss and extrinsic mortality from roadkill and persecution (Jones 2000; Jones et al. 2003). The protection of core refuges and strongholds in formal reserves, with connectivity maintained at large landscape scales is vital to maintain viable populations of carnivores that retain their ecological functionality (Soule et al. 2006).

Methods:

Expert knowledge and recent research on these species shows that while their occurrence is associated with forest, they are not strictly dependent on forest cover and frequently use fragmented and edge habitats, and they do not show strong preferences for particular forest types and vegetation cover.

Therefore, we built our species distribution models using climate and weather variables, as the major likely determinants of productivity of environments for each species. We used the MaxEnt algorithm for model development. Additional details on methodology are provided in Appendix 1.

For each species, two distribution models were built:

1. A climate-based model, constructed by associating each location record with mean climate variables for that location over the period 1950-2010. The model describes suitability of environments for each carnivore, as a function of their typical climate

regimes. When projected onto the map of Tasmania, the model shows how environmental suitability varies across the island.

2. A weather-based model, which used the values of weather associated with each record. The weather-based model was then projected on to the map of Tasmania at monthly intervals from 1950 to 2010, to create a dynamic species distribution model showing the influence of climate variability on spatial variation in environmental suitability. For each 0.05^{o} x 0.05^{o} cell on this map, we calculated the proportion of time that conditions were suitable for each species. These proportions were then mapped, to identify areas that have the most stable conditions suitable for each species. These are the areas most likely to represent **'strongholds'** able to consistently support abundant populations, given climate variability likely to be encountered over a 60-year period.

We tested these maps against expert opinion (Menna Jones – all species; devils – Menna Jones, Nick Beetton; spotted-tail quoll – Shannon Troy; eastern quoll – Bronwyn Fancourt) to confirm that they agreed with field experience of each species.

Finally, we combined the stability maps for the three species into a single composite map to show areas supporting stable conditions for combinations of carnivore species (see appendix for detail on calculation of the composite index). The index used here was designed to give highest value to areas that are consistently favourable for all three species.

Outputs:

Copies below (Figures 1-7), for each species , are maps of climate suitability ("climate"), maps of stability of favourable conditions ("weather stability"), and the composite map showing stability for all three species combined. All maps are overlaid with the proposed ENGO reserves. The climate maps indicate the spatial climate envelope which is suitable for occupation by each species. The weather stability maps indicate refugia in the landscape within this climate envelope where these species are likely to persist in times of climatic variation. Species may disappear from parts of their range in extreme climatic conditions.

Appendix 2 provides a ranking for the potential of each reserve to improve reservation status and connectivity, for each species separately and for all three species combined. These rankings are based on information in both the climate and weather stability maps using expert opinion (Menna Jones). Figures 8-11 are maps that show priority rankings for each of the reserves; with a set of maps showing high, medium and low priority for the composite of all three species and for each of the three species separately.

High-resolution versions of all images, ESRI and .asc data files for all maps, are provided electronically.

Composite map of the potential for proposed ENGO reserves to improve reservation and connectivity for all three species of Tasmanian marsupial carnivores in sympatry

The composite carnivore map (Figure 1) shows where there is most potential for the proposed ENGO reserves to increase connectivity of reserved habitat, in areas that function as refugia by providing consistently suitable conditions for co-occurrence of all three species in Tasmania's large carnivore guild.

There are three clear hotspots with high potential in this regard: the lowland north-central area (bounded by the Tamar River to the east, Ulverstone to the west and the Great Western Tiers to the south), the north-east (bounded by the Tamar River and Fingal Valley but excluding highest altitude and coastal areas) and spreading down the Eastern Tiers to as far south as Reserves **40, 41** and **42**, and a linear corridor in the south-central part of the state comprised of the southern forests adjacent to the main Derwent River valley from Lake St Claire to Hobart. In the Derwent Valley area, about one third each of the proposed reserves are ranked each of high, medium and low significance, respectively. However, all of the reserves are closely adjacent to high quality refugia and are likely to be used by these wide-ranging carnivore species at least for movement between high quality habitat patches. For this reason, establishing greater security of connectivity along this long valley is important. The assigned rankings and comments for each reserve are in Table 1.

The formal establishment of ENGO reserves in the northeast of Tasmania and along the Eastern Tiers would greatly improve reservation/protection status and connectivity for the sympatric carnivore guild. This would include all proposed reserves to the east of the Tamar River and including and to the north of Reserves **208** and **166** in the western part of this area, and **150, 128** and **129** in the eastern part. There is also potential to greatly improve connectivity and population protection in the southern forests/Derwent Valley. There is less potential within the proposed ENGO reserves to improve the reservation and connectivity status of the Tasmanian carnivore guild in refugia "hot spot" in the northern central part of the state because much of the core refugia lacks reserves. There are, however, quite a number of proposed reserves in the area bounded by Westbury-Deloraine-Birralee-Frankford (Reserve numbers **169, 170, 180, 186, 188, 195, 203, 206, 218, 232, 234, 239**) and along the Great Western Tiers (**110, 114, 115, 116, 120, 121, 125**) along the southern edge of this region. These are very important to establish connectivity, even if they are not ranked high as refugia because they are proximate to high quality refugia and serve as stepping stones for landscape scale movement for carnivores.

These refugia based on concurrent distributions capture the distribution strongholds for the Tasmanian devil and eastern quoll well. Connectivity of reserved habitats for these two species could be enhanced with additional reserves along the full length of the Eastern Tiers to as far south as Sorell, both capturing the core refugia and distribution strongholds and providing north-south latitudinal connectivity. This includes all of the

proposed reserves in this area, excluding those on the Forestier and Tasman peninsulas. The spotted-tailed quoll is not adequately represented by the concurrent refugia. For this species, the north coast (lowland coastal areas west of Ulverstone) and the northwest (from Temma across to Rocky Cape) provide the most important refugia, as shown by the specific maps for this species. The northwest corner of Tasmania has relatively few proposed ENGO reserves so there is limited potential to protect the most important area for spotted-tailed quolls. This places a greater emphasis on the reserves that are proposed in this area. These reserve numbers are: **227, 238, 241, 244, 246, 249, 252, 254, 257, 259, 261, 263, 267, 268, 269, 278** in the far northwest and also **178, 183, 196** and **229** on the northern slopes.

Figure 1. Putative refugia for all three Tasmanian carnivore species, using composite weather stability (with ENGO proposed reserves overlaid).

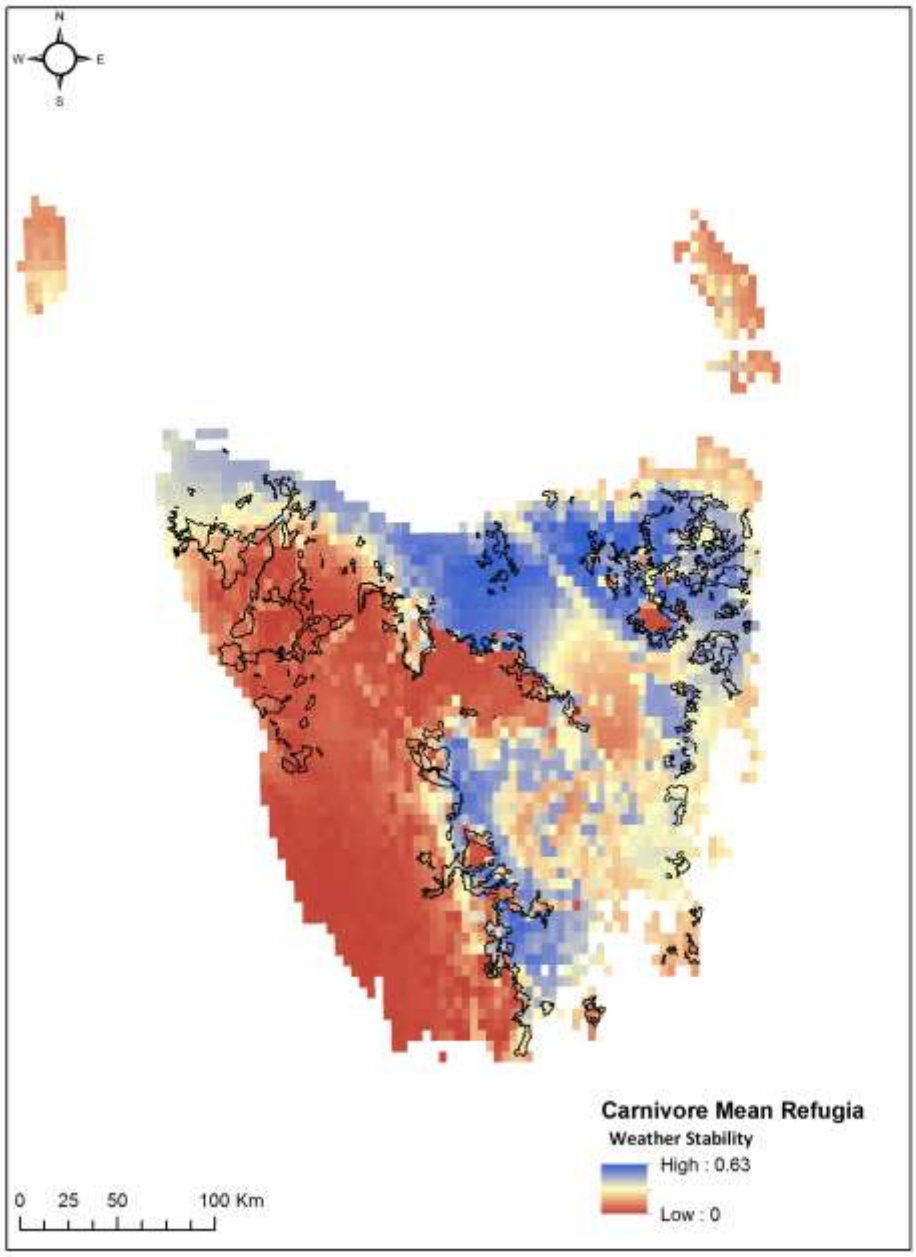


Figure 2. Tasmanian devil, climate suitability.

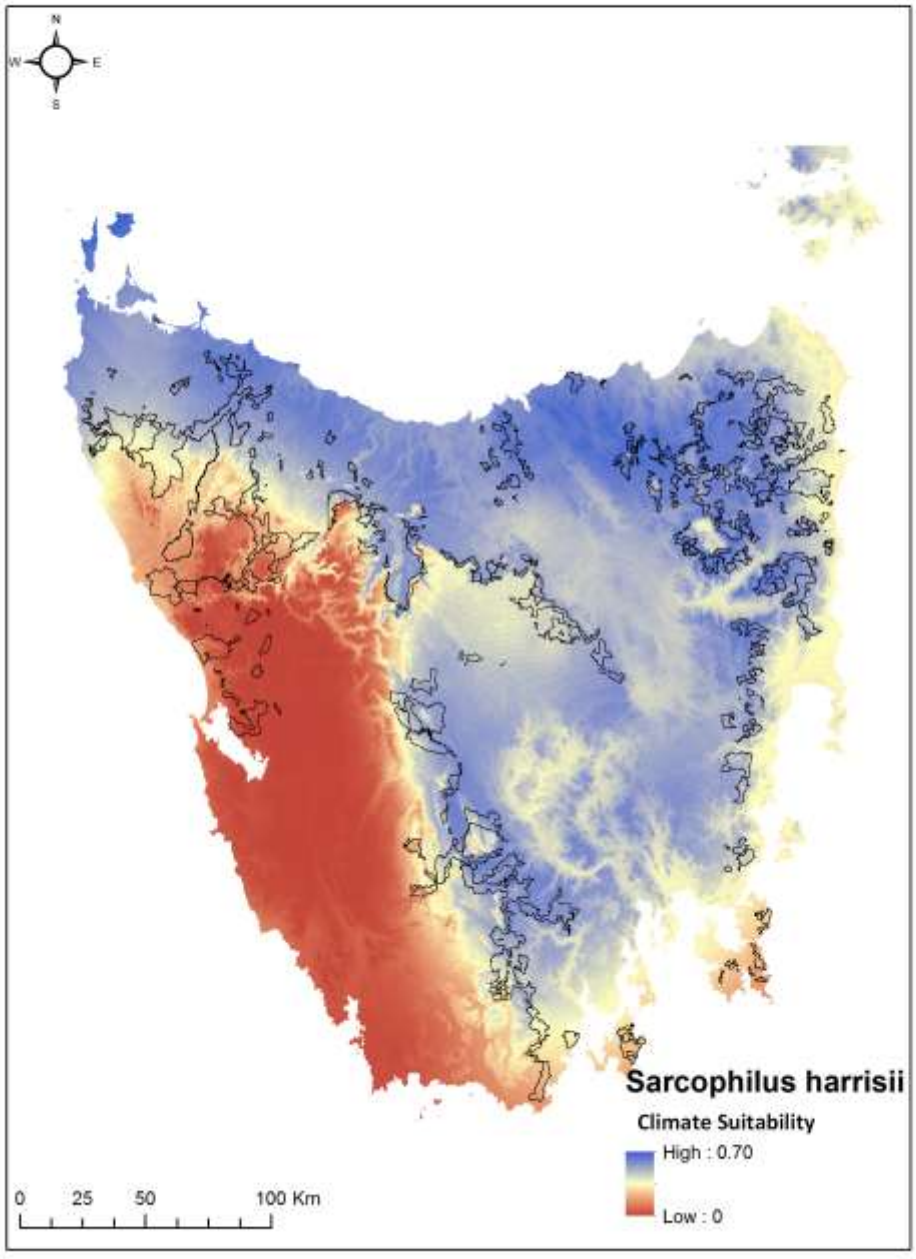


Figure 3. Tasmanian devil, weather stability.

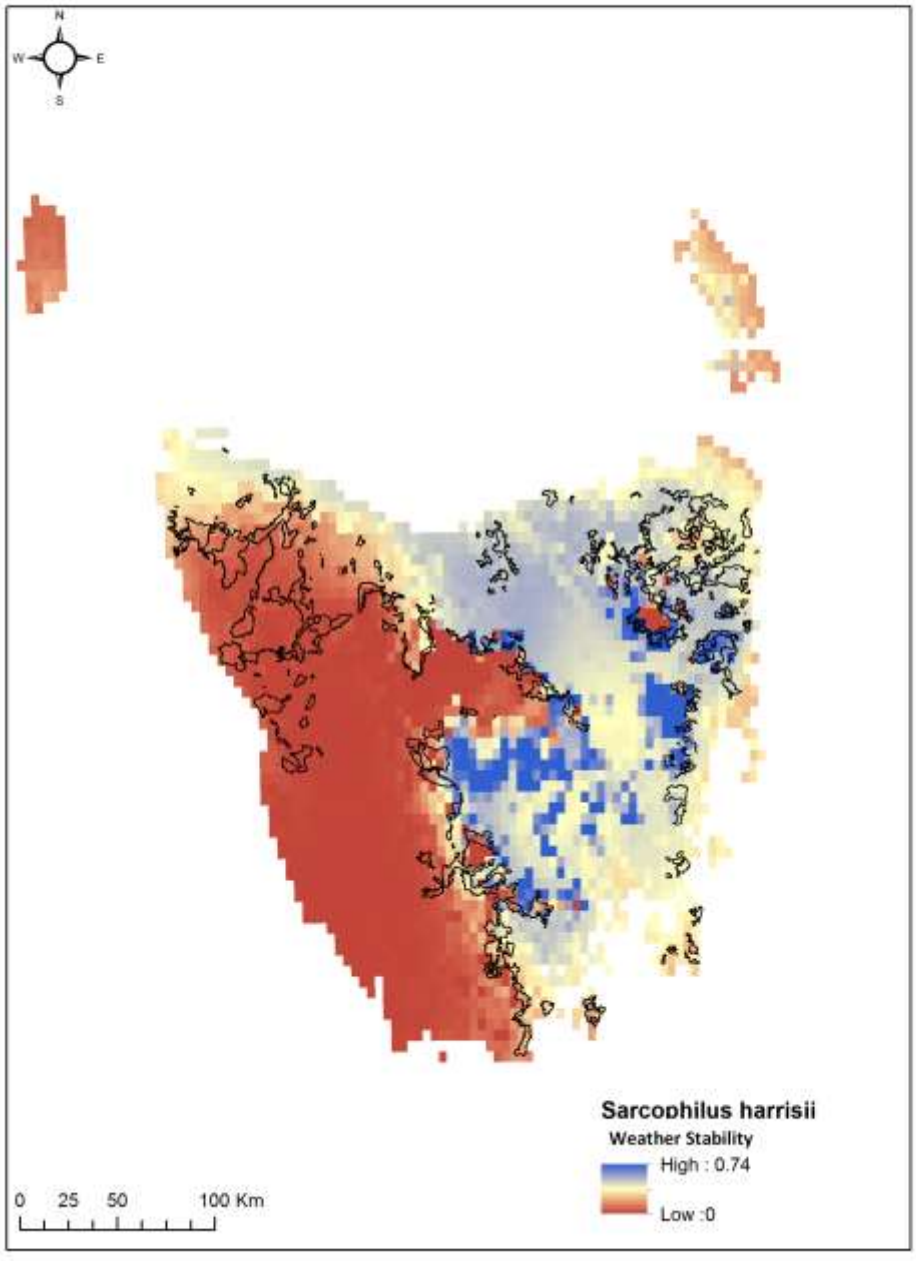


Figure 4. Spotted-tail quoll, climate suitability.

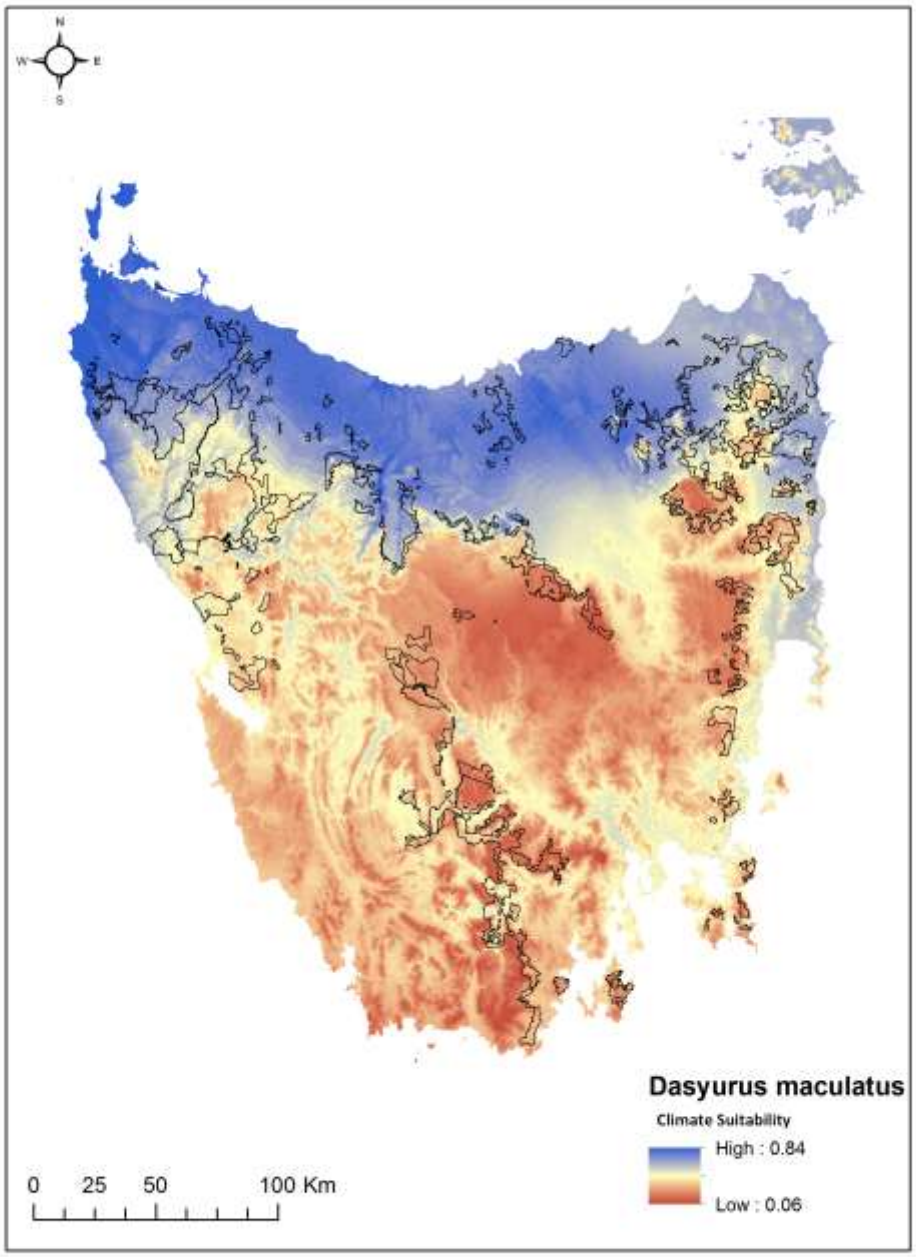


Figure 5. Spotted-tail quoll, weather stability.

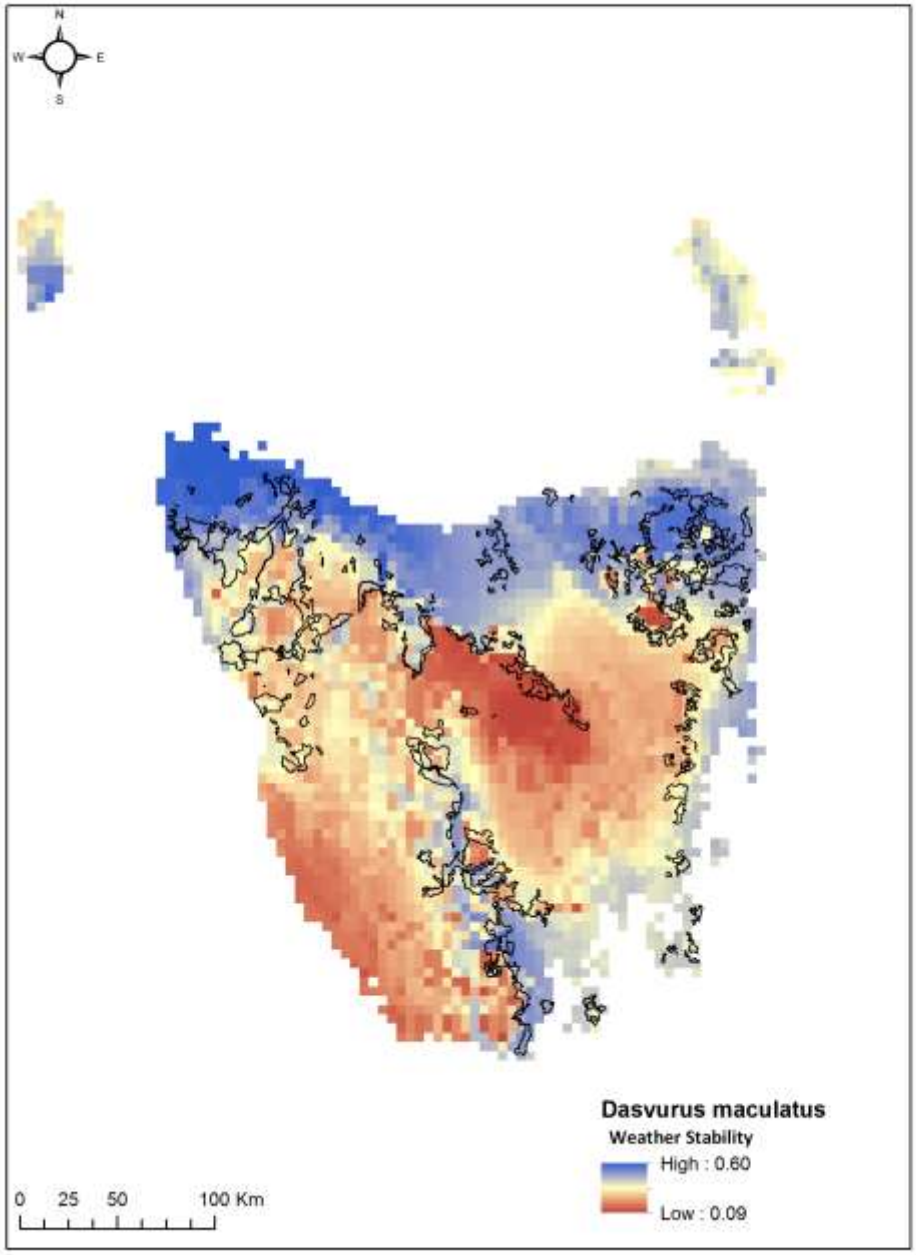


Figure 6. Eastern quoll, climate suitability.

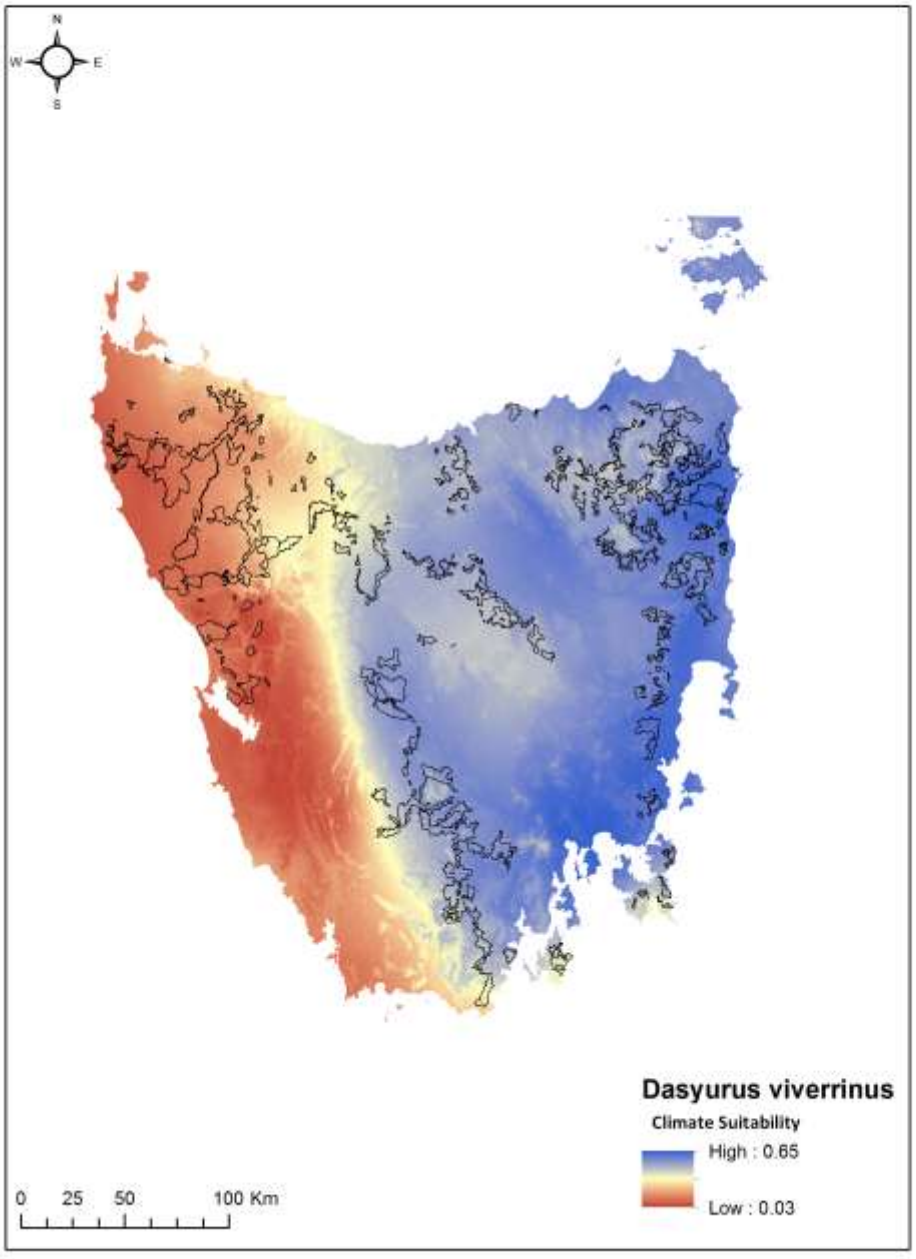


Figure 7. Eastern quoll, weather stability.

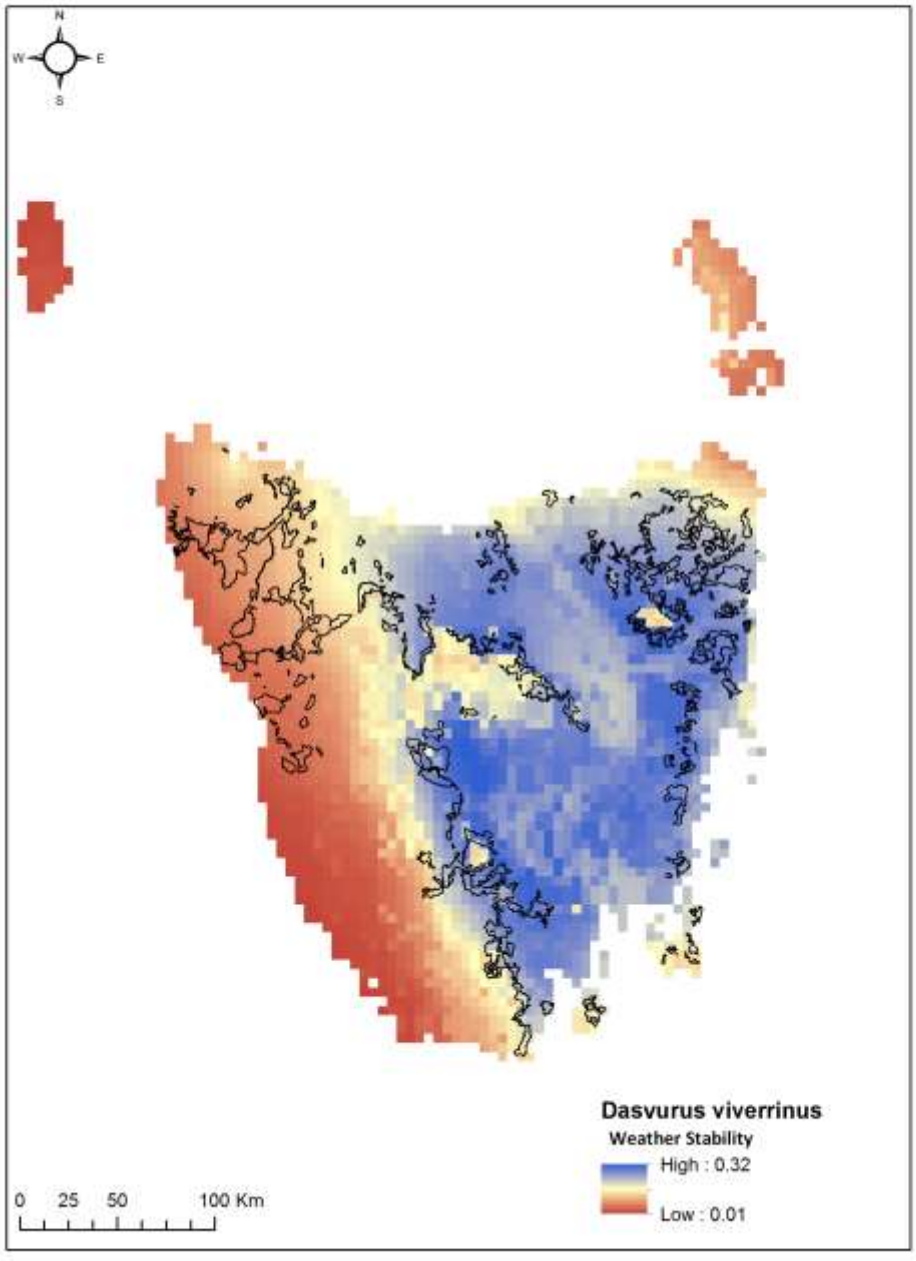


Figure 8. Key reserves for improvement of reservation status and connectivity for a composite of all three marsupial carnivore species.

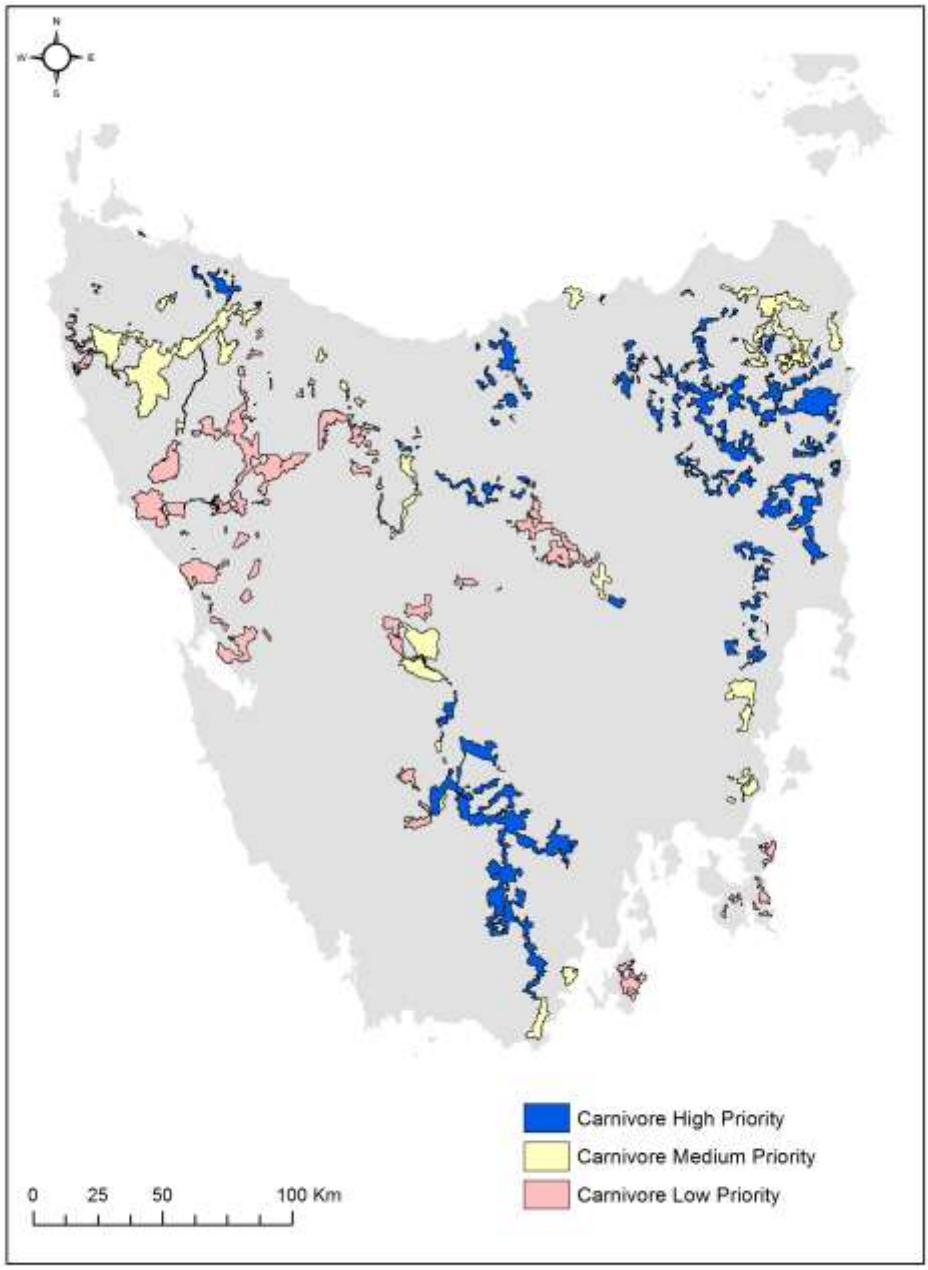


Figure 9. Key reserves for improvement of reservation status and connectivity for Tasmanian devils.

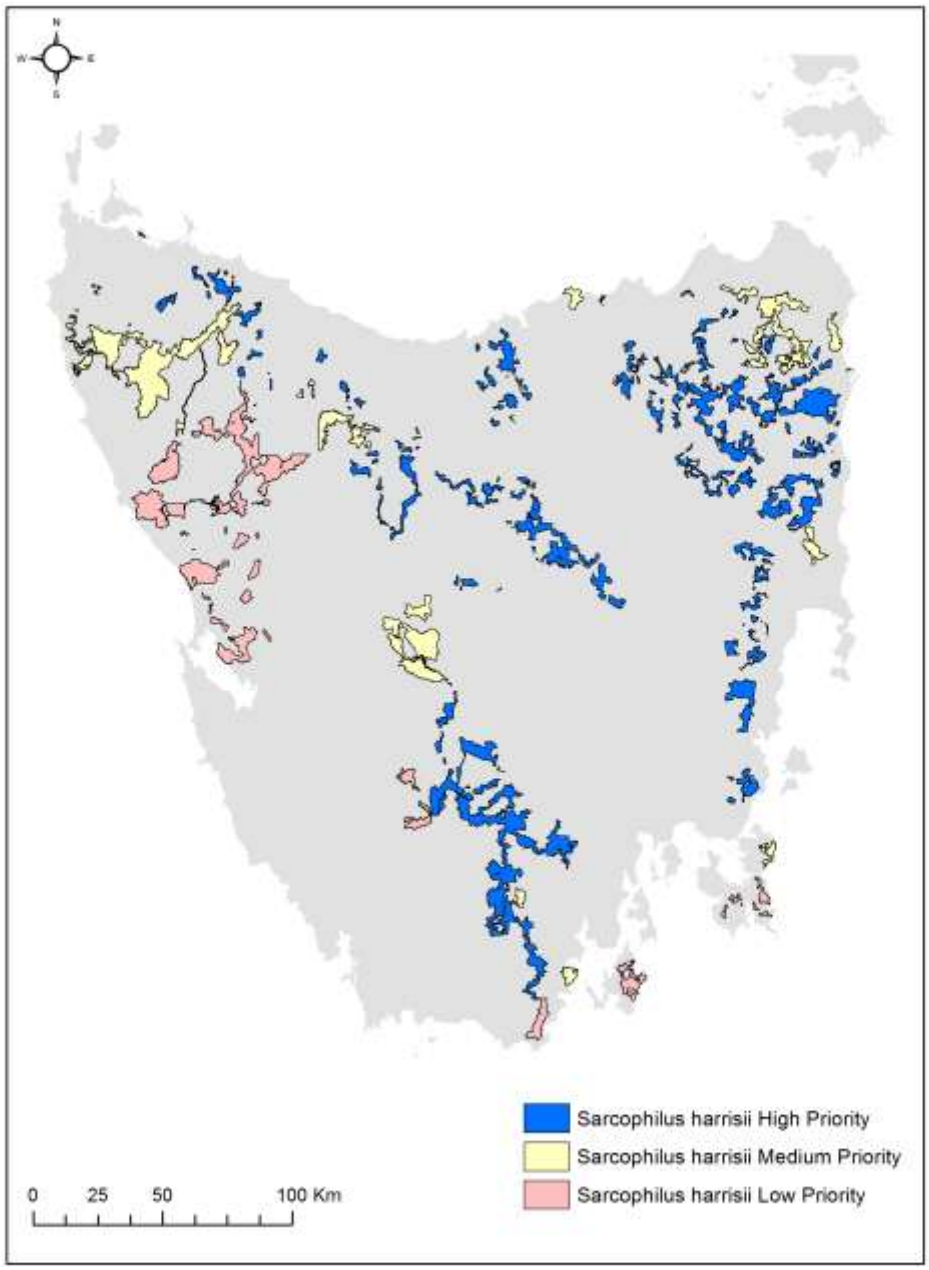


Figure 10. Key reserves for improvement of reservation status and connectivity for spotted-tailed quolls.

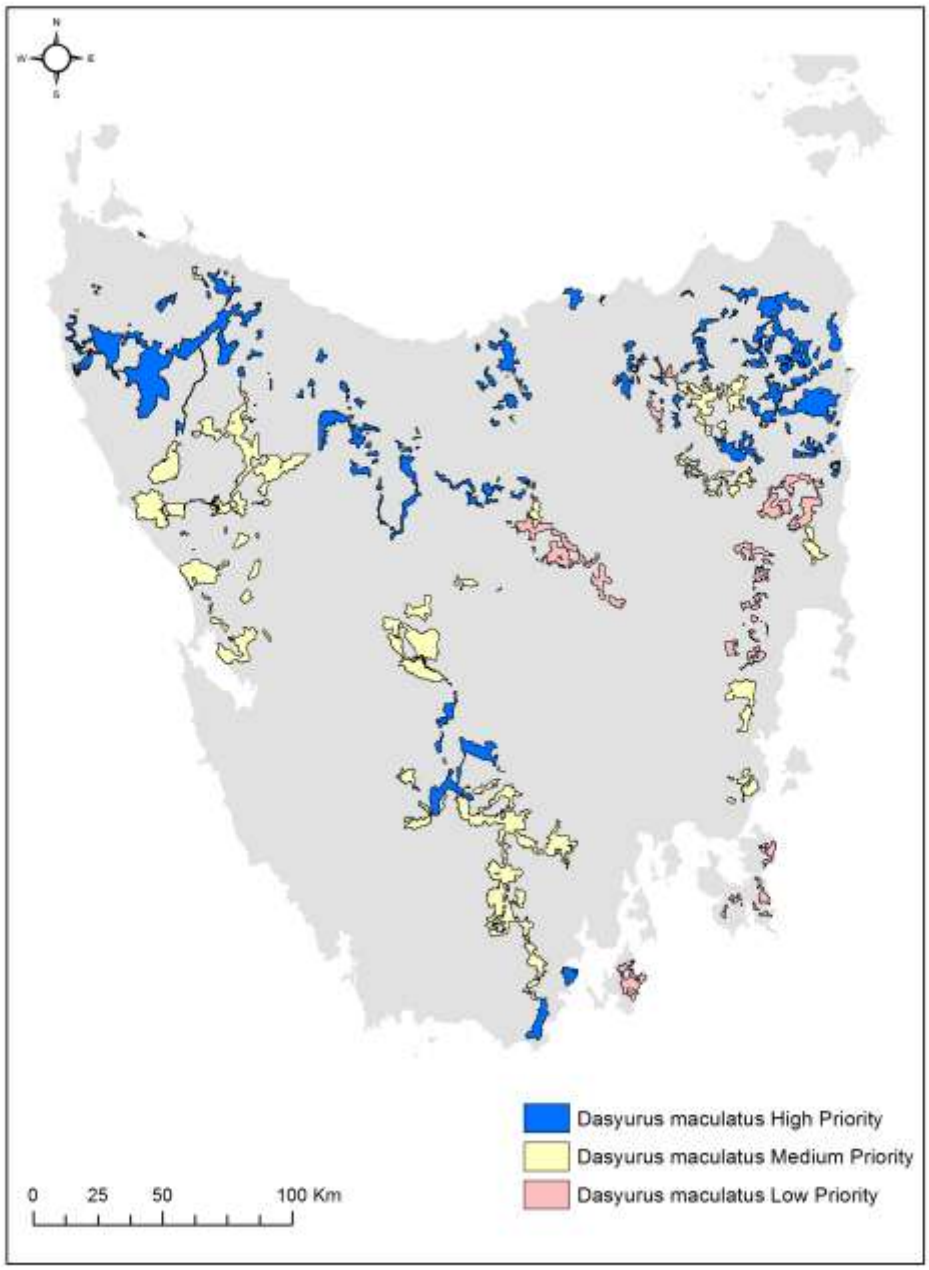
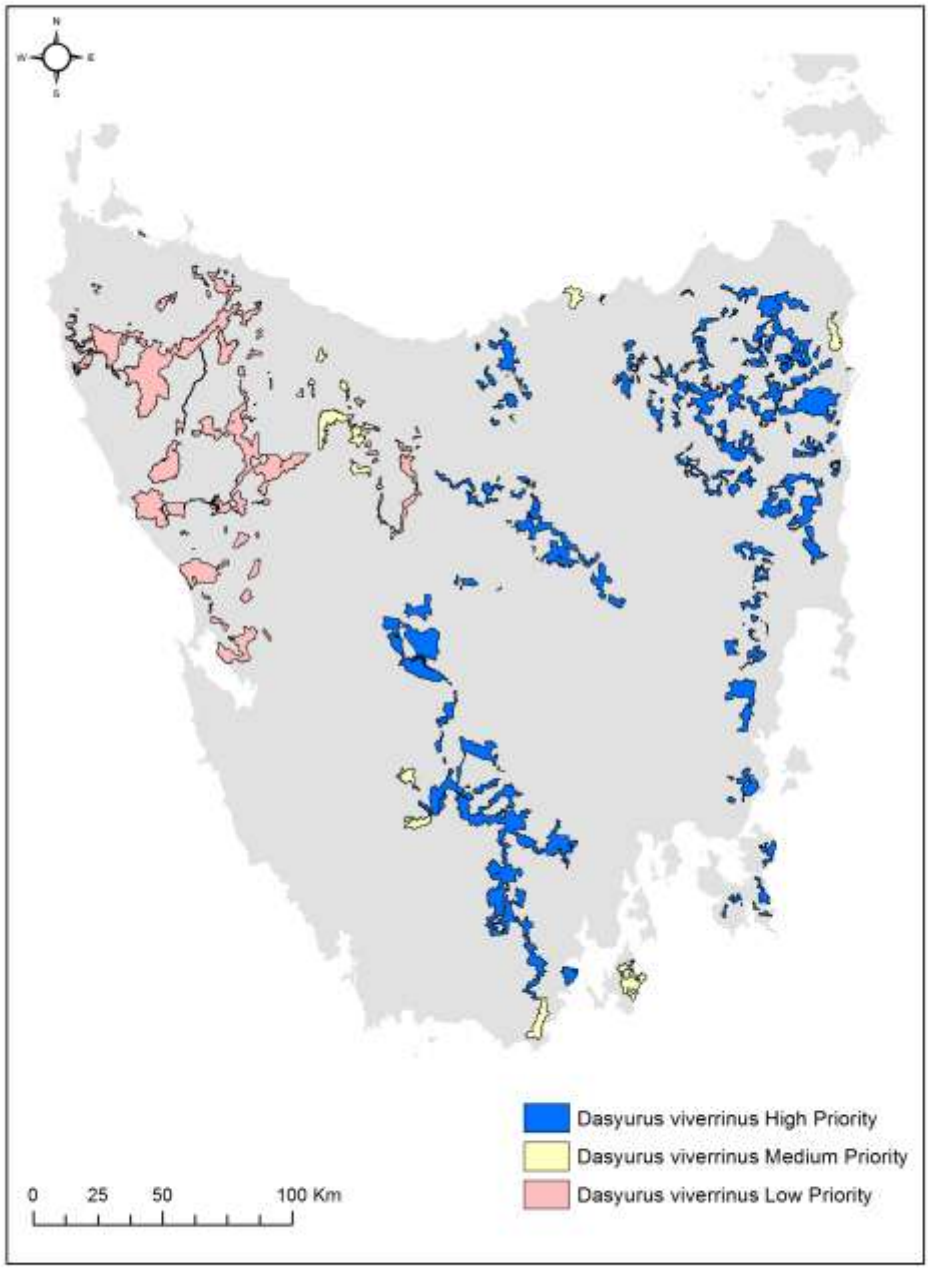


Figure 11. Key reserves for improvement of reservation status and connectivity for eastern quolls.



Appendix 1: Maximum Entropy Modeling (MaxEnt) modelling methodology

Occurrence records for each species were compiled from existing data sources: the Department of Primary Industries, parks, water & Environment (DPIPWE')s Natural Values Atlas, results from the DPIPWE statewide spotlight counts, plus other research reports and trapping studies. Data were collated by Shannon Troy (s-t quoll) Bronwyn Fancourt (e quoll) and Nick Beeton (Tas devil). Records were used if they included both a location and a date of collection.

Weather data were sourced from the Australian Water Availability Project (AWAP) (<www.bom.gov.au/jsp/awap>). Daily temperature and precipitation values were downloaded from AWAP weather datasets (0.05^{o} x 0.05^{o}) for Tasmania covering the period 1950 to 2010.

Weather data were summarised into the following 8 weather variables relating to the year preceding each record:

bc01 = Annual Mean Temperature
bc04 = Temperature Seasonality (standard deviation *100)
bc05 = Max Temperature of Warmest Month
bc06 = Min Temperature of Coldest Month
bc12 = Annual Precipitation
bc15 = Precipitation Seasonality (Coefficient of Variation)
bc16 = Precipitation of Wettest Quarter
bc17 = Precipitation of Driest Quarter

The spatial/temporal occurrence records with associated weather information were used to train species distribution models (SDM), using MaxEnt as per Reside et al (2010) and VanDerWal et al (in review).

The resulting SDM for the associated species were then projected onto 732 monthly time slices from 1950 to 2012, to produce weather suitability maps (at monthly intervals) in geographical space.

The frequency that suitable weather occurs, from 1950-2010, within each grid cell of the potential distribution was calculated.

- the summation of all monthly weather suitability maps, depicting how often a 5km grid cell experiences suitable weather from 1950-2010 (values from 0 to 1)
- this was used to calculate the proportion of time that weather was suitable as an index of consistency in occurrence of suitable weather across the landscape

Climate models were created for the species using occurrence records (spatial data only) and long term climate variables (ANUCLIM 1961-1990 climate data) as per Bateman et al (2011). ANUCLIM variables used were the same 8 as listed above.

Appendix 2. Rankings of the priority for improving reservation status and connectivity for Tasmanian devils, spotted-tailed quolls and eastern quolls and for a composite of all three species occurring in sympatry. Bioregions: TCH = Tasmanian Central Highlands, TNS = Tasmanian Northern Slopes, BL = Ben Lomond, TSE = Tasmanian South East TNM = Tasmanian Northern Midlands, TFL = Flinders, KIN = King, TSR = Tasmanian Southern Ranges, TWE = Tasmanian West.

High priority = 3; Medium priority = 2; Low priority = 1.

The rankings are based on both the weather stability and the climate maps, interpreted using expert opinion (Menna Jones).

Note that Bruny Island is ranked low for devils and spotted-tailed quolls because these species are not present on the island. Eastern quolls are present on Bruny Island and are the only marsupial carnivore currently on an offshore island.

ENGO Reserve No.	IBRA	Tasmanian devil (climate and weather)	Spotted-tailed quoll (climate and weather)	Eastern quoll (climate and weather)	Composite (weather stability)
1	TSR	1	3	2	2
2	TSR	1	3	2	2
3	TSR	2	3	3	2
4	TSR	1	1	2	1
5	TSR	1	1	2	1
6	TSR	2	1	2	3
7	TSE	1	1	3	1
8	TSE	1	1	3	1
9	TSE	1	1	3	1
10	TSE	1	1	3	1
11	TSR	2	2	3	3
12	TSE	1	1	3	1
13	TSR	2	2	3	3
14	TSE	1	1	3	1
15	TSR	3	1	3	2
16	TSR	3	2	3	2
17	TSE	2	1	3	1
18	TWE	1	2	2	2
19	TSR, TWE	1	2	2	1
20	TSR, TWE	1	2	3	1
21	TSE	3	2	3	2
22	TSE	3	2	3	2

ENGO Reserve No.	IBRA	Tasmanian devil (climate and weather)	Spotted-tailed quoll (climate and weather)	Eastern quoll (climate and weather)	Composite (weather stability)
23	TSR	3	2	3	2
24	TSR	3	2	3	2
25	TSR	3	2	3	3
26	TSR	3	2	3	3
27	TSE	3	2	3	2
28	TSR	3	2	3	2
29	TSE	3	2	3	2
30	TWE	1	2	2	1
31	TSR	3	2	3	1
32	TSR	3	2	3	2
33	TSR	3	3	3	3
34	TSR	3	3	3	2
35	TSR	3	3	3	3
36	TSR	3	3	3	3
37	TSR	3	3	3	3
38	TSR	3	3	3	3
39	TSE	3	2	3	2
40	TSE	3	1	3	3
41	TSE	3	1	3	3
42	TSE	3	1	3	3
43	TSR	2	2	3	3
44	TSR	2	2	3	2
45	TSE	3	1	3	3
46	TSE	3	1	3	3
47	TSE	3	1	3	3
48	TSE	3	1	3	3
49	TSE	3	1	3	3
50	TWE	1	2	1	1
51	TSE	3	1	3	3
52	TWE	1	2	1	1
53	TSE	3	1	3	3
54	TSR	2	2	3	2
55	TSE	3	1	3	3
56	TSE	3	1	3	3
57	TSE	3	1	3	3
58	TSR, TCH	2	2	3	1
59	TWE	1	2	1	1

ENGO Reserve No.	IBRA	Tasmanian devil (climate and weather)	Spotted-tailed quoll (climate and weather)	Eastern quoll (climate and weather)	Composite (weather stability)
60	TSE	3	1	3	3
61	TWE	1	2	1	1
62	TWE	3	2	3	1
63	TSE	3	1	3	3
64	TWE	1	2	1	1
65	TCH, TNM	3	1	3	3
66	TSR, TCH	2	2	3	1
67	TWE	1	2	3	1
68	TSE	3	1	3	3
69	TWE	1	2	1	1
70	TSE	3	1	3	3
71	TCH	3	2	3	1
72	TSE	3	1	3	3
73	TCH	3	2	3	1
74	TCH	3	2	3	1
75	TCH	3	2	3	1
76	TSE	3	1	3	3
77	TSE	3	1	3	3
78	TCH, TNM	3	1	3	2
79	TWE	1	2	1	1
80	TCH, TWE	1	2	1	1
81	TWE	1	2	1	1
82	TSE	3	1	3	3
83	TCH	3	1	2	1
84	TCH, TNM	3	1	3	2
85	TWE	1	2	1	1
86	TCH	3	1	2	1
87	TSE	3	1	3	3
88	TCH	1	2	1	1
89	TCH	1	2	1	1
90	TWE	1	2	1	1
91	TNS	3	3	1	1
92	TWE	1	2	1	1
93	TSE	2	2	3	3
94	TCH, TNS	2	1	3	1
95	TCH	2	1	2	1
96	TWE	1	2	1	1

ENGO Reserve No.	IBRA	Tasmanian devil (climate and weather)	Spotted-tailed quoll (climate and weather)	Eastern quoll (climate and weather)	Composite (weather stability)
97	TCH, TNS, TNM	3	1	3	1
98	TWE	1	2	3	1
99	TWE	1	2	1	1
100	TWE	1	2	3	1
101	TWE	1	2	3	1
102	TWE	1	2	1	1
103	BL	3	1	3	3
104	TWE	1	2	1	1
105	TWE	1	2	1	1
106	TCH, TNS	3	2	3	1
107	TCH	3	3	1	1
108	TNS	3	3	3	3
109	TNS	3	3	3	3
110	TNM, TCH	3	3	3	3
111	TWE	1	2	1	1
112	TNS, TCH	3	3	1	2
113	BL,TNM	3	1	3	3
114	TNS	3	3	3	3
115	TNS, TCH	3	3	3	3
116	TNS	3	3	3	3
117	BL	3	2	3	3
118	BL	3	2	3	3
119	BL	3	2	3	3
120	TNS	3	3	3	3
121	TNS	3	3	3	3
122	TCH, TNS	3	3	1	1
123	BL, TSE, TNM	3	1	3	3
124	BL	3	2	3	3
125	TCH, TNS	3	3	3	3
126	BL	3	2	3	3
127	BL,TNM	3	2	3	3
128	BL	3	3	3	3
129	BL	3	3	3	3
130	TCH, TNS	3	3	2	1
131	TCH	3	3	3	2
132	TNS	3	3	1	2
133	TCH	3	3	3	2

ENGO Reserve No.	IBRA	Tasmanian devil (climate and weather)	Spotted-tailed quoll (climate and weather)	Eastern quoll (climate and weather)	Composite (weather stability)
134	TCH	3	3	3	2
135	TCH	3	3	3	2
136	TCH, TNS	3	3	1	2
137	BL	3	2	3	3
138	BL	3	3	3	3
139	TCH	3	3	3	2
140	TNS	3	3	1	1
141	TCH, TNS	3	3	1	3
142	TNS	3	3	1	3
143	TWE	1	2	1	1
144	TNS	2	3	3	2
145	BL	3	2	3	3
146	TNS	2	3	1	1
147	BL	3	3	3	3
148	TCH	3	3	1	3
149	TWE	1	2	1	1
150	BL	3	3	3	3
151	TCH, TNS	1	3	3	2
152	TNS	3	3	3	2
153	TFL	3	3	3	3
154	TFL,BL	3	3	3	3
155	TNS	3	3	3	2
156	BL	3	3	3	3
157	TNS	3	3	3	3
158	TCH	3	3	1	3
159	TNS	2	3	1	2
160	TNS	2	3	1	2
161	TNS	3	3	3	3
162	BL	3	3	3	3
163	BL	3	3	3	3
164	TFL	3	3	3	3
165	TNS	3	3	3	3
166	BL	3	2	3	3
167	TCH	1	2	3	1
168	TCH	1	2	3	1
169	TNS	3	3	3	3
170	TNS	3	3	3	3

ENGO Reserve No.	IBRA	Tasmanian devil (climate and weather)	Spotted-tailed quoll (climate and weather)	Eastern quoll (climate and weather)	Composite (weather stability)
171	TCH	1	2	1	1
172	TNS	3	3	3	3
173	BL	3	3	3	3
174	TFL	3	3	3	3
175	TFL	3	3	3	3
176	TNS, TCH	2	3	2	1
177	TNS	3	3	3	2
178	TNS	3	3	2	2
179	TCH	3	2	1	1
180	TNS	3	3	3	3
181	BL	3	1	3	3
182	BL	3	3	3	3
183	TNS	3	3	1	2
184	BL	3	3	3	3
185	BL	3	3	3	3
186	TNS	3	3	3	3
187	BL	3	3	3	3
188	TNS	3	3	3	3
189	BL	3	3	3	3
190	TNS	3	3	3	3
191	TNS	2	3	2	1
192	TNS	2	3	2	1
193	TFL,BL	3	3	3	3
194	TNS	3	3	3	3
195	TNS	3	3	3	3
196	TNS	3	3	2	2
197	BL	3	3	3	3
198	TCH, TWE, TNS	1	2	1	1
199	TNS	2	3	2	1
200	TNS	3	3	2	1
201	TNS	3	3	3	3
202	BL	3	3	3	3
203	TNS	3	3	3	3
204	BL	3	3	3	3
205	BL	3	3	3	3
206	TNS	3	3	3	3
207	BL, TFL	3	3	3	3

ENGO Reserve No.	IBRA	Tasmanian devil (climate and weather)	Spotted-tailed quoll (climate and weather)	Eastern quoll (climate and weather)	Composite (weather stability)
208	BL	3	2	3	3
209	BL	3	3	3	3
210	TNS	3	3	2	1
211	BL	3	3	3	3
212	BL	3	3	3	3
213	BL	3	3	3	3
214	TFL	3	3	3	3
215	TFL	3	3	3	3
216	BL	3	3	3	3
217	BL, TFL	3	3	3	3
218	TNS	3	3	3	3
219	TNS	3	3	1	1
220	BL	3	3	3	3
221	BL	3	3	3	3
222	BL	3	3	3	3
223	BL	3	3	3	3
224	BL	3	1	3	3
225	BL	3	3	3	3
226	BL	3	3	3	3
227	TNS	3	3	1	1
228	BL	3	3	3	3
229	TNS	3	3	2	2
230	BL	3	3	3	3
231	BL	3	3	3	3
232	TFL	3	3	3	3
233	BL	3	3	3	3
234	TNS	3	3	3	3
235	BL	3	3	3	3
236	BL	3	3	3	3
237	BL	3	3	3	3
238	TNS	3	3	1	1
239	TNS	3	3	3	3
240	BL, TFL	3	3	3	3
241	KIN	2	3	1	2
242	BL	3	3	3	3
243	BL, TFL	3	3	3	3
244	KIN, TWE	2	3	1	1

ENGO Reserve No.	IBRA	Tasmanian devil (climate and weather)	Spotted-tailed quoll (climate and weather)	Eastern quoll (climate and weather)	Composite (weather stability)
245	TFL,BL	2	3	2	2
246	KIN	2	3	1	2
247	BL	3	3	3	3
248	KIN	3	3	3	3
249	TNS	3	3	1	2
250	BL	3	3	3	3
251	TFL	3	3	3	2
252	KIN, TNS, TWE	2	3	1	2
253	TFL	3	3	3	3
254	TNS	3	3	1	3
255	TFL	3	3	3	3
256	TFL	3	3	3	3
257	KIN	3	3	1	2
258	BL, TFL	2	3	3	2
259	KIN, TNS	3	3	1	3
260	TFL	2	3	3	2
261	KIN	3	3	1	3
262	TFL	2	3	2	2
263	KIN	3	3	1	3
264	BL	2	3	3	2
265	KIN	3	3	3	3
266	KIN	1	3	3	1
267	KIN	3	2	1	3
268	KIN, TNS	3	3	1	3
269	KIN	3	2	1	3
270	KIN	3	3	1	3

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