

Supporting Information for “Spatial conservation prioritisation in data-poor countries: a quantitative sensitivity analysis using multiple taxa” – BMC Ecology

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Table S1: List of species used or excluded in this study. **RL** represents per-species national Red List status; while **W** represent the assigned weight

(A) Study species

	Species	RL	W
	Butterflies		
1	<i>Agrodiaetus loewii</i>	VU	3
2	<i>Apharitis acamas</i>	VU	3
3	<i>Azamus ubaldus</i>	LC	1
4	<i>Belenois aurota</i>	NA	1
5	<i>Borbo borbonica</i>	NA	1
6	<i>Catopsilia florella</i>	NA	1
7	<i>Chilades trochylus</i>	LC	1
8	<i>Colias croceus</i>	NA	1
9	<i>Colotis fausta</i>	VU	3
10	<i>Danaus chrysippus</i>	LC	1
11	<i>Deudorix livia</i>	LC	1
12	<i>Euchloe aegyptiaca</i>	EN	4
13	<i>Euchloe belemia</i>	DD	1
14	<i>Gegenes nostradamus</i>	LC	1
15	<i>Hypolimnas misippus</i>	NA	1
16	<i>Iolana alferii</i>	LC	1
17	<i>Junonia hierta</i>	LC	1
18	<i>Lampides boeticus</i>	LC	1
19	<i>Leptotes pirithous</i>	LC	1
20	<i>Lycaena phlaeas</i>	NA	1
21	<i>Melitaea deserticola</i>	VU	3
22	<i>Papilio saharae</i>	VU	3
23	<i>Pelopidas thrax</i>	LC	1
24	<i>Pieris rapae</i>	LC	1
25	<i>Plebejus philbyi</i>	VU	3
26	<i>Pontia daplidice</i>	LC	1
27	<i>Pontia glauconome</i>	LC	1
28	<i>Spialia doris</i>	LC	1
29	<i>Tarucus rosaceus</i>	LC	1
30	<i>Vanessa atalanta</i>	NA	1

	Species	RL	W
31	<i>Vanessa cardui</i>	NA	1
32	<i>Zizeeria karsandra</i>	LC	1
	Reptiles		
33	<i>Acanthodactylus aegyptius</i>	LC	1
34	<i>Acanthodactylus boskianus</i>	LC	1
35	<i>Acanthodactylus longipes</i>	VU	3
36	<i>Acanthodactylus pardalis</i>	VU	3
37	<i>Acanthodactylus scutellatus</i>	LC	1
38	<i>Agama spinosa</i>	LC	1
39	<i>Cerastes cerastes</i>	LC	1
40	<i>Cerastes vipera</i>	LC	1
41	<i>Chalcides cf. humilis</i>	LC	1
42	<i>Chalcides ocellatus</i>	LC	1
43	<i>Chamaeleo africanus</i>	EN	4
44	<i>Chamaeleo chamaeleon</i>	LC	1
45	<i>Cyrtopodion scabrum</i>	LC	1
46	<i>Echis coloratus</i>	LC	1
47	<i>Echis pyramidum</i>	LC	1
48	<i>Eirenis coronella</i>	VU	3
49	<i>Eryx colubrinus</i>	VU	3
50	<i>Eryx jaculus</i>	LC	1
51	<i>Eumeces schneiderii</i>	LC	1
52	<i>Hemidactylus flaviviridis</i>	VU	3
53	<i>Hemidactylus robustus</i>	VU	3
54	<i>Hemidactylus turcicus</i>	LC	1
55	<i>Laudakia stellio</i>	LC	1
56	<i>Leptotyphlops cairi</i>	EN	4
57	<i>Lytorhynchus diadema</i>	LC	1
58	<i>Macroprotodon cucullatus</i>	VU	3
59	<i>Malpolon moilensis</i>	LC	1

	<i>Species</i>	RL	W
60	<i>Malpolon monspessulanus</i>	LC	1
61	<i>Mesalina bahaeldini</i>	VU	3
62	<i>Mesalina guttulata</i>	LC	1
63	<i>Mesalina olivieri</i>	LC	1
64	<i>Mesalina pasteuri</i>	VU	3
65	<i>Mesalina rubropunctata</i>	LC	1
66	<i>Naja haje</i>	LC	1
67	<i>Naja nubiae</i>	VU	3
68	<i>Natrix tessellata</i>	VU	3
69	<i>Ophisops occidentalis</i>	VU	3
70	<i>Platyceps florulentus</i>	LC	1
71	<i>Platyceps rogersi</i>	LC	1
72	<i>Platyceps saharicus</i>	LC	1
73	<i>Pristurus flavipunctatus</i>	VU	3
74	<i>Psammophis aegyptius</i>	LC	1
75	<i>Psammophis schokari</i>	LC	1
76	<i>Psammophis sibilans</i>	LC	1
77	<i>Pseudotrapelus sinaitus</i>	LC	1
78	<i>Ptyodactylus guttatus</i>	LC	1
79	<i>Ptyodactylus hasselquistii</i>	LC	1
80	<i>Ptyodactylus siphonorhina</i>	LC	1
81	<i>Ramphotyphlops braminus</i>	NA	1
82	<i>Scincus scincus</i>	LC	1
83	<i>Spalerosophis diadema</i>	LC	1
84	<i>Sphenops sepsoides</i>	LC	1
85	<i>Stenodactylus mauritanicus</i>	VU	3
86	<i>Stenodactylus petrii</i>	LC	1
87	<i>Stenodactylus sthenodactylus</i>	LC	1
88	<i>Tarentola annularis</i>	LC	1
89	<i>Tarentola mauritanica</i>	LC	1
90	<i>Tarentola mindiae</i>	VU	3
91	<i>Telescopus dhara</i>	LC	1
92	<i>Testudo kleinmanni</i>	VU	3
93	<i>Trachylepis quinquetaeniata</i>	LC	1
94	<i>Trachylepis vittata</i>	VU	3
95	<i>Trapelus mutabilis</i>	LC	1
96	<i>Trapelus pallidus</i>	LC	1
97	<i>Trapelus savignii</i>	VU	3
98	<i>Tropiocolotes bisharicus</i>	VU	3
99	<i>Tropiocolotes nattereri</i>	LC	1
100	<i>Tropiocolotes steudneri</i>	LC	1
101	<i>Tropiocolotes tripolitanus</i>	LC	1
102	<i>Uromastix aegyptia</i>	LC	1
103	<i>Uromastix ocellata</i>	EN	4
104	<i>Uromastix ornata</i>	VU	3
105	<i>Varanus griseus</i>	LC	1
106	<i>Varanus niloticus</i>	VU	3
107	<i>Walterinnesia aegyptia</i>	VU	3
Mammals			
108	<i>Hemiechinus auritus</i>	LC	1
109	<i>Paraechinus aethiopicus</i>	LC	1
110	<i>Crocidura olivieri</i>	VU	3
111	<i>Roussettus aegyptiacus</i>	LC	1
112	<i>Taphozous nudiventris</i>	VU	3
113	<i>Taphozous perforatus</i>	LC	1
114	<i>Asellia tridens</i>	LC	1
115	<i>Rhinolophus clivosus</i>	LC	1
116	<i>Rhinolophus mehelyi</i>	EN	4
117	<i>Rhinopoma cystops</i>	LC	1
118	<i>Rhinopoma microphyllum</i>	VU	3

	<i>Species</i>	RL	W
119	<i>Tadarida aegyptiaca</i>	VU	3
120	<i>Tadarida teniotis</i>	VU	3
121	<i>Nycteris thebaica</i>	LC	1
122	<i>Eptesicus bottae</i>	VU	3
123	<i>Hypsugo ariel</i>	VU	3
124	<i>Otonycteris hemprichii</i>	LC	1
125	<i>Pipistrellus kuhlii</i>	LC	1
126	<i>Pipistrellus rueppellii</i>	VU	3
127	<i>Plecotus christii</i>	LC	1
128	<i>Lepus capensis</i>	LC	1
129	<i>Allactaga tetradactyla</i>	EN	4
130	<i>Jaculus jaculus</i>	LC	1
131	<i>Jaculus orientalis</i>	VU	3
132	<i>Eliomys melanurus</i>	EN	4
133	<i>Acomys cahirinus</i>	LC	1
134	<i>Acomys dimidiatus</i>	LC	1
135	<i>Acomys russatus</i>	LC	1
136	<i>Arvicanthis niloticus</i>	LC	1
137	<i>Dipodillus campestris</i>	VU	3
138	<i>Dipodillus dasyurus</i>	LC	1
139	<i>Dipodillus mackilligini</i>	VU	3
140	<i>Dipodillus simoni</i>	VU	3
141	<i>Gerbillus amoenus</i>	LC	1
142	<i>Gerbillus andersoni</i>	VU	3
143	<i>Gerbillus floweri</i>	VU	3
144	<i>Gerbillus gerbillus</i>	LC	1
145	<i>Gerbillus henleyi</i>	LC	1
146	<i>Gerbillus perpallidus</i>	LC	1
147	<i>Gerbillus pyramidum</i>	LC	1
148	<i>Meriones crassus</i>	LC	1
149	<i>Meriones libycus</i>	LC	1
150	<i>Meriones shawi</i>	EN	4
151	<i>Mus musculus</i>	NA	1
152	<i>Nesokia indica</i>	EN	4
153	<i>Pachyuromys duprasi</i>	VU	3
154	<i>Psammomys obesus</i>	LC	1
155	<i>Rattus norvegicus</i>	NA	1
156	<i>Rattus rattus</i>	NA	1
157	<i>Sekeetamys calurus</i>	LC	1
158	<i>Spalax aegyptiacus</i>	EN	4
159	<i>Canis aureus</i>	DD	1
160	<i>Vulpes rueppellii</i>	LC	1
161	<i>Vulpes vulpes</i>	LC	1
162	<i>Vulpes zerda</i>	EN	4
163	<i>Acinonyx jubatus</i>	CR	5
164	<i>Caracal caracal</i>	DD	1
165	<i>Felis chaus</i>	LC	1
166	<i>Felis margarita</i>	VU	3
167	<i>Felis silvestris</i>	LC	1
168	<i>Panthera pardus</i>	CR	5
169	<i>Herpestes ichneumon</i>	LC	1
170	<i>Hyaena hyaena</i>	LC	1
171	<i>Ictonyx libyca</i>	EN	4
172	<i>Mustela subpalmata</i>	VU	3
173	<i>Procapra capensis</i>	LC	1
174	<i>Equus asinus</i>	CR	5
175	<i>Ammotragus lervia</i>	CR	5
176	<i>Capra nubiana</i>	EN	4
177	<i>Gazella dorcas</i>	VU	3
178	<i>Gazella leptoceros</i>	EN	4

(B) Excluded species

Butterflies

Azanus jesous
Chilades eleusis
Colotis phisadia
Elphinstonia charlonia
Lycaena thersamon
Carcharodus alceae
Carcharodus stauderi
Colotis danae
Pseudotergumia pisidice
Anthene amarah
Apharitis myrmecophila
Calopieris eulimene
Charaxes hansali
Chazara persephone
Colotis chrysonome
Colotis liagore
Euchloe falloui
Gomalia elma
Melitaea trivia
Pieris brassicae
Polyommatus icarus
Pseudophilotes abencerragus
Pseudophilotes sinaicus
Sarangesa phidyle
Satyrium jebelia
Tomares ballus
Zegris eupheme
Zizina otis

Reptiles

Ablepharus rueppellii
Atractaspis engaddensis
Dasypeltis scabra
Dolichophis jugularis
Hemidactylus foudaii
Hemidactylus mindiae
Hemidactylus sinaitus
Hemorrohis algirus
Hemorrohis nummifer
Latastia longicaudata
Leptotyphlops macrorhynchus
Leptotyphlops nursii
Lycophidion capense
Mesalina brevirostris
Mesalina martini
Ophisops elbaensis
Ophisops elegans
Philochortus zolii
Platyiceps sinai

Psammophis punctulatus
Pseuderemias mucronata
Pseudocerastes persicus
Ptyodactylus ragazzi
Rhynchocalamus melanocephalus
Telescopus hoogstraali
Tropicolotes nubicus
Typhlops vermicularis

Mammals

Crocidura floweri
Crocidura suaveolens
Pipistrellus deserti
Crocidura religiosa
Rhinolophus hipposideros
Atelerix algirus
Suncus murinus
Barbastella leucomelas
Nycticeinops schlieffeni
Hystrix cristata
Hystrix indica
Gerbillus nanus
Meriones sacramenti
Meriones tristrami
Vulpes cana
Proteles cristata
Ictonyx striatus
Meles meles
Vormela peregusna
Genetta genetta
Gazella gazella

Table S2: Kendall’s correlation between priority rankings of different surrogate groups (bias-free predictions) using core-area zonation (light grey) and additive-benefit function (dark grey); using Maxent (A) and elastic net (B).

(A) Maxent

	Butterflies	Reptiles	Mammals	All species
Butterflies		0.28	0.21	0.30
Reptiles	0.47		0.40	0.49
Mammals	0.43	0.44		0.39
All species	0.41	0.49	0.44	

(B) elastic net

	Butterflies	Reptiles	Mammals	All species
Butterflies		0.31	0.20	0.31
Reptiles	0.54		0.40	0.54
Mammals	0.38	0.48		0.43
All species	0.47	0.56	0.43	

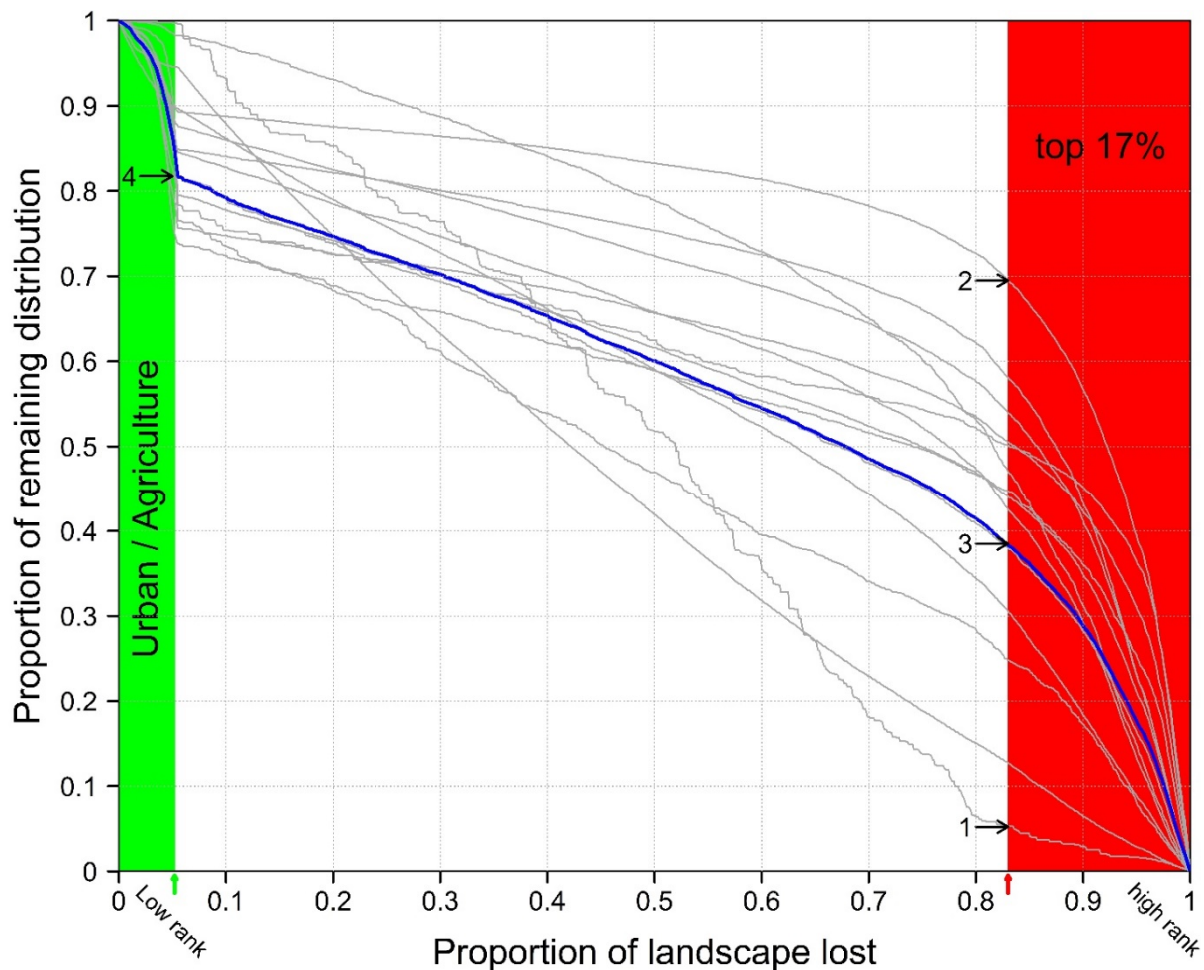


Figure S1: An example performance curve produced during the Zonation analysis. This curve quantifies the proportion of features' original distribution remaining (here, 14 species; y-axis) at each top fraction of the cells (x-axis). The x-axis denotes the priority ranking of the solution, with the highest rank site has a value of one, while the lowest rank site has a value of zero. The per-species performance curve is shown as grey curves, with their overall average in blue. It is possible in some Zonation analyses to handle hundreds of species, and hence the per-species performance curve can be hard to interpret. The overall mean (or per taxonomic group) performance curve is more appropriate in many situations.

It is possible for any percentage of the top (or low) priority fraction of the landscape to get representation level of each species. In this figure, the red area represents the top 17% priority cells. The minimum (1), maximum (2), and the overall mean (3) species representation are shown in the figure. Similarly, the green area represents the urban and agricultural areas in Egypt (Fig. S2.2) which were forced in our analyses to have the lowest priority ranking. The mean species representation in this area is also shown (4). For an example performance curve using the full species list, see Fig. 5.

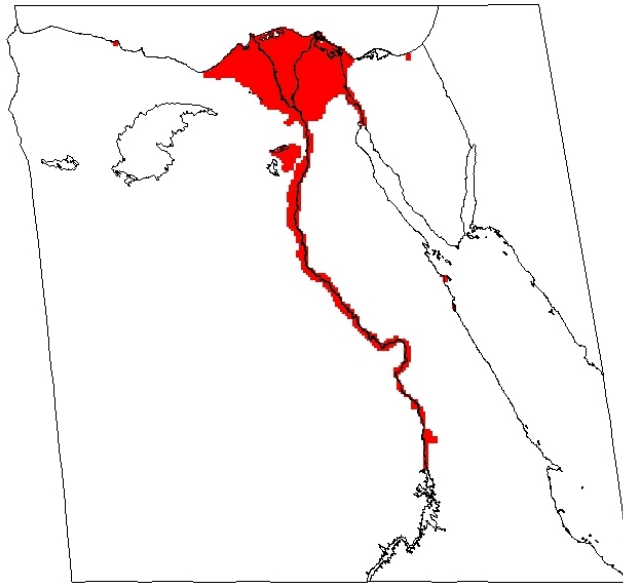


Figure S2: Urban and agricultural areas masked during Zonation prioritisation. These areas have high human population density, more polluted, and are of exceptionally high economic value (replacement cost), and hence it is challenging to apply strict conservation actions or construct new PAs in these areas.

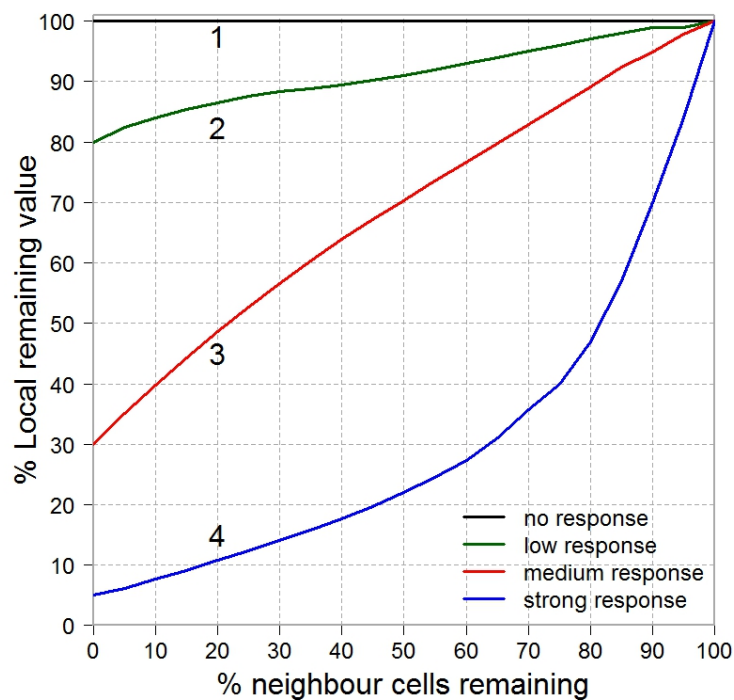


Figure S3: Response curves used in the boundary-quality penalty connectivity analyses. These curves describe a range of species sensitivity to habitat loss in neighbour cells, ranging from no response (1) to strong response (4). The x-axis shows the percentage of neighbour cells (specified by three values of radii) remaining: 100 represents no habitat loss; while 0 represents total habitat loss of all neighbour cells. The y-axis shows the percentage reduction in local cell value in response to habitat loss.

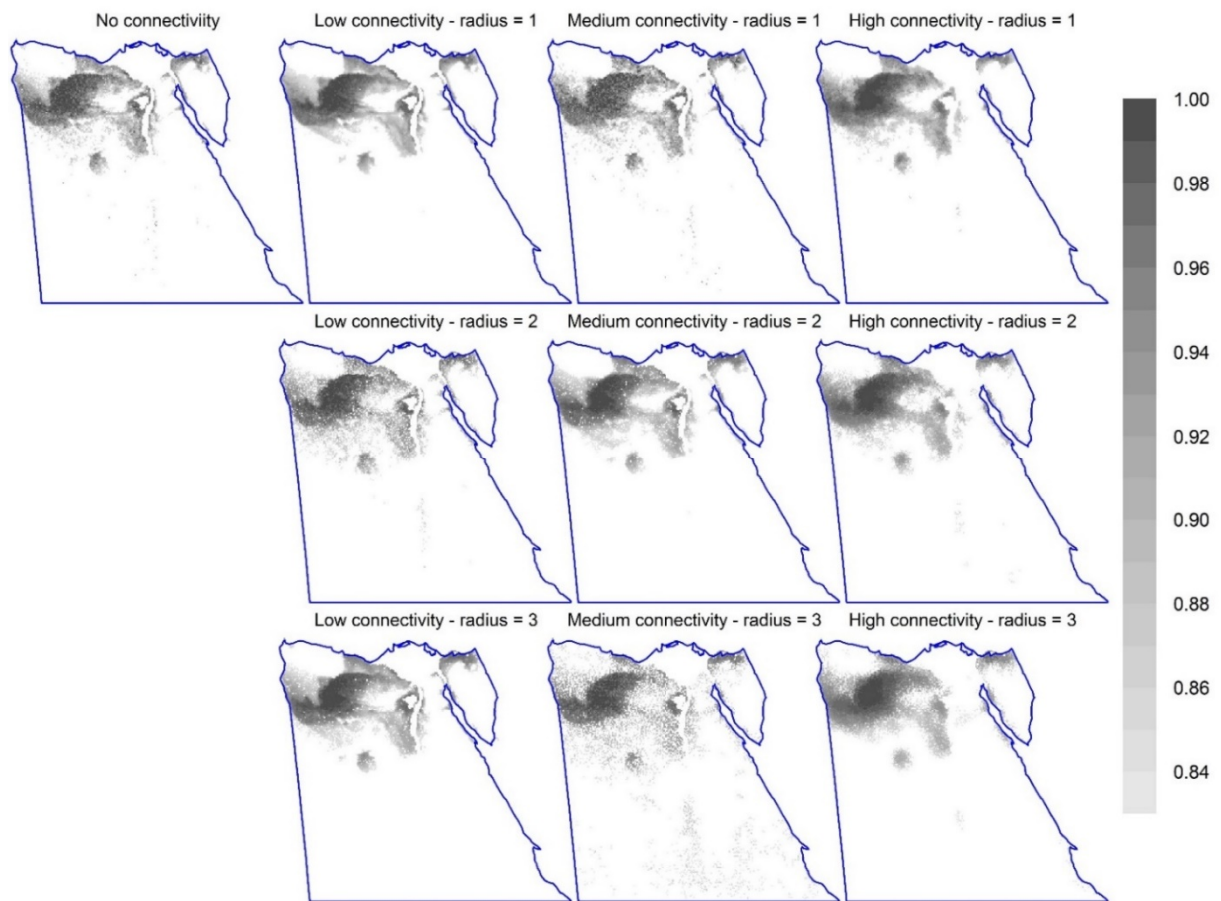


Figure S4: The spatial distribution of the top 17% priority cells at different options of connectivity (additive-benefit function; using bias-free predictions of all the study species for Maxent). The top-left map shows the pattern of important sites without connectivity integration. The second to the fourth column is for equivalent maps with steeper response curves (low, medium, and high connectivity; curves 2-4 in Fig. S2.3, respectively); while rows are for different number of effective neighbour cells used (1 to 3). Equivalent maps using core-area zonation are shown in Fig. 2.

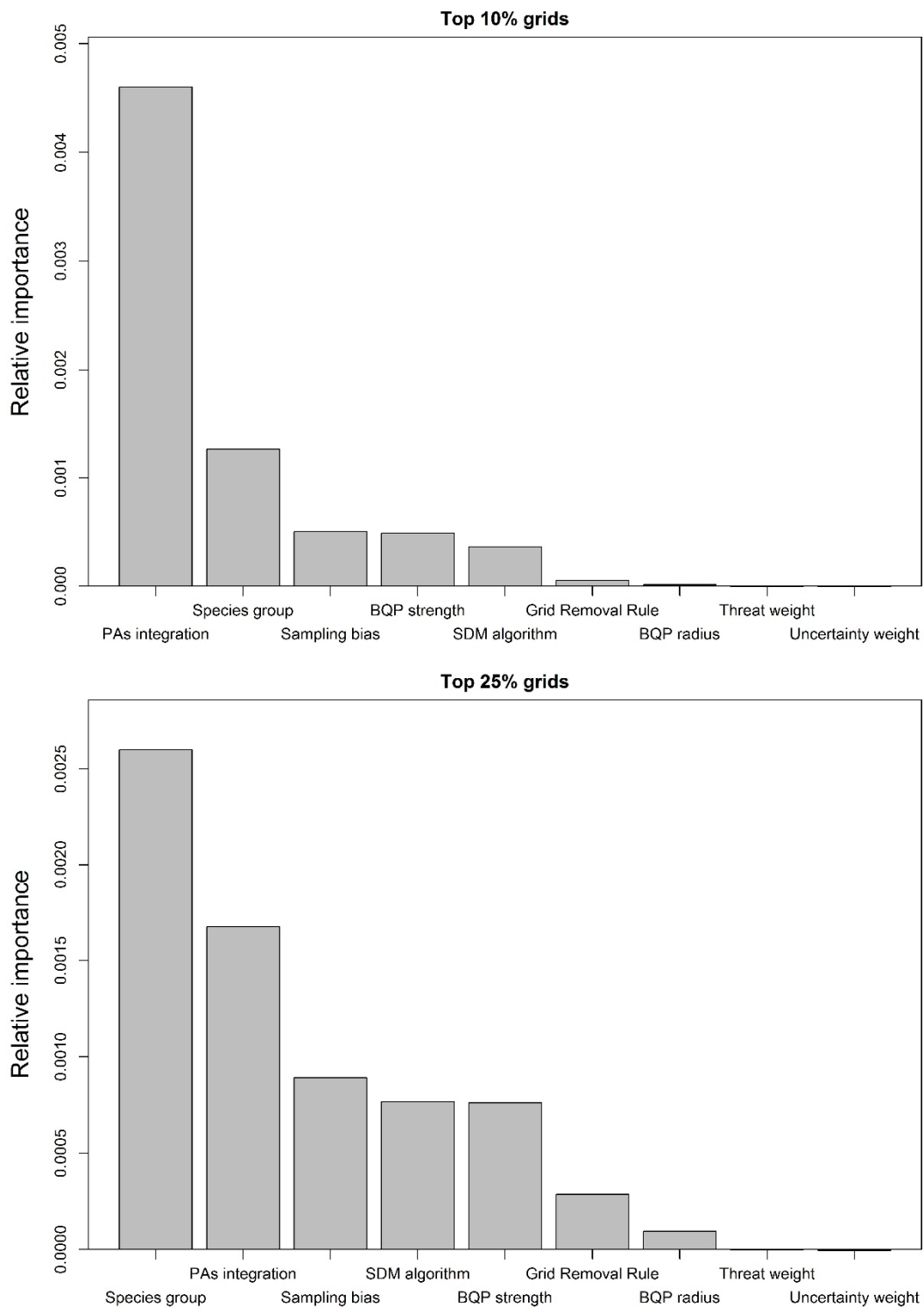


Figure S5: Permutation importance of factors affecting the Zonation output's uncertainty, calculated from a randomForest model (varimp function using party package). Here, the dependent variable is the mean species representation at the top 10% (above) and 25% (below) priority cells.

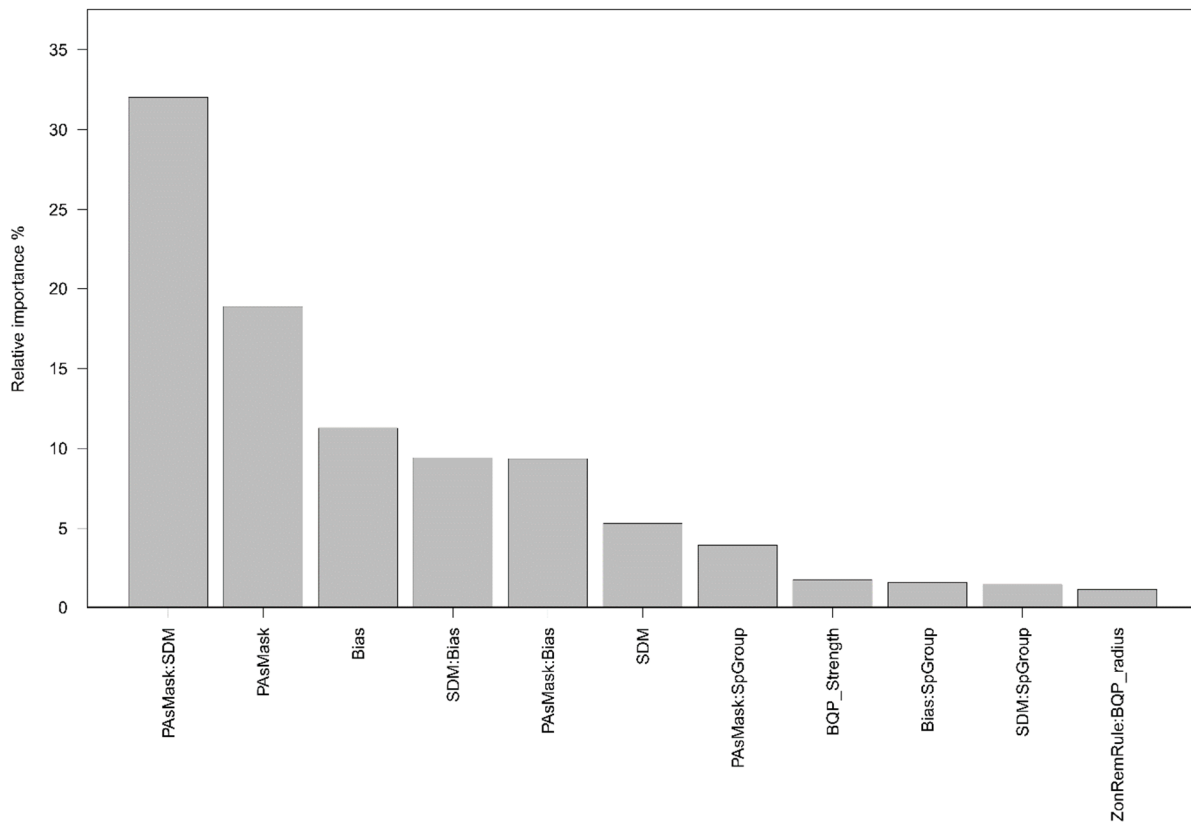


Figure S6: The relative importance of various factors affecting the uncertainty of Zonation's prioritisation (and their first order interactions) using the mean sum of squares from a generalised linear model. Only variables having more than 1% importance are shown.

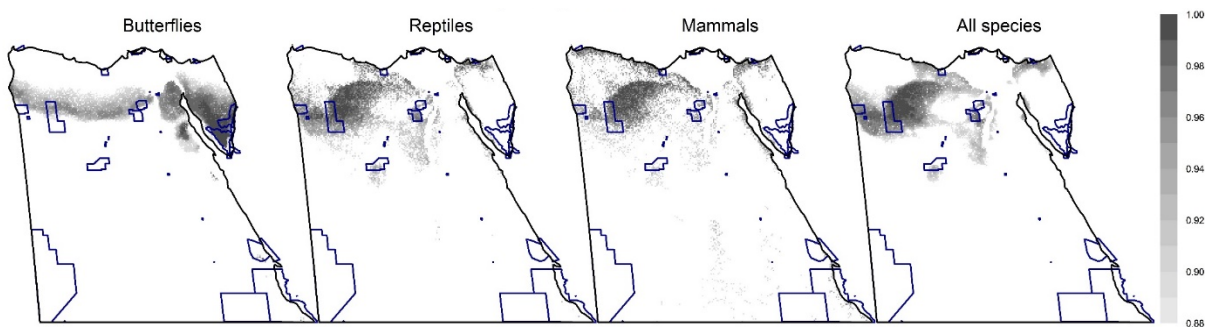


Figure S7: The spatial distribution of the top priority cells of equal area to current PAs (the darker, the higher the priority) for different surrogates using additive-benefit function, overlaid with current protected areas in Egypt (blue borders). These maps were prepared using bias-free predictions from Maxent. Equivalent maps using core-area zonation are shown in Fig. 3.

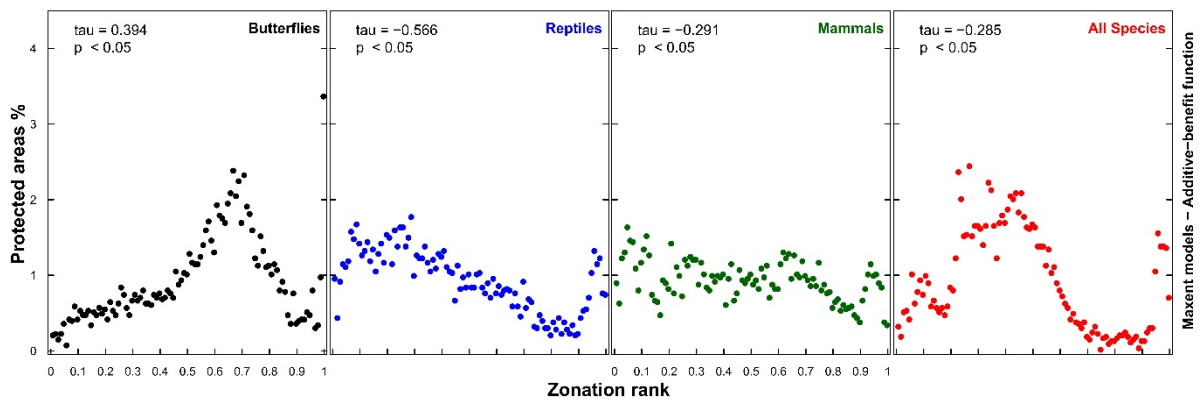


Figure S8: The fraction of cells protected at each 1% intervals of Zonation rank for different surrogates using additive-benefit function (using bias-free predictions from Maxent). The number at each panel represents Kendall's correlation coefficient. Equivalent results for core-area zonation are shown in Fig. 4; while results using elastic net are shown in Fig. S2.9.

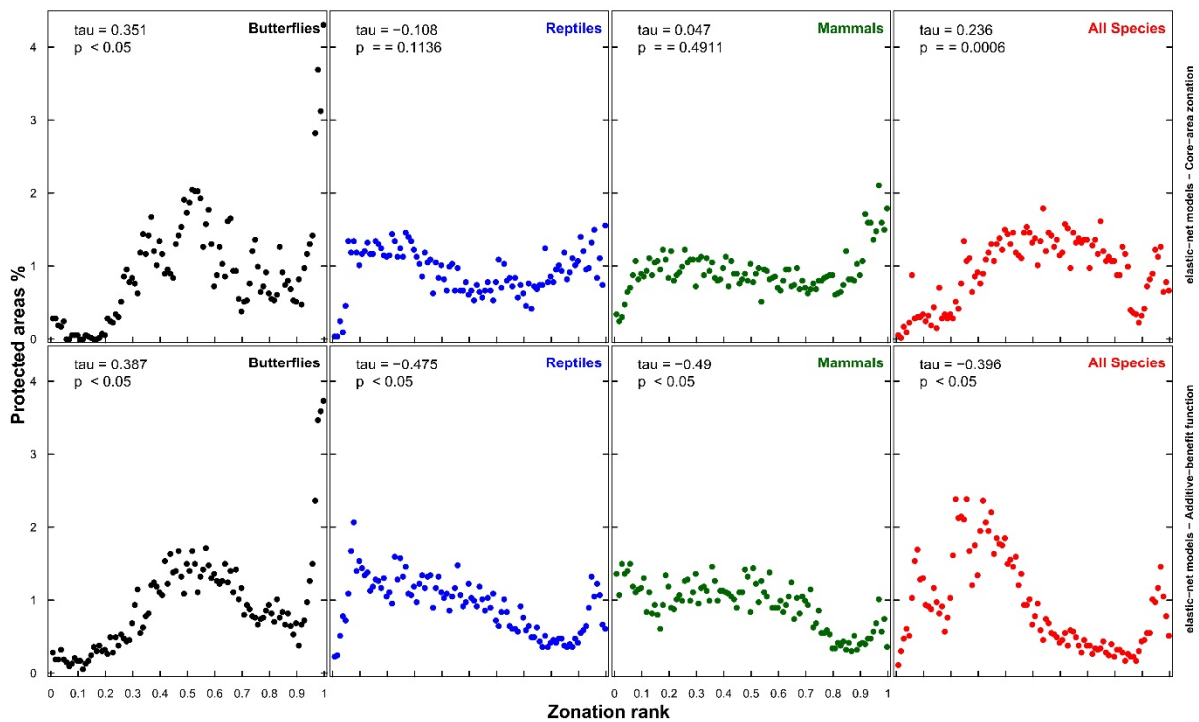


Figure S9: The fraction of cells protected at each 1% intervals of Zonation rank for different surrogates using core-area zonation (top row) or additive-benefit function (bottom row), using bias-free predictions for elastic net. The numbers at each panel represent Kendall's correlation coefficient.

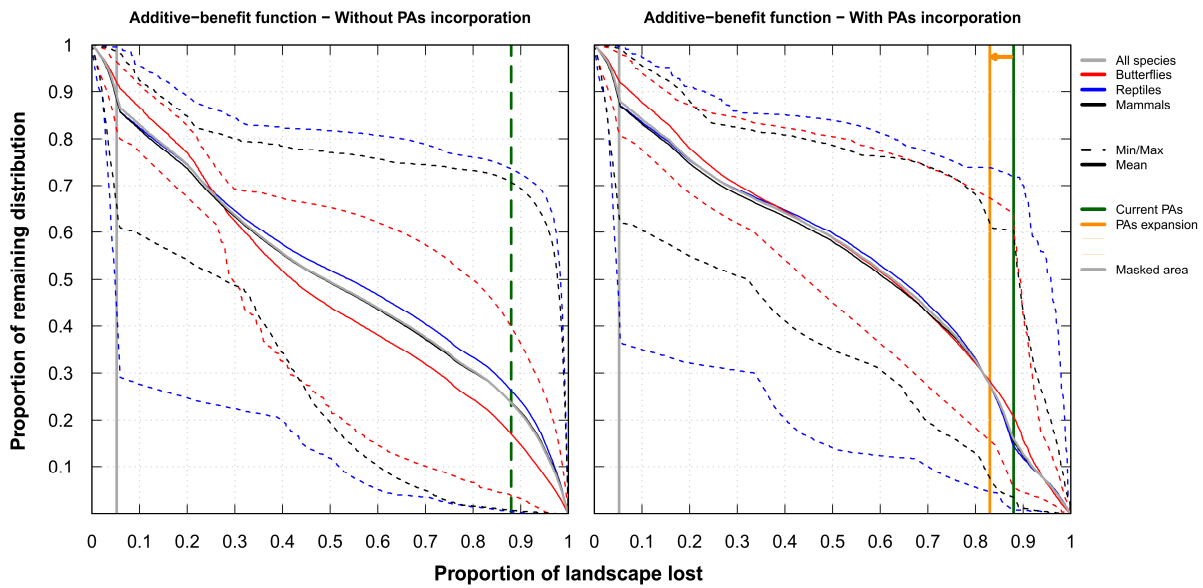
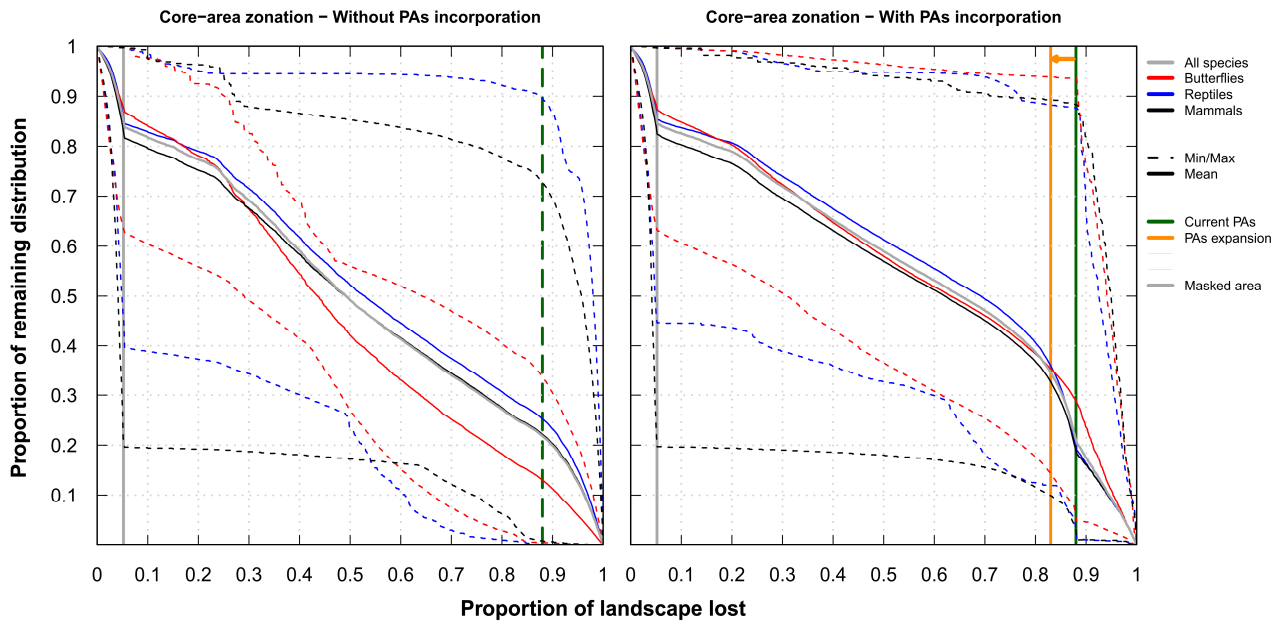
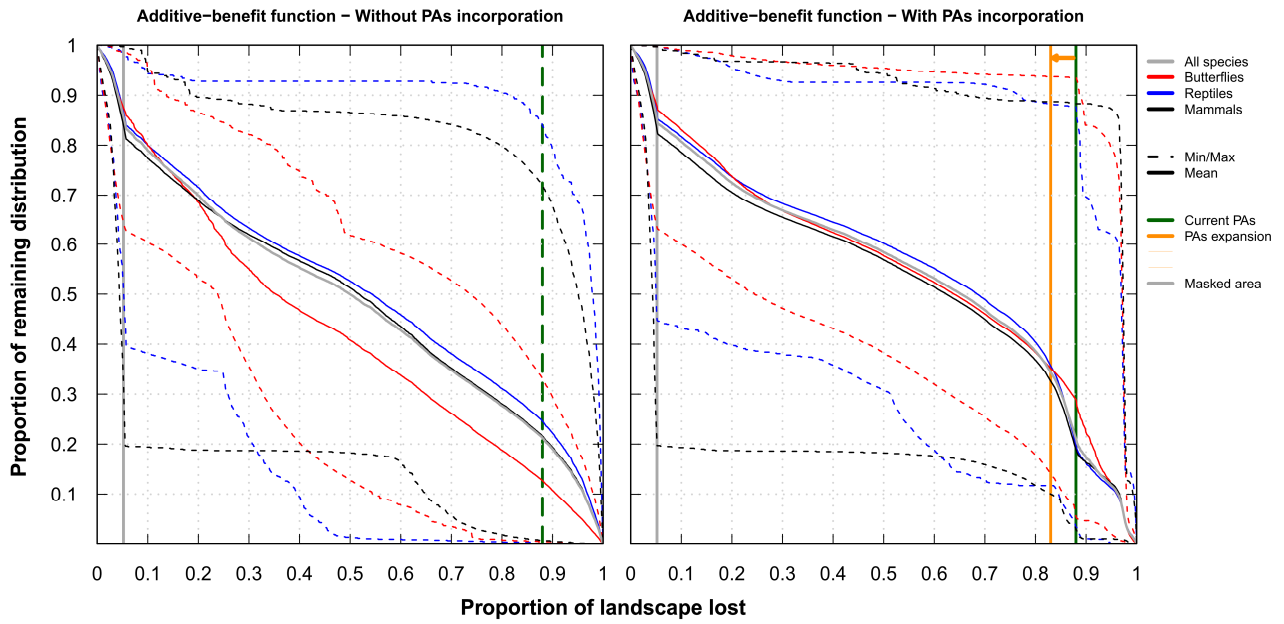


Figure S10: Performance curves for Zonation analyses (Maxent – additive-benefit function – all species together). Left panel represents analysis without Egyptian PAs integration. Solid curves represent the average performance curve for all species or per species-group; while dashed lines represent the overall minimum and maximum performance curves per species group. The vertical grey line is for urban and agricultural areas (Fig. S2.2) forced to have low priority value; while the dashed vertical green line represents top priority sites existent in an area equals to the area covered by PAs. The right panel represents equivalent analysis with Egyptian PAs forced to have highest priority scores. The vertical green line represents the area covered by PAs; while the vertical orange line represents the proposed areas for PAs expansion to 17% of Egypt. For equivalent curves using core-area zonation, see Fig. 5. Results for elastic net are shown in Fig. S2.11.



(A)



(B)

Figure S11: Performance curves for elastic-net models using core-area zonation (A) and additive benefit function (B). For more details, see Fig. 5 and main text.

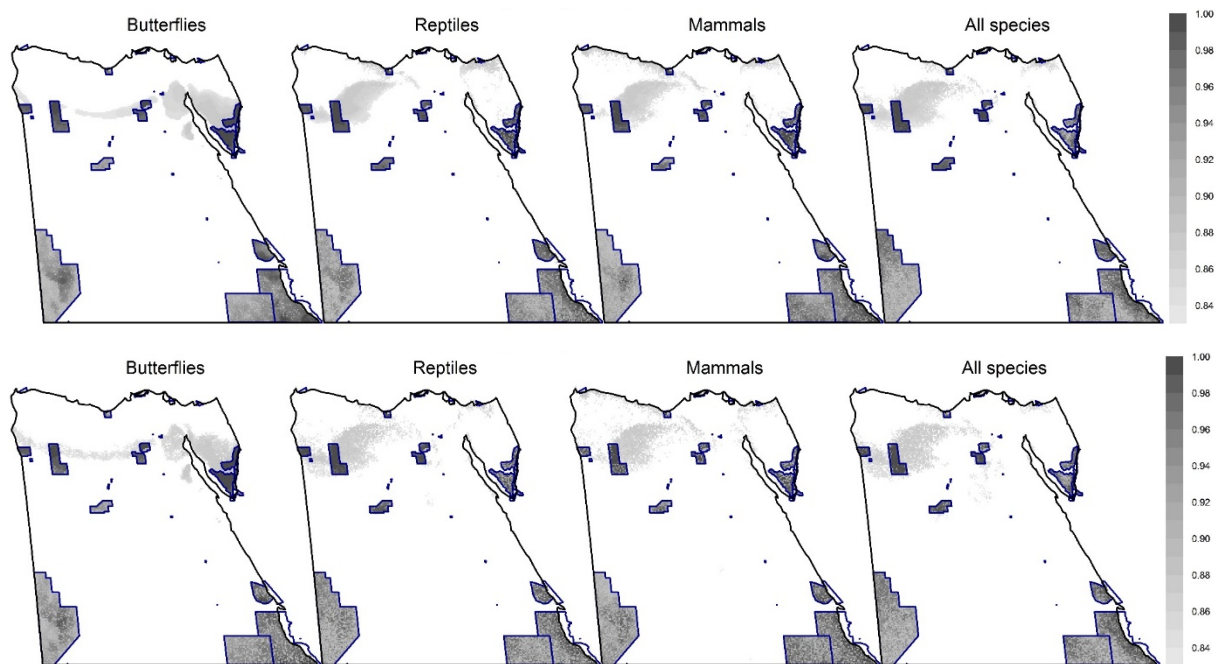


Figure S12: Potential areas for Egyptian PAs expansion (to 17% of Egypt) using core-area zonation (above) and additive-benefit function (below) for each surrogate. All maps use bias-free predictions from Maxent. Egyptian PAs (shown in blue) were always forced to have the highest ranking. Grey areas outside PAs represent potential areas for Egyptian PAs expansion. The ranking of these maps are added together to summarise the overall pattern of important sites outside PAs (see Fig. 6, and similarly Fig. S2.13 for elastic net).

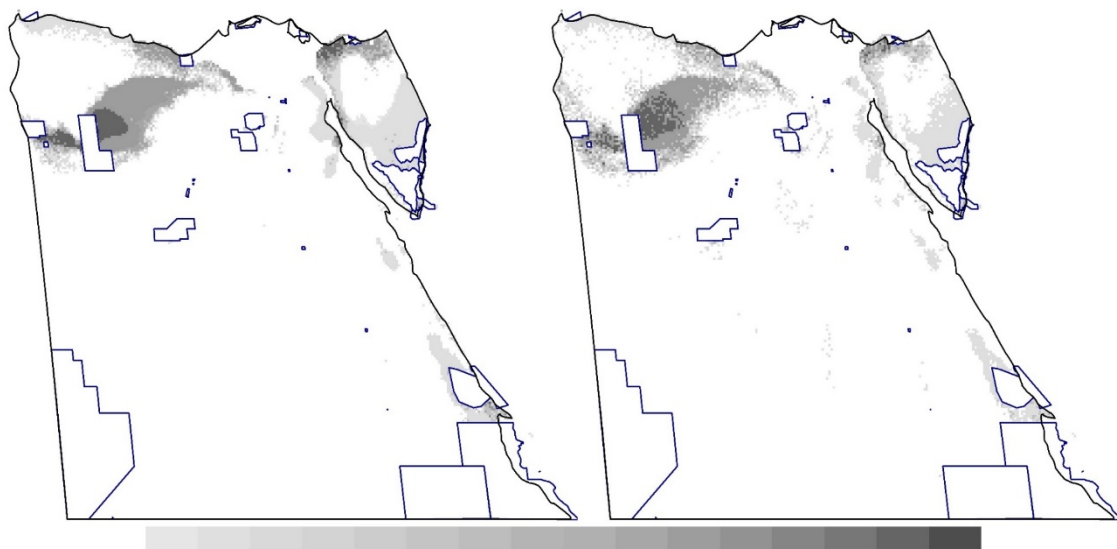


Figure S13: The overall pattern of top priority sites using core-area zonation (left) or additive-benefit function (right), both using bias-free predictions from elastic net. Each map shows the summed rankings of the top 17% sites from the four surrogates used. Top priority sites within current protected areas (blue borders) are not shown to highlight the overall pattern of potential areas for PAs expansion (the darker the colour, the higher the cumulative rank of the site using the four surrogates). For equivalent maps using Maxent, see Fig. 6.

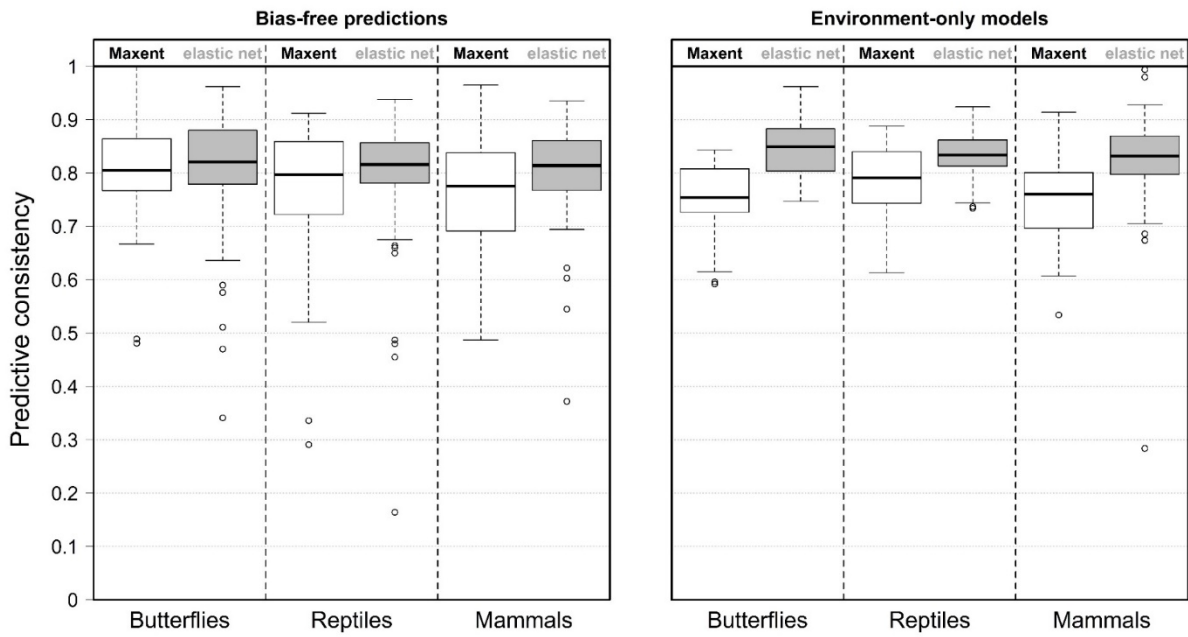
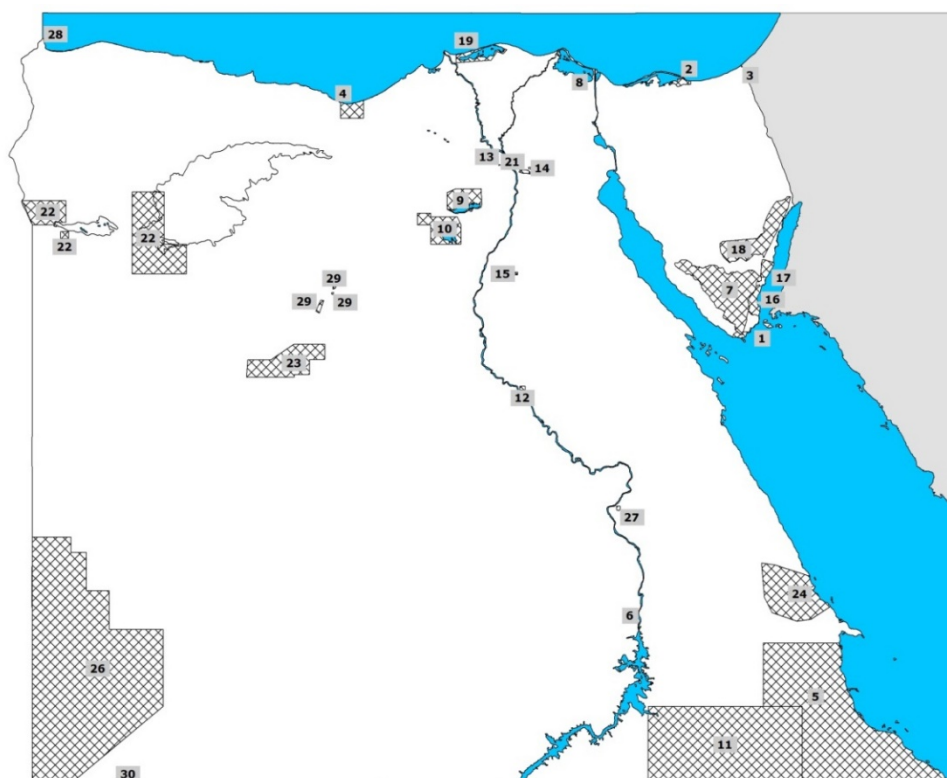


Figure S14: Boxplots for the predictive consistency of cross-validated models with (left) and without (right) correction for sampling bias. Predictions from Maxent are shown in white boxes, while elastic-net is shown in grey boxes. The median predictive consistency is about 0.8, with relatively higher median consistency for elastic net (environment-only models). Predictive consistency was one method of weighting species in Zonation, see the main text for details.



No.	Protectorate Name	Declaration Date	Area Km ²	Governorate
1	Ras Mohamed National Park	1983	850	South Sinai
2	Zaranik Protectorate	1985	230	North Sinai
3	Ahrash Protectorate	1985	8	North Sinai
4	El-Omayed Protectorate	1986	700	Matrouh
5	Elba National Park	1986	35600	Red Sea
6	Saluga and Ghazal Protectorate	1986	0.5	Aswan
7	St. Katherine National Park	1988	4250	South Sinai
8	Ashtum El-Gamil Protectorate	1988	180	Port Said
9	Lake Qarun Protectorate	1989	250	El Fayoum
10	Wadi El-Rayan Protectorate	1989	1225	El Fayoum
11	Wadi Allaqi Protectorate	1989	30000	Aswan
12	Wadi El-Assuti Protectorate	1989	35	Assuit
13	El Hassana Dome Protectorate	1989	1	Giza
14	Petrified Forest Protectorate	1989	7	Cairo
15	Sannur Cave Protectorate	1992	12	Beni Suef
16	Nabq Protectorate	1992	600	South Sinai
17	Abu Galum Protectorate	1992	500	South Sinai
18	Taba Protectorate	1998	3595	South Sinai
19	Lake Burullus Protectorate	1998	460	Kafr El Sheikh
20	Nile Islands Protectorates	1998	160	All Governorates on the Nile
21	Wadi Degla Protectorate	1999	60	Cairo
22	Siwa	2002	7800	Matrouh
23	White Desert	2002	3010	Matrouh
24	Wadi El-Gemal/Hamata	2003	7450	Red Sea
25	Red Sea Northern Islands	2006	1991	Red Sea
26	El-Gilf El-Kebir	2007	48523	New Valley
27	El-Dababya	2007	1	Qena
28	El-Salum Gulf	2010	383	Matrouh
29	El-Wahat El-Bahreya	2010	109	6th October
30	Mount Kamel Meteor Protectorate	2012	1	New Valley

Figure S15: Current Egyptian protected areas.

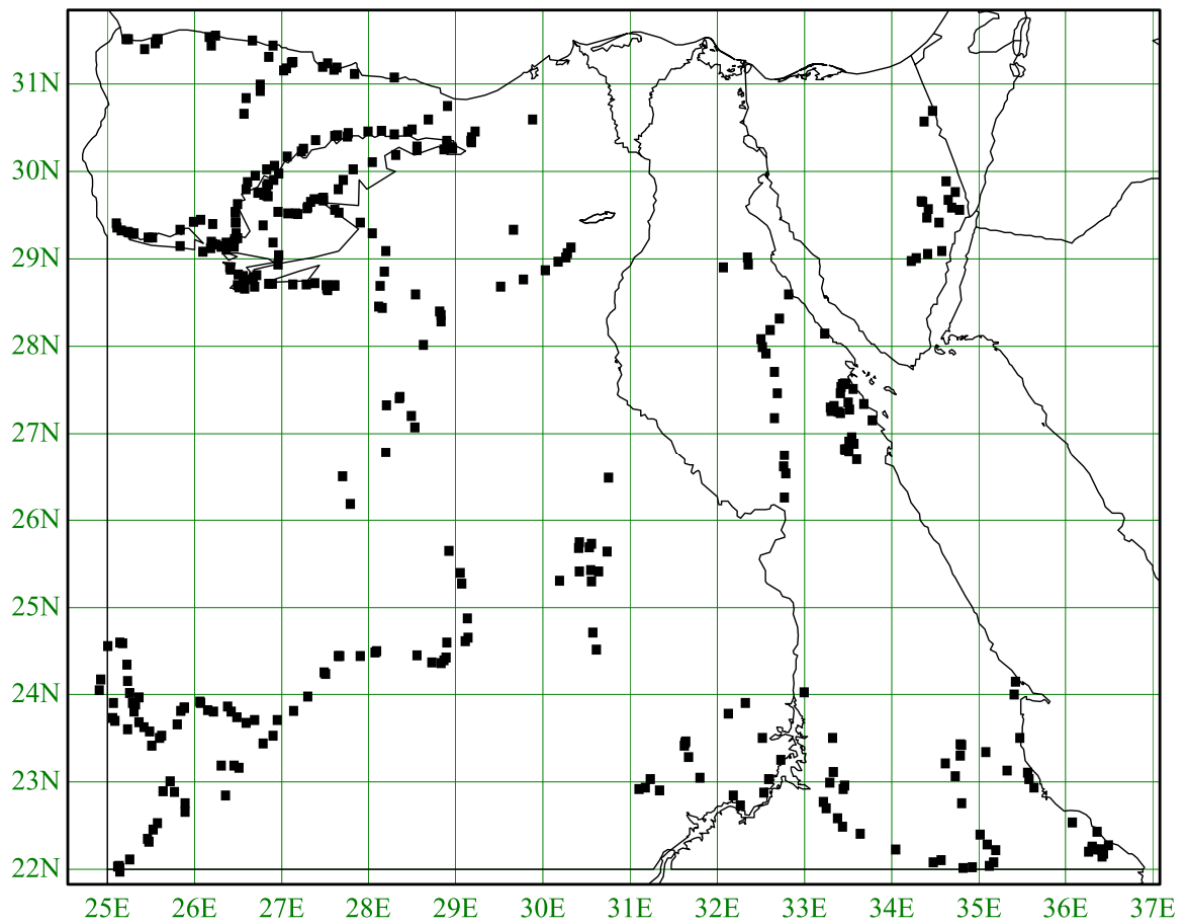


Figure S16: Field evaluation sites visited during protected areas identification mission between December 1996 and April 1998. (Sherif Baha El Din, pers. comm.).

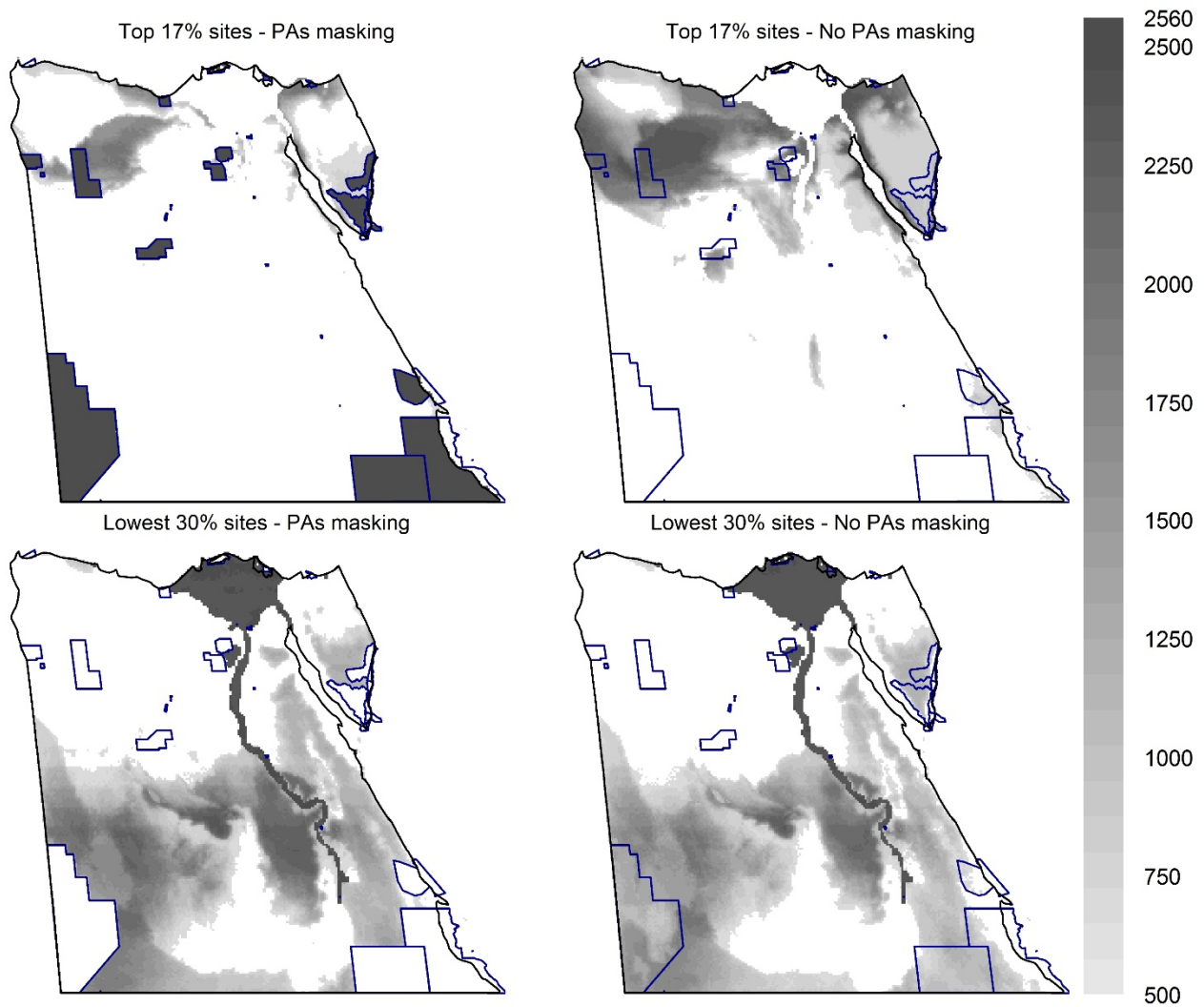


Figure S17: The frequency with which each cell was located at the top or lowest priority sites across all prioritization analyses performed. For each of the 2,560 Zonation analysis, the top 17% (above) or lowest 30% (below) priority sites were determined and the number of times each cell was chosen is reported, either with forcing PAs to have highest scores (left) or not (right). Only cells chosen in more than 500 zonation solutions are shown.

Appendix S1: Data sources

List of literature resources used for extracting Egyptian records.

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