Appendix

Appendix S1. Wild bee sampling in community plots

Appendix S2. Bee species included in the study

Appendix S3. Occurrence data

Appendix S4. Conceptual framework

Appendix S5. Functional traits

Appendix S6. Diversity metrics

Appendix S7. Additional description for the calculation of climate principal components analysis axes

Appendix S8. Principal components analysis for climate

Appendix S9. Maps of climatic predictors

Appendix S10. Additional description for the calculation of vegetation principal components analysis axes

Appendix S11. Principal components analysis for plants

Appendix S12. Maps of vegetation predictors

Appendix S13. Land-use data

Appendix S14. Land use in Switzerland

Appendix S15. Maps of the land-use metrics

Appendix S16. Correlations between predictors

Appendix S17. Maps of beekeeping intensity

Appendix S18. Relationship between predictors and elevation

Appendix S19. Protected areas

Appendix S20. Performance of the models

Appendix S21. Predictive performance of the α and ß taxonomic diversity and functional diversity metrics

Appendix S22. Predictive performance of the community-weighted mean of the eight studied traits

Appendix S23. Distribution of the community-weighted mean of the eight studied traits

Appendix S24. Relationship between α and ß taxonomic diversity metrics and elevation and between functional diversity metrics and elevation

Appendix S25. Relationship between the community-weighted mean of the eight traits and elevation

Appendix S26. Variable importance for the models of the community-weighted mean of the eight traits

Appendix S27. Partial dependence plots for the models of the community-weighted mean of the eight traits

Appendix S28. Flat violin plots & boxplots of diversity metrics

Appendix S29. Flat violin plots & boxplots of the community-weighted mean of the eight traits

Appendix. S30. Flat violin plots & boxplots of α and ß taxonomic diversity and functional diversity at mid elevation

Appendix S31. Flat violin plots & boxplots of α and ß taxonomic diversity and functional diversity at high elevation

Appendix S32. Flat violin plots & boxplots of the community-weighted mean of the eight traits at low elevation

Appendix S33. Flat violin plots & boxplots of the community-weighted mean of the eight traits at mid elevation

Appendix S34. Flat violin plots & boxplots of the community-weighted mean of the eight traits at high elevation

Appendix S35. Overlap between biodiversity hotspots and all protected areas.

Appendix S36. Overlap between species occurrence and protected areas.

Appendix S1. The aim of each visit during the update of the red list of wild bees from Switzerland was to maximise the list of species on the corresponding day for the entire plot. Therefore, the collaborators decided themselves, taking into account sunlight, phenology, floral offer, small structures, etc. during each field visit, which habitats, structures or floral populations should be surveyed and for how long. For instance, if a large colony of Lasioglossum malachurum is found during a visit or if many patrolling males of Andrena flavipes are observed on a flower-rich slope, at least 5 individuals should be collected in the corresponding sub-square or noted in the data file. If on the same day many males of Andrena flavipes are again observed in another sub-square, at least 5 individuals should again be collected or recorded in this sub-square. Food plants of particular importance to wild bees were listed and were given special attention, as all mass-flowering plants (e.g., umbellifers). Besides flowers, small structures (earthen edges, steepy walls, patchy soil, sunny dead wood,...) were also checked during fieldwork.

Appendix S2. The 547 bee species found in the community plots used in this study. Species are sorted according to family. For each species, the number of occurrences in the sampled plots is provided. Not that the occurrences are only a presence indicator, and thus do not relate to the species local abundance.

Andrenidae			**51**	*Andrena intermedia*	180	**102**	*Andrena trimmerana*	676
1	*Andrena aeneiventris*	8	**52**	*Andrena labialis*	44	**103**	*Andrena vaga*	180
2	*Andrena afrensis*	16	**53**	*Andrena labiata*	224	**104**	*Andrena varians*	44
3	*Andrena agilissima*	25	**54**	*Andrena lagopus*	76	**105**	*Andrena ventralis*	224
4	*Andrena alfkenella*	62	**55**	*Andrena lapponica*	68	**106**	*Andrena viridescens*	76
5	*Andrena allosa*	11	**56**	*Andrena lathyri*	136	**107**	*Andrena vulpecula*	68
6	*Andrena alutacea*	1	**57**	*Andrena limata*	3	**108**	*Andrena wilkella*	136
7	*Andrena amieti*	73	**58**	*Andrena marginata*	23	**109**	*Melitturga clavicornis*	3
8	*Andrena ampla*	3	**59**	*Andrena minutula*	912	**110**	*Panurginus herzi*	23
9	*Andrena anthrisci*	16	**60**	*Andrena minutuloides*	377	**111**	*Panurginus montanus*	912
10	*Andrena apicata*	25	**61**	*Andrena mitis*	30	**112**	*Panurgus banksianus*	377
11	*Andrena argentata*	4	**62**	*Andrena montana*	11	**113**	*Panurgus calcaratus*	30
12	*Andrena barbareae*	58	**63**	*Andrena nana*	34	**114**	*Panurgus dentipes*	11
13	*Andrena barbilabris*	76	**64**	*Andrena nanula*	2	**Apidae**		34
14	*Andrena bicolor*	692	**65**	*Andrena nigroaenea*	160	**115**	*Amegilla albigena*	2
15	*Andrena bimaculata*	23	**66**	*Andrena nigroolivacea*	41	**116**	*Amegilla garrula*	160
16	*Andrena bucephala*	111	**67**	*Andrena nitida*	630	**117**	*Ammobates punctatus*	41
17	*Andrena carantonica*	242	**68**	*Andrena nitidiuscula*	33	**118**	*Anthophora aestivalis*	630
18	*Andrena chrysopus*	3	**69**	*Andrena niveata*	2	**119**	*Anthophora balneorum*	33
19	*Andrena chrysosceles*	415	**70**	*Andrena nuptialis*	4	**120**	*Anthophora bimaculata*	2
20	*Andrena cineraria*	328	**71**	*Andrena ovatula*	865	**121**	*Anthophora crassipes*	4
21	*Andrena clarkella*	24	**72**	*Andrena pandellei*	89	**122**	*Anthophora crinipes*	865
22	*Andrena coitana*	23	**73**	*Andrena parviceps*	21	**123**	*Anthophora dispar*	89
23	*Andrena combinata*	93	**74**	*Andrena pilipes*	15	**124**	*Anthophora furcata*	21
24	*Andrena confinis*	1	**75**	*Andrena polita*	24	**125**	*Anthophora mucida*	15
25	*Andrena congruens*	42	**76**	*Andrena potentillae*	16	**126**	*Anthophora plagiata*	24
26	*Andrena curvungula*	168	**77**	*Andrena praecox*	87	**127**	*Anthophora plumipes*	16
27	*Andrena denticulata*	12	**78**	*Andrena probata*	24	**128**	*Anthophora pubescens*	87
28	*Andrena distinguenda*	2	**79**	*Andrena propinqua*	58	**129**	*Anthophora quadrimaculata*	24
29	*Andrena dorsata*	325	**80**	*Andrena proxima*	169	**130**	*Anthophora retusa*	58
30	*Andrena falsifica*	239	**81**	*Andrena ranunculorum*	4	**131**	*Apis mellifera*	169
31	*Andrena ferox*	4	**82**	*Andrena rogenhoferi*	26	**132**	*Biastes emarginatus*	4
32	*Andrena flavipes*	773	**83**	*Andrena rosae*	29	**133**	*Bombus alpinus*	26
33	*Andrena florea*	93	**84**	*Andrena ruficrus*	44	**134**	*Bombus argillaceus*	29
34	*Andrena floricola*	6	**85**	*Andrena rufizona*	30	**135**	*Bombus barbutellus*	44
35	*Andrena florivaga*	6	**86**	*Andrena rufula*	5	**136**	*Bombus bohemicus*	30
36	*Andrena freygessneri*	6	**87**	*Andrena rugulosa*	3	**137**	*Bombus campestris*	5
37	*Andrena fucata*	48	**88**	*Andrena schencki*	1	**138**	*Bombus cryptarum*	1
38	*Andrena fulva*	130	**89**	*Andrena semilaevis*	28	**139**	*Bombus distinguendus*	28
39	*Andrena fulvago*	337	**90**	*Andrena similis*	41	**140**	*Bombus flavidus*	41
40	*Andrena fulvata*	327	**91**	*Andrena simillima*	56	**141**	*Bombus gerstaeckeri*	56
41	*Andrena fulvicornis*	3	**92**	*Andrena simontornyella*	7	**142**	*Bombus hortorum*	7
42	*Andrena fulvida*	6	**93**	*Andrena strohmella*	14	**143**	*Bombus humilis*	14
43	*Andrena fuscipes*	4	**94**	*Andrena subopaca*	326	**144**	*Bombus hypnorum*	326
44	*Andrena gelriae*	10	**95**	*Andrena suerinensis*	690	**145**	*Bombus inexspectatus*	690
45	*Andrena gravida*	501	**96**	*Andrena symphyti*	1	**146**	*Bombus jonellus*	1
46	*Andrena haemorrhoa*	801	**97**	*Andrena synadelpha*	4	**147**	*Bombus lapidarius*	4
47	*Andrena hattorfiana*	279	**98**	*Andrena taraxaci*	3	**148**	*Bombus lucorum*	3
48	*Andrena helvola*	159	**99**	*Andrena tarsata*	12	**149**	*Bombus mendax*	12
49	*Andrena hesperia*	1	**100**	*Andrena thoracica*	11	**150**	*Bombus mesomelas*	11
50	*Andrena humilis*	677	**101**	*Andrena tibialis*	57	**151**	*Bombus monticola*	57

Appendix S2. Cont.

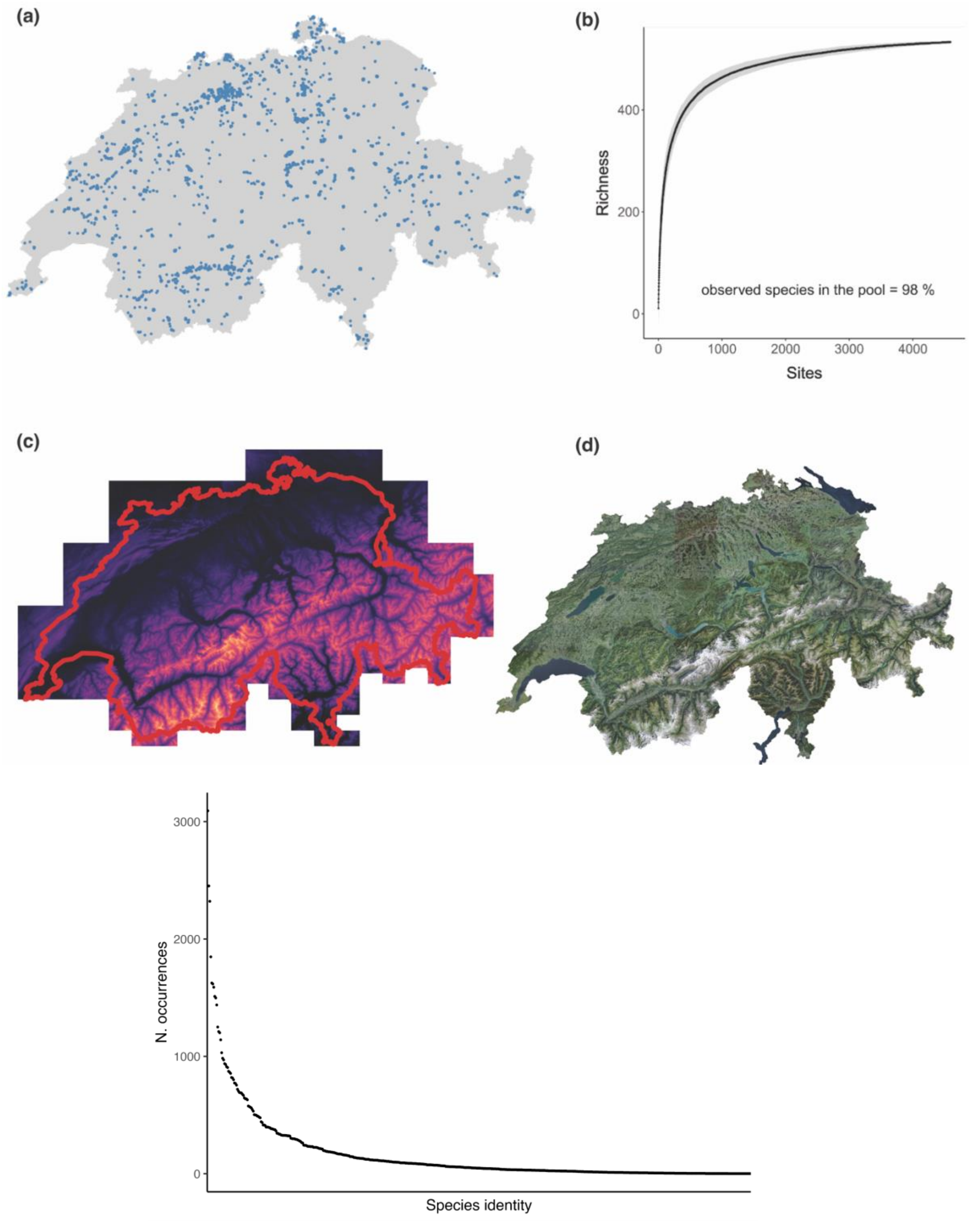
152	*Bombus mucidus*	161	**203**	*Nomada flava*	365	**Colletidae**		
153	*Bombus muscorum*	35	**204**	*Nomada flavilabris*	2	**254**	*Colletes cunicularius*	48
154	*Bombus norvegicus*	61	**205**	*Nomada flavoguttata*	572	**255**	*Colletes daviesanus*	344
155	*Bombus pascuorum*	3092	**206**	*Nomada flavopicta*	158	**256**	*Colletes fodiens*	7
156	*Bombus pratorum*	1617	**207**	*Nomada fucata*	80	**257**	*Colletes hederae*	25
157	*Bombus pyrenaeus*	218	**208**	*Nomada fulvicornis*	76	**258**	*Colletes impunctatus*	99
158	*Bombus quadricolor*	76	**209**	*Nomada furva*	2	**259**	*Colletes marginatus*	45
159	*Bombus ruderarius*	394	**210**	*Nomada fuscicornis*	12	**260**	*Colletes mlokossewiczi*	18
160	*Bombus ruderatus*	67	**211**	*Nomada goodeniana*	338	**261**	*Colletes nigricans*	15
161	*Bombus rupestris*	477	**212**	*Nomada gransassoi*	2	**262**	*Colletes sierrensis*	40
162	*Bombus sichelii*	321	**213**	*Nomada guttulata*	25	**263**	*Colletes similis*	4
163	*Bombus soroeensis*	984	**214**	*Nomada hirtipes*	93	**264**	*Colletes succinctus*	288
164	*Bombus subterraneus*	53	**215**	*Nomada integra*	146	**265**	*Hylaeus alpinus*	115
165	*Bombus sylvarum*	489	**216**	*Nomada kohli*	7	**266**	*Hylaeus angustatus*	60
166	*Bombus sylvestris*	855	**217**	*Nomada lathburiana*	119	**267**	*Hylaeus annulatus*	93
167	*Bombus terrestris*	1141	**218**	*Nomada leucophthalma*	12	**268**	*Hylaeus brevicornis*	67
168	*Bombus vestalis*	164	**219**	*Nomada marshamella*	156	**269**	*Hylaeus clypearis*	215
169	*Bombus veteranus*	28	**220**	*Nomada moeschleri*	20	**270**	*Hylaeus communis*	50
170	*Bombus wurflenii*	755	**221**	*Nomada mutica*	3	**271**	*Hylaeus confusus*	970
171	*Ceratina chalybea*	110	**222**	*Nomada nobilis*	2	**272**	*Hylaeus cornutus*	720
172	*Ceratina cucurbitina*	198	**223**	*Nomada obscura*	5	**273**	*Hylaeus crassanus*	52
173	*Ceratina cyanea*	577	**224**	*Nomada obtusifrons*	3	**274**	*Hylaeus difformis*	11
174	*Ceratina gravidula*	2	**225**	*Nomada panzeri*	225	**275**	*Hylaeus dilatatus*	154
175	*Ceratina nigrolabiata*	1	**226**	*Nomada piccioliana*	3	**276**	*Hylaeus duckei*	145
176	*Epeoloides coecutiens*	33	**227**	*Nomada pleurosticta*	4	**277**	*Hylaeus gibbus*	10
177	*Epeolus alpinus*	13	**228**	*Nomada posthuma*	9	**278**	*Hylaeus glacialis*	116
178	*Epeolus cruciger*	33	**229**	*Nomada roberjeotiana*	3	**279**	*Hylaeus gredleri*	9
179	*Epeolus productulus*	3	**230**	*Nomada ruficornis*	231	**280**	*Hylaeus hyalinatus*	375
180	*Epeolus variegatus*	59	**231**	*Nomada rufipes*	6	**281**	*Hylaeus incongruus*	327
181	*Eucera interrupta*	34	**232**	*Nomada sexfasciata*	116	**282**	*Hylaeus kahri*	53
182	*Eucera longicornis*	293	**233**	*Nomada sheppardana*	37	**283**	*Hylaeus leptocephalus*	83
183	*Eucera nigrescens*	769	**234**	*Nomada signata*	49	**284**	*Hylaeus moricei*	42
184	*Eucera nigrifacies*	1	**235**	*Nomada similis*	17	**285**	*Hylaeus nigritus*	1
185	*Melecta albifrons*	76	**236**	*Nomada stigma*	1	**286**	*Hylaeus nivalis*	298
186	*Melecta festiva*	6	**237**	*Nomada striata*	84	**287**	*Hylaeus paulus*	46
187	*Melecta luctuosa*	33	**238**	*Nomada succincta*	58	**288**	*Hylaeus pectoralis*	30
188	*Nomada alboguttata*	73	**239**	*Nomada villosa*	14	**289**	*Hylaeus pfankuchi*	19
189	*Nomada argentata*	2	**240**	*Nomada zonata*	19	**290**	*Hylaeus pictipes*	35
190	*Nomada armata*	38	**241**	*Pasites maculatus*	30	**291**	*Hylaeus pilosulus*	37
191	*Nomada atroscutellaris*	59	**242**	*Pseudapis diversipes*	99	**292**	*Hylaeus punctatus*	1
192	*Nomada bifasciata*	171	**243**	*Tetralonia dentata*	34	**293**	*Hylaeus punctulatissimus*	153
193	*Nomada braunsiana*	3	**244**	*Tetralonia fulvescens*	6	**294**	*Hylaeus rinki*	58
194	*Nomada castellana*	17	**245**	*Tetralonia salicariae*	29	**295**	*Hylaeus signatus*	36
195	*Nomada conjungens*	25	**246**	*Thyreus hirtus*	9	**296**	*Hylaeus sinuatus*	242
196	*Nomada discrepans*	2	**247**	*Thyreus histrionicus*	1	**297**	*Hylaeus styriacus*	233
197	*Nomada distinguenda*	24	**248**	*Thyreus orbatus*	15	**298**	*Hylaeus taeniolatus*	168
198	*Nomada emarginata*	24	**249**	*Thyreus ramosus*	9	**299**	*Hylaeus tyrolensis*	71
199	*Nomada fabriciana*	436	**250**	*Thyreus truncatus*	5	**300**	*Hylaeus variegatus*	22
200	*Nomada facilis*	31	**251**	*Xylocopa iris*	20	**Halictidae**		
201	*Nomada femoralis*	25	**252**	*Xylocopa valga*	42	**301**	*Dufourea alpina*	41
202	*Nomada ferruginata*	7	**253**	*Xylocopa violacea*	183	**302**	*Dufourea dentiventris*	60

Appendix S2. Cont.

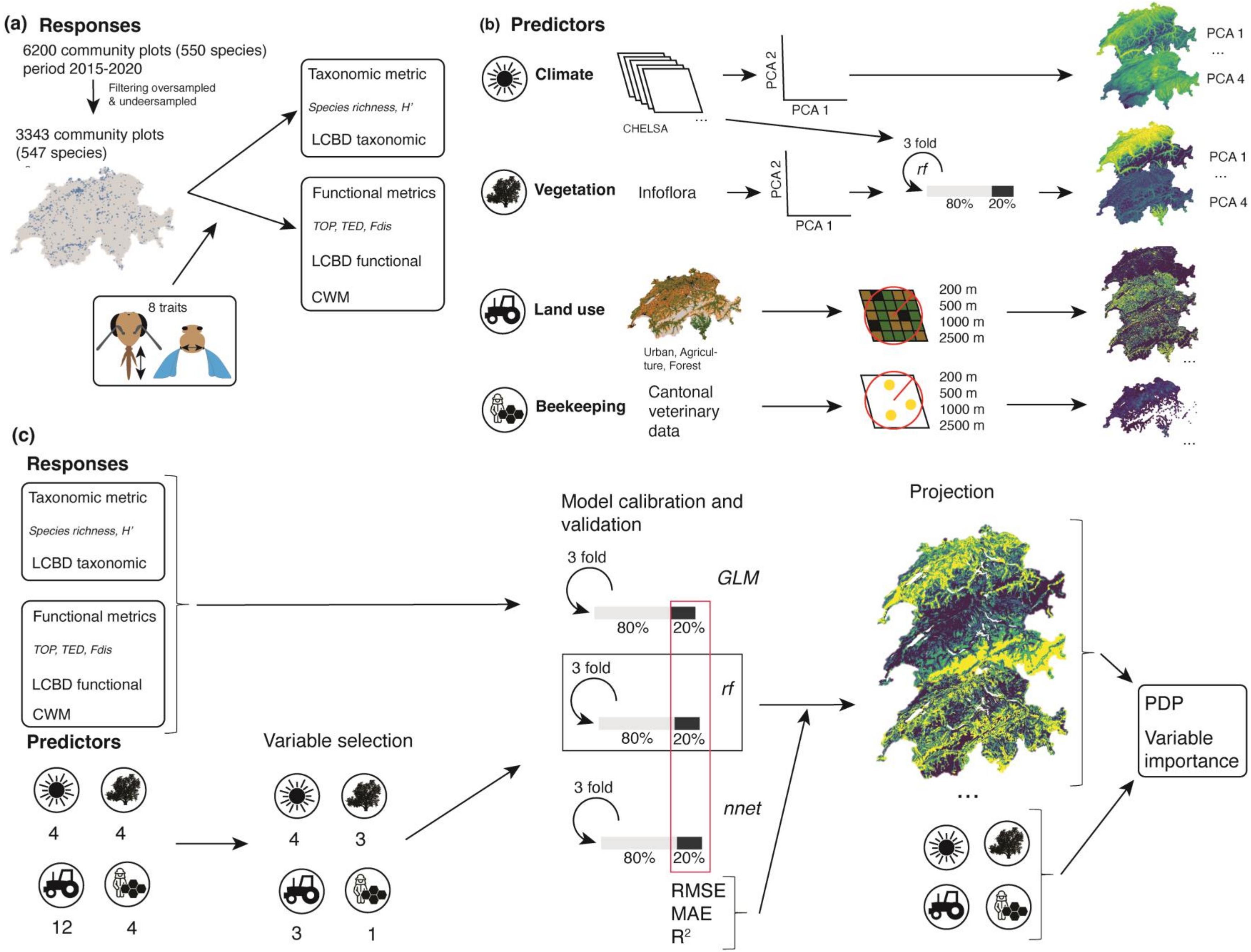
303	*Dufourea halictula*	83
304	*Dufourea inermis*	5
305	*Dufourea minuta*	11
306	*Dufourea paradoxa*	23
307	*Halictus carinthiacus*	1
308	*Halictus confusus*	5
309	*Halictus eurygnathus*	110
310	*Halictus langobardicus*	16
311	*Halictus leucaheneus*	123
312	*Halictus maculatus*	22
313	*Halictus quadricinctus*	322
314	*Halictus rubicundus*	86
315	*Halictus scabiosae*	815
316	*Halictus seladonius*	904
317	*Halictus sexcinctus*	10
318	*Halictus simplex*	181
319	*Halictus subauratus*	638
320	*Halictus submediterraneus*	502
321	*Halictus tumulorum*	60
322	*Lasioglossum aeratum*	48
323	*Lasioglossum albipes*	84
324	*Lasioglossum albocinctum*	930
325	*Lasioglossum alpigenum*	9
326	*Lasioglossum bavaricum*	10
327	*Lasioglossum bluethgeni*	14
328	*Lasioglossum brevicorne*	34
329	*Lasioglossum breviventre*	73
330	*Lasioglossum buccale*	5
331	*Lasioglossum calceatum*	8
332	*Lasioglossum clypeare*	2452
333	*Lasioglossum convexiusculum*	9
334	*Lasioglossum costulatum*	26
335	*Lasioglossum cupromicans*	87
336	*Lasioglossum discum*	118
337	*Lasioglossum elegans*	13
338	*Lasioglossum euboeensis*	5
339	*Lasioglossum fratellum*	15
340	*Lasioglossum fulvicorne*	97
341	*Lasioglossum glabriusculum*	938
342	*Lasioglossum griseolum*	411
343	*Lasioglossum intermedium*	13
344	*Lasioglossum interruptum*	45
345	*Lasioglossum laeve*	138
346	*Lasioglossum laevidorsum*	8
347	*Lasioglossum laevigatum*	2
348	*Lasioglossum laterale*	265
349	*Lasioglossum laticeps*	2
350	*Lasioglossum lativentre*	1438
351	*Lasioglossum leucopus*	323
352	*Lasioglossum leucozonium*	225
353	*Lasioglossum limbellum*	1250
354	*Lasioglossum lineare*	54
355	*Lasioglossum lissonotum*	123
356	*Lasioglossum lucidulum*	12
357	*Lasioglossum majus*	112
358	*Lasioglossum malachurum*	47
359	*Lasioglossum marginatum*	1031
360	*Lasioglossum marginellum*	108
361	*Lasioglossum minutissimum*	1
362	*Lasioglossum minutulum*	45
363	*Lasioglossum morio*	25
364	*Lasioglossum nigripes*	1589
365	*Lasioglossum nitidiusculum*	299
366	*Lasioglossum nitidulum*	82
367	*Lasioglossum pallens*	303
368	*Lasioglossum parvulum*	70
369	*Lasioglossum pauxillum*	184
370	*Lasioglossum pleurospeculum*	1510
371	*Lasioglossum podolicum*	9
372	*Lasioglossum politum*	3
373	*Lasioglossum punctatissimum*	560
374	*Lasioglossum puncticolle*	231
375	*Lasioglossum pygmaeum*	85
376	*Lasioglossum quadrinotatulum*	28
377	*Lasioglossum quadrisignatum*	4
378	*Lasioglossum rufitarse*	1
379	*Lasioglossum sabulosum*	91
380	*Lasioglossum semilucens*	23
381	*Lasioglossum setulosum*	73
382	*Lasioglossum sexnotatum*	3
383	*Lasioglossum sexstrigatum*	22
384	*Lasioglossum subfasciatum*	73
385	*Lasioglossum subfulvicorne*	53
386	*Lasioglossum subhirtum*	23
387	*Lasioglossum tarsatum*	5
388	*Lasioglossum tricinctum*	16
389	*Lasioglossum villosulum*	98
390	*Lasioglossum xanthopus*	1201
391	*Lasioglossum zonulum*	89
392	*Rhophitoides canus*	12
393	*Rophites algirus*	3
394	*Rophites quinquespinosus*	31
395	*Sphecodes albilabris*	6
396	*Sphecodes alternatus*	194
397	*Sphecodes crassus*	1
398	*Sphecodes cristatus*	233
399	*Sphecodes croaticus*	1
400	*Sphecodes dusmeti*	12
401	*Sphecodes ephippius*	1
402	*Sphecodes ferruginatus*	639
403	*Sphecodes geoffrellus*	380
404	*Sphecodes gibbus*	190
405	*Sphecodes hyalinatus*	384
406	*Sphecodes longulus*	167
407	*Sphecodes majalis*	68
408	*Sphecodes marginatus*	8
409	*Sphecodes miniatus*	2
410	*Sphecodes monilicornis*	31
411	*Sphecodes niger*	297
412	*Sphecodes pellucidus*	106
413	*Sphecodes pseudofasciatus*	108
414	*Sphecodes puncticeps*	29
415	*Sphecodes reticulatus*	187
416	*Sphecodes rubicundus*	103
417	*Sphecodes ruficrus*	6
418	*Sphecodes rufiventris*	44
419	*Sphecodes scabricollis*	60
420	*Sphecodes schenckii*	133
421	*Sphecodes spinulosus*	96
422	*Sphecodes zangherii*	2
423	*Systropha curvicornis*	1
Megachilidae		
424	*Anthidiellum strigatum*	327
425	*Anthidium florentinum*	345
426	*Anthidium manicatum*	8
427	*Anthidium montanum*	390
428	*Anthidium oblongatum*	56
429	*Anthidium punctatum*	482
430	*Anthidium septemdentatum*	284
431	*Anthidium septemspinosum*	31
432	*Chelostoma campanularum*	1
433	*Chelostoma distinctum*	442
434	*Chelostoma florisomne*	196
435	*Chelostoma foveolatum*	704
436	*Chelostoma grande*	4
437	*Chelostoma rapunculi*	32
438	*Coelioxys afra*	499
439	*Coelioxys alata*	81
440	*Coelioxys aurolimbata*	3
441	*Coelioxys conica*	29
442	*Coelioxys conoidea*	106
443	*Coelioxys echinata*	31
444	*Coelioxys elongata*	3
445	*Coelioxys inermis*	38
446	*Coelioxys lanceolata*	31
447	*Coelioxys mandibularis*	11
448	*Coelioxys rufescens*	19
449	*Dioxys cincta*	46
450	*Dioxys tridentata*	10
451	*Heriades crenulatus*	1848
452	*Heriades rubicola*	62
453	*Heriades truncorum*	1
454	*Hoplitis acuticornis*	533

Appendix S2. Cont.

455	*Hoplitis adunca*	2	**506**	*Osmia labialis*	35
456	*Hoplitis anthocopoides*	397	**507**	*Osmia latreillei*	50
457	*Hoplitis claviventris*	36	**508**	*Osmia leaiana*	1
458	*Hoplitis dalmatica*	212	**509**	*Osmia mustelina*	210
459	*Hoplitis lepeletieri*	27	**510**	*Osmia nigriventris*	110
460	*Hoplitis leucomelana*	123	**511**	*Osmia niveata*	28
461	*Hoplitis loti*	298	**512**	*Osmia parietina*	58
462	*Hoplitis mitis*	130	**513**	*Osmia pilicornis*	144
463	*Hoplitis praestans*	84	**514**	*Osmia rufohirta*	17
464	*Hoplitis ravouxi*	2	**515**	*Osmia scutellaris*	125
465	*Hoplitis robusta*	43	**516**	*Osmia spinulosa*	2
466	*Hoplitis tridentata*	21	**517**	*Osmia steinmanni*	93
467	*Hoplitis tuberculata*	66	**518**	*Osmia submicans*	5
468	*Hoplitis villosa*	118	**519**	*Osmia tergestensis*	138
469	*Icteranthidium laterale*	37	**520**	*Osmia uncinata*	28
470	*Lithurgus chrysurus*	820	**521**	*Osmia viridana*	71
471	*Megachile alpicola*	117	**522**	*Osmia xanthomelana*	3
472	*Megachile analis*	98	**523**	*Protosmia minutula*	30
473	*Megachile apicalis*	53	**524**	*Pseudoanthidium scapulare*	99
474	*Megachile centuncularis*	3	**525**	*Rhodanthidium caturigense*	87
475	*Megachile circumcincta*	130	**526**	*Stelis breviuscula*	9
476	*Megachile ericetorum*	244	**527**	*Stelis franconica*	52
477	*Megachile flabellipes*	415	**528**	*Stelis minima*	8
478	*Megachile genalis*	7	**529**	*Stelis minuta*	2
479	*Megachile lagopoda*	2	**530**	*Stelis nasuta*	8
480	*Megachile lapponica*	34	**531**	*Stelis odontopyga*	8
481	*Megachile leachella*	1	**532**	*Stelis ornatula*	2
482	*Megachile ligniseca*	34	**533**	*Stelis phaeoptera*	44
483	*Megachile maritima*	100	**534**	*Stelis punctulatissima*	21
484	*Megachile melanopyga*	49	**535**	*Stelis signata*	116
485	*Megachile nigriventris*	89	**536**	*Stelis simillima*	23
486	*Megachile parietina*	115	**537**	*Trachusa byssina*	5
487	*Megachile pilicrus*	134	**538**	*Trachusa interrupta*	383
488	*Megachile pilidens*	14	**Melittidae**		
489	*Megachile pyrenaea*	262	**539**	*Dasypoda argentata*	11
490	*Megachile pyrenaica*	35	**540**	*Dasypoda hirtipes*	8
491	*Megachile rotundata*	99	**541**	*Macropis europaea*	6
492	*Megachile sculpturalis*	89	**542**	*Macropis fulvipes*	187
493	*Megachile versicolor*	11	**543**	*Melitta dimidiata*	33
494	*Megachile willughbiella*	231	**544**	*Melitta haemorrhoidalis*	17
495	*Osmia alticola*	19	**545**	*Melitta leporina*	214
496	*Osmia anceyi*	10	**546**	*Melitta nigricans*	222
497	*Osmia andrenoides*	4	**547**	*Melitta tricincta*	106
498	*Osmia aurulenta*	28			
499	*Osmia bicolor*	688			
500	*Osmia bicornis*	398			
501	*Osmia brevicornis*	668			
502	*Osmia caerulescens*	32			
503	*Osmia cornuta*	331			
504	*Osmia gallarum*	112			
505	*Osmia inermis*	91			



Appendix S3. Summary of the occurrence data: (a) spatial distribution of sampled plots and (b) species accumulation curves. These curves were used to estimate the total number of species present in Switzerland (extrapolated species richness in the species pool based on bootstrap resampling). In total, our data include more than 98% of the bee species predicted to be present in Switzerland. (c) Digital height model (dark colours depict lower elevation, warm colours depict higher elevation). (d) Aerial photograph of Switzerland. (e) Rank-occurrence diagram of the wild bee species collected in the community plots. Every dot corresponds to one species, which is sorted decreasingly according to the number of occurrences (i.e., the number of community plots where the species was sam



(a) Responses
6200 community plots (550 species)
period 2015-2020
Filtering oversampled
& undeersampled
3343 community plots
(547 species)
8 traits
Taxonomic metric
Species richness, H'
LCBD taxonomic
Functional metrics
TOP, TED, Fdis
LCBD functional
CWM
(b) Predictors
Climate
CHELSA
PCA 2
PCA 1
PCA 1
PCA 4
3 fold
rf
80%
20%
Vegetation
Infoflora
Land use
Urban, Agricul-
ture, Forest
200 m
500 m
1000 m
2500 m
Beekeeping
Cantonal
veterinary
data
(c)
Responses
Taxonomic metric
Species richness, H'
LCBD taxonomic
Functional metrics
TOP, TED, Fdis
LCBD functional
CWM
Predictors
4
4
12
4
Variable selection
4
3
3
1
Model calibration and
validation
3 fold
GLM
rf
nnet
80%
20%
RMSE
MAE
R2
Projection
PDP
Variable
importance

Appendix S4. Methodological framework depicting the computation of the responses considered (a), the predictors (b) and the modelling pipeline. (a) Using 4591 community plots and 8 functional traits (i.e. intertegular distance ITD, tongue length, solitary, belowground, cleptoparasite, phenology start, phenology duration, and feeding specialisation, see also Appendix S2), we calculated α taxonomic (i.e. species richness, H') and α functional (i.e. TOP for functional richness, TED for functional evenness, FDis for functional divergence) metrics, as well as LCBD as a metric of taxonomic and functional uniqueness. (b) We used four types of predictors: climate, vegetation, land use and beekeeping. For climate, we used the 16 climatic variables from the CHELSA dataset (Krager et al., 2015), conducted a principal components analysis (PCA) and kept the first four axes (Appendix S3). For vegetation metrics, we used plant community plots, applied a PCA, and kept the first four axes. We then modelled the countrywide distribution as random forests, using climatic variables as predictors (see Methods). We calculated the land-use metrics by measuring the amount of agricultural, forest and urban land use within buffers of 200, 500, 1000 and 2500 m. Beekeeping intensity maps were produced by calculating the number of honeybee hives within the buffers. (c) Modelling pipeline. Note that although we considered three different algorithms (GLM, rf, nnet), we only used rf because it outperformed the other algorithms (see Methods). H' = Shannon diversity; TOP = trait onion peeling; TED = trait evenness distribution; FDis = functional dispersion; LCBD = local community contributions to ß-diversity; rf = random forest; PCA = principal components analysis; GLM = generalised linear model; nnet = neural network; RMSE = root mean squared error; MAE = mean absolute error; PDP = partial dependence pl

Appendix S5. Trait data for the different species were collected within a European level effort. We used eight functional traits: (1) *intertegular distance* (ITD) reflects species dispersal capacity and body size and is defined as the distance in millimetres between the two tegula. It is obtained by measuring the SPAN between the wing bases in a bee's thorax (Cariveau et al., 2016) (2) *Feeding specialisation* provides information about the number of plant families exploited by a species. We classified species into two categories, polylectic species (feeding on more than five plant genus from more than three plant families, classified as "1") and species with other strategies, including oligolectic and monolectic (species feeding on fewer than five plant genus or a single plant species, classified as "0"). This definition corresponds to "Polylecty sensu lato" in Robertson (1925) and to "meso-lecty + Polylecty" in Cane and Sipes (2006) and Müller and Kuhlmann (2008). (3) *Tongue length* indicates the diversity of floral resources a species can access. Species were classified as having either a long tongue (indicating a narrower range of resources, classified as "0") or short tongue (indicating a broader range of resources, classified as "1"). We summarised the phenology of wild bee species as two traits, (4) *the month when the activity period of the adults starts* and (5) *the duration of the activity period in months*. Phenology of species is obtained from individuals from within their ranges in Europe. The nesting or reproductive strategy is an important trait determining, for instance, the response of wild bees to land-use change (Buchholz & Egerer, 2020). In that regard, species were classified as below-ground nesters, above-ground nesters and kleptoparasites. To include the information contained in this categorical variable in our analyses, we created dummy variables. Specifically, we created three numerical variables (one for each category) where a species belonging to a given category takes the value of 1 and 0 otherwise. When defining dummy variables, a common mistake is to define too many variables (commonly referred to as the "dummy variable trap", see Gujarati, 2012). In our case, the categorical variable can take on 3 values. To include all the information in our analysis, we only need 2 dummy variables (n-1). Specifically, we defined nesting mode and kleptoparasitic behaviour. Nesting mode was obtained by classifying non-kleptoparasitic species as either belowground nesters (value 1) or not belowground nesters, that is, aboveground nesters (value 0). Belowground nesters build a nest below ground or use existing cavities below ground. Thus, aboveground nesters were not included to avoid collinearity. We also included the kleptoparasitic behaviour (7). Kleptoparasite bees lay their eggs inside nests constructed by other bee species, and their larvae feed on pollen provided by the host. (8) *Solitary* describes the degree of social organisation of each wild bee species. We used two main categories, solitary bees (non-social bees that do not show any type of social organisation, classified as "1") and social bees (including primitive social, subsocial and eusocial wild bee species, classified as "0").

Appendix S6. Functional richness, i.e. the amount of multidimensional functional trait space filled by the community, and functional evenness, i.e. the regularity in the spacing of species within that functional trait space, were measured using the trait onion peeling (TOP) and trait evenness diversity (TED) indices, respectively, both introduced by Fontana et al. (2016). Functional dispersion, i.e. the multivariate degree of spread around the centre of gravity of the species trait distribution, was measured using the FDis index proposed by Laliberté and Legendre (2010).

For taxonomic LCBD, we used the matrix of species occurrence to compute a pairwise dissimilarity matrix using the Sorensen index and the function 'beta.pair' from the package betapart (Baselga, 2010) in R v. 4.0.3 (R Core Team, 2020). We then used the resulting dissimilarity matrix to calculate LCBD using the function 'LCBD.comp' from the R package adespatial (Legendre & De Cáceres, 2013). For functional LCBD, we used the CWM matrix to calculate a Sorensen derived pairwise functional dissimilarity matrix, which was used to calculate functional LCBD as done for taxonomic LCBD. We used principal components analysis (PCA) to reduce the dimensionality of the trait matrix to allow the computation of LCBD in communities with fewer species than traits. Three PCA axes were kept, representing 86% of the total variation in the original standardised trait matrix (PCA1 = 63%; PCA2 = 14%, PCA3 = 9%; other axes < 5%).

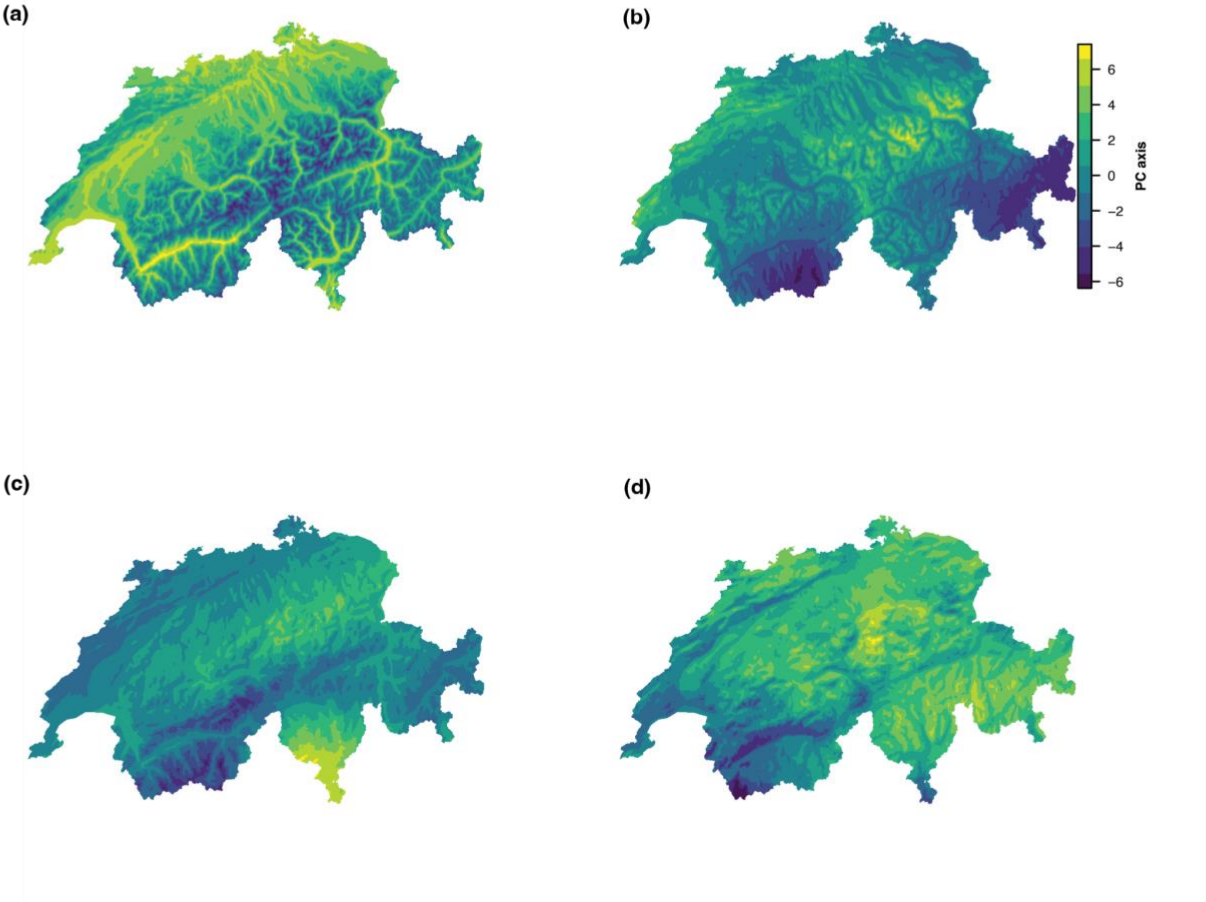
Appendix S7. The first principal components analysis (PCA) axis was related to elevation-driven temperature, with higher values indicating warmer conditions (Appendix S3, hereafter referred to as temperature). The second PCA axis was related to precipitation, with lower PCA values indicating lower precipitation (Appendix S3, hereafter precipitation). The third axis was related to variability in both temperature and precipitation, with higher PCA values indicating higher variability (Appendix S3, hereafter seasonality). The fourth axis was related to changes in temperature range (Appendix S3, temperature range), where places with positive values indicating lower temperature range. (Appendix S3, hereafter temperature range). The description of each axis is based on the contribution of the raw variables (or factor loading).

Appendix S8. Factor loading in climate principal components analysis (PCA) on the CHELSA climate variables (Krager et al., 2017). Bold = 3 variables with the highest absolute loading on each axis. PCA1 represents changes in temperature. PCA2 represents changes in precipitation. PCA3 represents changes in climate (temperature and precipitation) seasonality. PCA4 represents changes in temperature range, where places with a higher PCA values having lower temperature range.

CHELSA climate variable	PCA1 (39%)	PCA2 (28%)	PCA3 (20%)	PCA4 (6%)
clim1: Annual Mean Temperature	**0.3211**	0.1770	0.1341	0.0141
clim2: Mean Diurnal Range	-0.1238	-0.2319	0.2647	**-0.4788**
clim3: Isothermality	-0.2655	0.0363	-0.2153	-0.1058
clim4: Temperature Seasonality	0.1005	-0.2037	**0.3973**	-0.2886
clim5: Max Temperature of Warmest Month	**0.3225**	0.1607	0.1549	-0.0273
clim6: Min Temperature of Coldest Month	0.3178	0.2023	0.0893	0.0442
clim7: Temperature Annual Range	0.0135	-0.2413	**0.3639**	**-0.4022**
clim8: Mean Temperature of Wettest Quarter	0.1556	0.0012	0.2525	0.3495
clim9: Mean Temperature of Driest Quarter	0.2408	0.2322	-0.0551	-0.2778
clim10: Mean Temperature of Warmest Quarter	**0.3224**	0.1620	0.1545	-0.0068
clim11: Mean Temperature of Coldest Quarter	0.3187	0.1934	0.1092	0.0291
clim12: Annual Precipitation	-0.2286	0.2615	0.2358	-0.0148
clim13: Precipitation of Wettest Month	-0.2393	0.1699	0.3154	0.1074
clim14: Precipitation of Driest Month	-0.1644	**0.3720**	0.0134	-0.1388
clim15: Precipitation Seasonality	-0.0913	-0.2307	**0.3215**	**0.3674**

clim16: Precipitation of Wettest Quarter	-0.2407	0.1800	0.3090	0.1182
clim17: Precipitation of Driest Quarter	-0.1737	**0.3682**	0.0198	-0.1498
clim18: Precipitation of Warmest Quarter	-0.2412	0.1708	0.2886	0.2221
clim19: Precipitation of Coldest Quarter	-0.1300	**0.3789**	-0.0546	-0.2443

CHELSA codes: clim1 = Annual Mean Temperature [°C*10]; clim2 = Mean Diurnal Range [°C]; clim3 = Isothermality; clim4 = Temperature Seasonality [standard deviation]; clim5 = Max Temperature of Warmest Month [°C*10]; clim6 = Min Temperature of Coldest Month [°C*10]; clim7 = Temperature Annual Range [°C*10]; clim8 = Mean Temperature of Wettest Quarter [°C*10]; clim9 = Mean Temperature of Driest Quarter [°C*10]; clim10 = Mean Temperature of Warmest Quarter [°C*10]; clim11 = Mean Temperature of Coldest Quarter [°C*10]; clim12 = Annual Precipitation [mm/year]; clim13 = Precipitation of Wettest Month [mm/month]; clim14 = Precipitation of Driest Month [mm/month]; clim15 = Precipitation Seasonality [coefficient of variation]; clim16 = Precipitation of Wettest Quarter [mm/quarter]; clim17 = Precipitation of Driest Quarter [mm/quarter]; clim18 = Precipitation of Warmest Quarter [mm/quarter]; clim19 = Precipitation of Coldest Quarter [mm/quarter]



Appendix S9. Maps of the four climatic variables used in the model. (a) Map corresponding to PCA1, which depicts changes in temperature (Appendix S3), with blue values indicating lower temperatures and yellow values indicating higher temperatures. (b) Map corresponding to PCA2, which depicts changes in precipitation (Appendix S3), with blue values indicating higher precipitation and yellow ones indicating lower precipitation. (c) Map corresponding to PCA3 (climate seasonality), which depicts changes in temperature and precipitation seasonality (Appendix S3), with blue values indicating lower seasonality and yellow ones indicating higher seasonality. (d) Map corresponding to PCA4 (temperature ranges), which depicts changes in temperature range, with blue values indicating a wider temperature range but low precipitation seasonality, and yellow values indicating a smaller temperature range and higher precipitation seasonality.

Appendix S10. To model vegetation in relation to the 19 raw CHELSA variables, the random forest algorithm was trained on 80% of the data and evaluated on the remaining 20%, stratified according to the response variable (function 'createDataPartition' in R package caret v. 6.0-86, Kuhn, 2008). Model training and parameter tuning were done using three times three-fold cross-validation (function 'train' in R package caret). The best model was chosen based on the root mean squared error (RMSE), mean absolute error (MAE) and R2 measured on the trained dataset. The performance of the selected model was further evaluated on the test dataset using the same metrics. Predictions across the whole of Switzerland were performed based on the raw CHELSA data (downscaled version, 100 m).

The first principal components analysis (PCA) axis was related to the elevation gradient and was removed from the analysis because it was strongly correlated with climate PCA1 (r = 0.85). Pearson correlations (r) between climate and all other vegetation principal components were between 0.39 and 0.01. The second PCA axis (named mid-elevation coniferous) represents a gradient in the dominance of coniferous plant communities, with negative values indicating coniferous plant communities (fir, spruce and Scots pine forest with the associated herbaceous plants, e.g. *Silene dioica*, *Petasites albus*, *Veronica urticifolia*, Appendix S4) and positive values indicating other vegetation types, including lowland vegetation at intermediate positive values and high-elevation plants at large positive values (e.g. *Salix herbacea*, *Leucanthemopsis alpina*, *Gnaphalium supinum*). The third PCA axis (named dry–wet) depicts a dry to wet gradient, with positive values indicating ruderal and/or dry open vegetation (e.g. *Echium vulgare*, *Silene vulgaris*, *Artemisia vulgaris,* Appendix S4) and negative values indicating wet forest vegetation (e.g. *Veronica montana*, *Carex remota*, *Lysimachia nemorum*, Appendix S4). The fourth PCA axes (named forest) depicts a gradient from woody to open vegetation, with positive values indicating plant assemblages from forests and shrublands (e.g. *Polypodium vulgare*, *Hypericum montanum*, *Salvia glutinosa*, Appendix S4) and negative values indicating plant assemblages from meadows, pastures and other types of open vegetation (e.g. *Plantago atrata*, *Carex flacca*, *Centaurea jacea*, Appendix S4).

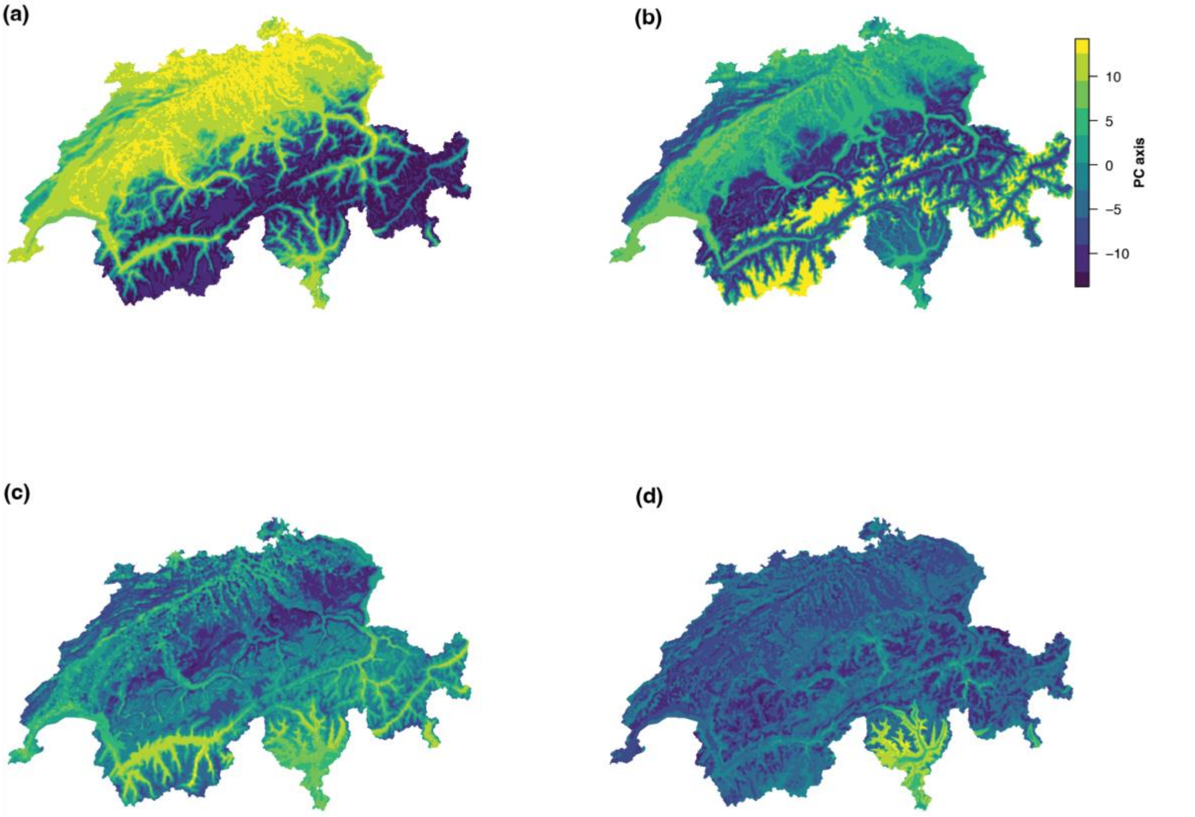
Appendix S11. Factor loading in plant principal components analysis (PCA) for selected species. The five species with the highest/lowest loading on each axis are shown (bold values). The most common tree species in our dataset are also included.

Species	PCA1 (24%)	PCA2 (12%)	PCA3 (4%)	PCA4 (3%)
Abies alba	0.0376	-0.0547	-0.0810	0.0472
Acer campestre	0.0606	0.0183	0.0047	0.0013
Acer platanoides	0.0512	0.0056	-0.0164	-0.0064
Acer pseudoplatanus	0.0563	-0.0523	-0.0150	0.0065
Alnus glutinosa	0.0292	0.0116	-0.0105	0.0142
Alnus incana	0.0174	-0.0461	-0.0232	0.0509
Alnus viridis	-0.0475	-0.0503	0.0497	-0.0071
Artemisia vulgaris	0.0200	0.0032	**0.0995**	0.0245
Campanula scheuchzeri	**-0.0710**	-0.0051	0.0118	0.0006
Carex flacca	0.0238	-0.0643	-0.0368	**-0.0903**
Carex remota	0.0416	-0.0080	**-0.1030**	0.0285
Carpinus betulus	0.0508	0.0349	0.0002	-0.0393
Centaurea jacea	0.0448	-0.0397	-0.0012	**-0.0843**
Crataegus laevigata	0.0324	-0.0028	-0.0450	0.0079
Crataegus monogyna	0.0610	0.0051	0.0058	0.0011
Dryopteris affinis	0.0010	-0.0337	-0.0273	**0.1286**

Echium vulgare	0.0258	-0.0025	**0.1243**	0.0250
Euphrasia rostkoviana	-0.0256	**-0.0842**	0.0118	-0.0152
Fagus sylvatica	0.0486	-0.0421	-0.0746	0.0432
Frangula alnus	0.0306	0.0100	-0.0152	0.0305
Fraxinus excelsior	**0.0705**	-0.0274	0.0002	0.0268
Gentiana verna	-0.0482	-0.0362	0.0196	**-0.0831**
Geum urbanum	**0.0721**	-0.0203	-0.0024	0.0268
Glechoma hederacea	**0.0706**	-0.0074	-0.0184	-0.0093
Gnaphalium supinum	-0.0566	**0.0624**	-0.0389	0.0188
Homogyne alpina	**-0.0720**	-0.0118	-0.0037	-0.0213
Hypericum montanum	0.0072	-0.0395	0.0396	**0.1303**
Ilex aquifolium	0.0351	-0.0032	-0.0499	0.0439
Juglans regia	0.0603	0.0273	0.0127	0.0212
Lapsana communis	**0.0716**	-0.0043	-0.0235	0.0025
Larix decidua	-0.0171	-0.0192	0.0498	0.0506
Leucanthemopsis alpina	-0.0563	**0.0628**	-0.0385	0.0185
Luzula nivea	-0.0132	-0.0312	0.0950	**0.1296**
Lysimachia nemorum	0.0279	-0.0541	**-0.1092**	-0.0140
Petasites albus	-0.0036	**-0.0860**	-0.0377	0.0197
Picea abies	0.0140	-0.0724	-0.0238	0.0117

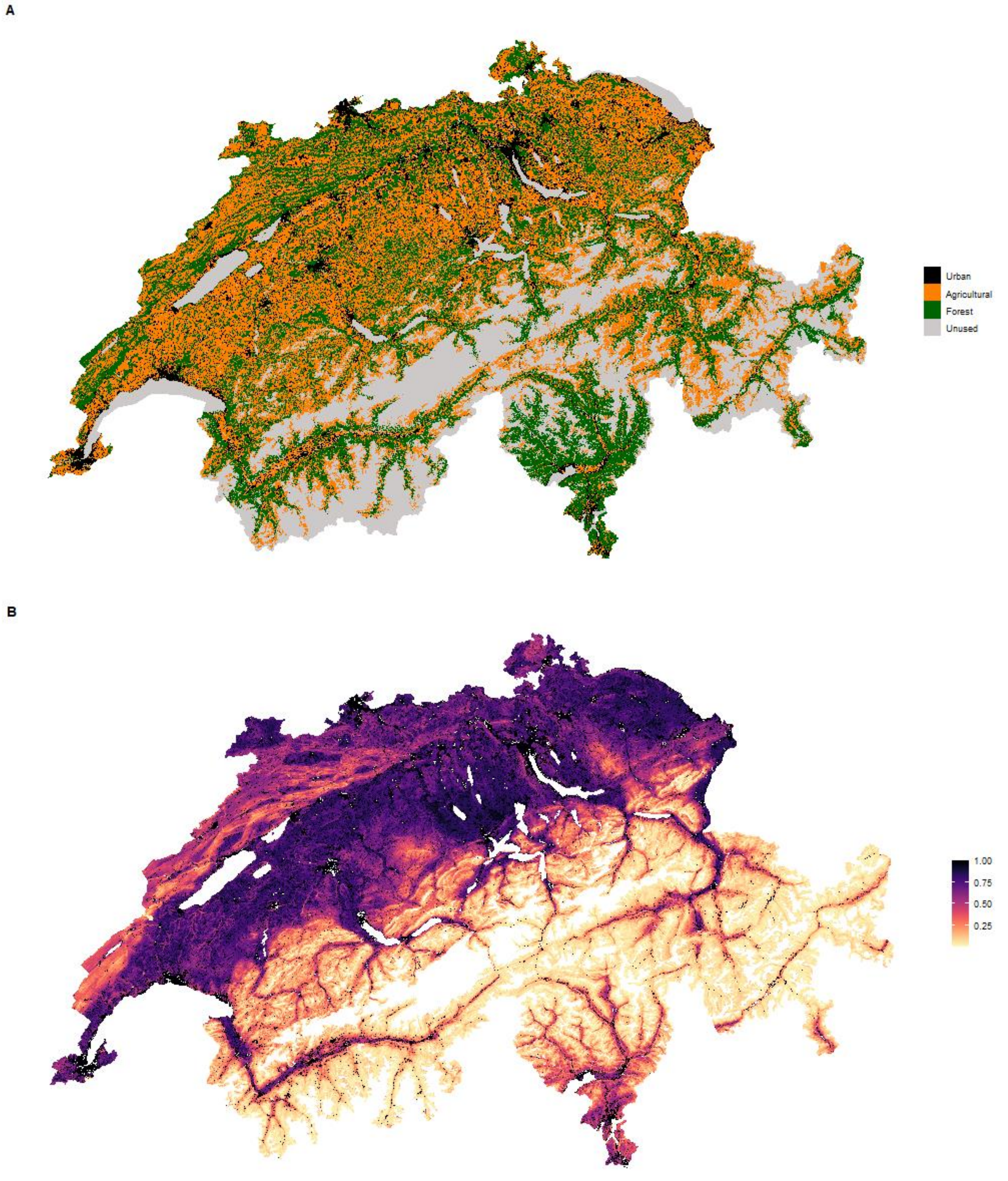
Pinus sylvestris	0.0287	-0.0055	-0.0064	0.0234
Plantago alpina	-0.0508	-0.0199	0.0138	**-0.0810**
Plantago atrata	-0.0434	-0.0340	0.0244	**-0.0940**
Poa alpina	**-0.0730**	-0.0173	0.0031	-0.0288
Polygonum viviparum	**-0.0717**	-0.0012	0.0058	-0.0475
Polypodium vulgare	-0.0154	-0.0302	0.0794	**0.1333**
Populus tremula	0.0207	-0.0361	0.0323	0.0563
Potentilla erecta	-0.0232	**-0.0845**	0.0157	0.0320
Primula elatior	0.0280	-0.0566	**-0.0983**	-0.0578
Quercus petraea	0.0268	-0.0024	0.0365	0.0633
Quercus robur	0.0604	0.0185	-0.0333	0.0029
Ranunculus montanus aggr.	**-0.0699**	-0.0170	0.0136	-0.0004
Salix appendiculata	-0.0255	-0.0714	0.0029	0.0134
Salix caprea	0.0371	-0.0575	-0.0152	-0.0190
Salix herbacea	-0.0556	**0.0584**	-0.0387	0.0042
Salix myrsinifolia	-0.0247	-0.0322	0.0237	-0.0057
Salix purpurea	0.0103	-0.0293	0.0047	-0.0091
Salix retusa	-0.0548	0.0257	-0.0262	-0.0495
Salvia glutinosa	0.0092	-0.0360	0.0388	**0.1300**
Salvia pratensis	0.0438	0.0112	**0.0990**	0.0009

Sibbaldia procumbens	-0.0563	**0.0610**	-0.0362	0.0141
Silene dioica	-0.0057	**-0.0850**	-0.0003	0.0136
Silene exscapa	-0.0504	**0.0572**	-0.0306	0.0196
Silene nutans	-0.0191	-0.0451	**0.1051**	0.0462
Silene vulgaris	-0.0078	-0.0434	**0.1059**	-0.0055
Sorbus aria	0.0128	-0.0740	0.0112	0.0658
Sorbus aucuparia	0.0079	-0.0776	0.0058	0.0451
Tilia cordata	0.0353	0.0142	0.0305	0.0494
Tilia platyphyllos	0.0485	0.0056	-0.0134	-0.0116
Ulmus glabra	0.0407	-0.0237	-0.0452	0.0366
Veronica beccabunga	0.0195	-0.0551	**-0.0992**	-0.0368
Veronica montana	0.0375	-0.0084	**-0.1017**	0.0039
Veronica persica	**0.0712**	0.0060	-0.0101	-0.0208
Veronica urticifolia	-0.0090	**-0.0864**	0.0026	0.0655

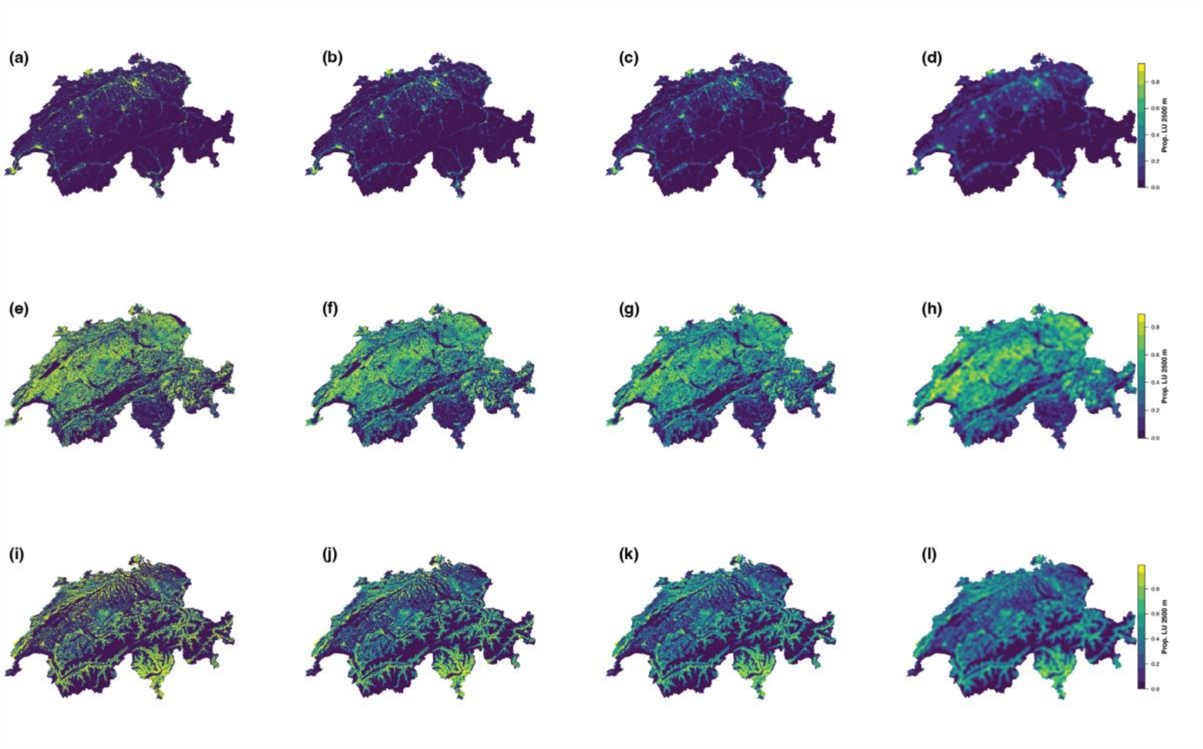


Appendix S12. Maps of the four vegetation variables used in the model. (a) Map corresponding to PCA1, which reflects the elevation gradient, with positive values indicating more colline–montane species (e.g. *Geum urbanum*, *Lapsana communis, Veronica persica*) and negative values indicating subalpine–alpine species (e.g. *Poa alpina*, *Homogyne alpina*, *Polygonum viviparum*). This variable was not used because it was highly correlated with climate PCA1. (b) Map corresponding to PCA2 (named mid-elevation coniferous), which shows a gradient in the dominance of coniferous plant communities, with negative values indicating coniferous plant communities (fir, spruce and Scots pine forest with the associated herbaceous plants, e.g. *Silene dioica*, *Petasites albus*, *Veronica urticifolia)* and positive values indicating other vegetation types, including lowland vegetation at intermediate positive values and high-elevation plants at large positive values (e.g. *Salix herbacea*, *Leucanthemopsis alpina*, *Gnaphalium supinum)*. (c) Map corresponding to PCA3 (named dry–wet), which depicts a dry to wet gradient, with positive values indicating ruderal and/or dry open vegetation (e.g. *Echium vulgare*, *Silene* *vulgaris*, *Artemisia vulgaris*) and negative values indicating wet forest vegetation (e.g. *Veronica montana*, *Carex remota*, *Lysimachia nemorum*). (d) Map corresponding to PCA4 (named forest), which depicts a gradient from woody to open vegetation, with positive values indicating plant assemblages from forests and shrublands (e.g. *Polypodium vulgare*, *Hypericum montanum*, *Salvia glutinosa*) and negative values indicating plant assemblages from meadows, pastures and other types of open vegetation (e.g. *Plantago atrata*, *Carex flacca*, *Centaurea jacea*).

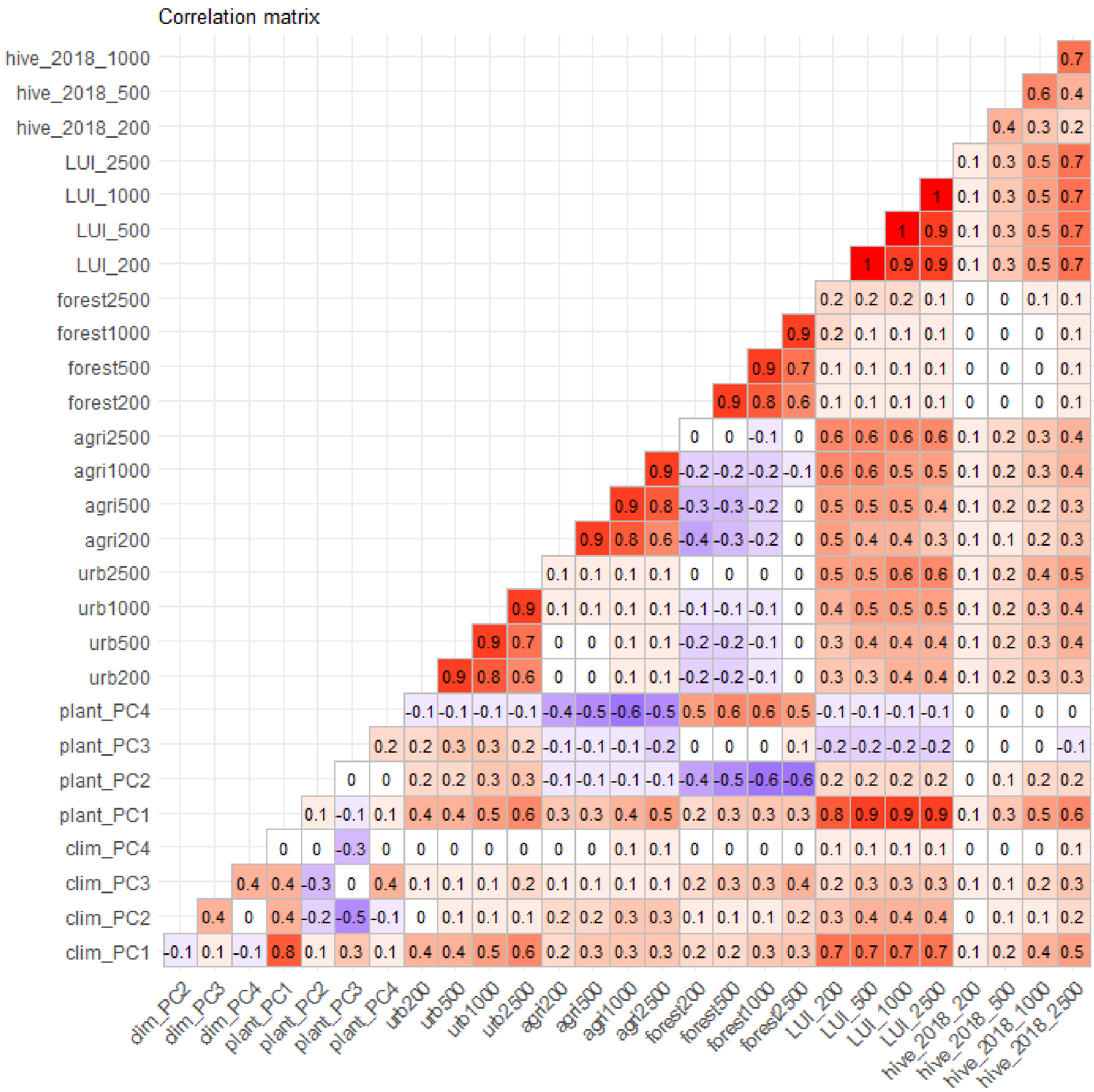
Appendix S13. The Land Use and Land Cover data include 4 principal types (urban, rural, forest, unproductive), 10 classes, and 46 basic categories, and they have a resolution of 100 m by 100 m, thus matching that of the bee data. We focused on three of the four principal domains: urban, agricultural and forest. Urban (Buchholz et al., 2020; Fournier et al., 2020), agricultural (Evans et al., 2018), and forest (Brosi et al., 2007) land-use types were all shown to be important drivers of the functional and taxonomic composition of bee communities. Urban land-use (7.5 % of the total surface area) includes all types of settlements and build-up infrastructure, including buildings, transportation infrastructure, special infrastructure, sport and leisure areas and urban green areas (e.g. gardens, cemeteries, parks). Thus, they not only indicate major settlements but also, e.g., sparse infrastructure, towns, transportation networks, which is the main case at higher elevations. Agricultural land-use (35.9 % of the total surface area) encompasses productive surfaces relating to crop growing, livestock and fruit cultivation. They include all herbaceous, arbustive and arboreous crops, as well as alpine meadows, pastures and other grazing areas. Finally, forest land use (31.3 % of the total surface area) includes all the different types of forest found in Switzerland except agroforestry. For details, see Altwegg and Weibel (2015) and FSO (2013). We excluded unproductive land-use types, such as water bodies, glaciers and permanent snow, as they mostly represent non-bee habitat.

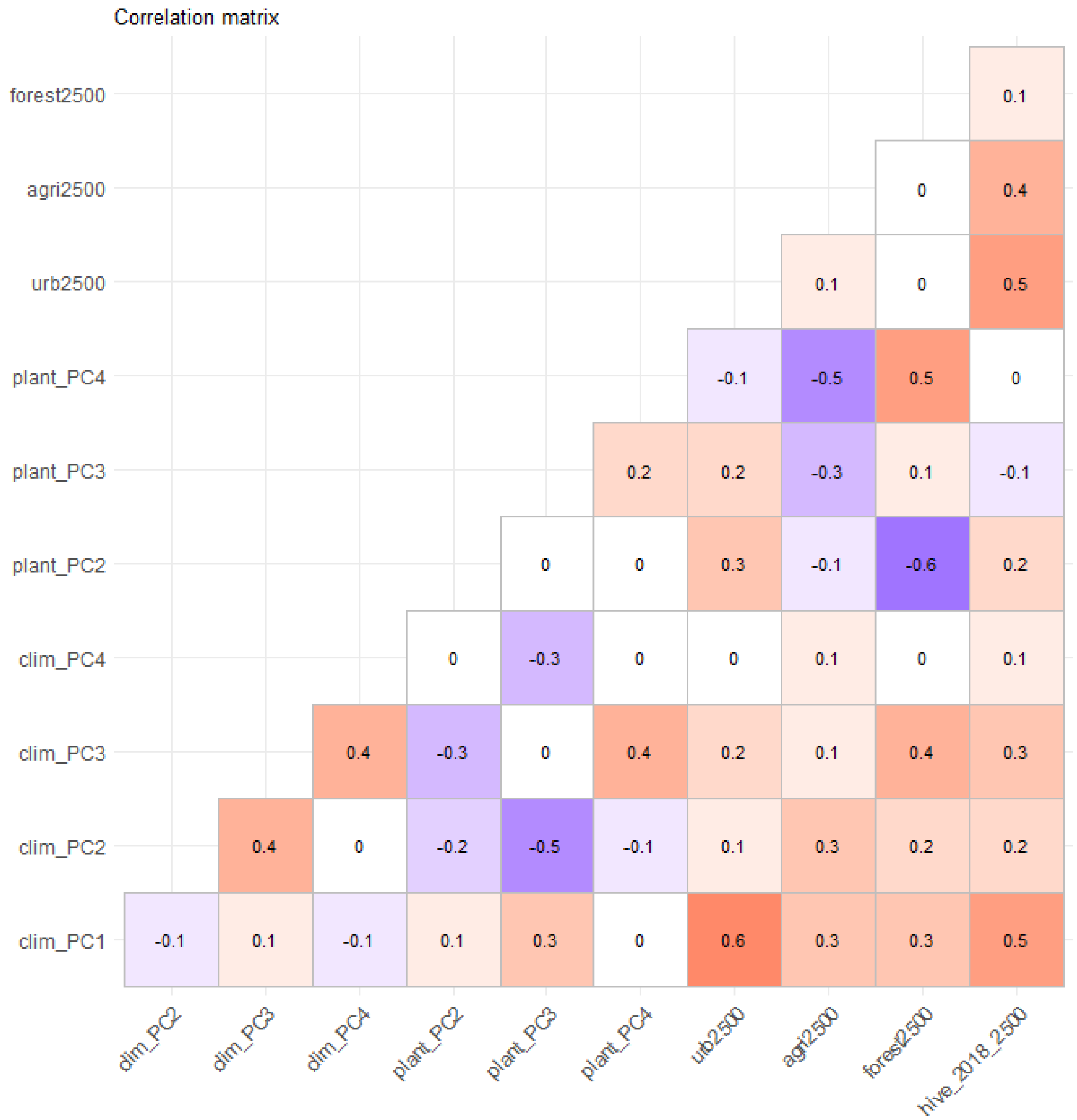


Appendix S14. Maps of (a) land use and (b) land-use intensity in Switzerland, based on Meier et al. (2020).

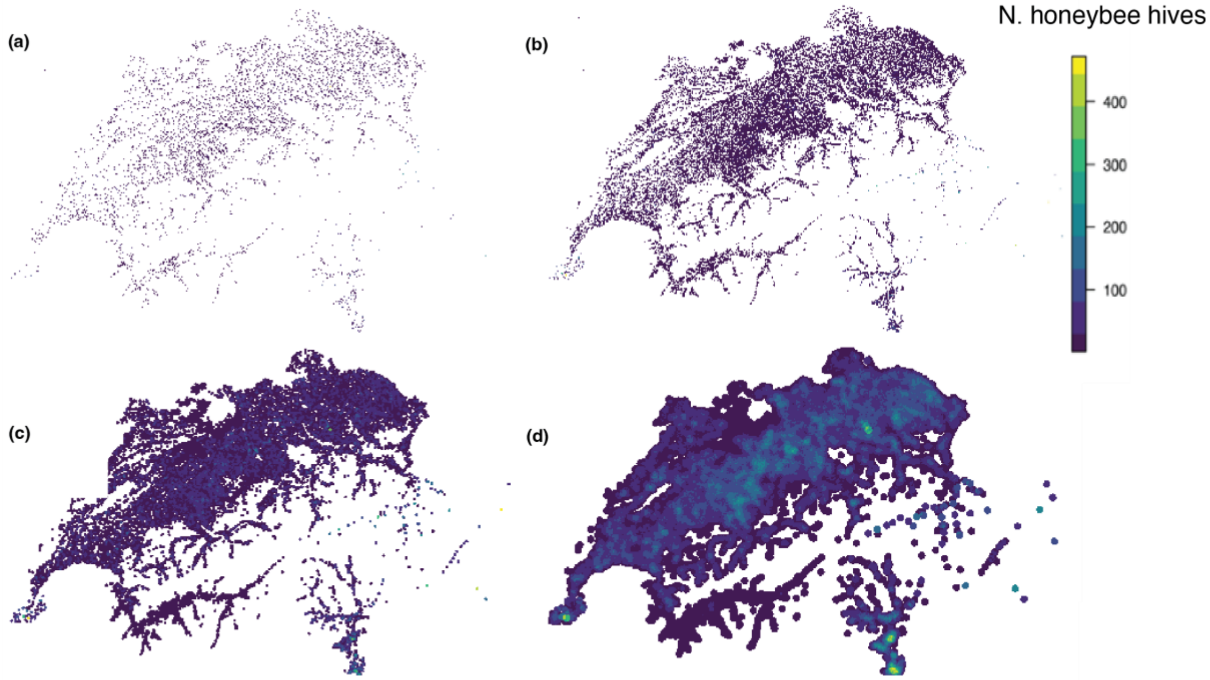


Appendix S15. Maps depicting the landscape metrics in the three land-use categories (agricultural, forest, urban). (a–d) Proportion of urban land use in 200, 500, 1000 and 2500 m radii around each raster cell centre. (e–h) Proportion of agricultural land use in 200, 500, 1000 and 2500 m radii. (i–l) Proportion of forest land use in 200, 500, 1000 and 2500 m radii.

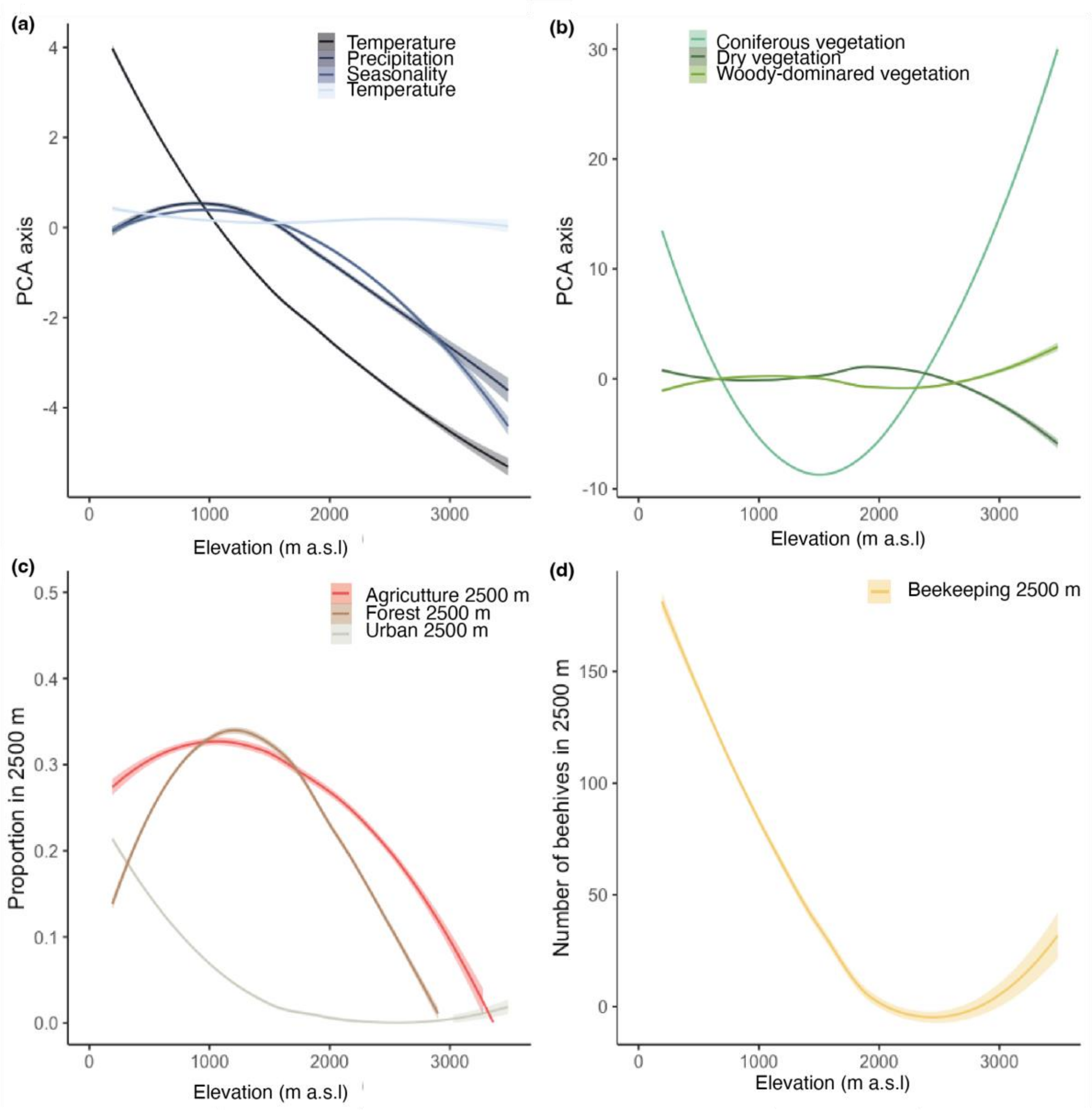

Correlation matrix
hive_2018_1000
hive_2018_500
hive_2018_200
LUI_2500
LUI_1000
LUI_500
LUI_200
forest2500
forest1000
forest500
forest200
agri2500
agri1000
agri500
agri200
urb2500
urb1000
urb500
urb200
plant_PC4
plant_PC3
plant_PC2
plant_PC1
clim_PC4
clim_PC3
clim_PC2
clim_PC1
clim_PC2
clim_PC3
clim_PC4
plant_PC1
plant_PC2
plant_PC3
plant_PC4
urb200
urb500
urb1000
urb2500
agri200
agri500
agri1000
agri2500
forest200
forest500
forest1000
forest2500
LUI_200
LUI_500
LUI_1000
LUI_2500
hive_2018_200
hive_2018_500
hive_2018_1000
hive_2018_2500



Appendix S16. Correlation matrices between predictors. (a) Correlation matrix between all candidate predictors and (b) correlation matrix among the selected predictors. Red shading indicates positive correlations and blue indicates negative correlations.



Appendix S17. Maps depicting beekeeping intensity in Switzerland. Number of beehives in a (a) 200 m, (b) 500 m, (c) 1000 m, and (d) 2500 m radius around each raster cell centre.



Appendix S18. Relationship between the selected climate (four predictors, a), vegetation (three predictors, b), land use (three predictors, c), and beekeeping intensity (one predictor, d) predictors and elevation. Climate predictors represent principal components analysis (PCA) axes 1–4, which are related to temperature, precipitation, seasonality and precipitation seasonality (see details in Appendix S3). Vegetation predictors represent PCA axes 2–4, which are related to mid-elevation coniferous plant communities, dry plant communities, and forest plant communities (see details in Appendix S4 and Fig. S7). Land-use metrics represent the proportion of each land-use type (i.e. agricultural, forest, urban) within a 2500 m radius from each focal cell. Beekeeping intensity represents the number of beehives within a 2500 m radius from each focal cell. Note that the upper value of the elevation range has been narrowed to 3500 m a.s.l. for simplicity.

Appendix S19. Types of protected areas considered. For each protected area type, we indicate in what group of protected areas were included according to their protective measures (Classification), that is, strict protection = Protected areas *sensu stricto*; less strict protection = Protected areas *sensu lato*. We also indicate the main legislative authority, the equivalence with the IUCN categories, when possible, the proportion of the Swiss surface they represent, a description, some indication on the protection provisions, the existing law and reference to the official administrative bodies.

Protected area	Classification	Authority	IUCN category	Proportion surface	Description	Protection provisions	Law	Reference
Biotopes of National Interest: dry medows Biotopes of National Interest: bogs Biotopes of National Interest: floodplains Biotopes of National Interest: fens Biotopes of National Interest: amphibian reproduction sites	Strictly protected areas	Confederation	Not assessed officially, but likely IV	2.17%	Highly mencaed biotop types, which are highly monitored to preserve them. The aim of these inventories is to effectively protect the habitats of endangered animals and plants.	Management intensity and anthropogenic influence to the minimum. E.g.: No agricultural activities No hunting No leisure or other anthropogenic activities Continuous monitoring Specific management to promote biodiverssity and matian habitats might occur.	451: Loi fédérale sur la protection de la nature et du paysage	FOEN 2012a, FOEN, 2022
Ramsar		International	Not assessed officially, but likely IV	0.20%	Areas aimed at guaranteing the sustainable use and protection of waterfowl habitats.		451: Loi fédérale sur la protection de la nature et du paysage 0.451.45: Convention relative aux zones humides d'importance internationale particulièrement comme habitats des oiseaux d'eau	Ramsar, 2022
National Park		Confederation	II	0.41%	The only national park of the country, which has beeen assessed by the IUCN and classified within category II		454 Loi fédérale sur le Parc national suisse dans le canton des Grisons	Swiss National Park, 2022
Forest reserves		Confederation	Not assessed officially, but likely IV	2.10%	Forest reserves are among the core areas that form the basis of the ecological infrastructure in forests. In natural forest reserves, no silvicultural intervention is carried out and the forest is left to develop naturally. In special forest reserves, targeted interventions are aimed at promoting threatened species, which are mainly light and heat demanding species.		921.0: Loi fédérale sur les forêts	FOEN, 2020, 2021b
Pro Natura forest reserves		NGO		0.09%	Privately owned forest reserves. These forests are either untouched or used in traditional ways, with special measures in place to support biodiversity. In this manner, many habitats are preserved along with all their fauna and flora.		921.0: Loi fédérale sur les forêts	Pronatura, 2022
Pro Natura nature reserves		NGO		0.65%	Privately owned Natural reserves, which are either untouched or		Private law	Pronatura, 2022

Appendix S19. *Continuation*

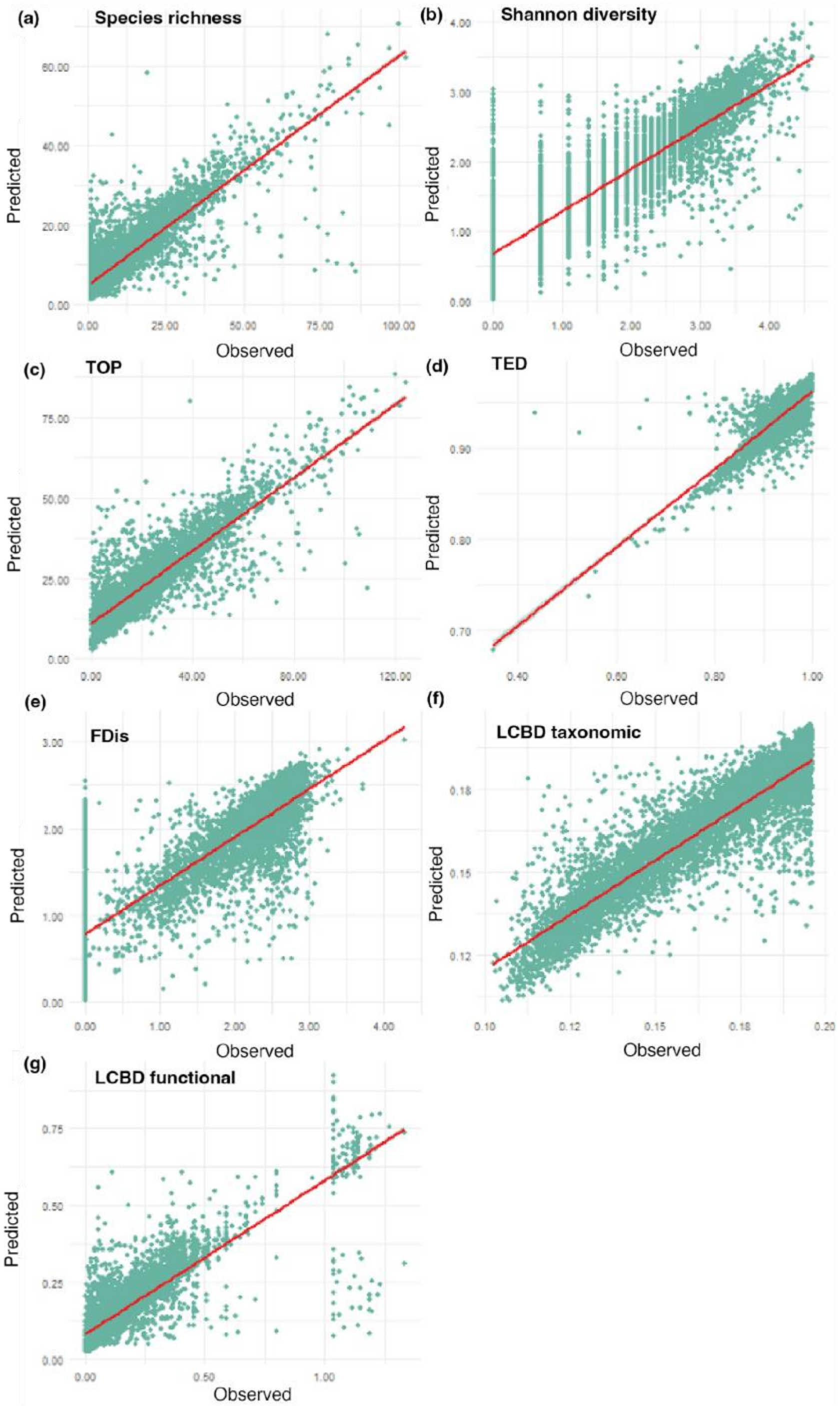
Protected area	Classification	Authority	IUCN category	Proportion surface	Description	Protection provisions	Law	Reference
Water and migrant bird reserves	Protected multiple use areas	Confederation / International	Not assessed officially, possible IV	4,84%	Areas aimed to protect the natural habitats of migratory birds that live in Switzerland throughout the year.	Variable management intensity and anthropogenic influence.	922.32: Ordonnance sur les réserves d'oiseaux d'eau et de migrateurs d'importance internationale et nationale	FOEN, 2002
Emerald sites		International	Not assessed	1.56%	The Emerald Network aims to protect species and natural environments of particularly high ecological value in Europe. Switzerland, as a Contracting Party to the Bern Convention, is also committed to this goal. So far, 37 areas proposed by Switzerland have been included in this international network.		0.455: Convention relative à la conservation de la vie sauvage et du milieu naturel de l'Europe	FOEN, 2003, 2012b
Swiss parks		Cantonal, municipal	Not assessed, some could be V or VI	12.28%	Regional nature parks are partly inhabited rural areas with a high level of natural, landscape and cultural wealth. They enhance the quality of nature and landscape and promote the sustainable development of the regional economy. Peri-urban nature parks are areas in the vicinity of a highly urbanised region which offer intact natural habitats for indigenous flora and fauna in their core area. The core area is surrounded by a transition zone that serves as a buffer and offers a variety of opportunities for education, discovery and recreation, thus making an important contribution to the quality of life of the urban population.		451: Loi fédérale sur la protection de la nature et du paysage	FOEN, 2018a
UNESCO Natural Heritage		International	Not assessed officially, possible III, V, VI	2.80%	The World Heritage List is an instrument of the Convention concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention). It lists properties classified by the World Heritage Committee for their outstanding universal value.		International law RO 1975 2221 Arrêté fédéral du 19 juin 1975 approuvant deux conventions de l'UNESCO en matière de protection du patrimoine culturel et naturel et de conservation des zones humides	FOEN, 2016
Game reserves		Confederation	Not assessed officially, some could be V	3.63%	In accordance with the provisions of the Ordinance on Federal Game Reserves, game reserves "are intended to protect and conserve rare and endangered wild mammals and birds and to protect and conserve their biotopes. They are also intended to maintain healthy populations of huntable species adapted to local conditions		922.0: Loi fédérale sur la chasse et la protection des mammifères et oiseaux sauvages	FOEN, 2018b
UNESCO Biosphere		International	Not assessed officially, possible III, V, VI	2.94%	The United Nations Educational, Scientific and Cultural Organisation (UNESCO) has set up the Man and Biosphere Programme (MAB) with the aim of developing new models for the sound management of natural environments. The MAB programme is implemented in UNESCO biosphere reserves. It applies the principles of sustainable and environmentally friendly development.		International law RO 1975 2221 Arrêté fédéral du 19 juin 1975 approuvant deux conventions de l'UNESCO en matière de protection du patrimoine culturel et naturel et de conservation des zones humides	UNESCO, 2022

Appendix S20. Performance of the different algorithms used to predict the α and ß taxonomic and functional attributes of wild bee communities in Switzerland. Three performance metrics were calculated on the test dataset (i.e. data not used for model calibration): root mean squared error (RMSE), R^2 and mean absolute error (MAE).

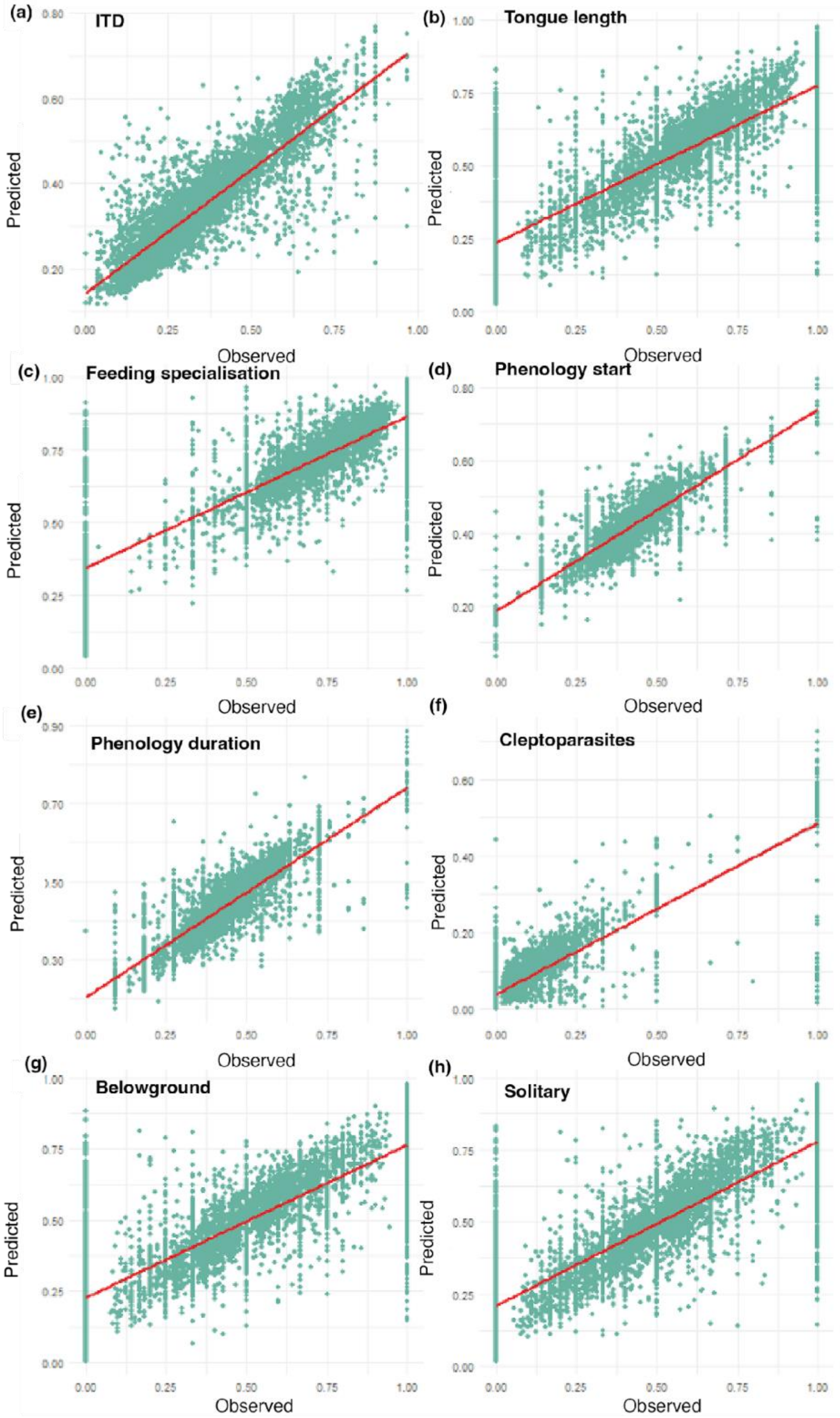
RMSE	R^2	MAE	Response	Model
5.03	0.91	3.36	Richness	Random forest
15.89	NA	9.59	Richness	Neural networks
12.40	0.04	8.83	Richness	Generalized linear models
0.45	0.92	0.37	Shannon	Random forest
1.40	0.02	1.18	Shannon	Neural networks
1.19	0.04	1.02	Shannon	Generalized linear models
0.43	0.91	0.35	FDis	Random forest
1.30	0.02	1.21	FDis	Neural networks
1.04	0.02	0.90	FDis	Generalized linear models
7.94	0.91	5.97	TOP	Random forest
30.62	NA	23.54	TOP	Neural networks
19.09	0.05	14.76	TOP	Generalized linear models
0.02	0.90	0.01	TED	Random forest
0.04	0.01	0.03	TED	Neural networks

0.04	0.01	0.03	TED	Generalised linear models
0.07	0.91	0.05	ITD	Random forest
0.16	0.14	0.12	ITD	Neural networks
0.16	0.11	0.12	ITD	Generalised linear models
0.12	0.91	0.09	Feeding specialisation	Random forest
0.28	0.05	0.21	Feeding specialisation	Neural networks
0.28	0.03	0.21	Feeding specialisation	Generalised linear models
0.14	0.91	0.11	Tongue length	Random forest
0.32	0.11	0.26	Tongue length	Neural networks
0.32	0.08	0.26	Tongue length	Generalised linear models
0.05	0.90	0.03	Phenology start	Random forest
0.11	0.12	0.08	Phenology start	Neural networks
0.11	0.09	0.08	Phenology start	Generalised linear models
0.05	0.90	0.04	Phenology duration	Random forest
0.11	0.12	0.08	Phenology duration	Neural networks
0.12	0.09	0.08	Phenology duration	Generalised linear models
0.07	0.90	0.04	Cleptoparasite	Random forest
0.15	0.03	0.09	Cleptoparasite	Neural networks

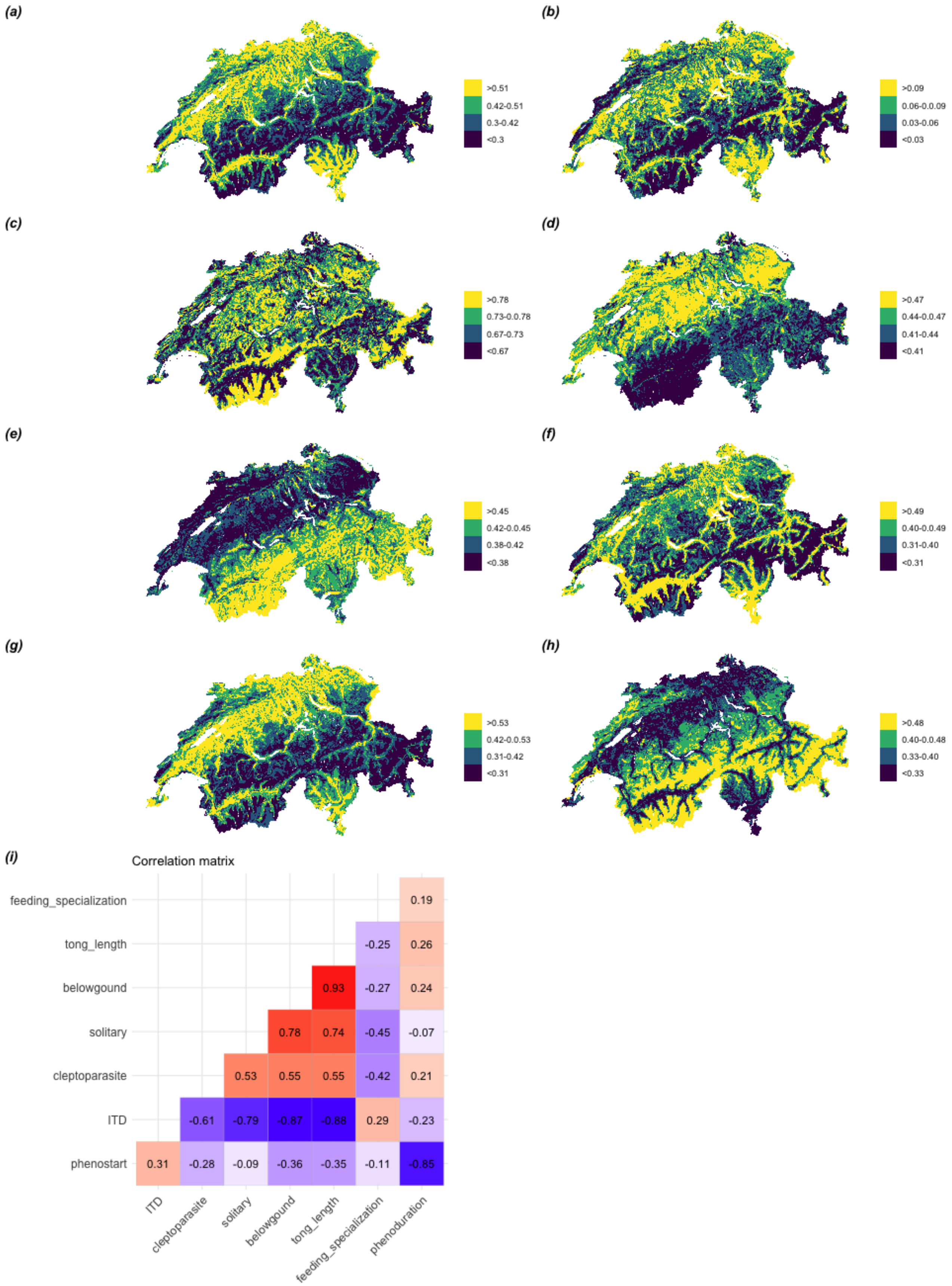
0.15	0.02	0.09	Cleptoparasite	Generalised linear models
0.14	0.91	0.11	Belowground	Random forest
0.32	0.08	0.25	Belowground	Neural networks
0.32	0.08	0.25	Belowground	Generalised linear models
0.13	0.91	0.10	Solitary	Random forest
0.30	0.16	0.24	Solitary	Neural networks
0.31	0.12	0.25	Solitary	Generalised linear models
0.00	0.92	0.00	LCBD taxonomic	Random forest
0.00	NA	0.00	LCBD taxonomic	Neural networks
0.00	0.14	0.00	LCBD taxonomic	Generalised linear models
0.00	0.90	0.00	LCBD functional	Random forest
0.00	NA	0.00	LCBD functional	Neural networks
0.00	0.01	0.00	LCBD functional	Generalised linear models



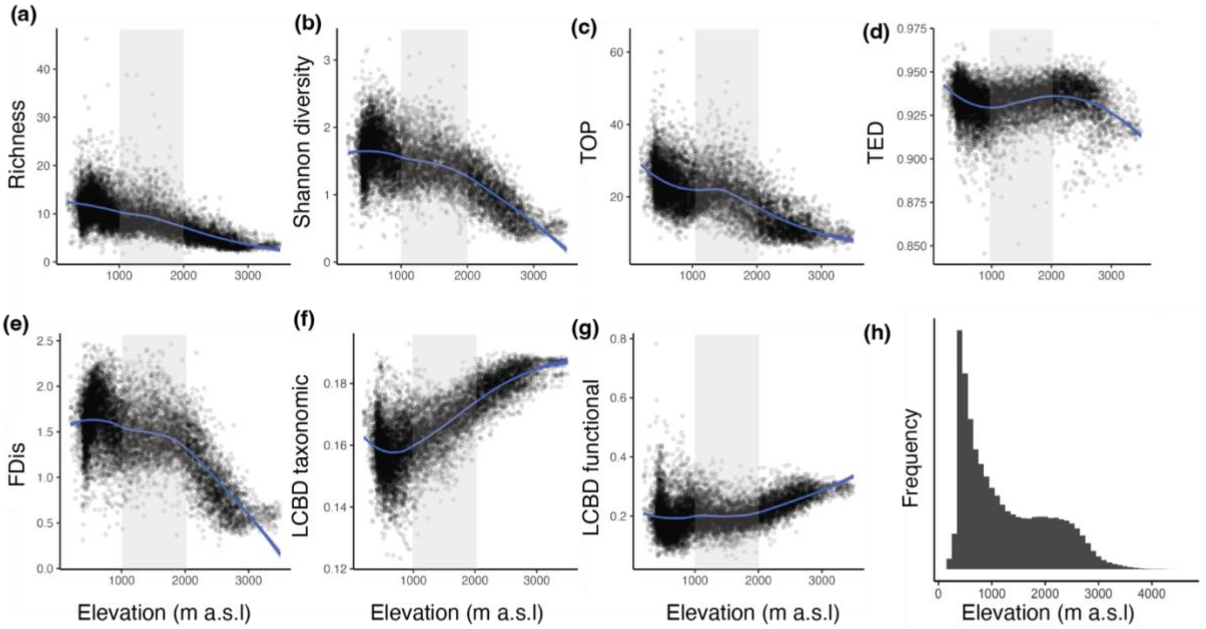
Appendix S21. Scatterplots of the predictive performance (observed vs. predicted values) of random forest models for diversity metrics. (a) species richness , (b) Shannon diversity, (c) trait onion peeling (TOP), (d) trait evenness distribution (TED), (e) functional dispersion (FDis), (f) local community contributions to the taxonomic ß-diversity (LCBD taxonomic), and (g) local community contributions to the functional ß-diversity (LCBD functional).



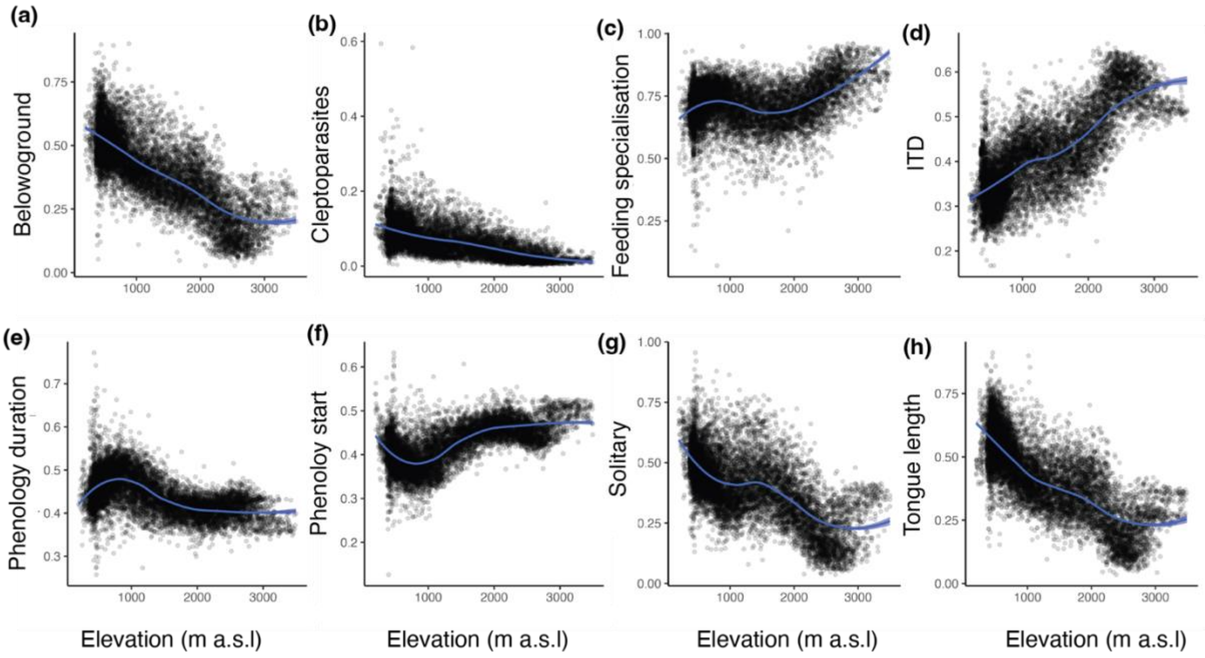
Appendix S22. Scatterplots of the predictive performance (observed vs. predicted values) of random forest models for community-weighted means of the eight studied wild bee traits. (a) intertegular distance (ITD), (b) tongue length, (c) feeding specialisation, (d) start of phenology, (e) duration of phenology, (f) % cleptoparasite, (g) % belowground nester, and (h) % solitary.


(a)
>0.51
0.42-0.51
0.3-0.42
<0.3
(b)
>0.09
0.06-0.0.09
0.03-0.06
<0.03
(c)
>0.78
0.73-0.0.78
0.67-0.73
<0.67
(d)
>0.47
0.44-0.0.47
0.41-0.44
<0.41
(e)
>0.45
0.42-0.0.45
0.38-0.42
<0.38
(f)
>0.49
0.40-0.0.49
0.31-0.40
<0.31
(g)
>0.53
0.42-0.0.53
0.31-0.42
<0.31
(h)
>0.48
0.40-0.0.48
0.33-0.40
<0.33
(i)
Correlation matrix
feeding_specialization 0.19
tong_length -0.25 0.26
belowgound 0.93 -0.27 0.24
solitary 0.78 0.74 -0.45 -0.07
cleptoparasite 0.53 0.55 0.55 -0.42 0.21
ITD -0.61 -0.79 -0.87 -0.88 0.29 -0.23
phenostart 0.31 -0.28 -0.09 -0.36 -0.35 -0.11 -0.85
ITD
cleptoparasite
solitary
belowgound
tong_length
feeding_specialization
phenoduration

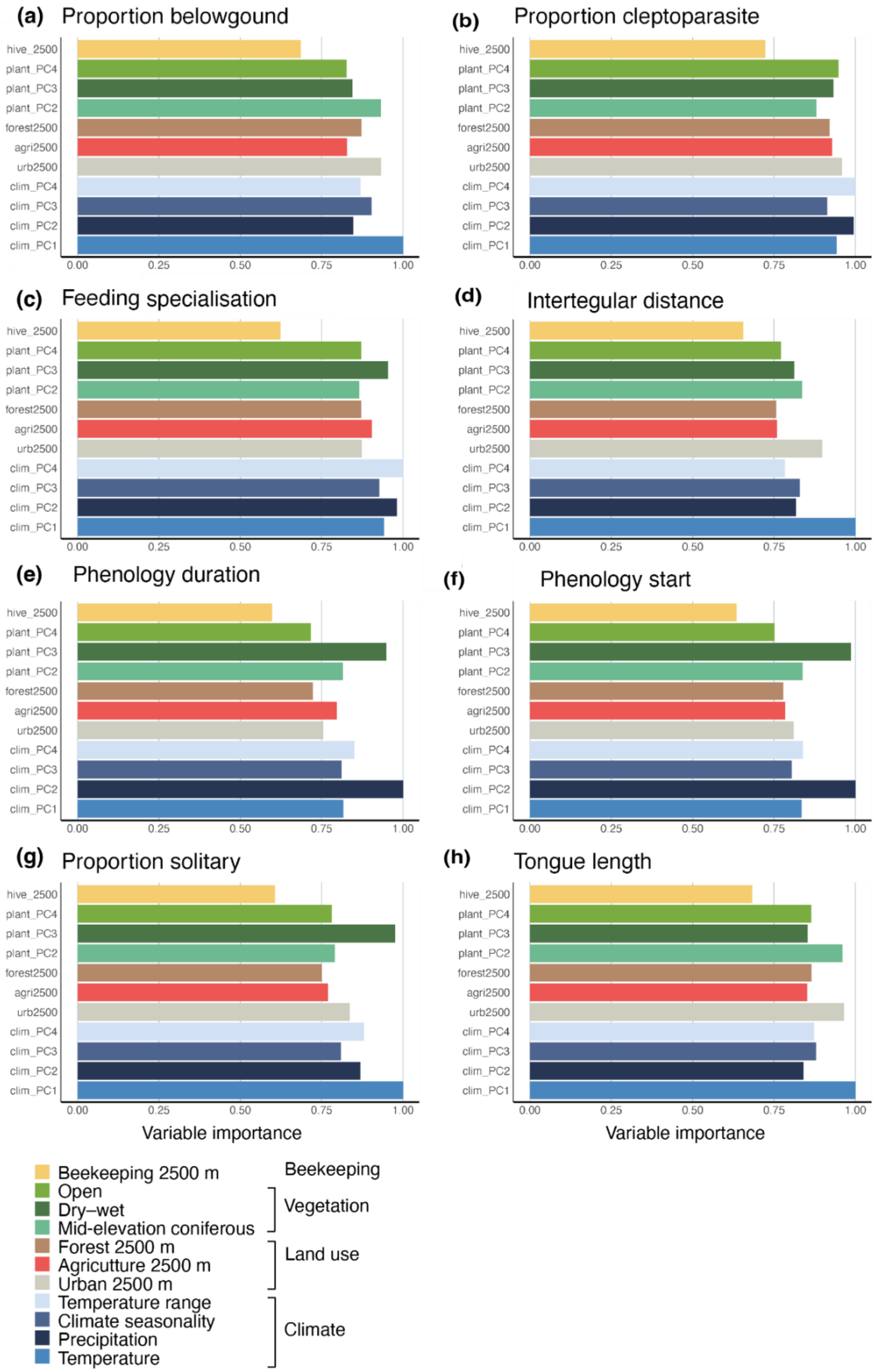
Appendix S23. Wild bee trait distribution in Switzerland. Maps depict the community-weighted means (CWMs) of (a) proportion of belowground species, (b) proportion of cleptoparasitic species (cleptoparasite), (c) feeding specialisation (feeding_specialisation), (d) duration of phenology (phenoduration), (e) proportion of solitary species (solitary), (f) tongue length (tong_length), and (g) intertegular distance (ITD). (h) Pearson correlations between the CWMs of the seven studied traits.



Appendix S24. Relationship between the predicted α and ß taxonomic diversity and elevation and between functional community attributes and elevation based on 10000 randomly selected cells. Fitted lines and the 95% confidence intervals (shaded bands) were obtained using local polynomial regression (LOESS).Relationships are shown between elevation and wild bee (a) species richness (rich), (b) Shannon diversity (shannon), (c) trait onion peeling (TOP), (d) trait evenness distribution (TED), (e) functional dispersion (FDis), (f) local community contributions to the taxonomic ß-diversity (LCBD_taxo), and (g) local community contributions to the functional ß-diversity (LCBD_fun). (h) Histogram of the digital elevation model for Switzerland. Note that the upper value of the elevation range has been narrowed to 3500 m a.s.l. for simplicity.

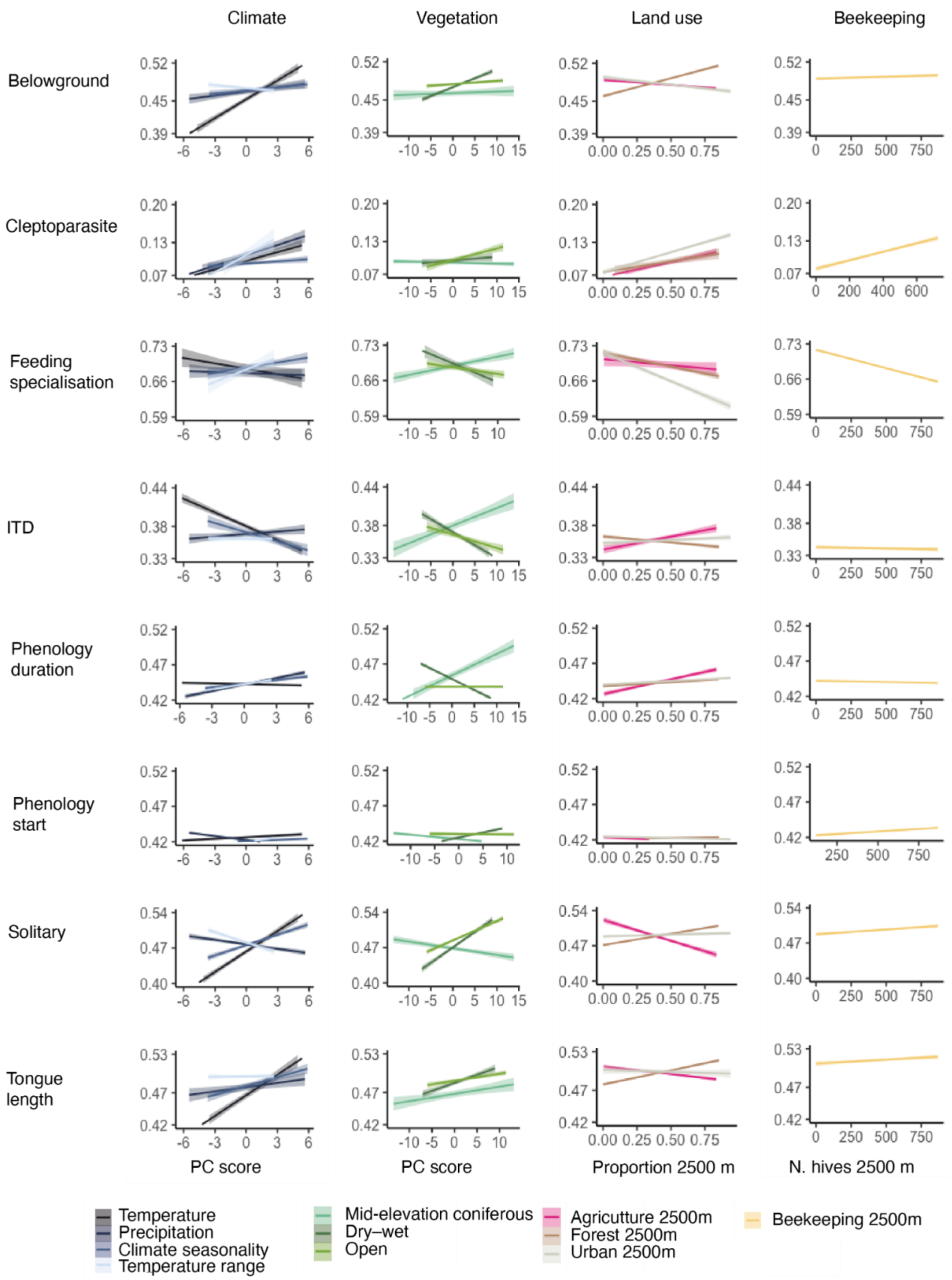


Appendix S25. Relationship between the community-weighted means (CWMs) of the eight studied traits and elevation based on 10000 randomly selected cells. Fitted lines and the 95% confidence intervals (shaded bands) were obtained from local polynomial regression (LOESS). Relationships are shown between elevation and (a) proportion of belowground species (belowground; high values = more belowground nesters, low values = fewer belowground nesters), (b) proportion of cleptoparasitic species (cleptoparasite; high values = more cleptoparasites, low values = less cleptoparasites), (c) feeding specialisation (feeding_specialisation; high values = less specialisation, low values = more specialisation), (d) intertegular distance (ITD), (e) duration of the phenology (phenoduration), (f) start of phenology (phenostart); (g) proportion of solitary species (solitary; high values = more solitary species, low values = fewer solitary species), and (h) tongue length (tongue_length; high values = longer tongues, low values = shorter tongues).

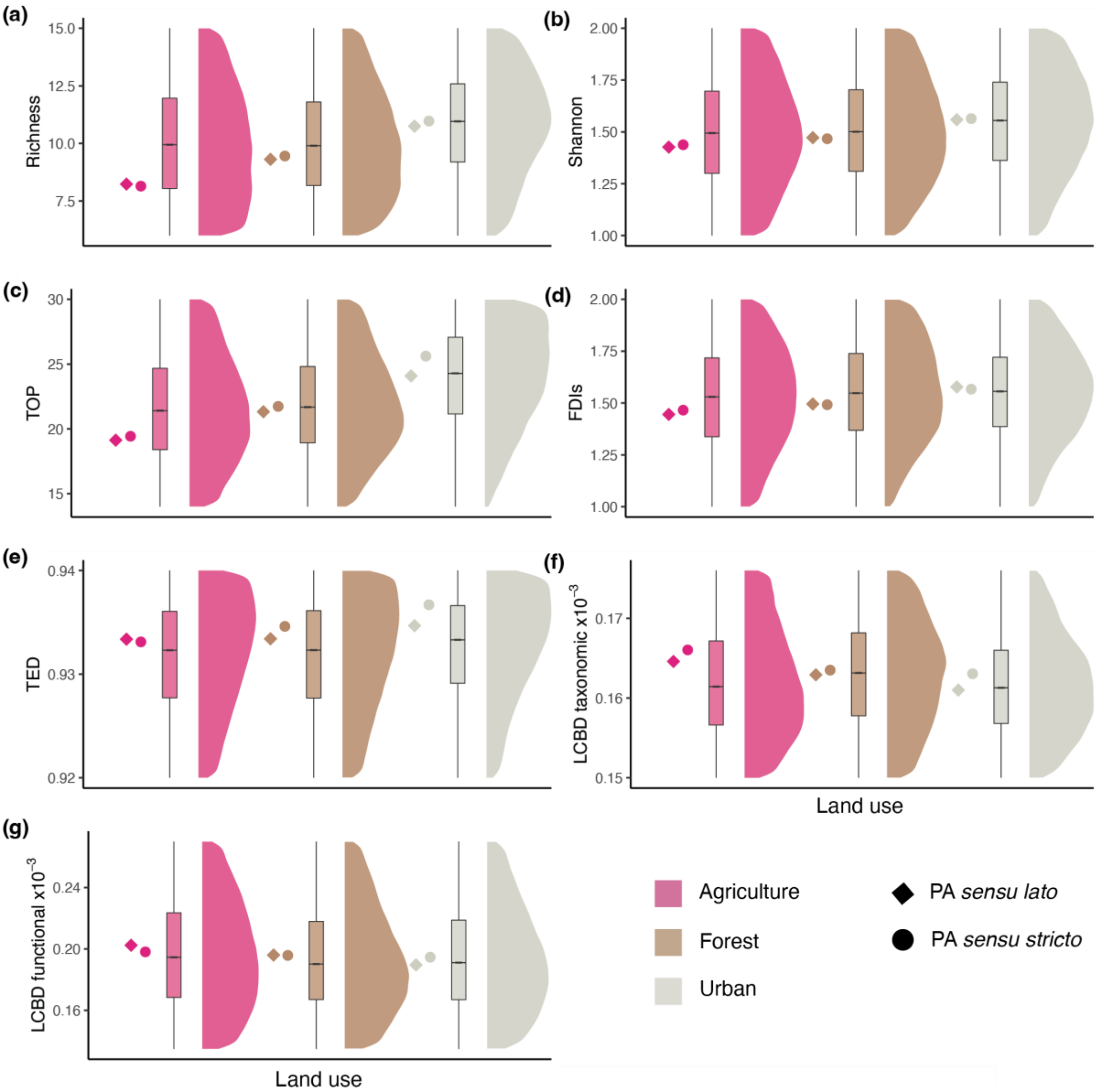


(a) Proportion belowgound
(b) Proportion cleptoparasite
(c) Feeding specialisation
(d) Intertegular distance
(e) Phenology duration
(f) Phenology start
(g) Proportion solitary
(h) Tongue length
hive_2500
plant_PC4
plant_PC3
plant_PC2
forest2500
agri2500
urb2500
clim_PC4
clim_PC3
clim_PC2
clim_PC1
0.00
0.25
0.50
0.75
1.00
Variable importance
Beekeeping 2500 m
Open
Dry–wet
Mid-elevation coniferous
Forest 2500 m
Agricutture 2500 m
Urban 2500 m
Temperature range
Climate seasonality
Precipitation
Temperature
Beekeeping
Vegetation
Land use
Climate

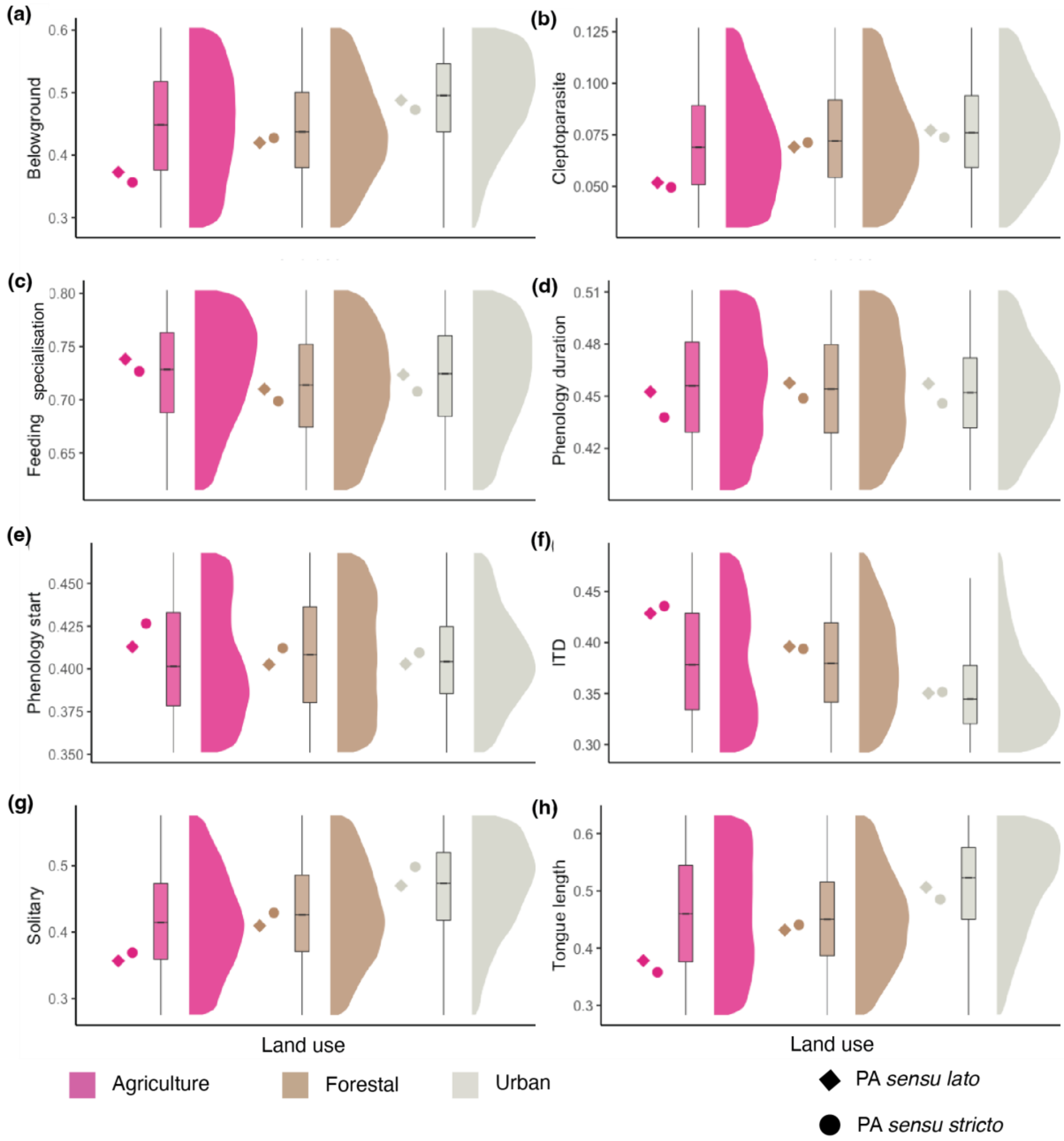
Appendix S26. Importance of the environmental variables as predictors of the community-weighted means of the eight studied wild bee traits in Switzerland. Predictors were classified into four main categories: climate, vegetation, land use and beekeeping. Variable importance was estimated using the residual sum of squares from random forest models (Breiman, 2001). Longer bars indicate variables that are better predictors of community attributes. Note that all importance values were divided by the maximum value to obtain a comparable range from 0 to 1. Climate and vegetation variables represent the principal components analysis (PCA) axis (PCA 1–4 for climate, PCA 2–4 for vegetation, representing 17% of the variation; for details see Methods, Tables S3–S4 and Figs S4–S5).



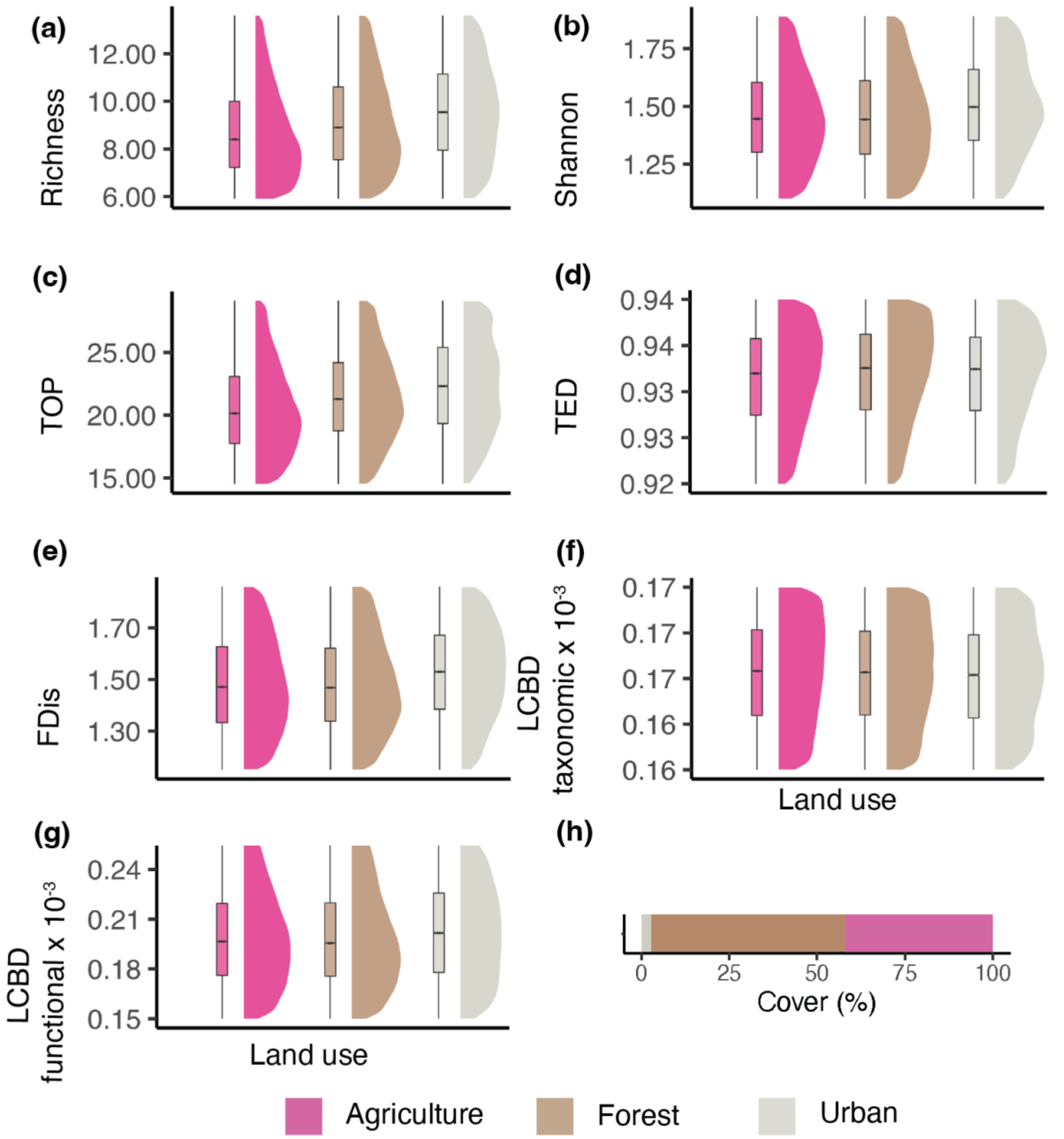
Appendix S27. Predicted changes in the community-weighted means (CWMs) of the eight studied wild bee traits along multiple environmental gradients. Partial dependence plots showing the shifts induced by selected variables representing climate, vegetation, land-use and beekeeping gradients, indicated by the CWM of the proportion of belowground species (belowground), proportion of cleptoparasitic species (cleptoparasite), feeding specialisation, intertegular distance (ITD), start of phenology (phenology start), duration of phenology (phenology duration), proportion of solitary species (solitary), and tongue length. Shaded bands indicate 95% confidence intervals. Climate and vegetation variables represent the principal components analysis (PCA) axis (PCA 1–4 for climate, PCA 2–4 for vegetation). For details see Methods, Tables S3–S4 and Figs S4–S5.



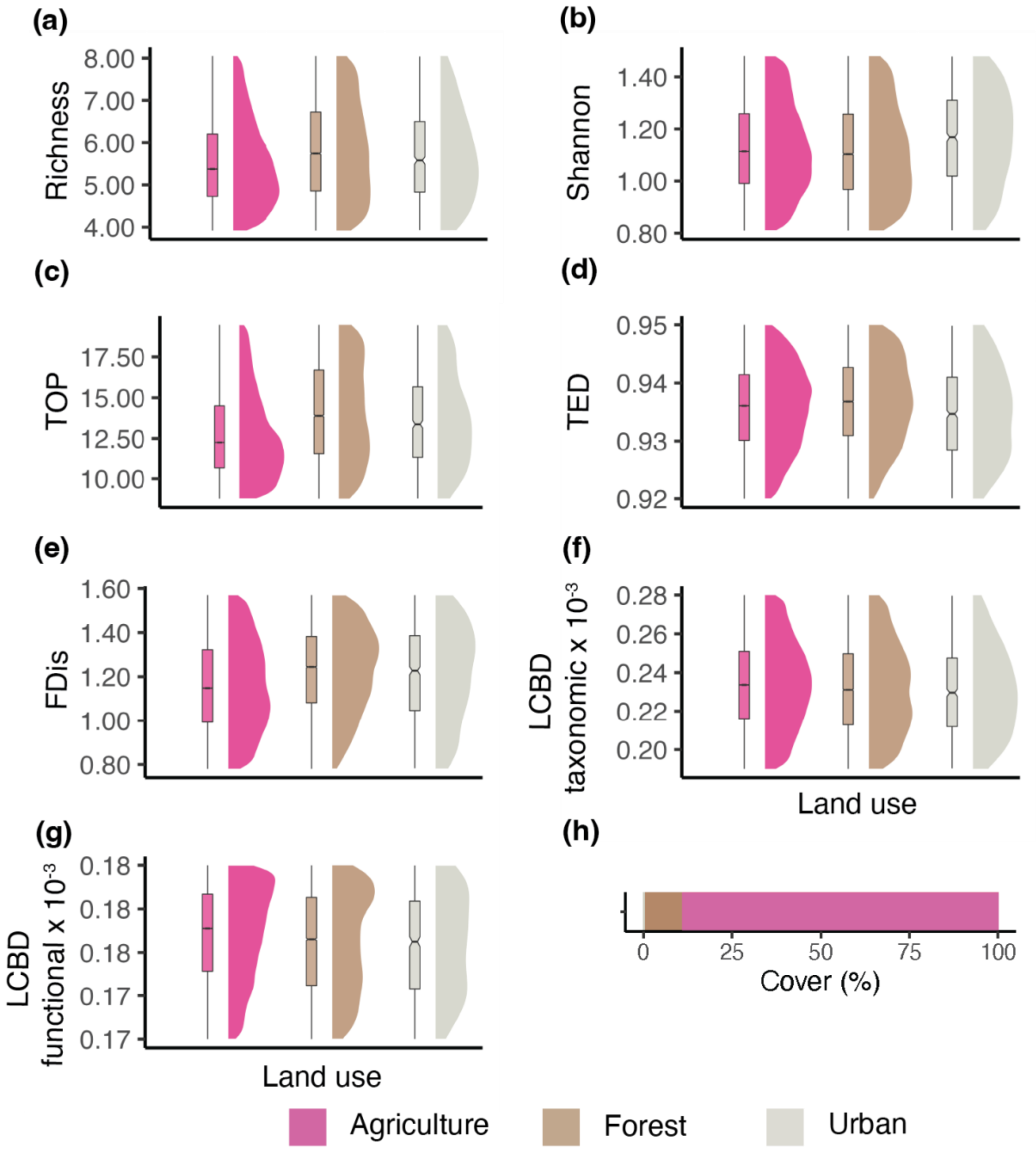
Appendix S28. Flat violin plots and boxplots showing the differences in the α and ß taxonomic diversity and functional diversity metrics among the three main land-use types agricultural, urban and forest. Notches in the boxplots indicate the 95% confidence interval of the median. Dots and diamonds indicate the median value of the metric in protected areas (PA) *sensu stricto* and *sensu lato*, respectively. (a) Species richness, (b) Shannon diversity, (c) functional richness (trait onion peeling TOP), (d) functional evenness (trait evenness distribution TED), (e) functional dispersion (FDis), (f) local community contributions to taxonomic ß-diversity (LCBD taxonomic), and (g) local community contributions to functional ß-diversity (LCBD functional).



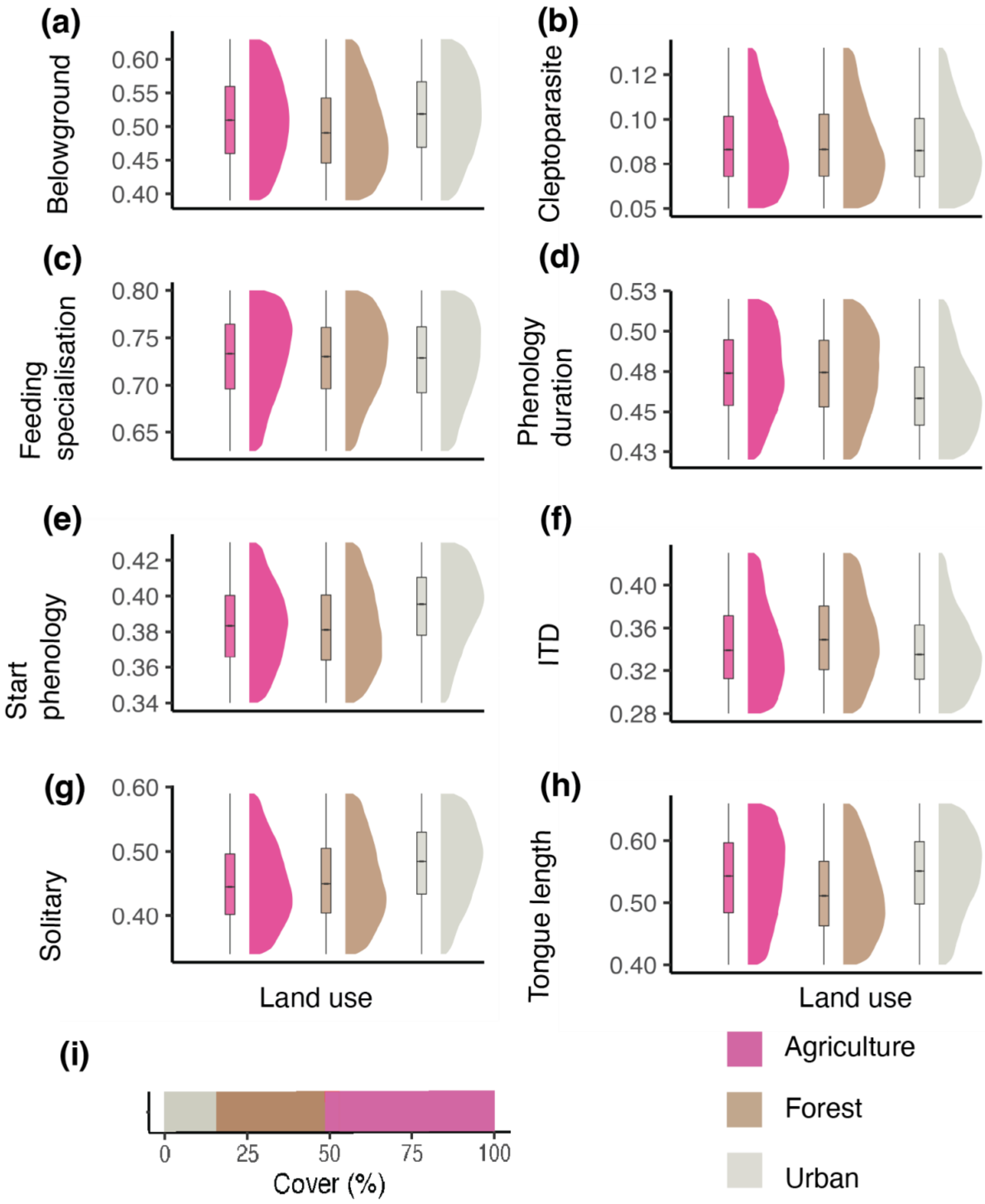
Appendix S29. Flat violin plots and boxplots showing the differences in the community-weighted means of the eight studied wild bee traits among the three main land-use types agricultural, urban and forest. Notches in the boxplots indicate the 95% confidence interval of the median. Dots and diamonds indicate the median value of the metric in protected areas (PA) *sensu stricto* and *sensu lato*, respectively. (a) Belowground nesters, (b) cleptoparasites, (c) feeding specialisation, (d) duration of phenology, (e) start of phenology, (f) intertegular distance (ITD), (g) solitary, and (h) tongue length. Note that trait values have been standardised.



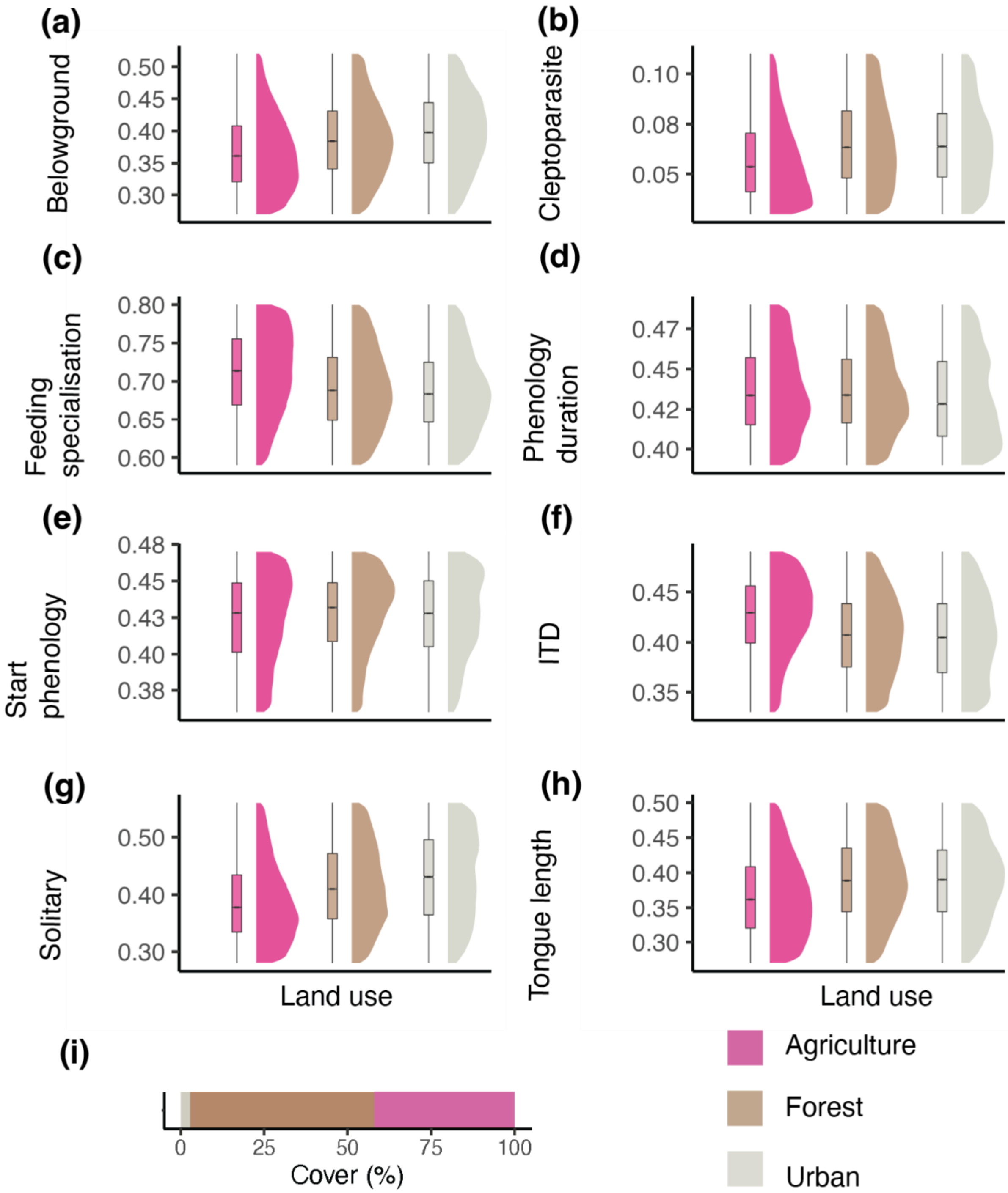
Appendix S30. Flat violin plots and boxplots showing the differences in the α and ß taxonomic and functional diversity metrics among the three main land-use types, agricultural, urban and forest, at mid elevation (1000–2000 m a.s.l.). Notches in the boxplots indicate the 95% confidence interval of the median. (a) Species richness, (b) Shannon diversity, (c) functional richness (trait onion peeling TOP), (d) functional evenness (trait evenness distribution TED), (e) functional dispersion (FDis), (f) local community contributions to taxonomic ß-diversity (LCBD taxonomic), and (g) local community contributions to functional ß-diversity (LCBD functional). Note that to facilitate the comparison of the boxplots, the Appendix Shows the data between the 10th and the 90th percentiles. Note that to facilitate the comparison of the boxplots, the Appendix Shows the data between the 10th and the 90th percentiles. (h) Land-use composition (% cover) at mid elevations.



Appendix S31. Flat violin plots and boxplots showing the differences in the α and ß taxonomic and functional metrics among the three main land-use types, agricultural, urban and forest, at high elevation (> 2000 m a.s.l.). Notches in the boxplots indicate the 95% confidence interval of the median. (a) Species richness, (b) Shannon diversity, (c) functional richness (trait onion peeling TOP), (d) functional evenness (trait evenness distribution TED), (e) functional dispersion (FDis), (f) local community contributions to taxonomic ß-diversity (LCBD taxonomic), and (g) local community contributions to functional ß-diversity (LCBD functional). (h) Land-use composition (% cover) at high elevations. Note that to facilitate the comparison of the boxplots, the Appendix Shows the data between the 10th and the 90th percentiles. Furthermore, urban land-use at high elevation refers mostly to sparse infrastructure (e.g. small roads, damps, avalanche protection areas, small resorts, sport surfaces) rather than densely build-up surfaces.

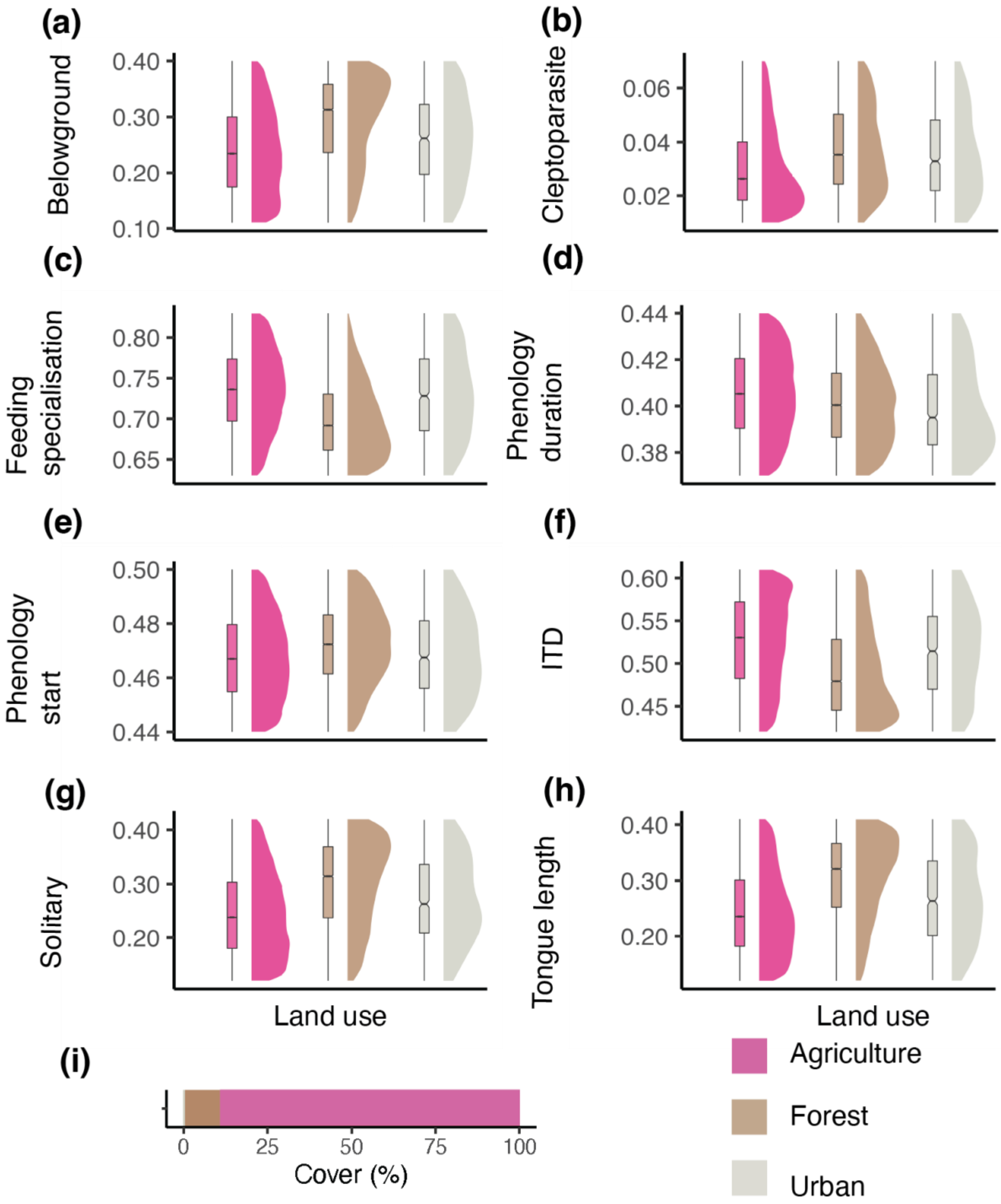


Appendix S32. Flat violin plots and boxplots showing the differences in the community-weighted means of the eight studied wild bee traits among the three main land-use types, agricultural, urban and forest, at low elevation (197–1000 m a.s.l.). Notches in the boxplots indicate the 95% confidence interval of the median. (a) Belowground nesters, (b) cleptoparasites, (c) feeding specialisation, (d) duration of phenology, (e) start of phenology, (f) intertegular distance (ITD), (g) solitary, and (h) tongue length. (i) Land-use composition (% cover) at low elevations. Note that trait values have been standardised. Note that to facilitate the comparison of the boxplots, the Appendix Shows the data between the 10th and the 90th percentiles.

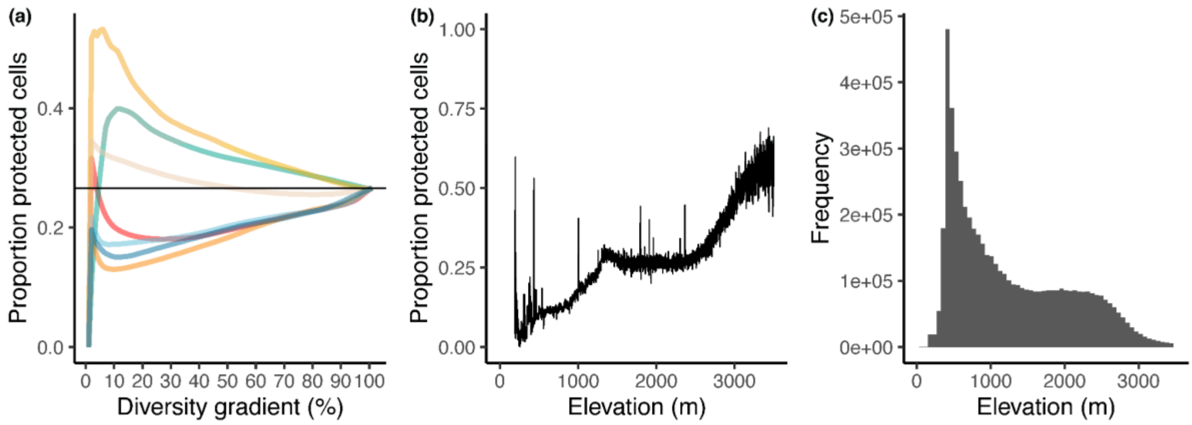


Appendix S33. Flat violin plots and boxplots showing the differences in the community-weighted means of the eight studied wild bee traits among the three main land-use types, agricultural, urban and forest, mid elevation (1000–2000 m a.s.l.). Notches in the boxplots indicate the 95% confidence interval of the median. (a) Belowground nesters, (b) cleptoparasites, (c) feeding specialisation, (d) duration of phenology, (e) start of phenology, (f) intertegular distance (ITD), (g) solitary, and (h) tongue length. (i)

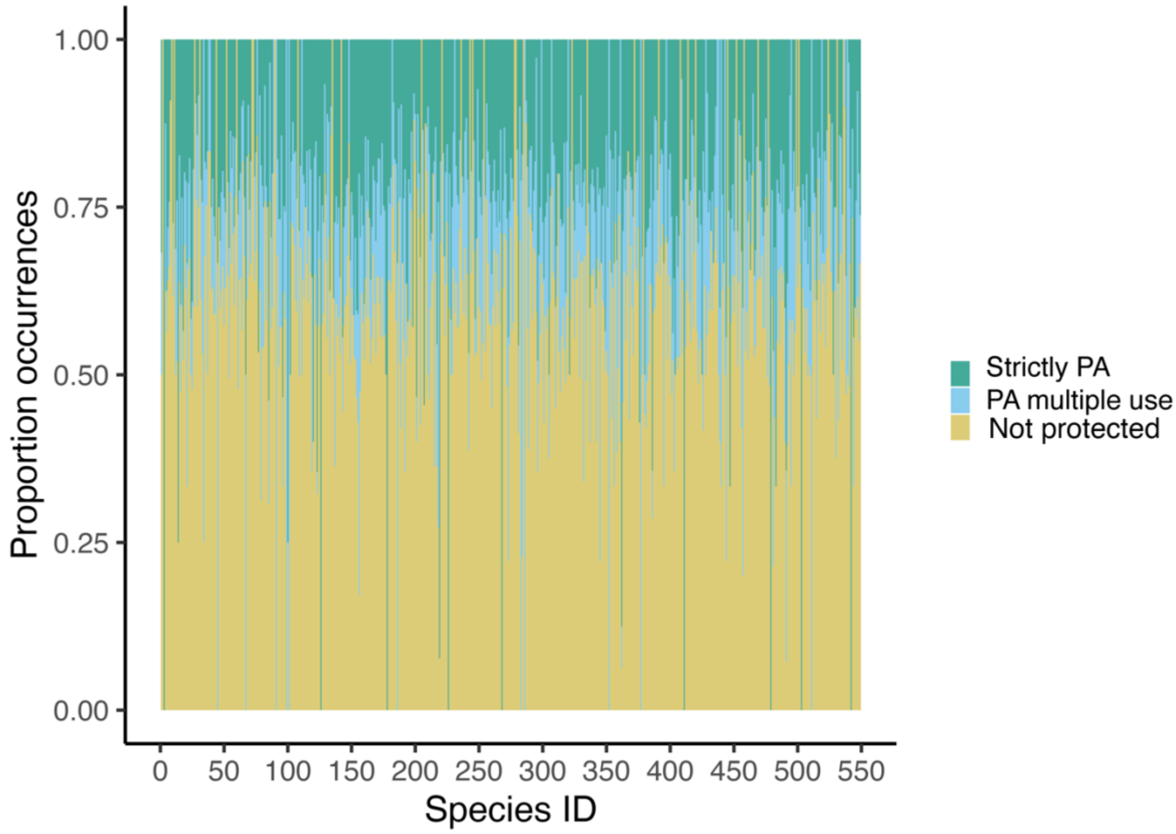
Land-use composition (% cover) at mid elevations. Note that trait values have been standardised. Note that to facilitate the comparison of the boxplots, the Appendix Shows the data between the 10th and the 90th percentiles.



Appendix S34. Flat violin plots and boxplots showing the differences in the community-weighted means of the eight studied wild bee traits among the three main land-use types, agricultural, urban and forest, at high elevation (> 2000 m a.s.l.). Notches in the boxplots indicate the 95% confidence interval of the median. (a) Belowground nesters, (b) cleptoparasites, (c) feeding specialisation, (d) duration of phenology, (e) start of phenology, (f) intertegular distance (ITD), (g) solitary, and (h) tongue length. (i) Land-use composition (% cover) at high elevations. Note that trait values have been standardised. Note that to facilitate the comparison of the boxplots, the Appendix Shows the data between the 10th and the 90th percentiles. Furthermore, urban land-use at high elevation refers mostly to sparse infrastructure (e.g. small roads, damps, avalanche protection areas, small resorts, sport surfaces) rather than densely build-up surfaces.



Appendix S35. Proportion of taxonomic and functional diversities included in all the protected areas (protected areas *sensu lato* + protected areas *sensu stricto*). For each diversity metric, we ranked each cell from the most to the least diverse using quantile values. The x-axis (diversity gradient in percentage) depicts a decreasing diversity gradient inversely related to the quantiles of the diversity metrics, with lower x-axis values indicating the most diverse cells. The y-axis depicts the cumulative proportion of cells belonging to protected areas. The horizontal black line indicates the proportion of protected cells in all of Switzerland (ca. 27 % of the surface). (a) is based on Devictor et al. (2010). Taxonomic α-diversity metrics = species richness and Shannon diversity; functional α-diversity metrics = functional richness (trait onion peeling TOP), functional evenness (trait evenness distribution TED), and functional dispersion (FDis). Taxonomic ß-diversity metrics = local community contributions to taxonomic diversity (LCBD taxonomic); functional ß-diversity metrics = local community contributions to functional diversity (LCBD functional). Proportion of protected cells along an elevation gradient considering protected areas (b). The upper maps show the distribution of the protected areas in Switzerland (in grey).



Appendix S36. Overlap between species occurrence and protected areas. The X-axis shows the 550 species sampled in the unfiltered 6200 community plots (each bar is a species) and the Y-axis depicts the proportion of occurrences in protected areas *sensu lato (PA SL)*, protected areas *sensu stricto* (PA ss) and in unprotected areas (Not protected). Seven species only occurred in protected areas s.s., that is, *Andrena saxonica, Andrena suerinensis, Andrena synadelpha, Hylaeus pilosulus, Lasioglossum quadrisignatum, Megachile genalis, Sphecodes marginatus*. Nine species only occurred in protected areas s.l., that is, *Ammobates punctatus, Anthophora dispar, Ceratina nigrolabiata, Eucera nigrifacies, Hylaeus crassanus, Nomada discrepans, Osmia steinmanni, Sphecodes dusmeti, Thyreus histrionicus*.

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