

## **ELECTRONIC SUPPLEMENTARY MATERIAL 1 (ESM1)**

### **OECOLOGIA**

#### **Assessing coexisting plant extinction debt and colonization credit in a grassland-forest change gradient**

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**Table S1.** List of plant species found in the survey. The classification in grassland specialists and forest specialists was performed using regional floras (Rivas-Martínez et al. 2001; Bolòs et al. 2005) and expert advice. In addition to the plants in the list, two *Apiaceae*, two *Asteraceae*, one *Caryophyllaceae*, one *Cruciferae*, and four *Poaceae* species were found during the survey and included in the analyses, but we were not able to identify them to species or genus level.

Taxa	Grassland specialist	Forest specialist
<i>Acer opalus</i> Mill.		x
<i>Aegilops triuncialis</i> L.		
<i>Aethionema saxatile</i> (L.) R. Br.		
<i>Allium senescens</i> L.	x	
<i>Allium</i> sp. L.		
<i>Althaea hirsuta</i> L.	x	
<i>Amelanchier ovalis</i> Medik.		x
<i>Anemone hepatica</i> L.		x
<i>Anthericum liliago</i> L.	x	
<i>Anthyllis montana</i> L.	x	
<i>Anthyllis vulneraria</i> L.	x	
<i>Aphyllanthes monspeliensis</i> L.	x	
<i>Aquilegia vulgaris</i> L.		x
<i>Arabis auriculata</i> Lam.	x	
<i>Arabis hirsuta</i> (L.) Scop.	x	
<i>Arabis scabra</i> All.	x	
<i>Arctostaphylos uva-ursi</i> (L.) Spreng.	x	
<i>Arenaria conimbricensis</i> Brot.	x	
<i>Arenaria tetraquetra</i> L.	x	
<i>Argyrolobium zanonii</i> (Turra) P. W. Ball	x	
<i>Arrhenatherum elatius</i> (L.) P. Beauv. ex J. et C. Presl	x	
<i>Asperula cynanchica</i> L.	x	
<i>Asphodelus cerasiferus</i> Gay	x	
<i>Asplenium adiantum-nigrum</i> L.		x
<i>Asplenium trichomanes</i> L.		
<i>Asterolinon linum-stellatum</i> (L.) Duby in DC.	x	
<i>Atractylis humilis</i> L.	x	
<i>Avenula pratensis</i> (L.) Dumort.	x	
<i>Biscutella laevigata</i> L.	x	
<i>Blackstonia perfoliata</i> (L.) Huds.		
<i>Brachypodium distachyon</i> (L.) P. Beauv.	x	
<i>Brachypodium phoenicoides</i> (L.) Roem. et Schultes	x	
<i>Brachypodium retusum</i> (Pers.) P. Beauv.	x	
<i>Brachypodium sylvaticum</i> (Huds.) P. Beauv.		x
<i>Briza media</i> L.		
<i>Bromus erectus</i> Huds.	x	
<i>Bupleurum baldense</i> Turra	x	
<i>Bupleurum fruticosum</i> L.	x	
<i>Bupleurum fruticosum</i> L.		x
<i>Bupleurum rigidum</i> L.	x	

<i>Buxus sempervirens</i> L.		X
<i>Campanula persicifolia</i> L.		X
<i>Campanula rotundifolia</i> L.	X	
<i>Campanula speciosa</i> Pourr.		
<i>Campanula trachelium</i> L.		X
<i>Carduncellus monspelliensium</i> All.	X	
<i>Carduus nigrescens</i> Vill.	X	
<i>Carex flacca</i> Schreber		
<i>Carex halleriana</i> Asso	X	
<i>Carex humilis</i> Leysser	X	
<i>Carlina vulgaris</i> L.	X	
<i>Centaurea linifolia</i> L.	X	
<i>Centaureum quadrifolium</i> (L.) G. López et Ch. E. Jarvis	X	
<i>Cephalanthera longifolia</i> (L.) Fritsch		X
<i>Cerastium pumilum</i> Curtis	X	
<i>Ceterach officinarum</i> DC. in Lam. et DC.		
<i>Chaenorhinum organifolium</i> (L.) Kostel.		
<i>Cistus albidus</i> L.		
<i>Cistus clusii</i> Dunal	X	
<i>Clematis flammula</i> L.		X
<i>Clematis vitalba</i> L.		X
<i>Conopodium majus</i> (Gouan) Loret in Loret et Barrandon	X	
<i>Convolvulus arvensis</i> L.		
<i>Convolvulus lanuginosus</i> Desr.	X	
<i>Coris monspeliensis</i> L.	X	
<i>Coronilla emerus</i> L.		X
<i>Coronilla minima</i> L.	X	
<i>Crataegus monogyna</i> Jacq.		X
<i>Crepis albida</i> Vill.	X	
<i>Crucianella angustifolia</i> L.	X	
<i>Cruciata glabra</i> (L.) Ehrend.		X
<i>Crupina vulgaris</i> Cass.	X	
<i>Cytisophyllum sessilifolium</i> (L.) O. Lang		X
<i>Daphne gnidium</i> L.		
<i>Daphne laureola</i> L.		X
<i>Dianthus pungens</i> L.	X	
<i>Dipcadi serotinum</i> (L.) Medik.	X	
<i>Dorycnium pentaphyllum</i> Scop.	X	
<i>Echinops ritro</i> L.	X	
<i>Echium vulgare</i> L.		
<i>Epipactis</i> sp. Zinn		X
<i>Erica multiflora</i> L.	X	
<i>Erinacea anthyllis</i> Link	X	
<i>Eryngium campestre</i> L.	X	
<i>Erysimum grandiflorum</i> Desf.	X	
<i>Euphorbia amygdaloides</i> L.		X
<i>Euphorbia exigua</i> L.	X	
<i>Euphorbia flavicoma</i> DC.	X	
<i>Euphorbia minuta</i> Loscos	X	
<i>Euphorbia nevadensis</i> Boiss. et Reut.	X	
<i>Euphorbia nicaeensis</i> All.	X	
<i>Euphorbia serrata</i> L.	X	
<i>Festuca</i> gr. <i>ovina</i> L.	X	
<i>Festuca rubra</i> L.		
<i>Filipendula vulgaris</i> Moench	X	

<i>Fritillaria pyrenaica</i> L.	X	
<i>Fumana ericoides</i> (Cav.) Gand.	X	
<i>Galium parisiense</i> L.	X	
<i>Galium pumilum</i> Murray		
<i>Galium verum</i> L.	X	
<i>Genista hispanica</i> L.	X	
<i>Genista scorpius</i> (L.) DC. in Lam. et DC.	X	
<i>Geranium robertianum</i> L.		X
<i>Geum sylvaticum</i> Pourr.		X
<i>Gladiolus illyricus</i> Koch	X	
<i>Globularia vulgaris</i> L.	X	
<i>Gymnadenia conopsea</i> (L.) R. Br.	X	
<i>Hedera helix</i> L.		X
<i>Helianthemum apenninum</i> (L.) Mill.	X	
<i>Helianthemum hirtum</i> (L.) Mill.	X	
<i>Helianthemum ledifolium</i> (L.) Mill.	X	
<i>Helianthemum oelandicum</i> (L.) DC. in Lam. et DC.	X	
<i>Helichrysum stoechas</i> (L.) Moench	X	
<i>Helleborus foetidus</i> L.		X
<i>Hieracium</i> gr. <i>murorum</i> L.		X
<i>Hieracium pilosella</i> L.	X	
<i>Hippocrepis comosa</i> L.	X	
<i>Hornungia petraea</i> (L.) Rchb.	X	
<i>Ilex aquifolium</i> L.		X
<i>Inula montana</i> L.	X	
<i>Iris lutescens</i> Lam.	X	
<i>Jasminum fruticans</i> L.		
<i>Jasonia tuberosa</i> (L.) DC.		
<i>Juniperus communis</i> L.		X
<i>Juniperus oxycedrus</i> L.		
<i>Juniperus phoenicea</i> L.		
<i>Knautia arvensis</i> (L.) Coult.	X	
<i>Koeleria vallesiana</i> (Honck.) Gaudin	X	
<i>Lactuca perennis</i> L.		
<i>Laserpitium gallicum</i> L.	X	
<i>Lathyrus filiformis</i> (Lam.) Gay	X	
<i>Lavandula angustifolia</i> Mill.	X	
<i>Lavandula latifolia</i> Medik.	X	
<i>Leontodon taraxacoides</i> (Vill.) Mérat	X	
<i>Leuzea conifera</i> (L.) DC. in Lam. et DC.	X	
<i>Lilium martagon</i> L.		X
<i>Linaria supina</i> (L.) Chaz.	X	
<i>Linum narbonense</i> L.	X	
<i>Linum tenuifolium</i> L.	X	
<i>Lithospermum fruticosum</i> L.	X	
<i>Lonicera etrusca</i> Santi		X
<i>Lonicera implexa</i> Aiton		X
<i>Lonicera xylosteum</i> L.		X
<i>Lotus corniculatus</i> L.	X	
<i>Melica ciliata</i> L.	X	
<i>Micropus erectus</i> L.	X	
<i>Micropyrum tenellum</i> (L.) Link		
<i>Moehringia pentandra</i> Gay		
<i>Muscari neglectum</i> Guss. ex Ten.	X	
<i>Narcissus assoanus</i> Dufour	X	

<i>Odontides viscosus</i> (L.) Clairv.		
<i>Ononis minutissima</i> L.	X	
<i>Ononis spinosa</i> L.		
<i>Ophrys fusca</i> Link	X	
<i>Ophrys scolopax</i> Cav.	X	
<i>Orchis maculata</i> L.		
<i>Orobanche amethystea</i> Thuill	X	
<i>Orobanche gracilis</i> Sm.	X	
<i>Orobanche latisquama</i> (F. W. Schultz) Batt.	X	
<i>Orobanche</i> sp. L.		
<i>Petrorhagia prolifera</i> (L.) P. W. Ball et Heywood	X	
<i>Phillyrea latifolia</i> L.		X
<i>Phlomis lychnitis</i> L.	X	
<i>Phyteuma orbiculare</i> L.	X	
<i>Picris hieracioides</i> L.	X	
<i>Pinus halepensis</i> Mill.		X
<i>Pinus nigra</i> Arnold		X
<i>Pinus pinaster</i> Aiton		X
<i>Pinus pinea</i> L.		X
<i>Pinus sylvestris</i> L.		X
<i>Plantago lanceolata</i> L.	X	
<i>Platanthera bifolia</i> (L.) Rich.		
<i>Polygala calcarea</i> F. W. Schultz	X	
<i>Polygala rupestris</i> Pourr.	X	
<i>Polygala vulgaris</i> L.	X	
<i>Polygonatum odoratum</i> (Mill.) Druce		X
<i>Polypodium vulgare</i> L.		
<i>Potentilla hirta</i> L.		
<i>Potentilla neumanniana</i> Rchb.	X	
<i>Primula veris</i> L.		X
<i>Prunella grandiflora</i> (L.) Scholler		
<i>Prunus mahaleb</i> L.		X
<i>Prunus spinosa</i> L.		
<i>Pteridium aquilinum</i> (L.) Kuhn		
<i>Pyrola chlorantha</i> Sw.		X
<i>Quercus x cerrioides</i> Willk. et Costa		X
<i>Quercus coccifera</i> L.		X
<i>Quercus faginea</i> Lam.		X
<i>Quercus ilex</i> L.		X
<i>Ranunculus gramineus</i> L.	X	
<i>Rhamnus alaternus</i> L.		X
<i>Rhamnus saxatilis</i> Jacq.		
<i>Rosa pimpinellifolia</i> L.		
<i>Rosa</i> sp. L.		
<i>Rosmarinus officinalis</i> L.	X	
<i>Rubia peregrina</i> L.		
<i>Rubus ulmifolius</i> Schott		
<i>Ruscus aculeatus</i> L.		X
<i>Salvia officinalis</i> L.	X	
<i>Sanguisorba minor</i> Scop.	X	
<i>Santolina chamaecyparissus</i> L.	X	
<i>Saponaria ocymoides</i> L.		
<i>Satureja montana</i> L.	X	
<i>Scabiosa columbaria</i> L.	X	
<i>Scorzonera angustifolia</i> L.	X	

<i>Scorzonera hispanica</i> L.	X	
<i>Sedum acre</i> L.	X	
<i>Sedum album</i> L.	X	
<i>Sedum sediforme</i> (Jacq.) Pau	X	
<i>Senecio doronicum</i> (L.) L.	X	
<i>Serratula nudicaulis</i> (L.) DC. in Lam. et DC.	X	
<i>Sideritis hirsuta</i> L.		
<i>Silene nutans</i> L.		
<i>Smilax aspera</i> L.		X
<i>Solidago virgaurea</i> L.		
<i>Sorbus aria</i> (L.) Crantz		X
<i>Stachys officinalis</i> (L.) Trevis.		
<i>Stachelina dubia</i> L.	X	
<i>Stipa offneri</i> Breistr.	X	
<i>Stipa pennata</i> L.	X	
<i>Tanacetum corymbosum</i> (L.) Schultz Bip.		
<i>Taraxacum serotinum</i> (Waldst. et Kit.) Poiret in Lam.	X	
<i>Taxus baccata</i> L.		X
<i>Teucrium botrys</i> L.	X	
<i>Teucrium chamaedrys</i> L.		X
<i>Teucrium polium</i> L.	X	
<i>Thalictrum tuberosum</i> L.	X	
<i>Thesium humifusum</i> DC.	X	
<i>Thymelaea tinctoria</i> (Pourr.) Endl.	X	
<i>Thymus serpyllum</i> L.	X	
<i>Thymus vulgaris</i> L.	X	
<i>Trinia glauca</i> (L.) Dumort.	X	
<i>Tulipa sylvestris</i> L.	X	
<i>Ulex parviflorus</i> Pourr.		
<i>Viburnum lantana</i> L.		X
<i>Viburnum tinus</i> L.		X
<i>Vicia cracca</i> L.		
<i>Vicia sepium</i> L.		X
<i>Viola alba</i> Besser		X
<i>Viola rupestris</i> F. W. Schmidt	X	
<i>Viola willkommi</i> Roem.		X

## References for Table S1

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**Table S2.** Basic descriptive statistics for response variables (plant richness for the different groups: all species, grassland specialists, forest specialists), local and landscape predictors, and historical and current tree covers, by plot category. Mean and standard deviation for continuous variables, and counts for each level for factors are given.

	Persistent grasslands	Wooded grasslands	Persistent forests
All species' richness	31.0±7.9	28.0±9.1	21.1±6.1
Grassland specialists' richness	26.6±7.6	17.3±10.2	7.8±5.2
Forest specialists' richness	2.3±1.6	7.0±3.9	10.2±3.0
Solar radiation availability ratio	5.74±13.03	1.59±5.40	0.68±2.61
Soil depth (cm)	15.39±10.38	22.08±11.60	16.36±6.60
Soil pH	7.71±0.54	7.39±0.73	7.04±0.74
Clay proportion	0.23±0.11	0.25±0.10	0.32±0.13
Historical grassland/forest ratio	4.93±2.90	4.45±3.84	1.84±1.92
Current grassland/forest ratio	0.81±0.20	0.56±0.20	0.56±0.08
Historical grassland availability ratio	2.31±1.02	2.60±1.81	1.14±0.83
Current grassland availability ratio	0.75±0.13	0.54±0.18	0.52±0.07
Historical forest availability ratio	0.22±0.11	0.33±0.21	0.65±0.24
Current forest availability ratio	1.24±0.35	1.97±0.89	1.58±0.34
Historical tree cover proportion	0.07±0.11	0.18±0.16	0.74±0.15
Current tree cover proportion	0.33±0.12	0.72±0.12	0.75±0.07
Grazing (Yes/No)	Yes: 27 / No: 57	Yes: 30 / No: 126	Yes: 2 / No: 18

**Table S3.** Predicted values by general linear mixed models (LMMs) of species richness between plot categories for each species group. Estimates and standard errors (SE) are given. Each row corresponds to a model for a species group (all species, grassland specialists and forest specialists).

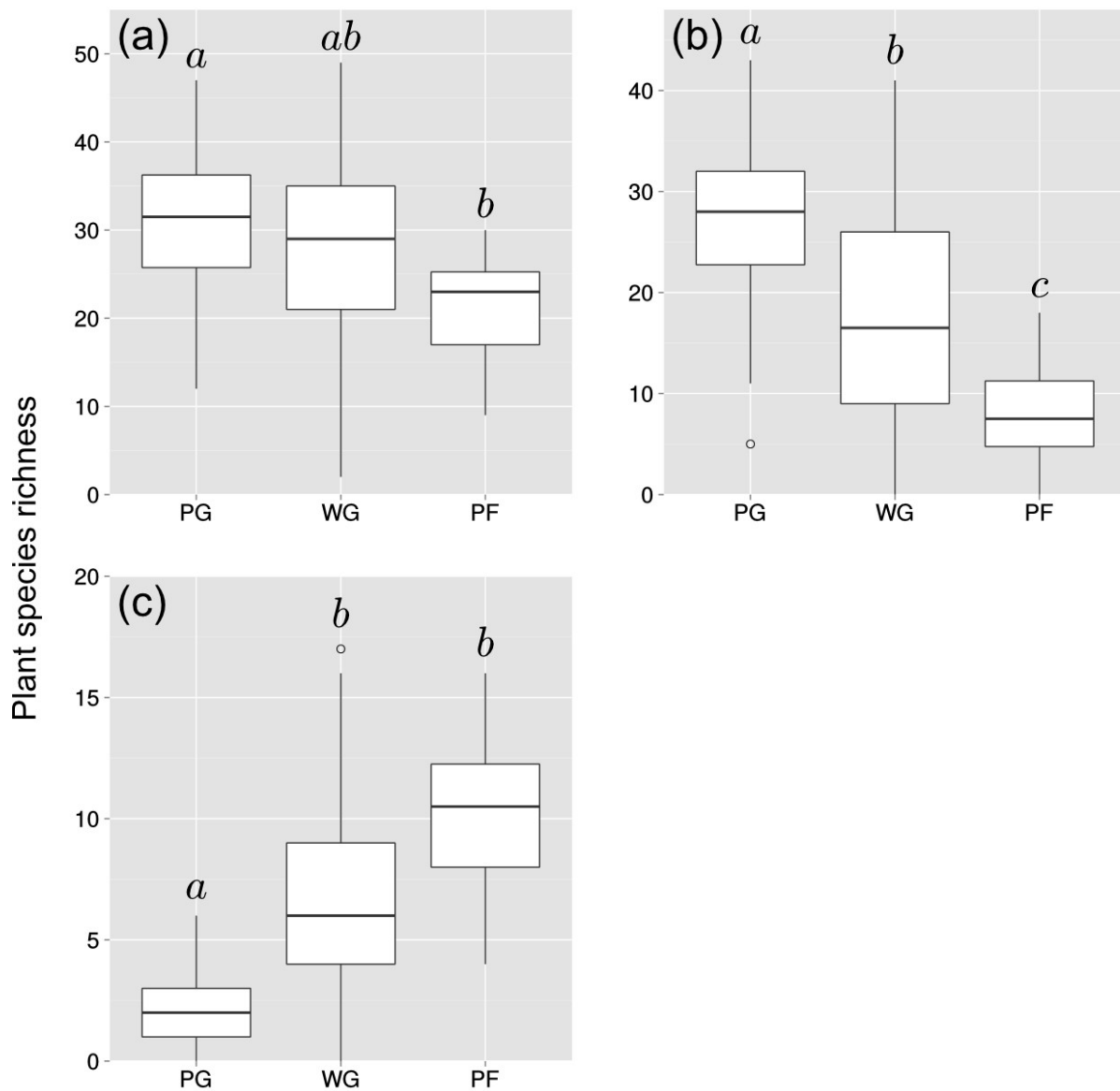
	Persistent grasslands	Wooded grasslands	Persistent forests
All species	29.67±1.52	28.43±1.37	23.24±2.68
Grassland specialists	22.82±1.86	18.77±1.75	12.18±2.86
Forest specialists	4.23±0.71	6.23±0.68	7.84±1.03



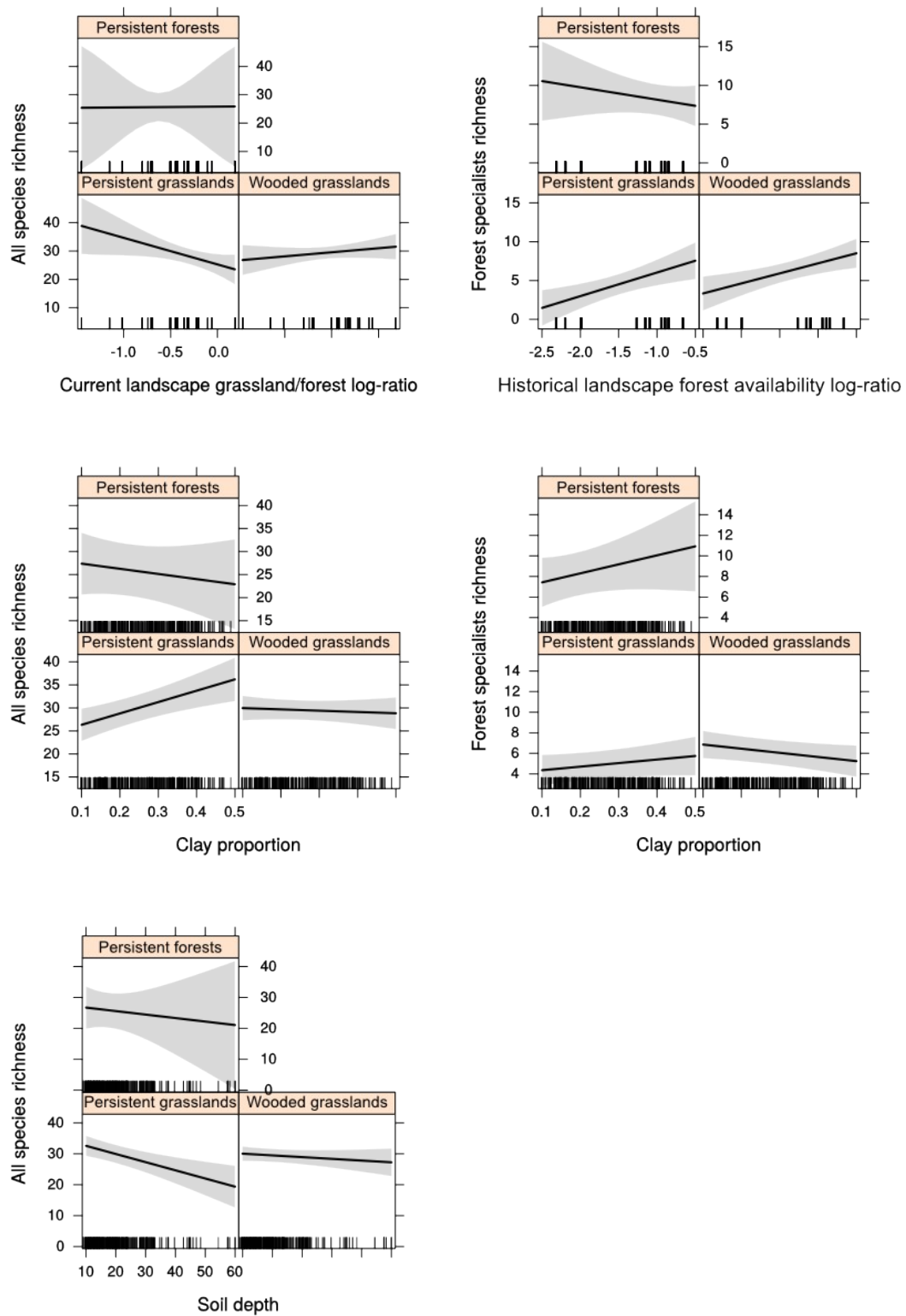
**Table S4** Results of selected model for species richness in all species. The model with all parameters significant and lowest AICc was selected and fitted by restricted maximum likelihood (REML). Significant predictors and interactions at  $P < 0.05$  are marked in bold, and those that are significant only in an interaction term are also included as main effects. Estimates and  $P$ -values for all pair-wise comparisons between factor levels (for the factor plot category and interactions between it and a covariable) were obtained using post-hoc Tukey tests. PG, persistent grasslands; WG, wooded grasslands, and PF, persistent forests.

Predictor	All species Estimate $\pm$ SE
(Intercept)	-0.84 $\pm$ 5.88
Plot category (WG - PG)	<b>8.60<math>\pm</math>3.02</b>
Plot category (PF - PG)	6.64 $\pm$ 9.66
Plot category (PF - WG)	-1.96 $\pm$ 9.48
Current landscape <sup>2</sup>	<b>-9.37<math>\pm</math>4.39</b>
Solar radiation availability log-ratio	<b>1.61<math>\pm</math>0.25</b>
Clay proportion	<b>24.70<math>\pm</math>7.22</b>
Soil pH	<b>3.54<math>\pm</math>0.67</b>
Soil depth	<b>-0.26<math>\pm</math>0.08</b>
Current landscape <sup>2</sup> *Plot category (WG - PG)	<b>12.24<math>\pm</math>4.30</b>
Current landscape <sup>2</sup> *Plot category (PF - PG)	9.64 $\pm$ 13.51
Current landscape <sup>2</sup> *Plot category (PF - WG)	-2.60 $\pm$ 12.85
Clay proportion*Plot category (WG - PG)	<b>-27.52<math>\pm</math>9.00</b>
Clay proportion*Plot category (PF - PG)	-35.91 $\pm$ 16.27
Clay proportion*Plot category (PF - WG)	-8.39 $\pm$ 15.79
Soil depth*Plot category (WG - PG)	<b>0.21<math>\pm</math>0.09</b>
Soil depth*Plot category (PF - PG)	0.15 $\pm$ 0.25
Soil depth*Plot category (PF - WG)	-0.06 $\pm$ 0.25
Likelihood-ratio based pseudo-R <sup>2</sup>	0.52

<sup>2</sup>Grassland/forest log-ratio in current landscape.



**Figure S1.** Box and whisker plots for observed species richness at sampling plots of 3 m of diameter for the different species groups between sampling plot categories: PG, persistent grasslands; WG, wooded grasslands, and PF, persistent forests. The main horizontal line shows the median, the bottom and the top of the box are the first and third quartiles, respectively, whiskers show extreme values or 1.5 times the inter-quartile range (whichever is smaller), and points are potential outliers. Letters a, b and c show significantly different species richness between sampling plot categories within each species group, according to post-hoc Tukey tests. Plot (a) shows species richness for all species, plot (b) for grassland specialists, and plot (c) for forest specialists.



**Figure S2.** Effect plots of significant interactions between sampling plot category (persistent grasslands, wooded grasslands and persistent forests) and local and landscape variables for the general linear mixed models (LMMs). Shaded area indicates 95% confidence intervals. Left column shows plots for all species model, and right column shows plots for forest specialists model.