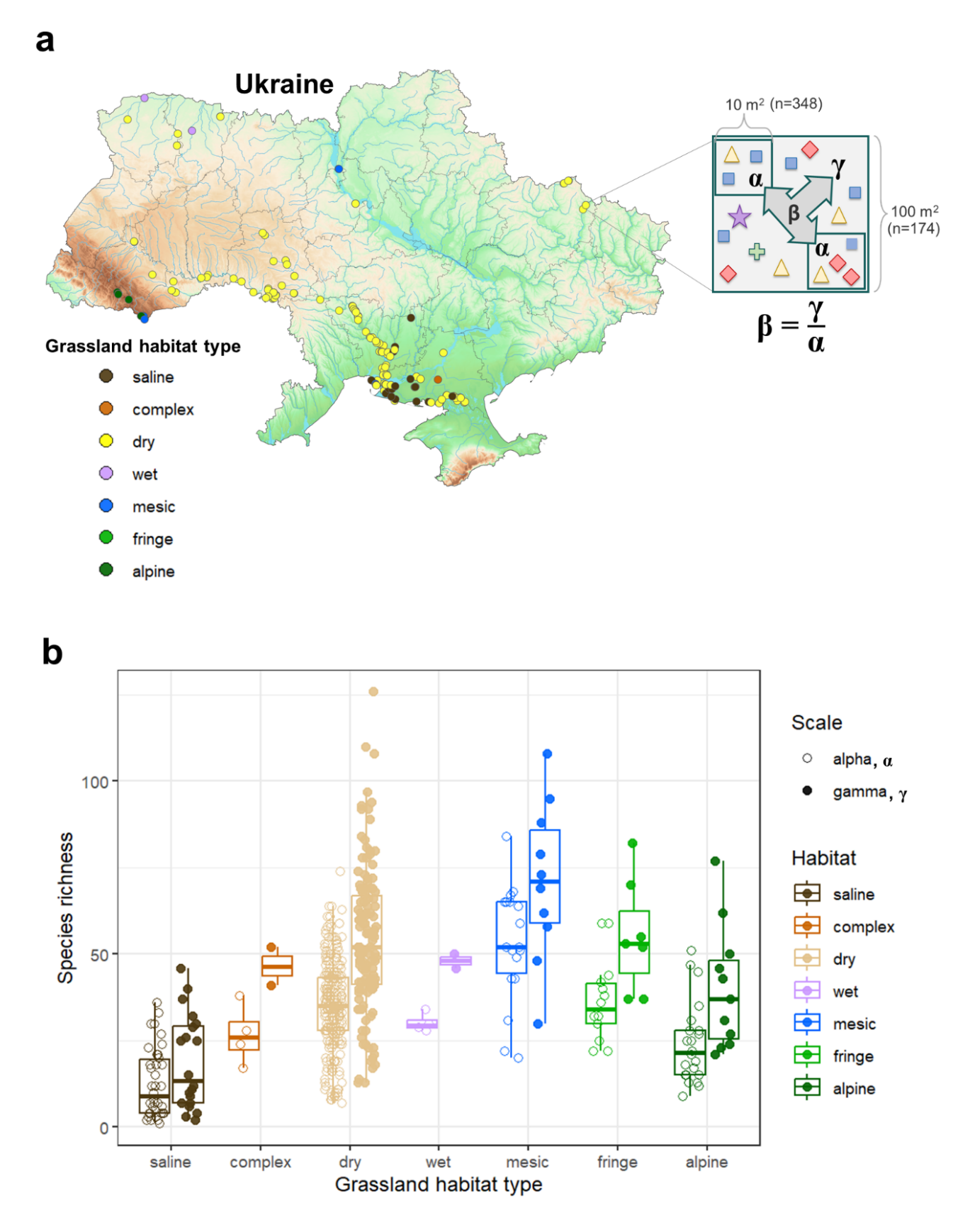
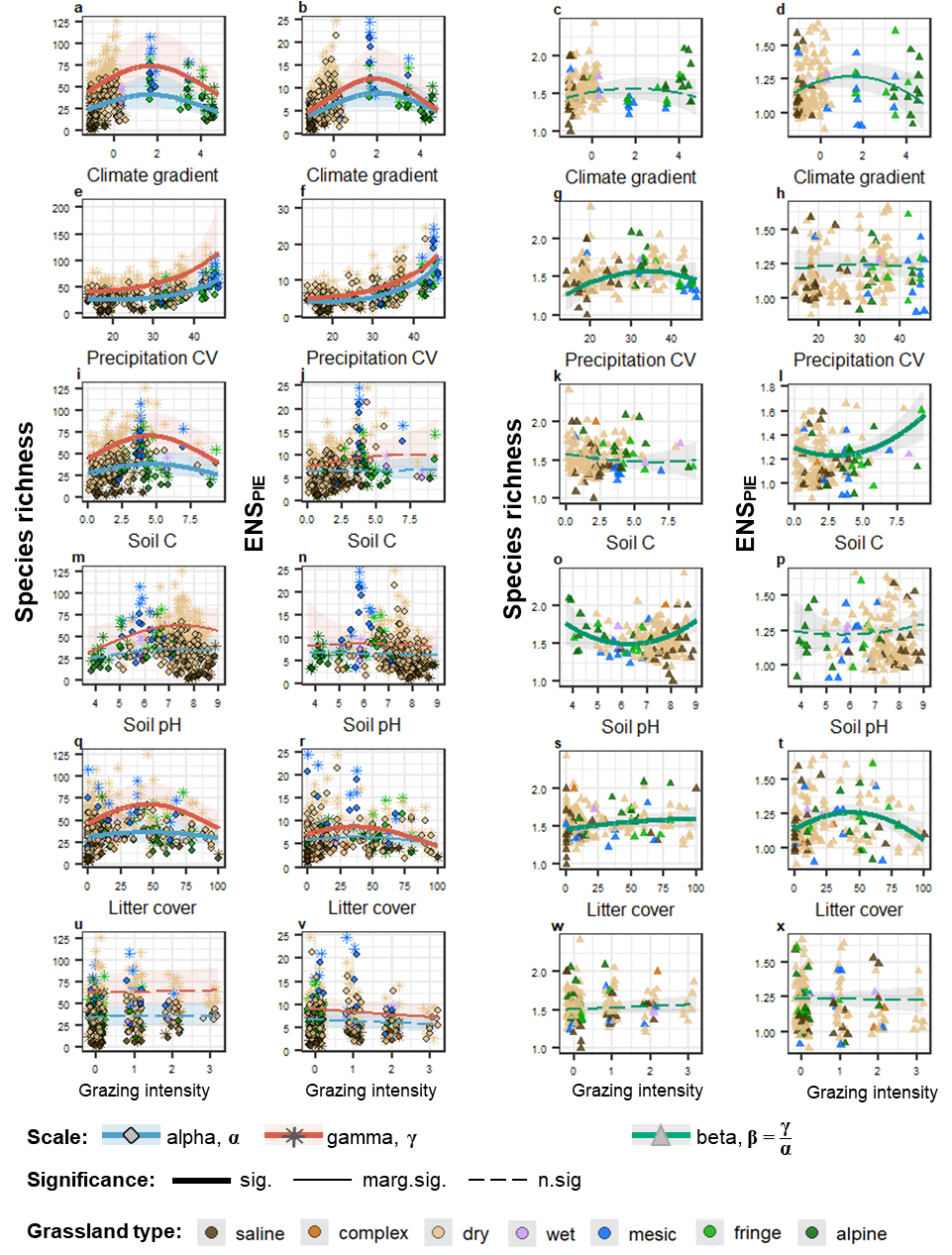
**Figures:**



**Fig. 1.** **(a)** Map of Ukraine showing 174 vegetation plots, indicated with the points on the map (some points overlap), where the color of the points indicates different grassland habitat type. Each of the monitoring plots has grain size 100 m2 and is referred to as gamma (**γ**) scale. Each vegetation plot includes two nested subplots (348 subplots in total) with the grain size 10 m2, referred to as alpha (**α**) scale. The icons of different shapes and color on the scheme of the nested-plot design represent different plant species. Beta (**β**) is the scaling factor among the two grain sizes and shows the spatial difference in plant biodiversity (species richness or ENSPIE) between **α** and **γ** spatial scales. The map was created using QGIS software (QGIS Development Team 2023). The color gradient on the map ranging from green to brown areas shows the elevational gradient from lowlands to highlands and mountains. Blue areas indicate rivers and other water bodies. **(b)** Plant species richness for each spatial scale within each grassland habitat type (indicated by different colors). Boxplot shows minimum, median, and maximum values of species richness. Points show the values for each plot, where the transparent and filled points are shown for **α**- and **γ-**scale, respectively.

** Fig. 2.** Results from mixed models testing the effects of environmental drivers on species richness and ENSPIE at **α-** and **γ-**scales (shown by blue and red lines, respectively) and on **β-**diversity ─ the scaling factor among the two scales (shown by green lines). For the model results see Table S2 and Table S3. Solid thick lines show significant effects (P<0.05), solid thin lines show marginally significant effects (0.05≤P<0.1), and dashed lines show non-significant effects (P>0.09). Shaded areas around lines show 95% confidence intervals. Different shapes of data points indicate different spatial scales: diamonds for **α-**diversity, stars for **γ-**diversity, and triangles for **β-**diversity. Colors of data points indicate grassland habitat types. To improve the visibility of comparisons among the slopes of **α-**diversity and **γ-**diversity, the results for both scales are shown on the same plots. Plots for each scale separately are provided in Fig. S5.

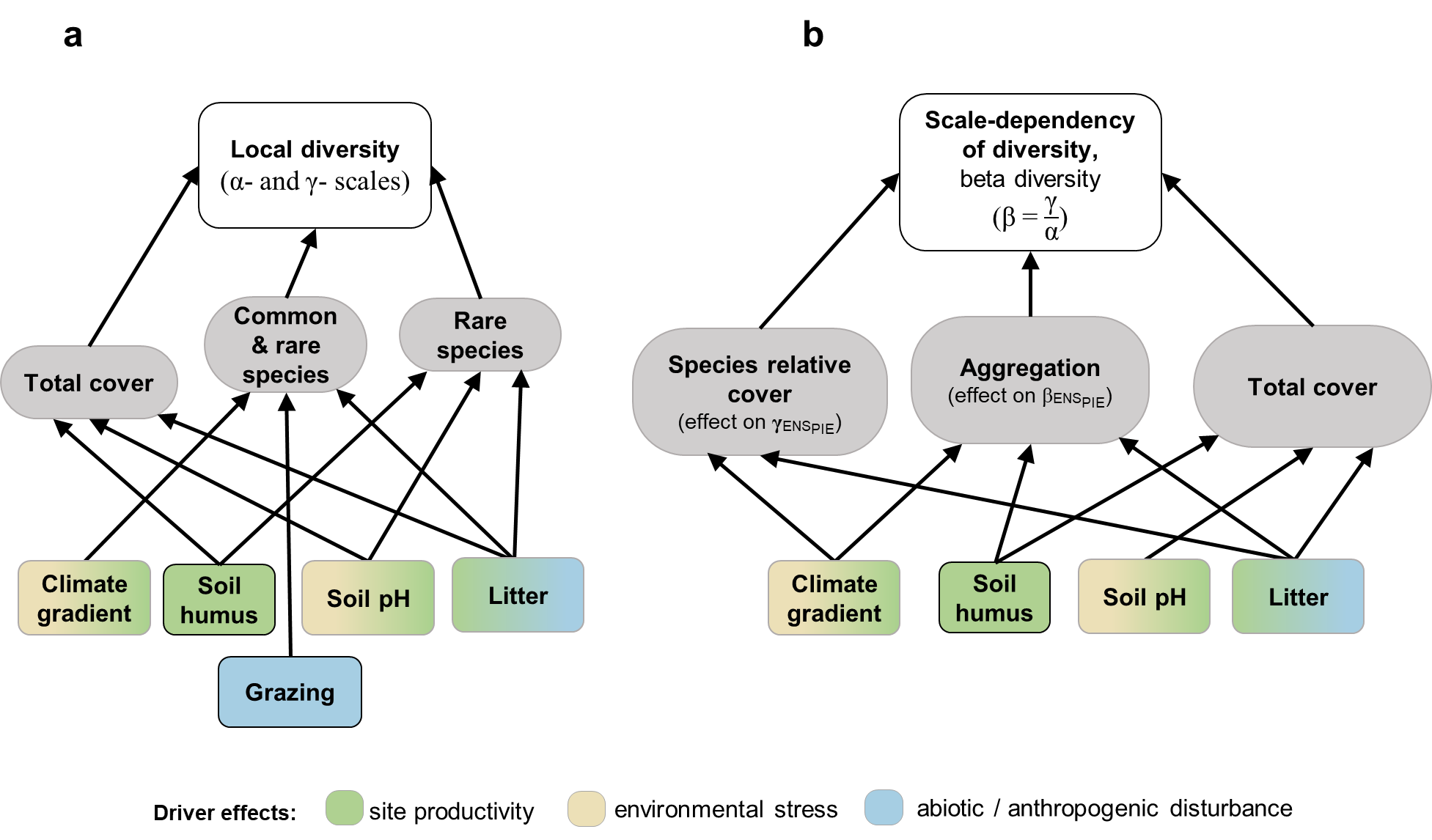
**A screenshot of a computer

Description automatically generatedFig. 3. (a)** Relative strengths (standardized effect size) of the effects of each environmental driver on **α-** and **γ-**diversity measures (species richness and ENSPIE), shown by blue and red bars for **α-** and **γ-**scale, respectively. Blue and red icons show the shape of the effects and their significance for each driver and respective scale, with the following levels of significance: \*P≤0.05; \*\*P≤0.01; \*\*\*P≤0.001; and ‘P≤0.09 (marginally significant). Green icons show the shape for only significant effects (bars marked by stars) on **β-**diversity ─ the scaling factor among the two spatial scales. **(b)** Relative importance of the environmental drivers in governing **α-**, **γ-**, and **β-**diversity measures. Circle sizes are proportional to the fraction of variance explained (partial R2) by the study drivers for each response variable. For the model results see Table S2 and Table S3.

**A graph with different colored dots

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**Fig. 4**. Scale-dependent effects of environmental drivers on **α-** and **γ-**diversity measures (species richness and ENSPIE). Points show the standardized effect sizes of each environmental driver (marked by colors of points) on the diversity measures at **α-**scale (*x*-axis) compared to **γ-**scale (*y*-axis). The solid gray line indicates the 1 : 1 line expected if effect sizes were not scale-dependent. Points above and below this line indicate effect sizes that are larger or smaller, respectively, as scale increases.



**Fig. 5**. Conceptual diagrams summarizing the results of this study for the mechanisms underlying the effects of the study environmental drivers on local diversity at **α-** and **γ-**scales (**a**) and on **β-**diversity ─ the scaling factor among the two scales (**b**). Environmental drivers of local plant diversity (**α-** and **γ-**scales, Fig. 5a) operated via the responses of rare species when there was a marked difference in results for species richness from the results for ENSPIE, while low difference implied significant contributions from the responses of the entire community, including both common and rare species (Fig. 2). Total plant cover affected **α-**, **γ-** and **β-**diversity (Fig. S4), and thus could mediate the effects of biodiversity drivers. When the effect of an environmental driver on total plant cover deviated from zero (Fig. S8), the effects of this driver on the respective biodiversity measure (i.e., **α-**, **γ-** or **β-**diversity) were mediated by the altered total cover (Fig. 5a-b). When the effect size on ENSPIE at the largest sampling scale (i.e., on ) deviates from zero, the ecological driver altered the species evenness in their relative cover in the community, and thus affected **β-**diversity via the altered distributions in relative cover of species (Fig. 5b). When the effect of driver on ENSPIE changed with sampling grain (i.e. the effect on was significant), the biodiversity driver altered the intraspecific aggregation of the community (Fig. 5b). Drivers are color-coded based on the nature of their effects. Two colors indicate that the effects cannot be separated, such as when productivity effects are the inverse of environmental stress effects.