**Fig. S1.** Annual values of growing degree days (GDD), freezing degree days (FDD) and snow cover duration (Snow) averaged from soil climatic data recorded during 10 years in four alpine sites of the Picos de Europa National Park (Spain).

**Gráfico, Histograma

Descripción generada automáticamente**

**Fig. S2.** Principal Component Analysis of the variation in soil bioclimatic indices. Data includes the temporal survey (triangles, 4 sites x 10 years) and the spatial survey (squares, 4 sites x 20 plots) of alpine soils in the Picos de Europa National Park (Spain). Bioclimatic variables include the annual mean temperature (bio1), the diurnal thermal range (bio2), the annual thermal range (bio7), the duration of snow cover (Snow), the growing degree days (GDD) and the freezing degree days (FDD). The lower table shows the Pearson´s correlation of the bioclimatic indices with the main two PCA axes.

Mapa

Descripción generada automáticamente

|  |  |  |
| --- | --- | --- |
|  | PCA 1 | PCA 2 |
| Mean anual temperatura (bio1, ºC) | 0.78 | 0.59 |
| Diurnal thermal range (bio2, ºC) | 0.83 | -0.09 |
| Annual termal range (bio7, ºC) | 0.68 | -0.48 |
| Annual snow cover (days) | -0.53 | 0.34 |
| Annual freezing degree days (FDD, ºC) | 0.41 | -0.69 |
| Annual growing degree days (GDD, ºC) | 0.83 | 0.48 |

**Table S1.** Mean values and standard error for soil bioclimatic indices calculated from the spatial and temporal surveys (N = 84) conducted in our four alpine sites of the Picos de Europa National Park, Spain. T and p values correspond to a sided paired t-test.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Bioclimatic index | Spatial mean ± SE | Temporal mean ± SE | T | Df | p-value |
| Bio1 | 2.38 ± 0.537 | 1.95 ±0.26 | 1.13 | 3 | 0.1702 |
| Bio2 | 3.16 ± 0.139 | 1.22 ± 0.26 | 12.70 | 3 | < 0.005 |
| Bio7 | 8.99 ± 2.07 | 7.95 ± 1.99 | 0.765 | 3 | 0.2499 |
| Snow | 202 ± 22.4 | 88.2 ± 7.76 | 13 | 3 | < 0.005 |
| GDD | 752 ± 104 | 647 ± 110 | 1.01 | 3 | 0.1934 |
| FDD | 121 ± 62 | 134 ± 86.4 | -0.29 | 3 | 0.6047 |

**Table S2.** Species registered during the temporal and spatial surveys in 84 vegetation plots sampled in the Picos de Europa National Park, Spain, with their corresponding abbreviations and scores obtained from the NMDS (Fig 1D).

|  |  |  |  |
| --- | --- | --- | --- |
| Species | Abbreviation | NMDS 1 | NMDS 2 |
| *Agrostis schleicheri* | Agrsch | -0.22626249 | -0.32865479 |
| *Alchemilla catalaunica* | Alccat | -0.24786943 | 0.44510949 |
| *Androsace villosa* | Andvil | -0.56092072 | -0.13187965 |
| *Anemone pavoniana* | Anepav | -0.30701826 | -0.00645525 |
| *Anthyllis vulneraria* | Antvul | 0.09275869 | -0.19304245 |
| *Arabis alpina* | Araalp | 0.24387917 | 0.3089445 |
| *Arenaria erinacea* | Areeri | -0.40324069 | -0.37136211 |
| *Arenaria grandiflora* | Aregra | 0.57040639 | 0.03229533 |
| *Arenaria moehringioides* | Aremoe | 0.37818069 | -0.18958146 |
| *Arenaria purpurascens* | Arepur | -0.29890923 | -0.05363037 |
| *Armeria cantabrica* | Armcan | 0.55688866 | 0.12081685 |
| *Botrychium lunaria* | Botlun | 0.23467495 | 0.33913668 |
| *Carduus carlinoides* | Carcar | 0.66358154 | -0.17465052 |
| *Carex ornithopoda* | Carorn | 0.37664498 | 0.13271975 |
| *Carex pulicaris* | Carpul | 0.58957326 | 0.25104494 |
| *Carex sempervirens* | Carsem | -0.38531771 | 0.22600719 |
| *Cystopteris fragilis* | Cysfra | -0.14760722 | -0.35747592 |
| *Dethawia splendens subsp. cantabrica* | Detspl | -0.40297643 | 0.07236984 |
| *Draba dedeana* | Draded | -0.43467822 | 0.49376216 |
| *Erigeron alpinus* | Erialp | 0.10832918 | 0.22171564 |
| *Eryngium bourgatii* | Erybou | -0.18389075 | 0.21969489 |
| *Euphorbia pyrenaica* | Euppyr | -0.41246197 | -0.09036552 |
| *Euphrasia salisburgensis* | Eupsal | -0.22463362 | -0.34160941 |
| *Festuca glacialis* | Fesgla | 0.70335011 | 0.10426121 |
| *Festuca gr. rubra* | Fesrub | -0.07073091 | 0.39051504 |
| *Festuca hystrix* | Feshys | -0.39802784 | -0.24144864 |
| *Festuca picoeuropeana* | Fespic | -0.24077199 | -0.37138493 |
| *Galium pumilum* | Galpum | 0.05775293 | 0.62816766 |
| *Galium pyrenaicum* | Galpyr | 0.07784597 | -0.62731841 |
| *Genista legionensis* | Genleg | -0.59950319 | -0.08017966 |
| *Gentiana nivalis* | Genniv | 0.14433934 | 0.08736727 |
| *Gentiana verna* | Genver | -0.37209895 | 0.08123781 |
| *Gentianella campestris* | Gencam | -0.29402477 | 0.03083168 |
| *Gnaphalium hoppeanum* | Gnahop | 0.36306039 | 0.37459588 |
| *Gypsophila repens* | Gyprep | -0.41713995 | -0.18485794 |
| *Helianthemum apenninum subsp. cantabricum* | Helcan | -0.24673604 | 0.53550255 |
| *Helianthemum apenninum subsp. urrielense* | Helurr | 0.245896 | 0.20158793 |
| *Helianthemum canum* | Helcan | -0.36110367 | -0.14829857 |
| Species (cont.) | Abbreviation | NMDS 1 | NMDS 2 |
| *Helictotrichon sedenense* | Helsed | 0.11271417 | -0.36558285 |
| *Herniaria glabra* | Hergla | 0.24357241 | 0.27885013 |
| *Hippocrepis comosa* | Hipcom | -0.28729515 | 0.32971575 |
| *Hornungia alpina* | Horalp | -0.13351775 | 0.47141159 |
| *Iberis carnosa* | Ibecar | 0.46144181 | -0.36236435 |
| *Jacobaea boissieri* | Jacboi | -0.1924265 | -0.73282049 |
| *Jasione cavanillesii* | Jascav | 0.57937134 | -0.1176246 |
| *Jurinea humilis* | Jurhum | -0.49422318 | 0.11829457 |
| *Kobresia myosuroides* | Kobmyo | -0.44449408 | -0.33052187 |
| *Koeleria vallesiana* | Koeval | -0.17264968 | 0.28080103 |
| *Linaria alpina* | Linalp | 0.37222351 | 0.12164061 |
| *Lotus corniculatus* | Lotcor | -0.25730487 | 0.270113 |
| *Luzula pediformis* | Luzped | 0.06005125 | 0.54201188 |
| *Minuartia verna* | Minver | -0.14282894 | -0.18459774 |
| *Oxytropis neglecta* | Oxyneg | -0.21519678 | -0.09516628 |
| *Paronychia kapela subsp. serpyllifolia* | Parkap | -0.36367437 | 0.03166732 |
| *Pedicularis pyrenaica* | Pedpyr | -0.46045857 | -0.0387913 |
| *Phyteuma orbiculare* | Phyorb | -0.53012903 | 0.19782045 |
| *Pilosella officinarum* | Piloff | -0.33275803 | 0.05725185 |
| *Plantago alpina* | Plaalp | -0.07503951 | 0.30626518 |
| *Poa alpina* | Poaalp | 0.17499679 | 0.52416381 |
| *Potentilla crantzii* | Potcra | -0.24968586 | 0.28787799 |
| *Ranunculus carinthiacus* | Rancar | 0.08426838 | 0.40420889 |
| *Ranunculus parnassiifolius subsp. favargeri* | Ranpar | 0.25504086 | -0.48631208 |
| *Salix breviserrata* | Salbre | 0.2215869 | -0.67289038 |
| *Saxifraga conifera* | Saxcon | -0.06149894 | 0.23007927 |
| *Saxifraga oppositifolia* | Saxopp | 0.26347407 | -0.75611155 |
| *Saxifraga paniculata* | Saxpan | 0.17472814 | 0.20689849 |
| *Scilla verna* | Sciver | -0.31485349 | 0.24837992 |
| *Sedum album* | Sedalb | -0.01947289 | 0.36454999 |
| *Sedum atratum* | Sedatr | 0.3383434 | -0.09301587 |
| *Sempervivum vicentei* | Semvic | -0.32351823 | 0.15798158 |
| *Silene acaulis* | Silaca | 0.54757546 | -0.05851618 |
| *Silene ciliata* | Silcil | 0.3222897 | 0.1622936 |
| *Teucrium pyrenaicum* | Teupyr | -0.65936597 | -0.12521348 |
| *Thesium pyrenaicum* | Thepyr | -0.62590247 | 0.03910524 |
| *Thymus praecox subsp. ligusticus* | Thypra | 0.01181457 | 0.11542884 |
| *Veronica nummularia* | Vernum | 0.50973766 | -0.24495923 |
| *Viola rupestris* | Viorup | -0.2901378 | 0.21205072 |