

In the format provided by the authors and unedited.

Plant functional trait change across a warming tundra biome

Anne D. Björkman^{1,2,3*}, Isla H. Myers-Smith¹, Sarah C. Elmendorf^{4,5,6}, Signe Normand^{1,7,8}, Nadja Rüger^{9,10}, Pieter S. A. Beck¹¹, Anne Blach-Overgaard^{1,8}, Daan Blok¹², J. Hans C. Cornelissen¹³, Bruce C. Forbes¹⁴, Damien Georges^{1,15}, Scott J. Goetz¹⁶, Kevin Guay¹⁷, Gregory H. R. Henry¹⁸, Janneke HilleRisLambers¹⁹, Robert D. Hollister²⁰, Dirk N. Karger²¹, Jens Kattge^{9,22}, Peter Manning³, Janet S. Prevéy²³, Christian Rixen²³, Gabriela Schaepman-Strub²⁴, Haydn J. D. Thomas¹, Mark Vellend²⁵, Martin Wilms²⁶, Sonja Wipf²³, Michele Carbone²⁷, Luise Hermanutz²⁸, Esther Lévesque²⁹, Ulf Molau³⁰, Alessandro Petraglia²⁷, Nadejda A. Soudzilovskaia³¹, Marko J. Spasojevic³², Marcello Tomaselli²⁷, Tage Vowles³³, Juha M. Alatalo³⁴, Heather D. Alexander³⁵, Alba Anadón-Rosell^{26,36,37}, Sandra Angers-Blondin¹, Mariska te Beest^{38,39}, Logan Berner¹⁶, Robert G. Björk^{33,40}, Agata Buchwal^{41,42}, Allan Buras⁴³, Katherine Christie⁴⁴, Elisabeth J. Cooper⁴⁵, Stefan Dullinger⁴⁶, Bo Elberling⁴⁷, Anu Eskelinen^{9,48,49}, Esther R. Frei^{18,21}, Oriol Grau^{50,51}, Paul Grogan⁵², Martin Hallinger⁵³, Karen A. Harper⁵⁴, Monique M. P. D. Heijmans⁵⁵, James Hudson⁵⁶, Karl Hülber⁴⁶, Maitane Iturrate-García²⁴, Colleen M. Iversen⁵⁷, Francesca Jaroszynska^{23,58}, Jill F. Johnstone⁵⁹, Rasmus Halfdan Jørgensen⁶⁰, Elina Kaarlejärvi^{38,61}, Rebecca Kladny⁶², Sara Kuleza⁵⁹, Aino Kulonen²³, Laurent J. Lamarque²⁹, Trevor Lantz⁶³, Chelsea J. Little^{24,64}, James D. M. Speed⁶⁵, Anders Michelsen^{47,66}, Ann Milbau⁶⁷, Jacob Nabe-Nielsen⁶⁸, Sigrid Schøler Nielsen¹, Josep M. Ninot^{36,37}, Steven F. Oberbauer⁶⁹, Johan Olofsson³⁸, Vladimir G. Onipchenko⁷⁰, Sabine B. Rumpf⁴⁶, Philipp Semenchuk^{45,46}, Rohan Shetti²⁶, Laura Siegwart Collier²⁸, Lorna E. Street¹, Katharine Suding⁴, Ken D. Tape⁷¹, Andrew Trant^{28,72}, Urs A. Treier^{1,7,8}, Jean-Pierre Tremblay⁷³, Maxime Tremblay²⁹, Susanna Venn⁷⁴, Stef Weijers⁷⁵, Tara Zamin⁵², Noemie Boulanger-Lapointe¹⁸, William A. Gould⁷⁶, David S. Hik⁷⁷, Annika Hofgaard⁷⁸, Ingibjörg S. Jónsdóttir^{79,80}, Janet Jorgenson⁸¹, Julia Klein⁸², Borgthor Magnusson⁸³, Craig Tweedie⁸⁴, Philip A. Wookey⁸⁵, Michael Bahn⁸⁶, Benjamin Blonder^{87,88}, Peter M. van Bodegom⁸⁹, Benjamin Bond-Lamberty⁹⁰, Giandiego Campetella⁹¹, Bruno E. L. Cerabolini⁹², F. Stuart Chapin III⁹³, William K. Cornwell⁹⁴, Joseph Craine⁹⁵, Matteo Dainese⁹⁶, Franciska T. de Vries⁹⁷, Sandra Díaz⁹⁸, Brian J. Enquist^{99,100}, Walton Green¹⁰¹, Ruben Milla¹⁰², Ülo Niinemets¹⁰³, Yusuke Onoda¹⁰⁴, Jenny C. Ordoñez¹⁰⁵, Wim A. Ozinga^{106,107}, Josep Penuelas^{51,108}, Hendrik Poorter^{109,110}, Peter Poschod¹¹¹, Peter B. Reich^{112,113}, Brody Sandel¹¹⁴, Brandon Schamp¹¹⁵, Serge Sheremetev¹¹⁶ & Evan Weiher¹¹⁷

¹School of GeoSciences, University of Edinburgh, Edinburgh, UK. ²Ecoinformatics and Biodiversity, Department of Bioscience, Aarhus University, Aarhus, Denmark. ³Senckenberg Gesellschaft für Naturforschung, Biodiversity and Climate Research Centre (BiK-F), Frankfurt, Germany. ⁴Department of Ecology and Evolutionary Biology, University of Colorado, Boulder, CO, USA. ⁵National Ecological Observatory Network, Boulder, CO, USA. ⁶Institute of Arctic and Alpine Research, University of Colorado, Boulder, CO, USA. ⁷Arctic Research Center, Department of Bioscience, Aarhus University, Aarhus, Denmark. ⁸Center for Biodiversity Dynamics in a Changing World (BIOCHANGE), Department of Bioscience, Aarhus University, Aarhus, Denmark. ⁹German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Leipzig, Germany. ¹⁰Smithsonian Tropical Research Institute, Balboa, Panama. ¹¹European Commission, Joint Research Centre, Directorate D — Sustainable Resources, Bio-Economy Unit, Ispra, Italy. ¹²Department of Physical Geography and Ecosystem Science, Lund University, Lund, Sweden. ¹³Systems Ecology, Department of Ecological Science, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands. ¹⁴Arctic Centre, University of Lapland, Rovaniemi, Finland. ¹⁵International Agency for Research in Cancer, Lyon, France. ¹⁶School of Informatics, Computing and Cyber Systems, Northern Arizona University, Flagstaff, AZ, USA. ¹⁷Bigelow Laboratory for Ocean Sciences, East Boothbay, ME, USA. ¹⁸Department of Geography, University of British Columbia, Vancouver, British Columbia, Canada. ¹⁹Biology Department, University of Washington, Seattle, WA, USA. ²⁰Biology Department, Grand Valley State University, Allendale, MI, USA. ²¹Swiss Federal Research Institute WSL, Birmensdorf, Switzerland. ²²Max Planck Institute for Biogeochemistry, Jena, Germany. ²³WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland. ²⁴Department of Evolutionary Biology and Environmental Studies, University of Zurich, Zurich, Switzerland. ²⁵Département de biologie, Université de Sherbrooke, Sherbrooke, Québec, Canada. ²⁶Institute of Botany and Landscape Ecology, Greifswald University, Greifswald, Germany. ²⁷Department of Chemistry, Life Sciences and Environmental Sustainability, University of Parma, Parma, Italy. ²⁸Department of Biology, Memorial University, St. John's, Newfoundland and Labrador, Canada. ²⁹Département des Sciences de l'environnement et Centre d'études nordiques, Université du Québec à Trois-Rivières, Trois-Rivières, Québec, Canada. ³⁰Department of Biological and Environmental Sciences, University of Gothenburg, Gothenburg, Sweden. ³¹Environmental Biology Department, Institute of Environmental Sciences, Leiden University, Leiden, The Netherlands. ³²Department of Evolution, Ecology and Organismal Biology, University of California Riverside, Riverside, CA, USA. ³³Department of Earth Sciences, University of Gothenburg, Gothenburg, Sweden. ³⁴Department of Biological and Environmental Sciences, Qatar University, Doha, Qatar. ³⁵Department of Forestry, Forest and Wildlife Research Center, Mississippi State University, Mississippi State, MS, USA. ³⁶Department of Evolutionary Biology, Ecology and Environmental Sciences, University of Barcelona, Barcelona, Spain. ³⁷Biodiversity Research Institute, University of Barcelona, Barcelona, Spain. ³⁸Department of Ecology and Environmental Science, Umeå University, Umeå, Sweden. ³⁹Environmental Sciences, Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, The Netherlands. ⁴⁰Gothenburg Global Biodiversity Centre, Göteborg, Sweden. ⁴¹Institute of Geoeology and Geoinformation, Adam Mickiewicz University, Poznan, Poland. ⁴²Department of Biological Sciences, University of Alaska, Anchorage, Anchorage, AK, USA. ⁴³Forest Ecology and Forest Management, Wageningen University and Research, Wageningen, The Netherlands. ⁴⁴The Alaska Department of Fish and Game, Anchorage, AK, USA. ⁴⁵Department of Arctic and Marine Biology, Faculty of Biosciences, Fisheries and Economics, UiT—The Arctic University of Norway, Tromsø, Norway. ⁴⁶Department of Botany and Biodiversity Research, University of Vienna, Vienna, Austria. ⁴⁷Center for Permafrost (CENPERM), Department of Geosciences and Natural Resource Management, University of Copenhagen, Copenhagen, Denmark. ⁴⁸Department of Physiological Diversity, Helmholtz Centre for Environmental Research—UFZ, Leipzig, Germany. ⁴⁹Department of Ecology and Genetics, University of Oulu, Oulu, Finland. ⁵⁰Global Ecology Unit, CREA-FCIS-UB, Cerdanyola del Vallès, Spain. ⁵¹CREAF, Cerdanyola del Vallès, Spain. ⁵²Department of Biology, Queen's University, Kingston, Ontario, Canada. ⁵³Biology Department, Swedish Agricultural University (SLU), Uppsala, Sweden. ⁵⁴Biology Department, Saint Mary's University, Halifax, Nova Scotia, Canada. ⁵⁵Plant Ecology and Nature Conservation Group, Wageningen University and Research, Wageningen, The Netherlands. ⁵⁶British Columbia Public Service, Surrey, British Columbia, Canada. ⁵⁷Climate Change Science Institute and Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN, USA. ⁵⁸Institute of Biological and Environmental Sciences, University of Aberdeen, Aberdeen, UK. ⁵⁹Department of Biology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. ⁶⁰Forest and Landscape College, Department of Geosciences and Natural Resource Management, University of Copenhagen, Nødebo, Denmark. ⁶¹Department of Biology, Vrije Universiteit Brussel (VUB), Brussels, Belgium. ⁶²Department of Forest Resources Management, Faculty of Forestry, University of British Columbia, Vancouver, British Columbia, Canada. ⁶³School of Environmental Studies, University of Victoria, Victoria, British Columbia, Canada. ⁶⁴Department of Aquatic Ecology, Eawag: Swiss Federal Institute of Aquatic Science and Technology, Dübendorf, Switzerland. ⁶⁵NTNU University Museum, Norwegian University of Science and Technology, Trondheim, Norway. ⁶⁶Department of Biology, University of Copenhagen, Copenhagen, Denmark. ⁶⁷Research Institute for Nature and Forest (INBO), Brussels, Belgium. ⁶⁸Department of Bioscience, Aarhus University, Roskilde, Denmark. ⁶⁹Department of Biological Sciences, Florida International University, Miami, FL, USA. ⁷⁰Department of Geobotany, Lomonosov Moscow State University, Moscow, Russia. ⁷¹Institute of Northern Engineering, University of Alaska Fairbanks, Fairbanks, AK, USA. ⁷²School of Environment, Resources and Sustainability, University of Waterloo, Waterloo, Ontario, Canada. ⁷³Département de biologie, Centre d'études nordiques et Centre d'étude de la forêt, Université Laval, Québec City, Québec, Canada. ⁷⁴Centre for Integrative Ecology, School of Life and Environmental Sciences, Deakin University, Burwood, Victoria, Australia. ⁷⁵Department of Geography, University of Bonn, Bonn, Germany. ⁷⁶USDA Forest Service International Institute of Tropical Forestry, Rio Piedras, Puerto Rico. ⁷⁷Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia, Canada. ⁷⁸Norwegian Institute for Nature Research, Trondheim, Norway. ⁷⁹Faculty of Life and Environmental Sciences, University of Iceland, Reykjavík, Iceland. ⁸⁰University Centre in Svalbard, Longyearbyen, Norway. ⁸¹Arctic National Wildlife Refuge, US Fish and Wildlife Service, Fairbanks, AK, USA. ⁸²Department of Ecosystem Science and Sustainability, Colorado State University, Fort Collins, CO, USA. ⁸³Icelandic Institute of Natural History, Gardabaer,

Iceland. ⁸⁴University of Texas at El Paso, El Paso, TX, USA. ⁸⁵Biology and Environmental Sciences, Faculty of Natural Sciences, University of Stirling, Stirling, UK. ⁸⁶Institute of Ecology, University of Innsbruck, Innsbruck, Austria. ⁸⁷Environmental Change Institute, School of Geography and the Environment, University of Oxford, Oxford, UK. ⁸⁸Rocky Mountain Biological Laboratory, Crested Butte, CO, USA. ⁸⁹Institute of Environmental Sciences, Leiden University, Leiden, The Netherlands. ⁹⁰Joint Global Change Research Institute, Pacific Northwest National Laboratory, College Park, MD, USA. ⁹¹School of Biosciences and Veterinary Medicine, Plant Diversity and Ecosystems Management Unit, University of Camerino, Camerino, Italy. ⁹²DiSTA, University of Insubria, Varese, Italy. ⁹³Institute of Arctic Biology, University of Alaska Fairbanks, Fairbanks, AK, USA. ⁹⁴School of Biological, Earth and Environmental Sciences, Ecology and Evolution Research Centre, UNSW Sydney, Sydney, New South Wales, Australia. ⁹⁵Jonah Ventures, Boulder, CO, USA. ⁹⁶Institute for Alpine Environment, Eurac Research, Bolzano, Italy. ⁹⁷School of Earth and Environmental Sciences, The University of Manchester, Manchester, UK. ⁹⁸Instituto Multidisciplinario de Biología Vegetal (IMBIV), CONICET and FCEfyN, Universidad Nacional de Córdoba, Córdoba, Argentina. ⁹⁹Department of Ecology and Evolutionary Biology, University of Arizona, Tucson, AZ, USA. ¹⁰⁰The Santa Fe Institute, Santa Fe, NM, USA. ¹⁰¹Department of Organismic and Evolutionary Biology, Harvard University, Cambridge, MA, USA. ¹⁰²Área de Biodiversidad y Conservación. Departamento de Biología, Geología, Física y Química Inorgánica, Universidad Rey Juan Carlos, Madrid, Spain. ¹⁰³Estonian University of Life Sciences, Tartu, Estonia. ¹⁰⁴Graduate School of Agriculture, Kyoto University, Kyoto, Japan. ¹⁰⁵World Agroforestry Centre — Latin America, Lima, Peru. ¹⁰⁶Team Vegetation, Forest and Landscape Ecology, Wageningen Environmental Research (Alterra), Wageningen, The Netherlands. ¹⁰⁷Institute for Water and Wetland Research, Radboud University Nijmegen, Nijmegen, The Netherlands. ¹⁰⁸Global Ecology Unit CREA-FCI-UAB, Consejo Superior de Investigaciones Científicas, Bellaterra, Spain. ¹⁰⁹Plant Sciences (IBG-2), Forschungszentrum Jülich GmbH, Jülich, Germany. ¹¹⁰Department of Biological Sciences, Macquarie University, North Ryde, New South Wales, Australia. ¹¹¹Ecology and Conservation Biology, Institute of Plant Sciences, University of Regensburg, Regensburg, Germany. ¹¹²Department of Forest Resources, University of Minnesota, St. Paul, MN, USA. ¹¹³Hawkesbury Institute for the Environment, Western Sydney University, Penrith, New South Wales, Australia. ¹¹⁴Department of Biology, Santa Clara University, Santa Clara, CA, USA. ¹¹⁵Department of Biology, Algoma University, Sault Ste. Marie, Ontario, Canada. ¹¹⁶Komarov Botanical Institute, St Petersburg, Russia. ¹¹⁷Department of Biology, University of Wisconsin — Eau Claire, Eau Claire, WI, USA. *e-mail: anne.bjorkman@senckenberg.de

SUPPLEMENTARY INFORMATION

1. Supplementary Table 1. Number of observations per trait.
2. Supplementary Table 2. Site names, survey duration, and coordinates.
3. Supplementary Table 3. Model output for *interspecific* spatial temperature-trait relationships.
4. Supplementary Table 4. Model output for *interspecific* spatial relationships with both temperature and soil moisture.
5. Supplementary Table 5. Model output for *intraspecific* spatial temperature-trait relationships.
6. Supplementary Table 6. Model output for interspecific trait change over time.
7. Supplementary Table 7. Model output for temperature sensitivity of community weighted trait means.
8. Supplementary Table 8. Model output for interspecific trait change over time with temperature change and soil moisture (static) as predictors of this change.
9. Supplementary Table 9. Probability that a species immigrated into a site ("gained") or disappeared from a site ("lost") as a function of its traits.
10. Supplementary Table 10. Abundance change for the most common (abundant and/or widespread) species in the vegetation survey dataset.
11. STAN code for the model of CWM trait – temperature relationships over space (Fig. 2a).
12. STAN code for the model of CWM trait change over time (Fig. 3a).
13. TRY trait data references.

Supplementary Table 1. Number of observations per trait. The minimum and mean percent of species per site with at least one trait observation, and the minimum and mean percent cover (abundance) of species per site with at least one trait observation. The maximum % species and % cover is 100 for all traits. All observations were used for estimating the species mean values used to calculate community weighted trait means, while only those with coordinates (latitude/longitude) were used to estimate intraspecific temperature-trait relationships.

<i>Trait</i>	<i>Num. of observations</i>	<i>Num. obs. w/ coordinates</i>	<i>% species (min)</i>	<i>% species (mean)</i>	<i>% cover (min)</i>	<i>% cover (mean)</i>
<i>Height</i>	23248	22129	48	95.2	38	96.8
<i>LDMC</i>	7331	7123	19	74.2	6	83.3
<i>Leaf Area</i>	10681	10445	20	83.4	10	91.0
<i>Leaf N</i>	4334	3852	29	71.7	30	87.0
<i>SLA</i>	10454	9651	20	77.9	10	87.4

Supplementary Table 2. Site names, survey duration, and coordinates. Region represents a unique CRU grid cell (0.5 degree grid).

Region	Site Name	Duration (years)	Latitude	Longitude
1	AKUREYRI:GA66	18	65.59	-17.97
2	AKUREYRI:HR58	18	65.56	-18.16
2	AKUREYRI:MD72	18	65.51	-18.08
2	AKUREYRI:SY59	18	65.51	-18.23
2	MODRUVELLIR:LH69	18	65.94	-18.11
2	MODRUVELLIR:ML54	18	65.74	-18.22
2	MODRUVELLIR:MV51	18	65.78	-18.27
2	MODRUVELLIR:MV52	18	65.77	-18.28
3	AKUREYRI:SB63	18	65.45	-18.24
4	ALEXFIORD:CASSIOPE	13	78.87	-75.78
4	ALEXFIORD:DOMEDOLOMITE	14	78.86	-75.9
4	ALEXFIORD:DOMEGRANITE	14	78.86	-75.9
4	ALEXFIORD:DRYAS	21	78.87	-75.78
4	ALEXFIORD:FERT	16	78.87	-75.79
4	ALEXFIORD:LEVDOLOMITE	18	78.86	-75.9
4	ALEXFIORD:MEADOW	16	78.88	-75.81
4	ALEXFIORD:WILLOW	21	78.87	-75.8
5	ANWR:ATIGUN-A	11	68.47	-149.35
5	ANWR:ATIGUN-B	11	68.48	-149.35
5	ANWR:ATIGUN-C	11	68.45	-149.32
6	ANWR:JAGO-A	10	69.7	-143.63
6	ANWR:JAGO-B	10	69.71	-143.62
7	ATQASUK:AD	16	70.45	-157.41
7	ATQASUK:AG	5	70.45	-157.4
7	ATQASUK:AW	16	70.45	-157.4
7	ATQASUK:RATE_BETULA_SHRUB	10	70.46	-157.41
7	ATQASUK:RATE_CAREX_WET_MEADOW	10	70.46	-157.41
7	ATQASUK:RATE_DRYAS_HEATH	10	70.46	-157.41
7	ATQASUK:RATE_ERIOPHORUM_WET_MEADOW	10	70.46	-157.41
7	ATQASUK:RATE_HIEROCHLOE_DRY_MEADOW	10	70.46	-157.41
8	AUDKULUHEIDI:BETULAHEATH	12	65.22	-19.71
9	BARROW:ARCTOPHILA_POND_ORDINATION	10	71.29	-156.64
9	BARROW:BD	18	71.32	-156.6
9	BARROW:BG	5	71.31	-156.59
9	BARROW:BW	17	71.31	-156.6
9	BARROW:CAREX WET MEADOW_ORDINATION	10	71.29	-156.64
9	BARROW:CAREX_MESIC MEADOW_ORDINATION	10	71.29	-156.64
9	BARROW:CAREX_MOIST MEADOW_ORDINATION	10	71.29	-156.64

9	BARROW:CAREX_MOIST_MEADOW_MICROTOPO	10	71.29	-156.64
9	BARROW:CAREX_WET_MEADOW_MICROTOPO	10	71.29	-156.64
9	BARROW:DRY_HEATH_ORDINATION	10	71.29	-156.64
9	BARROW:DUPONTIA_WET_MEADOW_MICROTOP	10	71.29	-156.64
10	BLONDUOS:SD33	19	65.5	-20.23
10	BLONDUOS:SD34	19	65.5	-20.23
11	BROOKS:SHEEN-B	11	68.57	-143.72
12	BYLOT:MESPOLYGON	7	73.15	-79.95
12	BYLOT:MESPRAIRIE	7	73.15	-79.95
13	DALSMYNNI:AG4	9	65.78	-19.31
13	DALSMYNNI:KD24	9	65.77	-19.03
13	DALSMYNNI:KD25	19	65.77	-19.04
13	DALSMYNNI:KK5	9	65.8	-19.36
14	DOVRE:KUNTSHOE	10	62.3	9.62
15	ENDALEN:BIS-H	7	78.19	15.74
15	ENDALEN:BIS-L	7	78.19	15.74
15	ENDALEN:CAS-H	7	78.19	15.74
15	ENDALEN:CAS-L	7	78.19	15.74
15	ENDALEN:DRY-H	7	78.19	15.74
15	ENDALEN:DRY-L	7	78.19	15.74
16	FURI:FURI4	17	61.64	12.64
16	FURI:FURI5	17	61.64	12.64
16	FURI:FURI6	17	61.64	12.64
17	GAVIA:POL	7	46.34	10.5
17	GAVIA:SAL	7	46.34	10.5
18	HJARDARLAND:HA75	18	64.07	-20.27
18	HJARDARLAND:HF73	18	64.04	-20.28
19	HJARDARLAND:LH92	18	64.22	-20.6
20	HJARDARLAND:SH90	8	63.98	-20.57
21	HOLTAVORDUHEIDI:AH36	19	65.08	-20.55
21	HOLTAVORDUHEIDI:AH37	19	65.07	-20.58
21	HOLTAVORDUHEIDI:AH38	19	65.08	-20.59
22	HOLTAVORDUHEIDI:VH49	19	65.23	-20.44
22	HOLTAVORDUHEIDI:VH50	19	65.24	-20.45
23	KLUANE:PIKA	12	61.22	-138.27
24	KYTALYK:LAKEBED	6	70.83	147.48
25	LATNJA:DRY_HEATH	14	68.36	18.5
25	LATNJA:DRY_MEADOW	19	68.36	18.5
25	LATNJA:TUSOCK_TUNDRA	20	68.36	18.49
25	LATNJA:WET_SEDGE	14	68.36	18.49
26	LOGH:LOGH2	17	62.1	12.34
26	LOGH:LOGH4	17	62.1	12.34

26	LOGH:LOGH5	17	62.1	12.34
26	LORI:LORI1	17	62.12	12.27
26	LORI:LORI3	17	62.12	12.27
26	LORI:LORI4	17	62.12	12.27
27	NIWOT:BARREN_SADDLE	8	40.05	-105.59
27	NIWOT:DRY MEADOW_SADDLE	8	40.05	-105.59
27	NIWOT:FELLFIELD_SADDLE	8	40.05	-105.59
27	NIWOT:KLEIN	8	40.05	-105.59
27	NIWOT:MOIST MEADOW_SADDLE	8	40.05	-105.59
27	NIWOT:ORDINATION_DRYMEADOW	11	40.05	-105.59
27	NIWOT:ORDINATION_FELLFIELD	11	40.05	-105.59
27	NIWOT:ORDINATION_MOISTMEADOW	11	40.05	-105.59
27	NIWOT:ORDINATION_MOISTSHRUB	11	40.05	-105.59
27	NIWOT:ORDINATION_SNOWBANK	11	40.05	-105.59
27	NIWOT:ORDINATION_WETMEADOW	11	40.05	-105.59
27	NIWOT:SNOW BANK_SADDLE	8	40.05	-105.59
27	NIWOT:WET MEADOW_SADDLE	8	40.05	-105.59
28	OXNADALSHEIDI:SA16	19	65.47	-18.7
28	OXNADALSHEIDI:SA17	19	65.47	-18.69
28	OXNADALSHEIDI:SA19	19	65.48	-18.9
29	QHI:HE	17	69.57	-138.86
29	QHI:KO	17	69.58	-138.87
30	RIRI:RIRI2	17	67.77	17.54
30	RIRI:RIRI4	17	67.77	17.54
30	RIRI:RIRI6	17	67.77	17.54
31	SVERDRUP:SVERDRUP	18	79.14	-79.62
32	THINGVELLIR:MOSS HEATH	12	64.28	-21.07
33	THYKKVIBAER:HH100	18	63.56	-20.17
34	THYKKVIBAER:RT81	18	63.99	-21.16
34	THYKKVIBAER:VE82	18	63.97	-21.17
35	TOOLIK:DRY	14	68.62	-149.61
35	TOOLIK:MOIST	15	68.62	-149.61
35	TOOLIK:TUS SOCKGRID	19	68.62	-149.61
36	TOOLIK:IMNAVAIT	19	68.62	-149.28
37	TORNGATS:NAKVAK DRY	9	58.64	-63.38
37	TORNGATS:NAKVAK WET	9	58.64	-63.38
38	VALBERCLA:ALPINE	20	46.48	9.58

Supplementary Table 3. Model output for *interspecific* spatial temperature-trait relationships. Bolded rows designate interspecific temperature-trait relationships (slope parameter) for which the 95% credible interval did not cross zero. The estimate type indicates the response variable: CWM = community weighted mean (turnover + abundance), NWM = non-weighted mean (due to turnover only), CWM+ITV = the community weighted mean with estimated intraspecific temperature-trait relationships included (see Methods). Climate variable indicates which temperature type was used (“summer” = warmest quarter temperature (bio 10), “winter” = coldest quarter temperature (bio 11)). Temperature was centered to improve model convergence; thus, the intercept parameter represents the trait value at approximately 6.88 °C for summer and -13.5 °C for winter. All parameter estimates are in transformed units (logit for LDMC, log for all others). For all models, n = 1520 plots nested within 117 sites nested within 72 regions (WorldClim grid cell). Only the first year of community composition data from each site were used to estimate spatial temperature-trait relationships.

<i>Trait</i>	<i>Climate Variable</i>	<i>Estimate Type</i>	<i>Parameter</i>	<i>mean</i>	<i>sd</i>	<i>2.5%</i>	<i>97.5%</i>
<i>Height</i>	summer	CWM	Intercept	2.546	0.057	2.434	2.655
<i>Height</i>	summer	CWM+ITV	Intercept	2.687	0.054	2.582	2.796
<i>Height</i>	summer	NWM	Intercept	2.515	0.042	2.430	2.590
<i>Height</i>	summer	CWM	Slope	0.115	0.023	0.069	0.162
<i>Height</i>	summer	CWM+ITV	Slope	0.131	0.023	0.086	0.176
<i>Height</i>	summer	NWM	Slope	0.083	0.017	0.050	0.117
<i>LDMC</i>	summer	CWM	Intercept	-0.549	0.030	-0.608	-0.490
<i>LDMC</i>	summer	CWM+ITV	Intercept	-0.576	0.028	-0.631	-0.519
<i>LDMC</i>	summer	NWM	Intercept	-0.700	0.031	-0.762	-0.640
<i>LDMC</i>	summer	CWM	Slope	-0.038	0.012	-0.062	-0.013
<i>LDMC</i>	summer	CWM+ITV	Slope	-0.043	0.012	-0.066	-0.019
<i>LDMC</i>	summer	NWM	Slope	-0.033	0.013	-0.059	-0.007
<i>Leaf Area</i>	summer	CWM	Intercept	0.446	0.103	0.263	0.649
<i>Leaf Area</i>	summer	CWM+ITV	Intercept	0.605	0.102	0.406	0.802
<i>Leaf Area</i>	summer	NWM	Intercept	0.394	0.072	0.250	0.537
<i>Leaf Area</i>	summer	CWM	Slope	0.018	0.041	-0.065	0.096
<i>Leaf Area</i>	summer	CWM+ITV	Slope	0.025	0.043	-0.058	0.111
<i>Leaf Area</i>	summer	NWM	Slope	0.006	0.031	-0.055	0.070
<i>Leaf N</i>	summer	CWM	Intercept	2.920	0.020	2.880	2.960
<i>Leaf N</i>	summer	CWM+ITV	Intercept	2.917	0.020	2.878	2.956
<i>Leaf N</i>	summer	NWM	Intercept	2.985	0.020	2.947	3.025
<i>Leaf N</i>	summer	CWM	Slope	-0.001	0.009	-0.018	0.015
<i>Leaf N</i>	summer	CWM+ITV	Slope	-0.001	0.008	-0.017	0.016
<i>Leaf N</i>	summer	NWM	Slope	0.009	0.008	-0.007	0.026

<i>Trait</i>	<i>Climate Variable</i>	<i>Estimate Type</i>	<i>Parameter</i>	<i>mean</i>	<i>sd</i>	<i>2.5%</i>	<i>97.5%</i>
<i>SLA</i>	summer	CWM	Intercept	2.559	0.027	2.505	2.611
<i>SLA</i>	summer	CWM+ITV	Intercept	2.581	0.027	2.529	2.634
<i>SLA</i>	summer	NWM	Intercept	2.635	0.023	2.587	2.680
<i>SLA</i>	summer	CWM	Slope	0.044	0.011	0.022	0.066
<i>SLA</i>	summer	CWM+ITV	Slope	0.051	0.011	0.028	0.073
<i>SLA</i>	summer	NWM	Slope	0.037	0.010	0.017	0.057
<i>Height</i>	winter	CWM	Intercept	2.541	0.058	2.425	2.656
<i>Height</i>	winter	CWM+ITV	Intercept	2.599	0.057	2.484	2.708
<i>Height</i>	winter	NWM	Intercept	2.542	0.040	2.464	2.623
<i>Height</i>	winter	CWM	Slope	0.019	0.005	0.010	0.029
<i>Height</i>	winter	CWM+ITV	Slope	0.020	0.005	0.011	0.029
<i>Height</i>	winter	NWM	Slope	0.015	0.003	0.009	0.022
<i>LDMC</i>	winter	CWM	Intercept	-0.616	0.025	-0.666	-0.568
<i>LDMC</i>	winter	CWM+ITV	Intercept	-0.872	0.032	-0.933	-0.810
<i>LDMC</i>	winter	NWM	Intercept	-0.758	0.034	-0.825	-0.692
<i>LDMC</i>	winter	CWM	Slope	-0.013	0.002	-0.017	-0.009
<i>LDMC</i>	winter	CWM+ITV	Slope	-0.017	0.003	-0.022	-0.012
<i>LDMC</i>	winter	NWM	Slope	-0.021	0.003	-0.027	-0.016
<i>Leaf Area</i>	winter	CWM	Intercept	0.457	0.098	0.262	0.643
<i>Leaf Area</i>	winter	CWM+ITV	Intercept	0.562	0.101	0.364	0.749
<i>Leaf Area</i>	winter	NWM	Intercept	0.572	0.079	0.416	0.727
<i>Leaf Area</i>	winter	CWM	Slope	0.008	0.008	-0.008	0.024
<i>Leaf Area</i>	winter	CWM+ITV	Slope	0.006	0.008	-0.010	0.022
<i>Leaf Area</i>	winter	NWM	Slope	-0.007	0.006	-0.020	0.005
<i>Leaf N</i>	winter	CWM	Intercept	2.919	0.019	2.881	2.956
<i>Leaf N</i>	winter	CWM+ITV	Intercept	2.949	0.019	2.912	2.987
<i>Leaf N</i>	winter	NWM	Intercept	2.997	0.019	2.962	3.033
<i>Leaf N</i>	winter	CWM	Slope	0.003	0.002	0.000	0.007
<i>Leaf N</i>	winter	CWM+ITV	Slope	0.004	0.002	0.001	0.007
<i>Leaf N</i>	winter	NWM	Slope	0.005	0.002	0.002	0.008
<i>SLA</i>	winter	CWM	Intercept	2.562	0.022	2.520	2.605
<i>SLA</i>	winter	CWM+ITV	Intercept	2.596	0.021	2.555	2.635
<i>SLA</i>	winter	NWM	Intercept	2.653	0.019	2.621	2.690
<i>SLA</i>	winter	CWM	Slope	0.014	0.002	0.010	0.017
<i>SLA</i>	winter	CWM+ITV	Slope	0.014	0.002	0.010	0.017
<i>SLA</i>	winter	NWM	Slope	0.012	0.001	0.009	0.015

Supplementary Table 4. Model output for *interspecific* spatial relationships with both temperature and soil moisture. Bolded rows designate predictors of community weighted trait means (CWM) for which the credible interval did not cross zero. All estimates are for summer temperature only (bio 10). Temperature and soil moisture values were centered to improve model convergence; thus, the intercept parameter represents the trait value at approximately 6.88 °C and “mesic” soil moisture. All parameter estimates are in transformed units (logit for LDMC, woodiness and evergreenness, log for all others). For all models, n = 1520 plots nested within 117 sites nested within 72 regions (WorldClim grid cell). Only the first year of community composition data from each site were used to estimate spatial temperature-trait relationships.

<i>Trait</i>	<i>Climate Variable</i>	<i>Parameter</i>	<i>mean</i>	<i>sd</i>	<i>2.5%</i>	<i>97.5%</i>
<i>Height</i>	summer	Intercept	2.527	0.048	2.435	2.620
<i>Height</i>	summer	Moisture	0.316	0.055	0.210	0.425
<i>Height</i>	summer	Temperature	0.106	0.020	0.066	0.146
<i>Height</i>	summer	Temperature*Moisture	-0.018	0.021	-0.060	0.023
<i>LDMC</i>	summer	Intercept	-0.553	0.029	-0.609	-0.497
<i>LDMC</i>	summer	Moisture	-0.066	0.035	-0.132	0.003
<i>LDMC</i>	summer	Temperature	-0.043	0.012	-0.066	-0.018
<i>LDMC</i>	summer	Temperature*Moisture	-0.044	0.013	-0.070	-0.017
<i>Leaf Area</i>	summer	Intercept	0.415	0.089	0.243	0.591
<i>Leaf Area</i>	summer	Moisture	0.896	0.118	0.668	1.126
<i>Leaf Area</i>	summer	Temperature	-0.002	0.037	-0.075	0.072
<i>Leaf Area</i>	summer	Temperature*Moisture	0.102	0.043	0.015	0.187
<i>Leaf N</i>	summer	Intercept	2.925	0.019	2.889	2.962
<i>Leaf N</i>	summer	Moisture	0.118	0.023	0.073	0.162
<i>Leaf N</i>	summer	Temperature	0.000	0.008	-0.016	0.016
<i>Leaf N</i>	summer	Temperature*Moisture	0.019	0.009	0.001	0.038
<i>SLA</i>	summer	Intercept	2.558	0.025	2.509	2.606
<i>SLA</i>	summer	Moisture	0.162	0.033	0.096	0.228
<i>SLA</i>	summer	Temperature	0.040	0.010	0.020	0.061
<i>SLA</i>	summer	Temperature*Moisture	0.032	0.013	0.007	0.056
<i>Woodiness</i>	summer	Intercept	-1.067	0.178	-1.409	-0.715
<i>Woodiness</i>	summer	Moisture	-1.308	0.006	-1.452	-0.887
<i>Woodiness</i>	summer	Temperature	-0.184	0.001	-0.230	-0.045
<i>Woodiness</i>	summer	Temperature*Moisture	-0.046	0.002	-0.100	0.114
<i>Evergreenness</i>	summer	Intercept	-0.599	0.199	-1.005	-0.220
<i>Evergreenness</i>	summer	Moisture	-1.304	0.006	-1.467	-0.815
<i>Evergreenness</i>	summer	Temperature	0.149	0.002	0.093	0.314
<i>Evergreenness</i>	summer	Temperature*Moisture	-0.133	0.002	-0.201	0.069

Supplementary Table 5. Model output for *intraspecific* spatial temperature-trait

relationships. Overall intraspecific temperature-trait relationships are estimated as the mean of 108-109 species for SLA, 80-86 species for plant height, 74-72 species for leaf nitrogen, 85-76 species for leaf area, and 43-52 species for LDMC, for summer and winter temperature, respectively (see *Methods: Analyses: Intraspecific Trait Variation* for details). Bolded rows designate intraspecific temperature-trait relationships (slope parameter) for which the 95% credible interval did not cross zero. Climate variable indicates which temperature type was used (summer temperature = bio 10, winter temperature = bio 11). Temperature was centered within each species to improve model convergence. The “Intercept Temp” column indicates the mean temperature at the intercept for each trait and climate variable. All parameter estimates are in transformed units (logit for LDMC, log for all others).

<i>Trait</i>	<i>Climate Variable</i>	<i>Estimate Type</i>	<i>Parameter</i>	<i>Intercept Temp (°C)</i>	<i>mean</i>	<i>sd</i>	<i>2.5%</i>	<i>97.5%</i>
Height	summer	ITV	Intercept	9.71	2.675	0.102	2.471	2.867
Height	summer	ITV	Slope		0.059	0.011	0.037	0.081
<i>LDMC</i>	summer	ITV	Intercept	10.70	-0.767	0.085	-0.932	-0.596
<i>LDMC</i>	summer	ITV	Slope		-0.008	0.007	-0.023	0.007
Leaf Area	summer	ITV	Intercept	10.61	0.547	0.172	0.211	0.885
Leaf Area	summer	ITV	Slope		0.050	0.013	0.024	0.075
Leaf N	summer	ITV	Intercept	11.19	2.983	0.045	2.896	3.066
Leaf N	summer	ITV	Slope		-0.002	0.004	-0.008	0.006
SLA	summer	ITV	Intercept	10.93	2.743	0.045	2.656	2.832
SLA	summer	ITV	Slope		0.005	0.003	-0.001	0.012
Height	winter	ITV	Intercept	-12.82	2.645	0.101	2.453	2.845
Height	winter	ITV	Slope		0.007	0.006	-0.004	0.019
<i>LDMC</i>	winter	ITV	Intercept	-12.22	-0.750	0.070	-0.890	-0.620
<i>LDMC</i>	winter	ITV	Slope		-0.020	0.003	-0.027	-0.014
Leaf Area	winter	ITV	Intercept	-10.50	0.615	0.173	0.265	0.936
Leaf Area	winter	ITV	Slope		0.013	0.008	-0.002	0.029
Leaf N	winter	ITV	Intercept	-9.69	2.977	0.047	2.888	3.063
Leaf N	winter	ITV	Slope		0.007	0.002	0.002	0.012
SLA	winter	ITV	Intercept	-9.83	2.744	0.045	2.660	2.835
SLA	winter	ITV	Slope		0.004	0.002	0.001	0.008

Supplementary Table 6. Model output for interspecific trait change over time. Bolded rows designate slope parameters (change over time) for which the 95% credible interval did not cross zero. The estimate type indicates the response variable: CWM = community weighted mean (turnover + abundance), NWM = non-weighted mean (due to turnover only), CWM+ITV = the community weighted mean with estimated intraspecific temperature-trait relationships included (see Methods). CWM+ITV was estimated based on summer temperature change only (bio 10). All parameter estimates are in transformed units (logit for LDMC, log for all others). For all models, n = 4575 plot-years nested within 117 sites nested within 38 regions (CRU grid cells).

<i>Trait</i>	<i>Climate Variable</i>	<i>Estimate Type</i>	<i>Parameter</i>	<i>mean</i>	<i>sd</i>	<i>2.5%</i>	<i>97.5%</i>
<i>Height</i>	-	CWM	Intercept	2.514	0.087	2.341	2.683
<i>Height</i>	summer	CWM+ITV	Intercept	2.691	0.087	2.514	2.858
<i>Height</i>	-	NWM	Intercept	2.495	0.072	2.357	2.635
<i>Height</i>	-	CWM	Slope	0.002	0.001	0.000	0.004
<i>Height</i>	summer	CWM+ITV	Slope	0.004	0.001	0.002	0.006
<i>Height</i>	-	NWM	Slope	0.002	0.001	0.001	0.004
<i>LDMC</i>	-	CWM	Intercept	-0.535	0.045	-0.624	-0.446
<i>LDMC</i>	summer	CWM+ITV	Intercept	-0.569	0.041	-0.649	-0.489
<i>LDMC</i>	-	NWM	Intercept	-0.677	0.044	-0.766	-0.596
<i>LDMC</i>	-	CWM	Slope	0.001	0.001	-0.001	0.002
<i>LDMC</i>	summer	CWM+ITV	Slope	0.000	0.001	-0.001	0.002
<i>LDMC</i>	-	NWM	Slope	0.000	0.000	-0.001	0.001
<i>Leaf Area</i>	-	CWM	Intercept	0.292	0.126	0.033	0.526
<i>Leaf Area</i>	summer	CWM+ITV	Intercept	0.461	0.125	0.213	0.697
<i>Leaf Area</i>	-	NWM	Intercept	0.337	0.108	0.124	0.550
<i>Leaf Area</i>	-	CWM	Slope	0.001	0.003	-0.006	0.007
<i>Leaf Area</i>	summer	CWM+ITV	Slope	0.001	0.003	-0.006	0.007
<i>Leaf Area</i>	-	NWM	Slope	0.003	0.002	-0.001	0.007
<i>Leaf N</i>	-	CWM	Intercept	2.896	0.032	2.833	2.960
<i>Leaf N</i>	summer	CWM+ITV	Intercept	2.895	0.031	2.835	2.958
<i>Leaf N</i>	-	NWM	Intercept	2.952	0.031	2.891	3.014
<i>Leaf N</i>	-	CWM	Slope	-0.001	0.001	-0.002	0.000
<i>Leaf N</i>	summer	CWM+ITV	Slope	-0.001	0.001	-0.002	0.000
<i>Leaf N</i>	-	NWM	Slope	-0.001	0.000	-0.001	0.000
<i>SLA</i>	-	CWM	Intercept	2.536	0.045	2.448	2.625
<i>SLA</i>	summer	CWM+ITV	Intercept	2.573	0.045	2.484	2.660
<i>SLA</i>	-	NWM	Intercept	2.613	0.039	2.535	2.688
<i>SLA</i>	-	CWM	Slope	0.000	0.001	-0.002	0.001
<i>SLA</i>	summer	CWM+ITV	Slope	0.000	0.001	-0.001	0.001
<i>SLA</i>	-	NWM	Slope	0.000	0.000	-0.001	0.001

Supplementary Table 7. Model output for temperature sensitivity of community

weighted trait means. Temperature sensitivity represents the correspondence between interannual variation in CWM traits and interannual variation in temperature (i.e., the amount of change in CWM trait per °C) across all sites (n = 4575 plot-years nested within 117 sites nested within 38 regions (CRU grid cells)). All estimates are for community-weighted mean (CWM) change only. Bolded rows designate slope parameters (sensitivity) for which the 95% credible interval did not cross zero. All parameter estimates are in transformed units (logit for LDMC, log for all others).

<i>Trait</i>	<i>Climate Variable</i>	<i>Parameter</i>	<i>mean</i>	<i>sd</i>	<i>2.50%</i>	<i>97.50%</i>
<i>Height</i>	summer	Intercept	2.518	0.086	2.350	2.679
<i>Height</i>	summer	Slope	0.039	0.019	0.002	0.078
<i>LDMC</i>	summer	Intercept	-0.535	0.045	-0.625	-0.449
<i>LDMC</i>	summer	Slope	-0.010	0.011	-0.033	0.013
<i>Leaf Area</i>	summer	Intercept	0.295	0.125	0.041	0.531
<i>Leaf Area</i>	summer	Slope	-0.031	0.044	-0.116	0.057
<i>Leaf N</i>	summer	Intercept	2.897	0.031	2.836	2.957
<i>Leaf N</i>	summer	Slope	0.006	0.009	-0.012	0.024
<i>SLA</i>	summer	Intercept	2.535	0.044	2.448	2.623
<i>SLA</i>	summer	Slope	0.009	0.011	-0.012	0.031
<i>Height</i>	winter	Intercept	2.514	0.086	2.342	2.684
<i>Height</i>	winter	Slope	0.012	0.009	-0.007	0.030
<i>LDMC</i>	winter	Intercept	-0.595	0.046	-0.684	-0.506
<i>LDMC</i>	winter	Slope	-0.001	0.005	-0.011	0.010
<i>Leaf Area</i>	winter	Intercept	0.286	0.129	0.023	0.526
<i>Leaf Area</i>	winter	Slope	0.026	0.023	-0.018	0.071
<i>Leaf N</i>	winter	Intercept	2.896	0.031	2.834	2.956
<i>Leaf N</i>	winter	Slope	0.003	0.004	-0.005	0.010
<i>SLA</i>	winter	Intercept	2.536	0.045	2.450	2.623
<i>SLA</i>	winter	Slope	0.003	0.005	-0.006	0.013

Supplementary Table 8. Model output for interspecific trait change over time with temperature change and soil moisture (static) as predictors of this change. Neither temperature change nor soil moisture was an important predictor of trait change over time (all credible intervals overlap zero). All estimates are for community-weighted mean (CWM) and summer temperature (bioclim 10) change only. All parameter estimates are in transformed units (logit for LDMC, log for all others). N = 4575 plot-years nested within 117 sites nested within 78 regions (CRU grid cell x soil moisture combinations).

<i>Trait</i>	<i>Climate Variable</i>	<i>Parameter</i>	<i>mean</i>	<i>sd</i>	<i>2.5%</i>	<i>97.5%</i>
<i>Height</i>	summer	Intercept	0.002	0.000	0.001	0.003
<i>Height</i>	summer	Moisture	0.000	0.001	-0.002	0.001
<i>Height</i>	summer	TemperatureChange	-0.002	0.008	-0.018	0.012
<i>Height</i>	summer	TemperatureChange*Moisture	0.007	0.016	-0.022	0.043
<i>LDMC</i>	summer	Intercept	0.001	0.000	0.001	0.002
<i>LDMC</i>	summer	Moisture	0.000	0.001	-0.002	0.001
<i>LDMC</i>	summer	TemperatureChange	-0.008	0.008	-0.023	0.008
<i>LDMC</i>	summer	TemperatureChange*Moisture	0.005	0.017	-0.030	0.034
<i>Leaf Area</i>	summer	Intercept	0.005	0.002	0.001	0.008
<i>Leaf Area</i>	summer	Moisture	-0.004	0.003	-0.011	0.003
<i>Leaf Area</i>	summer	TemperatureChange	-0.032	0.039	-0.112	0.045
<i>Leaf Area</i>	summer	TemperatureChange*Moisture	0.085	0.077	-0.069	0.225
<i>Leaf N</i>	summer	Intercept	-0.001	0.000	-0.001	0.000
<i>Leaf N</i>	summer	Moisture	0.000	0.000	-0.001	0.001
<i>Leaf N</i>	summer	TemperatureChange	0.005	0.006	-0.007	0.015
<i>Leaf N</i>	summer	TemperatureChange*Moisture	-0.007	0.011	-0.027	0.016
<i>SLA</i>	summer	Intercept	-0.001	0.000	-0.001	0.000
<i>SLA</i>	summer	Moisture	0.000	0.001	-0.001	0.001
<i>SLA</i>	summer	TemperatureChange	0.009	0.007	-0.005	0.022
<i>SLA</i>	summer	TemperatureChange*Moisture	-0.001	0.014	-0.027	0.027

Supplementary Table 9. Probability that a species immigrated into a site (“gained”) or disappeared from a site (“lost”) as a function of its traits. Only for plant height were the trait values of gained and lost species different – the probability of a species being gained was positively related to its height but the probability of a species being lost was not. Bold text designates slope parameters for which the 95% credible interval did not overlap zero. N = 2830 observations (species-site combinations) in 117 sites.

Trait	Direction	Parameter	mean	sd	2.5%	97.5%
<i>Height</i>	gained	Intercept	-2.402	0.221	-2.821	-1.948
<i>Height</i>	lost	Intercept	-1.786	0.223	-2.188	-1.358
<i>Height</i>	gained	Slope	0.247	0.082	0.081	0.403
<i>Height</i>	lost	Slope	0.039	0.080	-0.116	0.194
<i>LDMC</i>	gained	Intercept	-2.225	0.127	-2.474	-1.978
<i>LDMC</i>	lost	Intercept	-2.186	0.124	-2.432	-1.944
<i>LDMC</i>	gained	Slope	-0.438	0.100	-0.619	-0.225
<i>LDMC</i>	lost	Slope	-0.501	0.092	-0.666	-0.305
<i>Leaf Area</i>	gained	Intercept	-1.834	0.099	-2.037	-1.644
<i>Leaf Area</i>	lost	Intercept	-1.704	0.099	-1.881	-1.512
<i>Leaf Area</i>	gained	Slope	0.090	0.059	-0.024	0.211
<i>Leaf Area</i>	lost	Slope	-0.089	0.061	-0.207	0.046
<i>Leaf N</i>	gained	Intercept	-1.590	0.418	-2.423	-0.764
<i>Leaf N</i>	lost	Intercept	-2.184	0.377	-2.897	-1.427
<i>Leaf N</i>	gained	Slope	-0.067	0.137	-0.334	0.205
<i>Leaf N</i>	lost	Slope	0.170	0.124	-0.069	0.403
<i>SLA</i>	gained	Intercept	-2.872	0.116	-2.996	-2.569
<i>SLA</i>	lost	Intercept	-2.850	0.133	-2.995	-2.500
<i>SLA</i>	gained	Slope	0.421	0.054	0.302	0.517
<i>SLA</i>	lost	Slope	0.447	0.057	0.317	0.543

Supplementary Table 10. Abundance change for the most common (abundant and/or widespread) species in the vegetation survey dataset. Species are ordered from greatest increase to greatest decrease overall (across all regions). The “mean”, “sd”, “2.5%” and “97.5%” columns provide the mean, standard deviation, and 0.025 and 0.975 quantiles of the posterior distribution for the species-level model (plots, sites and regions are nested within each species). Species names in bold indicate that the 95% credible interval for the overall slope of abundance change over time did not overlap zero. The “Prop. Increase” and “Prop. Decrease” columns indicate the proportion of regions in which a given species was found to increase or decrease in abundance, as defined by an 80% credible interval for the region-specific slope of abundance change that did not cross zero. Abundance estimates (proportion of plot cover) are bounded between 0 and 1, inclusive. Thus, abundance change was modeled with a beta-Bernoulli mixture model and parameter estimates represent the change in cover on the logit scale.

<i>Name</i>	<i>mean</i>	<i>sd</i>	<i>2.5%</i>	<i>97.5%</i>	<i>Num. regions</i>	<i>Prop. Increase</i>	<i>Prop. Decrease</i>	<i>Growth Form</i>
<i>Calluna vulgaris</i>	0.072	0.011	0.047	0.092	5	100	0	evergreen shrub
<i>Loiseleuria procumbens</i>	0.061	0.027	0.009	0.116	4	100	0	evergreen shrub
<i>Alopecurus alpinus</i>	0.059	0.039	-0.019	0.139	5	100	0	graminoid
<i>Arctagrostis latifolia</i>	0.055	0.013	0.030	0.081	11	100	0	graminoid
<i>Carex rariflora</i>	0.044	0.034	-0.032	0.106	7	14	0	graminoid
<i>Carex nigra</i>	0.042	0.019	0.005	0.078	12	100	0	graminoid
<i>Eriophorum vaginatum</i>	0.038	0.015	0.006	0.070	9	100	0	graminoid
<i>Empetrum nigrum</i>	0.034	0.008	0.018	0.049	18	100	0	evergreen shrub
<i>Betula nana</i>	0.032	0.006	0.020	0.044	16	100	0	deciduous shrub
<i>Caltha leptosepala</i>	0.030	0.038	-0.046	0.104	1	0	0	forb
<i>Saxifraga foliolosa</i>	0.026	0.022	-0.015	0.069	4	25	0	forb
<i>Vaccinium uliginosum</i>	0.025	0.007	0.011	0.039	20	100	0	deciduous shrub
<i>Dryas octopetala</i>	0.023	0.014	-0.004	0.051	10	50	0	evergreen shrub
<i>Trifolium dasyphyllum</i>	0.023	0.031	-0.036	0.087	1	0	0	forb
<i>Vaccinium myrtillus</i>	0.022	0.028	-0.038	0.079	3	0	0	deciduous shrub
<i>Gagea serotina</i>	0.022	0.034	-0.055	0.085	3	0	0	forb
<i>Alchemilla alpina</i>	0.021	0.020	-0.019	0.059	5	0	0	forb
<i>Carex aquatilis</i>	0.020	0.017	-0.015	0.054	7	0	0	graminoid
<i>Luzula nivalis</i>	0.020	0.011	-0.002	0.044	9	78	0	graminoid
<i>Salix arctica</i>	0.019	0.010	0.000	0.039	10	80	0	deciduous

								shrub
<i>Salix herbacea</i>	0.019	0.009	0.001	0.038	16	88	0	deciduous shrub
<i>Salix pulchra</i>	0.018	0.008	0.001	0.035	5	60	0	deciduous shrub
<i>Salix polaris</i>	0.017	0.019	-0.021	0.055	4	0	0	deciduous shrub
<i>Arctous alpina</i>	0.017	0.019	-0.020	0.053	8	0	0	deciduous shrub
<i>Vaccinium vitis-idaea</i>	0.016	0.006	0.002	0.028	13	69	0	evergreen shrub
<i>Dryas integrifolia</i>	0.015	0.008	-0.001	0.030	9	44	0	evergreen shrub
<i>Phyllodoce caerulea</i>	0.014	0.012	-0.011	0.036	5	0	0	evergreen shrub
<i>Eriophorum angustifolium</i>	0.013	0.009	-0.005	0.031	18	11	0	graminoid
<i>Minuartia obtusiloba</i>	0.013	0.039	-0.047	0.109	2	0	0	forb
<i>Hierochloe alpina</i>	0.013	0.015	-0.015	0.043	6	0	0	graminoid
<i>Rubus chamaemorus</i>	0.012	0.010	-0.008	0.033	5	20	0	forb
<i>Luzula confusa</i>	0.011	0.010	-0.009	0.032	7	14	0	graminoid
<i>Stellaria longipes</i>	0.011	0.015	-0.018	0.040	12	0	0	forb
<i>Festuca brachyphylla</i>	0.010	0.017	-0.024	0.044	5	0	0	graminoid
<i>Carex vaginata</i>	0.010	0.015	-0.021	0.038	10	0	0	graminoid
<i>Juncus trifidus</i>	0.009	0.012	-0.015	0.030	12	0	0	graminoid
<i>Tephroseris frigida</i>	0.009	0.017	-0.022	0.044	8	0	0	forb
<i>Salix reticulata</i>	0.009	0.009	-0.009	0.025	12	0	0	deciduous shrub
<i>Petasites frigidus</i>	0.008	0.014	-0.020	0.038	7	0	0	forb
<i>Thalictrum alpinum</i>	0.008	0.008	-0.008	0.025	13	0	0	forb
<i>Trisetum spicatum</i>	0.008	0.017	-0.025	0.040	10	0	0	graminoid
<i>Salix glauca</i>	0.007	0.012	-0.014	0.032	16	0	0	deciduous shrub
<i>Salix planifolia</i>	0.007	0.024	-0.040	0.055	3	0	0	deciduous shrub
<i>Persicaria bistorta</i>	0.006	0.010	-0.013	0.025	7	0	0	forb
<i>Oxyria digyna</i>	0.006	0.018	-0.038	0.040	6	0	0	forb
<i>Carex bigelowii</i>	0.006	0.006	-0.008	0.018	21	0	0	graminoid
<i>Sibbaldia procumbens</i>	0.006	0.021	-0.045	0.042	5	0	0	forb
<i>Silene acaulis</i>	0.005	0.012	-0.016	0.029	14	0	0	forb
<i>Cassiope tetragona</i>	0.005	0.008	-0.011	0.021	12	0	0	evergreen shrub
<i>Saxifraga oppositifolia</i>	0.004	0.014	-0.023	0.033	5	0	0	forb
<i>Equisetum arvense</i>	0.004	0.008	-0.011	0.020	17	0	0	forb

<i>Equisetum variegatum</i>	0.004	0.009	-0.011	0.022	15	0	0	forb
<i>Poa arctica</i>	0.004	0.011	-0.017	0.028	11	0	0	graminoid
<i>Carex rupestris</i>	0.003	0.018	-0.032	0.038	7	0	0	graminoid
<i>Dupontia fisheri</i>	0.003	0.018	-0.034	0.038	2	0	0	graminoid
<i>Festuca rubra</i>	0.002	0.007	-0.013	0.015	15	0	0	graminoid
<i>Persicaria vivipara</i>	0.002	0.007	-0.013	0.014	29	0	0	forb
<i>Kobresia myosuroides</i>	0.001	0.011	-0.021	0.023	12	0	0	graminoid
<i>Artemisia scopulorum</i>	0.000	0.025	-0.045	0.054	1	0	0	forb
<i>Saxifraga cernua</i>	0.000	0.015	-0.029	0.032	6	0	0	forb
<i>Ranunculus nivalis</i>	0.000	0.022	-0.043	0.043	3	0	0	forb
<i>Pyrola grandiflora</i>	0.000	0.016	-0.031	0.029	6	0	0	forb
<i>Deschampsia flexuosa</i>	-0.001	0.013	-0.030	0.023	7	0	0	graminoid
<i>Ledum palustre</i>	-0.001	0.010	-0.022	0.017	6	0	0	evergreen shrub
<i>Poa pratensis</i>	-0.002	0.022	-0.041	0.045	11	0	0	graminoid
<i>Eriophorum chamissonis</i>	-0.005	0.026	-0.055	0.045	2	0	0	graminoid
<i>Erigeron grandiflorus</i>	-0.005	0.032	-0.064	0.065	1	0	0	forb
<i>Salix phlebophylla</i>	-0.007	0.013	-0.031	0.018	6	0	0	deciduous shrub
<i>Salix rotundifolia</i>	-0.007	0.030	-0.064	0.057	3	0	0	deciduous shrub
<i>Geum rossii</i>	-0.007	0.021	-0.049	0.037	1	0	0	forb
<i>Castilleja occidentalis</i>	-0.009	0.043	-0.083	0.087	1	0	0	forb
<i>Carex chordorrhiza</i>	-0.012	0.033	-0.088	0.048	7	0	0	graminoid
<i>Agrostis capillaris</i>	-0.013	0.021	-0.050	0.031	12	0	0	graminoid
<i>Hierochloe pauciflora</i>	-0.017	0.046	-0.116	0.074	2	0	0	graminoid
<i>Carex scopulorum</i>	-0.022	0.030	-0.080	0.038	1	0	0	graminoid
<i>Deschampsia cespitosa</i>	-0.024	0.019	-0.059	0.016	11	0	0	graminoid
<i>Bistorta bistortoides</i>	-0.029	0.024	-0.075	0.019	1	0	0	forb
<i>Trifolium parryi</i>	-0.032	0.046	-0.115	0.082	1	0	0	forb
<i>Calamagrostis holmii</i>	-0.113	0.086	-0.268	0.082	2	0	100	graminoid

Stan code for spatial community trait models. Relationship between log or logit CWM traits, temperature, and soil moisture over space (*Fig. 2a*).

```

data {
  int<lower=0> Nobs; // number of observations
  int<lower=0> Nsite; // number of sites
  int<lower=0> Nregion; // number of regions (WorldClim grid cell)
  int<lower=0> Nxhat; // length of xhat vector (for predictions)
  int<lower=1,upper=Nregion> region[Nobs];
  int<lower=1,upper=Nsite> site[Nobs];

  vector[Nobs] CWMmean; // mean CWM value per plot (calculated previously)
  vector[Nobs] CWMsd; // sd of CWM value per plot (calculated previously)
  vector[Nsite] soilmoist; // soil moisture value per site
  vector[Nsite] temp_site; // temperature per site
  vector[Nregion] temp_region; // temperature per region (WorldClim grid cell)
  vector[Nxhat] xhat1; // for predictions – gradient of soil moisture values
  vector[Nxhat] xhat2; // for predictions – gradient of temperature values
}

parameters {
  real<lower=-10,upper=10> as[Nsite]; // site effect
  real<lower=-2,upper=5> aMeanRegion[Nregion]; // region effect
  real<lower=-2,upper=5> gamma0; // intercept of trait-environment relationship (mean at temp = 0)
  real<lower=-2,upper=2> gamma1; // slope of moisture - trait relationship
  real<lower=-2,upper=2> gamma2; // temperature - soil moisture interaction
  real<lower=-2,upper=2> gamma3; // slope of temperature - trait relationship
  real<lower=0,upper=2> sigma_sm;
  real<lower=0,upper=3> sigma_overall;
}

transformed parameters {

  vector[Nobs] traitpred;

  for (i in 1:Nobs){

    traitpred[i] = as[site[i]] + aMeanRegion[region[i]];

  }
}

model {

  CWMmean ~ normal(traitpred, CWMsd);

  for (i in 1:Nsite){
    as[i] ~ normal(gamma1 * soilmoist[i] + gamma2 * soilmoist[i] * temp_site[i], sigma_sm);
  }

  for (i in 1:Nregion){
    aMeanRegion[i] ~ normal(gamma0 + gamma3 * temp_region[i], sigma_overall);
  }

}

generated quantities{ //get predictions per xhat (shown in Fig. 2a)

  vector[Nxhat] preds;

  for (i in 1:Nxhat){

```

```

    preds[i] = (gamma0 + gamma1*xhat1[i] + gamma2*xhat2[i] + gamma3*xhat1[i]*xhat2[i]);
  }

}

```

Stan code for change over time in log or logit CWM traits (Fig. 3a).

```

data {
  int<lower=1> Nplot; // number of plots
  int<lower=1> Nsite; // number of sites
  int<lower=1> Nregion; // number of regions (CRU grid cell)
  int<lower=1> Nobs; // number of observations
  int<lower=1> Nregionyears; // the number of region x year combinations
  int<lower=1> Nxhats; // length of xhat vector (for predictions)

  int<lower=1,upper=Nregion> region[Nobs];
  int<lower=1,upper=Nsite> site[Nobs];
  int<lower=1,upper=Nplot> plot[Nobs];
  int<lower=1,upper=Nregionyears> regionyear[Nobs];
  int<lower=1,upper=Nsite> siteplot[Nplot];
  int<lower=1,upper=Nregion> regionsite[Nsite];
  int xregion[Nregionyears];
  vector[Nregionyears] xyear; // year of observation (centered)
  vector[Nxhats] xhat1; // for predictions – gradient of values for “year” (centered)

  // these indicate whether a plot is repeatedly measured (1=yes, 0=no),
  // whether the plot is from a site that has multiple plots,
  // and whether the site is from a region that has multiple sites within in
  int<lower=0,upper=1> replots[Nobs];
  int<lower=0,upper=1> multplots[Nobs];
  int<lower=0,upper=1> replots2[Nplot];
  int<lower=0,upper=1> multplots2[Nplot];
  int<lower=0,upper=1> multisites[Nobs];
  int<lower=0,upper=1> multisites3[Nsite];

  vector[Nobs] CWMmean;
  vector[Nobs] CWMsd;
}

parameters {
  real<lower=-10,upper=10> ap[Nplot]; // plot effect
  real<lower=-10,upper=10> as[Nsite]; // site effect
  real<lower=-6,upper=6> ary[Nregionyears]; // region x year effect
  vector[Nregion] alpha; // intercept of region effect with time
  vector[Nregion] beta; // slope of region effect with time

  real<lower=-2,upper=6> mu_alpha; // normal hyperparameter for region effects (alpha)
  real<lower=-2,upper=2> mu_beta; // normal hyperparameter for the region effects (beta)
  real<lower=0,upper=3> sigma_alpha;
  real<lower=0,upper=3> sigma_beta;
  real<lower=0,upper=3> sigma_site[Nsite]; // plot-level variation within each site
  real<lower=0,upper=3> sigma_region[Nregion]; // site-level variation within each region
  real<lower=0,upper=3> sigma_ry; // variation of region x year combination effects around prediction
}

transformed parameters {
  vector[Nobs] traitpred;
  vector[Nobs] app;

```

```

vector[Nobs] ass;

for (i in 1:Nobs){

  if((repplots[i]==1 && multplots[i]==1))
    app[i] = ap[plot[i]];
  else app[i] = 0; // set plot effect to 0 if plot is not remeasured or is the only plot within a site

  if((multsites[i]==1))
    ass[i] = as[site[i]];
  else ass[i] = 0; // set site effect to 0 for sites that are the only site within a region

  traitpred[i] = app[i] + ass[i] + ary[regionyear[i]];

}
}

model {

  CWMmean ~ normal(traitpred, CWMsd);

  for(i in 1:Nregionyears){
    ary[i] ~ normal(alpha[xregion[i]] + beta[xregion[i]] * xyear[i], sigma_ry);
  }

  for (i in 1:Nplot){
    if(repplots2[i]==1 && multplots2[i]==1)
      ap[i] ~ normal(0, sigma_site[siteplot[i]]); // plot random effect
  }

  for (i in 1:Nsite){
    if(multsites3[i]==1)
      as[i] ~ normal(0, sigma_region[regionsite[i]]); // site random effect
  }

  for (i in 1:Nregion){
    alpha[i] ~ normal(mu_alpha, sigma_alpha); // intercept hyperparameter
    beta[i] ~ normal(mu_beta, sigma_beta); // slope hyperparameter (change over time)
  }

}

generated quantities{

  vector[Nxhats] preds;

  for (i in 1:Nxhats){
    preds[i] = (mu_alpha + mu_beta*xhat1[i]); // predictions
  }

}

```

TRY Data References

1. Atkin, O. K., M. H. M. Westbeek, M. L. Cambridge, H. Lambers, and T. L. Pons. 1997. Leaf respiration in light and darkness - A comparison of slow- and fast-growing *Poa* species. *Plant Physiology* 113:961-965.
2. Bahn, M., G. Wohlfahrt, E. Haubner, I. Horak, W. Michaeler, K. Rottmar, U. Tappeiner, and A. Cernusca. 1999. Leaf photosynthesis, nitrogen contents and specific leaf area of 30 grassland species in differently managed mountain ecosystems in the Eastern Alps. Pages 247-255 in A. Cernusca, U. Tappeiner, and N. Bayfield, editors. *Land-use changes in European mountain ecosystems. ECOMONT-Concept and Results*. Blackwell Wissenschaft, Berlin.
3. Bakker, C., J. Rodenburg, and P. Bodegom. 2005. Effects of Ca- and Fe-rich seepage on P availability and plant performance in calcareous dune soils. *Plant and Soil* 275:111-122.
4. Bakker, C., P. M. Van Bodegom, H. J. M. Nelissen, W. H. O. Ernst, and R. Aerts. 2006. Plant responses to rising water tables and nutrient management in calcareous dune slacks. *Plant Ecology* 185:19-28.
5. Blonder, B., Buzzard, B., Sloat, L., Simova, I., Lipson, R., Boyle, B., Enquist, B. The shrinkage effect biases estimates of paleoclimate. *American Journal of Botany* (2012).
6. Bond-Lamberty, B., C. Wang, and S. T. Gower (2002), Leaf area dynamics of a boreal black spruce fire chronosequence, *Tree Physiol.*, 22(14), 993-1001.
7. Burrascano S., Del Vico E., Fagiani S., Giarrizzo E., Mei M., Mortelliti A., Sabatini F.M., Blasi C., submitted. Environmental filtering of wild boar rooting activity on understorey composition and functional traits. *Plant Ecology*.
8. Byun C, S de Blois, J Brisson (2012) Plant functional group identity and diversity determine biotic resistance to invasion by an exotic grass. *Journal of Ecology*, doi: 10.1111/1365-2745.12016
9. Campbell, C., L. Atkinson, J. Zaragoza-Castells, M. Lundmark, O. Atkin, and V. Hurry. 2007. Acclimation of photosynthesis and respiration is asynchronous in response to changes in temperature regardless of plant functional group. *New Phytologist* 176:375-389.
10. Campetella, G; Botta-Dukát, Z; Wellstein, C; Canullo, R; Gatto, S; Chelli, S; Mucina, L; Bartha, S (2011): Patterns of plant trait-environment relationships along a forest succession chronosequence. *Agriculture, Ecosystems & Environment*, 145(1), 38-48. doi:10.1016/j.agee.2011.06.025
11. Cerabolini B.E.L., Brusa G., Ceriani R.M., De Andreis R., Luzzaro A. & Pierce S. 2010. Can CSR classification be generally applied outside Britain? *Plant Ecology* 210: 253-261
12. Choat, B. S. Jansen, T.J. Brodribb, H. Cochard, S. Delzon, R. Bhaskar, S.J. Bucci, T.S. Feild, S.M. Gleason, U.G. Hacke, A.L. Jacobsen, F. Lens, H. Maherali, J. Martinez-Vilalta, S. Mayr, M. Mencuccini, P.J. Mitchell, A. Nardini, J. Pittermann, R.B. Pratt, J.S. Sperry, M. Westoby, I.J. Wright & A.E. Zanne (2012) Global convergence in the vulnerability of forests to drought. *Nature* 491:752-755 doi:10.1038/nature11688
13. Ciocarlan V. (2009). The illustrated Flora of Romania. Pteridophyta et Spermatopyta. Editura Ceres, 1141 p (in Romanian).
14. Cornelissen, J. H. C. 1996. An experimental comparison of leaf decomposition rates in a wide range of temperate plant species and types. *Journal of Ecology* 84:573-582.
15. Cornelissen, J. H. C., B. Cerabolini, P. Castro-Diez, P. Villar-Salvador, G. Montserrat-Marti, J. P. Puyravaud, M. Maestro, M. J. A. Werger, and R. Aerts. 2003. Functional

traits of woody plants: correspondence of species rankings between field adults and laboratory-grown seedlings? *Journal of Vegetation Science* 14:311-322.

16. Cornelissen, J. H. C., H. M. Quested, D. Gwynn-Jones, R. S. P. Van Logtestijn, M. A. H. De Beus, A. Kondratchuk, T. V. Callaghan, and R. Aerts. 2004. Leaf digestibility and litter decomposability are related in a wide range of subarctic plant species and types. *Functional Ecology* 18:779-786.
17. Cornelissen, J. H. C., P. C. Diez, and R. Hunt. 1996. Seedling growth, allocation and leaf attributes in a wide range of woody plant species and types. *Journal of Ecology* 84:755-765.
18. Cornwell, W. K., J. H. C. Cornelissen, K. Amatangelo, E. Dorrepaal, V. T. Eviner, O. Godoy, S. E. Hobbie, B. Hoorens, H. Kurokawa, N. Pérez-Harguindeguy, H. M. Quested, L. S. Santiago, D. A. Wardle, I. J. Wright, R. Aerts, S. D. Allison, P. van Bodegom, V. Brovkin, A. Chatain, T. V. Callaghan, S. Díaz, E. Garnier, D. E. Gurvich, E. Kazakou, J. A. Klein, J. Read, P. B. Reich, N. A. Soudzilovskaia, M. V. Vaieretti, and M. Westoby. 2008. Plant species traits are the predominant control on litter decomposition rates within biomes worldwide. *Ecology Letters* 11:1065-1071.
19. Craine JM, Nippert JB, Towne EG, Tucker S, Kembel SW, Skibbe A, McLauchlan KK (2011) Functional consequences of climate-change induced plant species loss in a tallgrass prairie. *Oecologia* 165: 1109-1117
20. Craine JM, Towne EG, Ocheltree TW, Nippert JB (2012) Community traitscape of foliar nitrogen isotopes reveals N availability patterns in a tallgrass prairie. *Plant Soil* 356: 395-403
21. Craine, J. M., A. J. Elmore, M. P. M. Aida, M. Bustamante, T. E. Dawson, E. A. Hobbie, A. Kahmen, M. C. Mack, K. K. McLauchlan, A. Michelsen, G. B. Nardoto, L. H. Pardo, J. Penúelas, P. B. Reich, E. A. G. Schuur, W. D. Stock, P. H. Templer, R. A. Virginia, J. M. Welker, and I. J. Wright. 2009. Global patterns of foliar nitrogen isotopes and their relationships with climate, mycorrhizal fungi, foliar nutrient concentrations, and nitrogen availability. *New Phytologist* 183:980-992.
22. Craine, J. M., W. G. Lee, W. J. Bond, R. J. Williams, and L. C. Johnson. 2005. Environmental constraints on a global relationship among leaf and root traits of grasses. *Ecology* 86:12-19.
23. Díaz, S., J. G. Hodgson, K. Thompson, M. Cabido, J. H. C. Cornelissen, A. Jalili, G. Montserrat-Martí, J. P. Grime, F. Zarrinkamar, Y. Asri, S. R. Band, S. Basconcelo, P. Castro-Díez, G. Funes, B. Hamzehee, M. Khoshnevi, N. Pérez-Harguindeguy, M. C. Pérez-Rontomé, F. A. Shirvany, F. Vendramini, S. Yazdani, R. Abbas-Azimi, A. Bogaard, S. Boustani, M. Charles, M. Dehghan, L. de Torres-Espuny, V. Falczuk, J. Guerrero-Campo, A. Hynd, G. Jones, E. Kowsary, F. Kazemi-Saeed, M. Maestro-Martínez, A. Romo-Díez, S. Shaw, B. Siavash, P. Villar-Salvador, and M. R. Zak. 2004. The plant traits that drive ecosystems: Evidence from three continents. *Journal of Vegetation Science* 15:295-304.
24. Dainese M, Bragazza L (2012) Plant traits across different habitats of the Italian Alps: a comparative analysis between native and alien species. *Alpine Botany*
25. Everwand G, Fry, EL, Eggers T, Manning P (2014) Seasonal variation in the relationship between plant traits and grassland carbon and water fluxes. *Ecosystems* 17, 1095-1108
26. Fitter, A. H. and H. J. Peat 1994. The Ecological Flora Database. *Journal of Ecology* 82:415-425.

27. Freschet, G. T., J. H. C. Cornelissen, R. S. P. van Logtestijn, and R. Aerts. 2010. Evidence of the 'plant economics spectrum' in a subarctic flora. *Journal of Ecology* 98:362-373.
28. Fry, E.L., Power, S.A. Manning, P. (2014) Trait based classification and manipulation of functional groups in biodiversity-ecosystem function experiments. *Journal of Vegetation Science*, 25, 248-261.
29. Gallagher RV, MR Leishman (2012) A global analysis of trait variation and evolution in climbing plants. *Journal of Biogeography* 39, 1757-1771.
30. Garnier, E., S. Lavorel, P. Ansquer, H. Castro, P. Cruz, J. Dolezal, O. Eriksson, C. Fortunel, H. Freitas, C. Golodets, K. Grigulis, C. Jouany, E. Kazakou, J. Kigel, M. Kleyer, V. Lehsten, J. Lepš, T. Meier, R. Pakeman, M. Papadimitriou, V. P. Papanastasis, H. Quested, F. Quétier, M. Robson, C. Roumet, G. Rusch, C. Skarpe, M. Sternberg, J.-P. Theau, A. Thébault, D. Vile, and M. P. Zarovali. 2007. Assessing the effects of land-use change on plant traits, communities and ecosystem functioning in grasslands: A standardized methodology and lessons from an application to 11 European sites. *Annals of Botany* 99:967-985.
31. Green, W. 2009. USDA PLANTS Compilation, version 1, 09-02-02. (<http://bricol.net/downloads/data/PLANTSdatabase/>) NRCS: The PLANTS Database (<http://plants.usda.gov>, 1 Feb 2009). National Plant Data Center: Baton Rouge, LA 70874-74490 USA.
32. Guy, A. L., J. M. Mischkolz, and E. G. Lamb. 2013. Limited effects of simulated acidic deposition on seedling survivorship and root morphology of endemic plant taxa of the Athabasca Sand Dunes in well watered greenhouse trials. *Botany* 91:176-181.
33. Han, W. X., J. Y. Fang, D. L. Guo, and Y. Zhang. 2005. Leaf nitrogen and phosphorus stoichiometry across 753 terrestrial plant species in China. *New Phytologist* 168:377-385.
34. Hickler, T. 1999. Plant functional types and community characteristics along environmental gradients on Öland's Great Alvar (Sweden) Masters Thesis, University of Lund, Sweden.
35. Kattge, J., W. Knorr, T. Raddatz, and C. Wirth. 2009. Quantifying photosynthetic capacity and its relationship to leaf nitrogen content for global-scale terrestrial biosphere models. *Global Change Biology* 15:976-991.
36. Kerkhoff, A. J., W. F. Fagan, J. J. Elser, and B. J. Enquist. 2006. Phylogenetic and growth form variation in the scaling of nitrogen and phosphorus in the seed plants. *American Naturalist* 168:E103-E122.
37. Kichenin et al. 2013. Contrasting effects of plant inter- and intraspecific variation on community-level trait measures along an environmental gradient. *Functional Ecology*, in press.
38. Kleyer, M., R. M. Bekker, I. C. Knevel, J. P. Bakker, K. Thompson, M. Sonnenschein, P. Poschlod, J. M. van Groenendael, L. Klimes, J. Klimesova, S. Klotz, G. M. Rusch, Hermy, M. , D. Adriaens, G. Boedeltje, B. Bossuyt, A. Dannemann, P. Endels, L. Gözenberger, J. G. Hodgson, A.-K. Jackel, I. Kühn, D. Kunzmann, W. A. Ozinga, C. Römermann, M. Stadler, J. Schlegelmilch, H. J. Steendam, O. Tackenberg, B. Wilmann, J. H. C. Cornelissen, O. Eriksson, E. Garnier, and B. Peco. 2008. The LEDA Traitbase: a database of life-history traits of the Northwest European flora. *Journal of Ecology* 96:1266-1274.
39. Komac, B., C. Pladevall, J. Peñuelas, J. V. Conesa, and M. Domènech. 2015. Variations in functional diversity in snowbed plant communities determining snowbed continuity. *Plant Ecology* 216:1257-1274.

40. Louault, F., V. D. Pillar, J. Aufrere, E. Garnier, and J. F. Soussana. 2005. Plant traits and functional types in response to reduced disturbance in a semi-natural grassland. *Journal of Vegetation Science* 16:151-160.
41. Loveys, B. R., L. J. Atkinson, D. J. Sherlock, R. L. Roberts, A. H. Fitter, and O. K. Atkin. 2003. Thermal acclimation of leaf and root respiration: an investigation comparing inherently fast- and slow-growing plant species. *Global Change Biology* 9:895-910.
42. Meziane, D. and B. Shipley. 1999. Interacting determinants of specific leaf area in 22 herbaceous species: effects of irradiance and nutrient availability. *Plant Cell and Environment* 22:447-459.
43. Milla & Reich 2011 *Annals of Botany* 107: 455–465.
44. Niinemets, U. 2001. Global-scale climatic controls of leaf dry mass per area, density, and thickness in trees and shrubs. *Ecology* 82:453-469.
45. Onoda, Y., M. Westoby, P. B. Adler, A. M. F. Choong, F. J. Clissold, J. H. C. Cornelissen, S. Diaz, N. J. Dominy, A. Elgart, L. Enrico, P. V. A. Fine, J. J. Howard, A. Jalili, K. Kitajima, H. Kurokawa, C. McArthur, P. W. Lucas, L. Markesteijn, N. Perez-Harguindeguy, L. Poorter, L. Richards, L. S. Santiago, Jr. E. Sosinski, S. Van Bael, D. I. Warton, I. J. Wright, S. J. Wright, and N. Yamashita. 2011. Global patterns of leaf mechanical properties. *Ecology Letters* 14:301-312.
46. Ordonez, J. C., P. M. van Bodegom, J. P. M. Witte, R. P. Bartholomeus, J. R. van Hal, and R. Aerts. 2010. Plant Strategies in Relation to Resource Supply in Mesic to Wet Environments: Does Theory Mirror Nature? *American Naturalist* 175:225-239.
47. Paula, S., M. Arianoutsou, D. Kazanis, Ç. Tavsanoğlu, F. Lloret, C. Buhk, F. Ojeda, B. Luna, J. M. Moreno, A. Rodrigo, J. M. Espelta, S. Palacio, B. Fernández-Santos, P. M. Fernandes, and J. G. Pausas. 2009. Fire-related traits for plant species of the Mediterranean Basin. *Ecology* 90:1420.
48. Peco B., de Pablos I., Traba J., & Levassor C. (2005) The effect of grazing abandonment on species composition and functional traits: the case of dehesa grasslands. *Basic and Applied Ecology*, 6(2): 175-183
49. Pierce S., Brusa G., Sartori M. & Cerabolini B.E.L. 2012. Combined use of leaf size and economics traits allows direct comparison of hydrophyte and terrestrial herbaceous adaptive strategies. *Annals of Botany* 109(5): 1047-1053
50. Pierce S., Ceriani R.M., De Andreis R., Luzzaro A. & Cerabolini B. 2007. The leaf economics spectrum of Poaceae reflects variation in survival strategies. *Plant Biosystems* 141(3): 337-343.
51. Pierce S., Luzzaro A., Caccianiga M., Ceriani R.M. & Cerabolini B. 2007. Disturbance is the principal alpha-scale filter determining niche differentiation, coexistence and biodiversity in an alpine community. *Journal of Ecology* 95: 698-706.
52. Poorter, H., U. Niinemets, L. Poorter, I. J. Wright, and R. Villar. 2009. Causes and consequences of variation in leaf mass per area (LMA): a meta-analysis. *New Phytologist* 182:565-588.
53. Poschlod, P., M. Kleyer, A. K. Jackel, A. Dannemann, and O. Tackenberg. 2003. BIOPOP - a database of plant traits and Internet application for nature conservation. *Folia Geobotanica* 38:263-271.
54. Prentice, I.C., Meng, T., Wang, H., Harrison, S.P., Ni, J., Wang, G., 2011. Evidence for a universal scaling relationship of leaf CO₂ drawdown along a moisture gradient. *New Phytologist* 190: 169–180
55. Price, C.A. and B.J. Enquist. Scaling of mass and morphology in Dicotyledonous leaves: an extension of the WBE model. (2007) *Ecology* 88(5): 1132–1141.

56. Pyankov, V. I., A. V. Kondratchuk, and B. Shipley. 1999. Leaf structure and specific leaf mass: the alpine desert plants of the Eastern Pamirs, Tadjikistan. *New Phytologist* 143:131-142.
57. Quested, H. M., J. H. C. Cornelissen, M. C. Press, T. V. Callaghan, R. Aerts, F. Trosien, P. Riemann, D. Gwynn-Jones, A. Kondratchuk, and S. E. Jonasson. 2003. Decomposition of sub-arctic plants with differing nitrogen economies: A functional role for hemiparasites. *Ecology* 84:3209-3221.
58. Reich, P. B., J. Oleksyn, and I. J. Wright. 2009. Leaf phosphorus influences the photosynthesis-nitrogen relation: a cross-biome analysis of 314 species. *Oecologia* 160:207-212.
59. Reich, P. B., M. G. Tjoelker, K. S. Pregitzer, I. J. Wright, J. Oleksyn, and J. L. Machado. 2008. Scaling of respiration to nitrogen in leaves, stems and roots of higher land plants. *Ecology Letters* 11:793-801.
60. Sandel, B., J. D. Corbin, and M. Krupa 2011. Using plant functional traits to guide restoration: A case study in California coastal grassland. *Ecosphere* 2:art23.
61. Schweingruber, F.H., Landolt, W.: The Xylem Database. Swiss Federal Research Institute WSL Updated (2005)
62. Sheremet'ev S.N. (2005) Herbs on the soil moisture gradient (water relations and the structural-functional organization). KMK, Moscow, 271 pp. (In Russian)
63. Shipley B., 2002. Trade-offs between net assimilation rate and specific leaf area in determining relative growth rate: relationship with daily irradiance, *Functional Ecology* (16) 682-689
64. Shipley, B. 1995. Structured Interspecific Determinants of Specific Leaf-Area in 34 Species of Herbaceous Angiosperms. *Functional Ecology* 9:312-319.
65. Shipley, B. and M. J. Lechowicz. 2000. The functional co-ordination of leaf morphology, nitrogen concentration, and gas exchange in 40 wetland species. *Ecoscience* 7:183-194.
66. Shipley, B. and T. T. Vu. 2002. Dry matter content as a measure of dry matter concentration in plants and their parts. *New Phytologist* 153:359-364.
67. Spasojevic, M. J. and K. N. Suding. 2012. Inferring community assembly mechanisms from functional diversity patterns: the importance of multiple assembly processes. *Journal of Ecology* 100:652-661.
68. Tucker SS, Craine JM, Nippert JB (2011) Physiological drought tolerance and the structuring of tallgrass assemblages. *Ecosphere* 2(4): 48
69. van Bodegom, P. M., B. K. Sorrell, A. Oosthoek, C. Bakke, and R. Aerts. 2008. Separating the effects of partial submergence and soil oxygen demand on plant physiology. *Ecology* 89:193-204.
70. Vanessa Minden, Michael Kleyer (2011): Testing the effect–response framework: key response and effect traits determining above-ground biomass of salt marshes. *Journal of Vegetation Science* 22: 387-401
71. Vanessa Minden, Sandra Andratschke, Janina Spalke, Hanna Timmermann, Michael Kleyer (2012): Plant trait–environment relationships in salt marshes: Deviations from predictions by ecological concepts. *Perspectives in Plant Ecology, Evolution and Systematics*, 14: 183-192
72. Vergutz, L., S. Manzoni, A. Porporato, R.F. Novais, and R.B. Jackson. 2012. A Global Database of Carbon and Nutrient Concentrations of Green and Senesced Leaves. Data set. Available on-line [<http://daac.ornl.gov>] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

73. Wenxuan Han, Yahan Chen, Fang-Jie Zhao, Luying Tang, Rongfeng Jiang and Fusuo Zhang, 2011, Floral, climatic and soil pH controls on leaf ash content in China's terrestrial plants. *Global Ecology and Biogeography*, DOI: 10.1111/j.1466-8238.2011.00677.x
74. Wirth, C. and J. W. Lichstein. 2009. The Imprint of Species Turnover on Old-Growth Forest Carbon Balances - Insights From a Trait-Based Model of Forest Dynamics. Pages 81-113 in C. Wirth, G. Gleixner, and M. Heimann, editors. *Old-Growth Forests: Function, Fate and Value*. Springer, New York, Berlin, Heidelberg.
75. Wright, I. J., P. B. Reich, M. Westoby, D. D. Ackerly, Z. Baruch, F. Bongers, J. Cavender-Bares, T. Chapin, J. H. C. Cornelissen, M. Diemer, J. Flexas, E. Garnier, P. K. Groom, J. Gulias, K. Hikosaka, B. B. Lamont, T. Lee, W. Lee, C. Lusk, J. J. Midgley, M. L. Navas, U. Niinemets, J. Oleksyn, N. Osada, H. Poorter, P. Poot, L. Prior, V. I. Pyankov, C. Roumet, S. C. Thomas, M. G. Tjoelker, E. J. Veneklaas, and R. Villar. 2004. The worldwide leaf economics spectrum. *Nature* 428:821-827.
76. Yahan Chen , Wenxuan Han , Luying Tang , Zhiyao Tang and Jingyun Fang 2011 Leaf nitrogen and phosphorus concentrations of woody plants differ in responses to climate, soil and plant growth form. *Ecography* 34.