Vegetation responses to disturbance by trampling: a pan-European multi-site experiment to evaluate the coherence between functional traits, local environment and vegetation response

Markus Bernhardt-Römermann[1*], Alan Gray[2], Adam Vanbergen[2], Laurent Bergès[3], Andreas Bohner[4], Rob Brooker[5], Luc De Bruyn[6], Bruno De Cinti[7], Thomas Dirnböck[8], Ulf Grandin[9], Alison Hester[5], Róbert Kanka[10], Stefan Klotz[11], Grégory Loucougaray[12], Lars Lundin[9], Giorgio Matteucci[7], Ilona Mészáros[13], Viktor Oláh[13], Elena Preda[14], Bernard Prévosto[15], Juha Pykälä[16], Wolfgang Schmidt[17], Michele Taylor[18], Angheluta Vadineanu[14], Theresa Waldmann[17], Jutta Stadler[11]

[1] Goethe-Universität Frankfurt am Main; Institute of Ecology, Evolution & Diversity; Department of Ecology and Geobotany; Siesmayerstraße 70B; 60323 Frankfurt am Main, Germany; [2] NERC Centre for Ecology & Hydrology, Bush Estate, Penicuik, Edinburgh, EH26 0QB, UK; [3] Cemagref, UR EFNO, Domaine des Barres 45290 Nogent-sur-Vernisson, France; [4] Agricultural Research and Education Centre Raumberg-Gumpenstein; Department of Environmental Ecology; Raumberg 38; 8952 Irdning, Austria; [5] Macaulay Land Use Research Institute, Craigiebuckler, Aberdeen AB15 8QH, UK; [6] Research Institute for Nature and Forest (INBO), kliniekstraat 25, 1070 Brussel, Belgium; and Evolutionary Ecology, Department of Biology, University of Antwerp, Groenenborgerlaan 171, 2020 Antwerpen, Belgium; [7] CNR-IBAF, National Research Council, Institute of Environmental and Forestal Biology, Via Salaria Km 29,300 00016 Monterotondo Scalo, Roma, Italy; [8] Department for Ecosystem Research and Monitoring, Federal Environment Agency Austria, Spittelauer Lände 5, 1090 Vienna, Austria; [9] Swedish University of Agricultural Sciences, Department of Aquatic Sciences and Assessment, Box 7050, 750 07 Uppsala, Sweden; [10] Institute of Landscape Ecology Slovak Academy of Sciences, Dept. of Ecological Analyses; Štefánikova Str. 3, 814 99, Slovakia; [11] Helmholtz Centre for Environmental Research – UFZ, Department of Community Ecology; Theodor-Lieser-Str. 4, 06120 Halle/Saale, Germany; [12] Cemagref, UR Ecosystèmes Montagnards, Domaine Universitaire, 2 rue de la papeterie, BP 76, 38402 Saint Martin d'Hères, France; [13] University of Debrecen, Faculty of Sciences and Technology, Department of Botany, Debrecen Egyetem tér 1, 4032 Hungary; [14] University of Bucharest, Department of Systems Ecology and Sustainability, Splaiul Independentei 91-95, Sector 5, Bucharest, 050095, Romania; [15] Cemagref, UR Emax, Ecosystèmes méditerranéens et risques, 3275 Route Cézanne, CS 40061, 13612 Aix-en-Provence cedex 5, France; [16] Finnish Environment Institute, Natural Environment Centre, P. O. Box 140, 00251 Helsinki, Finland; [17] Georg-August University Göttingen, Faculty of Forest Sciences and Forest Ecology, Department Silviculture and Forest Ecology of the Temperate Zones; Büsgenweg 1, 37077 Göttingen, Germany; [18] NERC Centre for Ecology & Hydrology, Maclean Building, Crowmarsh Gifford, Wallingford, OX10 8BB, UK

Disturbance is among the important factors structuring the taxonomic, phylogenetic and functional composition of terrestrial plant assemblages (Pickett and White, 1985). The reaction of plant assemblages on disturbances has thereby at least two components: resistance (ability to withstand disturbance) or resilience (recovery from disturbance to the original state). Resistance and resilience is supposed to depend on the functional traits of the predominant species in the assemblage, which is strongly affected by land-use history. Therefore ecosystems with a history of frequent disturbances (e.g. grazing and trampling by livestock on grasslands) should consist of species with adaptations to frequent disturbances. To test this idea we designed an experiment inducing a disturbance event across a broad biogeographic gradient (see Fig 1) to test the following hypotheses:

1. Ecosystems with higher levels of anthropogenic disturbances will be composed of species adapted to these disturbances and thus the vegetation should be more resistant and resilient to experimental trampling by humans than ecosystems with infrequent disturbances.

2. Plant functional traits (e.g. growth form) allow to predict resistance and resilience of the vegetation. Perennial plants with a slow growth rate and below-ground buds will have high resistance while the ability to re-sprout as well as a high growth rate should favour resilience,.

In ten European countries we established 39 experimental sites (Fig. 1) either in grassland (n = 17) or forest ecosystems (n =22). On these sites we set one disturbance event with different levels of disturbance intensity by systematic human trampling of the field layer following a protocol recommended by Cole and Bayfield (1993). Vegetation surveys took place prior to the disturbance event and two to four weeks as well as one year after the event. Percentage cover of the vegetation (excluding litter and dead plant material) as well as for each species of vascular plants was visually estimated on each experimental plot. Therefore, our experiment investigated the vegetation response following trampling which affected aboveground tissues. Indices for resistance and resilience were calculated for the total vegetation as well as for the more common species.

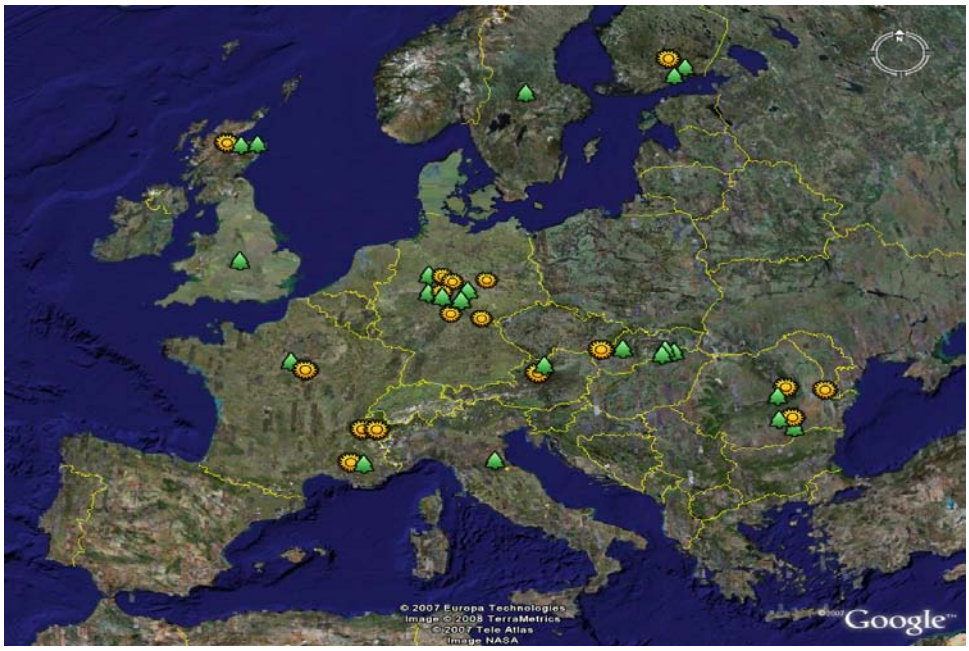

Fig. 1: Distribution of sites across a Pan-European network (yellow=grassland, green=forest)

For resistance, our results highlight the importance of the history of anthropogenic disturbances. This history is like a filter leading to an assembly of species from the regional pool with adaptations to disturbances (e.g. small leaves, rosettes). Therefore, ecosystems such as grassland with a long land-use history are more resistant to disturbance events than less frequently affected or managed ecosystems such as forests. In contrast to the results for resistance, we do not find differences in resilience between ecosystems with a different land-use history. For resilience, environmental factors such as higher irradiation (grassland, open forest) or water availability (higher precipitation) and functional traits related to potential growth rates are found to be most important (e.g. aridity, continentality, LDMC or SLA).

Overall our results support the hypotheses that resistance is a function of land-use history and traits of species. For resilience our results show that in contrast to our initial hypotheses environmental factors are more important than traits of species. Resilience, the ability of vegetation to re-develop when damaged, is crucially important in predicting responses to disturbance or other environmental change. Our finding that resilience depends on environmental factors suggests that climate change will also influence resilience of ecosystems and therefore also resilience of ecosystem processes and services.

Literature:

Pickett, S.T.A. & White, P.S. (1985) *The ecology of natural disturbance and patch dynamics.* Academic Press, Inc., San Diego, New York, Berkely, Boston, London, Sydney, Tokyo, Toronto

Cole, D.N. & Bayfield, N.G. (1993) Recreational trampling of vegetation - standard experimental procedures. *Biological Conservation,* **63,** 209-215