Multi-site experiment II: Variation of litter decomposition across a European gradient

Jutta Stadler[1], Frederic Archaux[2], Marie Baltzinger[2], Claus Baessler[3], Markus Bernhardt-Roemermann[4], Andreas Bohner[5], Anne Bousquet-Melou[6], Thomas Dirnboeck[7], Beverly Dodd[8], Maria-Theresia Grabner[7], Ulf Grandin[9], Marianne Evju[10], Andrej Halabuk[11], Robert Kanka[11], Gregory Loucougaray[12], Ilona Meszaros[13], Victor Olah[13], Elena Preda[14], Bernard Prevosto[6], Anna Repo[15], Rob Rose[8], Michelle Taylor[16], Pekka Vanhala[15]

[1]Helmholtz Centre for Environmental Research – UFZ, Department of Community Ecology; Theodor-Lieser-Str. 4, 06120 Halle/Saale, Germany; [2]Cemagref, UR EFNO, Domaine des Barres 45290 Nogent-sur-Vernisson, France; [3]Nationalparkverwaltung Bayerischer Wald, Sachgebiet Forschung und Dokumentation, Freyunger Str. 2, 94481 Grafenau, Germany, [4]Goethe-Universität Frankfurt am Main; Institute of Ecology, Evolution & Diversity; Department of Ecology and Geobotany; Siesmayerstraße 70B; 60323 Frankfurt am Main, Germany; [5]Agricultural Research and Education Centre Raumberg-Gumpenstein; Department of Environmental Ecology; Raumberg 38; 8952 Irdning, Austria,;[6]Cemagref, UR Emax, Ecosystèmes méditerranéens et risques, 3275 Route Cézanne, CS 40061, 13612 Aix-en-Provence cedex 5, France; [7]Department for Ecosystem Research and Monitoring, Federal Environment Agency Austria, Spittelauer Lände 5, 1090 Vienna, Austria; [8]NERC Centre for Ecology & Hydrology, Lancaster Environment Centre, Library Avenue, Bailrigg, Lancaster LA1 4AP, UK, [9]Swedish University of Agricultural Sciences, Department of Aquatic Sciences and Assessment, Box 7050, 750 07 Uppsala, Sweden; [10]NINA-Norwegian Institute for Nature Research, Gaustadalleen 21, NO-0349 Oslo, Norway; [11]Institute of Landscape Ecology Slovak Academy of Sciences, Dept. of Ecological Analyses; Štefánikova Str. 3, 814 99, Slovakia; [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]Finnish Environment Institute, Natural Environment Centre, P. O. Box 140, 00251 Helsinki, Finland.

General:

Climate change may influence decomposition depending on the local situation of a given site. The mobilization of nutrients that are necessary for primary production e.g. is expected to increase in alpine/arctic environments because of soil warming. This will lead to higher levels of microbial activity and increased decomposition. At the same time northerly movement of plant species will lead to an influx of less recalcitrant litter, which will also help to speed up decomposition by increasing nutrient availability. However, this would only be the case for soils where low temperatures limit decomposition. In other soils climate change may not be associated with increased nutrient availability. In oceanic climates increasing rainfall might constrain decomposition through enhanced peat formation, while in water-limited Mediterranean systems climate change may be associated with drought. Water stress is expected to counteract the effects of elevated temperature in terms of nutrient mobilization (see also EU funded project CLIMOOR and VULCAN). We investigated the impact of nutrient availability along a broad climatic gradient to explore the impact of nutrients and climate on decomposition.

Why is a harmonised Pan-European investigation of decomposition important?

- The biogeographic gradient covers a variety of biomes and allows to draw general conclusions on ecosystem functioning.
- Decomposition is an important ecosystem service and is a surrogate measure for several ecosystem functions.
- It is related to carbon sequestration.
- It is influenced by global change.

Which hypotheses can be tested with this experiment?

- Decomposition rate shows a humped-shaped distribution along the geographic gradient: in boreal as well as Mediterranean ecosystem decomposition will be lower than in Middle Europe due to climatic constraints.
- Increase in nutrient availability will increase decomposition rate along the biogeographic gradient in a non-linear way.
- There is a positive relationship between C/N ratio of substrate and decomposition rate
- (The contrast between fast and slow decomposing litter species will be lower in constrained environments)

Experimental layout:

In ten European countries we established 20 experimental sites either in grassland (n = 8) or forest (n =12) ecosystems. Each ecosystem is available in almost all countries and this will provide some extra information according to the comparison of decomposition processes along the gradient.

We used a random block design to establish the experimental plots (see Fig. 1). Blocks were randomly distributed among all suitable substrates within an area of about 20 x 20 m, but with at least 2 m between blocks. According to the

literature we used a plot size of 1x1 m² with three treatment plots in each block. Each block was repeated 5 times. Each 1x1 m² plot contained 12 randomly distributed litter bags filled with standardized litter. Additionally, 5 Bait-lamina-strips for measuring the feeding activity of soil animals were placed randomly within each plot (at least 10 cm distance between the stripes). Litter bags will be collected from the sites at 3 times between August 2010 and April 2011. This allows calculating an integrative decay (k-) factor .

To standardise relative measures of decomposition rate across sites, the most common approach is to use a common litter, although there may be some issues relating to local adaptation of soil microbial flora to particular plant species. Our litter bags (10 x 10 cm) were filled with 2 g of dried barley leaves which was cultivated in 2 quality levels (grown under fertilized/unfertilized conditions). To evaluate the influence of macro- and microfauna on decomposition we used two different mesh sizes for the litter bags: Mesh size 1 was 5x5 mm² and allows the meso- and macrofauna to enter the bags. Mesh size 2 was 20x20 µm²: This mesh size is fine enough to allow access by bacteria, fungal hyphae, most nematodes and protozoa while restricting access by mesofauna and macrofauna. Bags will be removed from the field at 3 dates (August and October 2010 and April 2011).

Mobilization of nutrients that are necessary for increased primary production is likely to increase in response to elevated temperature, building a potential for increased carbon sequestration by terrestrial organisms. In contrast, (summer) drought (a likely scenario in most ecosystems) is expected to counteract the effects of elevated temperature. Nevertheless, nitrogen deposition, although decreasing (in Germany at present 10 kg total N /ha and year), is still an issue in European countries. Soil organisms and decomposers are generally assumed to be limited by the availability of carbon and nitrogen (bottom-up control; Wardle 1992). We therefore designed an experiment with the following treatments: Unfertilized plots (control)/ N-fertilized plots (addition of NH4NO3)/ C-Fertilized plots (addition of saccharose). For both C- and N-fertilization the design was related to recommendations in literature (Scheu & Schaefer 1998; Bowmann et al. 2006).

Throughout the vegetation period in 2010 all plots were watered regularly with 1l of de-ionized water only (control) or watered with 1l of the respective fertilization treatment (N- or C-addition). According to literature we simulate a nitrogen input of 80 to 100 kg N/ha/yr (equivalent to 8 to 10 g N/m²/yr) and an carbon input of 1200 to 1500 g C/m²/yr. Carbon input was high to simulate the total per year C-input due to decomposition.

Work done up to now:

The first set of litter bags had been sampled by all partners mid September and were either sent back to the UFZ for further analyses or were analysed by partners themselves. The second set of litter bags was and will be collected during the second week of October onwards and some samples arrived already at the UFZ. The third set will be collected in spring 2011.

Additionally, at the end of July at each plot 5 bait laminas had been exposed. After 15 days the bait laminas were removed and sent to the UFZ for further analysis. At the moment we are scoring the amount of removed baits.

Judging from the available data the most northern as well as the most southern sites show a very slow decomposition rate. Less than one third of the leave litter was decomposed at these sites while partners in middle Europe report that 80 % and more of the litter was already decomposed. Furthermore we found that the treatment with sugar had quite negative effects on plants and the soil organisms. Sugar content may have been too high causing osmotic problems.

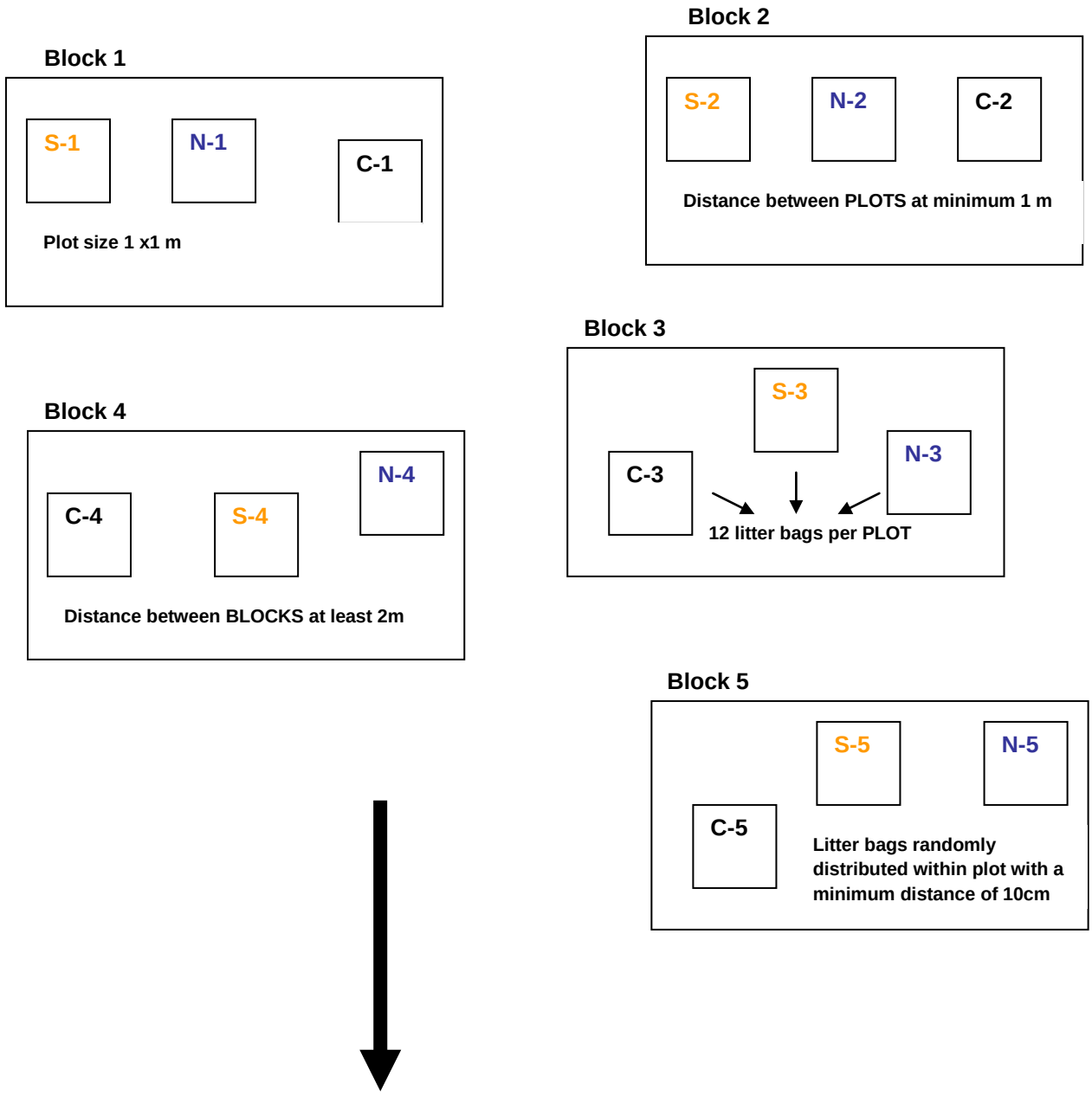
Most partners fulfilled their tasks with great accuracy and we stick perfectly to our timetable. The weather conditions of the coming weeks will show whether we can continue with our fertilization treatments as initially planned or whether we have to stop. Two partners received the equipment but then decided afterwards not to participate in the experiment.

Literature

Bowman et al.(2006): Nitrogen critical loads for alpine vegetation and terrestrial ecosystem response: are we there yet? *Ecological Applications* 16(3)

Scheu & Schaefer(1998): Bottom-up control of the soil macrofauna community in a beechwood on limestone:manipulation of food resources. *Ecology* 79(5)

Fig. 1: Random block design for per site distribution for control (C), N-fertilization (N) and C-fertilization (S)



Design per BLOCK

PLOT: Control	**PLOT: Saccarose**	**PLOT: NH4NO3**
3 bags low quality substrate/ mesh size (1)	3 bags low quality substrate/ mesh size (1)	3 bags low quality substrate/ mesh size (1)
3 bags low quality substrate/ mesh size (2)	3 bags low quality substrate/ mesh size (2)	3 bags low quality substrate/ mesh size (2)
3 bags high quality substrate/ mesh size (1)	3 bags high quality substrate/ mesh size (1)	3 bags high quality substrate/ mesh size (1)
3 bags high quality substrate/ mesh size (2)	3 bags high quality substrate/ mesh size (2)	3 bags high quality substrate/ mesh size (2)
5 Bait-lamina-strips	5 Bait-lamina-strips	5 Bait-lamina-strips