Site Information

1 Lahav

Main references for site description

Tielbörger K, Bilton MC, Metz J et al. (2014) Middle-Eastern plant communities tolerate 9 years of drought in a multi-site climate manipulation experiment. *Nature Communications*, 5, doi:10.1038/ncomms6102

Info

Land Cover Composition. The vegetation is dominated by annuals, which cover, depending on rainfall, between 10% and 25% of the area. Shrubs - mostly the dwarf shrub *Sarcopoterium spinosum*- are common and cover approx. 25%. The spatial pattern of annuals varies among years, and they tend to be less abundant under shrubs in dry years but exhibit no difference between microhabitats in wet years. Annuals include approx. 90% of all species in that region and herbaceous plants, most of which are annuals, account for 80-90% of the annual primary production.

Above-ground biomass was assessed at peak season by nondestructive estimates of aerial cover multiplied by mean plant height in all permanent quadrats.

Measurement height = not specified

Soil texture (approximate) = 22.6% Sand, 39.7% Silt, and 37.7% Clay, Soil Water Content (SWC) at field capacity 0.37, SWC at wilting point 0.22

Soil depth = 0.3 m

Rooting depth = 0.25 m

Mean ANPP = 77 gDryMass/m^2 yr

2 Matta

Main references for site description

Tielbörger K, Bilton MC, Metz J et al. (2014) Middle-Eastern plant communities tolerate 9 years of drought in a multi-site climate manipulation experiment. *Nature Communications*, 5, doi:10.1038/ncomms6102

Info

Land Cover Composition. The vegetation consists of dwarf shrubs (dominated by *Sarcopoterium spinosum*) that cover approximately 40% of the area and annuals growing mostly in open areas and partly beneath shrubs. Annuals cover up to 90% of the open areas and include approx. 80% of all species. Herbaceous plants (mostly annuals) account for 50% (ungrazed areas) to 90% (normally grazed to overgrazed areas) of the ANPP.

Above-ground biomass was assessed at peak season by nondestructive estimates of aerial cover multiplied by mean plant height in all permanent quadrats.

Measurement height = not specified

Soil texture (approximate) = 19% Sand, 29.2% Silt and 51.8% Clay, SWC at field capacity 0.45, SWC at wilting point 0.31

Soil depth = 0.4 m

Rooting depth = 0.35 m

Mean ANPP = 188 gDM/m^2 yr

3 Brandbjerg

Main references for the site description

Larsen KS, Andresen LC, Beier C et al. (2011) Reduced N cycling in response to drought, warming, and elevated CO2 in a Danish heathland: synthesizing results of the CLIMAITE project after two years of treatments. *Global Change Biology*, 17, 1884–1899.

Mikkelsen TN, Beier C, Jonasson S et al. (2008) Experimental design of multifactor climate change experiments with elevated CO2, warming and drought: the CLIMAITE project. *Functional Ecology*, 22, 185–195.

Kongstad, J., Schmidt, I.K., Riis-Nielsen, T., Arndal, M.F., Mikkelsen, T.N. & Beier, C. (2012) High resilience in heathland plants to changes in temperature, drought, and CO2 in combination: results from the CLIMAITE experiment. Ecosystems, 15, 269–283.

Info

Land Cover Composition. The site is a dry heath/grassland ecosystem consisting of 30–40 cm tall vegetation cover dominated by grass (*Deschampsia flexuosa* , ~ 70% cover) and an evergreen dwarf shrub (*Calluna vulgaris* , ~ 30% cover), a low cover of other herb, mosses and grass species (total 17 species) and an open moss cover beneath the canopy of vascular plants. The above-ground biomass is ~ 720 gDM m^{-2} and the root biomass is ~ 550 gDM m^{-2}. The soil is a well-drained, nutrient-poor sandy deposit with a pH of 4–5 and an organic top layer ranging from 2 to 5 cm in depth.

To estimate ANPP, non-destructive pin-point analysis where a frame with a 10×10 cm^2 fixed grid pattern is placed above the vegetation was used. The biomass was estimated from a linear regression model with incorporation of vegetation height and number of hits per pin for the biomass of D. flexuosa and C. vulgaris based on a pin-point analysis followed by a harvest of the same plots outside the experimental plots. (See Kongstad et al 2012, Ecosystems)

Measurement height = not specified

Soil texture (approximate) = 88-95% Sand, 2-9% Silt, and 1-2% Clay, SWC at field capacity 0.113, SWC at wilting point 0.027

Soil depth = several meters

Rooting depth = 0.6 m

Mean ANPP = 369 gDM/m^2 yr

4 Prades

Main references for the site description

Ogaya R, Penuelas J (2007) Tree growth, mortality, and above-ground biomass accumulation in a holm oak forest under a five-year experimental field drought. *Plant Ecology*, 189, 291–299

Info

Land Cover Composition. This holm oak forest has a very dense multi stem crown (16616 trees ha^{-1}, and 115 Mg ha^{-1}) and it is dominated by *Quercus ilex L*. (8633 trees ha^{-1}, and 89 Mg ha^{-1}), *Phillyrea latifolia L*. (3600 trees ha^{-1}, and 14 Mg ha^{-1}) and *Arbutus unedo L*. (2200 trees ha^{-1}, and 9 Mg ha^{-1}) with abundant presence of other evergreen species well adapted to dry conditions (*Erica arborea L., Juniperus oxycedrus L., Cistus albidus* L.), and occasional individuals of deciduous species (*Sorbus torminalis*(L.) Crantz and *Acer monspessulanum* L.). This forest has not been perturbed for the last 60 years.

Specific leaf area *Quercus Ilex* = 0.010 [m^2 /gC]
Specific leaf area *Philiyrea* = 0.014 [m^2 /gC]

Measurement height = not specified

Soil texture = 48% Sand, 32% Silt and 20% Clay

Soil depth = 60 cm. The soil is a Dystric Cambisol over Paleozoic schist, and its depth ranges from 35 to 90 cm.

Rooting depth = 0.6-1 m

Mean ANPP = 390 g DM m^{-2} y^{-1}

5 Garraf

Main references for the site description

Beier C, Emmett BA, Tietema A et al. (2009) Carbon and nitrogen balances for six shrublands across Europe. *Global Biogeochemical Cycles*, 23, GB4008.

Penuelas J, Prieto P, Beier C et al. (2007) Response of plant species richness and primary productivity in shrublands along a north-south gradient in Europe to seven years of experimental warming and drought: reductions in primary productivity in the heat and drought year of 2003. *Global Change Biology*, 13, 2563–2581.

Info

Land Cover Composition = *Erica multiflora Globularia alypum.* Plant cover 70%. Aboveground plant biomass ≈ gC/m^2 278. Root biomass ≈ 318 gC/$m^{2.}$

Measurement height = not specified

Soil texture (approximate) = 41% Sand, 39% Silt and 18% Clay

Soil depth = 0.3-0.4 m

Rooting depth = 0.10 m

Mean ANPP = 134 gDM/m^2 yr

6 Stubai

Main references for the site description

Bahn M, Knapp M, Garajova Z, Pfahringer N, Cernusca A. 2006. Root respiration in temperate mountain grasslands differing in land use. *Global Change Biology* 12: 995–1006

Grigulis, K., Lavorel, S., Krainer, U., Legay, N., Baxendale, C., Dumont, M., Kastl, E., Arnoldi, C., Bardgett, R. D., Poly, F., Pommier, T., Schloter, M., Tappeiner, U., Bahn, M., Clément, J.-C. (2013), Relative contributions of plant traits and soil microbial properties to mountain grassland ecosystem services. *Journal of Ecology*, 101: 47–57. doi: 10.1111/1365-2745.12014

Hasibeder, R., Fuchslueger, L., Richter, A. and Bahn, M. (2015), Summer drought alters carbon allocation to roots and root respiration in mountain grassland. *New Phytologist*, 205: 1117–1127. doi: 10.1111/nph.13146

Fuchslueger L, Bahn M, Fritz K, Hasibeder R, Richter A. 2014. Experimental drought reduces the transfer of recently fixed plant carbon to soil microbes and alters the bacterial community composition in a mountain meadow. *New Phytologist* 201: 916–927

Wohlfahrt, G., A. Hammerle, A. Haslwanter, M. Bahn, U. Tappeiner, and A. Cernusca (2008), Seasonal and inter-annual variability of the net ecosystem CO2 exchange of a temperate mountain grassland: Effects of weather and management, *J. Geophys. Res*., 113, D08110, doi:10.1029/2007JD009286.

Obojes, N., Bahn, M., Tasser, E., Walde, J., Inauen, N., Hiltbrunner, E., Saccone, P., Lochet, J., Clément, J. C., Lavorel, S., Tappeiner, U., and Körner, Ch. (2015), Vegetation effects on the water balance of mountain grasslands depend on climatic conditions. *Ecohydrol*., 8, 550–567. doi: 10.1002/eco.1524.

Info

Land Cover Composition = C3 Grassland (*Agrostis capillaris, Festuca rubra, Ranunculus montanus, Trifolium pratense, Trifolium repens*). Cut once per year, grazed in late summer, manured every 2–3 years.

Measurement height = 3 m

Soil texture (approximate) = 42.2% sand, 47% silt and 10.8% Clay, with high levels of organic carbon content on top layer.

Soil depth = 0.8 m

Rooting depth = Roots reach down to 0.5 m, but 80% of them are concentrated in the upper 0.13 m of the soil.

Mean ANPP = 470-500 gDM/m^2 yr. The study site is characterized by high plant productivity, with peak above- and belowground biomasses ranging between 240 and 440 gDM m^{-2} and between 420 and 980 gDM m^{-2}, respectively.

7 Puechabon

Main references for the site description

Martin-StPaul, N. K., Limousin, J.-M., Vogt-Schilb, H., Rodríguez-Calcerrada, J., Rambal, S., Longepierre, D. and Misson, L. (2013), The temporal response to drought in a Mediterranean evergreen tree: comparing a regional precipitation gradient and a throughfall exclusion experiment. *Global Change Biology*, 19: 2413–2426. doi: 10.1111/gcb.12215

Allard, V., Ourcival, J. M., Rambal, S., Joffre, R. and Rocheteau, A. (2008), Seasonal and annual variation of carbon exchange in an evergreen Mediterranean forest in southern France. *Global Change Biology*, 14: 714–725. doi: 10.1111/j.1365-2486.2008.01539.x

Info

Land Cover Composition = Holm oak (*Quercus ilex*). Dense overstorey of the evergreen Holm oak (Q. ilex L.). Understorey coverage is low (<25%) and consists mainly of *Buxus sempervirens*, *Phyllirea latifolia*, *Pistacia terebinthus and Juniperus oxycedrus*. Clear-cut in 1942. Current tree height: 5 m.

Measurement height = 10 m

Soil texture = (35% silt and 39% clay 26 % sand). A lot of stones.

Soil depth = 0.5 m

Rooting depth = About 90% of the root mass can be found in the first 50 cm, but some roots have been found up to 4.5 m deep.

Mean GPP = 1275 [gC / m^2 yr]

LAI = 2.2 - 2.5 m^2m^{-2}

Leaf Litterfall = 220-240 [gDM/m^2 yr]

8 Walker Branch

Main references for the site description

Hanson PJ, Todd DE, Huston MA et al. (1998) Description and Field Performance of the Walker Branch Throughfall Displacement Experiment: 1993–1996, ORNL/TM-13586. Oak Ridge National Laboratory, Oak Ridge, TN

Hanson, P. J., D. E. Todd, and J. S. Amthor. 2001. A six year study of sapling and large-tree growth and mortality responses to natural and induced variability in precipitation and throughfall. *Tree Physiology* 21:345–358.

Wilson, K. B., and D. D. Baldocchi. 2000. Seasonal and interannual variability of energy fluxes over a broadleaved temperate deciduous forest in North America. *Agricultural and Forest Meteorology* 100:1–18

Hanson, P.J., Amthor, J.S., Wullschleger, S.D., Wilson, K.B., Grant, R.F., Hartley, A., Hui, D., Hunt JR., E.R., Johnson, D.W., Kimball, J.S., King, A.W., Luo, Y., McNulty, S.G., Sun, G., Thornton, P.E., Wang, S.S., Williams, M., Cushman, R.M., 2004. Oak forest carbon and water simulations: model intercomparisons and evaluations against independent data. *Ecol. Monogr*. 74 (3), 443–489

Info

Land Cover Composition = Mostly Broadleaves Deciduous Temperate Forest. Quercus spp. (Chestnut oak (*Quercus prinus* L.), white oak (*Quercus alba* L.) northern red oak (*Quercus rubra* L.),) and Acer spp (*Acer rubrum L., Acer saccharum*) were the major canopy dominants, *Liriodendron tulipifera* L. was a canopy dominant on the lower slope positions, and *Nyssa sylvatica* Marsh. and *Oxydendrum arboretum* (L.) D.C. were the predominant species occupying mid-canopy locations.

Canopy height: 26 m

Measurement height = 36 m

Soil texture = Sand (28%), Silt (60%), Clay (12%). Water content at field capacity ≈ 0.25-0.28. Water content at wilting point ≈ 0.06

Soil depth = Depth to bedrock at this location is approximately 30 m

Rooting depth = 60% of all fine roots in the 0–0.90-m.

Peak LAI = 5.5-6.2

Mean ANPP = 600-630 gC/m^2 yr

9 Shortgrass steppe

Data elaborated from the originals available at:
http://sgslter.colostate.edu/data_policy.aspx

Main references for the site description

LeCain DR, Morgan JA, Schuman GE, Reeder JD, Hart RH. 2002. Carbon exchange and species composition of grazed pastures and exclosures in the shortgrass steppe of Colorado. *Agriculture Ecosystems and Environment* 93: 421–435.

Milchunas, D.G., Forwood, J.R., Lauenroth, W.K., 1994. Productivity of long-term grazing treatments in response to seasonal precipitation. *J. Range Manage*. 47, 133–139

Lauenroth WK, Burke IC (eds) (2008) Ecology of the shortgrass steppe: a long-term perspective. Oxford University Press, New York

HEISLER-WHITE, J. L., BLAIR, J. M., KELLY, E. F., HARMONEY, K. and KNAPP, A. K. (2009), Contingent productivity responses to more extreme rainfall regimes across a grassland biome. *Global Change Biology*, 15: 2894–2904. doi: 10.1111/j.1365-2486.2009.01961.

Knapp AK, Carroll CJW, Denton EM, La Pierre KJ, Collins SL, Smith MD (2015) Differential sensitivity to regional-scale drought in six central U.S. grasslands. *Oecologia*. doi:10.1007/s00442-015-3233-6.

Info

Land Cover Composition = Vegetation is primarily composed of C4 grasses, mostly blue grama (*Bouteloua gracilis* (H.B.K.) Lag. Ex Steud.) and buffalo grass (*Buchloe dactyloides* (Nutt) Engelm.), mixed with varying amounts of C3 grasses, cactus, shrubs and forb. Colorado Shortgrass site is

dominated by C4 plants (although C4 % is lower in humid years). It has 80-90% C4 grasses by biomass and 70% by cover (information from Melinda).

Measurement height = 4.0 m

Soil texture = Sand 14% – Silt 58% – Clay 28%

(Alternative source) Sand%: 66.5, Silt% 13.4, Clay% 20.1. Bulk density and soil C measurements: SOC = 1260 gC m^{-2} (0-10 cm) and bulk density = 1.26 g cm^{-3} (0-30 cm).

Soil depth = not specified

Rooting depth = not specified

Mean ANPP = 90-100 gDM/m^2

10 Konza

- Data elaborated from the originals available at:

http://www.konza.ksu.edu/knz/pages/data/knzdata.aspx

Main references for the site description

Collins, S. L., Koerner, S. E., Plaut, J. A., Okie, J. G., Brese, D., Calabrese, L. B., Carvajal, A., Evansen, R. J. and Nonaka, E. (2012), Stability of tallgrass prairie during a 19-year increase in growing season precipitation. *Functional Ecology*, 26: 1450–1459. doi: 10.1111/j.1365-2435.2012.01995.x

Nippert JB, Knapp AK, Briggs JM. 2006. Intra-annual rainfall variability and grassland productivity: can the past predict the future? *Plant Ecology* 184: 65–74.

Nippert, J.B., Ocheltree, T.W., Skibbe, A.M., Kangas, L.C., Ham, J.M., Schonkwiler Arnold, K.B. & Brunsell, N.A. (2011) Linking plant growth responses across topographic gradients in tallgrass prairie. *Oecologia*, 166, 1131–1142.

Fay PA, Carlisle JD, Knapp AK, Blair JM, Collins SL. (2003). Productivity responses to altered rainfall patterns in a C-4 dominated grassland. *Oecologia* 137:245–51.

Heisler-White, J. L., Blair, J. M., Kelly, E. F., Harmoney, K. and Knapp, A. K. (2009), Contingent productivity responses to more extreme rainfall regimes across a grassland biome. *Global Change Biology*, 15: 2894–2904. doi: 10.1111/j.1365-2486.2009.01961.

Knapp, A.K., Briggs, J.M. & Koelliker, J.K. (2001) Frequency and extent of water limitation to primary production in a mesic temperate grassland. *Ecosystems*, 4, 19–28

Knapp AK, Beier C, Briske DD *et al*. (2008) Consequences of more extreme precipitation regimes for terrestrial ecosystems. *Bioscience*, 58, 811–821.

Wilcox, K. R., von Fischer, J. C., Muscha, J. M., Petersen, M. K. and Knapp, A. K. (2015), Contrasting above- and belowground sensitivity of three Great Plains grasslands to altered rainfall regimes. *Global Change Biology*, 21: 335–344. doi: 10.1111/gcb.12673

Knapp, A. K., Briggs, J. M., Smith, M. D. (2012), Community stability does not preclude ecosystem sensitivity to chronic resource alteration. *Functional Ecology*, 26: 1231–1233. doi: 10.1111/j.1365-2435.2012.02053.x

Nippert JB, Wieme RA, Ocheltree TW, Craine JM (2012) Root characteristics of C4 grasses limit reliance on deep soil water in tallgrass prairie. *Plant and Soil*, 355, 385–394.

Info

Land Cover Composition = Mixed C3/C4 Grassland. 9% C3 and 91% C4 grassland in the burned location; 20% C3 and 80% C4 grassland in the unburned location.

C3 Forbs Perennial [*Solidago canadensis, Aster ericoides, Salix missouriensis*]
C4 Grassland [*Andropogon gerardii, Sorghastrum nutans, Panicum virgatum*]

Measurement height = 3 m

Soil texture (approximate) = 35% Clay; 10% Sand.

Soil depth = Less than 0.5 m in the upland, more than 2 m in the lowland locations.

Rooting depth = 0.35-0.4 m

Mean ANPP = 380-470 gDM/m^2