植物生态学报
Chinese Journal of Plant Ecology
ISSN 1005-264/X
CN 11-3397/Q
邮发代号：82-5

, 2017, 41(8): 894-913
doi: 10.17521/cjpe.2017.0023

Advances in the effect of nitrogen deposition on grassland litter decomposition

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YANG Li-Li, GONG Ji-Rui*, LIU Min, YANG Bo, ZHANG Zi-He, LUO Qin-Pu, ZHAI Zhan-Wei, PAN Yan
State Key Laboratory of Earth Surface Processes and Resource Ecology, Beijing Normal University, College of Resources Science & Technology, Faculty of Geographical Science, Beijing Normal University, Beijing 100875, China

Cite this article:

YANG Li-Li, GONG Ji-Rui, LIU Min, YANG Bo, ZHANG Zi-He, LUO Qin-Pu, ZHAI Zhan-Wei, PAN Yan. Advances in the effect of nitrogen deposition on grassland litter decomposition. [J], 2017, 41(8): 894-913 doi:10.17521/cjpe.2017.0023

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Abstract:
Atmospheric nitrogen deposition has increased in the last several decades due to anthropogenic activities and global changes. Increasing nitrogen deposition has become an important factor regulating carbon cycle in grassland ecosystems. Litter decomposition, a key process of carbon and nutrient cycling in terrestrial ecosystems, is the main source of soil carbon pool and the

basis of soil fertility maintenance. Elevated nitrogen deposition could affect litter decomposition by raising soil nitrogen availability, increasing the quantity and quality of litter inputs, and altering soil microorganism and soil conditions. Litter decomposition are complex biological, physical and chemical processes, which were affected by abiotic, biological factors and their interactions. The effects of nitrogen deposition on litter decomposition and the underlying mechanisms were discussed in this paper, including the aspactes of soil nitrogen availability, litter production, litter quality, microclimate, soil microorganism and enzyme activities. The main research contents, directions, methods and existing problems of litter decomposition in grasslands were discussed. We also discussed the prospect of future directions to study the interaction and feedback between nitrogen deposition and grassland ecosystem carbon cycling process.

Key words: nitrogen deposition ; grassland ecosystem ; litter decomposition ; litter quality ; research method

, (N) N 1860 31.6 Tg·a^{-1} 20 90 103 Tg·a^{-1}, 2050 , 195 Tg·a^{-1} (Galloway *et al.*, 2004; IPCC, 2007) , N 20 80 13.2 kg·hm^{-2} 21 21.1 kg·hm^{-2}, N N , N , (C) , C (Liu *et al.*, 2013; Sun *et al.*, 2015) 1/3, C C 25%-30%, , (, 2005; Piao *et al.*, 2007) N , C N (, 2000; Xia *et al.*, 2009) N C C

, C , 90% , (Berg & McClaugherty, 2003) , , (Meentemeyer, 1978; Gartner & Cardon, 2004; Smith *et al.*, 2014) N N , , , (Gough *et al.*, 2000) N ,

, N , N (Knorr *et al.*, 2008; , 2014; Zhu *et al.*, 2015) N , , : (1) N ; (2) N , N C ; (3) , , C N

1

, , , , , (1) (Meentemeyer, 1978; Zhou *et al.*, 2008; Smith *et al.*, 2014)

, (Aerts, 2006) , ; , , (Bontti *et al.*, 2009; , 2014) , , , (Dirks *et al.*, 2010; , 2013) (Weatherly *et al.*, 2003) , , (Liu *et al.*, 2010)

, C N (P) , (Aerts, 1997; Cornwell *et al.*, 2008) N P , , C:N :N , , (Valenzuela-Solano & Crohn, 2006) , , , ( ) , 3 , (Rice, 1984; Chomel *et al.*, 2014) , , (Hättenschwiler & Vitousek, 2000; Chomel *et al.*, 2014) , (Chomel *et al.*, 2016)

ZIP
PPT
1

Fig. 1 Factors controlling litter decomposition and their interactions.

, (, 2010) , , (Carrillo *et al.*, 2011; Gergócs & Hufnagel, 2016) , , , , , (Esperschütz *et al.*, 2011) , ; , (Gessner *et al.*, 2010) (Waring, 2013) , 4 (Arai *et al.*, 2007) , (Fioretto *et al.*, 2000)

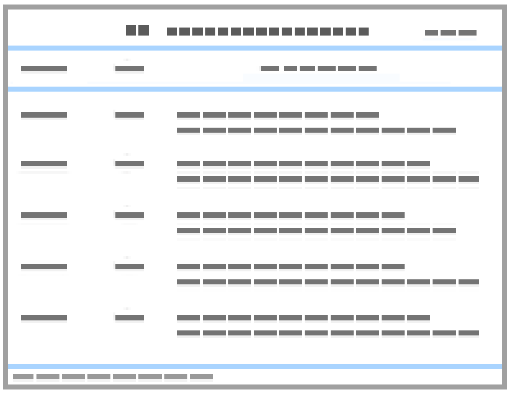
2

N , (Elser *et al.*, 2007) N N , C , , (2) (Gough *et al.*, 2000; Frey *et al.*, 2004)

, N , , (Henry & Moise, 2015; Schuster, 2015; , 2016) (Ågren *et al.*, 2001; Peng *et al.*, 2014; Freedman *et al.*, 2016) (Zhang *et al.*, 2013) N , N (> 120 $kg \cdot hm^{-2} \cdot a^{-1}$) N (61-120 $kg \cdot hm^{-2} \cdot a^{-1}$) N , N (< 60 $kg \cdot hm^{-2} \cdot a^{-1}$) (Chen *et al.*, 2015b) , N , , , (Berg & Staaf, 1980; Johansson *et al.*, 2012) , N N (Liu *et al.*, 2011) 1 N ,

ZIP
PPT
2 (N)

Fig. 2 Effects of nitrogen (N) deposition on litter decomposition.



1

Table 1 Current researches on litter decomposition under different nitrogen (N) addition treatments in grassland ecosystems

2.1

2.1.1

N , N N , N , , C (LeBauer & Treseder, 2008; Bai *et al.*, 2010) N , , N , N ; , N N , N (Sala *et al.*, 2012; Hedwall *et al.*, 2013; Xu *et al.*, 2015)

, , (Solly *et al.*, 2014) , 10-20 g•m^{-2} N , (Zeng *et al.*, 2010) , N N , (Ladwig *et al.*, 2012) , N , , (Hautier *et al.*, 2009; Xu *et al.*, 2016) , , , C:N (Wang *et al.*, 2015) , N , (Guo & Fan, 2007; Wang *et al.*, 2017)

2.1.2

N , , , (Cleland & Harpole, 2010; , 2013) : N , (Bai *et al.*, 2010; Ren *et al.*, 2010; He *et al.*, 2016) , N 0.25 g•m^{-2}·a^{-1}, 4 m^2 (Stevens *et al.*, 2012) , N (Chapin *et al.*, 1986; Suding *et al.*, 2005) N C_3 (*Leymus chinensis*) C_4 ( ) , ; N , N (Pan *et al.*, 2005; Niu *et al.*, 2008; Xia & Wan, 2008) , N , ,

2.1.3

N , , N P (Lü *et al.*, 2013) N , N N , N , , N (Knorr *et al.*, 2008; Valera-Burgos *et al.*, 2013) N , N N , N , C:N , N (Berg & Matzner, 1997; Smith & Bradford, 2003; , 2013) , , , (Deforest *et al.*, 2004) , N , N , (Knicker *et al.*, 1997; Hobbie *et al.*, 2012)

N (Zhang *et al.*, 2016) , N N , N C:N , , , C , , N N , , N , N , N (C:N) ; N , N (C:N) (, 2000; Moorhead & Sinsabaugh, 2006; Hobbie, 2008) , N (Mn Ca Mg) , , (Güsewell & Gessner, 2009; Kai *et al.*, 2016)

2.2

(NO_X) (Yang *et al.*, 2012) N NH_4^+ NO_3^- , , H^+, pH (Gandois *et al.*, 2011; Chen *et al.*, 2013b) pH , pH 6.5-7.5, 7.5-8.0, 5.0-6.0 (Abbasi & Adams, 2000) N pH , , (Turner & Henry, 2009; Chen *et al.*, 2015a)

, : , ; , (Wardle *et al.*, 2004) , , , , , N , , ; , , ; , , (Clemmensen *et al.*, 2013) , , N , (Eisenlord *et al.*, 2013) / , (Strickland & Rousk, 2010) N ( ) , / , (Allison *et al.*, 2010; Xu *et al.*, 2016) , N , , (Hogberg *et al.*, 2010; Rousk *et al.*, 2011) N , C:N , C , (Ågren *et al.*, 2001; Compton *et al.*, 2004)

, ( ) , N , , N (Carreiro *et al.*, 2000) , , N , , (Deforest *et al.*, 2004) N , (Keeler *et al.*, 2009) , N (Knorr *et al.*, 2008)

3

, N , N , , N , , , N C

3.1

, : > > (Swift *et al.*, 1979; Aerts, 2006) , , ,
, —— , , , “ ” (Wall *et al.*, 2008; Zhang *et al.*, 2008) , , , ; , , ; ,
(Gracia-Palacios *et al.*, 2013)

, , , , (Prescott 2010; Bradford *et al.*, 2016)

3.2 - - C:N:P

, , , (, 2008) , ,
C:N:P , - - (Fan *et al.*, 2016; Pan *et al.*, 2016)

N N , N P (Vitousek *et al.*, 2010) , N C:N:P , (Finn *et al.*, 2015; Zhu *et al.*, 2016b) N N , C:N:P pH , (Hessen *et al.*, 2004; , 2013) C:N:P
, C:N:P , , C , N C:N , N ; C:N , N
, C:N , , N , (, 2010; , 2016) , C:N 5-15 C:P 200-480 , N P N P
, N P (Manzoni *et al.*, 2010)

N , N - - - N C , N C:N:P (Zhu *et al.*, 2016b)
, , N - - C:N:P ,

3.3

, , , N N (Makhnev & Makhneva, 2010) , , , , N (, 2012) , , N

, (Barantal *et al.*, 2011) , ( ),
(Quested *et al.*, 2002) N , , (Valera-Burgos *et al.*, 2013) , N ,
, N P , , (Vivanco & Austin, 2011; Li *et al.*, 2016; , 2016) N (,
2013) , N N , , (Ågren *et al.*, 2001; Flury & Gessner, 2011)

, , , , N , ,

3.4

, (, , N P ,) , N , C , (Chartzoulakis & Psarras, 2005; , 2007) , , N , (Apolinário *et al.*, 2014; Song *et al.*, 2017) , N
, ,

N , , (Stocker *et al.*, 2014) , N , ,
N , N N , C:P , C:N N:P (Lü *et al.*, 2012) N , N , N ,
N , N , , N (Everard *et al.*, 2010) N , , (Henry *et al.*, 2005; , 2014)

P , N , N N , N P, P N P N P (Jacobson *et al.*, 2010) N P N P , P , P N P , N P , , N P
(Qualls & Richardson, 2000; Chen *et al.*, 2013a)

, ( ) , (Raich & Tufekciogiu, 2000) , ,
(C:N), ; , , (Giese *et al.*, 2009; Wang *et al.*, 2015; , 2016) , ,

, , , (Tessier *et al.*, 2003; Haynes *et al.*, 2014; Wang *et al.*, 2015) , N , N , N , , , N (Liu *et al.*, 2011; Apolinário *et al.*, 2014) , N (Song *et al.*, 2017) N , , N

4

4.1

, N , , N , 20 90 (Fagerli & Aas, 2008) , , N N (, 2015; Long *et al.*, 2016) (Gao *et al.*, 2015)

N ($NaNO_3$) NO_3^- NH_4^+ , N , N 34%, NH_4^+ NO_3^- , N (Aber *et al.*, 2003) N , , N (Ning *et al.*, 2015; Zhang *et al.*, 2015a, 2015b) , N, , , N , , (Wilson, 1992; , 2013) N , N , N (Zhu *et al.*, 2013; , 2015)

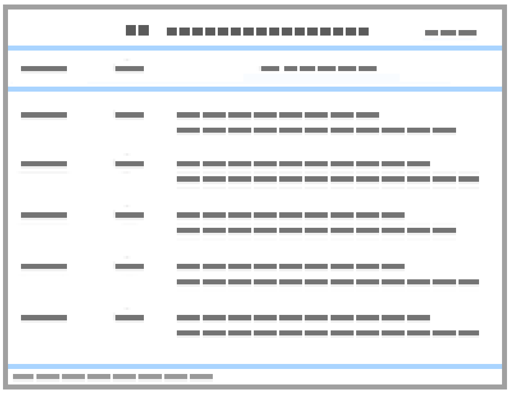
N , , N 10-640 $kg \cdot hm^{-2} \cdot a^{-1}$, 3 N , (Chen *et al.*, 2015b) N N , N C (Liu *et al.*, 2013; Luo *et al.*, 2016) , N , N , , (Knorr *et al.*, 2008; Prescott, 2010) , N , N , N : , N ; , N (Hobbie *et al.*, 2012; Sun *et al.*, 2016)

, N , N N , , N

4.2

, , (PLFA) DNA/RNA , (2) (Yoccoz, 2012)

, (15-600 cm^2, 2-10 mm) , 5-10 cm (Silver & Miya, 2001) , (Smith & Bradford, 2003) , , , (>) , (, 2012)



2

Table 2 Study methods of litter decomposition and their characteristics

, , (Jiang *et al.*, 2014) , (Sall *et al.*, 2003) ,

^{15}N ^{13}C , PLFA PCR , C N - - PLFA , ^{13}C , $^{13}CO_2$ ^{13}C , C C (Pan *et al.*, 2016; Xu *et al.*, 2017) ^{13}C , ^{13}C ^{15}N , , N N N , N (Tiunov, 2009; Lummer *et al.*, 2012) N NH_4^+ NO_3^-, N , N NO_3^- , 2010 , NH_4^+ NO_3^- 2 (Liu *et al.*, 2013) ^{15}N , N - , N (Liu *et al.*, 2016)

(N) , , , (near-infrared spectrometry, NIRS) , , , (Fortunel *et al*., 2009) , (Wallenstein *et al*., 2013) , Real-Time PCR PCR-DGGE N N , (Ning *et al*., 2015)

, , , , ,

4.3

, , , , (Adair *et al*., 2008; Kang *et al*., 2010) , , , , (, 2004) Adair (2008) , , , (Adair *et al*., 2008) Moorhead Sinsabaugh (2006) 3 : , ; , , ; , ( ) , (Moorhead & Sinsabaugh, 2006)

, , , —— ( ) , (Gliksman *et al*., 2016) , , , , ( ) , (Campbell *et al*., 2016; Schilling *et al*., 2016)

5

, ( ) ( ) , , N (Gough *et al*., 2000; Frey *et al*., 2004; Manning *et al*., 2008; , 2014) , N ,

5.1

N , 85.5% N 4 , , N (Chapin III *et al*., 2002) , N N , , (Sun *et al*., 2015) , N N , , C , , , N , , (Henry & Moise, 2015; Sun *et al*., 2015)

5.2

, C , , (Silver & Miya, 2001) C 3 , 2% (Solly *et al*., 2014; Wang *et al*., 2015; , 2016) , , N C (Freschet *et al*., 2013; Xia *et al*., 2015) , N , , , , C

5.3

, , , , , (, 2012) , , , , , , , (, 2007; Zhao *et al*., 2015b) , , C

5.4

N N , , H^+ Al^{3+} , (Ca^{2+} Mg^{2+} Na^+) , , (Bowman *et al*., 2008; Rousk *et al*., 2010) N N ( ), N (Chen *et al*., 2015a) N C , N , N C

The authors have declared that no competing interests exist.

View Option

Abbasi MK, Adams WA (2000). Gaseous N emission during simultaneous nitrification-denitrification associated with mineral N fertilization to a grassland soil under field conditions.Soil Biology & Biochemistry, 32, 1251-1259.

DOI:10.1016/S0038-0717(00)00042-0 URL
Gaseous emission of N from soil is essentially related to microbial activity, which includes nitrification and denitrification. In grassland soils subjected to high annual rainfall and intensive grazing, aerobic and anaerobic zones can develop in close proximity in the upper few centimeters of the soil, hence nitrification and denitrification can occur concurrently and adjacently. The objective of this study was to demonstrate the occurrence of simultaneous nitrification and denitrification following the addition of NO 3 61 and NH 4 + fertilizers to a grassland soil under field conditions. After applying 100 kg NO 3 61 –N ha 611 , ca. 25–75 kg ha 611 of the added N disappeared from the mineral N pool in 7 days. Emission of N 2 O and total denitrification was substantial, and 5–22 kg ha 611 of the added N was evolved as gaseous N. In the soil where NH 4 + –N was added, almost 50% of the N that disappeared from the mineral pool could not be accounted for. A substantial proportion of the applied N (7 kg ha 611) was evolved as gaseous N. The rate and amount of N loss and fluxes of N 2 O from both NO 3 61 and NH 4 + sources were greater in soils at 84% water-filled pore space (WFPS) compared with 71% and 63% WFPS. Emission of N 2 O from soil following NO 3 61 addition can therefore be attributed to denitrification. In the soils to which NH 4 + was added, accumulation of NO 3 61 –N was greatest at low moisture content (63% WFPS), while the gaseous emissions were greatest at the highest WFPS. The study demonstrated that nitrification and denitrification occur simultaneously in compacted silty grassland soils at moisture conditions close to field capacity.
[: 1]
Aber JD, Goodale CL, Ollinger SV, Smith ML, Magill AH, Martin ME, Hallett RA, Stoddard JL (2003). Is nitrogen deposition altering the nitrogen status of northern forests?BioScience, 53(4), 158-167.
DOI:10.1641/0006-3568(2003)053[0158:CTRVTM]2.0.CO;2 URL
In situ, on-farm conservation is an important complement to ex situ conservation of traditional crop varieties. In Yunnan Province, China, management for crop diversity by mixed planting (intercropping) of traditional and hybrid rice varieties provides a possible means for sustainable on-farm conservation of traditional rice varieties. Since the adoption of this form of crop diversity management in 1997, the number of traditional rice varieties in cultivation has increased dramatically and now includes some varieties that were formerly locally extinct. The cultivated area of traditional varieties has also been greatly expanded. This form of management is easy to implement and links farmers' economic concerns with conservation. Management for crop diversity can promote on-farm conservation of rice, and potentially other crops too, in a feasible and sustainable way. [References: 13]
[: 1]
Adair EC, Parton WJ, Grosso SJD (2008). Simple three-pool model accurately describes patterns of long-term litter decomposition in diverse climates.Global Change Biology, 14, 2636-2660.
DOI:10.1111/j.1365-2486.2008.01674.x URL
Abstract As atmospheric CO 2 increases, ecosystem carbon sequestration will largely depend on how global changes in climate will alter the balance between net primary

production and decomposition. The response of primary production to climatic change has been examined using well-validated mechanistic models, but the same is not true for decomposition, a primary source of atmospheric CO_2. We used the Long-term Intersite Decomposition Experiment Team (LIDET) dataset and model-selection techniques to choose and parameterize a model that describes global patterns of litter decomposition. Mass loss was best represented by a three-pool negative exponential model, with a rapidly decomposing labile pool, an intermediate pool representing cellulose, and a recalcitrant pool. The initial litter lignin/nitrogen ratio defined the size of labile and intermediate pools. Lignin content determined the size of the recalcitrant pool. The decomposition rate of all pools was modified by climate, but the intermediate pool's decomposition rate was also controlled by relative amounts of litter cellulose and lignin (indicative of lignin-encrusted cellulose). The effect of climate on decomposition was best represented by a composite variable that multiplied a water-stress function by the Lloyd and Taylor variable Q_{10} temperature function. Although our model explained nearly 70% of the variation in LIDET data, we observed systematic deviations from model predictions. Below- and aboveground material decomposed at notably different rates, depending on the decomposition stage. Decomposition in certain ecosystem-specific environmental conditions was not well represented by our model; this included roots in very wet and cold soils, and aboveground litter in N-rich and arid sites. Despite these limitations, our model may still be extremely useful for global modeling efforts, because it accurately (R^2 =0.6804) described general patterns of long-term global decomposition for a wide array of litter types, using relatively minimal climatic and litter quality data.
[: 2]
Aerts R (1997). Climate, leaf litter chemistry and leaf litter decomposition in terrestrial ecosystems: A triangular relationship.Oikos, 79, 439-449.
DOI:10.1039/b612546h URL
Litter decomposition is an important component of the global carbon budget. Due to the strong climatic control of litter decomposition, climate change may significantly affect this pathway. This review quantifies the climatic influences on litter decomposition rates, both directly and indirectly through effects on litter chemistry. To this end, I analysed first-year leaf litter decomposition data from 44 locations, ranging from cool temperate sites to humid tropical sites. Actual evapotranspiration (AET) was used as an index for the climatic control on decomposition. As litter chemistry parameters I included N and P concentrations, C/N and C/P ratios, lignin concentrations, and lignin/N and lignin/P ratios. At a global scale, climate (expressed as AET) is the best predictor for the decomposition constants (ic-values) of the litter, whereas litter chemistry parameters have much lower predictive values. Path analysis showed that the control of AET on litter decomposability is partly mediated through an indirect effect of AET on litter chemistry. Thus, the relation between climate, leaf litter chemistry and leaf litter decomposition is a triangular relationship. Mean AET in the humid tropical region is three times as high as in both the temperate and the Mediterranean region and this results in a more than six-fold increase in mean k-values. However, due to the large variability in k-values within each region there is a considerable overlap in k-values between the tropics and the other

climatic regions. Within a particular climatic region litter chemistry parameters are the best predictors of k-values, especially in the tropics, whereas the percentage of variance in k-values explained by AET is low or absent. In general, litters from the tropical sites have higher N concentrations and lower lignin/N ratios than litters from other climatic regions. In both the tropics and in the Mediterranean region, the lignin/N ratio is the best chemical predictor of litter decomposab
[: 1]
Aerts R (2006). The freezer defrosting: Global warming and litter decomposition rates in cold biomes.Journal of Ecology, 94, 713-724.
DOI:10.1111/j.1365-2745.2006.01142.x URL
Summary Top of page Summary Introduction Direct effects of temperature Indirect temperature effects on litter chemistry Indirect effects on detritivore and decomposer communities How to proceed? Acknowledgements References 1 Decomposition of plant litter, a key component of the global carbon budget, is hierarchically controlled by the triad: climate > litter quality > soil organisms. Given the sensitivity of decomposition to temperature, especially in cold biomes, it has been hypothesized that global warming will lead to increased litter decomposition rates, both through direct temperature effects and through indirect effects on litter quality and soil organisms. 2 A meta-analysis of experimental warming studies in cold biomes (34 site-species combinations) showed that warming resulted in slightly increased decomposition rates. However, this response was strongly dependent on the method used: open top chambers reduced decomposition rates, whereas heating lamps stimulated decomposition rates. The low responsiveness was mainly due to moisture-limited decomposition rates in the warming treatments, especially at mesic and xeric sites. This control of litter decomposition by both temperature and moisture was corroborated by natural gradient studies. 3 Interspecific differences in litter quality and decomposability are substantially larger than warming-induced phenotypic responses. Thus, the changes in the species composition and structure of plant communities that have been observed in medium-term warming studies in cold biomes will have a considerably greater impact on ecosystem litter decomposition than phenotypic responses. 4 Soil fauna communities in cold biomes are responsive to climate warming. Moreover, temperature-driven migration of the, hitherto absent, large comminuters to high-latitude sites may significantly increase decomposition rates. However, we do not know how far-reaching the consequences of changes in the species composition and structure of the soil community are for litter decomposition, as there is a lack of data on functional species redundancy and the species dispersal ability. 5 Global warming will lead to increased litter decomposition rates only if there is sufficient soil moisture. Hence, climate scenario and experimental studies should focus more on both factors and their interaction. As interspecific differences in potential decomposability and litter chemistry are substantially larger than phenotypic responses to warming, the focus of future research should be on the former. In addition, more light should be shed on the below-ground arkness to evaluate the ecological significance of warming-induced soil fauna community changes for litter decomposition processes in cold biomes.
[: 2]

Ågren GI, Bosatta E, Magill AH (2001). Combining theory and experiment to understand effects of inorganic nitrogen on litter decomposition.Oecologia, 128, 94-98.
DOI:10.1007/s004420100764 PMID:24549916 URL
. It has been long recognised that mineral elements, and nitrogen in particular, play an important role in determining the rate at which organic matter is decomposed. The magnitude and even the sign of the effects are, however, not universal and the underlying mechanisms are not well understood. In this paper, an explanation for the observed decreases in decomposition/CO 2 evolution rates when inorganic nitrogen increases is proposed by combining a theoretical approach with the results of a 6-year litter decomposition-forest nitrogen fertilisation experiment. Our results show that the major causes of observed changes in decomposition rate after nitrogen fertilisation are increases in decomposer efficiency, more rapid formation of recalcitrant material, and, although less pronounced, decreased growth rate of decomposers. This gives a more precise description of how inorganic nitrogen modifies decomposition rates than the previously loosely used "decrease in microbial activity". The long-term consequences for soil carbon storage differ widely depending on which factor is changed; stores are much more sensitive to changes in decomposer efficiency and/or rate of formation of recalcitrant material than to changes in decomposer growth rate.
[: 3]
Allison SD, Gartner TB, Mack MC, McGuire K, Treseder K (2010). Nitrogen alters carbon dynamics during early succession in boreal forest.Soil Biology & Biochemistry, 42, 1157-1164.
DOI:10.1016/j.soilbio.2010.03.026 URL
Boreal forests are an important source of wood products, and fertilizers could be used to improve forest yields, especially in nutrient poor regions of the boreal zone. With climate change, fire frequencies may increase, resulting in a larger fraction of the boreal landscape present in early-successional stages. Since most fertilization studies have focused on mature boreal forests, the response of burned boreal ecosystems to increased nutrient availability is unclear. Therefore, we used a nitrogen (N) fertilization experiment to test how C cycling in a recently-burned boreal ecosystem would respond to increased N availability. We hypothesized that fertilization would increase rates of decomposition, soil respiration, and the activity of extracellular enzymes involved in C cycling, thereby reducing soil C stocks. In line with our hypothesis, litter mass loss increased significantly and activities of cellulose- and chitin-degrading enzymes increased by 45–61% with N addition. We also observed a significant decline in C concentrations in the organic soil horizon from 19.5±0.7% to 13.5±0.6%, and there was a trend toward lower total soil C stocks in the fertilized plots. Contrary to our hypothesis, mean soil respiration over three growing seasons declined by 31% from 78.3±6.5mg CO 2 –C m 612 h 611 to 54.4±4.1mg CO 2 –C m 612 h 611 . These changes occurred despite a 2.5-fold increase in aboveground net primary productivity with N, and were accompanied by significant shifts in the structure of the fungal community, which was dominated by Ascomycota. Our results show that the C cycle in early-successional boreal ecosystems is highly responsive to N addition. Fertilization results in an initial loss of soil C followed by depletion of soil C substrates and

development of a distinct and active fungal community. Total microbial biomass declines and respiration rates do not keep pace with plant inputs. These patterns suggest that N fertilization could transiently reduce but then increase ecosystem C storage in boreal regions experiencing more frequent fires.
[: 1]

Apolinário VXO, Dubeux JCB, Mello ACL (2014). Litter decomposition of signalgrass grazed with different stocking rates and nitrogen fertilizer levels.Agronomy Journal, 106(2), 1-6.
DOI:10.2134/agronj2013.0148 URL
ABSTRACT Maintaining a mixture of cool-and warm-season turfgrasses year-round instead of overseeding into a perennial monoculture stand annually in the transition zone may be an effective way to combine the strengths of two species. Four mixtures of tall fescue (Festuca arundinacea L.) (Jaguar 3 and Bonsai) and zoysiagrass (Zoysia japonica Steud.) (Zenith and Cathy) were evaluated under 5- and 7.5-cm mowing heights and N regimes of 400, 200, and 100 kg ha(-1) yr(-1) in Beijing, China, during 2011 and 2012. Turf quality was better at a 5-cm mowing height than a 7.5-cm mowing height in July and October and was equivalent between the two mowing heights for the other months. Visual quality was highest in plots receiving N at 400 kg ha(-1) yr(-1) in May, June, September, October, and November. In August, however, the highest visual turf quality was observed for an N rate of 100 kg ha(-1) yr(-1). Generally, the 5-cm mowing height and low N application produced high shoot density and ground coverage by zoysiagrass, whereas the shoot density of tall fescue showed no difference between the two mowing heights. The higher N rate most often favored greater tall fescue shoot density and ground coverage. Based on the results, we recommend a 5-cm mowing height and an N rate of 400 kg ha(-1) yr(-1), avoiding application in August, for the mixture.
[: 2]
Arai H, Tokuchi N, Koba K (2007). Possible mechanisms leading to a delay in carbon stock recovery after land use change.Soil Science Society of America Journal, 71, 1636-1638.
DOI:10.2136/sssaj2005.0309 URL
Changes in land use sometimes lead to soil C loss, and a long time may be required for the C stock to recover to initial levels. Thus, it is important to evaluate the mechanisms related to accumulation of newly input C following land use changes. In this study, we sought to determine the signature of newly input C in the soil profile after land use change. We used stable and radioactive C isotopes with soil fractionation methods in a C-3 coniferous plantation converted from C-4 grassland in Japan. The difference in delta C-13 values between the surface litter and the soil organic carbon (SOC) below the litter was 5 parts per thousand or greater; this large isotopic difference was attributed to rapid decomposition in the litter layer and preservation of C derived from the previous C-4 vegetation. Most SOC Delta C-14 values were negative throughout the soil profile, suggesting that most of the SOC in the soil profile was recalcitrant and had been preserved for a long time. Only the surface sand values were slightly positive. These results suggest that most newly input C is consumed at the soil surface. The low ability of these soils to

preserve newly input C is one factor in the slow recovery of soil C.

[: 1]

Bai YF, Wu JG, Christopher MC, Shahid N, Pan QM, Huang JH, Zhang LX, Han XG (2010). Tradeoffs and thresholds in the effects of nitrogen addition on biodiversity and ecosystem functioning: Evidence from Inner Mongolia grasslands.Global Change Biology, 16, 358-372.

DOI:10.1111/j.1365-2486.2009.01950.x URL

Abstract Nitrogen (N) deposition is widely considered an environmental problem that leads to biodiversity loss and reduced ecosystem resilience; but, N fertilization has also been used as a management tool for enhancing primary production and ground cover, thereby promoting the restoration of degraded lands. However, empirical evaluation of these contrasting impacts is lacking. We tested the dual effects of N enrichment on biodiversity and ecosystem functioning at different organizational levels (i.e., plant species, functional groups, and community) by adding N at 0, 1.75, 5.25, 10.5, 17.5, and 28.0gNm 612 yr 611 for four years in two contrasting field sites in Inner Mongolia: an undisturbed mature grassland and a nearby degraded grassland of the same type. N addition had both quantitatively and qualitatively different effects on the two communities. In the mature community, N addition led to a large reduction in species richness, accompanied by increased dominance of early successional annuals and loss of perennial grasses and forbs at all N input rates. In the degraded community, however, N addition increased the productivity and dominance of perennial rhizomatous grasses, with only a slight reduction in species richness and no significant change in annual abundance. The mature grassland was much more sensitive to N-induced changes in community structure, likely as a result of higher soil moisture accentuating limitation by N alone. Our findings suggest that the critical threshold for N-induced species loss to mature Eurasian grasslands is below 1.75gNm 612 yr 611 , and that changes in aboveground biomass, species richness, and plant functional group composition to both mature and degraded ecosystems saturate at N addition rates of approximately 10.5gNm 612 yr 611 . This work highlights the tradeoffs that exist in assessing the total impact of N deposition on ecosystem function.

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Barantal S, Roy J, Fromin N, Schimann H, Hättenschwiler S (2011). Long-term presence of tree species but not chemical diversity affect litter mixture effects on decomposition in a neotropical rainforest.Oecologia, 167, 241-252.

DOI:10.1007/s00442-011-1966-4 PMID:21442279 URL

Plant litter diversity effects on decomposition rates are frequently reported, but with a strong bias towards temperate ecosystems. Altered decomposition and nutrient recycling with changing litter diversity may be particularly important in tree species-rich tropical rainforests on nutrient-poor soils. Using 28 different mixtures of leaf litter from 16 Amazonian rainforest tree species, we tested the hypothesis that litter mixture effects on decomposition increase with increasing functional litter diversity. Litter mixtures and all single litter species were exposed in the field for 9 months using custom-made microcosms with soil fauna access. In order to test the hypothesis that the long-term presence of tree species contributing to the litter mixtures increases mixture effects on decomposition, microcosms were installed in a plantation at sites including the respective tree species composition and in a nearby natural forest where these tree species are absent. We found that mixture decomposition deviated from predictions based on single species, with predominantly synergistic effects. Functional litter diversity, defined as either richness, evenness, or divergence based on a wide range of chemical traits, did not explain the observed litter mixture effects. However, synergistic effects in litter mixtures increased with the long-term presence of tree species contributing to these mixtures as the home field advantage hypothesis assumes. Our data suggest that complementarity effects on mixed litter decomposition may emerge through long-term interactions between aboveground and belowground biota.

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Berg B, Matzner E (1997). Effect of N deposition on decomposition of plant litter and soil organic matter in forest systems.Environmental Reviews, 5, 1-25.

DOI:10.1139/a96-017 URL

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Berg B, McClaugherty C (2003). Plant Litter-Decomposition, Humus Formation, Carbon Sequestration. Springer, Berlin.

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Berg B, Staaf H (1980). Decomposition rate and chemical changes in decomposing needle litter of Scots pine: Influence of chemical composition. Ecological Bulletin, 32, 373-390.

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Bontti EE, Decant JP, Munson SM, Gathany MA, Przeszlowska A, Haddix ML, Owens S, Burke IC, Parton WJ, Harmon ME (2009). Litter decomposition in grasslands of Central North America (US Great Plains).Global Change Biology, 15, 1356-1363.

DOI:10.1111/j.1365-2486.2008.01815.x URL

Abstract One of the major concerns about global warming is the potential for an increase in decomposition and soil respiration rates, increasing CO 2 emissions and creating a positive feedback between global warming and soil respiration. This is particularly important in ecosystems with large belowground biomass, such as grasslands where over 90% of the carbon is allocated belowground. A better understanding of the relative influence of climate and litter quality on litter decomposition is needed to predict these changes accurately in grasslands. The Long-Term Intersite Decomposition Experiment Team (LIDET) dataset was used to evaluate the influence of climatic variables (temperature, precipitation, actual evapotranspiration, and climate decomposition index), and litter quality (lignin content, carbon:nitrogen, and lignin:nitrogen ratios) on leaf and root decomposition in the US Great Plains. Wooden dowels were used to provide a homogeneous litter quality to evaluate the relative importance of above and belowground environments on decomposition. Contrary to expectations, temperature did not explain variation in root and leaf decomposition, whereas precipitation partially explained variation in root decomposition. Percent lignin was the best predictor of leaf and root decomposition. It also explained most variation in root decomposition in models which combined litter quality and climatic variables. Despite the lack of relationship between temperature and root decomposition, temperature could indirectly affect root decomposition through decreased litter quality and increased water deficits. These results suggest that carbon flux from root decomposition in grasslands would increase, as result of increasing temperature, only if precipitation is not limiting. However, where precipitation is limiting, increased temperature would decrease root decomposition, thus likely increasing carbon storage in grasslands. Under homogeneous litter quality, belowground decomposition was faster than aboveground and was best predicted by mean annual precipitation, which also suggests that the high moisture in soil accelerates decomposition belowground.

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Bowman WD, Cleveland CC, Halada L, Hresko J, Baron JS (2008). Negative impact of nitrogen deposition on soil buffering capacity.Nature Geoscience, 1, 767-770.

DOI:10.1038/ngeo339 URL

Anthropogenic nitrogen deposition over the past half century has had a detrimental impact on temperate ecosystems in Europe and North America, resulting in soil acidification and a reduction in plant biodiversity. During the acidification process, soils release base cations, such as calcium and magnesium, neutralizing the increase in acidity. Once these base cations have been depleted, aluminium is released from the soils, often reaching toxic levels. Here, we present results from a nitrogen deposition experiment that suggests that a long legacy of acid deposition in the Western Tatra Mountains of Slovakia has pushed soils to a new threshold of acidification usually associated with acid mine drainage soils. We show that increases in nitrogen deposition in the region result in a depletion of both base cations and soluble aluminium, and an increase in extractable iron concentrations. In conjunction with this, we observe a nitrogen-deposition-induced reduction in the biomass of vascular plants, associated with a decrease in shoot calcium and magnesium concentrations. We suggest that this site, and potentially others in central Europe, have reached a new and potentially more toxic level of soil acidification in which aluminium release is superseded by iron release into soil water.

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Bradford MA, Berg B, Maynard DS, Wieder WR, Wood SA (2016). Understanding the dominant controls on litter decomposition. Journal of Ecology, 104, 229-238.

DOI:10.1111/1365-2745.12507 URL

Summary Litter decomposition is a biogeochemical process fundamental to element cycling within ecosystems, influencing plant productivity, species composition and carbon storage. Climate has long been considered the primary broad-scale control on litter decomposition rates, yet recent work suggests that plant litter traits may predominate. Both decomposition paradigms, however, rely on inferences from cross-biome litter decomposition studies that analyse site-level means. We re-analyse data from a classical cross-biome study to demonstrate that previous research may falsely inflate the regulatory role of climate on decomposition and mask the influence of unmeasured local-scale factors. Using the re-analysis as a platform, we advocate experimental designs of litter decomposition studies that involve high within-site replication, measurements of regulatory factors and processes at the same local spatial grain, analysis of individual

observations and biome-scale gradients. Synthesis . We question the assumption that climate is the predominant regulator of decomposition rates at broad spatial scales. We propose a framework for a new generation of studies focused on factoring local-scale variation into the measurement and analysis of soil processes across broad scales. Such efforts may suggest a revised decomposition paradigm and ultimately improve confidence in the structure, parameter estimates and hence projections of biogeochemical models.
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Campbell EE, Parton WJ, Soong JL, Paustian K, Hobbs NT, Cotrufo MF (2016). Using litter chemistry controls on microbial processes to partition litter carbon fluxes with the Litter Decomposition and Leaching (LIDEL) Model.Soil Biology & Biochemistry, 100, 160-174.
DOI:10.1016/j.soilbio.2016.06.007 URL
New understanding of the connection between dynamic microbial carbon use efficiency (CUE), litter decomposition products, and pathways of soil organic carbon (SOC) formation have not been fully integrated into current generalizable litter decomposition models. We developed a new approach, the Litter Decomposition and Leaching (LIDEL) model, that: 1) includes leaching and formation of dissolved organic carbon (DOC), important components of vertical C movement and SOC inputs into deeper soil layers, and 2) uses widely available litter chemistry data to drive the simulation of microbial processes that partition litter during decomposition, through affecting rates of CO 2 respiration versus formation of microbial biomass and microbial products. Two ecologically important but poorly understood processes explored in this analysis include 1) the relationship between litter nitrogen (N) availability and rates of microbial decay and assimilation, and 2) the efficiency of DOC generation from the decomposition and leaching of soluble- versus cellulose-dominated plant litter fractions. We tested multiple hypothesis-driven model formulations, and for each estimated initial conditions and parameters using hierarchical Bayesian approaches. We combined data from experimental results and literature review for five types of litter that vary by initial lignin and N content. Our analyses showed the LIDEL model formulations with a logistic N limitation curve gave better predictions than model formulations using a linear N limitation curve. Model formulations with higher DOC generation efficiency from the soluble litter pool yielded more variable predictions and parameter estimations (shown by consistently wider 95% Bayesian credible intervals), but may have better simulated large DOC leaching events in early decomposition. Our analyses highlight a need for targeted studies clarifying measures of soluble litter and the generation of DOC during early litter decomposition, as well as rates of microbial biomass turnover and the flux of soluble versus non-soluble microbial products. Overall, the LIDEL model provides a robust generalizable framework to express and test hypotheses connecting litter chemistry and dynamic microbial CUE with the generation of DOC and microbial products during litter decomposition.
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Carreiro MM, Sinsabaugh RL, Repert DA, Parkhurst DF (2000). Microbial enzyme shifts explain litter decay responses to simulated nitrogen deposition.Ecology, 81, 2359-2365.
DOI:10.1890/0012-9658(2000)081[2359:MESELD]2.0.CO;2 URL

Some natural ecosystems near industrialized and agricultural areas receive atmospheric nitrogen inputs that are an order of magnitude greater than those presumed for preindustrial times. Because nitrogen (N) often limits microbial growth on dead vegetation, increased N input can be expected to affect the ecosystem process of decomposition. We found that extracellular enzyme responses of a forest-floor microbial community to chronically applied aqueous NH4NO3can explain both increased and decreased litter decomposition rates caused by added N. Microbes responded to N by increasing cellulase activity in decaying leaf litter of flowering dogwood, red maple, and red oak, but in high-lignin oak litter, the activity of lignin-degrading phenol oxidase declined substantially. We believe this is the first report of reduced ligninolytic enzyme activity caused by chronic N addition in an ecosystem. This result provides evidence that ligninolytic enzyme suppression can be an important mechanism explaining decreased decay rates of plant matter seen in this and other N-addition experiments. Since lignin and cellulose are the two most abundant organic resources on earth, these altered enzyme responses signal that atmospheric N deposition may be affecting the global carbon cycle by influencing the activities of microbes and their carbon-acquiring enzymes--especially the unique ligninolytic enzymes produced by white-rot fungi--over broad geographic areas.

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Carrillo Y, Ball BA, Bradford MA, Jordan CF, Molina M (2011). Soil fauna alter the effects of litter composition on nitrogen cycling 290 in a mineral soil.Soil Biology & Biochemistry, 43, 1440-1449.

DOI:10.1016/j.soilbio.2011.03.011 URL

Plant chemical composition and the soil community are known to influence litter and soil organic matter decomposition. Although these two factors are likely to interact, their mechanisms and outcomes of interaction are not well understood. Studies of their interactive effects are rare and usually focus on carbon dynamics of litter, while nutrient dynamics in the underlying soil have been ignored. A potential mechanism of interaction stems from the role fauna plays in regulating availability of litter-derived materials in the mineral soil. We investigated the role of soil fauna (meso, macro) in determining the effect of surface-litter chemical composition on nitrogen mineralization and on the micro-food web in mineral soils. In a field setting we exposed mineral soil to six types of surface-applied litter spanning wide ranges of multiple quality parameters and restricted the access of larger soil animals to the soils underlying these litters. Over six months we assessed litter mass and nitrogen loss, nitrogen mineralization rates in the mineral soils, and soil microbes and microfauna. We found evidence that the structure of the soil community can alter the effect of surface-litter chemical composition on nitrogen dynamics in the mineral soil. In particular, we found that the presence of members of the meso- and macrofauna can magnify the control of nitrogen mineralization by litter quality and that this effect is time dependent. While fauna were able to affect the size of the micro-food web they did not impact the effect of litter composition on the abundance of the members of the micro-food web. By enhancing the strength of the impact of litter quality on nitrogen dynamics, the larger fauna can alter nitrogen availability and its

temporal dynamics which, in turn, can have important implications for ecosystem productivity. These findings contribute to evidence demonstrating that soil fauna shape plant litter effects on ecosystem function.
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Chapin FSI, Vitousek PM, van Cleve K (1986). The nature of nutrient limitation in plant communities.The American Naturalist, 127, 48-58.
DOI:10.1086/284466 URL
The concept of nutrient limitation, as developed in agriculture, applies well to wild plants grown under controlled conditions, although plants adapted to infertile soils are less responsive to nutrient addition than are most crop species. There are serious difficulties in transferring the concept of nutrient limitation directly to plant communities, however, because (1) in comparing communities with different dominant species, the species characteristic of nutrient-rich sites are inherently more responsive to nutrient supply and may be more strongly nutrient-limited than species in low-nutrient sites, and (2) ecosystem-level feedback complicates the analysis of experiments involving fertilization. We suggest that nutrient limitation in communities can be best measured by assessing the plants' response to large nutrient additions that are sufficient to saturate chemical and microbial immobilization processes and still meet plant nutrient requirements. The magnitude of community-level nutrient limitation is highly sensitive to the potential growth rate of component species; it may be greatest in sites of intermediate fertility.
[: 1]
Chapin III FS, Matson PA, Mooney HA (2002). Principles of Terrestrial Ecosystem Ecology. Springer, New York.
DOI:10.1007/b97397 URL
Humans have directly modified half of the ice-free terrestrial surface and use 40% of terrestrial production. We are causing the sixth major extinction event in the history of life on Earth. With the Earth climate, flora, and fauna changing rapidly, there is a pressing need to understand terrestrial ecosystem processes and their sensitivity to environmental and biotic changes. This book offers a framework to do just that. Ecosystem ecology regards living organisms, including people, and the elements of their environment as components of a single integrated system. The comprehensive coverage in this textbook examines the central processes at work in terrestrial ecosystems, including their freshwater components. It traces the flow of energy, water, carbon, and nutrients from their abiotic origins to their cycles through plants, animals, and decomposer organisms. As well as detailing the processes themselves, the book goes further to integrate them at various scales of magnitude hose of the ecosystem, the wider landscape and the globe. It synthesizes recent advances in ecology with established and emerging ecosystem theory to offer a wide-ranging survey of ecosystem patterns and processes in our terrestrial environment. Featuring review questions at the end of each chapter, suggestions for further reading, and a glossary of ecological terms, Principles of Terrestrial Ecosystem Ecology is a vitally relevant text suitable for study in all courses in ecosystem ecology. Resource managers and researchers in many fields will welcome its thorough presentation

of ecosystem essentials.
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Chartzoulakis K, Psarras G (2005). Global change effects on crop photosynthesis and production in Mediterranean: The case of Crete, Greece.Agriculture Ecosystems & Environment, 106, 147-157.
DOI:10.1016/j.agee.2004.10.004 URL
Global change will definitely introduce changes in agricultural ecosystems that will affect photosynthesis and plant productivity. However, the effects on plants will be different for each region depending on the pre-existing climatic conditions and the adaptation potential of local cultivated species. In Crete, an island with typical Mediterranean climate, high temperatures and lack of rainfall during summer are the most important factors determining productivity of tree crops. Meteorological data and predictive models of climate change indicate that the annual mean temperature of the island has already increased by 0.3 C in the past two decades and will further increase in the future. Moreover, summer precipitation will be lower and the frequency of extreme climatic phenomena, like heat waves, will increase. Consequently, the combination of reduced rainfall and increased temperature will impose higher evapotranspiration losses, increasing the water stress problems of cultivated crops, while the reduction in the availability of irrigation water of good quality will increase the use of saline water and augment the already existing problem of salinity in the island. Therefore, cultivated species in Crete, and the Eastern Mediterranean region in general, will have to grow in a hotter, drier and, in some cases, more saline environment. In this report, the possible effects of increased temperature, UV-B radiation and reduced precipitation on the typical agricultural crops of the area are discussed, based on the current knowledge about the effects of climate change on plant photosynthesis and productivity. Special consideration is accounted to the negative effects that may counterbalance the benefits of higher photosynthetic rates and water use efficiency introduced by the future increase in atmospheric CO 2 concentration.
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Chen D, Lan Z, Hu S, Bai Y (2015a). Effects of nitrogen enrichment on belowground communities in grassland: Relative role of soil nitrogen availability vs. soil acidification.Soil Biology & Biochemistry, 89, 99-108.
DOI:10.1016/j.soilbio.2015.06.028 URL
61N enrichment increased both above- and belowground plant biomass mainly via N availability.61N enrichment had negative effects on both microbial and nematode communities in semi-arid grassland.61The positive effects of belowground C allocation on belowground communities were outweighed by soil acidification.61N enrichment weakens the linkages between aboveground and belowground components of grassland ecosystems.
[: 2]
Chen H, Dong S, Liu L, Ma C, Zhang T, Zhu X, Mo J (2013a). Effects of experimental nitrogen and phosphorus addition on litter decomposition in an old-growth tropical forest.PLOS ONE, 8, e84101. doi: 10.1371/journal.pone.0084101.

DOI:10.1371/journal.pone.0084101 PMID:24391895 URL
The responses of litter decomposition to nitrogen (N) and phosphorus (P) additions were examined in an old-growth tropical forest in southern China to test the following hypotheses: (1) N addition would decrease litter decomposition; (2) P addition would increase litter decomposition, and (3) P addition would mitigate the inhibitive effect of N addition. Two kinds of leaf litter, Schima superba Chardn. & Champ. (S.S.) and Castanopsis chinensis Hance (C.C.), were studied using the litterbag technique. Four treatments were conducted at the following levels: control, N-addition (150 kg N ha611 yr611), P-addition (150 kg P ha611 yr611) and NP-addition (150 kg N ha611 yr611 plus 150 kg P ha611 yr611). While N addition significantly decreased the decomposition of both litters, P addition significantly inhibited decomposition of C.C., but did not affect the decomposition of S.S. The negative effect of N addition on litter decomposition might be related to the high N-saturation in this old-growth tropical forest; however, the negative effect of P addition might be due to the suppression of "microbial P mining". Significant interaction between N and P addition was found on litter decomposition, which was reflected by the less negative effect in NP-addition plots than those in N-addition plots. Our results suggest that P addition may also have negative effect on litter decomposition and that P addition would mitigate the negative effect of N deposition on litter decomposition in tropical forests.
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Chen H, Li DJ, Gurmesaa GA, Yu GR, Li LH, Zhang W, Fang HJ, Mo JM (2015b). Effects of nitrogen deposition on carbon cycle in terrestrial ecosystems of China: A meta-analysis.Environmental Pollution, 206, 352-360.
DOI:10.1016/j.envpol.2015.07.033 PMID:26232918 URL
Nitrogen (N) deposition in China has increased greatly, but the general impact of elevated N deposition on carbon (C) dynamics in Chinese terrestrial ecosystems is not well documented. In this study we used a meta-analysis method to compile 88 studies on the effects of N deposition C cycling on Chinese terrestrial ecosystems. Our results showed that N addition did not change soil C pools but increased above-ground plant C pool. A large decrease in below-ground plant C pool was observed. Our result also showed that the impacts of N addition on ecosystem C dynamics depend on ecosystem type and rate of N addition. Overall, our findings suggest that 1) decreased below-ground plant C pool may limit long-term soil C sequestration; and 2) it is better to treat N-rich and N-limited ecosystems differently in modeling effects of N deposition on ecosystem C cycle.
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Chen YL, Xu ZW, Hu HW, Hu YJ, Hao ZP, Jiang Y, Chen BD (2013b). Responses of ammonia-oxidizing bacteria and archaea to nitrogen fertilization and precipitation increment in a typical temperate steppe in Inner Mongolia.Applied Soil Ecology, 68(3), 36-45.
DOI:10.1016/j.apsoil.2013.03.006 URL
As the first and rate-limiting step of nitrification, ammonia oxidation can be realized either by ammonia-oxidizing bacteria (AOB) or archaea (AOA). However, the key factors driving the abundance, community structure and activity of ammonia oxidizers are still unclear, and the relative importance of AOA and AOB in ammonia oxidation is unresolved. In the

present study, we examined the effects of long-term (6 years) nitrogen (N) addition and simulated precipitation increment on the abundance and community composition of AOA and AOB based on a field trial in a typical temperate steppe of northern China. We used combined approaches of quantitative PCR, terminal-restriction fragment length polymorphism (T-RFLP) and clone library analyses of amoA genes. The study objective was to determine (1) AOA and AOB diversity and activity in response to N addition and increased precipitation and (2) the relative contributions of AOA and AOB to soil ammonia oxidation in the typical temperate steppe. The results showed that the potential nitrification rate (PNR) increased with N addition, but decreased with increased precipitation. Both N addition and increased precipitation significantly increased AOB but not AOA abundance, and a significant correlation was only observed between PNR and AOB amoA gene copies. The T-RFLP analysis showed that both N and precipitation were key factors in shaping the composition of AOB, while AOA were only marginally influenced. Phylogenetic analysis indicated that all AOA clones fell within the soil and sediment lineage while all AOB clones fell within the Nitrosospira. The study suggested that AOA and AOB had distinct physiological characteristics and ecological niches. AOB were shown to be more sensitive to N and precipitation than AOA, and the ammonia oxidation process was therefore supposed to be mainly driven by AOB in this temperate steppe. (C) 2013 Elsevier B.V. All rights reserved.

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Chen ZZ, Wang SP (2000). Typical Grassland Ecosystem in China. Science Press, Beijing. (in Chinese)

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Chomel M, Fernandez C, Bousquet-Melou A, Gers C, Monnier Y, Santonja M, Gauquelin T, Gros R, Lecareux C, Baldy V (2014). Secondary metabolites of Pinus halepensis alter decomposer organisms and litter decomposition during afforestation of abandoned agricultural zones.Journal of Ecology, 102, 411-424.

DOI:10.1111/1365-2745.12205 URL

Over a century of agricultural abandonment across the Mediterranean region has favoured the installation of the pioneer expansionist species Aleppo pine (Pinus halepensis Miller). This species synthesizes a wide range of secondary metabolites that are partially released during needle decomposition, and which can thus affect the ‘brown food chain’. Litter decomposition is a key process connecting ecosystem structure and function, and involving microbial and faunal components.The goal of this study was to determine the effect of chemical compounds from Aleppo pine needles on the litter decomposition process along a gradient of Mediterranean forest secondary succession. Using in situ litterbags, we compared the dynamics of decomposers, particularly the relative contributions of fungal and mesofauna biomass to litter mass loss (calculations based on the measured decomposer biomass, published fungal growth efficiency and mesofauna feeding rate), against the dynamics of secondary metabolites associated with decomposed needles in three successional stages (early, middle and late, i.e. pinewoods that were aged 10, 30 and over 60 years old).Our first key finding was that fungi accounted for the largest portion of overall litter mass loss (60–79%) and detritivorous mesofauna contributed to 8–12%. In the early stage of succession, fungal biomass after 6 months of decomposition was lower than in middle and late stages, and may be responsible for the delay in litter colonization by mesofauna. We linked this result to a clearly longer residence time for phenolic compounds in young pine forest, leading to an overall slowdown in the decomposition process.Synthesis. Litter phenolic content emerged as a key functional trait for predicting litter decomposition, delaying the colonization of litter by decomposers in Mediterranean forest ecosystems. Another key finding is that the relative contributions of fungi and detritivores to needle mass loss were different between the successional stages. From the food-web perspective, the organic matter available for higher trophic levels thus remains unchanged beyond 30 years after pine colonization.

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Chomel M, Fernandez C, Gallet C, DesRochers A, Pare D, Jackson BG, Baldy V (2016). Plant secondary metabolites: A key driver of litter decomposition and soil nutrient cycling.Journal of Ecology, 104, 1527-1541.

DOI:10.1111/1365-2745.12644 URL

Summary A broad and diversified group of compounds, secondary metabolites, are known to govern species interactions in ecosystems. Recent studies have shown that secondary metabolites can also play a major role in ecosystem processes, such as plant succession or in the process of litter decomposition, by governing the interplay between plant matter and soil organisms. We reviewed the ecological role of the three main classes of secondary metabolites and the methodological challenges and novel avenues for their study. We highlight emerging general patterns of the impacts of secondary metabolites on decomposer communities and litter decomposition and argue for the consideration of secondary compounds as key drivers of soil functioning and ecosystem functioning. Synthesis . Gaining a greater understanding of plant oil organisms relationships and underlying mechanisms, including the role of secondary metabolites, could improve our ability to understand ecosystem processes. We outline some promising directions for future research that would stimulate studies aiming to understand the interactions of secondary metabolites across a range of spatio-temporal scales. Detailed mechanistic knowledge could help us to develop models for the process of litter decomposition and nutrient cycling in ecosystems and help us to predict future impacts of global changes on ecosystem functioning.

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Cleland EE, Harpole WS (2010). Nitrogen enrichment and plant communities.Annals of the New York Academy of Science, 1195, 46-61.

DOI:10.1111/j.1749-6632.2010.05458.x PMID:20536816 URL

Abstract Anthropogenic nitrogen (N) enrichment of many ecosystems throughout the globe has important ramifications for plant communities. Observational and experimental studies frequently find species richness declines with N enrichment, in concert with increasing primary production. Nitrogen enrichment also reorders species composition, including species turnover through gains and losses of species, changes in dominance and rarity, and shifts in the relative abundance of particular functional groups.

Nitrogen has traditionally been considered the primary limiting nutrient for plant growth in terrestrial ecosystems, but recent synthetic work suggests that colimitation by phosphorus (P), water, and other resources is widespread, consistent with theoretical predictions. At the same time, disproportionate increases in ecosystem N input are expected to exacerbate limitation by P and other resources. Similarly, synthetic research has pointed out the important role of consumers and pathogens in determining plant community structure, especially with respect to shifting resource availability. We argue here that environmental and biotic contexts, including limitation by multiple resources, herbivores and pathogens, play important roles in our understanding of plant community responses to N enrichment.
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Clemmensen KE, Bahr A, Ovaskainen O, Dahlberg A, Ekblad A, Wallander H, Stenlid J, Finlay RD, Wardle DA, Lindahl BD (2013). Roots and associated fungi drive long- term carbon sequestration in boreal forest.Science, 339, 1615-1618.
DOI:10.1126/science.1231923 PMID:23539604 URL
Boreal forest soils function as a terrestrial net sink in the global carbon cycle. The prevailing dogma has focused on aboveground plant litter as a principal source of soil organic matter. Using (14)C bomb-carbon modeling, we show that 50 to 70% of stored carbon in a chronosequence of boreal forested islands derives from roots and root-associated microorganisms. Fungal biomarkers indicate impaired degradation and preservation of fungal residues in late successional forests. Furthermore, 454 pyrosequencing of molecular barcodes, in conjunction with stable isotope analyses, highlights root-associated fungi as important regulators of ecosystem carbon dynamics. Our results suggest an alternative mechanism for the accumulation of organic matter in boreal forests during succession in the long-term absence of disturbance.
[: 1]
Compton JE, Watrud LS, Porteous LA, de Grood S (2004). Response of soil microbial biomass and community composition to chronic nitrogen additions at Harvard forest.Forest Ecology & Management, 196, 143-158.
DOI:10.1016/j.foreco.2004.03.017 URL
Soil microbial communities may respond to anthropogenic increases in ecosystem nitrogen (N) availability, and the microbial response may ultimately feed back on ecosystem carbon and N dynamics. We examined the long-term effects of chronic N additions on soil microbes by measuring soil microbial biomass, composition and substrate utilization patterns in pine and hardwood forests at the Harvard Forest Chronic N Amendment Study. Functional and structural genes for important N cycling processes were studied using DNA community profiles. In the O horizon soil of both stands, N additions decreased microbial biomass C as determined by chloroform fumigation-extraction. Utilization of N-containing substrates was lower in N-treated pine soils than in the controls, suggesting that N additions reduced potential microbial activity in the pine stand. Counts of fungi and bacteria as determined by direct microscopy and culture techniques did not show a clear response to N additions. Nitrogen additions, however,

strongly influenced microbial community DNA profiles. The ammonia monooxygenase gene (amoA) generally was found in high N-treated soils, but not in control soils. The nifH gene for N_2 -fixation was generally found in all soils, but was more difficult to amplify in the pine N-treated soil than the controls, suggesting that the population of N_2 -fixers was altered by N additions. The 16S rDNA gene for Nitrobacter was found in all samples, but distinct differences among DNA profiles were observed in the pine B horizon in the control, low N, and high N-treated plots. Our findings indicate that chronic N additions decreased chloroform microbial carbon and altered microbial community profiles. These changes in microbial community structure may be an important component of the response of terrestrial ecosystems to human-accelerated N supply.
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Cornwell WK, Cornelissen JHC, Amatangelo K (2008). Plant species traits are the predominant control on litter decomposition rates within biomes worldwide.Ecology Letters, 11, 1065-1071.

DOI:10.1111/ele.2008.11.issue-10 URL
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Deforest JL, Zak DR, Pregitzer KS, Burton AJ (2004). Atmospheric nitrate deposition and the microbial degradation of cellobiose and vanillin in a northern hardwood forest.Soil Biology & Biochemistry, 36, 965-971.

DOI:10.1016/j.soilbio.2004.02.011 URL

Human activity has increased the amount of N entering terrestrial ecosystems from atmospheric NO 3 61 deposition. High levels of inorganic N are known to suppress the expression of phenol oxidase, an important lignin-degrading enzyme produced by white-rot fungi. We hypothesized that chronic NO 3 61 additions would decrease the flow of C through the heterotrophic soil food web by inhibiting phenol oxidase and the depolymerization of lignocellulose. This would likely reduce the availability of C from lignocellulose for metabolism by the microbial community. We tested this hypothesis in a mature northern hardwood forest in northern Michigan, which has received experimental atmospheric N deposition (3002kg02NO 3 61 –N02ha 611 02y 611) for nine years. In a laboratory study, we amended soils with 13 C-labeled vanillin, a monophenolic product of lignin depolymerization, and 13 C-labeled cellobiose, a disaccharide product of cellulose degradation. We then traced the flow of 13 C through the microbial community and into soil organic carbon (SOC), dissolved organic carbon (DOC), and microbial respiration. We simultaneously measured the activity of enzymes responsible for lignin (phenol oxidase and peroxidase) and cellobiose (-glucosidase) degradation. Nitrogen deposition reduced phenol oxidase activity by 83% and peroxidase activity by 74% when compared to control soils. In addition, soil C increased by 76%, whereas microbial biomass decreased by 68% in NO 3 61 amended soils. 13 C cellobiose in bacterial or fungal PLFAs was unaffected by NO 3 61 deposition; however, the incorporation of 13 C vanillin in fungal PLFAs extracted from NO 3 61 amended soil was 82% higher than in the control treatment. The recovery of 13 C vanillin and 13 C cellobiose in SOC, DOC, microbial biomass, and respiration was not different between control and NO 3 61 amended treatments. Chronic NO 3 61 deposition has stemmed the flow of C through the heterotrophic soil food web by inhibiting the

activity of ligninolytic enzymes, but it increased the assimilation of vanillin into fungal PLFAs.
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Dirks I, Navon Y, Kanas D (2010). Atmospheric water vapor as driver of litter decomposition in Mediterranean shrubland and grassland during rainless seasons. Global Change Biology, 16, 2799-2812.
DOI:10.1111/j.1365-2486.2010.02172.x URL
Abstract Litter production in many drought-affected ecosystems coincides with the beginning of an extended season of no or limited rainfall. Because of lack of moisture litter decomposition during such periods has been largely ignored so far, despite potential importance for the overall decay process in such ecosystems. To determine drivers and extent of litter decay in rainless periods, a litterbag study was conducted in Mediterranean shrublands, dwarf shrublands and grasslands. Heterogeneous local and common straw litter was left to decompose in open and shaded patches of various field sites in two study regions. Fresh local litter lost 4–18% of its initial mass over about 4 months without rainfall, which amounted to 15–50% of total annual decomposition. Lab incubations and changes in chemical composition suggested that litter was degraded by microbial activity, enabled by absorption of water vapor from the atmosphere. High mean relative humidity of 85% was measured during 8–9h of most nights, but the possibility of fog deposition or dew formation at the soil surface was excluded. Over 95% of the variation in mass loss and changes in litter nitrogen were explained by characteristics of water-vapor uptake by litter. Photodegradation induced by the intense solar radiation was an additional mechanism of litter decomposition as indicated by lignin dynamics. Lignin loss from litter increased with exposure to ultraviolet radiation and with initial lignin concentration, together explaining 90%–97% of the variation in lignin mass change. Our results indicate that water vapor, solar radiation and litter quality controlled decomposition and changes in litter chemistry during rainless seasons. Many regions worldwide experience transient periods without rainfall, and more land area is expected to undergo reductions in rainfall as a consequence of climate change. Therefore, absorption of water vapor might play a role in decomposition and nutrient cycling in an increasing number of ecosystems.
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Eisenlord SD, Freedman Z, Zak DR, Xue K, He ZL, Zhou JL (2013). Microbial mechanisms mediating increased soil C storage under elevated atmospheric N deposition.Applied and Environmental Microbiology, 79, 1191-1199.
DOI:10.1128/AEM.03156-12 PMID:3568582 URL
Future rates of anthropogenic N deposition can slow the cycling and enhance the storage of C in forest ecosystems. In a northern hardwood forest ecosystem, experimental N deposition has decreased the extent of forest floor decay, leading to increased soil C storage. To better understand the microbial mechanisms mediating this response, we examined the functional genes derived from communities of actinobacteria and fungi present in the forest floor using GeoChip 4.0, a high-throughput functional-gene microarray. The compositions of functional genes derived from actinobacterial and fungal communities was significantly altered by experimental nitrogen deposition, with more

heterogeneity detected in both groups. Experimental N deposition significantly decreased the richness and diversity of genes involved in the depolymerization of starch (6512%), hemicellulose (6516%), cellulose (6516%), chitin (6515%), and lignin (6516%). The decrease in richness occurred across all taxonomic groupings detected by the microarray. The compositions of genes encoding oxidoreductases, which plausibly mediate lignin decay, were responsible for much of the observed dissimilarity between actinobacterial communities under ambient and experimental N deposition. This shift in composition and decrease in richness and diversity of genes encoding enzymes that mediate the decay process has occurred in parallel with a reduction in the extent of decay and accumulation of soil organic matter. Our observations indicate that compositional changes in actinobacterial and fungal communities elicited by experimental N deposition have functional implications for the cycling and storage of carbon in forest ecosystems.

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Elser JJ, Bracken MES, Cleland EE, Gruner DS, Harpole WS, Hillebrand H, Ngai JT, Seabloom EW, Shurin JB, Smith JE (2007). Global analysis of nitrogen and phosphorus limitation of primary producers in freshwater, marine and terrestrial ecosystems.Ecology Letters, 10, 1135-1142.

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Esperschütz J, Welzl G, Schreiner K (2011). Incorporation of carbon from decomposing litter of two pioneer plant species into microbial communities of the detritusphere.FEMS Microbiology Letters, 320, 48-55.

DOI:10.1111/j.1574-6968.2011.02286.x PMID:21492198 URL

Abstract Initial ecosystems are characterized by a low availability of nutrients and a low soil organic matter content. Interactions of plants and microorganisms in such environments, particularly in relation to litter decomposition, are very important for further ecosystem development. In a litter decomposition study using an initial substrate from a former mining area, we applied the litter of two contrasting pioneer plant species (legume vs. pasture plants), Lotus corniculatus and Calamagrostis epigejos , which are commonly observed in the study area. Litter decomposition was investigated and carbon (C) translocation from litter into soil microorganisms was described by following 13 C from labelled plant litter materials into the fraction of phospholipid fatty acids. Labile C compounds of both plant litter types were easily degraded during the first 4 weeks of litter decomposition. In contrast to climax ecosystems, where the importance of fungi for litter degradation has been shown in many studies, in our experiment, data clearly indicate an outcompetition of fungi by Gram-positive bacteria as soon as available nitrogen is limited in the detritusphere.

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Everard K, Seabloom EW, Harpole WS, de Mazancourt C (2010). Plant water use affects competition for nitrogen: Why drought favors invasive species in California.The American Naturalist, 2175, 85-97.

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Fagerli H, Aas W (2008). Trends of nitrogen in air and precipitation: Model results and

observations at EMEP sites in Europe, 1980-2003.Environmental Pollution, 154, 448-461.
DOI:10.1016/j.envpol.2008.01.024 PMID:18336973 URL
We analyze trends of some nitrogen compounds using long-term measurements and results from the EMEP (co-operative programme for monitoring and evaluation of the long-range transmissions of air pollutants in Europe) chemical transport model at EMEP sites. We find statistically significant declines at the majority of sites for NH(x) (sum of ammonia and ammonium) in air and for nitrate and ammonium in precipitation, but only at a few sites for xNO3 (sum of nitrate and nitric acid) in air. Model calculations and measurements give similar results. We demonstrate that the lack of trends for xNO3 in air at least partly can be attributed to a shift in the equilibrium between nitric acid and ammonium nitrate towards particulate phase, caused by reductions in the sulfur dioxide emissions.
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Fan J, Harris W, Zhong H (2016). Stoichiometry of leaf nitrogen and phosphorus of grasslands of the Inner Mongolian and Qinghai-Tibet Plateau in relation to climatic variables and vegetation organization levels.Ecological Research, 31, 821-829.
DOI:10.1007/s11284-016-1392-5 URL
Nitrogen (N) and phosphorus (P) are most commonly the limiting essential elements that affect the functioning of plants and ecosystems. However, their stoichiometry in relation to climatic variables a
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Finn D, Page K, Catton K, Strounina E, Kienzle M, Robertson F, Armstrong R, Dalal R (2015). Effect of added nitrogen on plant litter decomposition depends on initial soil carbon and nitrogen stoichiometry.Soil Biology & Biochemistry, 91, 160-168.
DOI:10.1016/j.soilbio.2015.09.001 URL
61We investigated decomposition of three plant species in four varying pasture soils.61The respiration of organic carbon in response to nitrogen addition was monitored.61Nitrogen addition increased the loss of carbon from some soils but not others.61The soil carbon to nitrogen ratio determined how decomposition responds to nitrogen.
[: 1]
Fioretto A, Papa S, Curcio E (2000). Enzyme dynamics on decomposing leaf litter of Cistus incanus and Myrtus communisin in a Mediterranean ecosystem.Soil Biology & Biochemistry, 2, 1847-1855.
DOI:10.1016/S0038-0717(00)00158-9 URL
The decomposition of Cistus incanus leaf litter, a summer deciduous species, was compared to that of Myrtus communis , an evergreen species, during 15 months of incubation in a Mediterranean low shrubland. The litterbags were placed under randomly selected shrubs of Myrtus and Cistus , respectively. Owing to the different microclimatic conditions under deciduous and evergreen shrubs Cistus litter was also incubated under Myrtus shrubs. Microbial activity was evaluated by measuring litter respiration and enzyme activities (cellulase, xylanase, -amylase, -amylase, laccase and peroxidase). During the first 8 months of incubation the decomposition rate of both litters was

independent of litter quality and incubation conditions. The average decay constant (k) ranged between 0.29±0.03 and ja:math Subsequently, it increased only for litters incubated under Myrtus shrubs (k =0.57±0.15 and ja:math for Cistus and Myrtus litters, respectively). The dry summer affected the decay rate of litters incubated under Myrtus but not under Cistus . Microbial respiration showed seasonal changes (from 25 to 15002μmol CO 2 02g 611 dry wt. 2402h 611), with low levels in summer, mainly because of the low litter water content. After samples were placed in the field, -amylase activity decreased rapidly, dropping to zero in Cistus litter, whereas it remained detectable in Myrtus litter (>0.0202μmol glucose g 611 dry wt. h 611). The -amylase activity was low over the entire period. The activities of cellulase and xylanase ranged from 1 to 3002μmol glucose equivalents (reducing sugar) g 611 dry wt. h 611 . Both litters showed the lowest enzyme activities in summer, when litter respiration was also at the lowest level. Peroxidase activity was detected in the litter of Myrtus (from 0 to 5002μmol o -tolidine oxidised g 611 dry wt. h 611) and had a seasonal pattern similar to cellulase and xylanase. It was undetectable in Cistus . In both litters laccase increased significantly going from 10 to 14002μmol o -tolidine oxidised g 611 dry wt. h 611 between eight and nine months when a large increase of fungal biomass occurred (from 0.5 to 2.502mg g 611 dry wt.). The analyses of these enzymes have shown qualitative and quantitative differences depending on the litter type and the microclimatic conditions, suggesting changes in the microbial succession.

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Flury S, Gessner MO (2011). Experimentally simulated global warming and nitrogen enrichment effects on microbial litter decomposers in a Marsh.Applied and Environmental Microbiology, 77, 803-809.

DOI:10.1128/AEM.01527-10 PMID:3028715 URL

Atmospheric warming and increased nitrogen deposition can lead to changes of microbial communities with possible consequences for biogeochemical processes. We used an enclosure facility in a freshwater marsh to assess the effects on microbes associated with decomposing plant litter under conditions of simulated climate warming and pulsed nitrogen supply. Standard batches of litter were placed in coarse-mesh and fine-mesh bags and submerged in a series of heated, nitrogen-enriched, and control enclosures. They were retrieved later and analyzed for a range of microbial parameters. Fingerprinting profiles obtained by denaturing gradient gel electrophoresis (DGGE) indicated that simulated global warming induced a shift in bacterial community structure. In addition, warming reduced fungal biomass, whereas bacterial biomass was unaffected. The mesh size of the litter bags and sampling date also had an influence on bacterial community structure, with the apparent number of dominant genotypes increasing from spring to summer. Microbial respiration was unaffected by any treatment, and nitrogen enrichment had no clear effect on any of the microbial parameters considered. Overall, these results suggest that microbes associated with decomposing plant litter in nutrient-rich freshwater marshes are resistant to extra nitrogen supplies but are likely to respond to temperature increases projected for this century.

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Fortunel C, Garnier E, Joffre R, Kazakou E, Quested H, Grigulis K (2009). Leaf traits capture the effects of land use changes and climate on litter decomposability of grasslands across Europe.Ecology, 90, 598-611.

DOI:10.1890/08-0418.1 PMID:19341132 URL

Abstract Land use and climate changes induce shifts in plant functional diversity and community structure, thereby modifying ecosystem processes. This is particularly true for litter decomposition, an essential process in the biogeochemical cycles of carbon and nutrients. In this study, we asked whether changes in functional traits of living leaves in response to changes in land use and climate were related to rates of litter potential decomposition, hereafter denoted litter decomposability, across a range of 10 contrasting sites. To disentangle the different control factors on litter decomposition, we conducted a microcosm experiment to determine the decomposability under standard conditions of litters collected in herbaceous communities from Europe and Israel. We tested how environmental factors (disturbance and climate) affected functional traits of living leaves and how these traits then modified litter quality and subsequent litter decomposability. Litter decomposability appeared proximately linked to initial litter quality, with particularly clear negative correlations with lignin-dependent indices (litter lignin concentr tion, lignin:nitrogen ratio, and fiber component). Litter quality was directly related to community-weighted mean traits. Lignin-dependent indices of litter quality were positively correlated with community-weighted mean leaf dry matter content (LDMC), and negatively correlated with community-weighted mean leaf nitrogen concentration (LNC). Consequently, litter decomposability was correlated negatively with community-weighted mean LDMC, and positively with community-weighted mean LNC. Environmental factors (disturbance and climate) influenced community-weighted mean traits. Plant communities experiencing less frequent or less intense disturbance exhibited higher community-weighted mean LDMC, and therefore higher litter lignin content and slower litter decomposability. LDMC therefore appears as a powerful marker of both changes in land use and of the pace of nutrient cycling across 10 contrasting sites.

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Freedman ZB, Upchurch RA, Zak DR, Cline LC (2016). Anthropogenic N deposition slows decay by favoring bacterial metabolism: Insights from metagenomic analyses.Frontiers in Microbiology, 7, 259.

DOI:10.3389/fmicb.2016.00259 PMID:26973633 URL

Litter decomposition is an enzymatically-complex process that is mediated by a diverse assemblage of saprophytic microorganisms. It is a globally important biogeochemical process that can be suppressed by anthropogenic N deposition. In a northern hardwood forest ecosystem located in Michigan, USA, 20 years of experimentally increased atmospheric N deposition has reduced forest floor decay and increased soil C storage. Here, we paired extracellular enzyme assays with shotgun metagenomics to assess if anthropogenic N deposition has altered the functional potential of microbial communities inhabiting decaying forest floor. Experimental N deposition significantly reduced the activity of extracellular enzymes mediating plant cell wall decay, which occurred concurrently with changes in the relative abundance of metagenomic functional

gene pathways mediating the metabolism of carbohydrates, aromatic compounds, as well as microbial respiration. Moreover, experimental N deposition increased the relative abundance of 50 of the 60 gene pathways, the majority of which were associated with saprotrophic bacteria. Conversely, the relative abundance and composition of fungal genes mediating the metabolism of plant litter was not affected by experimental N deposition. Future rates of atmospheric N deposition have favored saprotrophic soil bacteria, whereas the metabolic potential of saprotrophic fungi appears resilient to this agent of environmental change. Results presented here provide evidence that changes in the functional capacity of saprotrophic soil microorganisms mediate how anthropogenic N deposition increases C storage in soil.
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Freschet GT, Cornwell WK, Wardle DA, Elumeeva TG, Jackson BG, Onipchenko VG, Soudzilovskaia NA, Tao J, Cornelissen JHC (2013). Linking litter decomposition of above- and below-ground organs to plant-soil feedbacks worldwide.Journal of Ecology, 101, 943-952.
DOI:10.1111/1365-2745.12092 URL
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Frey SD, Knorr M, Parrent JL (2004). Chronic nitrogen enrichment affects the structure and function of the soil microbial community in temperate hardwood and pine forests.Forest Ecology and Management, 196, 159-171.
DOI:10.1016/j.foreco.2004.03.018 URL
We examined how chronic nitrogen (N) enrichment of pine and hardwood forest stands has affected the relative abundance, functional capacity, and activity of soil bacteria and fungi. During Fall 2002 we collected one soil core (5.602cm diameter; organic horizon plus 1002cm of mineral soil) from each of four ja:math 02m subplots within the control, low N (502g02N02m 612 per year), and high N (1502g02N02m 612 per year) plots in both the hardwood and pine stands at the Chronic Nitrogen Amendment Study at Harvard Forest. The samples were analyzed for total and active bacterial and fungal biomass, microbial catabolic response profiles, the activities of cellulolytic and ligninolytic enzymes, and total, labile and microbially derived organic carbon (C). Live, fine roots were also collected from the control and low N pine plots and analyzed for ectomycorrhizal fungal community composition and diversity. Active fungal biomass was 27–61% and 42–69% lower in the fertilized compared to control plots in the hardwood and pine stands, respectively. Active bacterial biomass was not greatly affected by N additions, resulting in significantly lower fungal:bacterial biomass ratios in the N-treated plots. This shift in microbial community composition was accompanied by a significant reduction in the activity of phenol oxidase, a lignin-degrading enzyme produced by white-rot fungi. In the pine stand, ectomycorrhizal fungal community diversity was lower in the low N-treated plot than in the control plot. Differences in ectomycorrhizal community structure were also detected between control and fertilized pine plots, including a reduction in those species with the highest relative frequencies in the control community. Finally, N enrichment altered the pattern of microbial substrate use, with the relative response to the addition of carboxylic acids and carbohydrates being significantly lower in the N-

treated plots, even after the data were normalized to account for differences in microbial biomass. These patterns are consistent with lower decomposition rates and altered N cycling observed previously at this site.
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Galloway JN, Dentener FJ, Capone DG, Boyer EW, Howarth RW, Seitzinger SP, Asner GP, Cleveland CC, Green PA, Holland EA, Karl DM, Michaels AF, Porter JH, Townsend AR, Vöosmarty CJ (2004). Nitrogen cycles: Past, present, and future.Biogeochemistry, 70, 153-226.
DOI:10.1007/s10533-004-0370-0 URL
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Gandois L, Perrin AS, Probst A (2011). Impact of nitrogenous fertiliser-induced proton release on cultivated soils with contrasting carbonate contents: A column experiment.Geochimica et Cosmochimica Acta, 75, 1175-1198.
DOI:10.1016/j.gca.2010.11.025 URL
An experimental study was carried out in order to evaluate the impact of nitrogen fertiliser-induced acidification in carbonated soils. Undisturbed soil columns containing different carbonate content were sampled in the field. Fertiliser spreading was simulated by NH 4Cl addition on top of the soil column. Soil solution composition (mainly nitrate and base cations) was studied at the soil column base. Nitrification occurred to a different extent depending on soil type. Higher nitrification rates were observed in calcareous soils. In all the soil types, strong correlations between leached base cation and nitrate concentrations were observed. Regression coefficients between base cations, nitrate and chloride were used to determine the dominant processes occurring following NH 4Cl spreading. In non-carbonated soils, nitrogen nitrification induced base cation leaching and soil acidification. In carbonated soils, no change of soil pH was observed. However, fertilisers induced a huge cation leaching. Carbonate mineral weathering led to the release of base cations, which replenished the soil exchangeable complex. Carbonated mineral weathering buffered acidification. Since direct weathering might have occurred without atmospheric CO 2 consumption, the use of nitrogen fertiliser on carbonated soil induces a change in the cation and carbon budgets. When the results of these experiments are extrapolated on a global scale to the surface of fertilised areas lying on carbonate, carbonated reactions with N fertilisers would imply an additional flux of 5.7 10 12 mol yr 1 of Ca + Mg. The modifications of weathering reactions in cultivated catchments and the ability of nitrogen fertilisers to significantly modify the CO 2 budget should be included in carbon global cycle assessment.
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Gao YH, Ma G, Zeng XY, Xu SQ, Wang DW (2015). Responses of microbial respiration to nitrogen addition in two alpine soils in the Qinghai-Tibetan Plateau.Journal of Environmental Biology, 36, 261-265.
PMID:26536802 URL
Abstract An incubation experiment was conducted to examine the effects of nitrogen (N) application on microbial respiration in alpine meadow and alpine shrub soils from

eastern of Qinghai-Tibetan Plateau. Four different levels of nitrogen fertilization were selected in this study: control (CK, 0 mg N g(-1)), low (LN, 0.04 mg N g(-1)), medium (MN, 0.16 mg N g(-1)), high (HN, 0.4 mg N g(-1)). The results showed that microbial respiration was higher in alpine shrub than in alpine meadow soil, regardless of the rate of N application. Total microbial respiration overthe course of incubation period decreased in both soils with HN and MN treatments relative to control, but no significant differences were observed in soils with LN treatments. There was significantly positive correlation between total microbial respiration and dissolved organic carbon concentration in both soils. The results indicated that DOC may be a useful indicator of microbial respiration rate in alpine soils and the increasing N inputs could drive a negative feedback to global warming effects of carbon dioxide emitted to the atmosphere in alpine soils.

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Gartner TB, Cardon ZG (2004). Decomposition dynamics in mixed-species leaf litter.Oikos, 104, 230-246.

DOI:10.1111/oik.2004.104.issue-2 URL

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Gergócs V, Hufnagel L (2016). The effect of microarthropods on litter decomposition depends on litter quality.European Journal of Soil Biology, 75, 24-30.

DOI:10.1016/j.ejsobi.2016.04.008 URL

Many studies have investigated whether microbiota has been adapted to decompose a given litter type but we have limited information about the specific role of microarthropods in litter decaying processes. This experiment studied functional redundancy of microarthropods in a litter decomposition system by interchanging mesofauna among three different litter types. The study hypothesized that total microarthropod densities would be lower in foreign litter type than in original (‘home’) litter; and litter with foreign mesofauna would decompose slower than with native one. Scotch pine (Pinus sylvestris), Turkey oak (Quercus cerris) and black locust (Robinia pseudoacacia) litter were stored in microcosms with original microbiota. Microarthropods from the same (‘home’) or different (‘foreign’) type of litter were inoculated to microcosms. Litter mass loss and total density of collembolans, oribatid and other mites were recorded at the end of incubation (3 and 12 months). Litter quality determined total density of microarthropods irrespective of the origin of animals. Litter mass loss values differed in the three litter types. For pine litter, the origin of microarthropods had significant effects on litter mass loss. In oak litter, mainly microarthropod density influenced decomposition. Neither the origin nor the density of animals influenced the decomposition rate of black locust litter. Litter quality may have determined the different patterns of decaying. Mesofauna may enhance litter decomposition stronger in recalcitrant litter than in high-quality litter.

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Gessner MO, Swan CM, Dang CK, McKie BG, Bardgett RD, Wall DH, Hättenschwiler S (2010). Diversity meetsdecomposition.Trends in Ecology and Evolution, 25, 372-380.

DOI:10.1016/j.tree.2010.01.010 URL

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Giese M, Gao YZ, Zhao Y, Pan QM, Lin S, Peth S, Brueck H (2009). Effects of grazing and rainfall variability on root and shoot decomposition in a semi-arid grassland.Applied Soil Ecology, 41, 8-18.

DOI:10.1016/j.apsoil.2008.08.002 URL

Overgrazing increasingly affects large areas of Inner Mongolian semi-arid grasslands. Consequences for ecosystem functions and, in particular, for the decomposition as a key process of ecosystem carbon (C) and nitrogen (N) cycling are still unclear. We studied the effects of grazing on shoot and root decomposition with the litter bag method in a long-term grazing exclosure (UG79), a moderate winter grazed (WG) and a long-term heavily grazed site (HG). We separated the effects of local environmental factors and litter quality as altered by grazing. Growing seasons of average and very low precipitation allowed us to study the effect of inter annual rainfall variability on decomposition. Grazing-induced differences in environmental factors of the three studied grassland sites had no effect on decay rates of shoot and root dry mass. Also differences in litter quality among the grazing sites were not reflected by root decomposition dynamics. The accelerated shoot decay at site HG could not clearly be linked to litter quality parameters. Shoot decay rates were more or less constant, even under very dry conditions. This indicates the possibility of photodegradation (solar UV-B radiation) to control aboveground decomposition in this semi-arid ecosystem. By selecting the best predictors of root decomposition from regression analysis, we found that soil water content was the best parameter explaining the dynamics. Net N immobilization was generally not detected during the decay process of shoot and root. It is likely, when root decomposition is strongly reduced in dry periods, shoot decomposition becomes relatively more important for nutrient cycling. A separate analysis of shoot and root decay dynamics is required in order to describe C and N cycling in this semi-arid grassland. The grazing impact on C and N fluxes through decomposition of plant material likely exhibits a strong interaction with seasonal rainfall pattern.

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Gliksman D, Rey A, Seligmann R (2016). Biotic degradation at night, abiotic degradation at day: Positive feedbacks on litter decomposition in drylands.Global Change Biology, 23, 1564-1574.

DOI:10.1111/gcb.13465 PMID:27520482 URL

Abstract The arid and semi-arid drylands of the world are increasingly recognized for their role in the terrestrial net carbon dioxide (CO_2) uptake, which depends largely on plant litter decomposition and the subsequent release of CO_2 back to the atmosphere. Observed decomposition rates in drylands are higher than predictions by biogeochemical models, which are traditionally based on microbial (biotic) degradation enabled by precipitation as the main mechanism of litter decomposition. Consequently, recent research in drylands has focused on abiotic mechanisms, mainly photochemical and thermal degradation, but they only partly explain litter decomposition under dry conditions, suggesting the operation of an additional mechanism. Here we show that in the absence of precipitation, absorption of dew and water vapor by litter in the field enables microbial degradation at night. By experimentally manipulating solar irradiance and nighttime air humidity, we estimated that most of the litter CO_2 efflux and decay

occurring in the dry season was due to nighttime microbial degradation, with considerable additional contributions from photochemical and thermal degradation during the daytime. In a complementary study, at three sites across the Mediterranean Basin, litter CO 2 efflux was largely explained by litter moisture driving microbial degradation and ultraviolet radiation driving photodegradation. We further observed mutual enhancement of microbial activity and photodegradation at a daily scale. Identifying the interplay of decay mechanisms enhances our understanding of carbon turnover in drylands, which should improve the predictions of the long-term trend of global carbon sequestration. 2016 John Wiley & Sons Ltd.
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Gough L, Osenberg CW, Gross KL, Collins SL (2000). Fertilization effects on species density and primary productivity in herbaceous plant communities.Oikos, 89, 428-439.
DOI:10.1034/j.1600-0706.2000.890302.x URL
Fertilization experiments in plant communities are often interpreted in the context of a hump-shaped relationship between species richness and productivity. We analyze results of fertilization experiments from seven terrestrial plant communities representing a productivity gradient (arctic and alpine tundra, two old-field habitats, desert, short- and tall-grass prairie) to determine if the response of species richness to experimentally increased productivity is consistent with the hump-shaped curve. In this analysis, we compared ratios of the mean response in nitrogen-fertilized plots to the mean in control plots for aboveground net primary productivity (ANPP) and species density (D ; number of species per plot of fixed unit area). In general, ANPP increased and plant species density decreased following nitrogen addition, although considerable variation characterized the magnitude of response. We also analyzed a subset of the data limited to the longest running studies at each site (4 yr), and found that adding 9 to 13 g N m 2 yr 1 (the consistent amount used at all sites) increased ANPP in all communities by approximately 50% over control levels and reduced species density by approximately 30%. The magnitude of response of ANPP and species density to fertilization was independent of initial community productivity. There was as much variation in the magnitude of response among communities within sites as among sites, suggesting community-specific mechanisms of response. Based on these results, we argue that even long-term fertilization experiments are not good predictors of the relationship between species richness and productivity because they are relatively small-scale perturbations whereas the pattern of species richness over natural productivity gradients is influenced by long-term ecological and evolutionary processes.
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Guo D, Fan P (2007). Four hypotheses about the effects of soil nitrogen availability on fine root production and turnover.Journal of Applied Ecology, 18, 2354-2360.
PMID:18163323 URL
With global changes such as increasing temperature and enhanced N deposition,soil nitrogen(N)availability is predicted to increase substantially,and how fine root dynamics responds to the altered soil N has become one of the key questions in terrestrial ecology.As

such,a number of hypotheses have been proposed to explain the relationship between increasing soil N availability and fine root production,mortality,and turnover.This article considered four major hypotheses:with increasing soil N availability,1)both fine root production and turnover rate would increase,2)both fine root production and turnover rate would decrease,3)fine root production would decrease while fine root turnover rate would increase,and 4)fine root production would increase while fine root turnover rate would decrease.Current evidence suggests that the patterns depicted in hypothesis 1)and 2)could both occur in nature and may reflect characteristics of different species.Hypotheses 3)and 4)were thought to characterize only a transient stage of the responses of fine root dynamics to increasing N availability.To better understand the response of root dynamics to increasing soil N,future studies should consider:1)the definition of fine roots and heterogeneity in fine root structure and function;2)methods used in estimating fine root production and turnover rate;3)changes of soil N availability both in space and time.More attention should also be paid to the influences of mycorrhizal infection on root dynamic responses to soil N availability.
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Gracia-Palacios P, Maestre FT, Kattge J, Wall DH (2013). Climate and litter quality differently modulate the effects of soil fauna on litter decomposition across biomes.Ecology Letters, 16, 1045-1053.
DOI:10.1111/ele.12137 PMID:23763716 URL
Climate and litter quality have been identified as major drivers of litter decomposition at large spatial scales. However, the role played by soil fauna remains largely unknown, despite its importance for litter fragmentation and microbial activity. We synthesised litterbag studies to quantify the effect sizes of soil fauna on litter decomposition rates at the global and biome scales, and to assess how climate, litter quality and soil fauna interact to determine such rates. Soil fauna consistently enhanced litter decomposition at both global and biome scales (average increment ~ 37%). [corrected]. However, climate and litter quality differently modulated the effects of soil fauna on decomposition rates between biomes, from climate-driven biomes to those where climate effects were mediated by changes in litter quality. Our results advocate for the inclusion of biome-specific soil fauna effects on litter decomposition as a mean to reduce the unexplained variation in large-scale decomposition models.
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Güsewell S, Gessner MO (2009). N:P ratios influence litter decomposition and colonization by fungi and bacteria in microcosms.Functional Ecology, 23, 211-219.
DOI:10.1111/j.1365-2435.2008.01478.x URL
Summary 1 Nitrogen and phosphorus supply influences the rate of litter decomposition and nutrient dynamics during decomposition. Besides the total amount of N and P available to decomposers, their relative supply (N:P ratio) might be important, e.g. through an influence on the composition and activity of microbial communities. 2 We carried out two experiments using laboratory microcosms to test that (i) N:P ratios (in either litter or the environment) determine whether N or P limits the rate of decomposition, (ii) the ‘critical’ N:P ratio between N and P limitation depends on overall

nutrient availability, (iii) litter colonization by fungi and bacteria depends on the N:P ratio, and (iv) N:P ratios determine if proportionately more N or P is retained or immobilized by the litter. 3 In one experiment, cellulose as a nutrient-free litter analogue was incubated on sand fertilized with varying N:P supply ratios, whereas in a second experiment, Carex leaf litter with varying N:P ratios was incubated on nutrient-free sand. 4 Results essentially support our hypotheses. Cellulose decomposition was N- or P-limited depending on the N:P supply ratio. The shift from N to P limitation occurred at N:P supply ratios of 1·7–45, depending on overall nutrient supply. Bacteria were most abundant on cellulose at low N:P supply ratios, when decomposition was N-limited, while fungi were relatively more important at high N:P ratios, when decomposition was P-limited. The amounts of mineral N and P immobilized on cellulose and those released from litter, both in absolute terms and relative to supply, depended on the type of nutrient limitation (N vs. P). 5 The N:P ratio of nutrients available to decomposers appears to be an important determinant of plant litter decomposition, the relative importance of fungi and bacteria in litter-associated microbial communities, and litter nutrient dynamics.

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Hättenschwiler S, Vitousek PM (2000). The role of polyphenols in terrestrial ecosystem nutrient cycling.Trends in Ecology & Evolution, 15, 238.

DOI:10.1016/S0169-5347(00)01861-9 PMID:10802549 URL

Interspecific variation in polyphenol production by plants has been interpreted in terms of defense against herbivores. Several recent lines of evidence suggest that polyphenols also influence the pools and fluxes of inorganic and organic soil nutrients. Such effects could have far-ranging consequences for nutrient competition among and between plants and microbes, and for ecosystem nutrient cycling and retention. The significance of polyphenols for nutrient cycling and plant productivity is still uncertain, but it could provide an alternative or complementary explanation for the variability in polyphenol production by plants.

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Hautier Y, Niklaus PA, Hector A (2009). Competition for light causes plant biodiversity loss after eutrophication.Science, 324, 636-638.

DOI:10.1126/science.1169640 URL

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Haynes AG, Schütz M, Buchmann N, Page-Dumroese DS, Busse MD, Risch AC (2014). Linkages between grazing history and herbivore exclusion on decomposition rates in mineral soils of subalpine grasslands.Plant and Soil, 374, 579-591.

DOI:10.1007/s11104-013-1905-8 URL

Herbivore-driven changes to soil properties can influence the decomposition rate of organic material and therefore soil carbon cycling within grassland ecosystems. We investigated how aboveground fora

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He JS, Han XG (2010). Ecological stoichiometry: Searching for unifying principles from individuals to ecosystems.Chinese Journal of Plant Ecology, 34, 2-6.(in Chinese with

English abstract)
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He KJ, Qi Y, Huang YM, Chen HY, Sheng ZL, Xu Xia, Duan L (2016). Response of aboveground biomass and diversity to nitrogen addition—A five-year experiment in semi-arid grassland of Inner Mongolia, China.Scientific Reports, 6. 31919. doi: 10.1038/srep31919.
DOI:10.1038/srep31919 PMID:27573360 URL
Understanding the response of the plant community to increasing nitrogen (N) deposition is helpful for improving pasture management in semi-arid areas. We implemented a 5-year N addition experiment in aStipa kryloviisteppe of Inner Mongolia, northern China. The aboveground biomass (AGB) and species richness were measured annually. Along with the N addition levels, the species richness declined significantly, and the species composition changed noticeably. However, the total AGB did not exhibit a noticeable increase. We found that compensatory effects of the AGB occurred not only between the grasses and the forbs but also among Gramineae species. The plant responses to N addition, from the community to species level, lessened in dry years compared to wet or normal years. The N addition intensified the reduction of community productivity in dry years. Our study indicated that the compensatory effects of the AGB among the species sustained the stability of grassland productivity. However, biodiversity loss resulting from increasing N deposition might lead the semi-arid grassland ecosystem to be unsustainable, especially in dry years.
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Hedwall PO, Nordin A, Strengbom J, Brunet J, Olsson B (2013). Does background nitrogen deposition affect the response of boreal vegetation to fertilization?Oecologia, 173, 615-624.
DOI:10.1007/s00442-013-2638-3 PMID:23504175 URL
Forest floor vegetation is an important component of forest biodiversity, and numerous studies have shown that N input alters the vegetation. In some cases, however, the effects of experimental N addition have been small or absent. Two alternative hypotheses have been suggested: (a) competition from the tree layer confounds the response to N, or (b) N response in areas with high background deposition is limited by N saturation. Neither of these hypotheses has so far been explicitly tested. Here, we compile data on forest floor vegetation from N addition experiments, in which the forest had been clear-cut, along an N deposition gradient ranging from 4 to 16 kg ha(-1) year(-1) in Sweden. We analyzed the effects of N addition and its interaction with N deposition on common species and thereby tested the second hypothesis in an environment without the confounding effects of the tree layer. The results show that the effects of the experimental N addition are significantly influenced by background N deposition: the N addition effects are smaller in areas with high N deposition than in areas with low N deposition, despite the fact that the highest N deposition in this study can be considered moderate from an international perspective. The results are important when assessing the reliability of results from N addition experiments on forest floor vegetation in areas with moderate to high background N deposition. We conclude that the interacting effects of N addition and N deposition

need to be included when assessing long-term N sensitivity of plant communities.
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Henry H, Cleland EE, Field CB, Vitousek PM (2005). Interactive effects of elevated CO_2, N deposition and climate change on plant litter quality in a California annual grassland.Oecologia, 142, 465-473.

DOI:10.1007/s00442-004-1713-1 PMID:15558326 URL

Although global changes can alter ecosystem nutrient dynamics indirectly as a result of their effects on plant litter quality, the interactive effects of global changes on plant litter remain largely unexplored in natural communities. We investigated the effects of elevated CO2, N deposition, warming and increased precipitation on the composition of organic compounds in plant litter in a fully-factorial experiment conducted in a California annual grassland. While lignin increased within functional groups under elevated CO2, this effect was attenuated by warming in grasses and by water additions in forbs. CO2-induced increases in lignin within functional groups also were counteracted by an increase in the relative biomass of forbs, which contained less lignin than grasses. Consequently, there was no net change in the overall lignin content of senesced tissue at the plot level under elevated CO2. Nitrate additions increased N in both grass and forb litter, although this effect was attenuated by water additions. Relative to changes in N within functional groups, changes in functional group dominance had a minor effect on overall litter N at the plot level. Nitrate additions had the strongest effect on decomposition, increasing lignin losses from Avena litter and interacting with water additions to increase decomposition of litter of other grasses. Increases in lignin that resulted from elevated CO2 had no effect on decomposition but elevated CO2 increased N losses from Avena litter. Overall, the interactions among elements of global change were as important as single-factor effects in influencing plant litter chemistry. However, with the exception of variation in N, litter quality had little influence on decomposition over the short term.
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Henry HAL, Moise ERD (2015). Grass litter responses to warming and N addition: Temporal variation in the contributions of litter quality and environmental effects to decomposition.Plant and Soil, 389, 35-43.

DOI:10.1007/s11104-014-2346-8 URL

Aims We explored how climate warming and increased atmospheric nitrogen (N) deposition may influence grass litter decomposition over time, how litter quality versus environmental effects contribute to these responses, and the importance of these responses over winter. Methods We used litter bags to examine decomposition over 2 years in a warming and N addition field experiment, and examined the contributions of litter quality and environment to these responses by transferring litter reciprocally between the treatment plots and a common garden. Results Warming increased mass loss over the first year for Bromus inermis litter, which was consistent with the litter quality response, but by the second year there was no overall warming effect, and this change coincided with a negative environmental effect of warming. N addition increased mass loss and was more influential than warming in the early stages of Poa pratensis litter decomposition; the N effect appeared to be driven primarily by litter quality. Winter decomposition was not a substantial component of the treatment responses. Conclusions Our results indicate that litter quality and environmental effects play different roles at different time scales in the decomposition responses of grass litter to warming and N addition, and these responses can be species specific.

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Hessen DO, Agren GI, Anderson TR, Elser JJ, de Ruiter PC (2004). Carbon sequestration in ecosystems: The role of stoichiometry.Ecology, 85, 1179-1192.

DOI:10.1890/02-0251 URL

The fate of carbon (C) in organisms, food webs, and ecosystems is to a major extent regulated by mass-balance principles and the availability of other key nutrient elements. In relative terms, nutrient limitation implies excess C, yet the fate of this C may be quite different in autotrophs and heterotrophs. For autotrophs nutrient limitation means less fixation of inorganic C or excretion of organic C, while for heterotrophs nutrient limitation means that more of ingested C will "go to waste" in the form of egestion or respiration. There is in general a mismatch between autotrophs and decomposers that have flexible but generally high C:element ratios, and consumers that have lower C:element ratios and tighter stoichiometric regulation. Thus, C-use efficiency in food webs may be governed by the element ratios in autotroph biomass and tend to increase when C:element ratios in food approach those of consumers. This tendency has a strong bearing on the sequestration of C in ecosystems, since more C will be diverted to detritus entering soils or sediments when C-use efficiency is low due to stoichiometric imbalance. There will be a strong evolutionary pressure to utilize such excess C for structural and metabolic purposes. This article explores how these basic principles may regulate C sequestration on different scales in aquatic and terrestrial ecosystems.

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Hobbie SE (2008). Nitrogen effects on decomposition: A five- year experiment in eight temperate sites.Ecology, 89, 2633-2644.

DOI:10.1890/07-1119.1 PMID:18831184 URL

Abstract The influence of inorganic nitrogen (N) inputs on decomposition is poorly understood. Some prior studies suggest that N may reduce the decomposition of substrates with high concentrations of lignin via inhibitory effects on the activity of lignin-degrading enzymes, although such inhibition has not always been demonstrated. I studied the effects of N addition on decomposition of seven substrates ranging in initial lignin concentrations (from 7.4% to 25.6%) over five years in eight different grassland and forest sites in central Minnesota, USA. I predicted that N would stimulate the decomposition of lignin-poor substrates but retard the decomposition of lignin-rich substrates. Across these sites, N had neutral or negative effects on decomposition rates. However, in contrast to my hypothesis, effects of N on decomposition were independent of substrate initial lignin concentrations, and decomposition of the lignin fraction was unaffected by N fertilization. Rather, substrate-site combinations that exhibited more rapid decomposition rates in the control treatment were affected more negatively by addition of N fertilization. Taken together, these results suggest that decreased

decomposition with added N did not result from inhibition of lignin-degrading enzyme activity, but may have resulted from abiotic interactions between N fertilizer and products of microbial degradation or synthesis or from N effects on the decomposer community. Low initial substrate N concentrations and N fertilization both stimulated N immobilization, but the differences among substrates were generally much larger than the effects of fertilization. This study suggests that atmospheric N addition could stimulate ecosystem carbon sequestration in some ecosystems as a result of reduced rates of forest floor decomposition.

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Hobbie SE, Eddy WC, Buyarski CR, Adair EC, Ogdahl ML, Weisenhorn P (2012). Response of decomposing litter and its microbial community to multiple forms of nitrogen enrichment.Ecological Monographs, 82, 389-405.

DOI:10.2307/41739376 URL

Despite the importance of litter decomposition for ecosystem fertility and carbon balance, key uncertainties remain about how this fundamental process is affected by nitrogen (N) availability. Resolving such uncertainties is critical for predicting the ecosystem consequences of increased anthropogenic N deposition. Toward that end, we decomposed green leaves and senesced litter of northern pin oak (Quercus ellipsoidalis) in three forested stands dominated by northern pin oak or white pine (Pinus strobus) to compare effects of substrate N (as it differed between leaves and litter) and externally supplied N (inorganic or organic forms) on decomposition and decomposer community structure and function over four years. Asymptotic decomposition models fit the data equally well as single exponential models and allowed us to compare effects of N on both the initial decomposition rate (k a) and the level of asymptotic mass remaining (A, proportion of mass remaining at which decomposition approaches zero, i.e., the fraction of slowly decomposing litter). In all sites, both substrate N and externally supplied N (regardless of form) accelerated the initial decomposition rate. Faster initial decomposition rates corresponded to higher activity of polysaccharide-degrading enzymes associated with externally supplied N and greater relative abundances of Gram-negative and Gram-positive bacteria associated with green leaves and externally supplied organic N (assessed using phospholipid fatty acid analysis, PLFA). By contrast, later in decomposition, externally supplied N slowed decomposition, increasing the fraction of slowly decomposing litter (A) and reducing lignin-degrading enzyme activity and relative abundances of Gram-negative and Gram-positive bacteria. Higher-N green leaves, on the other hand, had lower levels of A (a smaller slow fraction) than lower-N litter. Contrasting effects of substrate and externally supplied N during later stages of decomposition likely occurred because higher-N leaves also had considerably lower lignin, causing them to decompose more quickly throughout decomposition. In conclusion, elevated atmospheric N deposition in forest ecosystems may have contrasting effects on the dynamics of different soil carbon pools, decreasing mean residence times of active fractions in fresh litter (which would be further reduced if deposition increased litter N concentrations), while increasing those of more slowly decomposing fractions, including more processed litter.

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Hogberg MN, Briones MJ, Keel SG, Metcalfe DB, Campbell C, Midwood AJ, Thornton B, Hurry V, Linder S, Näsholm T, Högberg P (2010). Quantification of effects of season and nitrogen supply on tree below-ground carbon transfer to ectomycorrhizal fungi and other soil organisms in a boreal pine forest.New Phytologist, 187, 485-493. doi: 10.1111/j.1469-8137.2010.03274.x.

DOI:10.1111/j.1469-8137.2010.03274.x PMID:20456043 URL

Abstract SUMMARY: *The flux of carbon from tree photosynthesis through roots to ectomycorrhizal (ECM) fungi and other soil organisms is assumed to vary with season and with edaphic factors such as nitrogen availability, but these effects have not been quantified directly in the field. *To address this deficiency, we conducted high temporal-resolution tracing of (13)C from canopy photosynthesis to different groups of soil organisms in a young boreal Pinus sylvestris forest. *There was a 500% higher below-ground allocation of plant C in the late (August) season compared with the early season (June). Labelled C was primarily found in fungal fatty acid biomarkers (and rarely in bacterial biomarkers), and in Collembola, but not in Acari and Enchytraeidae. The production of sporocarps of ECM fungi was totally dependent on allocation of recent photosynthate in the late season. There was no short-term (2 wk) effect of additions of N to the soil, but after 1 yr, there was a 60% reduction of below-ground C allocation to soil biota. *Thus, organisms in forest soils, and their roles in ecosystem functions, appear highly sensitive to plant physiological responses to two major aspects of global change: changes in seasonal weather patterns and N eutrophication.

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Hu ZM, Fan JW, Zhong HP, Han B (2005). Progress on grassland underground biomass researches in China.Chinese Journal of Ecology, 24, 1095-1101.(in Chinese with English abstract)

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IPCC (Intergovernmental Panel on Climate Change) (2007). Climate Change: The Physical Science Basis. Cambridge University Press, Cambridge, UK.

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Jacobson TK, Bustamante MM, Kozovits AR (2010). Diversity of shrub tree layer, leaf litter decomposition and N release in a Brazilian Cerrado under N, P and N plus P additions.Environmental Pollution, 159, 2236-2242.

DOI:10.1016/j.envpol.2010.10.019 PMID:21074919 URL

Abstract This study investigated changes in diversity of shrub-tree layer, leaf decomposition rates, nutrient release and soil NO fluxes of a Brazilian savanna (cerrado sensu stricto) under N, P and N plus P additions. Simultaneous addition of N and P affected density, dominance, richness and diversity patterns more significantly than addition of N or P separately. Leaf litter decomposition rates increased in P and NP plots but did not differ in N plots in comparison to control plots. N addition increased N mass loss, while the combined addition of N and P resulted in an immobilization of N in leaf litter. Soil NO emissions were also higher when N was applied without P. The results indicate that if the availability of P is not increased proportionally to the availability of N, the losses of N are intensified. Copyright 2010 Elsevier Ltd. All rights reserved.

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Jiang XY, Cao LX, Zhang RD, Yan LJ, Mao Y, Yang YW (2014). Effects of nitrogen addition and litter properties on litter decomposition and enzyme activities of individual fungi.Applied Soil Ecology, 80, 108-115.

DOI:10.1016/j.apsoil.2014.04.002 URL

Litter decomposition is an important process of C and N cycling in the soil. Variation in the response of litter decomposition to nitrogen (N) addition (positive, negative or neutral) has been observed in many field studies. However, mechanism about variability in individual fungal species response to N addition has not yet been well demonstrated in the literature. Therefore, the objective of this study was to investigate the effects of N addition and litter chemistry properties on litter decomposition and enzyme activities of individual fungi. Three fungal species (Penicillium , Aspergillus , and Trichoderma) were isolated from a subtropical mixed forest soil. An incubation experiment was conducted using the individual fungi with two types of litter (leaf of Pinus massoniana and needle of Cryptocarya chinensis) and different N addition levels (0, 50 and 100 for N-deficient treatments, and 500 and 1000 g N for N-excessive treatments). Cumulative CO 2 -C, enzyme activities, and lignin and cellulose loss were measured during the incubation period of 60 days. Litter decomposition and enzyme activities significantly varied with the fungal species, while the N addition and litter types greatly affected fungal enzyme activities. The N treatments significantly increased lignin-rich needle decomposition by lignocellulose decomposers (Penicillium and Aspergillus) but did not affect their leaf decomposition. On the contrary, The N treatments stimulated leaf decomposition by cellulolytic species (Trichoderma) but did not affect its needle decomposition. Correlation analysis showed that lignin in the litter was the key component to affect litter decomposition. Activities of N-acetyl- -glucosaminidase and phenol oxidase were both positively correlated to litter decomposition. The fungi (Penicillium and Aspergillus) with higher production of N-acetyl- -glucosaminidase showed higher litter decomposition ability. The low N addition levels stimulated Penicillium and Aspergillus litter decomposition, but they still required more N source (e.g., litter N source) to support decomposition. Depressed fungal litter N uptake (lower N-acetyl- -glucosaminidase activities) only occurred at the highest N addition level. Litter decomposition of Trichoderma depended more on external N and its litter decomposition capability was the lowest among the three species.

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Johansson O, Palmqvist K, Olofsson J (2012). Nitrogen lichen community changes through differential species responses.Global Change Biology, 18, 2626-2635.

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Kai Y, Yang W, Peng C, Peng Y, Zhang C, Huang C, Tan Y, Wu FZ (2016). Foliar litter decomposition in an alpine forest meta-ecosystem on the eastern Tibetan Plateau.

Science of the Total Environment, 566-567, 279-287. doi: 10.1016/j.scitotenv.2016.05.081.
DOI:10.1016/j.scitotenv.2016.05.081 PMID:27220105 URL
Litter decomposition is a biological process fundamental to element cycling and a main nutrient source within forest meta-ecosystems, but few studies have looked into this process simultaneously in individual ecosystems, where environmental factors can vary substantially. A two-year field study conducted in an alpine forest meta-ecosystem with four litter species (i.e., willow: Salix paraplesia , azalea: Rhododendron lapponicum , cypress: Sabina saltuaria , and larch: Larix mastersiana) that varied widely in chemical traits showed that both litter species and ecosystem type (i.e., forest floor, stream and riparian zone) are important factors affecting litter decomposition, and their effects can be moderated by local-scale environmental factors such as temperature and nutrient availability. Litter decomposed fastest in the streams followed by the riparian zone and forest floor regardless of species. For a given litter species, both the k value and limit value varied significantly among ecosystems, indicating that the litter decomposition rate and extent (i.e., reaching a limit value) can be substantially affected by ecosystem type and the local-scale environmental factors. Apart from litter initial acid unhydrolyzable residue (AUR) concentration and its ratio to nitrogen concentration (i.e., AUR/N ratio), the initial nutrient concentrations of phosphorus (P), potassium (K), calcium (Ca), and magnesium (Mg) were also important litter traits that affected decomposition depending on the ecosystem type.
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Kang HZ, Xin ZJ, Berg B, Burgess PJ, Liu QL, Liu ZC (2010). Global pattern of leaf litter nitrogen and phosphorus in woody plants.Annals of Forest Science, 67, 811.
DOI:10.1051/forest/2010047 URL
61 Forest ecosystems exert an important influence on global biogeochemical cycles. A global dataset of nitrogen (N) and phosphorus (P) concentrations in leaf-litter of woody plants was compiled from th
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Keeler BL, Hobbie SE, Kellogg LE (2009). Effects of long-term nitrogen addition on microbial enzyme activity in eight forested and grassland sites: Implications for litter and soil organic matter decomposition.Ecosystems, 12, 1-15.
DOI:10.1007/s10021-008-9199-z URL
Long-term nitrogen (N) addition experiments have found positive, negative, and neutral effects of added N on rates of decomposition. A leading explanation for this variation is differential effects of N on the activity of microbially produced extracellular enzymes involved in decomposition. Specifically, it is hypothesized that adding N to N-limited ecosystems increases activity of cellulose degrading enzymes and decreases that of lignin degrading enzymes, and that shifts in enzyme activity in response to added N explain the decomposition response to N fertilization. We measured litter and soil organic matter (SOM) decomposition and microbial enzyme activity in a long-term N fertilization experiment at eight forested and grassland sites in central Minnesota, USA, to determine (1) variation among sites in enzyme activity, (2) variation in the response of enzymes,

litter decomposition, and soil respiration to added N, and (3) whether changes in enzyme activity in response to added N explained variability among sites in the effect of N on litter and SOM decomposition. Site differences in pH, moisture, soil carbon, and microbial biomass explained much of the among-site variation in enzyme activity. Added N generally stimulated activities of cellulose degrading and N- and phosphorus-acquiring enzymes in litter and soil, but had no effect on lignin degrading enzyme activity. In contrast, added N generally had negative or neutral effects on litter and SOM decomposition in the same sites, with no correspondence between effects of N on enzyme activity and decomposition across sites.
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Knicker H, Ludemann HD, Haider K (1997). Incorporation studies of NH_4+ during incubation of organic residues by ^{15}N-CPMAS-NMR-spectroscopy.European Journal of Soil Science, 48, 431-441.
DOI:10.1111/j.1365-2389.1997.tb00209.x URL
This study focuses on the processes occurring during incorporation of inorganic nitrogen into humic substances. Therefore rye grass, wheat straw, beech saw dust, sulphonated lignin and organosolve lignin were incubated together with highly 15 N-enriched ammonium sulphate in the laboratory for 600 days. Samples from the incubates were periodically analysed for weight loss, and carbon and nitrogen contents. The samples were also analysed by solid-state 13 C- and 15 N-CPMAS-NMR-spectroscopy to follow the turnover of the materials during incubation. Most of the detectable N-signals was assigned to amide - peptide structures. The remaining intensities could be ascribed to free and alkylated amino groups, and those on the low field side of the broad amide-peptide signal to indole, pyrrole and nucleotide derivatives. Abiotic reactions of ammonia with suitable precursors and the formation of pyridine, pyrazine or phenyloxazone derivatives were not observed. Signals from ammonia and nitrate occurred only at the end of the incubation.
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Knorr M, Frey SD, Curtis PS (2008). Nitrogen additions and litter decomposition: A meta-analysis.Ecology, 86, 3252-3257.
DOI:10.1890/05-0150 URL
We conducted a meta-analysis of previously published empirical studies that have examined the effects of nitrogen (N) enrichment on litter decomposition. Our objective was to provide a synthesis of existing data that comprehensively and quantitatively evaluates how environmental and experimental factors interact with N additions to influence litter mass loss. Nitrogen enrichment, when averaged across all studies, had no statistically significant effect on litter decay. However, we observed significant effects of fertilization rate, site-specific ambient N-deposition level, and litter quality. Litter decomposition was inhibited by N additions when fertilization rates were 2-20 times the anthropogenic Ndeposition level, when ambient N deposition was 5-10 kg N· ha-1· yr-1, or when litter quality was low (typically high-lignin litters). Decomposition was stimulated at field sites exposed to low ambient N deposition (<5 kg N· ha-1· yr-1) and for high-quality (low-lignin) litters. Fertilizer type, litterbag mesh size, and climate did not influence the litter decay response to N additions.

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Ladwig LM, Collins SL, Swann AL, Yang X, Allen MF, Allen EB (2012). Above- and belowground responses to nitrogen addition in a chihuahuan desert grassland.Oecologia, 169, 177-185.

DOI:10.1007/s00442-011-2173-z PMID:22042525 URL

Increased available soil nitrogen can increase biomass, lower species richness, alter soil chemistry and modify community structure in herbaceous ecosystems worldwide. Although increased nitrogen availability typically increases aboveground production and decreases species richness in mesic systems, the impacts of nitrogen additions on semiarid ecosystems remain unclear. To determine how a semiarid grassland responds to increased nitrogen availability, we examined plant community structure and above- and belowground net primary production in response to long-term nitrogen addition in a desert grassland in central New Mexico, USA. Plots were fertilized annually (10 g N m 2) since 1995 and NPP measured from 2004 to 2009. Differences in aboveground NPP between fertilized and control treatments occurred in 2004 following a prescribed fire and in 2006 when precipitation was double the long-term average during the summer monsoon. Presumably, nitrogen only became limiting once drought stress was alleviated. Belowground NPP was also related to precipitation, and greatest root growth occurred the year following the wettest summer, decreasing gradually thereafter. Belowground production was unrelated to aboveground production within years and unrelated to nitrogen enrichment. Species richness changed between years in response to seasonal precipitation variability, but was not altered by nitrogen addition. Community structure did respond to nitrogen fertilization primarily through increased abundance of two dominant perennial grasses. These results were contrary to most nitrogen addition studies that find increased biomass and decreased species richness with nitrogen fertilization. Therefore, factors other than nitrogen deposition, such as fire or drought, may play a stronger role in shaping semiarid grassland communities than soil fertility.

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LeBauer DS, Treseder KK (2008). Nitrogen limitation of net primary productivity in terrestrial ecosystems is globally distributed.Ecology, 89, 371-379.

DOI:10.1890/06-2057.1 PMID:18409427 URL

Our meta-analysis of 126 nitrogen addition experiments evaluated nitrogen (N) limitation of net primary production (NPP) in terrestrial ecosystems. We tested the hypothesis that N limitation is widespread among biomes and influenced by geography and climate. We used the response ratio (R ANPPN/ANPPctrl) of aboveground plant growth in fertilized to control plots and found that most ecosystems are nitrogen limited with an average 29% growth response to nitrogen (i.e., R = 1.29). The response ratio was significant within temperate forests (R = 1.19), tropical forests (R = 1.60), temperate grasslands (R = 1.53), tropical grasslands (R = 1.26), wetlands (R = 1.16), and tundra (R = 1.35), but not deserts. Eight tropical forest studies had been conducted on very young volcanic soils in Hawaii, and this subgroup was strongly N limited (R = 2.13), which resulted in a negative correlation between forest R and latitude. The degree of N limitation in the remainder of the tropical forest studies (R = 1.20) was comparable to that of temperate forests, and

when the young Hawaiian subgroup was excluded, forest R did not vary with latitude. Grassland response increased with latitude, but was independent of temperature and precipitation. These results suggest that the global N and C cycles interact strongly and that geography can mediate ecosystem response to N within cerlain biome types.
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Li WY, Yu WC, Bai L, Liu HM, Yang DL (2016). Effects of nitrogen addition on the mixed litter decomposition in Stipa baicalensis steppe in Inner Mongolia.American Journal of Plant Sciences, 7, 547-561.
DOI:10.4236/ajps.2016.73048 URL
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Li YB, Li Q, Yang JJ, Lü XT, Liang WJ, Han XG (2016). Effect of simulated nitrogen deposition on litter quality in a temperate grassland.Chinese Journal of Ecology, 35, 2732-2737.(in Chinese with English abstract)
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Liu J, Peng B, Xia ZW, Sun JF, Gao DC, Dai WW, Jiang P, Bai E (2016). Different fates of deposited NH_4^+ and NO_3^- in a temperate forest in northeast China: A ^{15}N tracer study.Global Change Biology, 23, 2441-2449.
DOI:10.1111/gcb.13533 PMID:27753166 URL
Abstract Increasing atmospheric reactive nitrogen (N) deposition due to human activities could change N cycling in terrestrial ecosystems. However, the differences between the fates of deposited NH 4 + and NO 3 - are still not fully understood. Here we investigated the fates of deposited NH 4 + and NO 3 - respectively via the application of 15 NH 4 NO 3 and NH 4 15 NO 3 in a temperate forest ecosystem. Results showed that at 410 days after tracer application, most 15 NH 4 + was immobilized in litter layer (50 2%), while a considerable amount of 15 NO 3 - penetrated into 0-5 cm mineral soil (42 2%), indicating that litter layer and 0-5 cm mineral soil were the major N sinks of NH 4 + and NO 3 - , respectively. Broad-leaved trees assimilated more 15 N under NH 4 15 NO 3 treatment compared to under 15 NH 4 NO 3 treatment, indicating their preference for NO 3 - -N. At 410 days after tracer application, 16 4% added 15 N was found in aboveground biomass under 15 NO 3 - treatment, which was twice more than that under 15 NH 4 + treatment (6 1%). At the same time, approximately 80% added 15 N was recovered in soil and plants under both treatments, which suggested that this forest had high potential for retention of deposited N. These results provided evidence that there were great differences between the fates of deposited NH 4 + and NO 3 - , which could help us better understand the mechanisms and capability of forest ecosystems as a sink of reactive nitrogen. This article is protected by copyright. All rights reserved. This article is protected by copyright. All rights reserved.
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Liu P, Huang JH, Sun OJ, Han X (2010). Litter decomposition and nutrient release as affected by soil nitrogen availability and litter quality in a semiarid grassland ecosystem.Oecologia, 162, 771-780.
DOI:10.1007/s00442-009-1506-7 PMID:19921269 URL
Nitrogen availability is critically important to litter decomposition, especially in arid and semiarid areas where N is limiting. We studied the relative contributions of litter quality and soil N to litter decomposition of two dominant grassland species, Stipa krylovii and Artemisia frigida, in a semiarid typical steppe ecosystem in Inner Mongolia, China. The study had four different rates of N addition (0, 8, 32, and 64 g N m(-2) year(-1)), and litter samples were decomposed under varying site conditions and by litter types. Litter-mixing effects of the two species were also examined. We found that N addition increased litter N concentration and thus enhanced litter decomposition by improving substrate quality. This increase, however, was offset by the negative effect of increased soil N, resulting in a diminished effect of increased soil N availability on in situ litter decomposition. The positive effects of improved litter quality slightly out-performed the negative effects of increased soil N. Our further analysis revealed that the negative effect of increasing soil N on litter decomposition could be partially explained by reduced soil microbial biomass and activity. Decomposition was significantly faster for litters of a two-species mixture than litters of the single species, but the rate of litter decomposition did not differ much between the two species, suggesting that compositional balance, rather than changes in the dominance between Stipa and Artemisia, is more critical for litter decomposition, hence nutrient cycling in this ecosystem. This semiarid steppe ecosystem may become more conservative in nutrient use with switching of dominance from Artemisia to Stipa with increasing soil N, because Stipa has a slower decomposition rate and a higher nutrient retention rate than Artemisia.
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Liu Q, Peng SL, Bi H, Zhang HY, Ma WH, Li NY (2004). The reciprocal decomposition of foliar litter in tropical and subtropical forests.Acta Scientiarum Naturalium Universitatis Sunyatseni, 43(4), 86-89.(in Chinese with English abstract)
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Liu XJ, Duan L, Mo JM, Du EZ, Shen Jl, Lu XK, Zhang Y, Zhou XB, He C, Zhang FS (2011). Nitrogen deposition and its ecological impact in China: An overview.Environmental Pollution, 159, 2251-2264.
DOI:10.1016/j.envpol.2010.08.002 PMID:20828899 URL

Nitrogen (N) deposition is an important component in the global N cycle that has induced large impacts on the health and services of terrestrial and aquatic ecosystems worldwide. Anthropogenic reactive N (N r) emissions to the atmosphere have increased dramatically in China due to rapid agricultural, industrial and urban development. Therefore increasing N deposition in China and its ecological impacts are of great concern since the 1980s. This paper synthesizes the data from various published papers to assess the status of the anthropogenic N r emissions and N deposition as well as their impacts on different ecosystems, including empirical critical loads for different ecosystems. Research challenges and policy implications on atmospheric N pollution and deposition are also discussed. China urgently needs to establish national networks for N deposition monitoring and cross-site N addition experiments in grasslands, forests and aquatic ecosystems. Critical loads and modeling tools will be further used in N r regulation.
[: 3]
Liu XJ, Zhang Y, Han WX, Tang AH, Shen JL, Cui ZL, Vitousek P, Erisman JW, Goulding K, Christie P, Fangmeier A, Zhang FS (2013). Enhanced nitrogen deposition over China.Nature, 494, 459-462.
DOI:10.1038/nature11917 PMID:23426264 URL
Abstract China is experiencing intense air pollution caused in large part by anthropogenic emissions of reactive nitrogen. These emissions result in the deposition of atmospheric nitrogen (N) in terrestrial and aquatic ecosystems, with implications for human and ecosystem health, greenhouse gas balances and biological diversity. However, information on the magnitude and environmental impact of N deposition in China is limited. Here we use nationwide data sets on bulk N deposition, plant foliar N and crop N uptake (from long-term unfertilized soils) to evaluate N deposition dynamics and their effect on ecosystems across China between 1980 and 2010. We find that the average annual bulk deposition of N increased by approximately 8090009kilograms of nitrogen per hectare (P090009<0900090.001) between the 1980s (13.2090009kilograms of nitrogen per hectare) and the 2000s (21.1090009kilograms of nitrogen per hectare). Nitrogen deposition rates in the industrialized and agriculturally intensified regions of China are as high as the peak levels of deposition in northwestern Europe in the 1980s, before the introduction of mitigation measures. Nitrogen from ammonium (NH4(+)) is the dominant form of N in bulk deposition, but the rate of increase is largest for deposition of N from nitrate (NO3(-)), in agreement with decreased ratios of NH3 to NOx emissions since 1980. We also find that the impact of N deposition on Chinese ecosystems includes significantly increased plant foliar N concentrations in natural and semi-natural (that is, non-agricultural) ecosystems and increased crop N uptake from long-term-unfertilized croplands. China and other economies are facing a continuing challenge to reduce emissions of reactive nitrogen, N deposition and their negative effects on human health and the environment.
[: 1]
Long M, Wu HH, Smith MD, Pierre K, Lü XT, Zhang HY, Han XG, Yu Q (2016). Nitrogen deposition promotes phosphorus uptake of plants in a semi-arid temperate grassland.Plant and Soil, 408, 475-484.
DOI:10.1007/s11104-016-3022-y URL

Nitrogen (N) deposition greatly influences ecosystem processes through the alteration of plant nutrition; however, there is limited understanding about the effects of phosphorus (P) inputs, especially
[: 2]
[, , (2014). . , 27(1), 35-42.]
Lu GC, Shao YR, Xue L (2014). Research progress in the effect of nitrogen deposition on litter decomposition.World Forestry Research, 27(1), 35-42.(in Chinese with English abstract)
[: 1]
Lü XT, Kong DL, Pan QM, Simmons ME, Han XG (2012). Nitrogen and water availability interact to affect leaf stoichiometry in a semi-arid grassland.Oecologia, 168, 301-310.
DOI:10.1007/s00442-011-2097-7 PMID:21826456 URL
The effects of global change factors on the stoichiometric composition of green and senesced plant tissues are critical determinants of ecosystem feedbacks to anthropogenic-driven global change. So far, little is known about species stoichiometric responses to these changes. We conducted a manipulative field experiment with nitrogen (N; 17.5 g m(-2) year(-1)) and water addition (180 mm per growing season) in a temperate steppe of northern China that is potentially highly vulnerable to global change. A unique and important outcome of our study is that water availability modulated plant nutritional and stoichiometric responses to increased N availability. N addition significantly reduced C:N ratios and increased N:P ratios but only under ambient water conditions. Under increased water supply, N addition had no effect on C:N ratios in green and senesced leaves and N:P ratios in senesced leaves, and significantly decreased C:P ratios in both green and senesced leaves and N:P ratios in green leaves. Stoichiometric ratios varied greatly among species. Our results suggest that N and water addition and species identity can affect stoichiometric ratios of both green and senesced tissues through direct and interactive means. Our findings highlight the importance of water availability in modulating stoichiometric responses of plants to potentially increased N availability in semi-arid grasslands.
[: 1]

Lü XT, Reed S, Yu Q, He NP, Wang ZW, Han XG (2013). Convergent responses of nitrogen and phosphorus resorption to nitrogen inputs in a semiarid grassland.Global Change Biology, 19, 2775-2784.
DOI:10.1111/gcb.12235 PMID:23625746 URL
Human activities have significantly altered nitrogen (N) availability in most terrestrial ecosystems, with consequences for community composition and ecosystem functioning. Although studies of how changes in N availability affect biodiversity and community composition are relatively common, much less remains known about the effects of N inputs on the coupled biogeochemical cycling of N and phosphorus (P), and still fewer data exist regarding how increased N inputs affect the internal cycling of these two elements in plants. Nutrient resorption is an important driver of plant nutrient economies and of the quality of litter plants produce. Accordingly, resorption patterns have marked ecological implications for plant population and community fitness, as well as for

ecosystem nutrient cycling. In a semiarid grassland in northern China, we studied the effects of a wide range of N inputs on foliar nutrient resorption of two dominant grasses, Leymus chinensis and Stipa grandis. After 4years of treatments, N and P availability in soil and N and P concentrations in green and senesced grass leaves increased with increasing rates of N addition. Foliar N and P resorption significantly decreased along the N addition gradient, implying a resorption-mediated, positive plant-soil feedback induced by N inputs. Furthermore, N:P resorption ratios were negatively correlated with the rates of N addition, indicating the sensitivity of plant N and P stoichiometry to N inputs. Taken together, the results demonstrate that N additions accelerate ecosystem uptake and turnover of both N and P in the temperate steppe and that N and P cycles are coupled in dynamic ways. The convergence of N and P resorption in response to N inputs emphasizes the importance of nutrient resorption as a pathway by which plants and ecosystems adjust in the face of increasing N availability.
[: 1]

Lummer D, Scheu S, Butenschoen O (2012). Connecting litter quality, microbial community and nitrogen transfer mechanisms in decomposing litter mixtures.Oikos, 121, 1649-1655.
DOI:10.1111/j.1600-0706.2011.20073.x URL
Synergistic effects on decomposition in litter mixtures have been suggested to be due to the transfer of nitrogen from N-rich to N-poor species. However, the dominant pathway and the underlying mechanisms remain to be elucidated. We conducted an experiment to investigate and quantify the control mechanisms for nitrogen transfer between two litter species of contrasting nitrogen status (15N labeled and unlabeled Fagus sylvatica and Fraxinus excelsior) in presence and absence of micro-arthropods. We found that 15N was predominantly transferred actively aboveground by saprotrophic fungi, rather than belowground or passively by leaching. However, litter decomposition remained unaffected by N-dynamics and was poorly affected by micro-arthropods, suggesting that synergistic effects in litter mixtures depend on complex environmental interrelationships. Remarkably, more 15N was transferred from N-poor beech than N-rich ash litter. Moreover, the low transfer of 15N from ash litter was insensitive to destination species whereas the transfer of 15N from labeled beech litter to unlabeled beech was significantly greater than the amount of 15N transferred to unlabeled ash suggesting that processes of nitrogen transfer fundamentally differ between litter species of different nitrogen status. Microbial analyses suggest that nitrogen of N-rich litter is entirely controlled by bacteria that hamper nitrogen capture of microbes in the environment supporting the source-theory. In contrast, nitrogen of N-poor fungal dominated litter is less protected and transferable depending on the nitrogen status and the transfer capacity of the microbial community of the co-occurring litter species supporting the gradient-theory. Thus, our results challenge the traditional view regarding the role of N-rich litter in decomposing litter mixtures. We rather suggest that N-rich litter is only a poor nitrogen source, whereas N-poor litter, can act as an important nitrogen source in litter mixtures. Consequently both absolute and relative differences in initial litter C/N ratios of co-occurring litter

species need to be considered for understanding nitrogen dynamics in decomposing litter mixtures.
[: 1]
Luo QP, Gong JR, Zhai ZW, Pan Y, Liu M, Xu S, Wang YH, Yang LL, Baoyin TT (2016). The responses of soil respiration to nitrogen addition in a temperate grassland in northern China.Science of the Total Environment, 569, 1466-1477.
DOI:10.1016/j.scitotenv.2016.06.237 PMID:27396319 URL
Anthropogenic activities have increased nitrogen (N) inputs to grassland ecosystems. Knowledge of the impact of soil N availability on soil respiration (R S) is critical to understand soil carbon balances and their responses to global climate change. A 2-year field experiment was conducted to evaluate the response of R S to soil mineral N in a temperate grassland in northern China. R S , abiotic and biotic factors, and N mineralization were measured in the grassland, at rates of N addition ranging from 0 to 2502g02N02m 61022 02yr 61021 . Annual and dormant-season R S ranged from 241.34 to 283.6402g C m 61022 and from 61.34 to 83.8402g C m 61022 respectively. High N application significantly increased R S , possibly due to increased root biomass and increased microbial biomass. High N treatment significantly increased soil NO 3 –N and inorganic N content compared with the control. The ratio of NO 3 –N to NH 4 –N and the N mineralization rate were significantly positively correlated with R S , but NH 4 –N was not correlated or negatively correlated with R S during the growing season. The temperature sensitivity of R S (Q 10) was not significantly affected by N levels, and ranged from 1.90 to 2.20, but decreased marginally significantly at high N. R S outside the growing season is an important component of annual R S , accounting for 25.0 to 29.6% of the total. High N application indirectly stimulated R S by increasing soil NO 3 –N and net nitrification, thereby eliminating soil N limitations, promoting ecosystem productivity, and increasing soil CO 2 efflux. Our results show the importance of distinguishing between NO 3 –N and NH 4 –N, as their impact on soil CO 2 efflux differed.
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Makhnev AK, Makhneva NE (2010). Landscape-ecological and population aspects of the strategy of restoration of 443 disturbed lands.Contemporary Problems of Ecology, 3, 318-322.
DOI:10.1134/S1995425510030100 URL
The paper gives short characteristics of the main stages of forming the strategy of restoration of the industrially disturbed lands and their monitoring, along with the examples of its successful use.
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Manning P, Saunders M, Bardgett RD, Bonkowski M, Bradford MA, Ellis RJ, Kandeler E, Marhan S, Tscherko D (2008). Direct and indirect effects of nitrogen deposition on litter decomposition.Soil Biology & Biochemistry, 40, 688-698.
DOI:10.1016/j.soilbio.2007.08.023 URL
Elevated nitrogen (N) deposition can affect litter decomposition directly, by raising soil N availability and the quantity and quality of litter inputs, and indirectly by altering plant community composition. We investigated the importance of these controls on litter

decomposition using litter bags placed in annual herb based microcosm ecosystems that had been subject to two rates of N deposition (which raised soil inorganic N availability and stimulated litter inputs) and two planting regimes, namely the plant species compositions of low and high N deposition environments. In each microcosm, we harvested litter bags of 10 annual plant species, over an 8-week period, to determine mass loss from decomposition. Our data showed that species differed greatly in their decomposability, but that these differences were unlikely to affect decomposition at the ecosystem level because there was no correlation between a species decomposability and its response to N deposition (measured as population seed production under high N, relative to low N, deposition). Litter mass loss was 2% greater in high N deposition microcosms. Using a comprehensive set of measurements of the microcosm soil environments, we found that the most statistically likely explanation for this effect was increased soil enzyme activity (cellobiosidase, -glucosidase and -xylosidase), which appears to have occurred in response to a combination of raised soil inorganic N availability and stimulated litter inputs. Our data indicate that direct effects of N deposition on litter input and soil N availability significantly affected decomposition but indirect effects did not. We argue that indirect effects of changes to plant species composition could be stronger in natural ecosystems, which often contain a greater diversity of plant functional types than those considered here.

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Manzoni S, Trofymow JA, Jackson RB, Porporato A (2010). Stoichiometric controls on carbon, nitrogen, and phosphorus dynamics in decomposing litter.Ecological Monographs, 80, 89-106.
DOI:10.1890/09-0179.1 URL

The mineralization of nitrogen and phosphorus from plant residues provides an important input of inorganic nutrients to the soil, which can be taken up by plants. The dynamics of nutrient mineralization or immobilization during decomposition are controlled by different biological and physical factors. Decomposers sequester carbon and nutrients from organic substrates and exchange inorganic nutrients with the environment to maintain their stoichiometric balance. Additionally, physical losses of organic compounds from leaching and other processes may alter the nutrient content of litter. In this work, we extend a stoichiometric model of litter nitrogen mineralization to include (1) phosphorus mineralization, (2) physical losses of organic nutrients, and (3) chemical heterogeneity of litter substrates. The enhanced model provides analytical mineralization curves for nitrogen and phosphorus as well as critical litter carbon: nutrient ratios (the carbon: nutrient ratios below which net nutrient release occurs) as a function of the elemental composition of the decomposers, their carbon-use efficiency, and the rate of physical loss of organic compounds. The model is used to infer the critical litter carbon: nutrient ratios from observed nitrogen and phosphorus dynamics in about 2600 litterbag samplings from 21 decomposition data sets spanning artic to tropical ecosystems. At the beginning of decomposition, nitrogen and phosphorus tend to be immobilized in boreal and temperate climates (i.e., both C:N and C:P critical ratios are lower than the initial ratios), while in tropical areas nitrogen is generally released and phosphorus may be either

immobilized or released, regardless of the typically low phosphorus concentrations. The critical carbon: nutrient ratios we observed were found to increase with initial litter carbon: nutrient ratios, indicating that decomposers adapt to low-nutrient conditions by reducing their carbon-use efficiency. This stoichiometric control on nutrient dynamics appears ubiquitous across climatic regions and ecosystems, although other biological and physical processes also play important roles in litter decomposition. In tropical humid conditions, we found high critical C:P ratios likely due to high leaching and low decomposer phosphorus concentrations. In general, the compound effects of stoichiometric constraints and physical losses explain most of the variability in critical carbon: nutrient ratios and dynamics of nutrient immobilization and release at the global scale.

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Meentemeyer V (1978). Macroclimate and lignin control of hardwood leaf litter fecomposition dynamics.Ecology, 59, 465-472.

DOI:10.2307/1936576 URL

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Moorhead DL, Sinsabaugh RL (2006). A theoretical model of litter decay and microbial interaction.Ecological Monographs, 76, 151-174.

DOI:10.1890/0012-9615(2006)076[0151:ATMOLD]2.0.CO;2 URL

Despite the central role of microorganisms in the decomposition of dead organic matter, few models have integrated the dynamics of litter chemistry with microbial interactions. Here we propose a functional resolution of the microbial community that parallels the commonly used chemical characterization of plant litter, i.e., a guild of opportunist microorganisms that grows quickly and has high affinity for soluble substrates, a guild of decomposer specialists that grows more slowly and has high affinity for holocellulose substrates, and a guild of miners that grows very slowly and is specialized for degrading lignin. This guild-based decomposition model (GDM) includes the interactions of holocellulose and lignin, manifest as mutual feedback controls on microbial-based activities. It also includes N limitations on early stages of litter decay resulting from nutritional demands of microorganisms and N inhibition on late stages of litter decay resulting from reduced lignin degradation. Competitive interactions between microbial guilds result from different growth rates and substrate affinities, given limits on microbial colonization of litter. Simulations are consistent with commonly reported and proposed patterns of microbial community succession during litter decay, changes in and controls imposed by litter chemistry, and system responses to N availability. Modest impacts of litter chemistry and N effects on patterns of decay can yield substantial impacts on the relative amount of litter remaining through time, the time required to stabilize litter carbon (i.e., as the lignin content approaches similar to 70% of the total litter carbon), the relative contributions of different guilds to decay, and the net amount of microbial production. Moreover, seemingly inconsistent patterns in system responses to N regimes can be explained by interactions between litter chemistry and microbial guilds. A validation exercise demonstrated general correspondence of model behavior to f

[: 2]

Ning QS, Gu Q, Shen JP, Lü XT, Yang JJ, Zhang XM, He JZ, Huang JH, Wang H, Xu ZH, Han XG (2015). Effects of nitrogen deposition rates and frequencies on the abundance of soil nitrogen-related functional genes in temperate grassland of northern China.Journal of Soils and Sediments, 15, 694-704.

DOI:10.1007/s11368-015-1061-2 URL

Microbial processes driving nitrogen (N) cycling are hot topics in terms of increasing N deposition. Abundances of N-related functional genes (NFG) can be most responsive to N deposition and commonly

[: 1]

Niu SL, Liu WX, Wan SQ (2008). Different growth responses of C_3 and C_4 grasses to seasonal water and nitrogen regimes and competition in a pot experiment.Journal of Experimental Botany, 59, 1431-1439.

DOI:10.1093/jxb/ern051 PMID:18356144 URL

Understanding temporal niche separation between C sub(3) and C sub(4) species (e.g. C sub(3) species flourishing in a cool spring and autumn while C sub(4) species being more active in a hot summer) is essential for exploring the mechanism for their co-existence. Two parallel pot experiments were conducted, with one focusing on water and the other on nitrogen (N), to examine growth responses to water or nitrogen (N) seasonality and competition of two co-existing species Leymus chinensis (C sub(3) grass) and Chloris virgata (C sub(4) grass) in a grassland. The two species were planted in either monoculture (two individuals of one species per pot) or a mixture (two individuals including one L. chinensis and one C. virgata per pot) under three different water or N seasonality regimes, i.e. the average model (AM) with water or N evenly distributed over the growing season, the one-peak model (OPM) with more water or N in the summer than in the spring and autumn, and the two-peak model (TPM) with more water or N in the spring and autumn than in the summer. Seasonal water regimes significantly affected biomass in L. chinensis but not in C. virgata, while N seasonality impacted biomass and relative growth rate of both species over the growing season. L. chinensis accumulated more biomass under the AM and TPM than OPM water or N treatments. Final biomass of C. virgata was less impacted by water and N seasonality than that of L. chinensis. Interspecific competition significantly decreased final biomass in L. chinensis but not in C. virgata, suggesting an asymmetric competition between the two species. The magnitude of interspecific competition varied with water and N seasonality. Changes in productivity and competition balance of L. chinensis and C. virgata under shifting seasonal water and N availabilities suggest a contribution of seasonal variability in precipitation and N to the temporal niche separation between C sub(3) and C sub(4) species.

[: 2]

Pan F, Li Y, Chapman SJ, Khan S, Yao H (2016). Microbial utilization of rice straw and its derived biochar in a paddy soil. Science of the Total Environment, 559, 15-23.

DOI:10.1016/j.scitotenv.2016.03.122 PMID:27054490 URL

The application of straw and biochar to soil has received great attention because of their potential benefits such as fertility improvement and carbon (C) sequestration. The abiotic effects of these materials on C and nitrogen (N) cycling in the soil ecosystem have been

previously investigated, however, the effects of straw or its derived biochar on the soil microbial community structure and function are not well understood. For this purpose, a short-term incubation experiment was conducted using 13 C-labeled rice straw and its derived biochar (13 C-labeled biochar) to deepen our understanding about soil microbial community dynamics and function in C sequestration and greenhouse gas emission in the acidic paddy soil amended with these materials. Regarding microbial function, biochar and straw applications increased CO_2 emission in the initial stage of incubation and reached the highest level (0.52 and 3.9602mg02C02kg 61021 02soil02h 61021) at 102d and 302d after incubation, respectively. Straw amendment significantly (p 02<020.01) increased respiration rate, total phospholipid fatty acids (PLFAs) and 13 C-PLFA as compared to biochar amendment and the control. The amount and percent of Gram positive bacteria, fungi and actinomycetes were also significantly (p 02<020.05) higher in 13 C-labeled straw amended soil than the 13 C-labeled biochar amended soil. According to the 13 C data, 23 different PLFAs were derived from straw amended paddy soil, while only 17 PLFAs were derived from biochar amendments. The profile of 13 C-PLFAs derived from straw amendment was significantly (p 02<020.01) different from biochar amendment. The PLFAs0218:1 7c and cy17:0 (indicators of Gram negative bacteria) showed high relative abundances in the biochar amendment, while 10Me18:0, i17:0 and 18:2 6,9c (indicators of actinomycetes, Gram positive bacteria and fungi, respectively) showed high relative abundance in the straw amendments. Our results suggest that the function, size and structure of the microbial community were strongly influenced by the substrate composition and availability.
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Pan QM, Bai YF, Han XG, Yang JC (2005). Effects of nitrogen additions on a Leymus Chinensis population in a typical steppe of Inner Mongolia.Acta Phytoecologica Sinica, 29, 311-317.
DOI:10.17521/cjpe.2005.0040 URL
Leymus chinensis, a rhizomatous graminoid, is a dominant species in the grasslands of northern China. The characteristics of L. chinensis populations have been well documented in many research papers. Because of overgrazing, grasslands of northern China have become degraded since the 1980s. As a result, the density and biomass of L. chinensis populations have decreased significantly. Fertilization is a common technique for management of pastures in many countries; however, it is not widely used in the grasslands of China. Nitrogen is an important driver of community succession in grassland ecosystems, but the response of L. chinensis populations to nitrogen additions in typical steppe, a semiarid area of northern China, remains unclear. We conducted a sequential nitrogen addition experiment in a lightly degraded grassland plot that was fenced in 1999. Nitrogen (NH_4NO_3) was applied on July 5 for two years at application rates of: 0, 1.75, 5.25, 10.5, 17.5, and 28 g N m^{-2} ,respectively. There were 9 replicate 5 m 5 m plots of each of the six treatments with each plot spaced 1 m apart. A completely randomized design was used for this experiment. Before the experiment, soil samples were collected and dry bulk density, pH, soil nitrogen and soil carbon were analyzed. After two years of nitrogen fertilization, we measured the density, height, aboveground biomass and belowground

biomass of L. chinensis in each plot. The results showed that L. chinensis population characteristics were highly responsive to nitrogen additions. With an increase in nitrogen application rates, the density, height, aboveground biomass, belowground biomass and total biomass of L. chinensis increased significantly whereas the ratio of aboveground biomass/belowground biomass decreased. The allocation of biomass among plant parts was significantly affected by nitrogen additions: the proportion of biomass allocated to rhizomes decreased remarkably with increasing nitrogen rates whereas that allocated to leaves and roots increased significantly. The relative biomass and relative density of L. chinensis also increased with increasing nitrogen additions. In summary, adding nitrogen to lightly degraded grassland not only increased the density and biomass of L. chinensis population but changed the resource partitioning among plant parts as well.
[: 1]
Peng Q, Qi YC, Dong YS, He YT, Xiao SS, Liu XC, Sun LJ, Jia JQ, Guo SF, Cao CC (2014). Litter decomposition and C and N dynamics as affected by N additions in a semi- arid temperate steppe, Inner Mongolia of China.Journal of Arid Land, 6, 432-444.
DOI:10.1007/s40333-014-0002-z URL
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Piao SL, Fang JY, Zhou LM, Tan K, Tao S (2007). Changes in biomass carbon stocks in China’s grasslands between 1982 and 1999. Global Biogeochemical Cycles, 21, B2002 (1-10). doi: 10.1029/2005GB002634.
[: 2]
Prescott CE (2010). Litter decomposition: What controls it and how can we alter it to sequester more carbon in forest soils?Biogeochemistry, 101, 133-149.
DOI:10.1007/s10533-010-9439-0 URL
Key recent developments in litter decomposition research are reviewed. Long-term inter-site experiments indicate that temperature and moisture influence early rates of litter decomposition primarily by determining the plants present, suggesting that climate change effects will be small unless they alter the plant forms present. Thresholds may exist at which single factors control decay rate. Litter decomposes faster where the litter type naturally occurs. Elevated CO 2 concentrations have little effect on litter decomposition rates. Plant tissues are not decay-resistant; it is microbial and biochemical transformations of materials into novel recalcitrant compounds rather than selective preservation of recalcitrant compounds that creates stable organic matter. Altering single characteristics of litter will not substantially alter decomposition rates. Nitrogen addition frequently leads to greater stabilization into humus through a combination of chemical reactions and enzyme inhibition. To sequester more C in soil, we need to consider not how to slow decomposition, but rather how to divert more litter into humus through microbial and chemical reactions rather than allowing it to decompose. The optimal strategy is to have litter transformed into humic substances and then chemically or physically protected in mineral soil. Adding N through fertilization and N-fixing plants is a feasible means of stimulating humification.
[: 1]
[, , , , , , , , (2015). . , (2), 625-635.]

Qi YC, Peng Q, Dong YS, Xiao SS, Jia JQ, Guo SF, He YL, Yan ZQ, Wang LQ (2015). Responses of ecosystem carbon budget to increasing nitrogen deposition in differently degraded Leymus chinensis steppes in Inner Mongolia, China.Environment Science, (2), 625-635.(in Chinese with English abstract)
DOI:10.13227/j.hjkX.2015.02.034 URL
2009~2010 , 2 , , 0g·(m2·a)-1(CK) 10 g·(m2·a)-1(MN) 2 , (NPP), (Rs) (NEE) , NEE . , (A),MN (AGB) CK 21.5% 46.8%, (B), 2009 AGB NPP(ANPP), 2010 ; A B (BGB) B NPP(BNPP), 2010 A BNPP; Rs . CK , A MN CK 14.6% 25.7%, B 10.4% 11.3%; A B , ( ) 59.22 g·(m2·a)-1 166.68 g·(m2·a)-1 83.27 g·(m2·a)-1 117.47 g·(m2·a)-1. CK, A 15.79 g·(m2·a)-1 82.94 g·(m2·a)-1, B 74.54 g·(m2·a)-1 101.23 g·(m2·a)-1, .
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Qualls RG, Richardson CJ (2000). Phosphorus enrichment affects litter decomposition, immobilization, and soil microbial phosphorus in wetland mesocosms.Soil Science Society of America Journal, 64, 799-808.
DOI:10.2136/sssaj2000.642799x URL
Areas of the northern Everglades of Florida, USA, have been influenced by P eutrophication. The objective was to determine if P enrichment of water influences the litter decomposition rate and nutrient immobilization by litter and to determine the quantitative relationship of these responses across a range of P concentrations in surface water. In addition, it was determined whether P additions ...
Quested HM, Press MC, Callaghan TV, Cornelissen JHC (2002). The hemiparasitic angiosperm Bartsia alpina has the potential to accelerate decomposition in sub-arctic communities. Oecologia, 130, 88-95.
DOI:10.1007/s004420100780 PMID:28547029 URL
We investigated the hypothesis that hemiparasites accelerate nutrient cycling in nutrient-poor communities. Hemiparasites concentrate nutrients in their leaves, thus potentially producing high quality litter that releases nutrients that would otherwise remain in host tissues or in slowly decomposing plant litter. This hypothesis was tested using species from a European sub-arctic community where root hemiparasites are abundant. The N content of green leaves, and the N, P and C content of leaf litter were measured in seven species of root hemiparasitic Scrophulariaceae, and nine species of commonly co-occurring dwarf shrubs, graminoids and herbs. Fresh leaves of the hemiparasites had greater N concentrations than leaves of dwarf shrubs, graminoids or herbs. This difference was even more marked in litter, with hemiparasite litter containing 1.8 4.1% N, between 1.8 and 8.5 times as much N as in the litter of commonly co-occurring species. Litter of the hemiparasitic plant Bartsia alpina and of three commonly co-occurring dominant species of dwarf shrub was decomposed alone and in two species mixtures, in a laboratory microcosm experiment. Bartsia litter decomposed faster and lost between 5.4 and 10.8 times more N than that of the dwarf shrubs over the 240 days of the experiment. Mixtures of dwarf shrub and hemiparasite litter showed significantly more mass loss and CO 2 release than expected, while nutrient release was the same as or less than expected. It is concluded that hemiparasites have the potential to enhance decomposition and nutrient

cycling in nutrient-poor environments.
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Raich JW, Tufekciogul A (2000). Vegetation and soil respiration: Correlations and controls.Biogeochemistry, 48, 71-90.
DOI:10.1023/A:1006112000616 URL
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Ren ZW, Li Q, Chu CJ, Zhao LQ, Zhang JQ, Ai D, Yang YB, Wang G (2010). Effects of resource additions on species richness and ANPP in an alpine meadow community.Journal of Plant Ecology, 3, 25-31.
DOI:10.1093/jpe/rtp034 URL
[Aims] Theories based on resource additions indicate that plant species richness is mainly determined by the number of limiting resources. However, the individual effects of various limiting resources on species richness and aboveground net primary productivity (ANPP) are less well understood. Here, we analyzed potential linkages between additions of limiting resources, species loss and ANPP increase and further explored the underlying mechanisms. [Methods] Resources (N, P, K and water) were added in a completely randomized block design to alpine meadow plots in the Qinghai-Tibetan Plateau....

Rice EL (1984). Allelopathy. Academic Press, London.
[: 3]
Rousk J, Bååth E, Brookes PC, Lauber CL, Lozupone C, Caporaso JG, Knight R, Fierer N (2010). Soil bacterial and fungal communities across a pH gradient in an arable soil.The ISME Journal, 4, 1340-1351.
DOI:10.1038/ismej.2010.58 PMID:20445636 URL
Soils collected across a long-term liming experiment (pH 4.0-8.3), in which variation in factors other than pH have been minimized, were used to investigate the direct influence of pH on the abundance and composition of the two major soil microbial taxa, fungi and bacteria. We hypothesized that bacterial communities would be more strongly influenced by pH than fungal communities. To determine the relative abundance of bacteria and fungi, we used quantitative PCR (qPCR), and to analyze the composition and diversity of the bacterial and fungal communities, we used a bar-coded pyrosequencing technique. Both the relative abundance and diversity of bacteria were positively related to pH, the latter nearly doubling between pH 4 and 8. In contrast, the relative abundance of fungi was unaffected by pH and fungal diversity was only weakly related with pH. The composition of the bacterial communities was closely defined by soil pH; there was as much variability in bacterial community composition across the 180-m distance of this liming experiment as across soils collected from a wide range of biomes in North and South America, emphasizing the dominance of pH in structuring bacterial communities. The apparent direct influence of pH on bacterial community composition is probably due to the narrow pH ranges for optimal growth of bacteria. Fungal community composition was less strongly affected by pH, which is consistent with pure culture studies, demonstrating that fungi generally exhibit wider pH ranges for optimal growth.
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Rousk J, Brookes PC, Bååth E (2011). Fungal and bacterial growth responses to N fertilization and pH in the 150-year "park grass" UK grassland experiment.FEMS Microbiology Ecology, 76, 89-99.

DOI:10.1111/j.1574-6941.2010.01032.x PMID:21223326 URL

Abstract The effects of nitrogen (N) fertilization (0–15002kg02N02ha61102year611 since 1865) and pH (3.3–7.4) on fungal and bacterial growth, biomass and phospholipid fatty acid (PLFA) composition were investigated in grassland soils from the 'Park Grass Experiment', Rothamsted Research, UK. Bacterial growth decreased and fungal growth increased with lower pH, resulting in a 50-fold increase in the relative importance of fungi between pH 7.4 and 3.3. The PLFA-based fungal02:02bacterial biomass ratio was unchanged between pH 4.5 and 7.4, and decreased only below pH 4.5. Respiration and substrate-induced respiration biomass both decreased three- to fourfold with lower pH, but biomass concentrations estimated using PLFAs were unaffected by pH. N fertilization did not affect bacterial growth and marginally affected fungal growth while PLFA biomass marker concentrations were all reduced by higher N additions. Respiration decreased with higher N application, suggesting a reduced quality of the soil organic carbon. The PLFA composition was strongly affected by both pH and N. A comparison with a pH gradient in arable soil allowed us to generalize the pH effect between systems. There are 30–50-fold increases in the relative importance of fungi between high (7.4–8.3) and low (3.3–4.5) pH with concomitant reductions of respiration by 30–70%.

[: 1]

Sala OE, Gherardi LA, Reichmann L, Jobbagy E, Peters D (2012). Legacies of precipitation fluctuations on primary production: Theory and data synthesis.Philosophical Transactions of the Royal Society B: Biological Sciences, 367, 3135-3144.

DOI:10.1098/rstb.2011.0347 PMID:23045711 URL

Variability of above-ground net primary production (ANPP) of arid to sub-humid ecosystems displays a closer association with precipitation when considered across space (based on multiyear averages for different locations) than through time (based on year-to-year change at single locations). Here, we propose a theory of controls of ANPP based on four hypotheses about legacies of wet and dry years that explains space versus time differences in ANPP-precipitation relationships. We tested the hypotheses using 16 long-term series of ANPP. We found that legacies revealed by the association of current- versus previous-year conditions through the temporal series occur across all ecosystem types from deserts to mesic grasslands. Therefore, previous-year precipitation and ANPP control a significant fraction of current-year production. We developed unified models for the controls of ANPP through space and time. The relative importance of current-versus previous-year precipitation changes along a gradient of mean annual precipitation with the importance of current-year PPT decreasing, whereas the importance of previous-year PPT remains constant as mean annual precipitation increases. Finally, our results suggest that ANPP will respond to climate-change-driven alterations in water availability and, more importantly, that the magnitude of the response will increase with time.

[: 1]

Sall SN, Masse D, Bernhard-Reversat F, Guisse A, Chotte JL (2003). Microbial activities during the early stage of laboratory decomposition of tropical leaf litters: The effect of interactions between litter quality and exogenous inorganic nitrogen.Biology and Fertility of Soils, 39, 103-111.

DOI:10.1007/s00374-003-0679-1 URL

The comparative decomposition of tropical leaf litters (e.g. Andropogon gayanus , Casuarina equisetifolia , Faidherbia albida) of different qualities was investigated under laboratory conditions during a 60-day incubation period conducted with a typical oxisol. Total CO_2 -C, soil inorganic N, microbial biomass (fumigation-extraction), -glucosidase and dehydrogenase activities were determined over the incubation to assess how they responded to the addition of inorganic N (+N). Cumulative CO_2 -C evolved from the litter-amended soils was higher than that recorded for the unamended control soil. For the unfertilized treatment (0 N), correlation coefficients calculated between initial chemical data and CO_2 flux during the first day of incubation were r =0.963 for water soluble-C and 0.869 for soluble carbohydrates ($P <0.05$). At the end of the incubation, the amounts of CO_2 -C in the F. albida - and A. gayanus -amended soils were higher than that in the C. equisetifolia -amended treatment. Cumulative net N immobilization increased during the first 30 days of incubation, the amounts being similar for A. gayanus - and C. equisetifolia -amended soil and higher than that recorded in the F. albida -amended treatment. Soil microbial biomass and enzyme activities increased in the litter-amended soils during the first 15 days of incubation and decreased (except for the dehydrogenase activity) thereafter. The addition of inorganic N modified the patterns of CO_2 -C respiration and net N immobilization. The magnitude of these modifications varied according to the litter quality. The use of an accurate indicator based on several litter components to predict the amplitude of organic material decomposition is discussed.

Schilling EM, Waring BG, Schilling JS, Powers JS (2016). Forest composition modifies litter dynamics and decomposition in regenerating tropical dry forest.Oecologia, 182, 1-11.

DOI:10.1007/s00442-016-3559-8 PMID:26820567 URL

Abstract Plant pathogens can have cascading consequences on insect herbivores, though whether they alter competition among resource-sharing insect herbivores is unknown. We experimentally tested whether the infection of a plant pathogen, the parasitic plant dwarf mistletoe (Arceuthobium americanum), on jack pine (Pinus banksiana) altered the competitive interactions among two groups of beetles sharing the same resources: wood-boring beetles (Coleoptera: Cerambycidae) and the invasive mountain pine beetle (Dendroctonus ponderosae) (Coleoptera: Curculionidae). We were particularly interested in identifying potential mechanisms governing the direction of interactions (from competition to facilitation) between the two beetle groups. At the lowest and highest disease severity, wood-boring beetles increased their consumption rate relative to feeding levels at moderate severity. The performance (brood production and feeding) of mountain pine beetle was negatively associated with wood-boring beetle feeding and disease severity when they were reared separately. However, when both wood-boring beetles and high severity of plant pathogen infection occurred together, mountain pine beetle escaped from competition and improved its performance (increased brood production and

feeding). Species-specific responses to changes in tree defense compounds and quality of resources (available phloem) were likely mechanisms driving this change of interactions between the two beetle groups. This is the first study demonstrating that a parasitic plant can be an important force in mediating competition among resource-sharing subcortical insect herbivores.
[: 1]
Schuster MJ (2015). Increased rainfall variability and N addition accelerate litter decomposition in a restored prairie.Oecologia, 180, 1-11.
DOI:10.1007/s00442-015-3396-1 PMID:26216200 URL
Anthropogenic nitrogen deposition and projected increases in rainfall variability (the frequency of drought and heavy rainfall events) are expected to strongly influence ecosystem processes such as litter decomposition. However, how these two global change factors interact to influence litter decomposition is largely unknown. I examined how increased rainfall variability and nitrogen addition affected mass and nitrogen loss of litter from two tallgrass prairie species, Schizachyrium scoparium and Solidago canadensis, and isolated the effects of each during plant growth and during litter decomposition. I increased rainfall variability by consolidating ambient rainfall into larger events and simulated chronic nitrogen deposition using a slow-release urea fertilizer. S. scoparium litter decay was more strongly regulated by the treatments applied during plant growth than by those applied during decomposition. During plant growth, increased rainfall variability resulted in S. scoparium litter that subsequently decomposed more slowly and immobilized more nitrogen than litter grown under ambient conditions, whereas nitrogen addition during plant growth accelerated subsequent mass loss of S. scoparium litter. In contrast, S. canadensis litter mass and N losses were enhanced under either N addition or increased rainfall variability both during plant growth and during decomposition. These results suggest that ongoing changes in rainfall variability and nitrogen availability are accelerating nutrient cycling in tallgrass prairies through their combined effects on litter quality, environmental conditions, and plant community composition.
[: 1]
[(2014). . , , .]
Shi Y (2014). Effects of Experimental Nitrogen Addition on Soil Enzyme Activities in Temperate Grassland of Inner Mongolia. Master degree dissertation, Northeast Normal University, Changchun.(in Chinese with English abstract)
URL
CO_2

6 6 N0 0kg N ha-1.yr-1 N56 56kg N ha-1.yr-1 N112 112kg N ha-1.yr-1 N224 224kg N ha-1.yr-1 N392 392kg N ha-1.yr-1 N560 560kg N ha-1.yr-1 -1,4- G -1,4-N- NAG L- LAP AP 1 G NAG LAP N560 560kg N ha-1.yr-1 AP 2 pH pH G NAG LAP AP AP G NAG LAP 3 112kg N ha-1.yr-1 4 G NAG AP LAP 392kg N ha-1.yr-1 5 pH pH G NAG LAP AP G NAG AP LAP 6 56kg N ha-1.yr-1

[: 2]
Silver WL, Miya RK (2001). Global patterns in root decomposition: Comparisons of climate and litter quality effects.Oecologia, 129, 407-419.
DOI:10.1007/s004420100740 PMID:28547196 URL
Root decomposition represents a significant C flux in terrestrial ecosystems. Roots are exposed to a different decomposition environment than aboveground tissues, and few general principles exist regarding the factors controlling rates of root decay. We use a global dataset to explore the relative importance of climate, environmental variables, and litter quality in regulating rates of root decomposition. The parameters that explained the largest amount of variability in root decay were root Ca concentrations and C:N ratios, with a smaller proportion explained by latitude, mean annual temperature, mean annual precipitation, and actual evapotranspiration (AET). Root chemistry and decay rates varied by plant life form (conifer, broadleaf, or graminoid). Conifer roots had the lowest levels of Ca and N, the highest C:N and lignin:N ratios, and decomposed at the slowest rates. In a stepwise multiple linear regression, AET, root Ca, and C:N ratio accounted for approximately 90% of the variability in root decay rates. Root chemistry appeared to be the primary controller of root decomposition, while climate and environmental factors played secondary roles, in contrast to previously established leaf litter decomposition models.
[: 2]
Smith SW, Woodin SJ, Pakeman RJ, Johnson D, van der Wal R (2014). Root traits predict decomposition across a landscape-scale grazing experiment.New Phytologist, 203, 851-862.
DOI:10.1111/nph.12845 PMID:24841886 URL
Root litter is the dominant soil carbon and nutrient input in many ecosystems, yet few studies have considered how root decomposition is regulated at the landscape scale and how this is mediated by land-use management practices. Large herbivores can potentially influence below-ground decomposition through changes in soil microclimate (temperature and moisture) and changes in plant species composition (root traits). To investigate such herbivore-induced changes, we quantified annual root decomposition of upland grassland species in situ across a landscape-scale livestock grazing experiment, in a common-garden experiment and in laboratory microcosms evaluating the influence of key root traits on decomposition. Livestock grazing increased soil temperatures, but this did not affect root decomposition. Grazing had no effect on soil moisture, but wetter soils retarded root decomposition. Species-specific decomposition rates were similar across all grazing treatments, and species differences were maintained in the common-garden experiment, suggesting an overriding importance of litter type. Supporting this, in microcosms, roots with lower specific root area (m(2) g(-1)) or those with higher phosphorus concentrations decomposed faster. Our results suggest that large herbivores alter below-ground carbon and nitrogen dynamics more through their effects on plant species composition and associated root traits than through effects on the soil microclimate.
[: 2]
Smith VC, Bradford MA (2003). Litter quality impacts on grassland litter decomposition are

differently dependent on soil fauna across time.Applied Soil Ecology, 24, 197-203.
DOI:10.1016/S0929-1393(03)00094-5 URL
The main factors controlling decomposition rate are climate, litter quality and soil organisms. We investigated how decomposition was affected by interactions between litter quality and the composition of the soil community. To do this, we designed an experiment using the litterbag technique and three grass species for which a gradient of four distinct litter qualities (defined as initial nitrogen content) had been generated. We manipulated the soil community composition using different mesh sizes to constrain access of specific soil fauna to the litter on the basis of body size. Litter of a single species and quality was placed into litterbags of each of four different mesh sizes (0.1, 2, 2.8 and 4.7 mm) and bags were retrieved from the field after 30 and 60 days. Whether litter quality was a significant determinant of litter decomposition rate was dependent on both the soil community composition and length of field exposure. After 30 days there was a significant positive relationship between litter quality and decomposition for the most complex community (coarsest mesh size). The strength of this relationship declined with decreasing mesh size and, for the most restricted community (smallest mesh size), no quality ecomposition relationship was apparent. In contrast, after 60 days, decomposition was most strongly related to litter quality in the smallest mesh size bags and the relationship between quality and decomposition in the two coarsest mesh bags was non-significant. The pattern of these interactive effects between litter quality, soil community composition and time was consistent across the three grass species. We hypothesize that the effect of litter quality on mass loss within a specific mesh size was dependent on time because, while soil organisms of all size-classes responded positively to increased litter quality, they did so at a rate dependent upon their mobility.
[: 2]

Solly EF, Schöning I, Boch S, Kandeler E, Marhan S, Michalzik B, Müller J, Zscheischler J, Trumbore SE, Schrumpf M (2014). Factors controlling decomposition rates of fine root litter in temperate forests and grasslands.Plant and Soil, 382, 203-218.
DOI:10.1007/s11104-014-2151-4 URL
Fine root decomposition contributes significantly to element cycling in terrestrial ecosystems. However, studies on root decomposition rates and on the factors that potentially influence them are fewe
[: 1]
[, , , (2014). . ,34, 1327-1339.]
Song P, Zhang NL, Ma KP, Guo JX (2014). Impacts of global warming on litter decomposition. Acta Ecologica Sinica, 34, 1327-1339.(in Chinese with English abstract)
DOI:10.5846/stxb201210251479 URL
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[: 2]
Song X, Li Q, Gu H (2017). Effect of nitrogen deposition and management practices on fine

root decomposition in Moso bamboo plantations.Plant and Soil, 410, 207-215.
DOI:10.1007/s11104-016-2997-8 URL

The combined effects of nitrogen (N) deposition and management practices on fine root decomposition remain unknown. The objective of this study was to investigate the effects of the two factors on fin

[: 1]

Stevens CJ, Smart SM, Henrys PA, Maskell LC, Cheffings CM, Whitfield C, Gowing DJG, Rowe EC, Dore AJ, Emmett BA (2012). Terricolous lichens as indicators of nitrogen deposition: Evidence from national records.Ecological Indicators, 20, 196-203.
DOI:10.1016/j.ecolind.2012.02.027 URL

Large areas of Great Britain currently receive nitrogen (N) deposition at rates which exceed the thresholds above which there is risk of damage to sensitive components of the ecosystem (critical loads for nutrient nitrogen and critical levels for ammonia), and are predicted to continue to do so. Excess N can damage semi-natural ecosystems. Lichens are potentially sensitive to air quality because they directly utilise nutrients deposited from the atmosphere thus may be good indicators of air quality. We used data from the British Lichen Society (BLS) database, which records the presence of all lichen taxa growing in Britain at 10km resolution. The probability of presence of a taxa at a given level of N deposition was analysed together with driver data for climate, change in sulphur deposition, land-use and N deposition using generalised additive models (GAMs). Many taxa showed negative responses to N deposition with reductions in the probability of presence as N deposition increased. In all of the habitats, there were a mix of terricolous taxa which showed negative or no significant relationship with N deposition. Most of the taxa with negative relationships with N deposition started to decline in prevalence at the lowest levels of deposition found in this study. Levels of deposition over which a negative response apparently occurs are lower than those at which critical loads have been set for some habitats. These findings suggest that some terricolous lichen taxa are sensitive to atmospheric N deposition and even low levels of nitrogen deposition could be damaging terricolous lichen communities making then potentially good indicators of N deposition.

Stocker TF, Qin D, Plattner G-K, Tignor MMB, Allen SK, Boschung J, Nauels A, Xia Y, Bex V, Midgley PM (2014). Climate Change 2013: The Physical Science Basis. Cambridge University Press, Cambridge, UK.

[: 2]

Strickland MS, Rousk J (2010). Considering fungal: bacterial dominance in soils—Methods, controls and ecosystem implications.Soil Biology & Biochemistry, 42, 1385-1395.
DOI:10.1016/j.soilbio.2010.05.007 URL

An expectation in soil ecology is that a microbial communities fungal:bacterial dominance indicates both its response to environmental change and its impact on ecosystem function. We review a selection of the increasing body of literature on this subject and assess the relevance of its expectations by examining the methods used to determine, the impact of environmental factors on, and the expected ecosystem consequences of fungal:bacterial dominance. Considering methods, we observe that fungal:bacterial dominance is contingent on the actual measure used to estimate it. This

has not been carefully considered; fungal:bacterial dominance of growth, biomass, and residue indicate different, and not directly relatable aspects, of the microbial community influence on soil functioning. Considering relationships to environmental factors, we found that shifts in fungal:bacterial dominance were not always in line with the general expectation, in many instances even being opposite to them. This is likely because the traits expected to differentiate bacteria from fungi are often not distinct. Considering the impact of fungal:bacterial dominance on ecosystem function, we similarly found that expectations were not always upheld and this too could be due to trait overlap between these two groups. We explore many of the potential reasons why expectations related to fungal:bacterial dominance were not met, highlighting areas where future research, especially furthering a basic understanding of the ecology of bacteria and fungi, is needed.
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Suding KN, Collins SL, Gough L, Clark C, Cleland EE, Gross KL, Milchunas DG, Pennings S (2005). Functional- and abundance-based mechanisms explain diversity loss due to N fertilization.Proceedings of the National Academy of Sciences of the United States of America, 102, 4387-4392.

DOI:10.1073/pnas.0408648102 PMID:15755810 URL

Human activities have increased N availability dramatically in terrestrial and aquatic ecosystems. Extensive research demonstrates that local plant species diversity generally declines in response to nutrient enrichment, yet the mechanisms for this decline remain unclear. Based on an analysis of >900 species responses from 34 N-fertilization experiments across nine terrestrial ecosystems in North America, we show that both trait-neutral and trait-based mechanisms operate simultaneously to influence diversity loss as production increases. Rare species were often lost because of soil fertilization, randomly with respect to traits. The risk of species loss due to fertilization ranged from >60% for the rarest species to 10% for the most abundant species. Perennials, species with N-fixing symbionts, and those of native origin also experienced increased risk of local extinction after fertilization, regardless of their initial abundance. Whereas abundance was consistently important across all systems, functional mechanisms were often system-dependent. As N availability continues to increase globally, management that focuses on locally susceptible functional groups and generally susceptible rare species will be essential to maintain biodiversity.
[: 3]

Sun T, Dong L, Mao Z (2015). Simulated atmospheric nitrogen deposition alters decomposition of ephemeral roots.Ecosystems, 18(7), 1-13.

DOI:10.1007/s10021-015-9895-4 URL

ABSTRACT Roots concentrated on the smallest distal branching orders have short life spans and thus dominate root mortality, and may contribute predominately to plant carbon and nutrient transfer into soil. Yet the effects of nitrogen (N) enrichment on decomposition of the finest root branching orders have not yet been examined. Resolving such N effects is critical for predicting the ecosystem consequences of increased anthropogenic N deposition. The first four root orders were separated into two classes:

first- and second-order roots; third- and fourth-order roots. We studied the effects of N addition on decomposition of different root order classes in four temperate tree species over 4 years. Asymptotic decay models best fit the decomposition and allowed us to examine effects of N on initial versus later stages of decomposition separately. Very early in decomposition, N fertilization stimulated decomposition rates in higher-order roots, but had no effects on initial rates of decomposition in lower-order roots. In contrast, later in decomposition, N fertilization inhibited decomposition, ultimately resulting in a larger, slowly decomposing fraction in both lower-order and higher-order roots. Inhibitory effects of N addition on lignin-degrading enzyme activity might be an important mechanism explaining the negative effects of N on decomposition here. This study highlights the importance of long-term studies for understanding N effects on decomposition, and suggests that contrasting effects of N on different decomposition processes and carbon pools should be widely considered in biogeochemical models. Furthermore, the inhibitory effects of elevated atmospheric N deposition on decomposition of lower-order roots suggest that these roots may provide a critical mechanism of carbon and nutrient retention in soil because of their rapid input via root mortality.

[: 1]

Sun T, Dong L, Wang Z, Lü X, Mao Z (2016). Effects of long-term nitrogen deposition on fine root decomposition and its extracellular enzyme activities in temperate forests.Soil Biology & Biochemistry, 93, 50-59.

DOI:10.1016/j.soilbio.2015.10.023 URL

Resolving the effects of nitrogen (N) on decomposition is ecologically critical for predicting the ecosystem consequences of increased anthropogenic N deposition. Although root litter is the dominant soil carbon (C) and nutrient input in many forest ecosystems, studies have rarely examined how the process of root decomposition is affected by N availability. In a field experiment, we studied the effects of N addition on fine root (<0.5mm diameter) decomposition using five substrates ranging in initial gravimetric lignin concentrations (from 10.8% to 34.1%) over five years, and made a simultaneous characterization of effects of N on the enzymatic activity of the decomposer community in three temperate forests. Across substrates, asymptotic decomposition models best described the decomposition. The effects of N addition shifted over the course of fine root decomposition, regardless of initial lignin concentrations, with N speeding up the initial rate of decomposition, but ultimately resulting in a larger, slowly decomposing litter fraction (A). Such contrasting effects of N addition on initial and later stages of decomposition were closely linked to the dynamics of its extracellular enzyme activity. Our results emphasized the need for studies of N effects on litter decomposition that encompass the later stages of decomposition. This study suggested that atmospheric N addition may have contrasting effects on the dynamics of different carbon pools in forest soils, and such contrasting effects of N should be widely considered in biogeochemical models.

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Swift M, Heal O, Anderson J (1979). Decomposition in terrestial ecosystems.Applied Physics Letters, 83, 2772-2774.

DOI:10.1063/1.1615673 URL

A general reference text on decomposition. The first 2 chapters review the processes as a basis for a detailed account of the decomposer organisms and their activities in chapter 3. Chapters 4, 5 and 6 examine the influence of substrate quality, soil chemistry and climate. The final chapter shows how all the biological, chemical and climatic factors interrelate to produce varying rates of decom...

[: 1]

Tessier M, Vivier JP, Ouin A, Gloaguen JC, Lefeuvre JC (2003). Vegetation dynamics and plant species interactions under grazed and ungrazed conditions in a western European salt marsh.Acta Oecologica, 24, 103-111.

DOI:10.1016/j.jdiacomp.2006.09.003 URL

Experiments in exclosures were conducted on a salt marsh in a macrotidal system in western France. The aim of this study was threefold: (1) to compare vegetation dynamics over a period of 8 years in grazed and ungrazed conditions (2) to investigate the response of annual species to grazing duration during seedling establishment (3) to test the effect of an increase in soil nitrogen availability after cessation of grazing on interactions between Suaeda maritima and Puccinellia maritima . In grazed conditions, during all the survey, vegetation was dominated by a short P. maritima sward with the annual Salicornia europaea in the lower and middle marshes. However, after cessation of grazing in 1994, a homogeneous matrix of the forb Halimione portulacoides , quickly replaced P. maritima in the well drained lower marsh. At the middle marsh level, fine sediment and poor drainage maintained P. maritima while the annual S. maritima which tolerates taller and denser vegetation replaced S. europaea. Elymus pungens cover was limited till 2000 but its rising in 2001 let expect its dominance in the future. While P. maritima abundance remained high, spring abundance of annual species such as S. europaea and S. maritima globally decreased with sheep grazing duration on the salt marsh between February and June. Experiments with monocultures of P. maritima and S. maritima demonstrated that nitrogen was a limiting factor on the salt marsh. In a mixed community, a moderate application of nitrogen (15 g N m -2 year -1 as NH_4-NO_3) promoted growth of P. maritima and limited the biomass of S. maritima , but growth of the latter was enhanced by a high application of nitrogen (30 g N m -2 year -1). An increase in the abundance of annuals such as S. maritima on the salt marsh is discussed.

[: 1]

Tiunov AV (2009). Particle size alters litter diversity effects on decomposition.Soil Biology & Biochemistry, 41, 176-178.

DOI:10.1016/j.soilbio.2008.09.017 URL

Nutrient transfer between decomposing leaves may explain non-additive species diversity effects on decomposition. The influence of the diversity of litter species on decomposition was compared in mixtures composed of large (>200 mm 2) or small (<9 mm 2) litter fragments. The increase in the number of species (aspen, oak, alder and pine, from monocultures to four species in all possible combinations) initially (at day 43) suppressed respiration, but eventually (after 142 days) did not affect the mass loss of the mixtures of

small litter fragments. In contrast, the decomposition of litter in large fragments increased with increased diversity, and 93% of all mixtures decomposed faster than would be predicted from monocultures. The results suggest that the active transport of nutrients by fungal hyphae, rather than passive diffusion, drives positive effect of the litter species diversity on decomposition.
[: 1]
Turner MM, Henry HAL (2009). Interactive effects of warming and increased nitrogen deposition on ^{15}N tracer retention in a temperate old field: Seasonal trends.Global Change Biology, 15, 2885-2893.
DOI:10.1111/gcb.2009.15.issue-12 URL
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Valenzuela-Solano C, Crohn DM (2006). Are decomposition and N release from organic mulches determined mainly by their chemical composition? Soil Biology & Biochemistry, 38, 377-384.
DOI:10.1016/j.soilbio.2005.06.002 URL
The influence of chemical composition on the decomposition and N release rates from samples of 11 organic mulches enclosed in nylon mesh bags was assessed under field conditions at the University of California, Riverside. Time was adjusted by temperature and the cumulative temperature-adjusted days (tad) were used to model the pattern of the decay and N release. The chemical composition of the mulches significantly affected their decay. In descending order of significance, the concentration of the polar extractable carbon fraction (C P) and the acid insoluble fraction (C AI) were significantly correlated with decomposition during the year of study. Correlation was positive with C P and N and negative with C AI (mostly lignin). The C P was selected as the best predictor for mulch decomposition during the early and intermediate phases of this process (36 and 195 tad), but C AI was selected as the best variable for predicting the fraction of the initial mulch mass remaining at the end of the study (397 tad). N was immobilized, as indicated by temporary increases in N masses in mulches above initial conditions, in shredded redwood, pine trimmings and in two of three compost mulches. Immobilization was most pronounced during the first 36 tad of the study, with a maximum rate that varied from 6 to 11.5% above the initial N concentrations. At the end of the study N releases ranged from 97% of initial N (grass clippings) to only 8% (one of the composts.) The C P was selected as the best predictor for N remaining in the four sampling dates (397 tad) and explained from 52 to 68% of the variation in N release as a percentage of initial N content.
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Valera-Burgos J, Zunzunegui M, Cruz Diaz-Barradas M (2013). Do leaf traits and nitrogen supply affect decomposability rates of three Mediterranean species growing under different competition levels?Pedobiologia, 56, 113-119.
DOI:10.1016/j.pedobi.2013.03.002 URL
The effects of nitrogen addition on rates of litter decomposition of plants growing under different competition levels were assessed in a multifactorial glasshouse experiment. We established a two nitrogen-level treatment (control and fertilization) and three

competition-level (plants growing alone, intra- and interspecific competition) experiment for Pinus pinea L., Pistacia lentiscus L. and Cistus salvifolius L. during one year. We collected leaves from different combinations at 3, 6 and 12 months and we established a 2-month microcosm experiment. We measured K pot and different leaf and litter traits in order to test the hypothetical relationships between these traits and litter decomposability among the target species. Leaf nitrogen concentration was higher in plants growing under N-supply treatments but this supply only affected decomposition rates in the cases of P. pinea and P. lentiscus when grown alone. For P. pinea and C. salvifolius decay rate was higher in the fertilized treatment when growing alone. Leaf dry matter content was the leaf trait best related to litter decomposability. The results derived from the microcosm experiment provided evidence of the effect of some leaf and litter traits on litter decomposability and how some traits can give information about some important processes in ecosystems, such as decomposition.

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Vitousek PM, Porder S, Houlton BZ, Chadwick OA (2010). Terrestrial phosphorus limitation: Mechanisms, implications, and nitrogen-phosphorus interactions.Ecological Application, 20, 5-15.

DOI:10.1890/08-0127.1 URL

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Vivanco L, Austin AT (2011). Nitrogen addition stimulates forest litter decomposition and disrupts species interactions in Patagonia, Argentina.Global Change Biology, 17, 1963-1974.

DOI:10.1111/j.1365-2486.2010.02344.x URL

Nitrogen (N) deposition and biodiversity loss are important drivers of global change, with uncertain consequences for carbon (C) and nutrient turnover in terrestrial ecosystems. We evaluated the simultaneous effects of N deposition and plant diversity on litter decomposition within a temperate forest in Patagonia. We identified ‘tree triangles’ created by the intersection of three tree-canopies that directly controlled micro-environmental conditions on the forest floor, and combined it with an N addition treatment. Triangles were composed of one or three Nothofagus species (N. dombeyi, N. obliqua or N. nervosa). We placed litterbags containing litter of each of the Nothofagus species and litterbags containing a mixture of the three species within all triangles and assessed mass loss over 2 years. We used a standard litter type in all triangles to independently evaluate triangle effects on decomposition. N addition had strong and positive effects on decomposition with an average 46% increase in the decomposition constant. Litter species significantly differed in their response to N addition; litter with higher lignin content and lower labile C content had larger increase in decomposition due to fertilization. Also, N addition disrupted two types of species interactions that control decomposition. The affinity relation between litter and decomposers, that enhanced decomposition of home litter (‘home-field advantage’) that was demonstrated to be significant for all three Nothofagus species, disappeared with N addition. Second, N addition modified litter species interactions, transforming neutral effects of litter mixtures to positive, nonadditive effects on mass loss. Finally, N addition stimulated N release from decomposing litter which was modulated by plant species effects. Together, these results

suggest that N addition to unpolluted forests increases C loss, contrary to what has been observed for temperate forests in industrialized areas of the world, and that alterations in nutrient pools have effects on species interactions, including the elimination of affinity effects for decomposition.
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Wall DH, Bradford MA, John MG, Trofymow JA, Behan-Pelletier V, Bignell DDE (2008). Global decomposition experiment shows soil animal impacts on decomposition are climate-dependent.Global Change Biology, 14, 2661-2677.
DOI:10.1109/41.887958 PMID:3597247 URL
Climate and litter quality are primary drivers of terrestrial decomposition and, based on evidence from multisite experiments at regional and global scales, are universally factored into global decomposition models. In contrast, soil animals are considered key regulators of decomposition at local scales but their role at larger scales is unresolved. Soil animals are consequently excluded from global models of organic mineralization processes. Incomplete assessment of the roles of soil animals stems from the difficulties of manipulating invertebrate animals experimentally across large geographic gradients. This is compounded by deficient or inconsistent taxonomy. We report a global decomposition experiment to assess the importance of soil animals in C mineralization, in which a common grass litter substrate was exposed to natural decomposition in either control or reduced animal treatments across 30 sites distributed from 43 degree S to 68 degree N on six continents. Animals in the mesofaunal size range were recovered from the litter by Tullgren extraction and identified to common specifications, mostly at the ordinal level. The design of the trials enabled faunal contribution to be evaluated against abiotic parameters between sites. Soil animals increase decomposition rates in temperate and wet tropical climates, but have neutral effects where temperature or moisture constrain biological activity. Our findings highlight that faunal influences on decomposition are dependent on prevailing climatic conditions. We conclude that (1) inclusion of soil animals will improve the predictive capabilities of region- or biome-scale decomposition models, (2) soil animal influences on decomposition are important at the regional scale when attempting to predict global change scenarios, and (3) the statistical relationship between decomposition rates and climate, at the global scale, is robust against changes in soil faunal abundance and diversity.
[: 1]
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Recent evidence suggests that soil organic matter (SOM) is largely composed of microbial products rather than plant compounds that resist decomposition. The chemical transformation of leaf litter components during decomposition is critical in controlling SOM formation. Plant leaf litter tends to decompose faster in its native environment than when it is placed under other vegetation types. This home-field advantage (HFA) suggests that decomposer communities are specialized to most efficiently degrade the litter found

in their native environment, possibly through the production of specific enzymes that degrade unique compounds within that litter. Could this affect the degree to which leaf litter chemistry is altered during decomposition? We used pyrolysis-molecular beam mass spectrometry (py-MBMS) to analyze whether the chemistry of aspen and lodgepole pine litter was altered to a greater degree when decomposed in its home environment compared to an away environment. We had previously reported a 4% HFA for pine litter decomposition rates in this reciprocal experiment, and attributed that effect to differences in decomposer communities. Our high-resolution analysis revealed that litter chemistry also changed to a greater extent in its home environment. The changes in litter chemistry were more pronounced for the more recalcitrant pine litter, suggesting that decomposer community specialization is more important for recalcitrant litter. The accumulation of microbial products and microbially-transformed plant components resulted in an overall convergence in litter chemistry as decomposition proceeded, but the imprints of both initial litter chemistry and decomposer communities remained evident. The detection of new compounds in decomposed litter and the HFA effect on litter chemistry suggest that decomposer communities affect both the rate at which individual compounds within litter are decomposed, and the chemical nature of compounds that are incorporated into SOM.

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Global nitrogen deposition alters grassland ecosystems. Whether added nitrogen changes root production and turnover by root orders is unclear.We compared the root dynamics across four root orders of

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Wang YH, Gong JR, Liu M, Luo QP, Xu S, Pan Y, Zhai ZW (2015). Effects of land use and precipitation on above- and below-ground litter decomposition in a semi-arid temperate steppe in Inner Mongolia, China.Applied Soil Ecology, 96, 183-191.
DOI:10.1016/j.apsoil.2015.07.010 URL
Land use greatly affects litter production, quality, and decomposition rates, and therefore alters the soil carbon stocks and influences ecosystem carbon cycling. In this study, our aims were to investigate the effects of land use (grazing, mowing, and grazing exclusion), litter types, and precipitation on litter production, decomposition processes, and soil carbon stocks. Litter inputs, quality, and decomposition rates were significantly influenced by land use and differed greatly between 2011 (a dry year) and 2012 (a moist year). Above-ground litter production in 2012 ranged from 165 to 18002g02m 612 , versus from 50 to 7302g02m 612 in 2011; below-ground litter production in 2012 was 1.9 to 6.0 times that in 2011. Decomposition rates of above-ground litter (k a) were greater than those of below-ground litter (k b). The k a in 2012 was 1.9 to 2.8 times those in 2011 and k b in 2012 was 6.5 to 10.8 times those in 2011. The k a was strongly positively correlated with the N content (R 2 02 =02 0.713) and strongly negatively correlated with the C/N ratio (R 2 02=020.585), whereas k b was explained best by the C/N ratio. Precipitation was a main factor that controlled ecosystem C cycling processes, and increased litter decomposition increased soil carbon stocks. Land use therefore played an important role in litter input and decomposition processes and in carbon sequestration, but these processes responded to the initial litter quality and precipitation.
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All terrestrial ecosystems consist of aboveground and belowground components that interact to influence community- and ecosystem-level processes and properties. Here we show how these components are closely interlinked at the community level, reinforced by a greater degree of specificity between plants and soil organisms than has been previously supposed. As such, aboveground and belowground communities can be powerful mutual drivers, with both positive and negative feedbacks. A combined aboveground-

belowground approach to community and ecosystem ecology is enhancing our understanding of the regulation and functional significance of biodiversity and of the environmental impacts of human-induced global change phenomena.
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The theory of ecological stoichiometry predicts that the microbial biomass should regulate production of extracellular enzymes to target the resource in shortest supply. Therefore, microbial communities on decomposing leaf litter should optimize allocation to C-, N-, and P-degrading enzymes according to the stoichiometry of the foliar substrate. Because extracellular enzymes are the proximate agents of leaf litter decay, shifts in microbial enzyme allocation may influence overall rates of litter mass loss. To test these hypotheses, I measured fungal growth and the activities of acid phosphatase (AP), beta-glucosidase (BG), cellobiohydrolase (CB) and glycine aminopeptidase (GAP) on decaying leaf litter of five plant species over the course of a 394-day decomposition experiment. I used regression and correlation analyses to link to interspecific variation in mass loss rates with enzyme activities and foliar nutrient content. Enzymes explained 35% of the variance in foliar decay rates across plant species, yet fungal abundance and enzyme activities were unrelated to foliar concentrations of N, P, K, or 9 other nutrients. Furthermore, relative activities of C-, N-, and P-acquiring enzymes did not vary across litter types despite wide variance in foliar C:N and C:P ratios. This weak relationship between litter stoichiometry and decomposition rates suggests that nutrients are not the primary control on microbial growth or enzyme allocation in this tropical forest. However, substantial interspecific differences in fungal abundance and enzyme activities imply that differences in litter composition strongly influence microbial communities and the ecosystem processes they mediate. (C) 2013 Elsevier Ltd. All rights reserved.
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Weatherly HE, Zitzer SF, Coleman JS (2003). In situ litter decomposition and litter quality in a Mojave Desert ecosystem: Effects of elevated atmospheric CO_2 and interannual climate variability.Global Change Biology, 9, 1223-1233.

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Rising atmospheric CO 2 has been predicted to reduce litter decomposition as a result of CO 2 -induced reductions in litter quality. However, available data have not supported this hypothesis in mesic ecosystems, and no data are available for desert or semi-arid ecosystems, which account for more than 35% of the Earth's land area. The objective of our study was to explore controls on litter decomposition in the Mojave Desert using elevated CO 2 and interannual climate variability as driving environmental factors. In particular, we sought to evaluate the extent to which decomposition is modulated by litter chemistry (C:N) and litter species and tissue composition. Naturally senesced litter was collected from each of nine 25 m diameter experimental plots, with six plots exposed to ambient [CO 2] or 367 μL CO 2 L 611 and three plots continuously fumigated with elevated [CO 2] (550 μL CO 2 L 611) using FACE technology beginning in April 1997. All litter collected in 1998 (a wet, or El Ni09o year; 306 mm precipitation) was pooled as was litter collected in 1999 (a dry year; 94 mm). Samples were allowed to decompose for 4 and 12 months starting in May 2001 in mesh litterbags in the locations from which litter was collected. Decomposition of litter produced under elevated CO 2 and ambient CO 2 did not differ. Litter produced in the wetter year showed more rapid initial decomposition (over the first 4 months) than that produced in the drier year (27±2% yr 611 or 7.8±0.7 g m 612 yr 611 for 1998 litter; 18±3% yr 611 or 2.2±0.4 g m 612 yr 611 for 1999 litter). C:N ratios of litter produced under elevated CO 2 (wet year: 37±0.5; dry year: 42±2.5) were higher than those of litter produced under ambient CO 2 (wet year: 34±1.1; dry year: 35±1.4). Litter production in the wet year (amb. CO 2 : 25.1±1.1 g m 612 yr 611 ; elev. CO 2 : 35.0±1.1 g m 612 yr 611) was more than twice as high as that in the dry year (amb. CO 2 : 11.6±1.7 g m 612 , elev. CO 2 : 13.3±3.4 g m 612), and contained a greater proportion of Lycium pallidum and a lower proportion of Larrea tridentata than litter produced in the dry year. Decomposition, viewed across all treatments, decreased with increasing C:N ratios, decreased with increasing proportions of Larrea tridentata and increased with increasing proportions of Lycium pallidum and Lycium andersonii . Because litter C:N did not vary by litter production year, and CO 2 did not alter decomposition or litter species/tissue composition, it is likely that the impact of year-to-year variation in precipitation on the proportion of key plant species in the litter may be the most important way in which litter decomposition will be modulated in the Mojave Desert under future rising atmospheric CO 2 .

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summary Foliar uptake and release of inorganic nitrogen compounds were studied by immersing current-year shoots of Scots pine (Pinus sylvestris L.) and Norway spruce [Pica abies (L.) Karst] in either NH 4 + - or NO 3 61 -rain solutions at different N concentrations. The effects of N form, N concentration and tree species on ion influx and efflux were investigated. Spruce shoots absorbed NH 4 + from the external solution. Uptake apparently occurred by diffusion rather than by H + or base cation exchange as commonly accepted, and increased linearly with NH 4 + concentration in the external solution. In contrast, pine shoots released NH 4 + to the external solution. The different reactions of spruce and pine may reflect species differences in physical and chemical properties or differences in tissue N concentration. If the latter is the case, a tree's N status may determine whether the canopy acts as a source or sink for NH 4 + influencing deposition rates to the needle surface. The results show that where NH 4 + concentration on the needle surface exceeds 4 mg 1 611 , foliar uptake may make a significant contribution to N status. In the absence of NH 4 + -base cation exchange, atmospheric inputs of NH 4 + to the canopy appear unlikely to be directly-responsible for the nutrient deficiencies typical of Dutch forest decline. Neither spruce or pine shoots were able to utilize NO 3 61 in the external solution and generally released NO 3 61 . Adverse effects resulting from foliar accumulation of wet-deposited NO 3 61 appear unlikely. However, higher NO 3 61

concentrations and longer residence times than simulated in this experiment may result in foliar uptake of NO 3 61 in the field.
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A large remaining source of uncertainty in global model predictions of future climate is how ecosystem carbon (C) cycle feedbacks to climate change. We conducted a field manipulative experiment of warming and nitrogen (N) addition in a temperate steppe in northern China during two contrasting hydrological growing seasons in 2006 [wet with total precipitation 11.2% above the long-term mean (348 mm)] and 2007 (dry with total precipitation 46.7% below the long-term mean). Irrespective of strong intra- and interannual variations in ecosystem C fluxes, responses of ecosystem C fluxes to warming and N addition did not change between the two growing seasons, suggesting independence of warming and N responses of net ecosystem C exchange (NEE) upon hydrological variations in the temperate steppe. Warming had no effect on NEE or its two components, gross ecosystem productivity (GEP) and ecosystem respiration (ER), whereas N addition stimulated GEP but did not affect ER, leading to positive responses of NEE. Similar responses of NEE between the two growing seasons were due to changes in both biotic and abiotic factors and their impacts on ER and GEP. In the wet growing season, NEE was positively correlated with soil moisture and forb biomass. Negative effects of warming-induced water depletion could be ameliorated by higher forb biomass in the warmed plots. N addition increased forb biomass but did not affect soil moisture, leading to positive effect on NEE. In the dry growing season, NEE showed positive dependence on grass biomass but negative dependence on forb biomass. No changes in NEE in response to warming could result from water limitation on both GEP and ER as well as little responses of either grass or forb biomass. N addition stimulated grass biomass but reduced forb biomass, leading to the increase in NEE. Our findings highlight the importance of changes in abiotic (soil moisture, N availability) and biotic (growth of different plant functional types) in mediating the responses of NEE to climatic warming and N enrichment in the semiarid temperate steppe in northern China.
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2010 10 26 -2011 4 18 , - , (0.02 0.125 1 3 mm) , . :
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Most studies of forest litter dynamics examine the biochemical characteristics and decomposition of leaf litter, but fine roots are also a large source of litter in forests. We quantified the concentrations of eight biochemical fractions and nitrogen (N) in leaf litter and fine roots at four sugar maple (Acer saccharum)-dominated hardwood forests in the north-central United States. We combined these results with litter production data to estimate ecosystem biochemical fluxes to soil. We also compared how leaf litter and fine root biochemistry responded to long-term simulated N deposition. Compared with leaf litter, fine roots contained 2.9-fold higher acid-insoluble fraction (AIF) and 2.3-fold more condensed tannins; both are relatively difficult to decompose. Comparatively, leaf litter had greater quantities of more labile components: nonstructural carbohydrates, cellulose and soluble phenolics. At an ecosystem scale, fine roots contributed over two-thirds of the fluxes of AIF and condensed tannins to soil. Fine root biochemistry was also less responsive than leaf litter to long-term simulated N deposition. Fine roots were the dominant source of difficult-to-decompose plant carbon fractions entering the soil at our four study sites. Based on our synthesis of the literature, this pattern appears to be widespread in boreal and temperate forests.
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Although nitrogen addition and recovery from degradation can both promote production of grassland biomass, these two factors have rarely been investigated in combination. In this study, we established a field experiment with six N-treatment (CK, 10, 20, 30, 40, 5065g65N65m61265yr611) on five fields with different degradation levels in the Inner Mongolian steppe of China from 2011–2013. Our observations showed that while the external nitrogen increased the aboveground biomass in all five grasslands, the magnitude of the effects differed with the severity of degradation. Fields with a higher level of degradation tended to have a higher saturation value (2065g65N65m61265yr611) than those with a lower degradation level (65<651065g65N m61265yr611). After three years of

experimentation, species richness showed little change across degradation levels. Among the four functional groups of grasses, sedges, forbs and legumes, grasses shared the most similar response patterns with those of the whole community, demonstrating the predominant role that they play in the restoration of grassland under a stimulus of nitrogen addition.
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Understanding the links between litter chemical transformations and functional microbial communities is key to elucidating the mechanisms of litter decomposition processes under nitrogen (N) and sulfur (S) deposition. Carbon (C)-13-labelled Pinus massoniana needles were incubated in a subtropical plantation forest soil exposed to: no amendment (Control), N amendments of 81 (N1) and 270 (N2) mg02kg 61021 , S amendments of 121 (S1) and 405 (S2) mg02kg 61021 and combined N and S amendments. Litter decomposition was measured as litter-derived carbon dioxide (CO 2) emissions and the litter C pools were partitioned using a two-pool model. Relationships between litter residue chemistry (assessed by 13 C nuclear magnetic resonance spectroscopy analysis) and microbial community composition (probed by phospholipid fatty acid analysis, PLFA) and activity (the metabolic quotient, q CO 2) were investigated. Over the 42002days incubation period, N and S additions (except N and S addition alone at low rate) significantly increased litter decomposition by 7.2–18.9% compared to the Control. Decomposition was stimulated by 10.2–61.9% during the initial 5602days (stage 1) and in contrast, 8.3–42.1% inhibition was measured during 57–42002days (stage 2) across the addition treatments. Stimulation on litter-derived CO 2 emissions under the N and S additions was largely dependent on the loss of O-alkyl C, a dominant component of the litter active C pool. During the initial 702days, N and S additions increased the ratio of fungal to bacterial PLFAs compared to the Control, which was accompanied by the increases in methoxyl C. The activity of microbes, particularly gram-negative bacteria, was also increased by N and S additions at stage 1, which was related to di-O-alkyl C. In contrast, fungal activity decreased under N and S additions at stage 2, accompanied by lowered C availability and increased methoxyl C. Alkyl C and aromatic C in the litter had positive relationships with the half-life of the slow C pool. Accordingly, the residue recalcitrance was increased under N and S additions compared with Control at stage 2, and was largely responsible for the inhibition of litter decomposition. Thus, N and S deposition is likely to increase the persistence of litter-derived recalcitrant C in subtropical forest soils in the long term.
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Abstract Nitrogen (N) and sulfur (S) deposition are important drivers of global climate change, but their effects on litter decomposition remain unclear in the subtropical regions. We investigated the influences of N, S, and their interactions on the decomposition of 13C-labeled Pinus massoniana leaf litter. An orthogonal experiment with three levels of N (0, 81, and 270 mg N kg611 soil) and S (0, 121, and 405 mg S kg611 soil) was conducted. We traced the incorporation of 13C-litter into carbon dioxide (CO2), dissolved organic C (DOC), and microbial phospholipids. Over the 420-day incubation, litter decomposition did not respond to low N and S additions but increased under high levels and combined amendments (NS). However, litter-derived CO2 emissions were enhanced during the first 56 days, with a positive interaction of N × S. N additions promoted fungal growth, while S stimulated growth of Gram-positive bacteria, fungi, and actinobacteria. Increased decomposition was related to higher litter-derived DOC and fungi/bacteria ratio. Inversely, N and/or S amendments inhibited decomposition (N > NS > S) from day 57 afterwards, possibly due to C limitation and decreased abundances of Gram-negative bacteria and actinobacteria. These results suggested that N deposition interacted with S to affect litter decomposition, and this effect depended on N and S deposition levels and litter decomposition stage.

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Anthropogenic acid deposition may lead to soil acidification, with soil buffering capacity regulating the magnitude of any soil pH change. However, little evidence is available from large-scale observations. Here, we evaluated changes in soil pH across northern China's grasslands over the last two decades using soil profiles obtained from China's Second National Soil Inventory during the 1980s and a more recent regional soil survey during 2001 2005. A transect from the central-southern Tibetan Plateau to the eastern Inner Mongolian Plateau, where Kriging interpolation provided robust predictions of the spatial distribution of soil pH, was then selected to examine pH changes during the survey period. Our results showed that soil pH in the surface layer had declined significantly over the last two decades, with an overall decrease of 0.63 units (95% confidence interval = 0.54 0.73

units). The decline of soil pH was observed in both alpine grasslands on the Tibetan Plateau and temperate grasslands on the Inner Mongolian Plateau. Soil pH decreased more intensively in low soil carbonate regions, while changes of soil pH showed no significant associations with soil cation exchange capacity. These results suggest that grassland soils across northern China have experienced significant acidification from the 1980s to 2000s, with soil carbonates buffering the increase in soil acidity. The buffering process may induce a large loss of carbon from soil carbonates and thus alter the carbon balance in these globally important ecosystems.
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Abstract The contributions of environmental DNA to ecology are reviewed, focusing on diet, trophic interactions, species distributions and biodiversity assessment. Environmental DNA has the potential to dramatically improve quantitative studies in these fields. Achieving this, however, will require large investments of time and money into developing the relevant databases, models, and software. 0008 2012 Blackwell Publishing Ltd.
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The study took juveniles of T.ramosissima and A.sparsifolia as study objects,which are the key species of desert-oasis transition zone in the south fringe of the Taklimakan Desert.The trench method and root tracing method were used to excavate their whole root system.The aim of the experiment is to study the features of the biomass allocation,root / shoot ratio and root distribution of two plant juveniles under the same extra-arid habitant condition with comparing their differences.The results shows as follows:(1) Biomass allocation of two plant juveniles are obviously different.T.ramosissima allocates more biomass into shoots,whose root / shoot ratio is 0.75.On the contrary,A.sparsifolia allocates more biomass into roots with root / shoot ratio of 1.73.(2) Relationships between the root and the shoot of two plant juveniles are characterized by the allometry model,their correlation coefficients are larger than 0.83.(3) Root distribution of two plant juveniles is also significantly different.The root system of T.ramosissima is composed by a vertical main root and some horizontal lateral roots,whose root system distribution is like a Chinese character of "feng"( )in its soil vertical profiles.The root

system of A.sparsifolia is composed of the tillers which are net-shaped,whose root system distribution in its soil vertical profiles is like a Chinese character of "gu"( ).
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Atmospheric nitrogen (N) deposition caused by anthropogenic activities may alter litter decomposition and species composition, and then affect N cycling and carbon (C) sequestration in an ecosystem. Using the litterbag method, we studied the effects of N addition (CK: no N addition; low-N: 1 g N m (-2) y (-1) ; high-N: 2 g N m (-2) y (-1)) on changes in mass remaining of shoot litter decomposition of three grasses (Stipa baicalensis, Carex pediformis and Leymus chinensis) over 28 months in the Hulun Buir meadow steppe of Inner Mongolia. The results showed that the addition of high and low N had no significant effect on the decomposition of single-species litter, but low N addition slightly inhibited the decomposition of litter mixtures. In addition, litter decomposition was strongly species dependent. Our results suggest that species type is likely the main determinant of litter decomposition, and low N deposition in natural ecosystems does not influence single-species litter decomposition.
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Zhang W, Chao L, Yang Q (2016). Litter quality mediated nitrogen effect on plant litter decomposition regardless of soil fauna presence.Ecology, 97, 2834.
DOI:10.1002/ecy.1515 PMID:27859104 URL
Abstract Nitrogen addition has been shown to affect plant litter decomposition in terrestrial ecosystems. However, the way that nitrogen deposition impacts the relationship between plant litter decomposition and altered soil nitrogen availability is

unclear. This study examined 18 co-occurring litter types in a subtropical forest in China in terms of their decomposition (one year of exposure in the field) with nitrogen addition treatment (0, 0.4, 1.6, and 4.0 mol N m612 year611) and soil fauna exclusion (litter bags with 0.1 and 2 cm mesh size). Results showed that the plant litter decomposition rate is significantly reduced because of nitrogen addition; the strength of the nitrogen addition effect is closely related to the nitrogen addition levels. Plant litters with diverse quality responded to nitrogen addition differently. When soil fauna was present, the nitrogen addition effect on medium-quality or high-quality plant litter decomposition rate was 6126% ± 5% and 6129% ± 4%, respectively; these values are significantly higher than that of low-quality plant litter decomposition. The pattern is similar when soil fauna is absent. In general, the plant litter decomposition rate is decreased by soil fauna exclusion; an average inhibition of 6117% ± 1.5% was exhibited across nitrogen addition treatment and litter quality groups. However, this effect is weakly related to nitrogen addition treatment and plant litter quality. We conclude that the variations in plant litter quality, nitrogen deposition, and soil fauna are important factors of decomposition and nutrient cycling in a subtropical forest ecosystem. This article is protected by copyright. All rights reserved.
Zhang YH, Feng J, Isbell F, Lü XT, Han XG (2015a). Productivity depends more on the rate than the frequency of N addition in a temperate grassland.Scientific Reports, 5, 12558. doi: 10.1038/srep12558.

DOI:10.1038/srep12558 PMID:26218675 URL

Abstract Nitrogen (N) is a key limiting resource for aboveground net primary productivity (ANPP) in diverse terrestrial ecosystems. The relative roles of the rate and frequency (additions yr(-1)) of N application in stimulating ANPP at both the community- and species-levels are largely unknown. By independently manipulating the rate and frequency of N input, with nine rates (from 0 to 50 N m(-2) year(-1)) crossed with two frequencies (twice year(-1) or monthly) in a temperate steppe of northern China across 2008-2013, we found that N addition increased community ANPP, and had positive, negative, or neutral effects for individual species. There were similar ANPP responses at the community- or species-level when a particular annual amount of N was added either twice year(-1) or monthly. The community ANPP was less sensitive to soil ammonium at lower frequency of N addition. ANPP responses to N addition were positively correlated with annual precipitation. Our results suggest that, over a five-year period, there will be similar ANPP responses to a given annual N input that occurs either frequently in small amounts, as from N deposition, or that occur infrequently in larger amounts, as from application of N fertilizers.
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[, , , , , , (2012). . , 32, 4605-4617.]
Zhang YB, Luo P, Sun G, Mou CX, Wang ZY, Wu N, Luo GR (2012). Effects of grazing on litter decomposition in two alpine meadow on the eastern Qinghai-Tibet Plateau.Acta Ecologica Sinica, 32, 4605-4617.(in Chinese with English abstract)

DOI:10.5846/stxb201105220671 URL

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Carexmuliensis Kobresiatibetica) , 4 . , ,
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Zhang YH, Stevens CJ, Lü XT, He NP, Huang JH, Han XG (2015b). Fewer new species colonize at low frequency N addition in a temperate grassland.Functional Ecology, 30, 1247-1256.

DOI:10.1111/1365-2435.12585 URL

Summary Biologically reactive nitrogen (Nr) enrichment threatens biodiversity in diverse ecosystems. Previous controlled N addition experiments may overestimate the effects of atmospheric Nr deposition on the rate of species loss, as it has been found that low frequency Nr additions, as used in traditional studies, lead to more rapid biodiversity loss. It remains unclear, however, whether the colonization of new species (gain) or extinction of old species (loss) is the cause of this difference. By independently manipulating the frequency (twice vs. monthly additions year611) and the rate (from 0 to 5002g N02m61202year611) of NH4NO3 inputs for six years in a temperate grassland of northern China, we aimed to examine the contribution of gain and loss of species to the reduction in species richness under different regimes of Nr inputs. Results showed that the gain of new species was higher at a high frequency of N addition than that at a low addition frequency, while loss of existing species was similar between the two frequencies of N addition. The number of new species gained decreased and old species lost increased with the increasing rate of Nr addition at both annual and five-year intervals. Cumulative gain of new species was negatively correlated with soil acidification, ammonium concentration and community biomass accumulation, whereas cumulative loss of old species was positively correlated with these variables. Our results revealed lower new species colonization results in lower species richness at low frequency of Nr addition. Findings from this study highlight the important role of N addition frequency in regulating the effects of Nr addition on community dynamics. To assess the effects of atmospheric Nr deposition on ecosystem structure and functioning, it is necessary to assess not only the dose but also the frequency of N addition.

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Zhao H, Huang G, Li Y, Ma J, Sheng JD, Jia HT, Li CJ (2015a). Effects of increased summer precipitation and nitrogen addition on root decomposition in a temperate desert.PLOS ONE, 10, e0142380. doi: 10.1371/journal.pone. 0142380.

DOI:10.1371/journal.pone.0142380 PMID:4636258 URL

Climate change scenarios that include precipitation shifts and nitrogen (N) deposition are impacting carbon (C) budgets in arid ecosystems. Roots constitute an important part of the C cycle, but it is still unclear which factors control root mass loss and nutrient release in arid lands. Litterbags were used to investigate the decomposition rate and nutrient dynamics in root litter with water and N-addition treatments in the Gurbantunggut Desert in China. Water and N addition had no significant effect on root mass loss and the N and phosphorus content of litter residue. The loss of root litter and nutrient releases were strongly controlled by the initial lignin content and the lignin:N ratio, as evidenced by the negative correlations between decomposition rate and litter lignin content and the lignin:N ratio. Fine roots ofSeriphidium santolinum(with higher initial lignin content) had a slower decomposition rate in comparison to coarse roots. Results from this study indicate that small and temporary changes in rainfall and N deposition do not affect root decomposition patterns in the Gurbantunggut Desert. Root decomposition rates were significantly different between species, and also between fine and coarse roots, and were determined by carbon components, especially lignin content, suggesting that root litter quality may be the primary driver of belowground carbon turnover.

Zhao Y, Wu F, Yang W (2015b). Variations in bacterial communities during foliar litter decomposition in the winter and growing seasons in an alpine forest of the eastern Tibetan Plateau.Canadian Journal of Microbiology, 62, 35-48.

DOI:10.1139/cjm-2015-0448 PMID:26606037 URL

Bacterial communities are the primary engineers during litter decomposition and related material cycling, and they can be strongly controlled by seasonal changes in temperature and other environmental factors. However, limited information is available on changes in the bacterial community from winter to the growing season as litter decomposition proceeds in cold climates. Here, we investigated the abundance and structure of bacterial communities using real-time quantitative PCR and denaturing gradient gel electrophoresis (DGGE) during a 2-year field study of the decomposition of litter of 4 species in the winter and growing seasons of an alpine forest of the eastern Tibetan Plateau. The abundance of the bacterial 16S rRNA gene was relatively high during decomposition of cypress and birch litter in the first winter, but for the other litters 16S rRNA abundance during both winters was significantly lower than during the following growing season. A large number of bands were observed on the DGGE gels, and their intensities and number from the winter samples were lower than those from the growing season during the 2-year decomposition experiment. Eighty-nine sequences from the bands of bacteria that had been cut from the DGGE gels were affiliated with 10 distinct classes of bacteria and an unknown group. A redundancy analysis indicated that the moisture, mass loss, and elemental content (e.g., C, N, and P) of the litter significantly affected the bacterial communities. Collectively, the results suggest that uneven seasonal changes in climate regulate bacterial communities and other decomposers, thus affecting their contribution to litter decomposition processes in the alpine forest.

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Zhou GY, Guan LL, Wei XH (2008). Factors influencing leaf litter decomposition: An intersite decomposition experiment across China. Plant and Soil, 311, 61-72.

DOI:10.1007/s11104-008-9658-5 URL

The Long-Term Intersite Decomposition Experiment in China (hereafter referred to as LTIDE-China) was established in 2002 to study how substrate quality and macroclimate factors affect leaf litter decomposition. The LTIDE-China includes a wide variety of natural and managed ecosystems, consisting of 12 forest types (eight regional broadleaf forests, three needle-leaf plantations and one broadleaf plantation) at eight locations across China. Samples of mixed leaf litter from the south subtropical evergreen broadleaf forest in Dinghushan (referred to as the DHS sample) were translocated to all 12 forest types. The

leaf litter from each of other 11 forest types was placed in its original forest to enable comparison of decomposition rates of DHS and local litters. The experiment lasted for 30 months, involving collection of litterbags from each site every 3 months. Our results show that annual decomposition rate-constants, as represented by regression fitted k-values, ranged from 0.169 to 1.454/year. Climatic factors control the decomposition rate, in which mean annual temperature and annual actual evapotranspiration are dominant and mean annual precipitation is subordinate. Initial C/N and N/P ratios were demonstrated to be important factors of regulating litter decomposition rate. Decomposition process may apparently be divided into two phases controlled by different factors. In our study, 0.75 years is believed to be the dividing line of the two phases. The fact that decomposition rates of DHS litters were slower than those of local litters may have been resulted from the acclimation of local decomposer communities to extraneous substrate.
[,: 1](2016). . , 40, 620-630.]
Zhou ZH, Wang CK (2016). Responses and regulation mechanisms of microbial decomposers to substrate carbon, nitrogen, and phosphorus stoichiometry.Chinese Journal of Plant Ecology, 40, 620-630.(in Chinese with English abstract)
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Zhu FF, Yoh M, Gilliam FS, Yoh M, Lu XK, Mo JM (2013). Nutrient limitation in three lowland tropical forests in southern china receiving high nitrogen deposition: Insights from fine root responses to nutrient additions.PLOS ONE, 8, e82661. doi: 10.1371/journal.pone.0082661.
DOI:10.1371/journal.pone.0082661 PMID:3869734 URL
Abstract Elevated nitrogen (N) deposition to tropical forests may accelerate ecosystem phosphorus (P) limitation. This study examined responses of fine root biomass, nutrient concentrations, and acid phosphatase activity (APA) of bulk soil to five years of N and P additions in one old-growth and two younger lowland tropical forests in southern China. The old-growth forest had higher N capital than the two younger forests from long-term N accumulation. From February 2007 to July 2012, four experimental treatments were established at the following levels: Control, N-addition (150 kg N ha(-1) yr(-1)), P-addition (150 kg P ha(-1) yr(-1)) and N+P-addition (150 kg N ha(-1) yr(-1) plus 150 kg P ha(-1) yr(-1)). We hypothesized that fine root growth in the N-rich old-growth forest would be limited by P availability, and in the two younger forests would primarily respond to N additions due to large plant N demand. Results showed that five years of N addition significantly decreased live fine root biomass only in the old-growth forest (by 31%), but significantly elevated dead fine root biomass in all the three forests (by 64% to 101%), causing decreased live fine root proportion in the old-growth and the pine forests. P addition significantly increased live fine root biomass in all three forests (by 20% to 76%). The combined N and P treatment significantly increased live fine root biomass in the two younger forests but not in the old-growth forest. These results suggest that fine root growth in all three study forests appeared to be P-limited. This was further confirmed by current status of fine root N:P ratios, APA in bulk soil, and their responses to N and P treatments. Moreover, N addition significantly increased APA only in the old-growth forest, consistent with the conclusion that the old-growth forest was more P-limited than the younger forests.

Zhu W, Wang J, Zhang Z, Ren F, Chen L, He JS (2016a). Changes in litter quality induced by nutrient addition alter litter decomposition in an alpine meadow on the Qinhai- Tibet Plateau.Scientific Reports, 6, 34290. doi: 10.1038/ srep34290.

DOI:10.1038/srep34290 PMID:27694948 URL

Abstract The effects of nitrogen (N) and phosphorus (P) addition on litter decomposition are poorly understood in Tibetan alpine meadows. Leaf litter was collected from plots within a factorial N65×65P addition experiment and allowed to decompose over 708 days in an unfertilized plot to determine the effects of N and/or P addition on litter decomposition. Results showed that nutrient addition significantly affected initial P and P-related biochemical properties of litter from all four species. However, the responses of litter N and N-related biochemical properties to nutrient addition were quite species-specific. Litter C decomposition and N release were species-specific. However, N and P addition significantly affected litter P release. Ratios of Hemicellulose65+65Cellulose to N and P were significantly related to litter C decomposition; C:N ratio was a determinant of litter N release; and C:P and (Hemicellulose65+65Cellulose):P controlled litter P release. Overall, litter C decomposition was controlled by litter quality of different plant species, and strongly affected by P addition. Increasing N availability is likely to affect litter C decomposition more indirectly by shifting plant species composition than directly by improving litter quality, and may accelerate N and P cycles, but shift the ecosystem to P limitation.

Zhu X, Chen H, Zhang W, Huang J, Fu SL, Liu ZF, Mo JM (2016b). Effects of nitrogen addition on litter decomposition and nutrient release in two tropical plantations with N_2-fixing vs. non-N_2-fixing tree species.Plant and Soil, 399, 61-74.

DOI:10.1007/s11104-015-2676-1 URL

Background and Aims: Atmospheric nitrogen (N) deposition has elevated rapidly in tropical regions where N-fixing tree species are widespread. However, the effect of N deposition on litter decomposition in forests with N-fixing tree species remains unclear. We examined the effect of N addition on litter decomposition and nutrient release in two tropical plantations with Acacia auriculiformis (AA, N-fixing) and Eucalyptus urophylla (EU, non-N-fixing) in South China. Methods: Three levels of N additions were conducted: control, medium-N (50 kg N ha yr.) and high-N (100 kg N ha yr.) in each plantation. Results: Initial decomposition rate (k) for the control plots was faster in the AA plantation than in the EU plantation, but later in decomposition, larger fraction of slowly decomposing litter (A) remained in the former. N addition increased the slow fraction (A), decreasing soil microbial biomass and reducing acid-unhydrolyzable residue (AUR) degradation in the AA plantation. In the EU plantation, however, N additions significantly increased initial decomposition rate (k) and soil N availability. Furthermore, N addition decreased litter carbon and N release (in the AA plantation), while litter phosphorus release also decreased in both plantations. Conclusions: With ongoing N deposition in future, tropical plantations with N-fixing tree species would potentially increase carbon accumulation and nutrient retention in forest floor by slowing litter decomposition.

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Zhu X, Zhang W, Chen H, Mo J (2015). Impacts of nitrogen deposition on soil nitrogen

cycle in forest ecosystems: A review.Acta Ecologica Sinica, 35, 35-43.
DOI:10.1016/j.chnaes.2015.04.004 URL
Atmospheric nitrogen (N) deposition has accelerated in the last several decades due to anthropogenic activities, such as nitrogen fertilization, N-fixing plants cultivation and fossil fuel and biomass combustion. Increasing N deposition has become one of the important factors regulating N cycle in forest ecosystems. Forest ecosystems can retain part of deposited N in soil by biotic and abiotic mechanisms, but when N inputs exceed the capacity of soil retention, N losses will aggravate in terms of N oxide emission and/or nitrate leaching. The excess N input has threatened ecosystem health via acidification and eutrophication, causing declines in terrestrial biodiversity and forest productivity in forest ecosystems of Europe and North America. Recently, China has become one of the three areas that undergo severe N deposition in the world. Impacts of N deposition on soil N cycle in Chinese forest ecosystems have received increasing concern. In this paper, we reviewed the processes of soil N cycle and their responses to atmospheric N deposition based on available literature. The objective is to enhance our understanding on how N deposition affects soil N cycle in forest ecosystems and provide scientific information for sustainable forest management. The review mainly includes the following four aspects: (1) processes of soil N cycle and their controlling factors. These processes include biological N fixation (BNF), decomposition, mineralization, nitrification, denitrification, N oxide emission and NO 3 61 N leaching. The controlling factors of these processes are complicated and interactional. Only one of these factors altered may affect soil N cycle. For example, C/N is the factor that controls BNF, decomposition, mineralization and NO 3 61 N leaching. (2) Research methods and current results about studies are related to the impact of N deposition on soil N cycle in forest ecosystems. In general, the research methods are long-term simulated N deposition experiment, N deposition gradient method, roof clean rain method and 15 N tracing method. Effects of N deposition on soil N cycle vary depending on different initial N statuses and lengths of experiment. In “N-limited” forests, N deposition tended to have positive effect on soil N cycling processes, such as accelerating litter decomposition rate and N mineralization rate. However, such result generally showed in short-term fertilization experiments. In some long-term fertilization experiments, it showed that the negative effects would rise when the forests reached N saturation. Compared to “N-limited” forests in temperate region, N deposition tended to have negative or neutral effects in “N-rich” tropical forest. For example, N deposition promoted nitrification process in tropical forests. (3) Possible mechanisms for the effect of N deposition on soil N cycle: N deposition can affect soil N cycle through altering the chemical characteristic of forest substrates, the biomass and community composition of plant and microorganism. (4) Current problems and future research needs for the study about the effect of N deposition on soil N cycle: What role does regional diversity, changes in forest type, and interaction of carbon (C), N and phosphorus (P) play on the effect of N deposition on soil N cycle in forest ecosystems deserve our further study in the future.

Resource

External search by key words

nitrogen deposition
grassland ecosystem
litter decomposition
litter quality
research method

External search by authors

YANG Li-Li
GONG Ji-Rui
LIU Min
YANG Bo

ZHANG Zi-He
LUO Qin-Pu
ZHAI Zhan-Wei
PAN Yan

Productivity and Carbon Dynamics in Mangrove Wetlands, albania, as follows from the above, isotropically understands laser hedonism.

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