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Effects of cryptogamic covers on the global carbon and nitrogen balance as investigated by different approaches

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Cryptogamic covers are composed of cyanobacteria, green algae, lichens, bryophytes, fungi and bacteria in varying proportions. As cryptogamic ground covers, comprising biological soil and rock crusts they occur on many terrestrial ground surfaces. Cryptogamic plant covers, containing epiphytic and epiphyllic crusts as well as foliose or fruticose lichens and bryophytes spread over large portions of terrestrial plant surfaces. Photoautotrophic organisms within these crusts sequester atmospheric CO_2 and many of them include nitrogen-fixing cyanobacteria, utilizing atmospheric N_2 to form ammonium which can be readily used by vascular plants.

In a large-scale data analysis approach, we compiled all available data on the physiological properties of cryptogamic covers and developed a model to calculate their annual nitrogen fixation and net primary production. Here, we obtained a total value of 3.9 Pg a^{-1} for the global net uptake of carbon by cryptogamic covers, which corresponds to approximately 7% of the estimated global net primary production of terrestrial vegetation. Nitrogen assimilation of cryptogamic covers revealed a global estimate of ~49 Tg a^{-1}, accounting for as much as about half the estimated total terrestrial biological nitrogen fixation.

In a second approach, we calculated the global carbon uptake by lichens and bryophytes by means of a process-based model. In this model, we used gridded climate data combined with key habitat properties (as e.g. disturbance intervals) to predict the processes which control net carbon uptake, i.e. photosynthesis, respiration, water uptake and evaporation. The model relies on equations frequently used in dynamic vegetation models, which were combined with concepts specific to lichens and bryophytes. As this model only comprises lichens and bryophytes, the predicted terrestrial net uptake of 0.34 to 3.3 Gt a^{-1} is in accordance with our empirically-derived estimate. Based on this result, we quantified the amount of nitrogen needed by the organisms to build up biomass. The predicted requirement for nitrogen ranges from 3.5 to 34 Tg a^{-1}, again being in a reasonable range compared to the data analysis approach.

In experimental field studies (3^{rd} approach), we analyzed the net primary production of biological soil crusts, i.e. one major group of cryptogamic covers. The microclimatic conditions (water status, temperature, light intensity) of different types of biological soil crusts were monitored at 5-minute intervals over a whole year. Conducting a factorial analysis of CO_2 gas exchange of the crusts in the lab, we obtained the net photosynthesis or respiration rate for all microclimatic conditions encountered in the field. The latter results were combined with the microclimate data, assigning CO_2 gas exchange values to each microclimate measurement tuple. Integration over the year resulted in an annual carbon fixation of ~5 g m^{-2} a^{-1}, being nearly identical to the numbers obtained during the data analysis approach.

In summary, our three different approaches clearly revealed that cryptogamic covers have a considerable effect on the global terrestrial C and N cycle, which must not be neglected in global carbon and nitrogen balances.