Impacts of major anthropogenic pressures on the terrestrial biosphere and its resilience to global change

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Summary

This thesis investigates impacts of human induced pressures on the Earth's biosphere and how resilient it might be against them. Besides others the two most important and most intensively studied pressures on the terrestrial biosphere are land-use change and climate change. Chapter 1 and 2 assess the consequences of future food demands for agricultural development and disentangle land-use change and climate change impacts on the biosphere. Chapter 1 points to the major increase of food production needed to supply the growing world population under climate change. A country wise self-supply overview until the year 2100 shows that the need for future agricultural productivity increase will be unequally distributed over the world. Especially the self-supply of tropical to sub-tropical regions is found to decrease most drastically due to highest population growth and the highest potential of changing consumption habits. Therefore, the natural biomes of those regions are currently under multiple pressures with land-use change and climate change leading the way. To assess the impacts on those kinds of biomes, it is important to investigate them in a regional context using specific land-use change scenarios. Therefore, chapter 2 investigates the biomes of Latin America as a large-scale case study. It reveals potential biome shifts until the year 2100 separately attributed to land-use or climate change. The most important result points to the possibility of climate change outweighing land-use change as the most important driver of future biome shifts, when land conversion of natural vegetation into arable land is effectively halted through policy making. In other words successful conservation efforts of natural habitats might be diminished by future climate change, even though the severity of climate change impacts remains highly uncertain. A globally important case where this issue could become relevant concerns the Amazon rainforest, since many studies with vegetation models projected vast losses of Amazonian rainforest under future climate change pressures alone. Whilst many follow up studies have found similar or less drastic results, including the results of chapter 2, they all share the same methodological limitation. The underlying models assume a non-adaptive vegetation, which is composed of a small subset of representative plant types for the global biomes with constant features over time and space. For example in chapter 2 the results for the tropical part of Latin America's forests are based on 2 average tree types representing 2 major growing strategies. The contrasting huge tree diversity of the real Amazon poses the question if this and other systems might actually be more adaptive than generally assumed, since the high variety of underlying tree features might offers a large bandwidth of possible vegetation responses to climate change. Chapter 3 presents the first global model able to address this question. It introduces a new methodology which simulates diverse forest communities with a wide spectrum of different growth strategies based on empirical data and ecological theory. Chapter 3 shows that local tree trait distributions of 12 sites distributed over Latin America as well as the Amazon basin wide tree trait pattern can be reproduced for current climate conditions. Applying the new model to climate change scenarios in chapter 4, the vegetation showed the ability to

recover its biomass from climate change impacts, contrasting the standard modelling approach used in chapter 1 and 2. As a response to climate change, vegetation composition also changed and hence, the dominance of certain growth strategies. It appeared that already small shifts in functional composition can induce biomass recovery. Overall, chapter 4 provides first evidence for an Amazon basin wide positive influence of functional diversity on biomass under climate change. Thus, biosphere assessments under global change like chapter 1 and 2 might draw a different picture when acknowledging adaptive vegetation responses mediated by biodiversity. The findings of chapter 4 have wide-ranging implications from ecological theory building right up to the science-policy interface, assigning biodiversity a new global value.