Summary of the thesis (Dr. rer. nat.)

Vegetation-ecological investigations of rangeland ecosystems in Western Mongolia. The assessment of grazing impact at various spatial scale levels

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For many years, rangeland ecologists have debated about whether the state of semi-arid and arid rangelands is the expression of an ecological equilibrium or non-equilibrium dynamics reached in response to grazing livestock. Since the problem has been considered at different spatial scales, it is recognised that the competing concepts of equilibrium and non-equilibrium dynamics need to be integrated. Furthermore, the role of environmental variables as vegetation driving factors has long been ignored in the discussion on grazing effects on ecosystems.

Present thesis, examines the dependence of plant communities on environmental in particular site-ecological conditions in three ecosystems of Western Mongolia established along a precipitation gradient to detect the vegetation-driving ecological factors involved. Furthermore, grazing impact is exemplary assessed in a desert steppe at additional spatial scales of plant communities and population.

At the **landscape level**, a classification of plant communities in dependence on environmental conditions is carried out. Additionally, the investigations focused on the impact of grazing on soil and on the occurrence of grazing-mediated plant communities. Data were sampled along an altitudinal gradient between 1150 m to 3050 m a.s.l. from arid lowland with desert steppe via semi-arid mountain steppe to humid alpine belt. Within each altitudinal belt, data sampling was carried out along grazing gradients, established from grazing hot spots to areas distant from them. By means of an environmentally based vegetation classification, factors with highest explanation values for largest variation in vegetation were identified and considered as most responsible for vegetation patterns. To validate and affirm the classification, three different statistical methods are applied: environmentally adjusted table work of vegetation relevés supported by cluster analysis of species distribution, detrended correspondence analysis of vegetation data separately from environmental data, and the principle component analysis of only environmental data. Vegetation-driving factors change along the altitudinal gradient from abiotic forces in the desert steppe, as e.g. altitude and soil texture, to abiotic and biotic forces in the alpine belt represented by soil texture, soil nutrients and grazing. Vegetation and soil of all ecosystems respond to grazing but with different patterns and to a different extent. While desert steppe does not indicate grazing communities, mountain steppe demonstrates grazing communities at fertilised sites and alpine belt at

nutrients depleted sites. Thus, the grazing sensitiveness of the ecosystems is assumed to be linked with plant productivity and the role of vegetation as site-determining factor (Chapter 2).

To examine grazing impact at lower spatial scales on desert steppe as the ecosystem with lowest grazing sensitiveness at the landscape scale, at **community scale** the total number of species, the total vegetation cover, the percentage of annual species, the cover of annual species, and properties of soil nutrient along gradients of grazing intensity within three different communities were assessed. Vegetation parameters respond to grazing in different ways, and the responses of the same parameters vary between plant communities. Correlations with grazing intensity indicate only partly statistical significance. Significant correlations of grazing intensity with concentrations of soil nutrient point to eutrophication in two communities. A comparison of vegetation and soil properties refers to a greater indirect influence of grazing via increased soil nutrients than the direct effect on vegetation (Chapter 4).

At the **population level**, data about stand density, aboveground biomass, individual plant weight, and the proportion of flowering plants of the dominant dwarf semi-shrub *Artemisia xerophytica* were collected along a grazing gradient. Soil data were used to distinguish between grazing and edaphic influences. All parameters of *Artemisia xerophytica* reflect the assumed gradient of grazing intensity up to 800 m distance from the grazing hot spot. As grazing pressure decreases, plant density and total biomass per plot increase. The average shrub weight, an indicator of plant vitality, is related to both: distance from the grazing hot spot and stand density, which may be explained by additional intraspecific competition at higher densities. At a longer distance, these effects are masked by variations in soil parameters determining water availability, leading to quite similar degradation forms. These results are in contrast to other studies carried out at the scale of plant communities which did not detect significant changes along a grazing gradient. One explanation is the different map scale: the study took place only within a single plant community comparing populations of one species (Chapter 3).

The comparative study demonstrates that even arid desert steppes of western Mongolia display equilibrial and non-equilibrial properties, depending on the observational scale: while no grazing mediated plant communities could be identified at the landscape scale as predicted by the non-equlilibrium model, at the community level vegetation parameters imply an intermediate position between equilibrium and non-equilibrium system. At the population level, the results clearly reflect the grazing gradient as predicted by the equilibrium model (Chapter 4).

As a consequence, the assessment of vegetation dynamics and grazing impact in rangelands requires a multiple-scale approach that duly considers different vegetation properties responding differently to grazing, climatic and edaphic variability at different spatial scales. It is further suggested, that future research should draw comparisons between landscapes that co-evolved with herbivory, and those that did without (Chapter 4).