Summary

Vegetation Responses to Climate Variability, Human Activities and Policy Shifts on the Mongolian Plateau

（モンゴル高原における気候変動、人間活動および政策転換に対する植生応答）

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Composed of the country of Mongolia and the Inner Mongolia Autonomous Region (IMAR), China, the Mongolian Plateau (MP) plays a significant role in global biogeochemical cycles and livestock production. Due to accelerated climate change and intensified human disturbance, grasslands on MP have been confronting with increased development pressure and higher degradation risks since the mid-20th century. As a response, the Chinese government has designed and implemented a range of ecological restoration programs (ERPs) in IMAR since the early 2000s, whereas parallel action has not yet been taken in Mongolia.

A great number of studies have been carried out to characterize and understand the vegetation dynamics on MP in recent decades based on Earth observation data, but to date, several specific issues have still not been sufficiently addressed. To contribute to a more comprehensive understanding of the vegetation responses to climate variability, human activities and policy shifts on MP, this dissertation consists of three specific studies.

Considering previous studies depended heavily on optical remote sensing-based normalized difference vegetation index (NDVI, a proxy of canopy greenness) to characterize vegetation dynamics and commonly analyzed the effects of climate variability and human activities separately, Chapter 2 employed a newly developed vegetation optical depth (VOD) retrieval, which is passive microwave satellite-based

and can serve as a proxy of aboveground biomass (AGB), to determine the relative importance of climatic and anthropogenic drivers on the dynamics of AGB in Mongolia and IMAR. The results revealed that: (1) since the political-economic transition in the early 1990s, AGB declined in most parts of the grazing zone of Mongolia. The reduction of precipitation, the rise of temperature and the intensification of livestock grazing were the major drivers behind it. Ranked by their relative importance, the order in the grazing zone with relatively humid climate was: precipitation ≈ temperature > livestock grazing; the order in the grazing zone with relatively arid climate was: precipitation > temperature > livestock grazing. (2) Since the implementation of ERPs in the early 2000s, AGB increased in most parts of the grazing zone of IMAR, and the increase of precipitation was the dominant driver behind it. (3) Since the early 2000s, AGB increased in most parts of the semi-grazing/farming zone of IMAR. The increase of precipitation, the decline of temperature and the intensification of grain production were the major drivers behind it. Ranked by their relative importance, the order was: precipitation > grain production > temperature. (4) Since the early 2000s, AGB increased in most parts of the farming zone of IMAR. The increase of precipitation and the intensification of grain production were the major drivers behind it. Ranked by their relative importance, the order was: grain production > precipitation. Other main findings of this chapter included: (5) the contribution of precipitation to the dynamics of AGB increased with aridity; (6) the contribution of livestock grazing to the decline of AGB increased with humidity.

As the human impacts on vegetation changes demonstrably vary over time and across space and few studies have explored this issue on MP in depth, Chapter 3 distinguished the human-induced vegetation dynamics from the effects of climate variability using the residual trend (RESTREND) method and examined how the human impacts varied between socio-institutional periods and among agricultural zones. Meanwhile, the differences and similarities between VOD and NDVI were investigated and discussed. The results showed that: (1) grasslands in Mongolia and the grazing zone of IMAR underwent a significant human-induced decrease in AGB during 1993-2012 and 1993-2000 respectively, which was attributable to the intensified livestock grazing stimulated by livestock privatization and market factors; by contrast, grasslands in these two regions did not experience a concurrent human-induced reduction in canopy greenness. (2) Grasslands in the grazing zone of IMAR underwent a significant human-induced increase in AGB since the early 2000s, which was attributable to the reduced grazing pressure induced by the implementation of ERPs; concurrently, grasslands in this region also experienced a remarkable increase in canopy greenness, however, this increase was found not directly caused by the decreased stocking densities. (3) Vegetation in the farming and semi-grazing/farming zone of IMAR underwent a significant human-induced increase in both AGB and canopy greenness since the early 2000s, which was attributable to the intensified grain production stimulated by market factors, open grazing regulation and confined feeding popularization.

Considering the implementation of ERPs has induced considerable land use/land cover change (LULCC) in IMAR within a relatively short period and few studies have evaluated the effects of these human-induced LULCC on regional vegetation productivity in the context of climate variability, Chapter 4 adopted the Carnegie-Ames-Stanford Approach (CASA) model framework to quantify the respective contribution of climate variability and human-induced LULCC to NPP dynamics in IMAR from 2001 to 2013 through designing different simulation scenarios. The main findings included: (1) since the implementation of ERPs, annual NPP in IMAR increased at a rate of 4.03 Tg C yr^{-1}. (2) The contribution of climate variability to the NPP increase ranged between 1.34 Tg C yr^{-1} and 3.49 Tg C yr^{-1}, which was mainly due to the reduction of water stress and the increase of radiation. (3) The contribution of LULCC to the NPP increase ranged between 0.33 Tg C yr^{-1} and 2.24 Tg C yr^{-1}, which mainly resulted from the forest expansion and the gobi(desert) shrinkage. (4) A considerable proportion (38.9%) of the newly generated grasslands, as well as some of the natural grasslands, were reconverted and reclaimed for cultivation after fixed-period government subsidy expired in 2008, which was seldom reported in previous studies and should be sufficiently emphasized and properly addressed in the future.