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Land use change and water yield in the Karst Gabin Basin: A regional study from southwest China

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Background

ARTICLES
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Increased vegetation growth and carbon stock in China karst via ecological engineering

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Afforestation and reforestation projects in the karst regions of southwest China aim to combat desertification and improve the ecological environment. However, it remains unclear at what scale conservation efforts have impacted on carbon stocks and if vegetation regrowth occurs at a large spatial scale as intended. Here we use satellite time series data and show a widespread increase in leaf area index (a proxy for green vegetation cover), and aboveground biomass carbon, which contrasted negative trends found in the absence of anthropogenic influence as simulated by an ecosystem model. In spite of drought conditions, aboveground biomass carbon increased by 9% (+0.05 Pg C y^{-1}), mainly in areas of high conservation effort. We conclude that large scale conservation projects can contribute to a greening Earth with positive effects on carbon sequestration to mitigate climate change. At the regional scale, such ecological engineering projects may reduce risks of desertification by increasing the vegetation cover and reducing the ecosystem sensitivity to climate perturbations.

The impacts of climate change and anthropogenic activities on Earth's vegetation and ecosystems have been in the spotlight of science in the past decades[1–6]. With increasing climate variability and more frequent occurrences of extreme events expected in the future[7], research has targeted the sensitivity of ecosystems[8,9]. At the same time, recent studies have shown globally increasing leaf area index (LAI; a proxy for green vegetation cover)[10], and aboveground biomass carbon (ABC)[11], also known as the greening Earth[10,12]. Dynamic vegetation models and Earth observation studies reveal climatic and atmospheric changes as the main drivers of large scale increases in LAI[10,13]. On the contrary, the anthropogenic footprint is usually found to cause land degradation and deforestation[13,14], and only a few studies find a direct positive effect of management on vegetation cover and biomass trends[2,11,15]. Although ecological conservation projects aim at increasing biodiversity, carbon sequestration and vegetation cover[16,17], the success of such conservation efforts is not easily quantifiable, and the spatial footprint of projects is not always commensurable with contemporary satellite- and modelling-based monitoring methods. Adaptation and mitigation strategies to climate change should be anchored in knowledge on how ecosystems respond to climatic and anthropogenic disturbances, but at present it is not known whether conservation projects impact on the ability of vegetation to alleviate the effects of climate change at large scales.

China's ecological restoration projects (for example, the Natural Forest Protection Project, the Grain to Green Project, and the Karst Rocky Desertification Restoration Project) are considered 'mega-engineering' activities and the most ambitious afforestation and conservation projects in human history[16–19]. The highly sensitive and vulnerable karst ecosystem in southwest China is one of the largest exposed carbonate rock areas (more than 0.54 million km^2) in the world. This area hosts 220 million people[20,21] and has been selected as a major target of restoration projects. Descriptions as early as the seventeenth century reported the rocky karst mountains as an area of sparse forest or vegetation cover[22], and accelerating desertification has been reported during the past half century, caused by the increasing intensity of human exploitation of natural resources[21–24]. As a result, approximately 0.13 million km^2 of karst areas previously covered by vegetation and soil were turned into a rocky landscape. To combat this severe form of land degradation and to relieve poverty, more than 130 billion yuan (~19 billion USD) have been invested in mitigation initiatives since the end of the 1990s[24]. The largest programme implemented, the Grain to Green Project, offers grain, cash and free seedlings as compensation for rural households to re-establish forests, shrub and/or grassland[24]. The costs of ecological engineering projects as a climate change mitigation measure are however only justified if ecosystem properties can be affected at large scales. If such afforestation projects are to be considered successful, a large-scale improvement in vegetation cover and carbon sequestration is required with a clear relation to the spatial extent of areas selected for conservation projects. If evidence of such large-scale projects can be found, we further expect these increases to be independent from climate trends.

Results

Shifts in satellite time series coincided with conservation project implementation. LAI from GIMMS-3g[10] (1982 to 2015) as well as ABC derived from vegetation optical depth (VOD)[11] (1992 to

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Satellite-Observed Major Greening and Biomass Increase in South China Karst During Recent Decade

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Journal of Hydrology
Volume 573, June 2019, Pages 246-254

Research papers

Rainfall driven transport of carbon and nitrogen along karst slopes and associative interaction characteristic

Xianwei Song [a, b], Yang Gao [a, b], Sophie M. Green [c], Xuefa Wen [a, b], Jennifer A.J. Dungait [d], Bailian Xiong [e], Timothy A. Quine [c], Nianpeng He [a, b]

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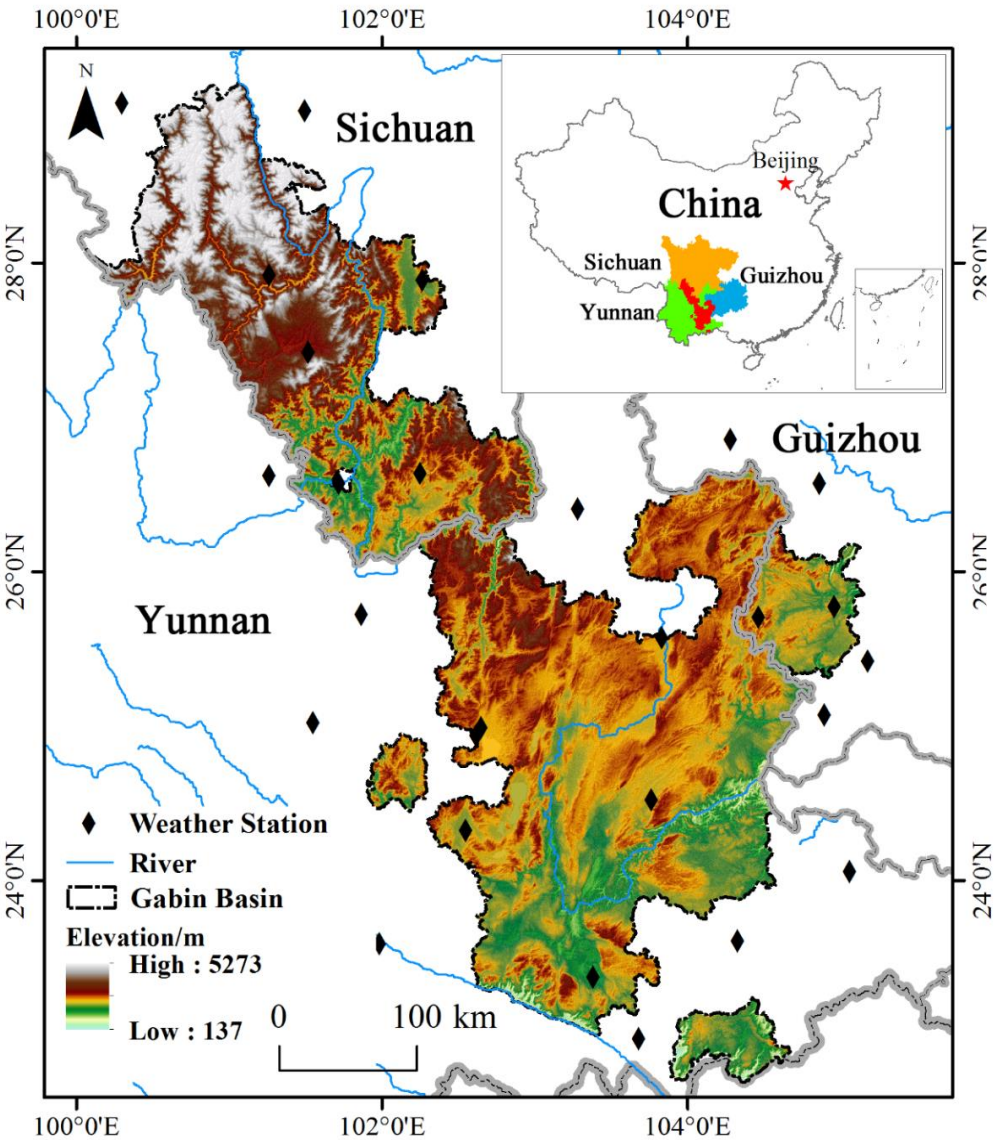
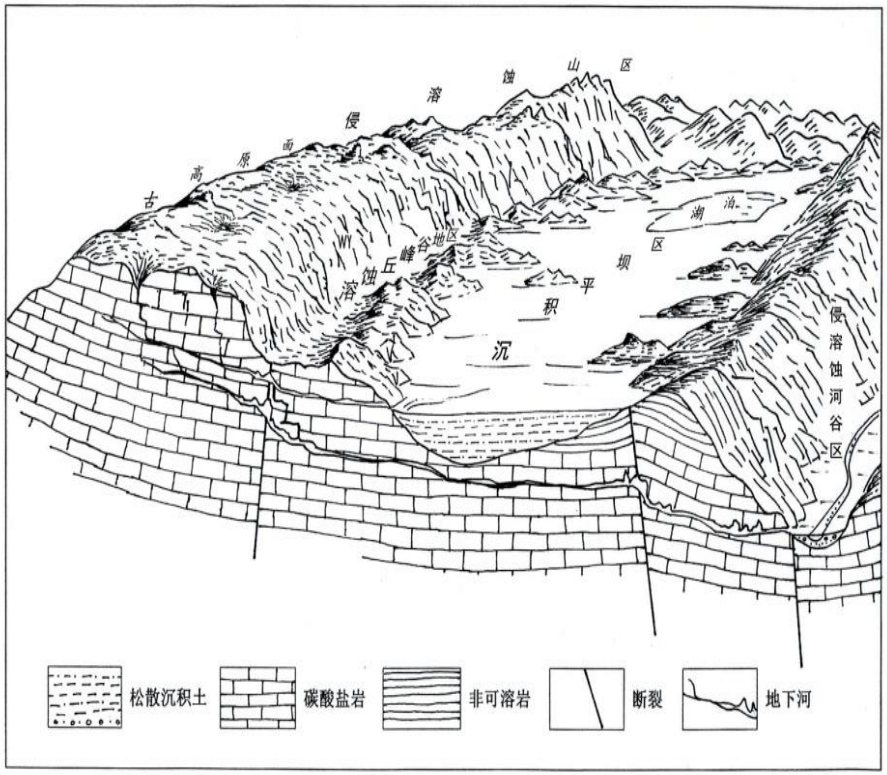
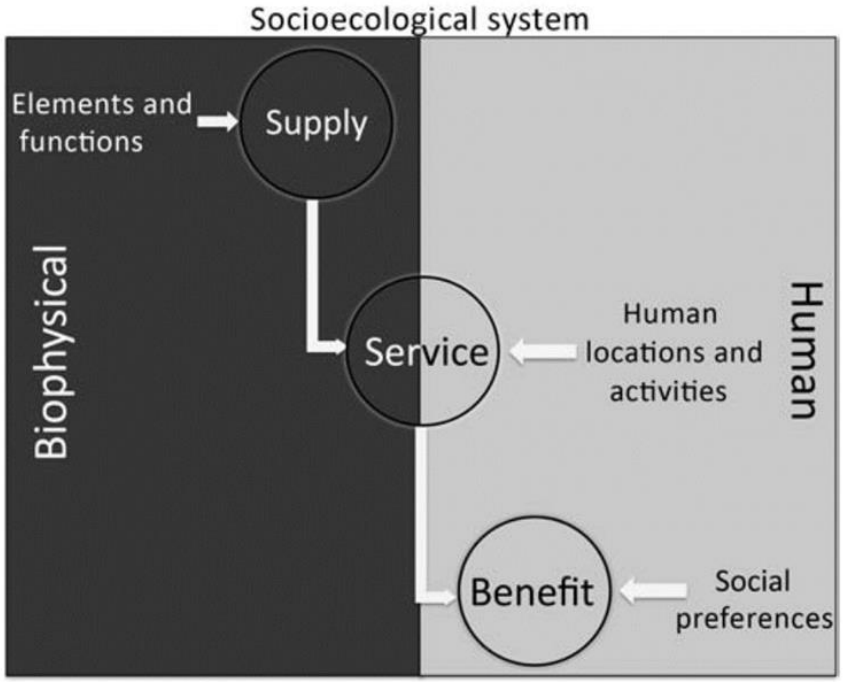
Study Area



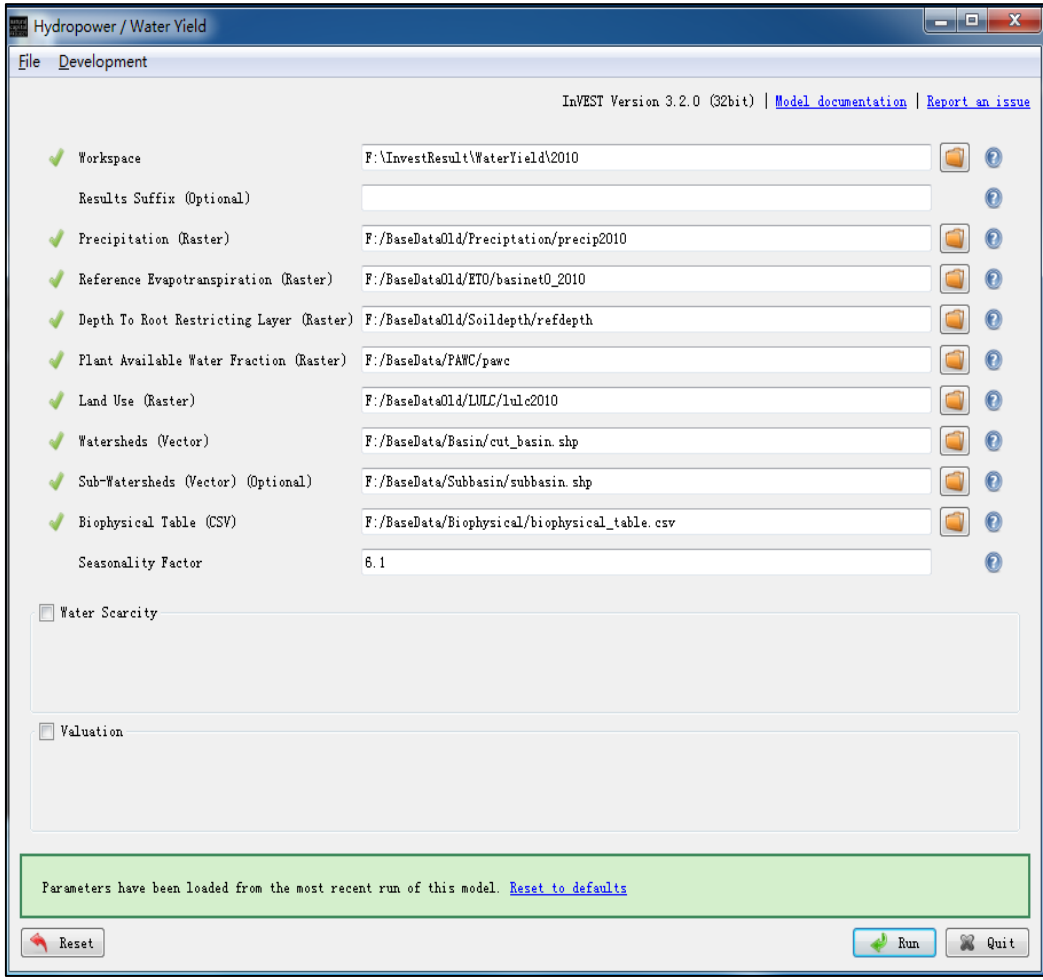


Located in the Yunnan-Guizhou Plateau, concentrated in the eastern Yunnan-Panxi region, and also in western Guizhou, a total of 43 counties and 10 national-level poor counties

Methods



INVEST—Water Yield MODEL



Long-term land use change in the Gabin Basin

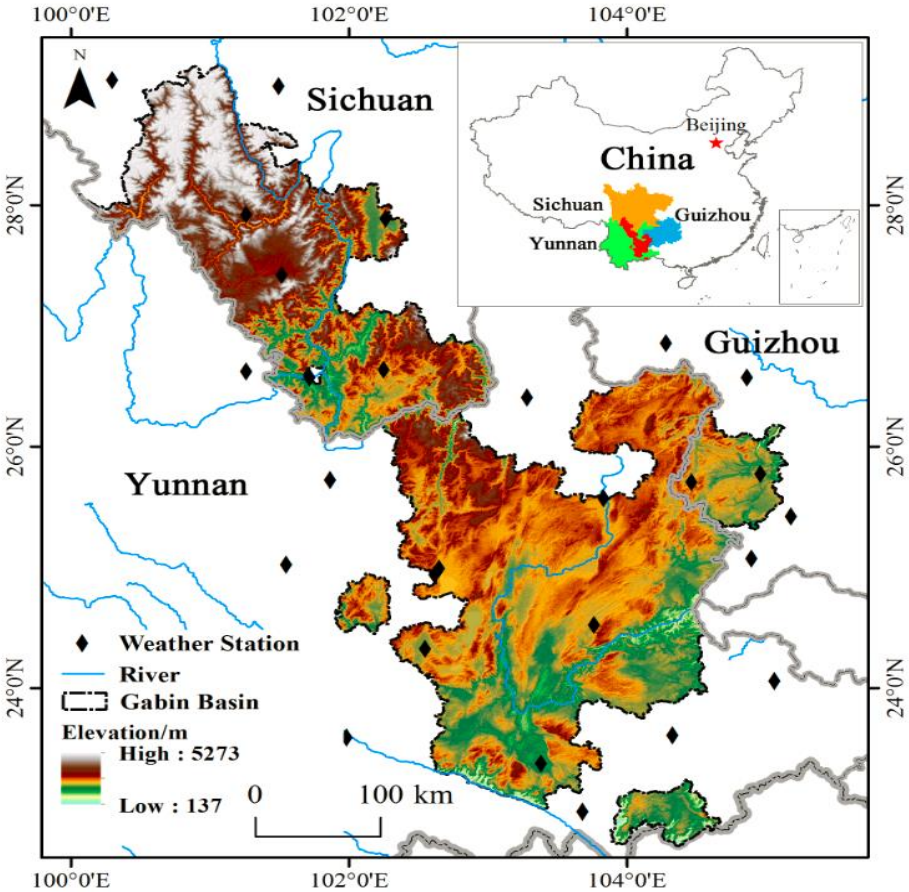
Land use data

Characteristics of degradation and restoration

Degradation (Restoration): Loss (Expansion) of woodland, grassland and water bodies.

Key areas for vegetation restoration?

Typical area identification



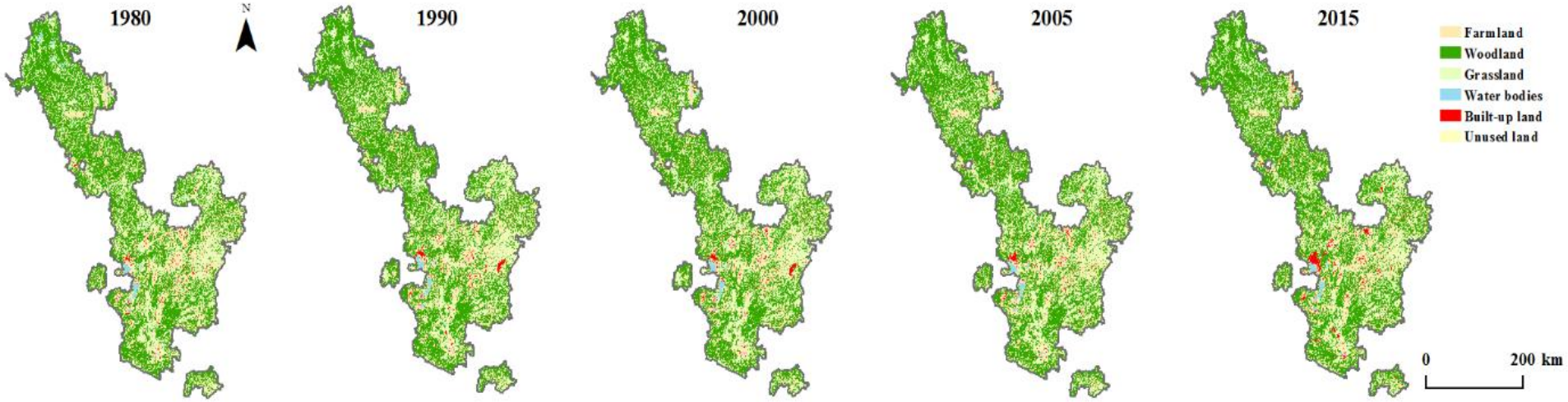
Water Yield at different periods

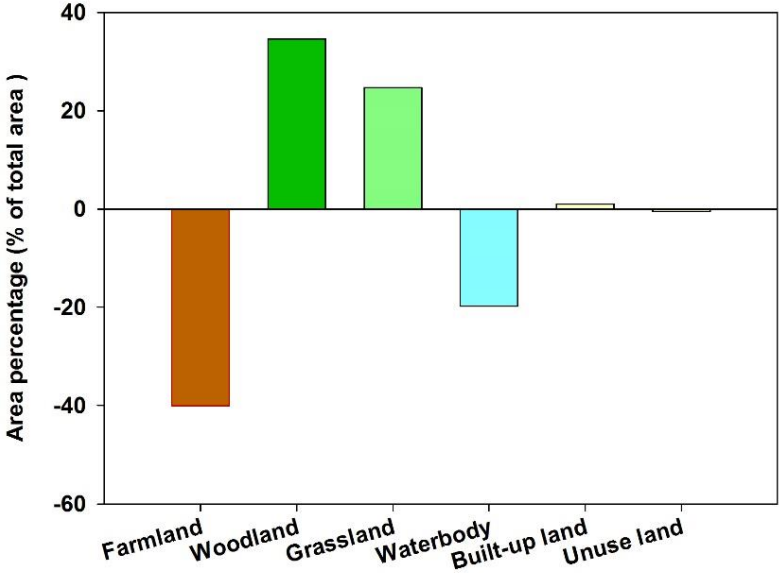
INVEST MODEL

Scientific Questions

Relationship between vegetation restoration and water yield?

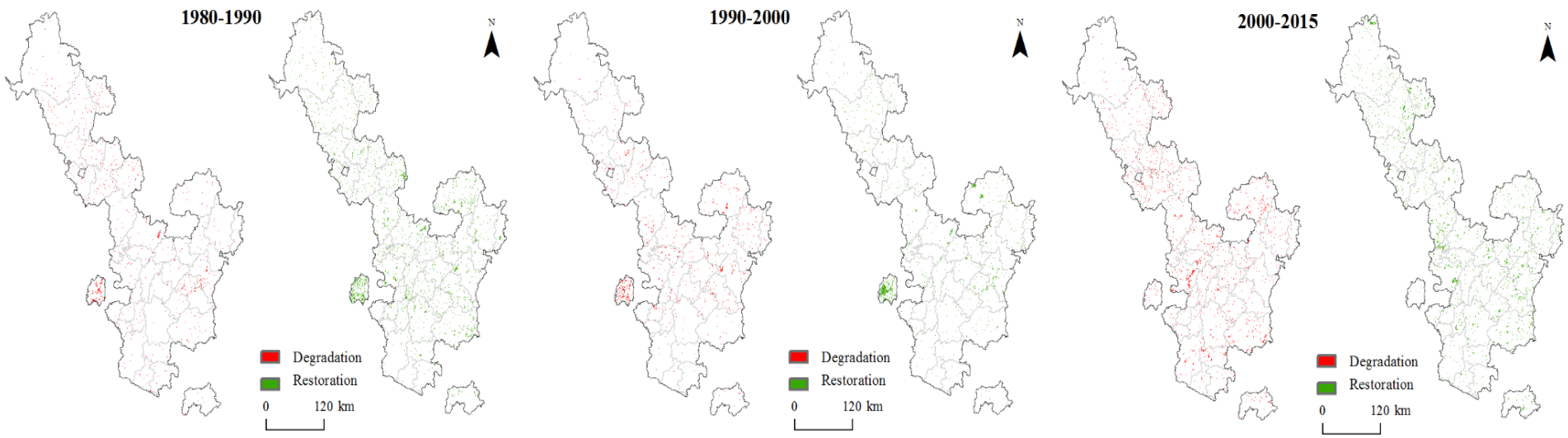
Results

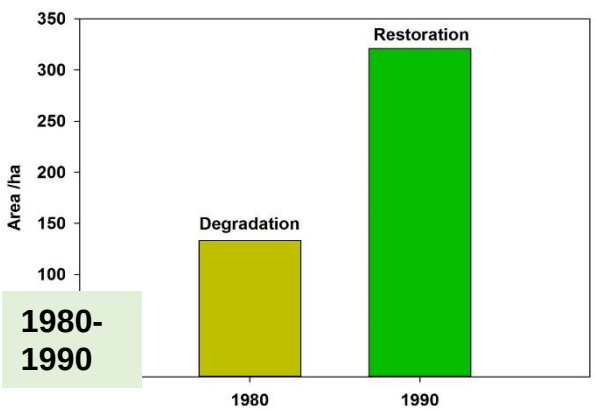


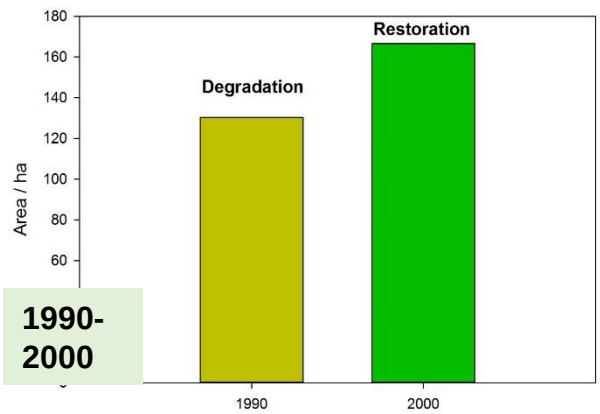


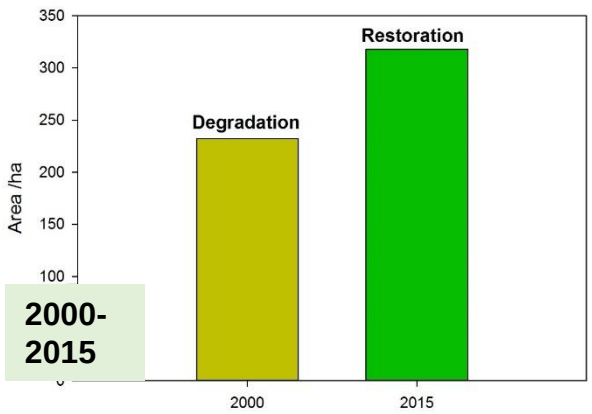
- ✓ Land cover changed dramatically in terms of both spatial pattern and area.
- ✓ Land use type increased most was woodland, followed by Grassland.
- ✓ Cropland decreased by 40%.

Results



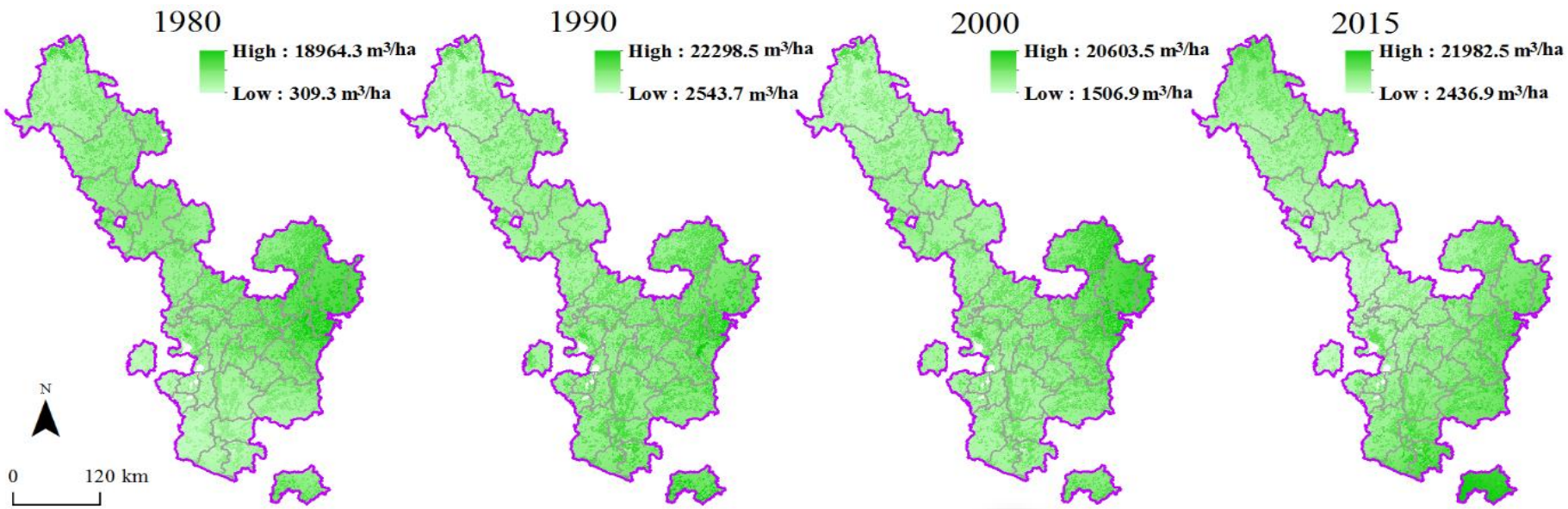




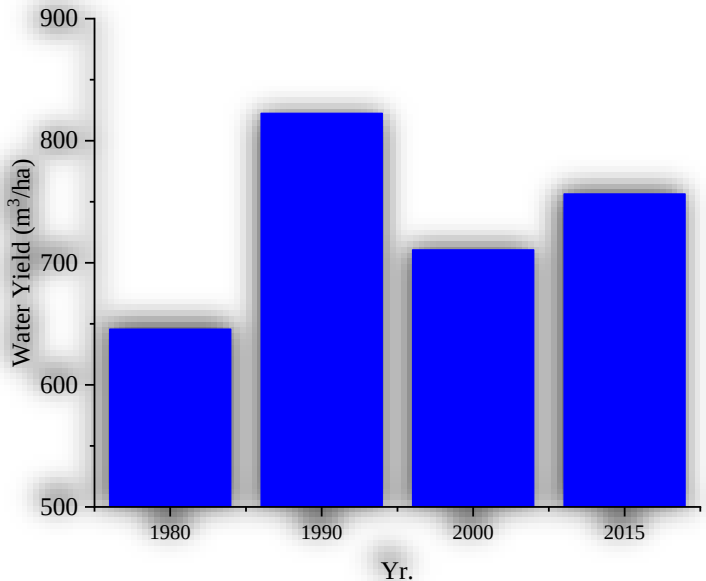


The restoration area is greater than the degraded area at each stage

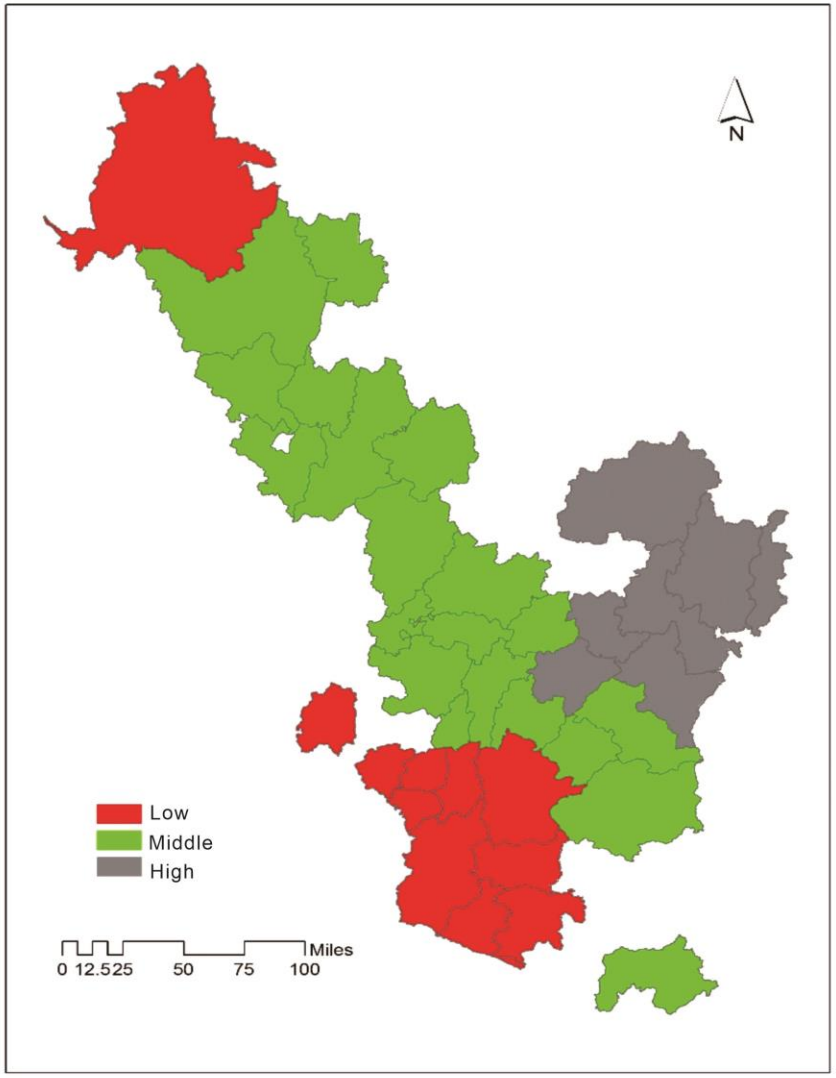
Results



- ✓ **Regional water yield has obvious spatial and temporal characteristics.**
- ✓ **Water yield showed different in different periods.**



Discussion



Ecological function zoning based on water yield

1） Low water yield region

2） High water yield region

3） Middle water yield region

Implication

1） Well vegetated through restoration

2） Strengthen the prevention of erosion

3） Moderate urbanization

Conclusion

- ✓ The Restoration area is greater than the area of degradation in the Karst Gabin Basin after long term vegetation restoration.
- ✓ Regional water yield has obvious spatial and temporal characteristics.
- ✓ Three ecological function zone were divided based on water yield.

Acknowledgements

IWHR

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Thank you for your attention!