Supplementary Data

Drivers and Dynamics of Forest and Grassland Ecosystems in the Altai Mountains: A Framework for National Park Conservation

Introduction

This supporting file includes five figures and two tables.

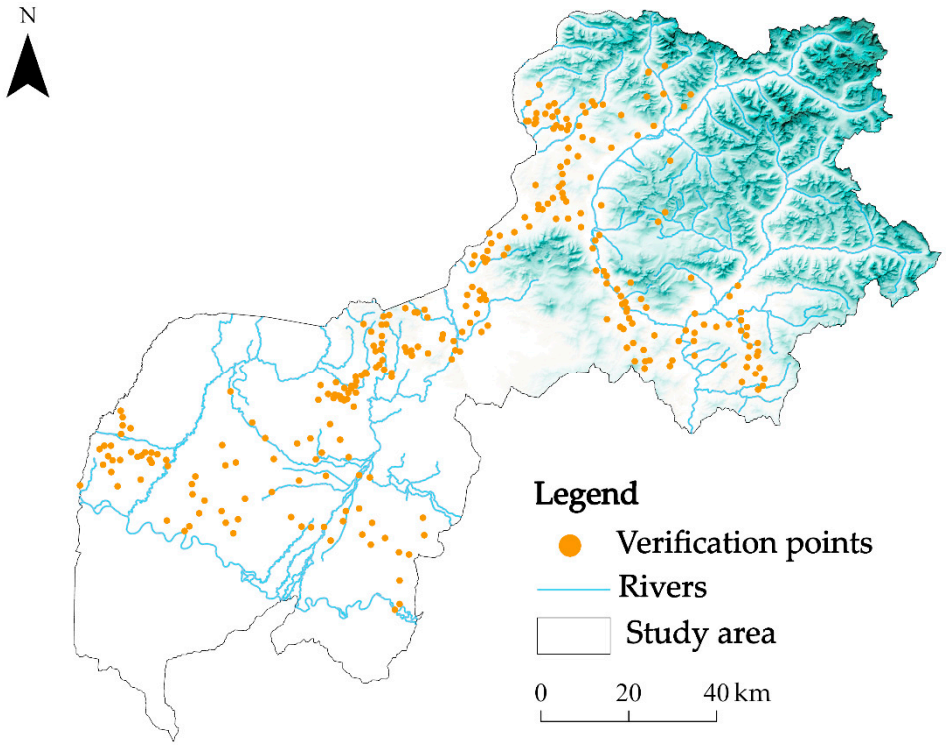

Figure S1. The location of the field verification in the Altai National Park Candidate Area.

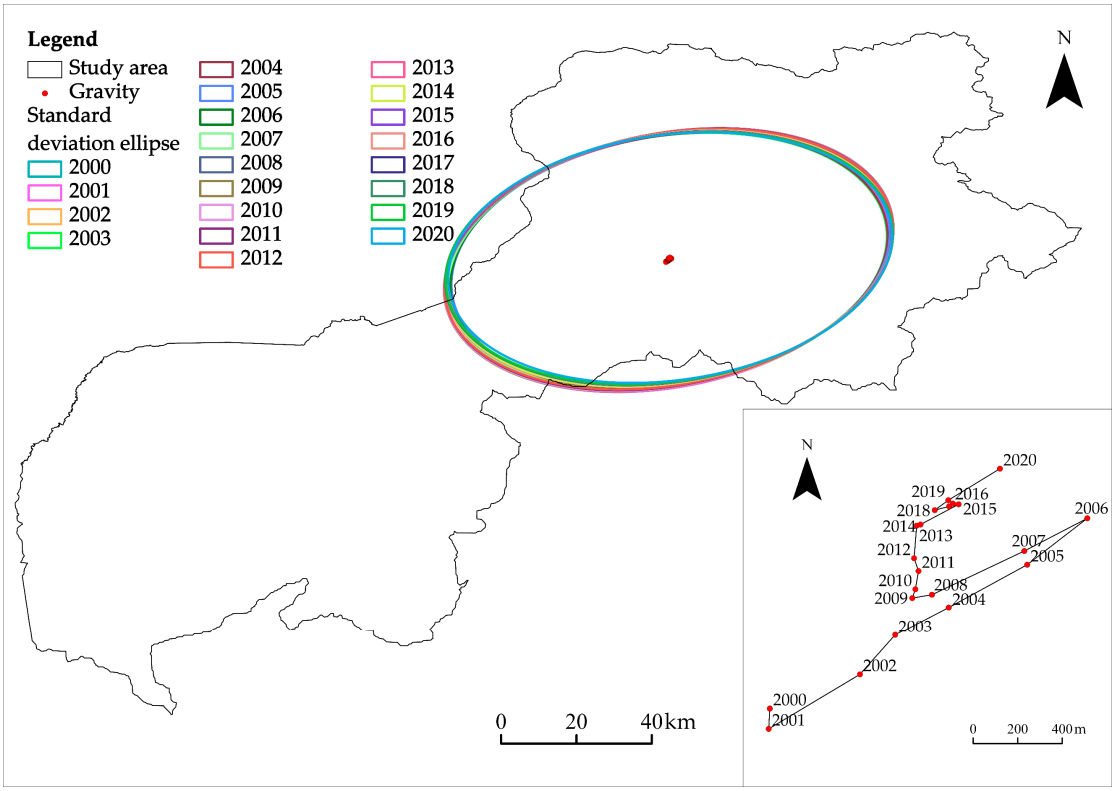

Figure S2. The location of the forest gravity center and the standard deviation ellipse in the Altai National Park Candidate Area from 2000 to 2020.

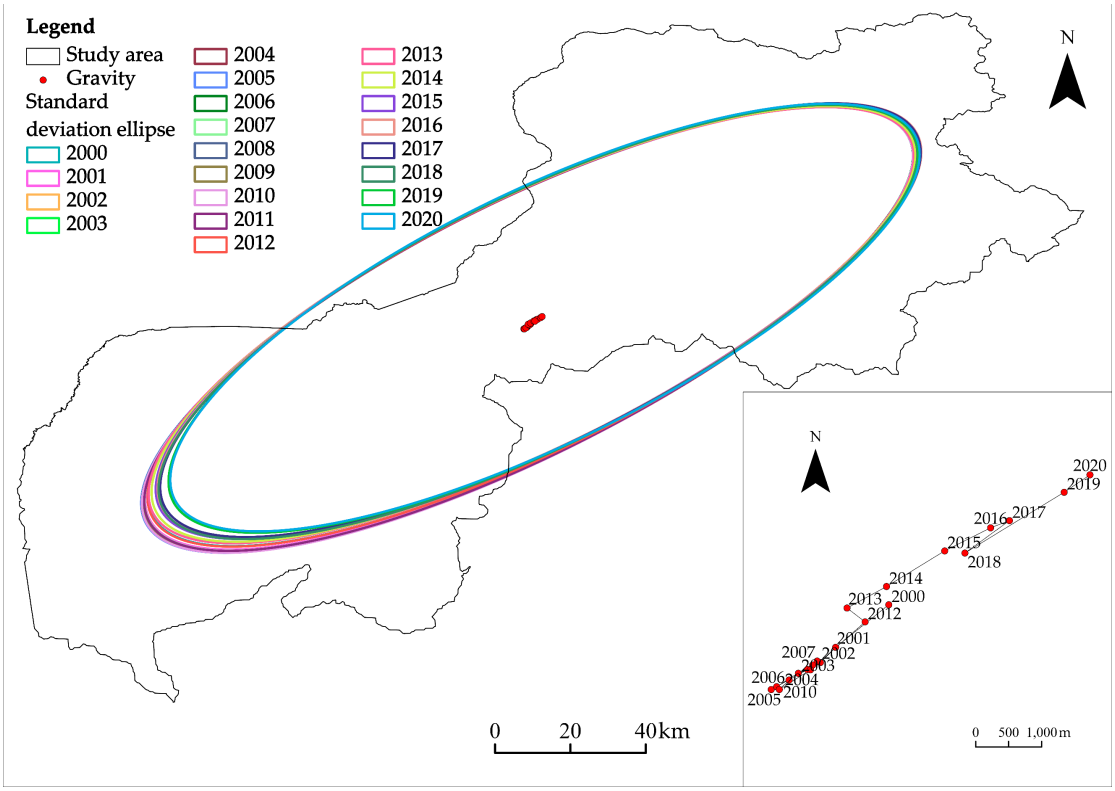

Figure S3. The location of the grassland gravity center and the standard deviation ellipse in the Altai National Park Candidate Area from 2000 to 2020.

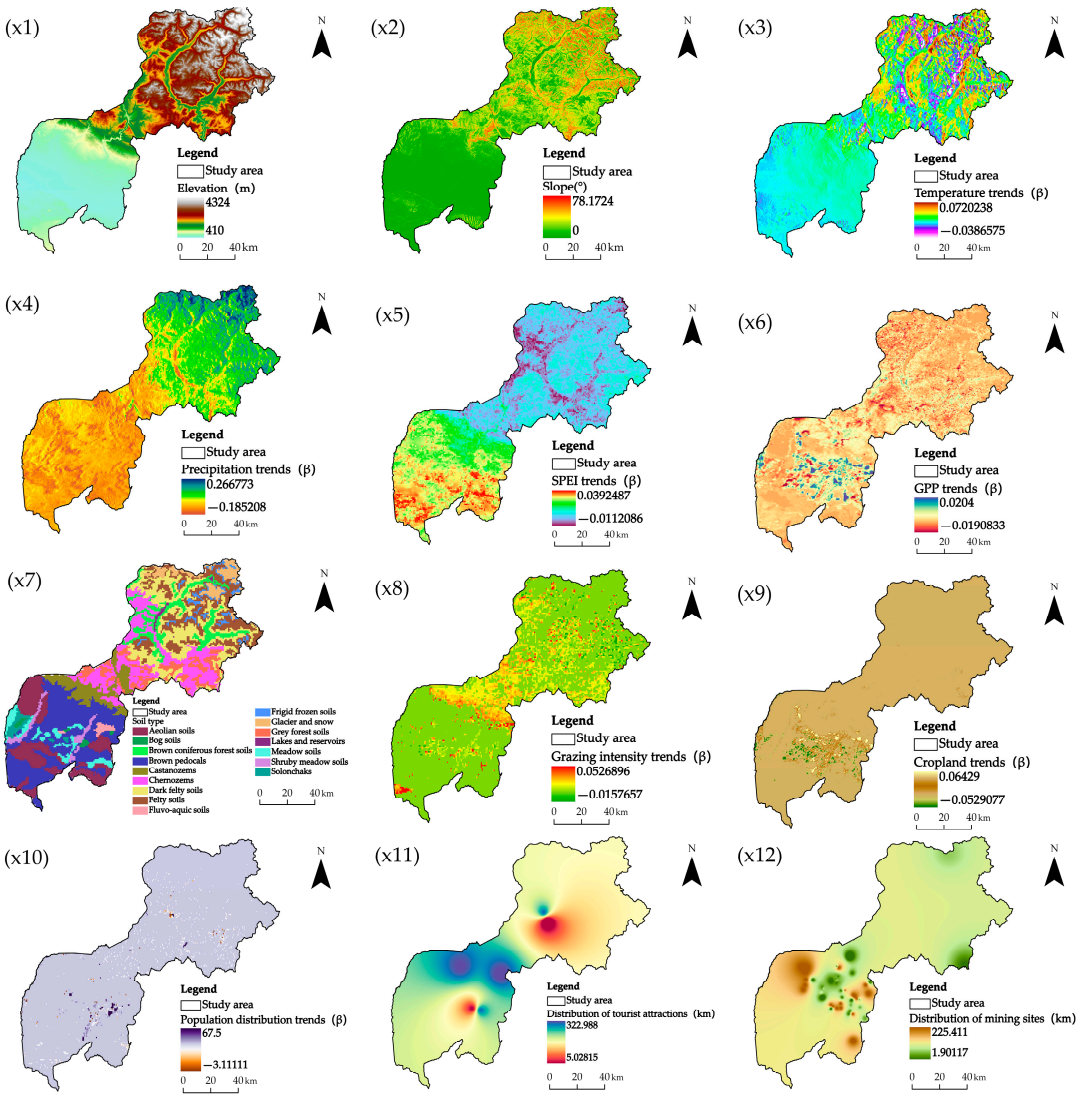

Figure S4. The spatial distributions of all factors (×1: elevation, ×2: slope, ×3: average annual temperature trends, ×4: average annual precipitation trends, ×5: SPEI trends, ×6: GPP trends, ×7: soil type, ×8: grazing intensity trends, ×9: cropland trends, ×10: population distribution trends, ×11: distribution of tourist attractions, ×12: distribution of mining sites).

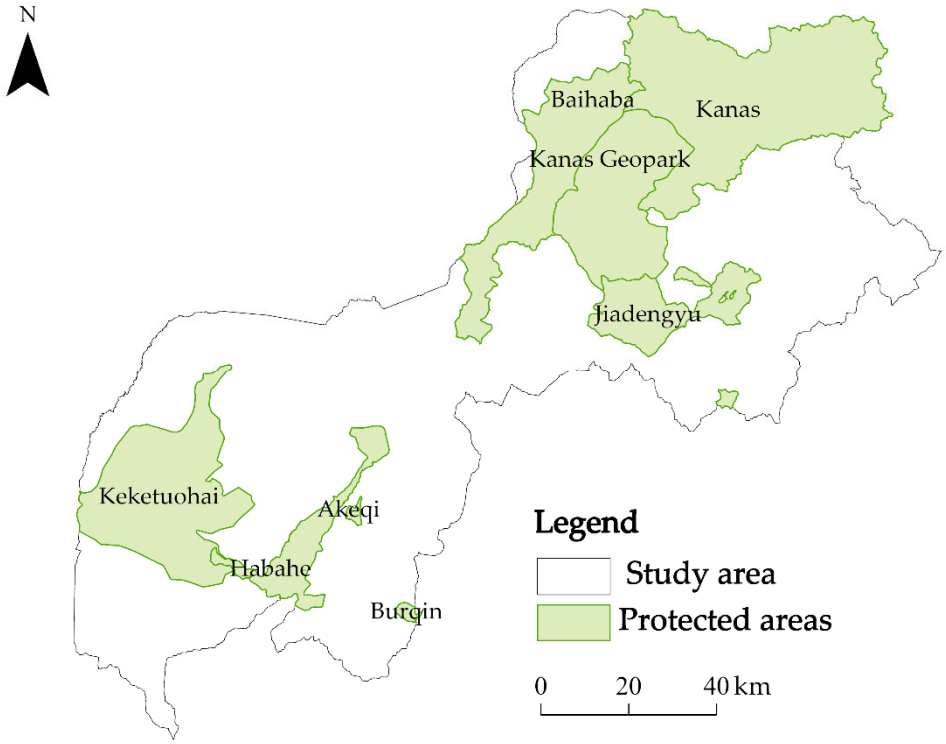

Figure S5. The distribution of protected areas in the Altai National Park Candidate Area (Kanas: Xinjiang Kanas National Nature Reserve. Baihaba: Baihaba National Forest Park. Keketuohai: Irtysh Keketuohai Wetland Nature Reserve. Habahe: Xinjiang Habahe Birch National Forest Park. Jiadengyu: Jiadengyu National Forest Park. Kanas GeoPark: Xinjiang Burqin Kanas Lake National GeoPark. Akeqi: Xinjiang Habahe Akeqi National Wetland Park. Burqin: Xinjiang Burqin National GeoPark).

Table S1. Data source of driving factors.

Data	Spatial Resolution (m)	Time Resolution (year)	Sources
Elevation	30	\	Digital Elevation Model (DEM) jointly surveyed by National Aeronautics and Space Administration and the National Imaging and Mapping Agency (https://cmr.earthdata.nasa.gov/, accessed on 16 February 2024)
Slope	30	\	Slope data were generated in ArcGIS Pro by calculating the slope using the DEM
Temperature	1000	2000–2020	National Tibetan Plateau Data Center (https://data.tpdc.ac.cn/, accessed on 16 February 2024)
Precipitation	1000	2000–2020	National Tibetan Plateau Data Center (https://data.tpdc.ac.cn/, accessed on 16 February 2024)
SPEI	1000	2001–2020	Standardized Precipitation Evapotranspiration Index (SPEI) from the National Ecosystem Science Data Center & Science Data Bank (https://ecodb.scidb.cn/, accessed on 20 February 2024)
GPP	500	2000–2020	Gross Primary Productivity (GPP) from the Google Earth Engine (GEE) (https://earthengine.google.com/, accessed on 16 February 2024)
Soil type	1000	\	Resource and Environmental Science Data Platform (https://www.resdc.cn/, accessed on 16 February 2024)
Grazing intensity	1000	2000–2020	National Earth Observation Data Center (https://noda.ac.cn/, accessed on 22 February 2024)
Cropland trends	500	2000–2020	The percentage of cultivated land for each year from 2000 to 2020 within the study area, as recorded in the CLCD, was extracted using ArcGIS Pro. Theil-Sen Median trend analysis was then applied to assess the trend in cultivated land change over this period.
Population distribution	1000	2000–2020	LandScan Global Population Distribution Data (https://landscan.ornl.gov/, accessed on 16 February 2024)
Distribution of tourist attractions	500	\	The list of Class A scenic spots, published by the Department of Culture and Tourism of Xinjiang, was analyzed using the inverse distance weighting (IDW) method in ArcGIS Pro
Distribution of mining sites	500	\	The 2021 version of the National Mineral Properties Database (http://ngac.org.cn/, accessed on 16 February 2024) was analyzed using the inverse distance weighting (IDW) method in ArcGIS Pro

Table S2. Results of PSM for average treatment effect on the treated (ATT) in protected areas during 2000–2020.

Variable	ATT	Std.err.	z	$p > \|z\|$	[95% Conf. Interval]		Treated	Controls	Difference %
Forest loss (m^2)	−1168.6844	251.9778	−4.64	<0.01	−1662.5520	−674.8171	−4862.3589	−3693.6744	−31.6402
Grassland loss (m^2)	3007.4244	758.9616	3.96	<0.01	1519.8870	4494.9620	21,485.1411	18,477.7167	16.276

Note: ATT represents the "average treatment effect on the treated" in protected areas, specifically the estimated average effect of established protected areas in mitigating forest and grassland loss between 2000 and 2020. A p-value < 0.01 indicates statistical significance. A significantly negative ATT suggests that the establishment of protected areas effectively reduces ecosystem loss.