

The background of the slide is a deep blue gradient. In the center, there is a faint, semi-transparent image of the Earth as seen from space, showing blue oceans and white cloud patterns. The text is overlaid on this background.

Distribution and Changes Of Different Grassland Types and Their NPP of North America, Europe , Australia and China in 1911-2000

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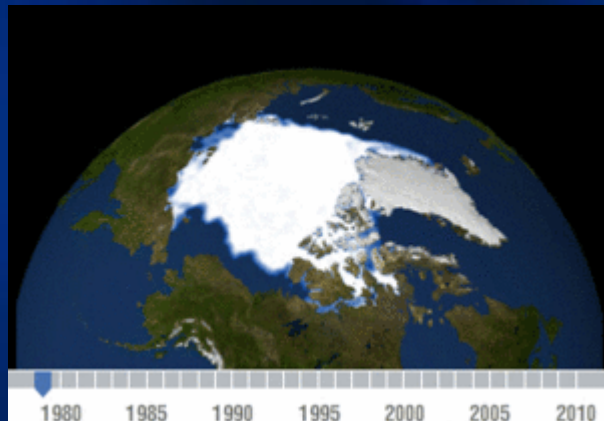
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Introduction

The area of global grassland is estimated at 52.5 million square kilometers, which accounts for 16.4% of the global terrestrial ecosystem. Grassland vegetation has significant impact on global climate change and carbon cycle. So it is of highly significance to study the grassland classification and NPP of different types at a global scale.



Methodology

❖ 1. Potential Natural Vegetation(PNV)

PNV maps express hypothetical assumptions of what corresponds to dominant or natural vegetation in each area. PNV has been used extensively in several European countries since the mid-1950s and was intended to be used to make a prediction of what vegetation would dominate in an area if human influence were removed.



❖ *2. The Comprehensive and Sequential Classification System (CSCS),*

As a bioclimatology-based vegetation classification approach, it is to study the characteristic of global PNV distribution.



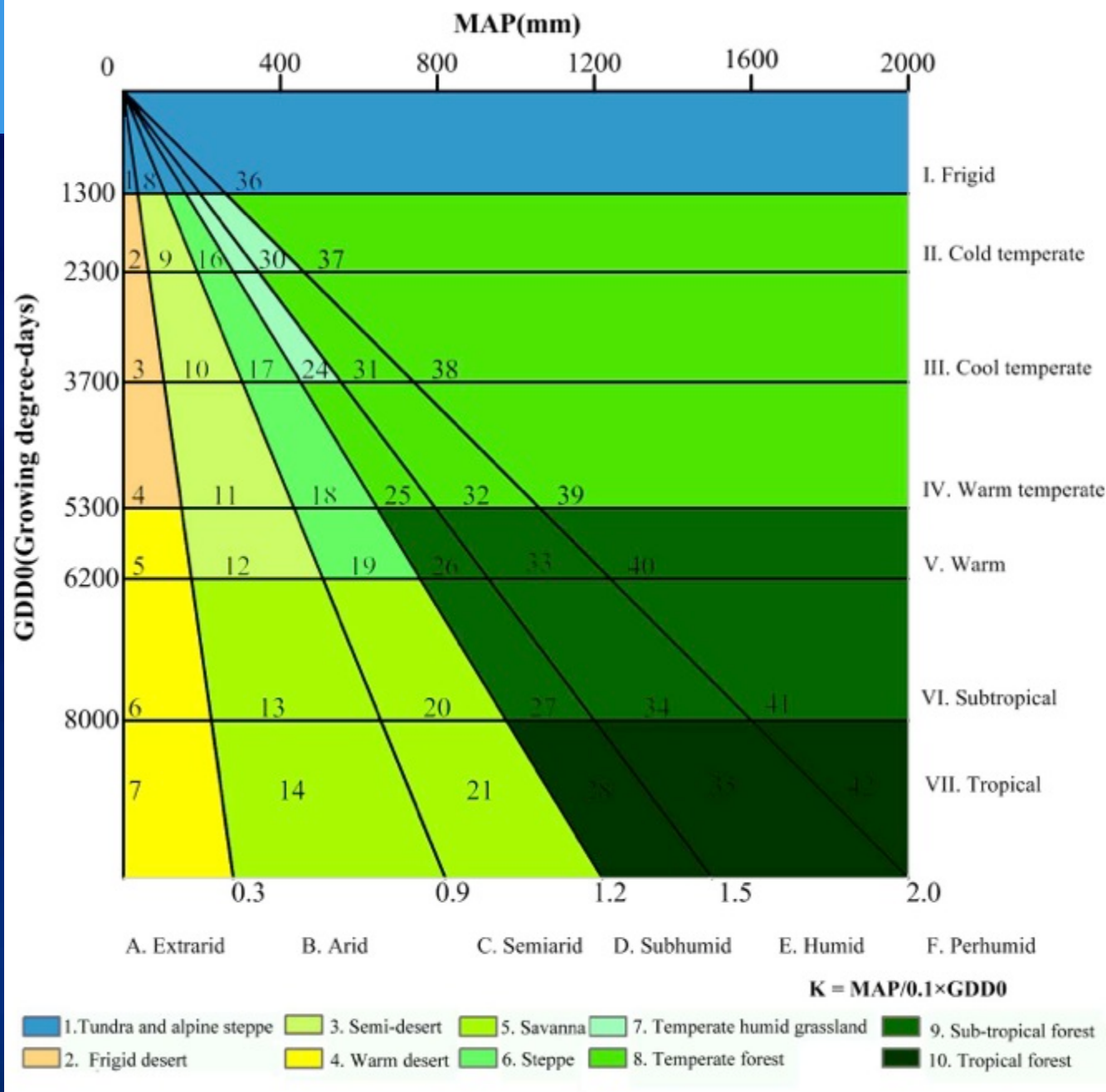


Fig.1. Index chart for determining PNV class and broad category in the CSCS model

Table. 1 The 8 broad CSCS PNV categories and 42 classes

Name of broad category	Name of class
<i>Tundra & alpine steppe</i>	<i>Frigid-extrarid frigid desert & alpine desert, Frigid-arid frigid zonal semidesert, alpine semidesert, Frigid-semiarid dry tundra, alpine steppe, Frigid-subhumid moist tundra, alpine meadow steppe, Frigid-humid tundra, alpine meadow, Frigid perhumid rain tundra, alpine meadow</i>
<i>Frigid desert</i>	<i>Cold temperate-extrarid montane desert, Cool temperate-extrarid temperate zonal desert, Warm temperate-extrarid warm temperate zonal desert</i>
<i>Semi-desert</i>	<i>Cold temperate-arid montane semidesert, Cool temperate-arid temperate zonal semidesert, Warm temperate-arid warm temperate zonal semidesert, Warm-arid warm subtropical semidesert</i>
<i>Warm desert</i>	<i>Warm-extrarid subtropical desert, Subtropical-extrarid subtropical desert, Tropical extrarid tropical desert</i>
<i>Savanna</i>	<i>Subtropical arid subtropical desert brush, Tropical arid tropical desert brush, Subtropical-semiarid subtropical brush steppe, Tropical-semiarid savanna, Tropicalsubhumid tropical xerophytic forest</i>
<i>Steppe</i>	<i>Cold temperate-semiarid montane steppe, Cool temperate-semiarid temperate typical steppe, Warm temperate-semiarid warm temperate typical steppe, Warm-semiarid subtropical grasses-fruticous steppe</i>
<i>Temperate humid grassland</i>	<i>Cold temperate-humid montane meadow, Cool temperate-subhumid meadow steppe, Cold temperate-humid montane meadow, Cool temperate-humid forest steppe, deciduous broad leaved forest</i>
<i>Forest, including temperate forest, sub-tropical forest and tropical forest</i>	<i>Warm temperate-subhumid forest steppe, Warm temperate-humid deciduous broad leaved forest, Warm temperate perhumid deciduous broad leaved forest, Cool temperate perhumid mixed coniferous broad leaved forest, Cold temperate perhumid taiga forest, Warm-subhumid deciduous broad leaved forest, Subtropical-subhumid sclerophyllous forest, Warm-humid evergreen-deciduous broad leaved forest, Subtropical-humid evergreen broad leaved forest, Warm-perhumid deciduous-evergreen broad leaved forest, Subtropical perhumid evergreen broad leaved forest, Tropical-humid seasonal rain forest, Tropical perhumid rain forest</i>



❖ 3. NPP models

3.1 Miami model (*Lieth, 1975*)

3.2 Schuur model (*Schuur, 2003*)

3.3 Thornthwaite Memorial model (*Lieth and Box, 1972*)



Meteorology Data:

Monthly precipitation and mean temperature grid data ($0.5^\circ \times 0.5^\circ$ resolution) for every 10 years from the Climate Research Unit (CRU) global climate dataset (*Mitchell et al., 2005*) was used in this study to produce global PNV maps based on the CSCS.



Results

- ❖ 1. The PNV distribution and changes at global scale and North American, Europe, Australia and China using CSCS method (in the period of 1911-2000)
- ❖ 2. NPP of different grassland types at global scale and North American, Europe, Australia and China (in the period of 1911-2000)



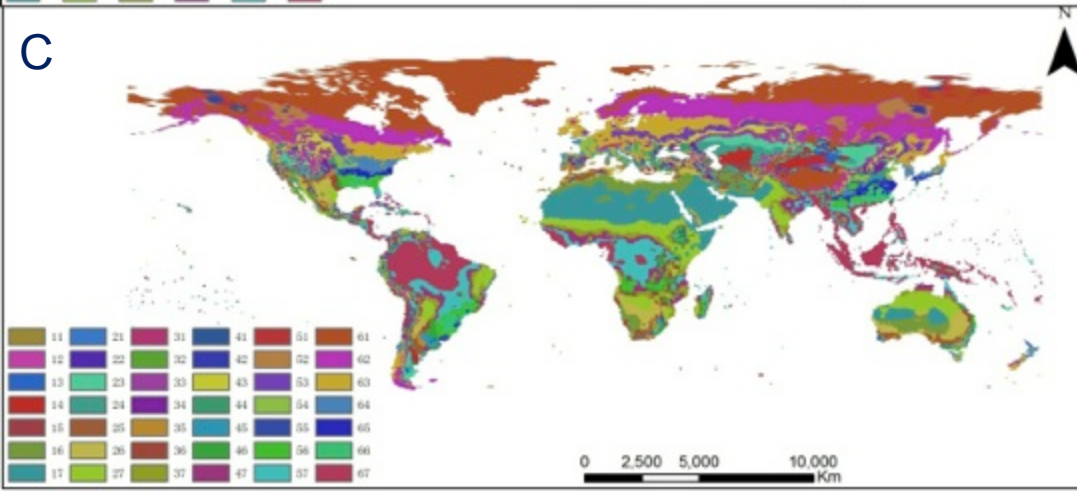
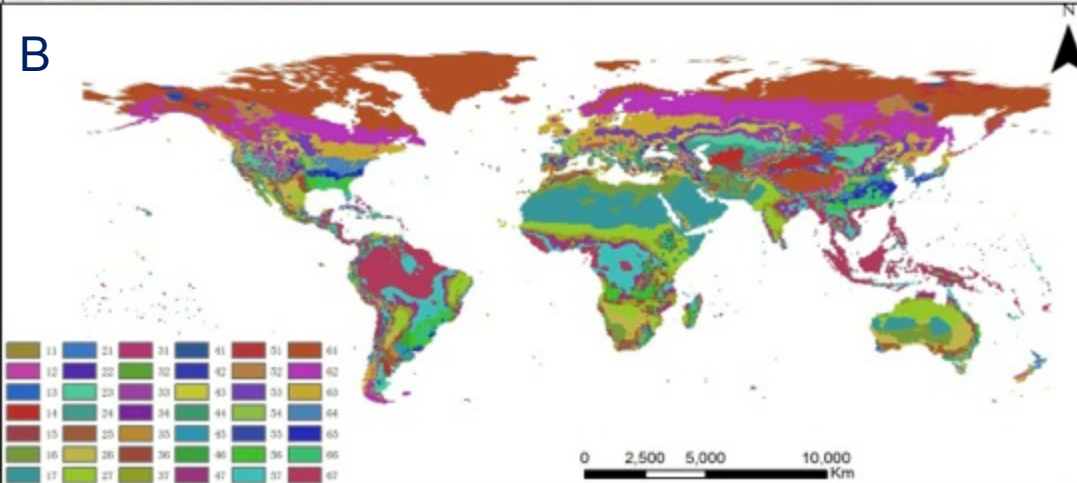
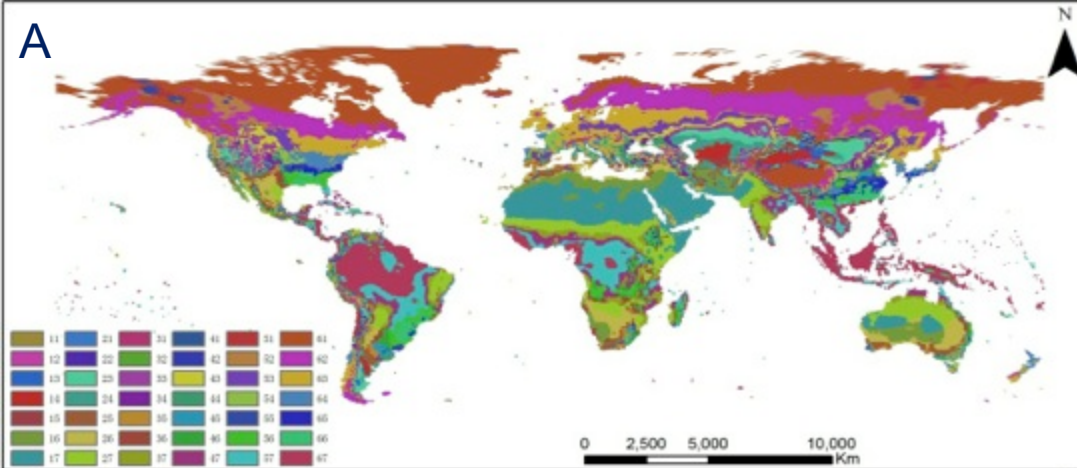


Fig. 2 The distribution of PNV 42 classes in the world (A:11-40; B:41-70; C: 71-00)



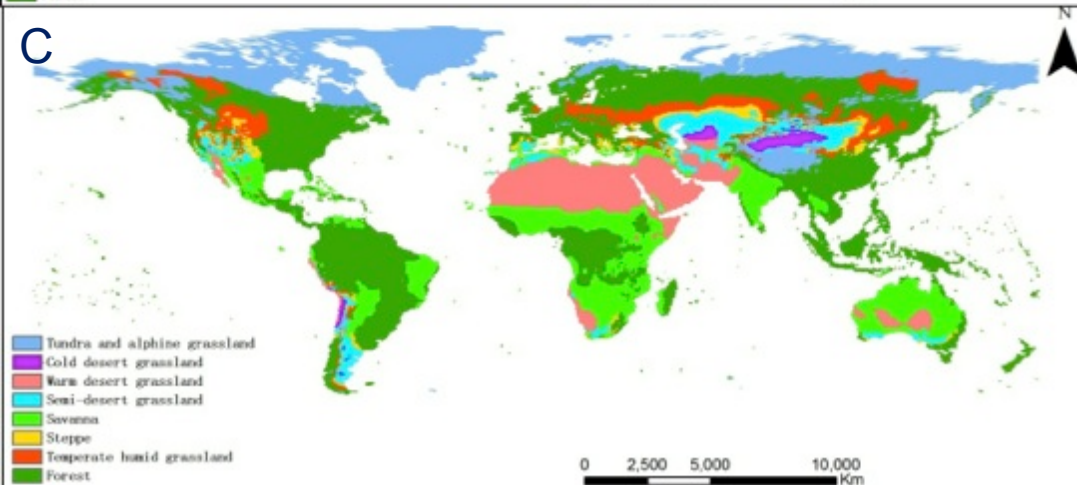
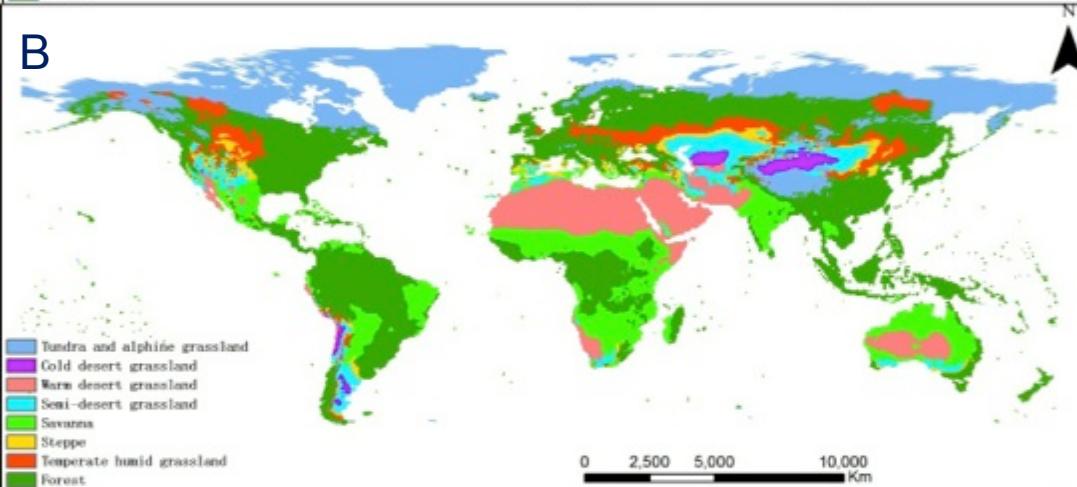
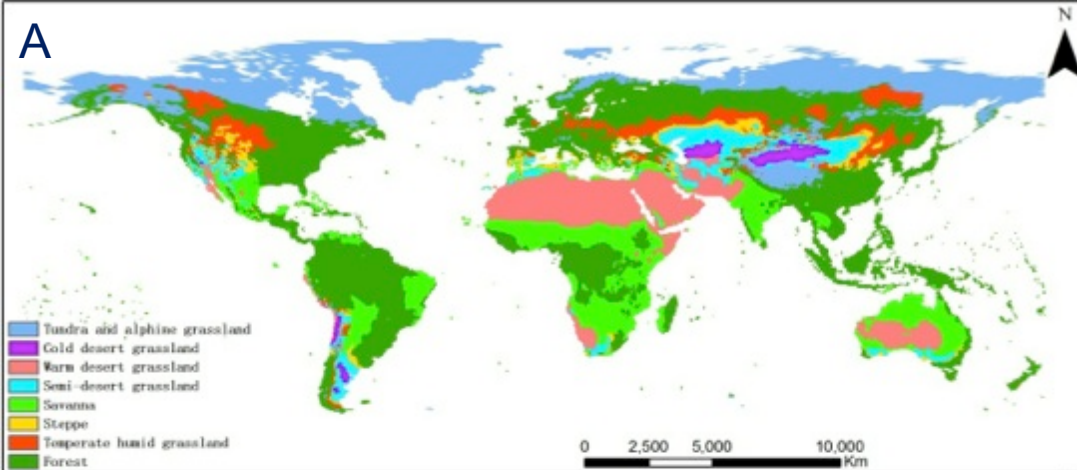


Fig. 3 The distribution of PNV 8 broad categories in the world (A:11-40; B:41-70; C:71-00)



Table 2 The area variation for the 8 broad vegetation categories in the periods 1911-1940(T1), 1941-1970(T2) and 1971-2000(T3) at global scale

Spatial scale	Broad vegetation category	Area (10 ⁴ km ²) in different periods			Variation rate (%)		
		T1	T2	T3	T1 to T2	T2 to T3	T1 to T3
Globe	Tundra and alpine steppe	1730.03	1693.13	1642.03	-2.13	-3.02	-5.09
	Cold desert	209.70	212.64	173.91	1.40	-18.21	-17.07
	Semi-desert	793.95	761.16	782.03	-4.13	2.74	-1.50
	Warm desert	1877.70	1842.70	1767.00	-1.86	-4.11	-5.90
	Steppe	445.61	403.36	403.84	-9.48	0.12	-9.37
	Savanna	1924.74	1943.23	2117.98	0.96	8.99	10.03
	Temperate humid grassland	504.24	449.47	460.84	-10.86	2.53	-8.61
	Forest	5988.11	6168.38	6126.42	3.01	-0.68	2.31

At global scale, over the last 90 years from 1911 to 2000 the area of tundra and alpine steppe and desert decreased by 5.09% and 5.82%, while the area of forest and grassland increased by 2.31% and 3.62%, respectively. However, there was a significant difference in the magnitude of area change for the same vegetation category in northern and southern hemispheres in the entire study period.



Table 3 The area variation for the 8 broad vegetation categories in the periods 1911-1940(T1), 1941-1970(T2) and 1971-2000(T3) in the northern hemisphere

Spatial scale	Broad vegetation category	Area (10 ⁴ km ²) in different periods			Variation rate (%)		
		T1	T2	T3	T1 to T2	T2 to T3	T1 to T3
Northern	Tundra and alpine steppe	1716.84	1681.92	1629.90	-2.03	-3.09	-5.06
Hemi-sphere	Cold desert	173.49	175.16	151.78	0.96	-13.35	-12.52
	Semi-desert	628.64	591.62	620.37	-5.89	4.86	-1.32
	Warm desert	1547.45	1535.91	1577.29	-0.75	2.69	1.93
	Steppe	381.21	342.75	345.48	-10.09	0.80	-9.37
	Savanna	930.50	938.46	992.98	0.86	5.81	6.71
	Temperate humid grassland	486.10	431.45	443.75	-11.24	2.85	-8.71
	Forest	4145.42	4312.38	4248.12	4.03	-1.49	2.48

Table 4 The area variation for the 8 broad vegetation categories in the periods 1911-1940(T1), 1941-1970(T2) and 1971-2000(T3) in the southern hemisphere

Spatial scale	Broad vegetation category	Area (10 ⁴ km ²) in different periods			Variation rate (%)		
		T1	T2	T3	T1 to T2	T2 to T3	T1 to T3
Southern Hemisphere	Tundra and alpine steppe	13.19	11.20	12.14	-15.08	8.36	-7.98
	Frigid desert	36.21	37.48	22.13	3.51	-40.94	-38.87
	Semi-desert	165.31	169.54	161.66	2.56	-4.65	-2.20
	Warm desert	330.25	306.80	189.71	-7.10	-38.16	-42.55
	Steppe	64.40	60.61	58.36	-5.89	-3.71	-9.38
	Savanna	994.24	1004.77	1125.00	1.06	11.97	13.15
	Temperate humid grassland	18.14	18.02	17.09	-0.66	-5.14	-5.76
	Forest	1842.69	1856.01	1878.32	0.72	1.20	1.93

The area decreasing rate of tundra and alpine steppe and desert in the northern hemisphere (5.06%) was smaller than that in the southern hemisphere (7.98%), while the increasing rate of forest in the northern hemisphere (2.48%) was larger than that in the southern hemisphere (1.93%). The area of decreasing rate of steppe is similar in the northern (9.37%) and southern hemisphere (9.38%), but the area of savanna increased strongly in the southern hemisphere (13.15%), with 6.71% increase in northern hemisphere.



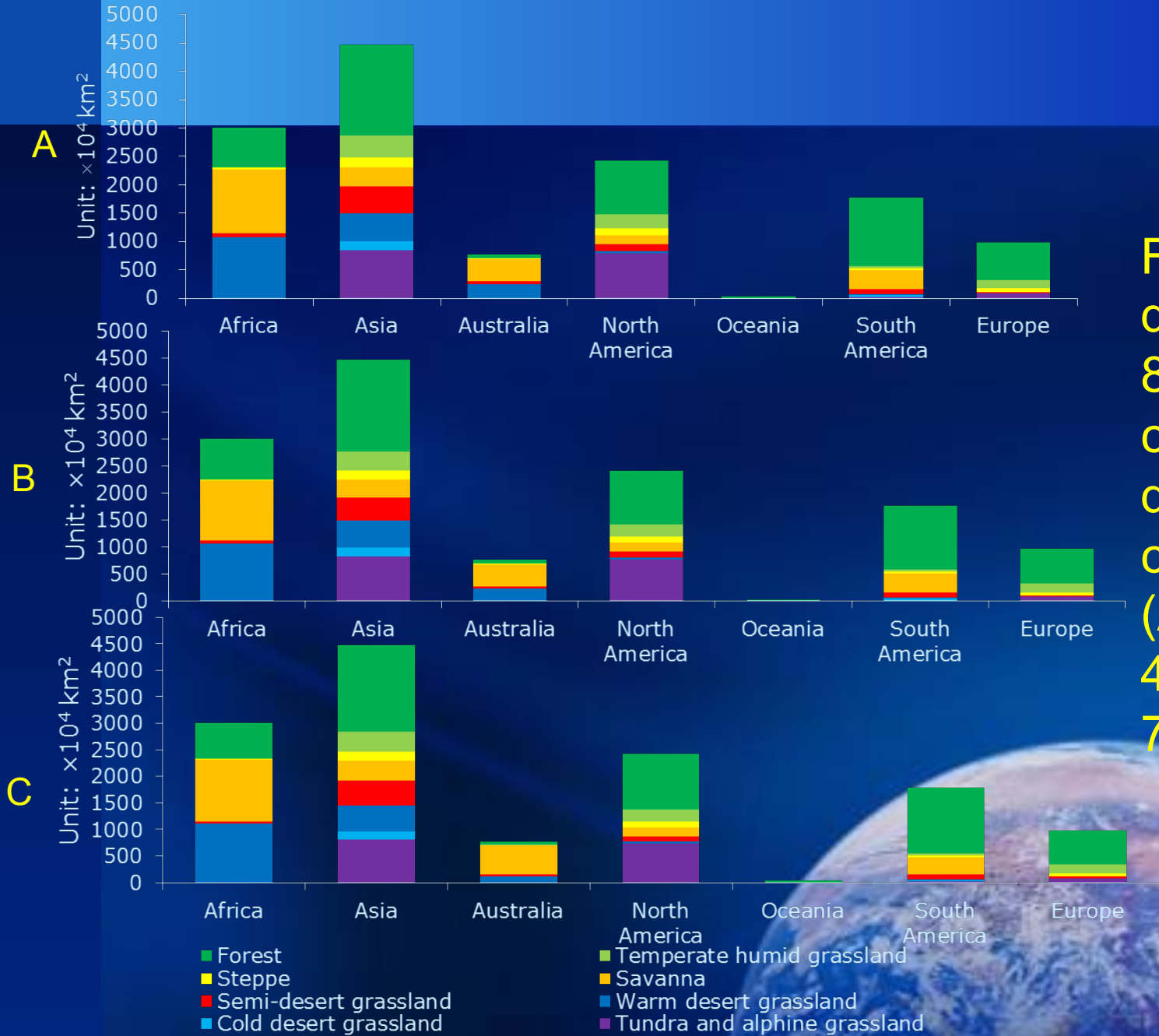


Fig. 4 The distribution of 8 broad categories in different continents (A:11-40; B: 41-70; C: 71-00)

Table 5. The variation rate of 8 broad categories in different continents from 1911-2000
 (“-” means decrease, %)

	Africa	Asia	Australia	North America	Oceania	South America	Europe
Tundra and alpine	0	-3.25	0	-7.45	0	-9.26	-3.87
Cold desert	0	-13.2	0	-88.89	0	-40.54	0
Warm desert	1.87	1.27	-55.44	-7.94	0	2.82	0
Semi-desert	-14.29	0.59	-11.05	-15.12	0	11.11	22.64
Savanna	2.23	9.46	37.08	4.04	-100	-4.73	35.71
Steppe	-16.83	-4.23	-16.36	-14.07	0	-8.39	-10.88
Temperate humid grassland	0	-2.19	100	-4.64	-33.33	-4.59	15.76
Forest	-4.61	1.57	2.42	10.73	1.23	2.14	-3.14

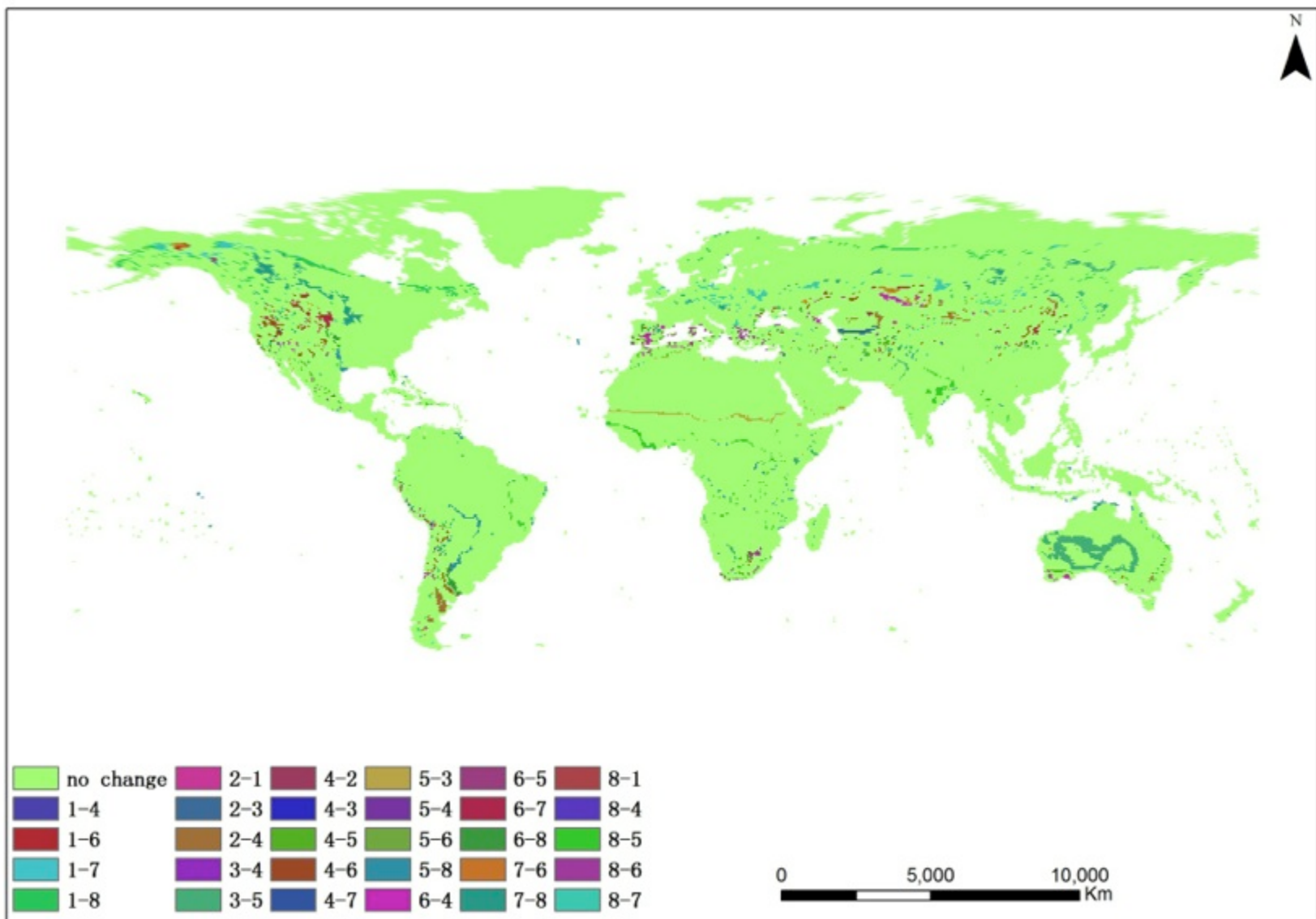


Fig. 5 Conversion of different PNV categories from 1911 to 2000
 1. Tundra and alpine grassland 2. cold desert 3. warm desert 4. semi-desert 5. Savanna 6. Steppe 7. Temperate humid grassland 8. Forest

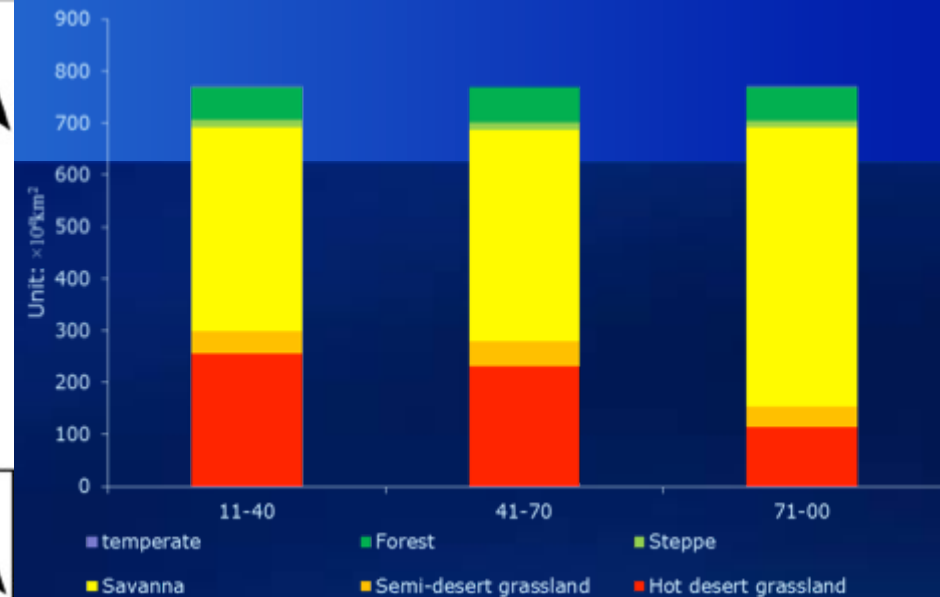
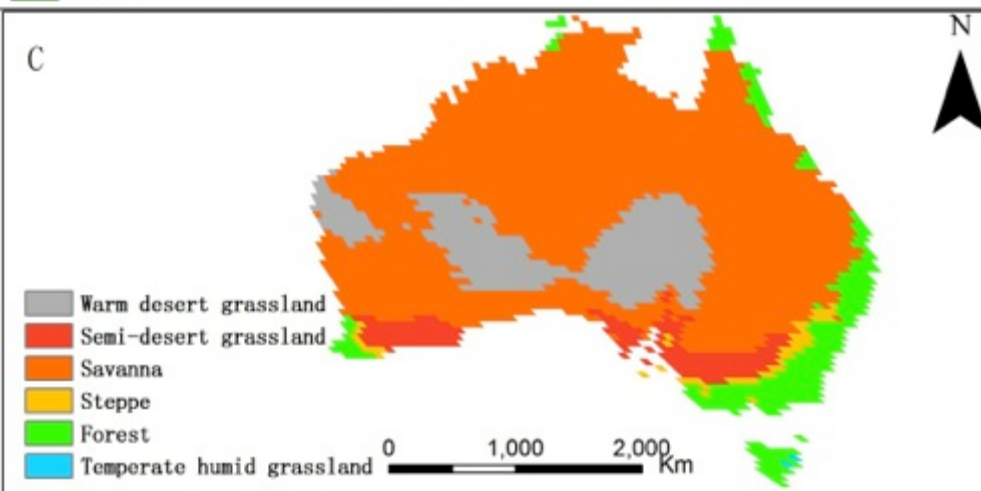
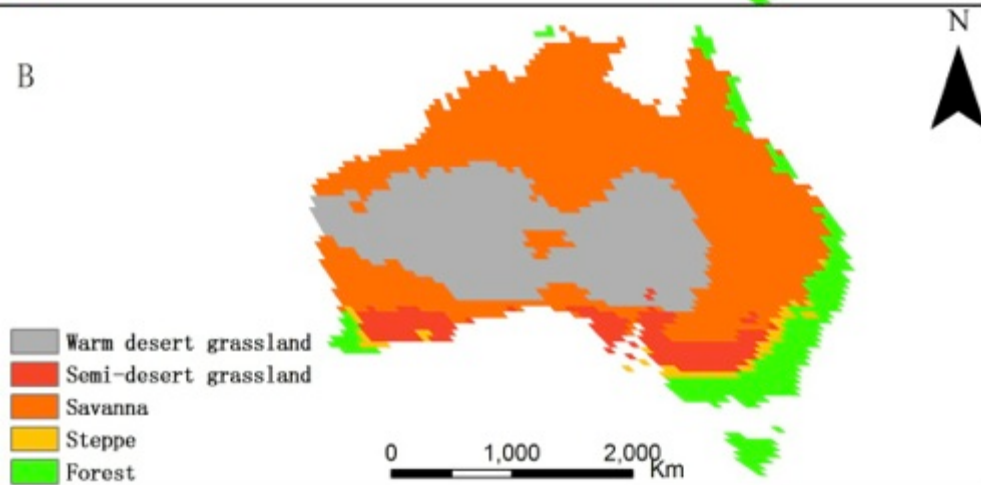
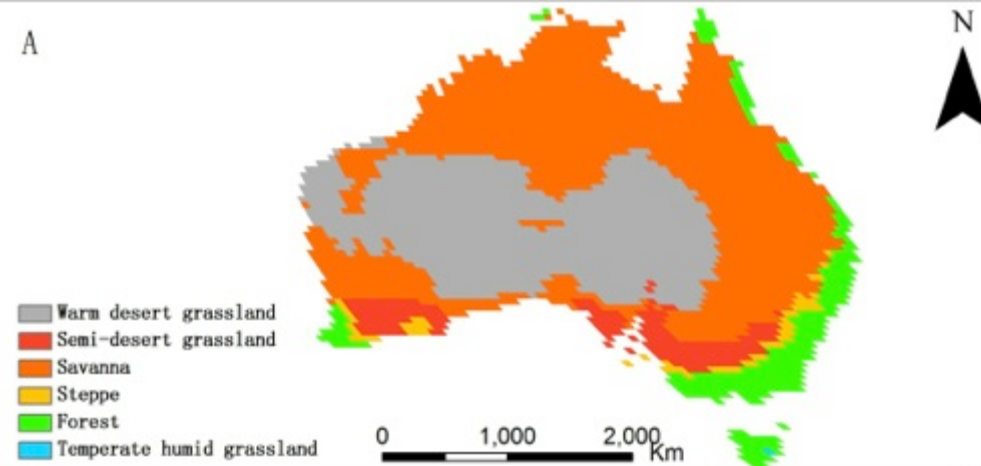


Fig. 6 The areas of PNV 8 broad categories in Australia (A:11-40; B:41-70; C:71-00)

From 1911 to 2000, the area of warm desert decreased by $140.75 \times 10^4 \text{ km}^2$, while the area of savanna increased by $145.75 \times 10^4 \text{ km}^2$, and the semi-desert and steppe decreased by $4.25 \times 10^4 \text{ km}^2$ and $2.75 \times 10^4 \text{ km}^2$, and the area of forest increased by $1.75 \times 10^4 \text{ km}^2$.

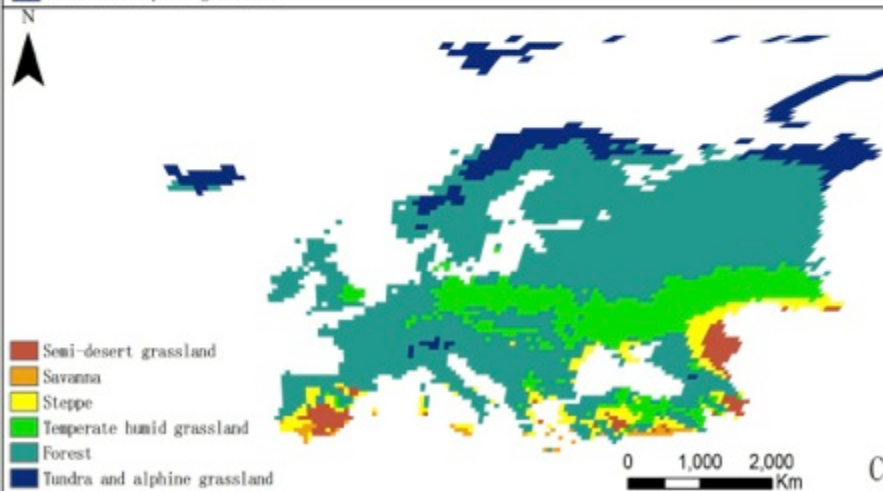
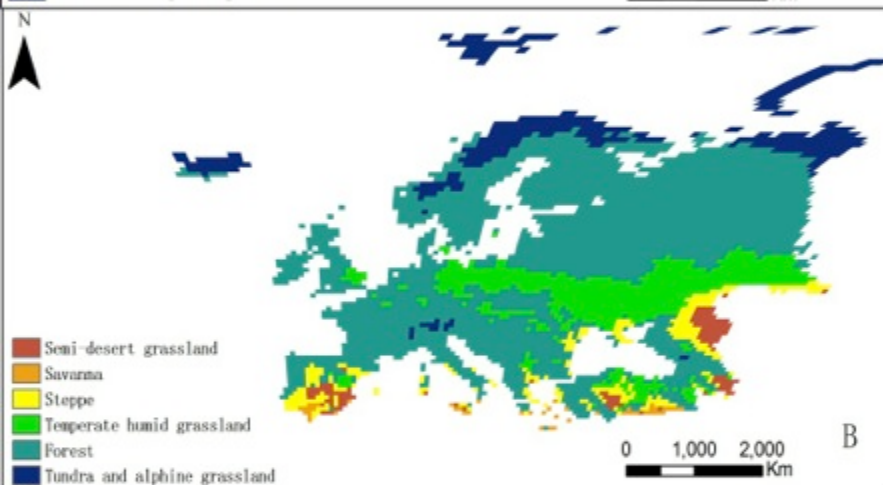
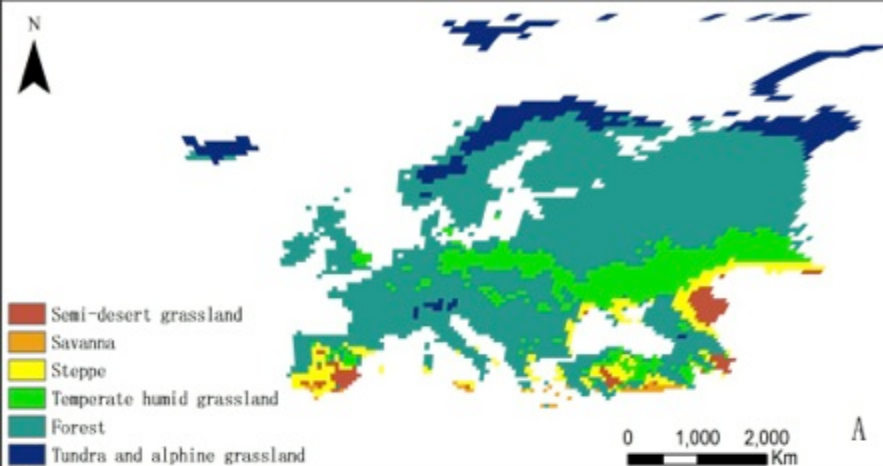


Fig. 7 The areas of PNV 8 broad categories of different countries in Europe (A:11-40; B:41-70; C:71-00)

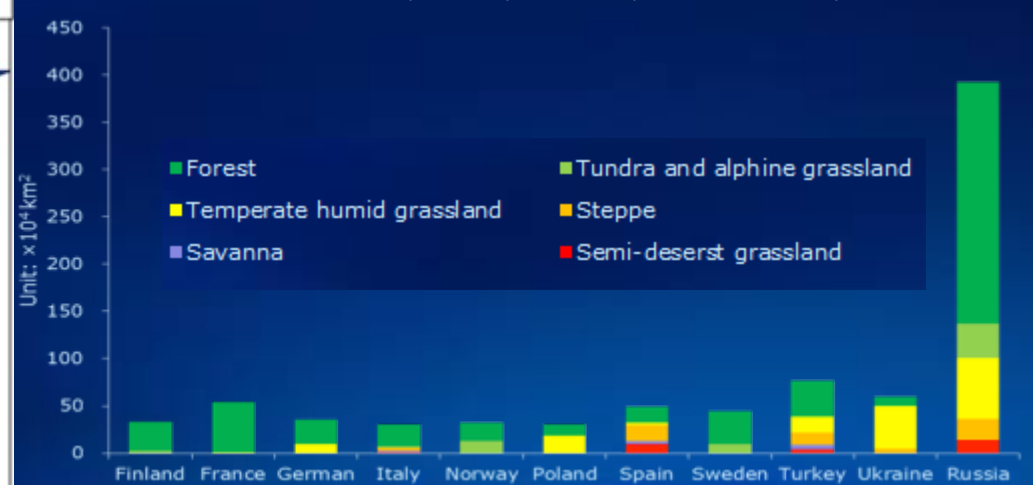
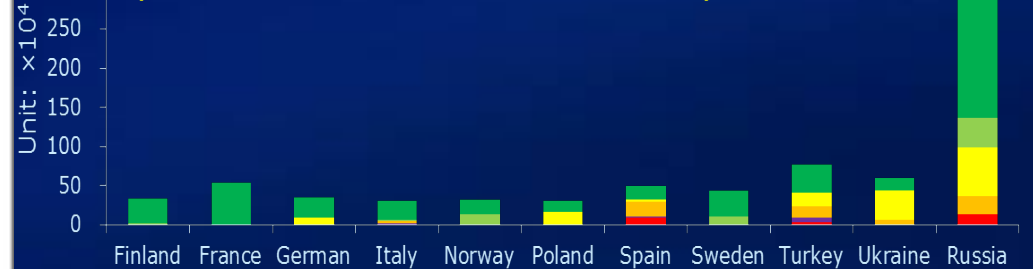


Table 6. The variation rate of 8 broad categories in different countries in Europe from 1911-2000
 (“-” means decrease, %)

	France	German	Italy	Norway	Poland	Spain	Sweden	Turkey	Ukraine	Russia
Semi-desert	0	0	0	0	0	46.15	0	0	-100.00	7.14
Savanna	0	0	20.00	0	0	150.00	0	-4.55	0	0
Steppe	0	0	25.00	0	0	-37.14	0	8.47	-28.00	-4.30
Temperate humid grassland	-66.67	27.78	0	0	23.88	-68.75	0	7.25	16.56	4.84
Tundra and alpine	0.00	0.00	0	-7.02	0	0	-2.50	0	0	-4.70
Forest	0.94	-9.52	-4.04	5.56	-29.09	14.93	0.73	-6.29	-26.98	-1.07

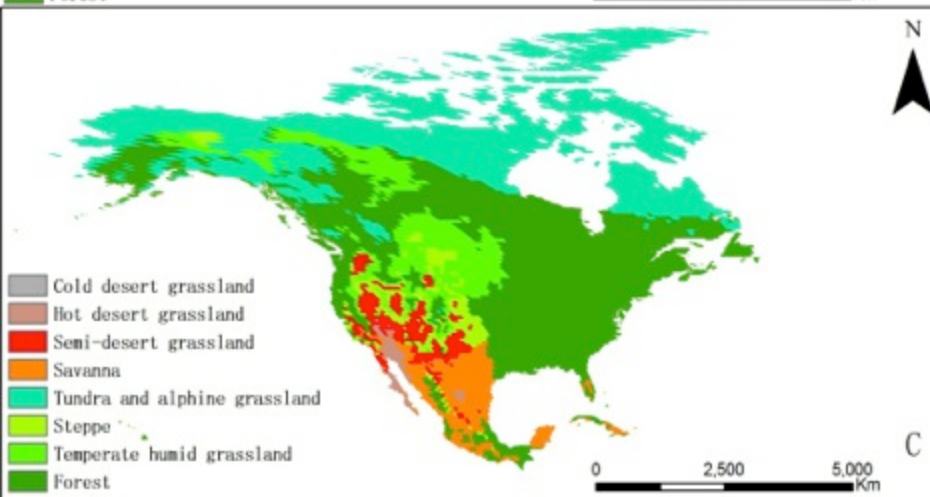
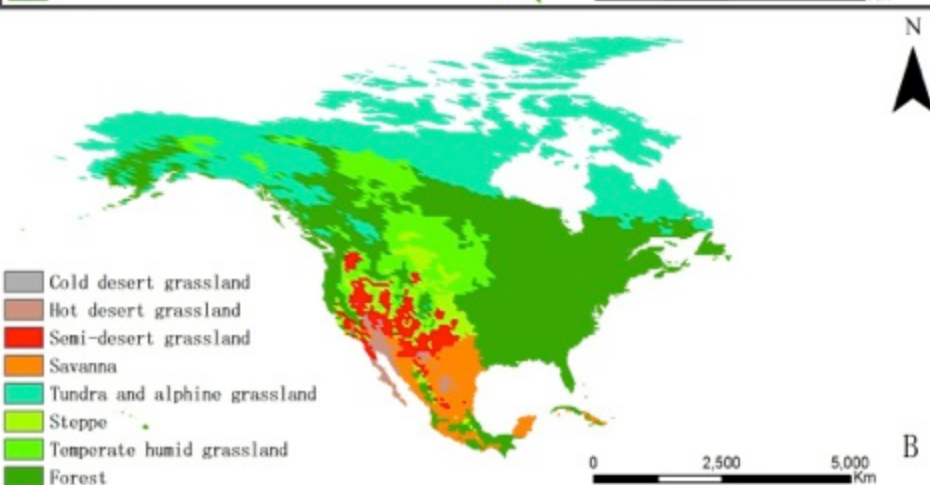
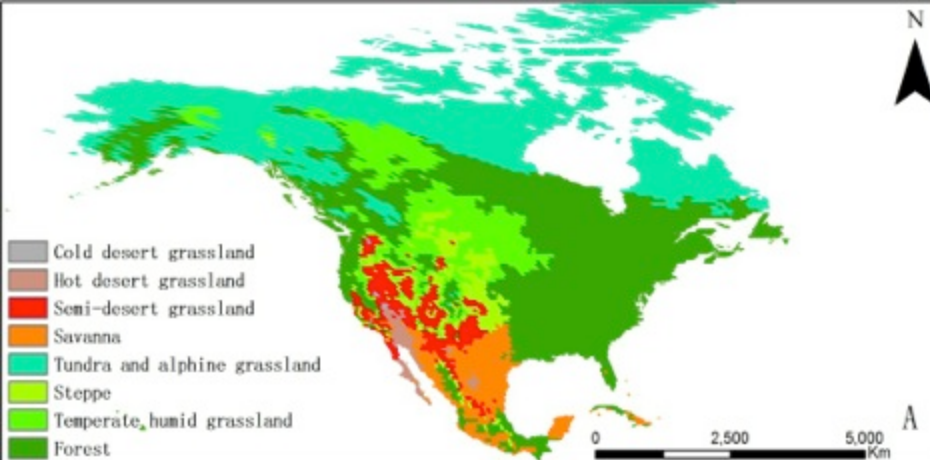


Fig. 8 The areas of PNV 8 broad categories of different countries in North America (A:11-40; B:41-70; C:71-00)

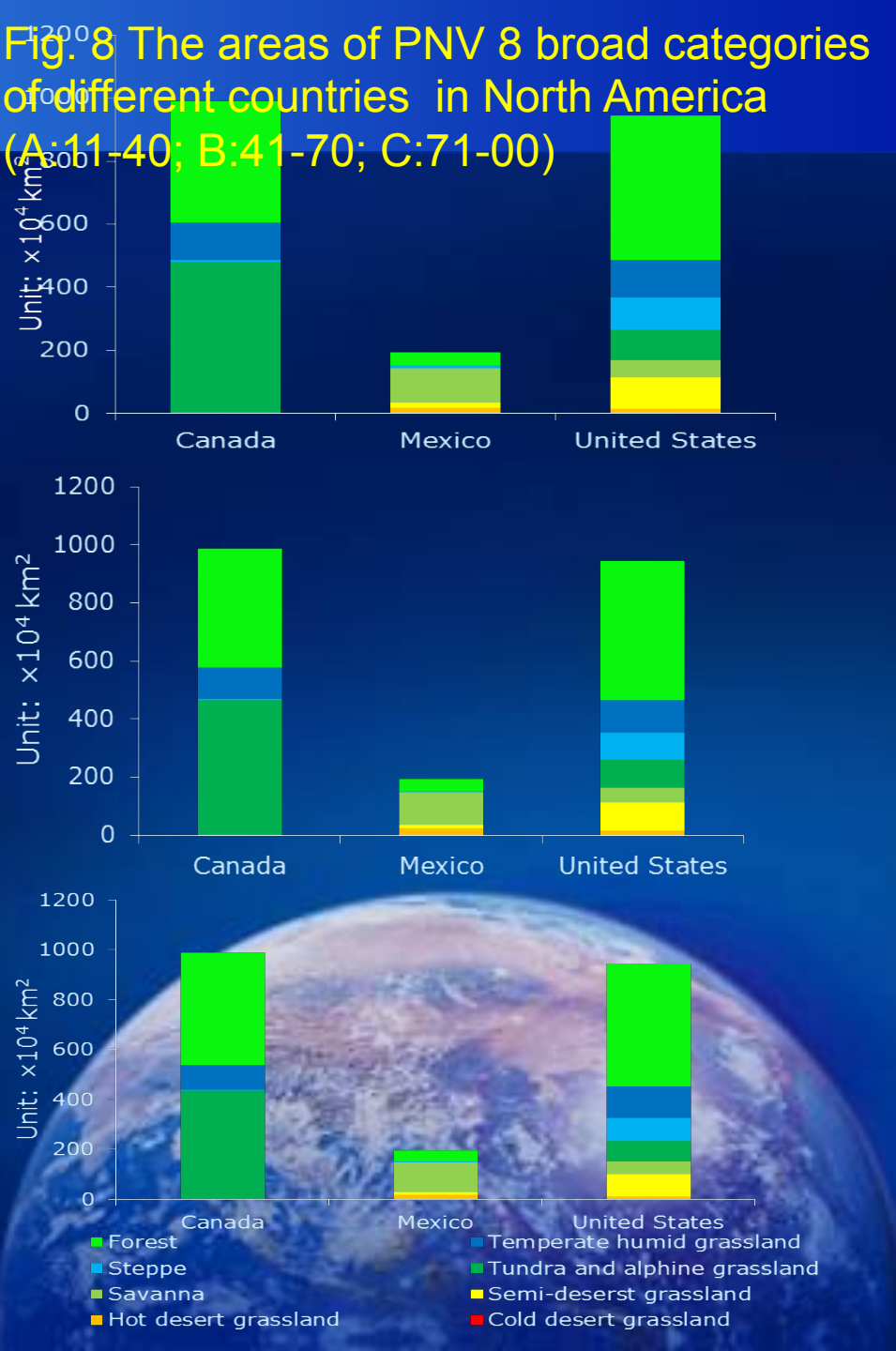


Table 7. The variation rate of 8 broad categories in different countries in North America from 1911-2000
 (“-” means decrease, %)

	Canada	Mexico	United States
Cold desert	0	0	-55.56
Warm desert	0	39.73	9.26
Semi-desert	0	-40	-1.5
Savanna	0	1.37	-5.14
Tundra and alpine grassland	-3.13	0	-1.3
Steppe	-38.46	-18.75	-10.44
Temperate humid grassland	-9.45	0	-4.02
Forest	7.49	-1.69	4.58

A

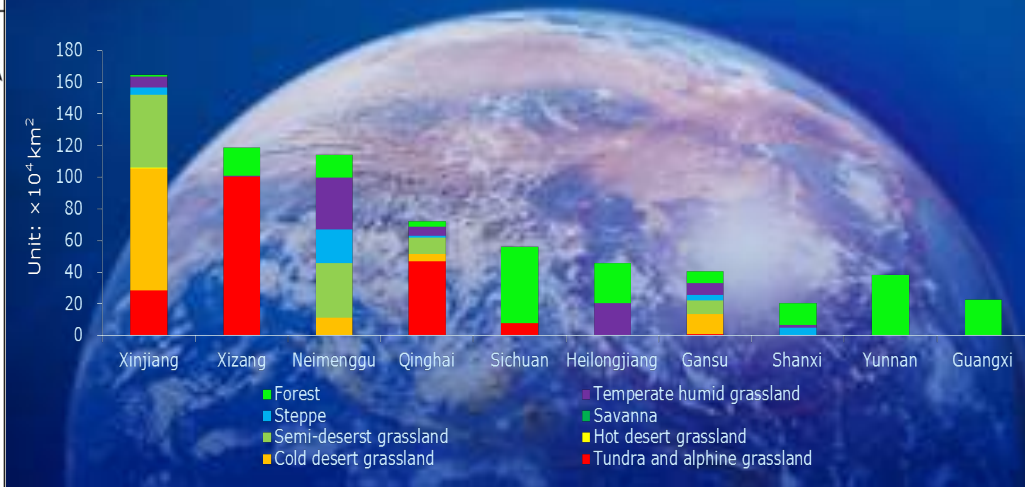
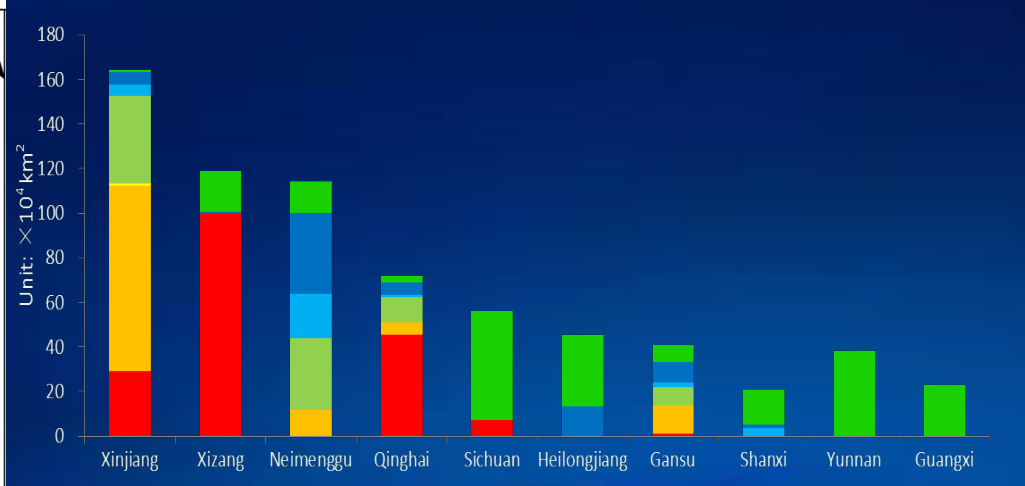
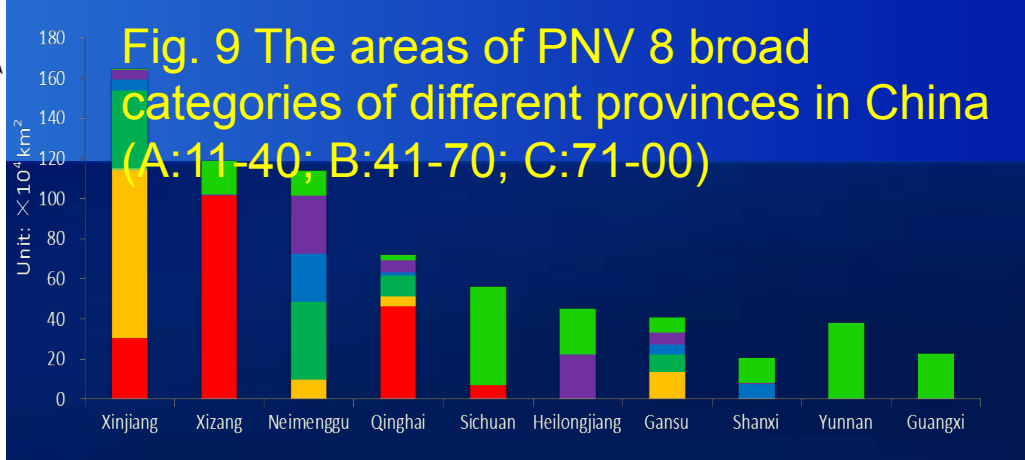


Table 8. The variation rate of 8 broad categories in different provinces in China from 1911-2000
 (“-”means decrease,%)

	Xinjiang	Xizang	Neimenggu	Qinghai	Sichuan	Heilongjiang	Gansu	Shanxi	Guangxi
Tundra and alpine	-7.02	-1.25	0	1.07	9.38	0	0	0	0
Cold desert	-9.12	0	13.33	-5.56	0	0	0	0	0
Hot desert	0	0	0	0	0	0	0	0	0
Semi-desert	16.22	0	-13.87	0	0	0	0	0	0
Savanna	0	0	0	0	0	0	0	0	100
Steppe	-16.67	0	-9.2	0	0	0	-50	-45	0
Temperate humid grassland	28.57	66.67	11.45	-13.64	0	-11.11	19.35	50	0
Forest	33.33	4.17	10.53	15.38	-1.56	8.91	0	10.71	-1.11

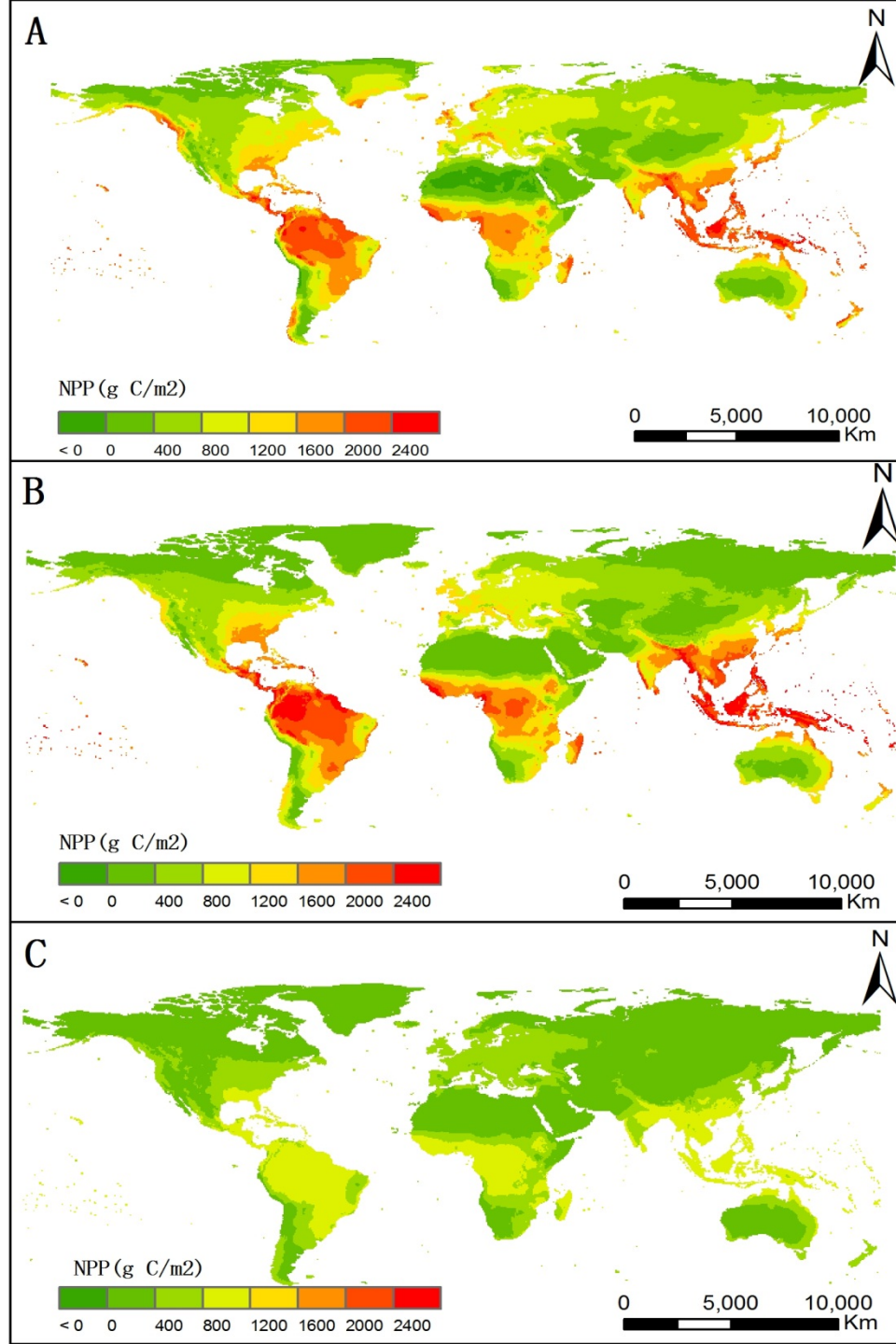


Fig. 9 The distribution of NPP using 3 climatic productivity models in 1911-1940

(A: *Thornthwaite Memorial model*
B: *Miami model*; C: *Schuur model*)



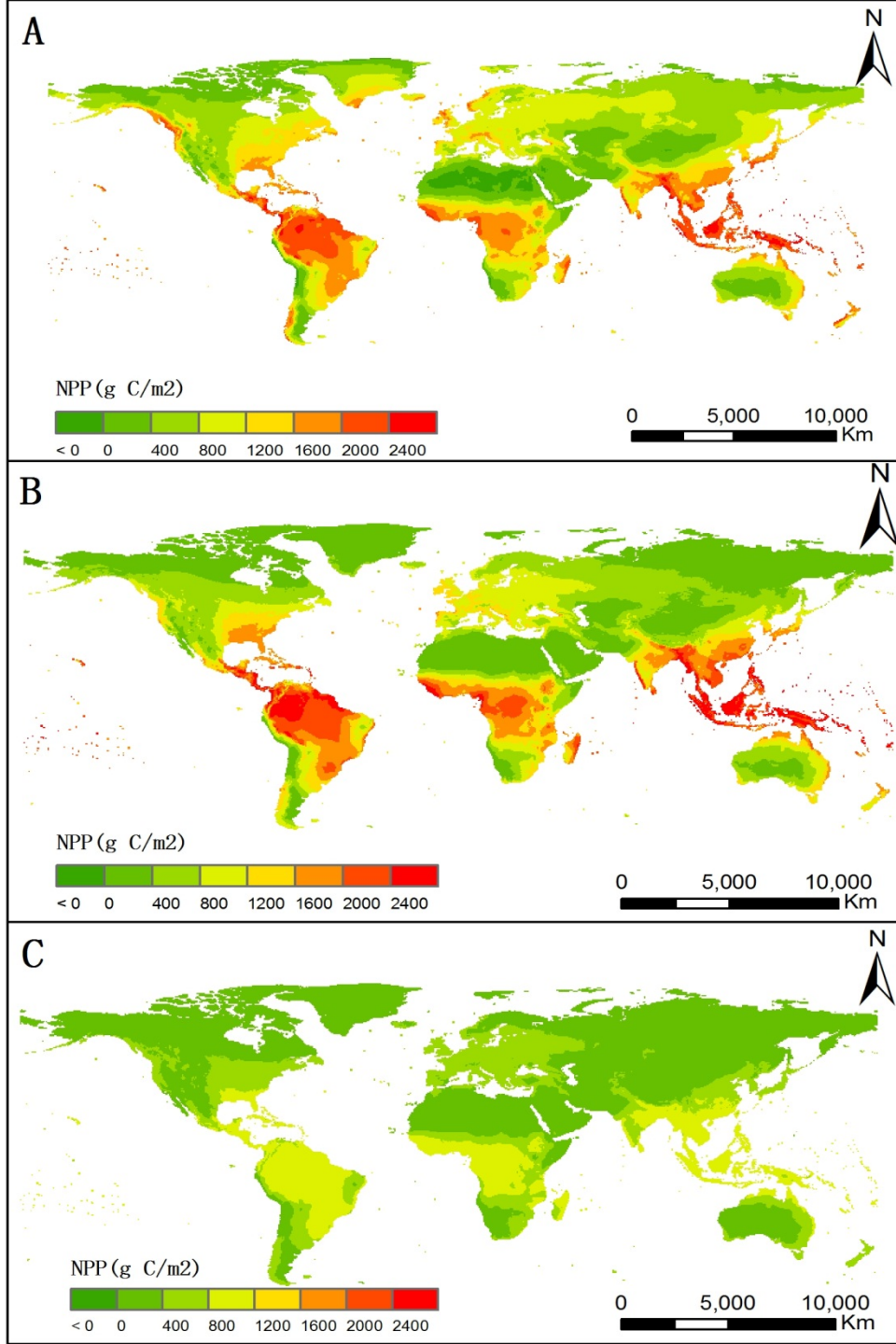


Fig. 10 The distribution of NPP using 3 climatic productivity models of 1941-1970

(A: *Thornthwaite Memorial model*
B: *Miami model*; C: *Schuur model*)



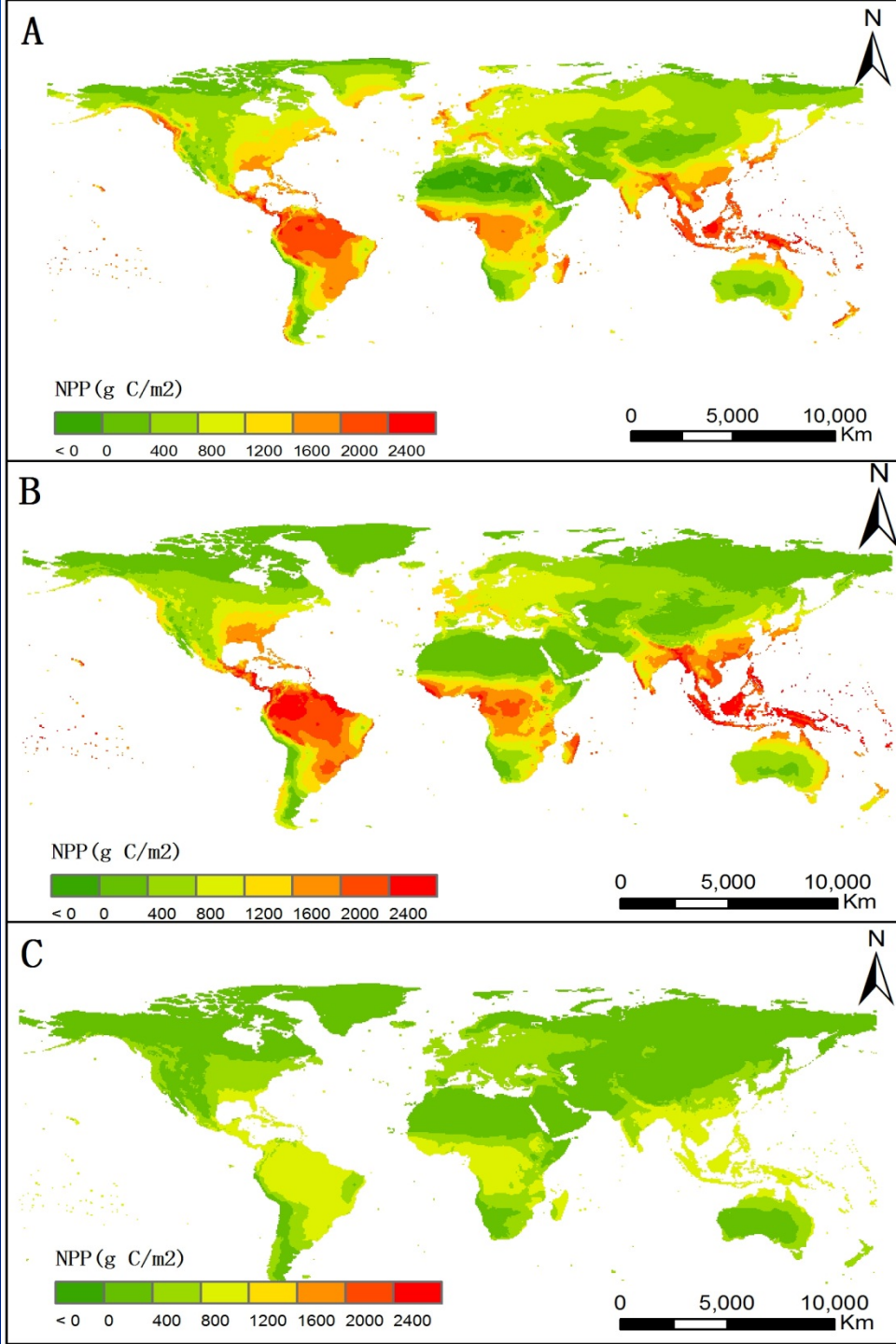


Fig. 11 The distribution of NPP using 3 climatic productivity models of 1971-2000

(A: *Thornthwaite Memorial model*
B: *Miami model*; C: *Schuur model*)



Table 9 The NPP variation for the ten broad vegetation categories in the periods 1911-1940(T1), 1941-1970(T2) and 1971-2000(T3) at global scale

Broad vegetation category	NPP (Tg C) in different periods			Variation rate (%)
	T1	T2	T3	T1 to T3
Tundra and alpine	11227.604	11224.073	10917.239	-2.76
Cold desert	250.679	246.252	186.743	-25.51
Warm desert	3040.771	2962.272	2572.930	-15.39
Semi-desert	3381.871	3318.014	3377.400	-0.13
Savanna	27226.091	27299.022	28891.282	6.12
Steppe	3155.299	2900.066	2907.371	-7.86
Temperate humid grassland	5316.628	5264.872	5521.142	3.85
Forest	87375.944	89425.676	89220.085	2.11

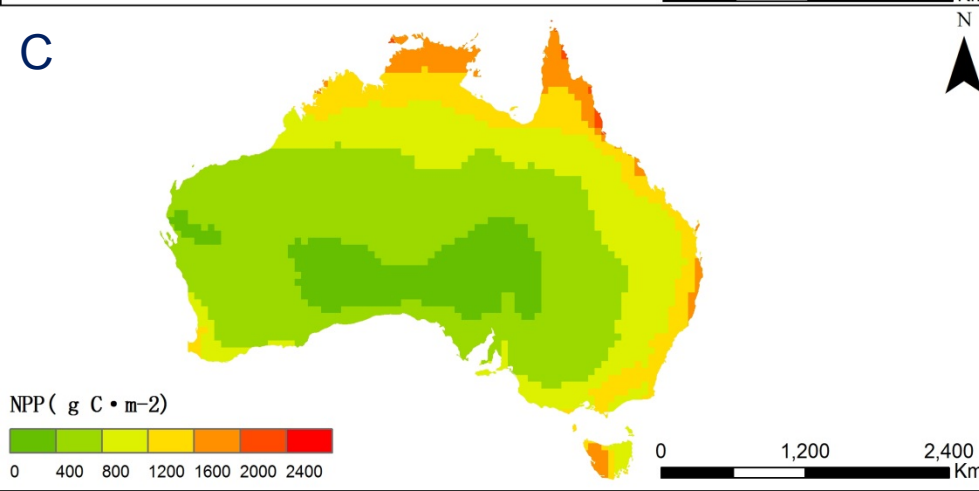
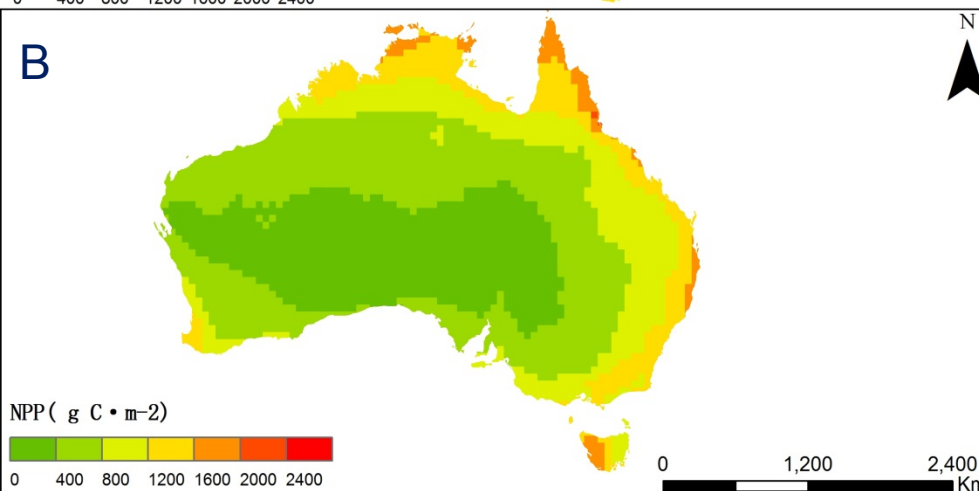
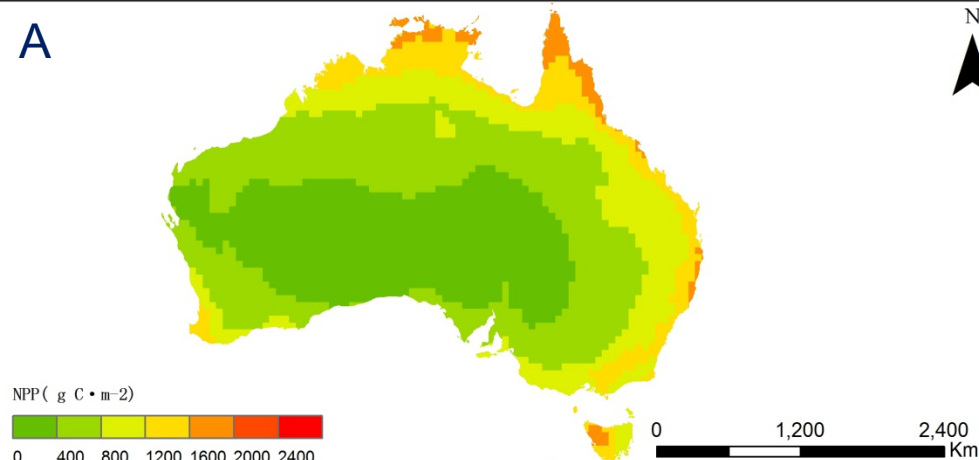
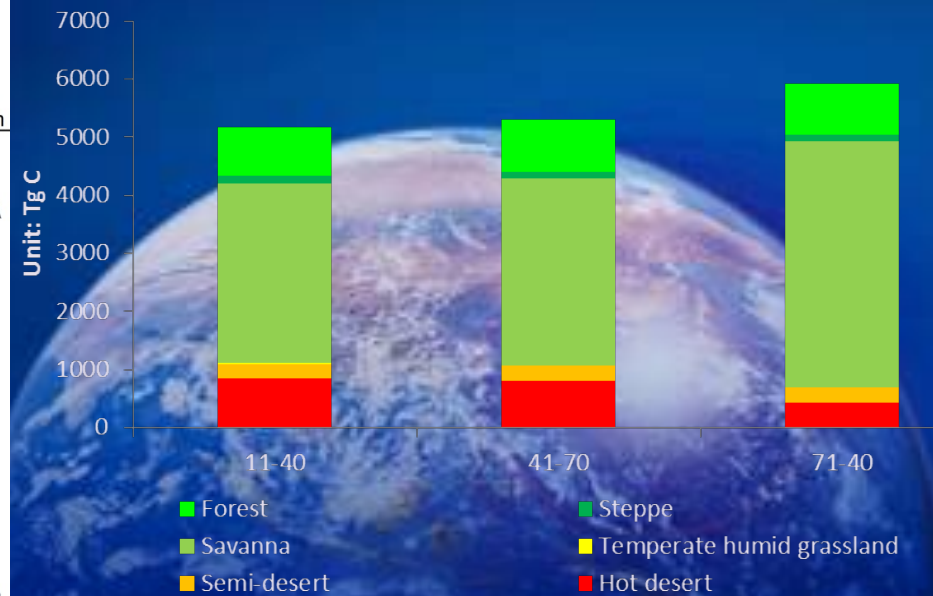


Fig. 12 The distribution of NPP of PNV 6 broad categories in Australia (A:11-40; B:41-70; C:71-00)

Variation rate of TNPP of PNV 8 broad categories in Australia from 1911-2000 (“-” means decrease)

Land cover type	Value(Tg C)	Percent(%)
Warm desert	-415.1042	-51.04
Semi-desert	-2.7106	-2.35
Temperate humid grassland	2.4547	93.59
Savanna	1139.2238	35.99
Steppe	-20.4146	-15.15
Forest	57.8814	10.57



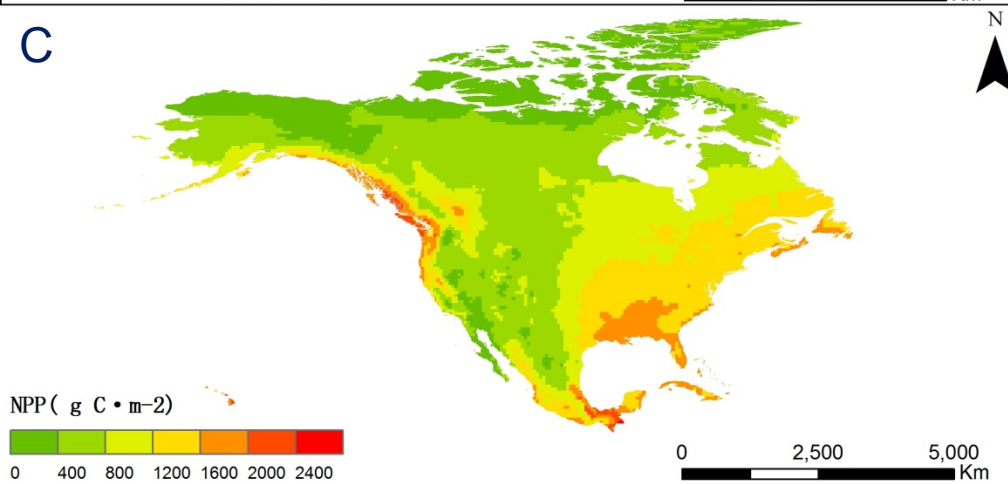
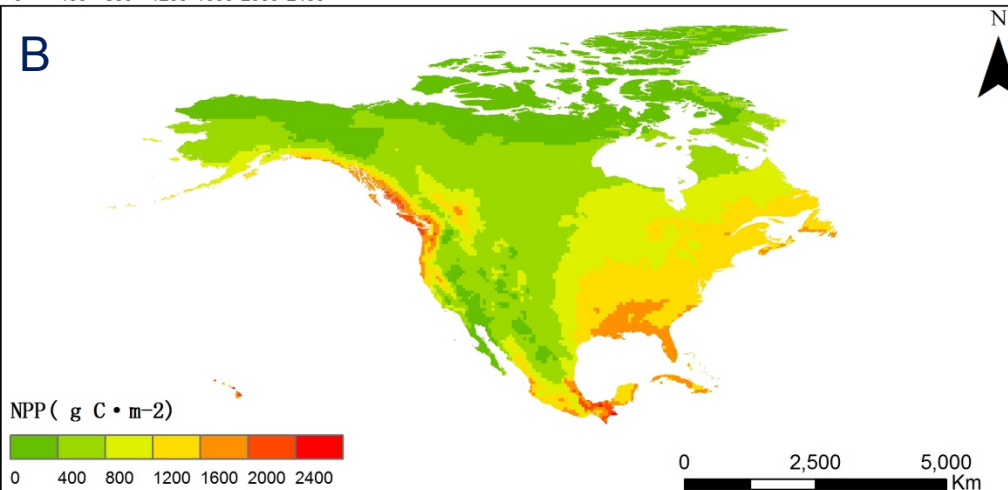
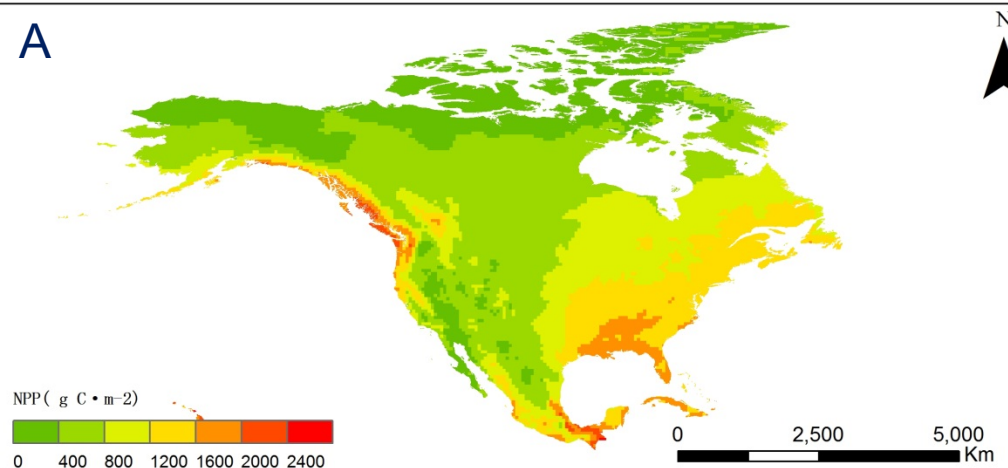
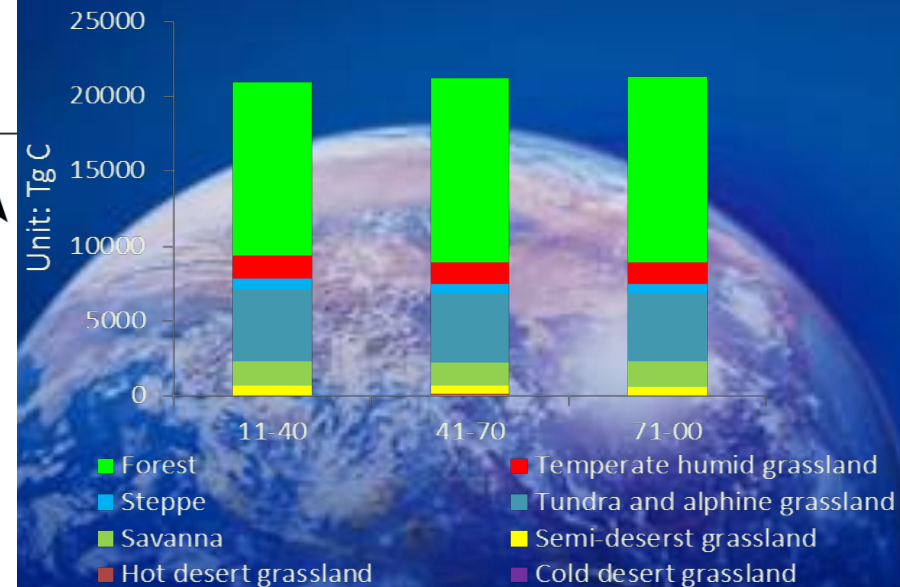


Fig. 13 The distribution of PNV 8 broad categories in North America (A:11-40; B:41-70; C:71-00)

Variation rate of TNPP of PNV 8 broad categories in North America from 1911-2000 (“-”means decrease)

Land cover type	Value(Tg C)	Percent(%)
Cold desert	-4.4946	-89.47
Warm desert	-3.4048	-3.85
Semi-desert	-75.6639	-12.54
Savanna	76.3800	4.75
Tundra and alpine	-285.2855	-5.96
Steppe	-107.1578	-13.71
Temperate humid grassland	-42.4247	-2.81
Forest	850.9048	7.37



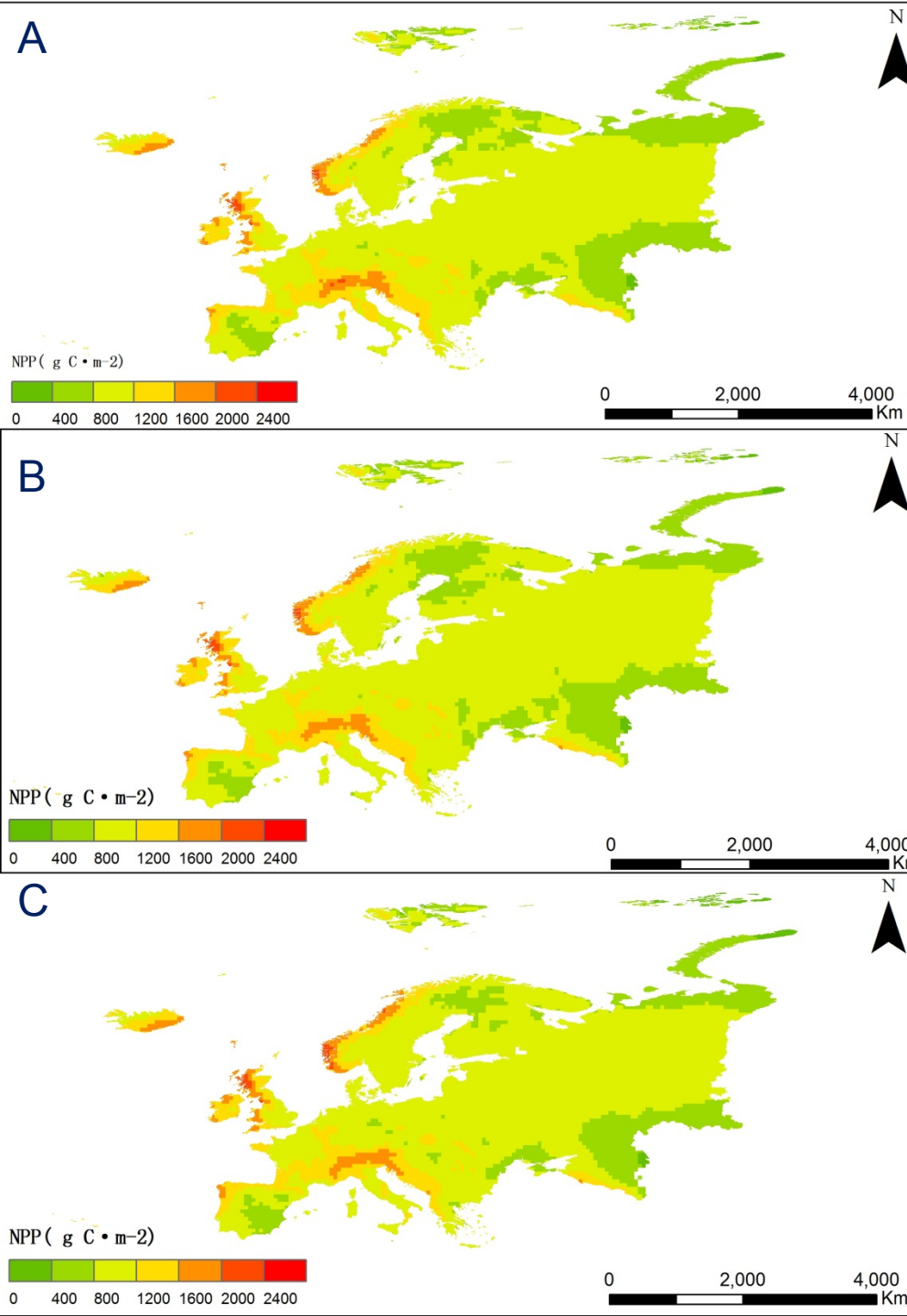
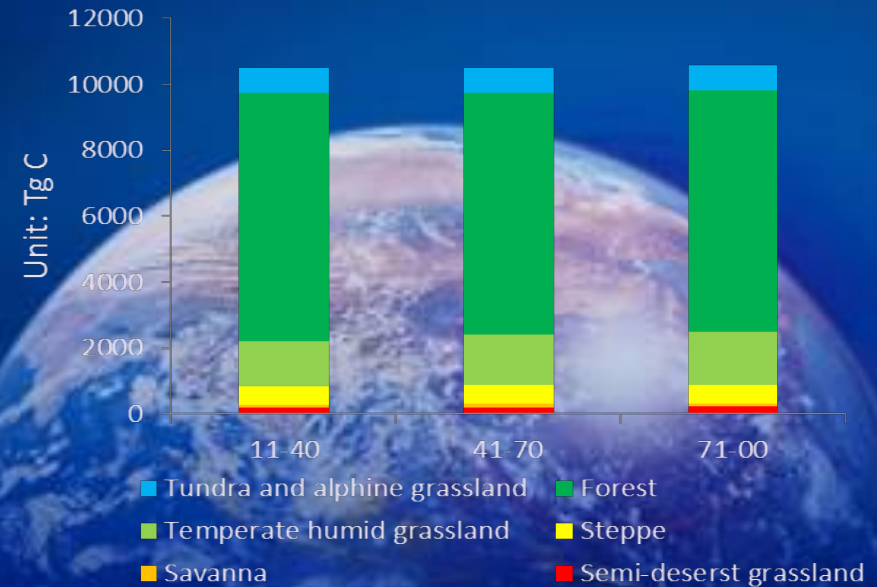


Fig. 14 The distribution NPP of PNVI 6 broad categories in Europe
(A:11-40; B:41-70; C:71-00)

Variation rate of TNPP of PNVI 6 broad categories in Europe from 1911-2000
("—" means decrease)

Land cover type	Value(Tg C)	Percent(%)
Semi-desert	48.923	25.96
Savanna	16.949	19.54
Steppe	-35.478	-6.20
Temperate humid grassland	230.081	16.64
Forest	-201.347	-2.68
Tundra and alpine	17.528	2.35



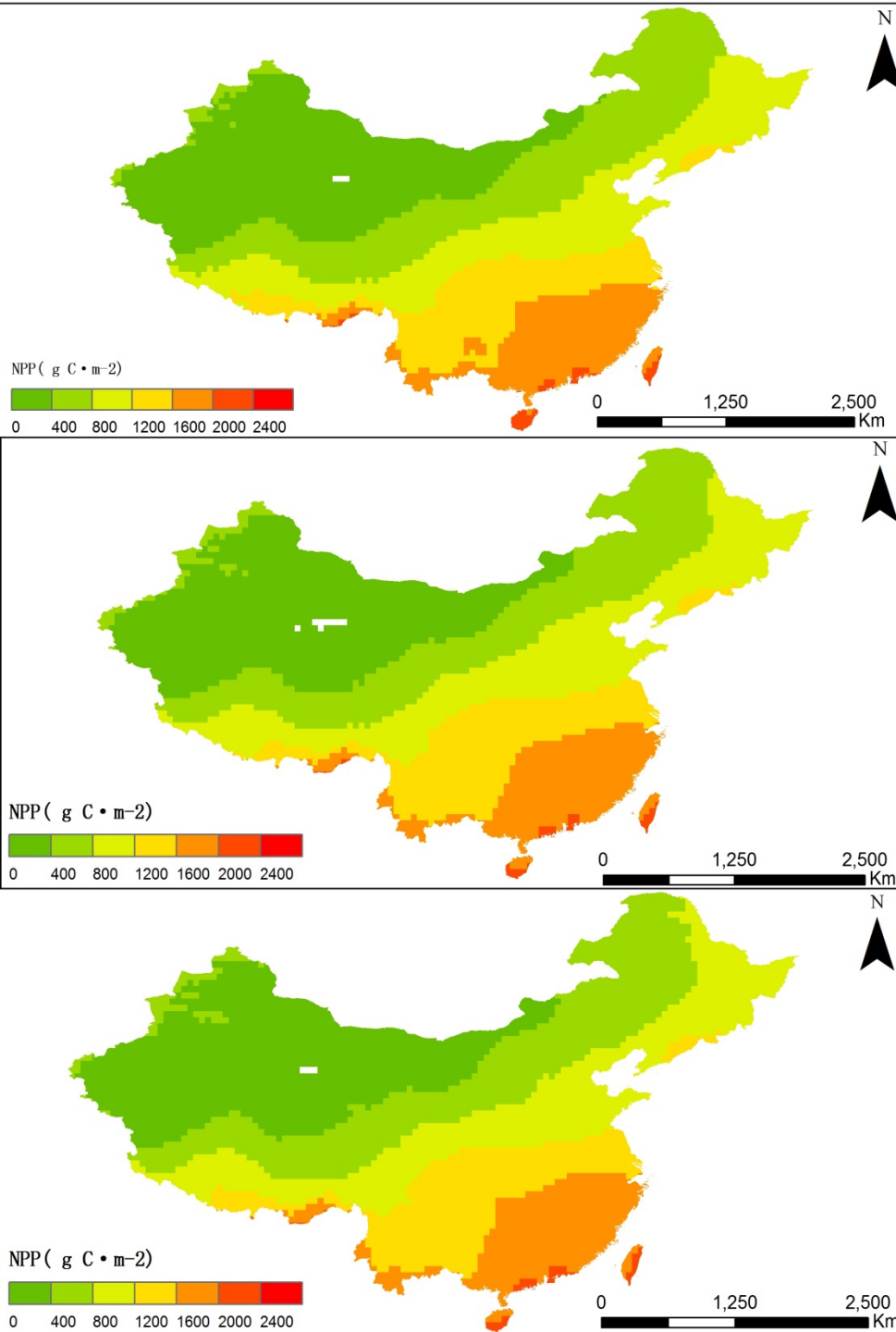


Fig. 14 The distribution of NPP of PNV 8 broad categories in China (A:11-40; B:41-70; C:71-00)

Variation rate of TNPP of PNV 8 broad categories in China from 1911-2000 ("-" means decrease)

Land cover type	Value(Tg C)	Percent(%)
Tundra and alpine	12.5257	1.13
Cold desert	-7.6999	-7.44
Warm desert	0.1076	20.11
Semi-desert	5.3363	2.01
Steppe	-46.7251	-11.94
Temperate humid grassland	28.1438	3.83
Savanna	3.7547	100
Forest	253.9554	4.86

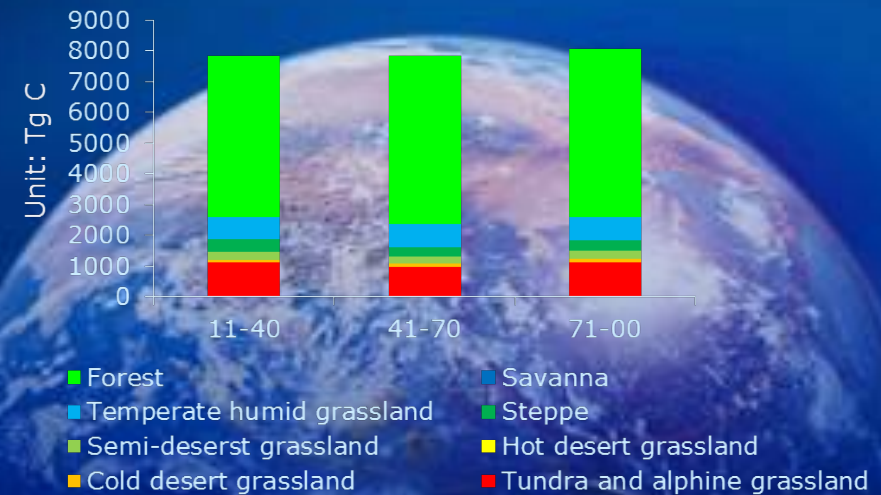


Table 10. Comparison of variation rate of total NPP of 8 broad vegetation categories in the period of 1911-2000
 ("-"means decrease,%)

	Australia	Europe	North America	China
Cold desert	0	0	-88.67	-7.44
Warm desert	-51.04	0	-4.21	0
Semi-desert	-2.35	26.3	-12.47	2.01
Savanna	35.99	16.39	5.3	100
Tundra and alpine	0	3.02	-11.73	1.13
Steppe	-15.15	-5.98	-13.75	-11.94
Temperate humid grassland	93.59	16.58	-3.01	3.83
Forest	10.57	-2.31	5.42	4.86

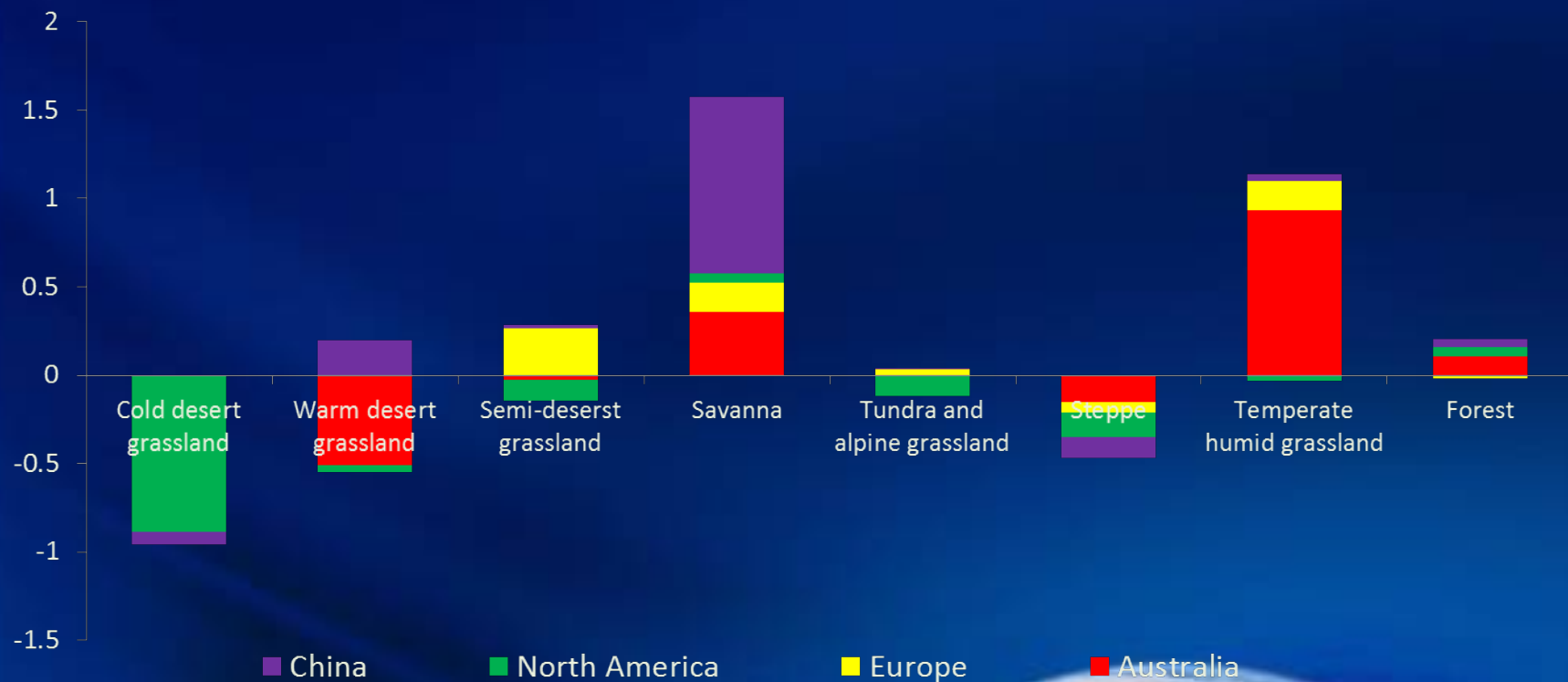


Fig. 15 Comparison of variation of TNPP of PNV 8 broad categories in North America, Europe, Australia and China from 1911-2000

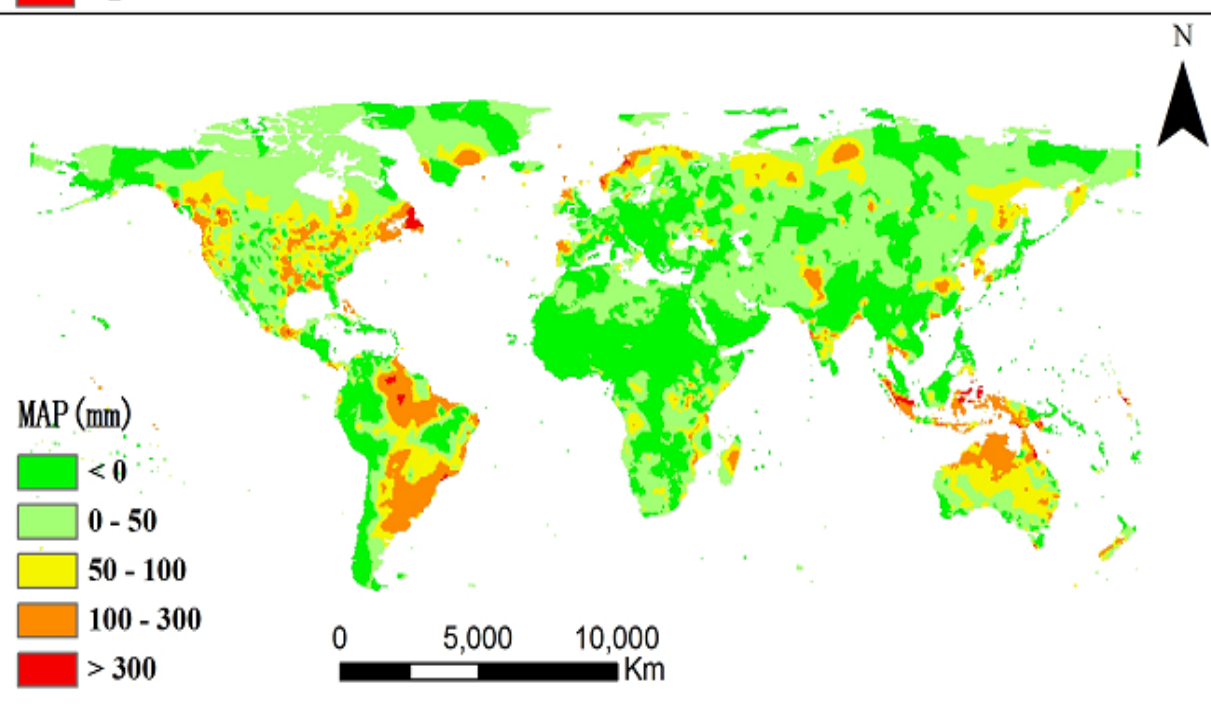
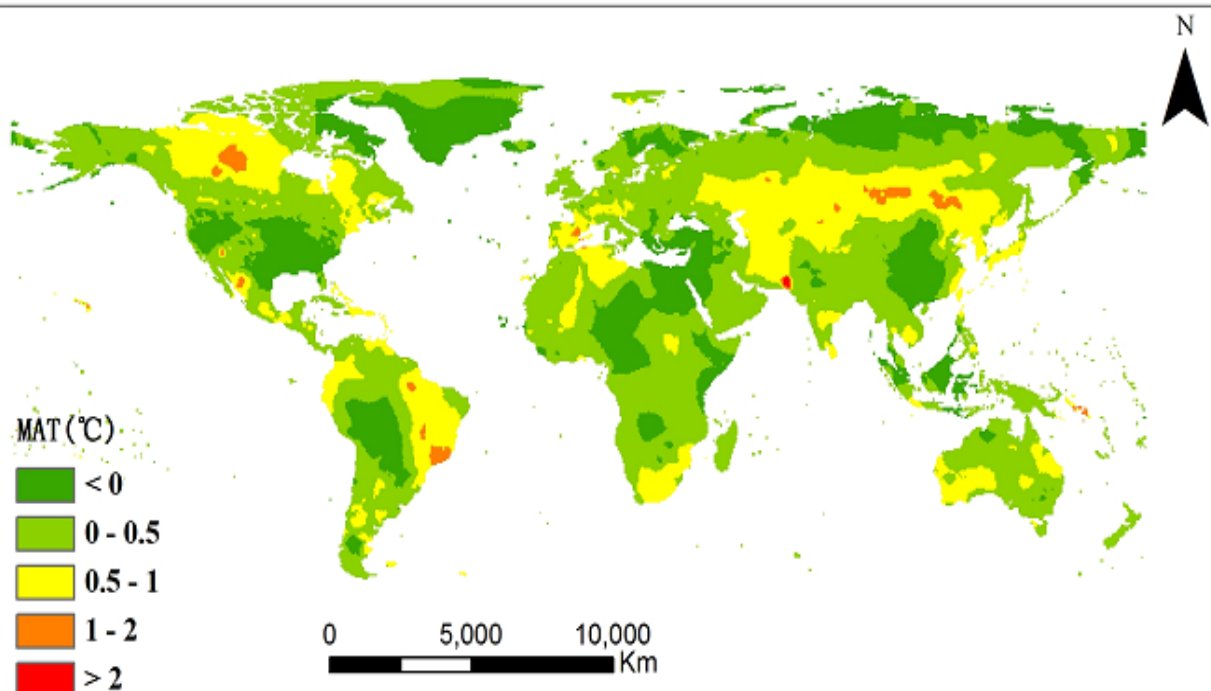
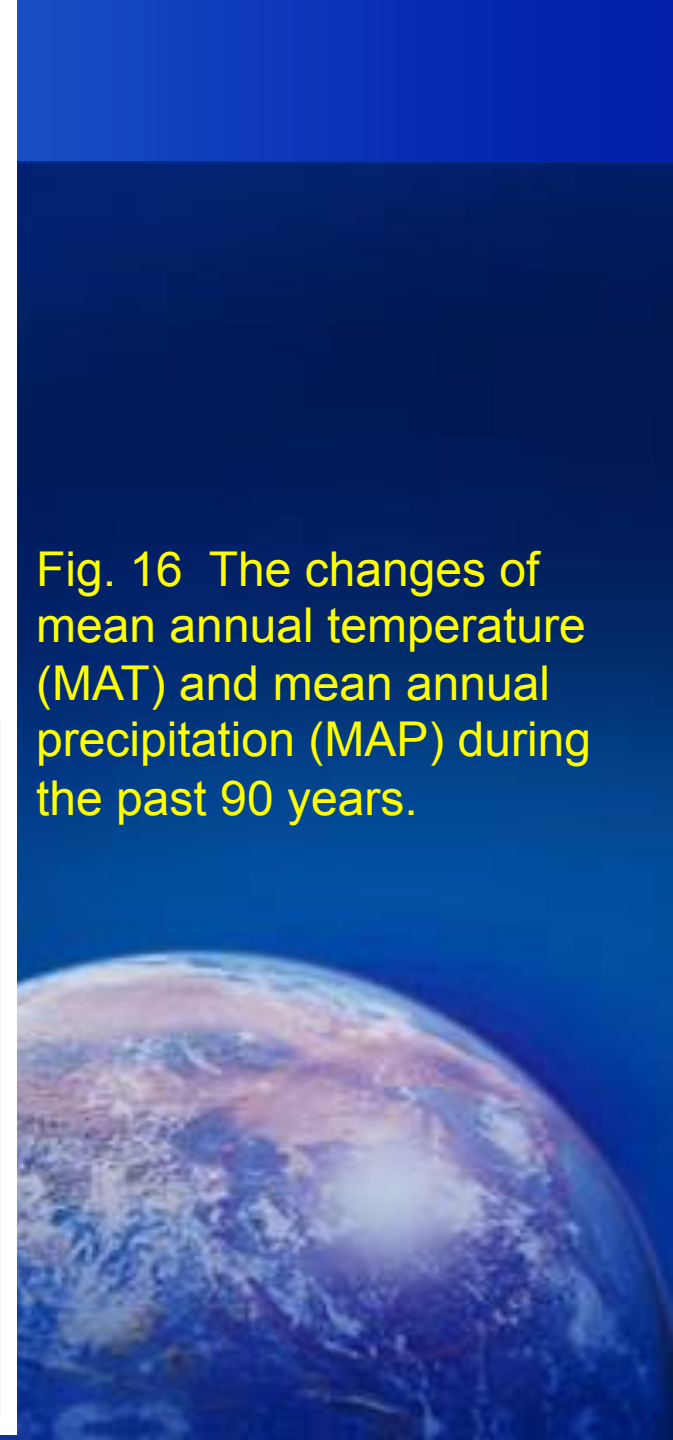


Fig. 16 The changes of mean annual temperature (MAT) and mean annual precipitation (MAP) during the past 90 years.



4. Conclusion

- ❖ 4.1 At global scale there were 8 broad vegetation categories, and 42 PNV classes according to the CSCS model. From 1911 to 2000, the area of tundra & alpine steppe and desert had decreasing trend (by 5.09% and 5.50%), while the area of forest and grassland had increasing trend (by 2.31% and 3.76%). However, there was a significant difference in the magnitude of area change for the same vegetation category in the northern and southern hemispheres.



- ❖ 4.2 The CSCS model has not only an advantage in mapping global potential grassland vegetation in details, but also has the ability to simulate the broad PNV categories and their distribution of tundra, desert and forest at global scale.



- ❖ 4.3 The NPP of global tundra & alpine and desert decreased by 2.8% and 8.03%, the cold desert grassland decreased by 88.67%, the NPP of temperate humid grassland in Australia, Europe, North America and China were all increased (93.59%, 16.64%, 2.81% and 3.83%), the NPP of forest in Europe was decreased(2.68%), while in Australia, North America and China were increased(10.57%, 7.37% and 4.86%).



图17. 新疆主要典型草地类型及其现场观测

Fig.17. Typical grassland type in Xinjiang





Thank You !

