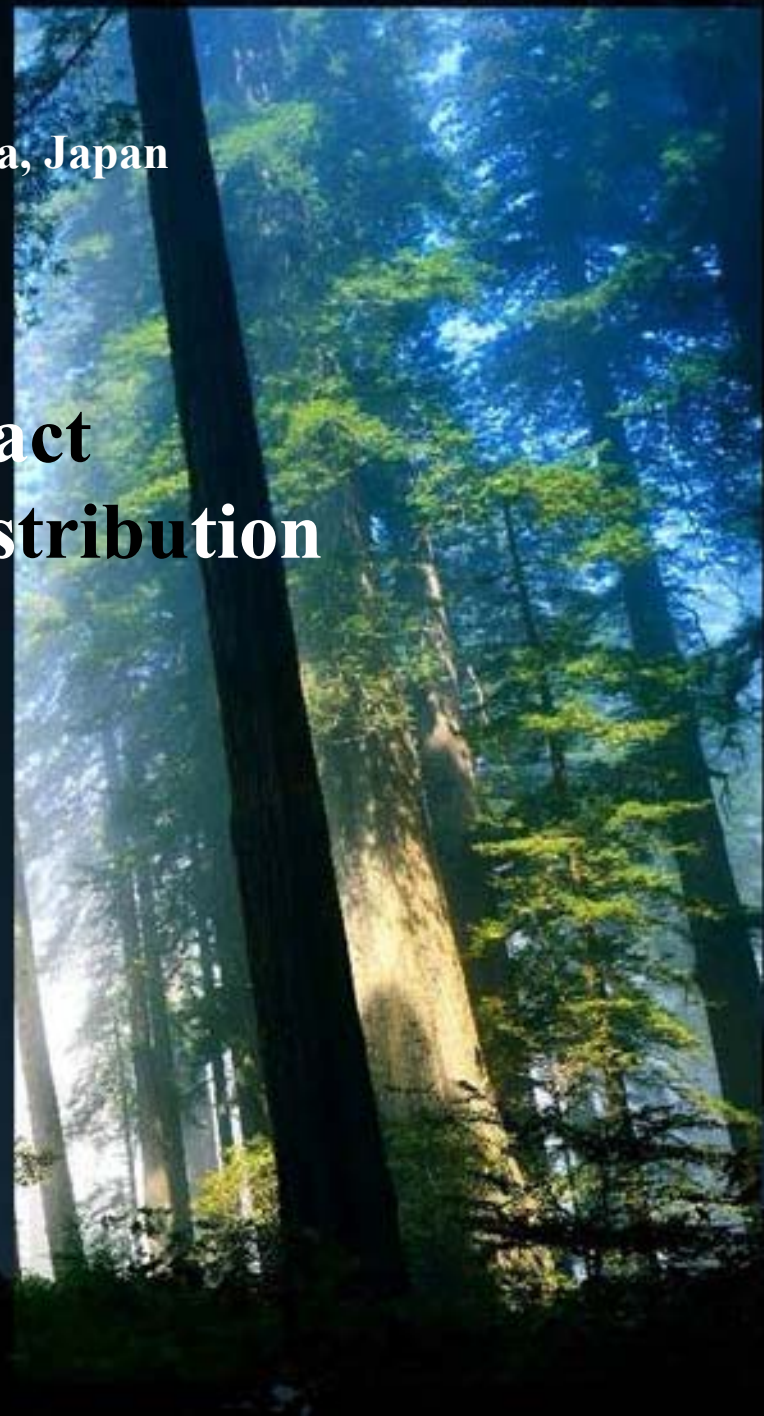# An Assessment of Potential Impact of Climate Change on Forest Distribution and Economic Value in Korea

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Dongkun Lee
Sunyong Sung
(Seoul National University, Korea)

Introduction

▶ Economic value of forestry

- Agriculture, Forestry and Fishery : 4.0% of $10,493 billion in GDP 2007

- Forestry : $38.3 billion (0.37% of GDP 2007)

- market value of net growing stock : $14.5 billion (37.8% of Forestry)

- public goods and services : $70.1 billion (8.2% of GDP 2005)

▶ Objectives

- To predict the spatial distribution of forest in South Korea

- To assess economic value of forest in the future

Introduction

▶ Net Growing Stock : growing stock of this year in contrast to grew stock of last year

▶ Market Value : economic value of net growing stock was reflected standard stumpage

year	Net Growing Stock (1,000㎥)				Market Value (billion won)			
	Coniferous Forest	Deciduous Forest	Mixed Forest	Total	Coniferous Forest	Deciduous Forest	Mixed Forest	Total
2005	11,798	5,739	6,944	24,481	5,211	2,185	2,917	10,313
2006	12,378	5,918	7,229	25,525	6,150	1,947	3,101	11,198
2007	13,242	6,136	7,426	26,804	7,529	2,369	3,556	13,454
2008	17,360	7,691	9,671	34,722	9,756	2,860	4,657	17,273

Source: Korea Forest Service, 2006~2009.

Materials

▶ Observed data

- 73 stations by Korea Meteorological Administration
- period : 1971~2000 (30 yrs mean)

▶ Climate model

- made by KMA
- scenario : IPCC A1B
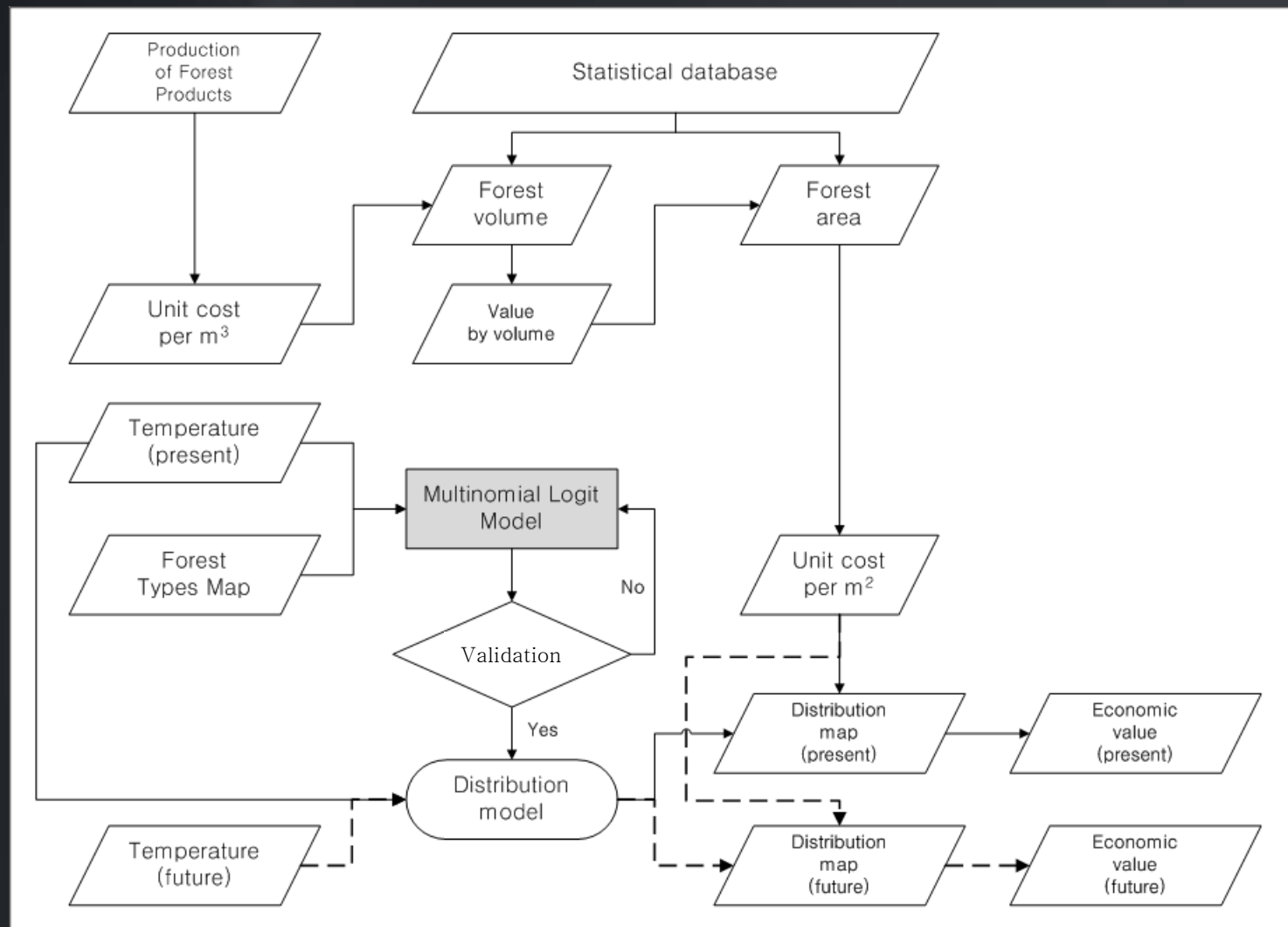- period : 2030(2026~2035), 2050(2046~2055), 2070(2066~2075), 2100(2096~2100)

▶ Forest types map
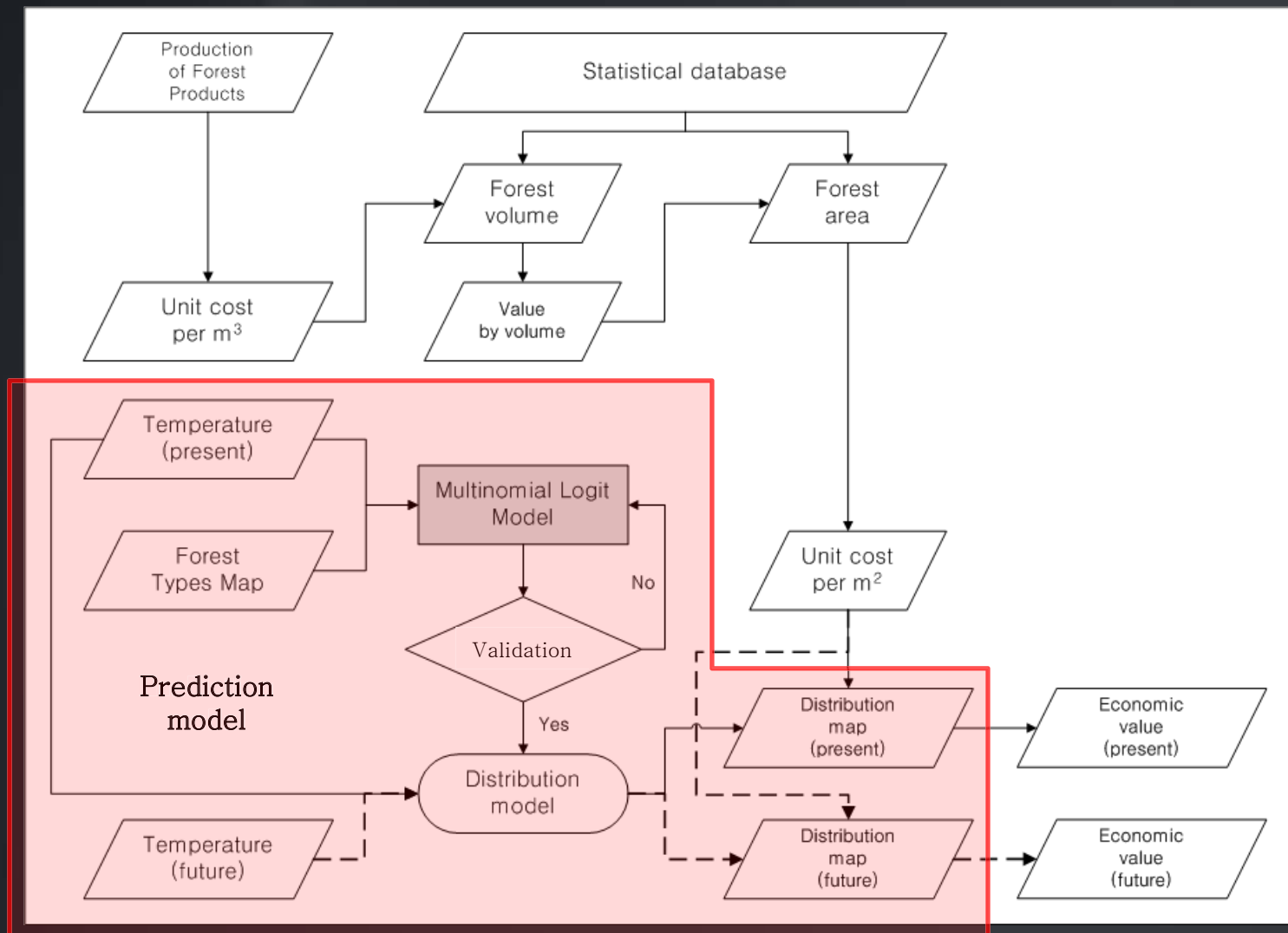
- field study from 1996 to 2005 by Korea Forest Service

▶ Statistical data

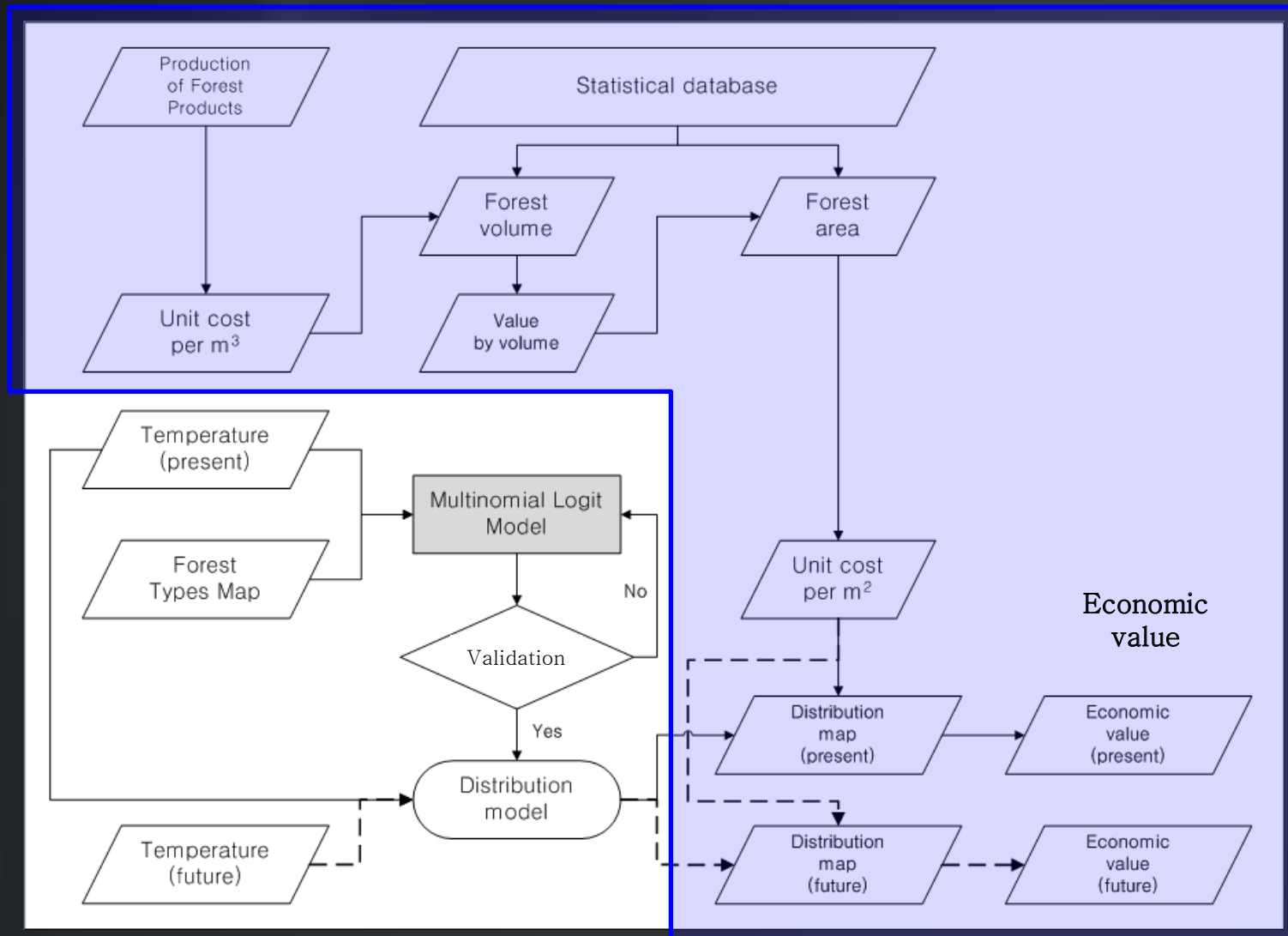- statistical yearbook of forestry, Production of forest products by KFS
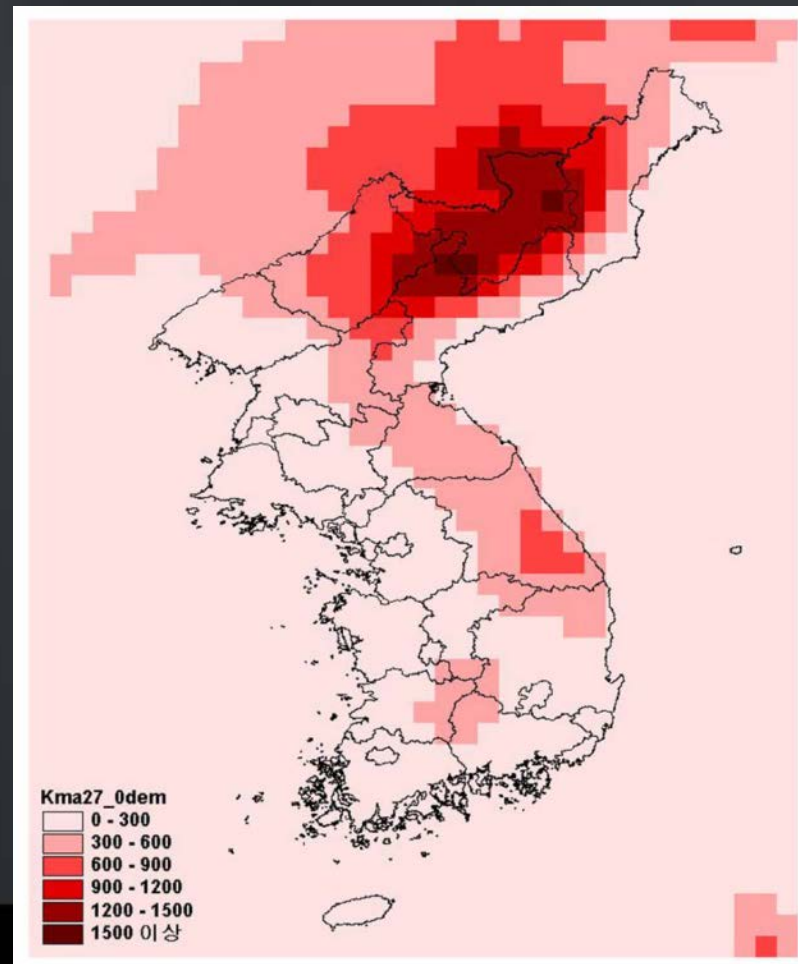
Methods

Methods

Methods

0. Validation of climate data

▶ Regional climate model (by KMA)

▪ scenario : IPCC A1B

Kma27_0dem
- 0 - 300
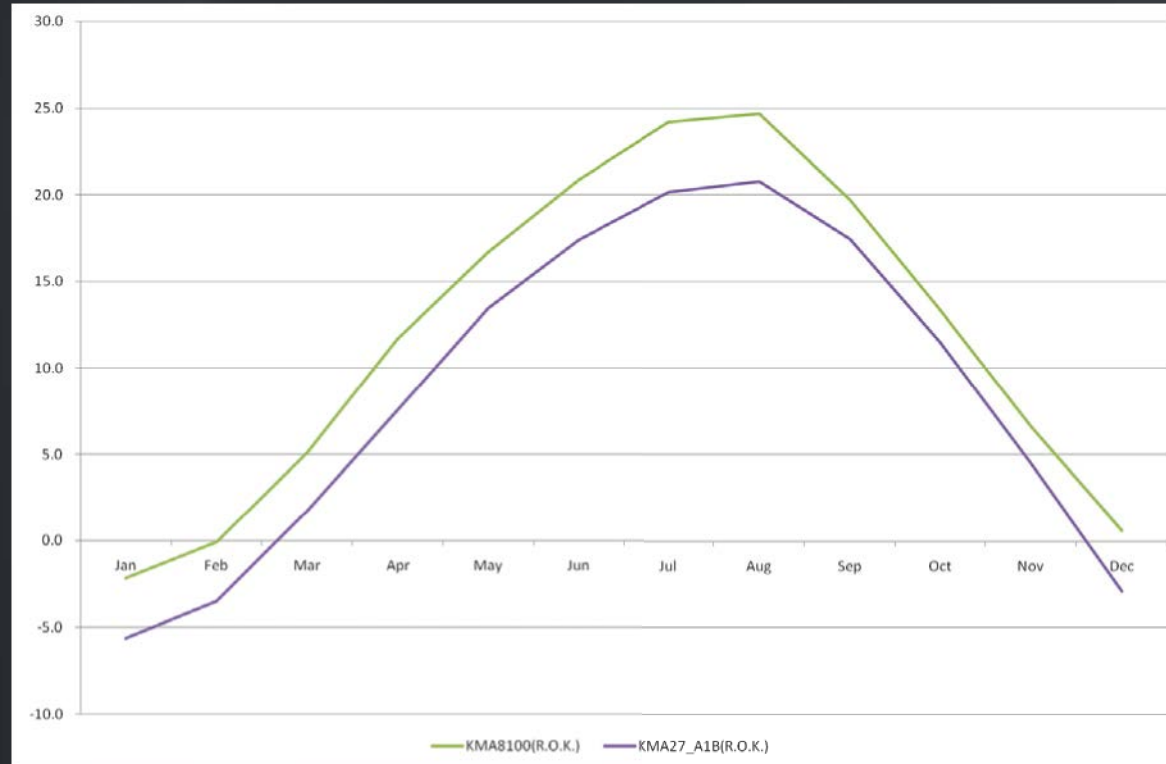- 300 - 600
- 600 - 900
- 900 - 1200
- 1200 - 1500
- 1500 이상

Results

0. Validation of climate data

▶ Mean Temperature (1981~2000)

- observed data : 11.8℃

- A1B scenario : 8.5℃

Results

0. Validation of climate data

|	daily T_{MAX}	daily T_{avg}	daily T_{min}
Jan	0.9159[a]	0.9359[a]	0.9110[a]
Feb	0.8970[a]	0.9248[a]	0.8970[a]
Mar	0.8486[a]	0.8895[a]	0.8713[a]
Apr	0.7220[a]	0.7828[a]	0.8123[a]
May	0.7104[a]	0.7827[a]	0.8539[a]
Jun	0.7619[a]	0.8064[a]	0.8795[a]
Jul	0.6481[a]	0.7162[a]	0.8807[a]
Aug	0.7607[a]	0.8505[a]	0.9053[a]
Sep	0.8675[a]	0.8953[a]	0.8864[a]
Oct	0.8995[a]	0.8882[a]	0.8558[a]
Nov	0.9055[a]	0.9051[a]	0.8645[a]
Dec	0.9112[a]	0.9167[a]	0.8741[a]

※ [a] : significant at $p < 0.01$

Results

0. Validation of climate data

▶ Mean Temperature (1981~2000)

- observed data : 11.8℃
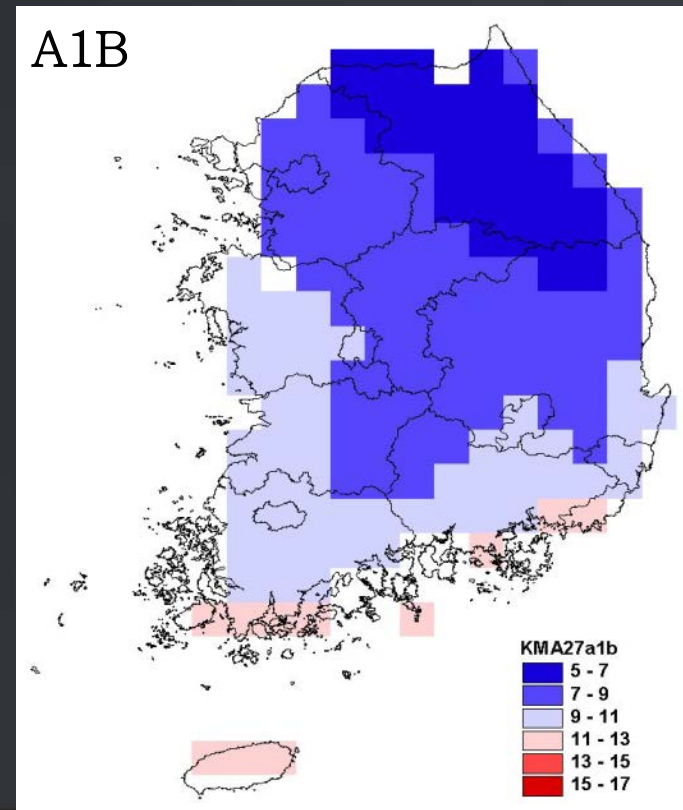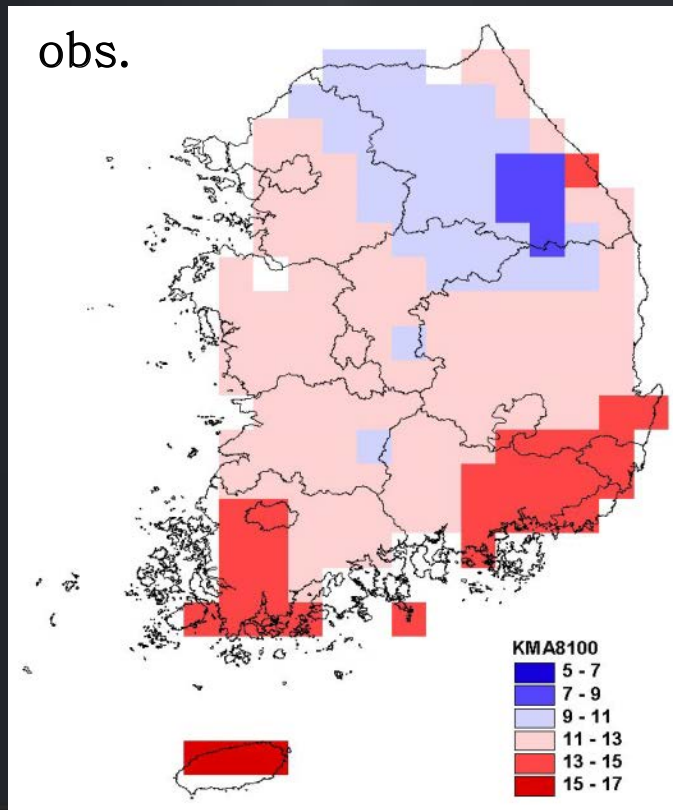
- A1B scenario : 8.5℃

1. Temperature in the future

▶ Mean Temperature (2030; 2026~2035)

▪ A1B scenario : 11.9℃

1. Temperature in the future

▶ Mean Temperature (2050; 2046~2055)

▪ A1B scenario : 12.9℃

Results

1. Temperature in the future
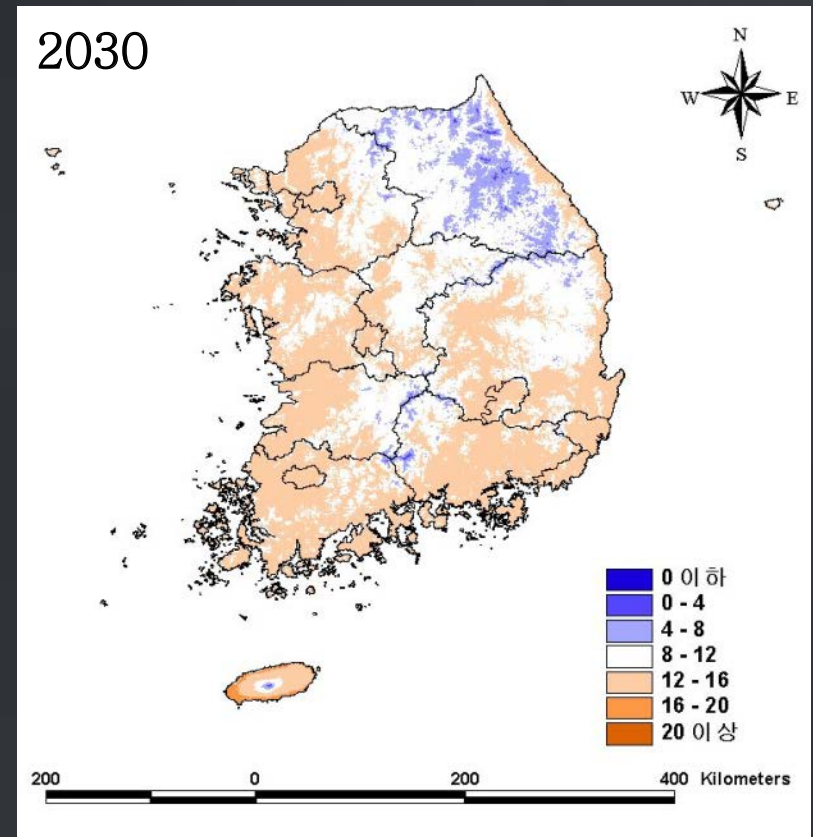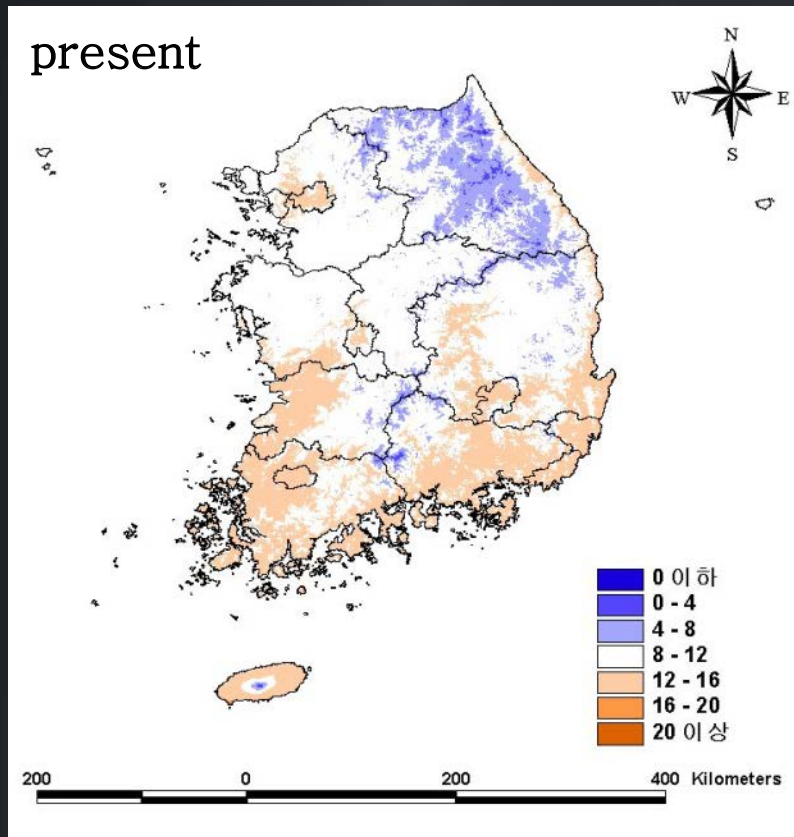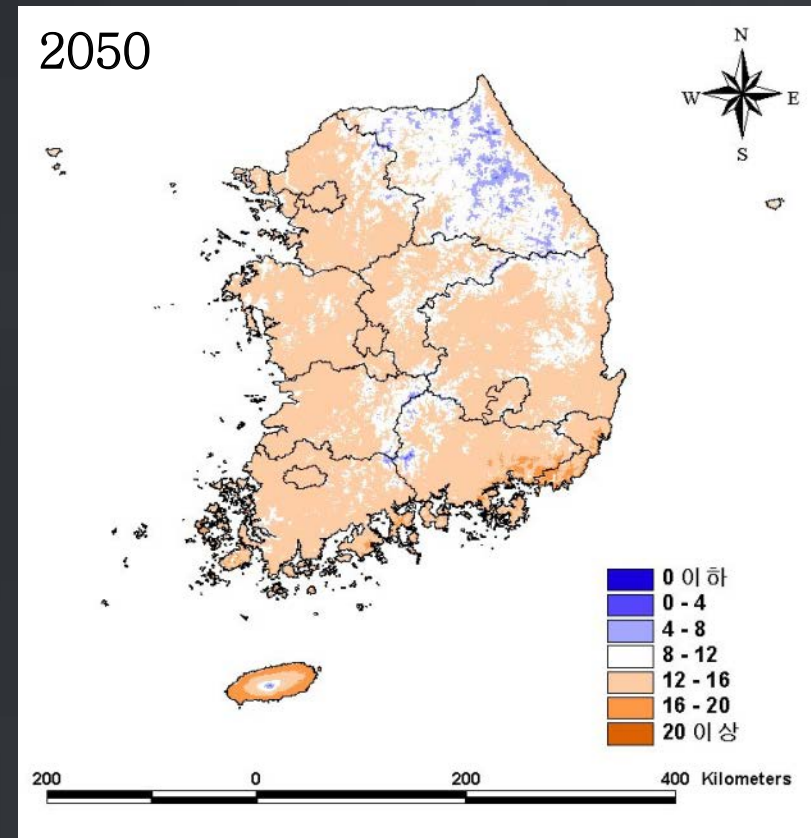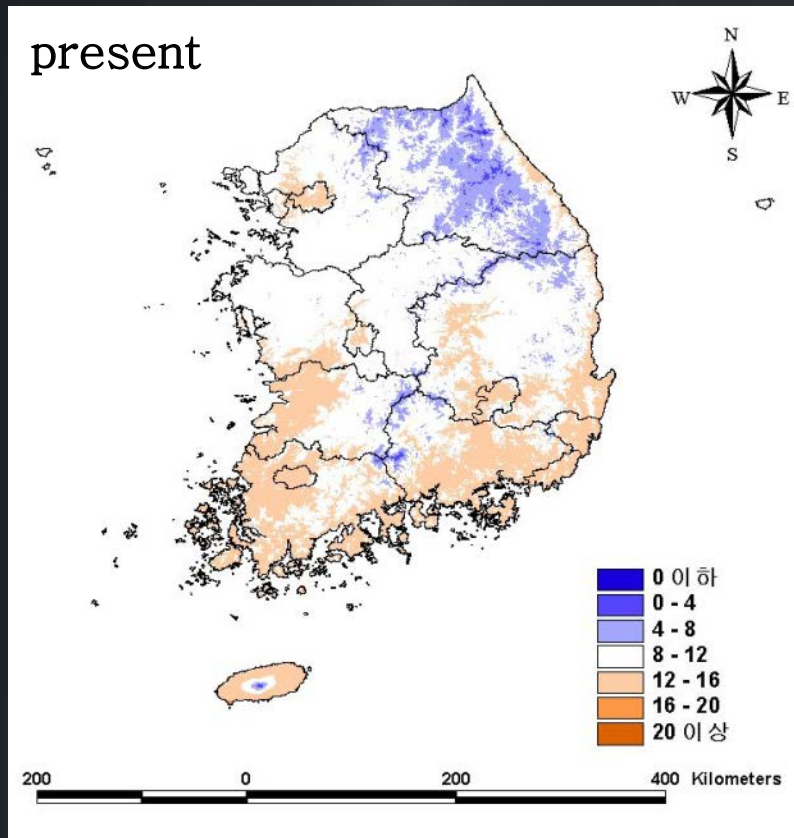
▶ Mean Temperature (2070; 2066~2075)

  ▪ A1B scenario : 13.9℃
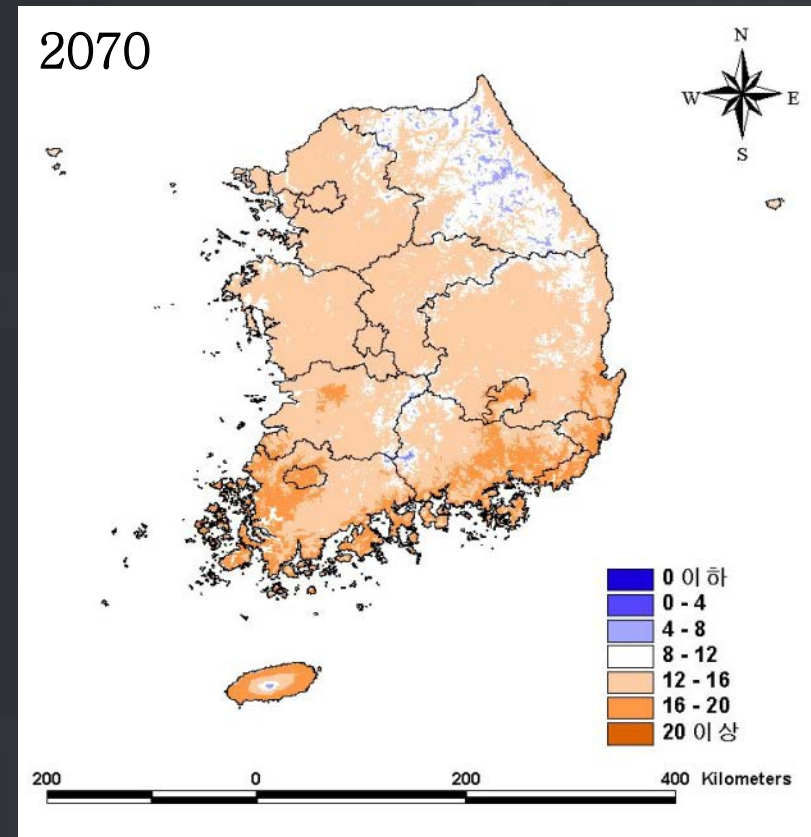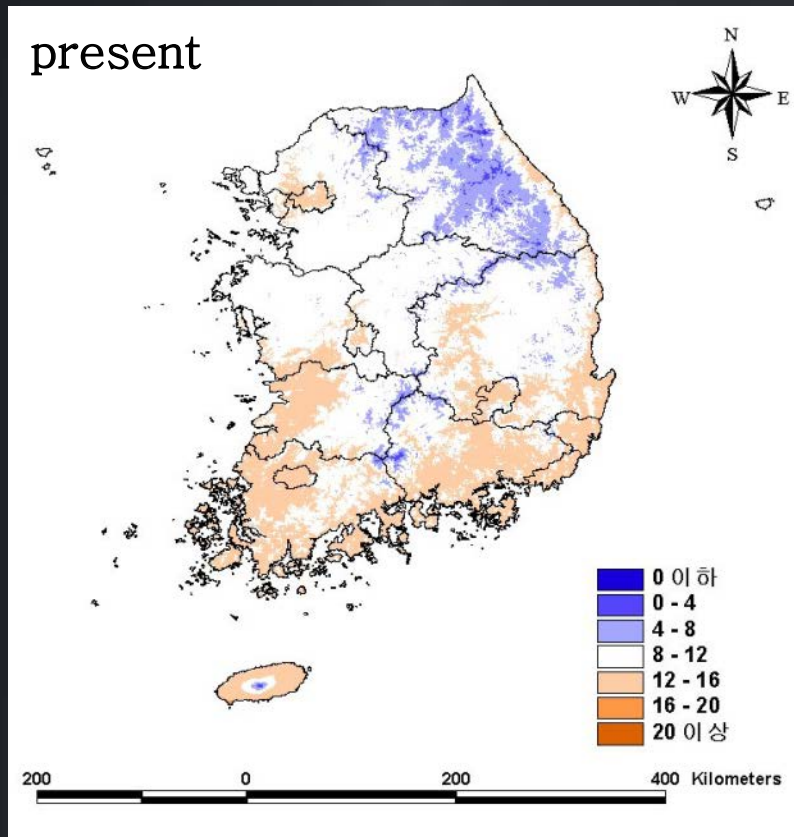
Results

1. Temperature in the future

▶ Mean Temperature (2100; 2096~2100)

▪ A1B scenario : 14.6℃
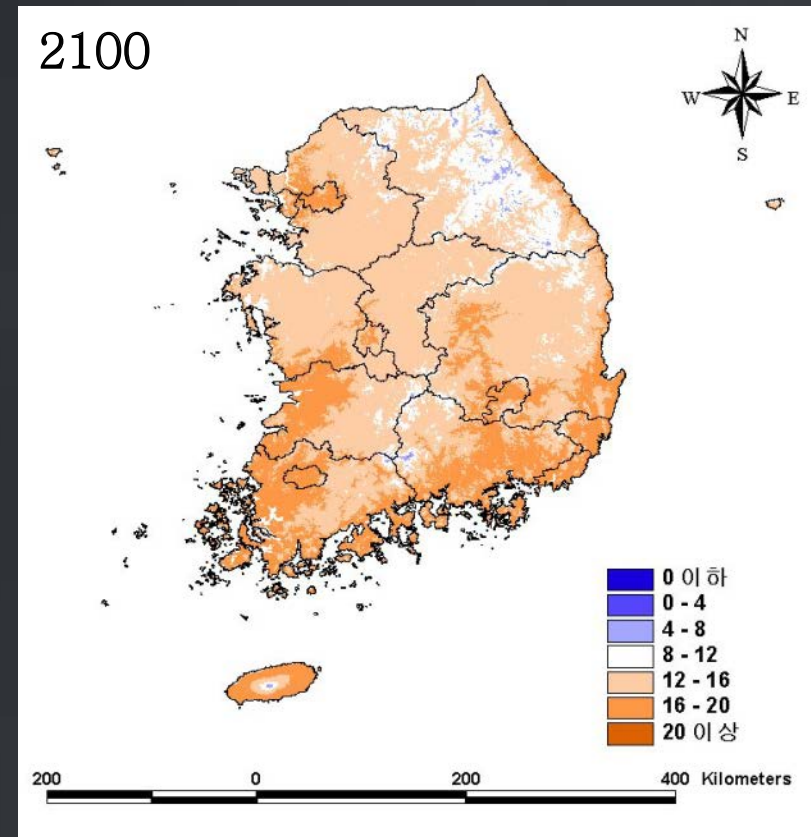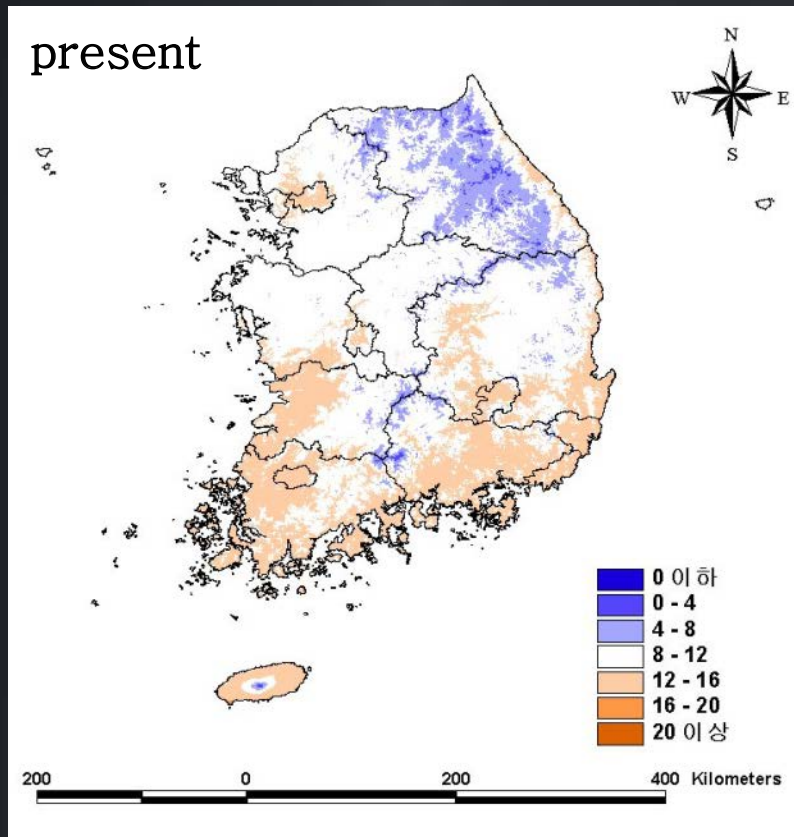
Results

2. Development of prediction model

▶ compared probabilities of forest distribution and then selected final forest types

	Coniferous Forest (P1)	Mixed Forest (P2)	Deciduous Forest (P3)	*Quercus myrsinaefolia* (P4)
Coniferous Forest (P1)	–	P2 > P1	P3 > P1	P4 > P1
Mixed Forest (P2)	P1 > P2	–	P3 > P2	P4 > P2
Deciduous Forest (P3)	P1 > P3	P2 > P3	–	P4 > P3
Quercus myrsinaefolia (P4)	P1 > P4	P2 > P4	P3 > P4	–

2. Development of prediction model

▶ selected factors by Multinomial Logit Model

▪ mean temperature in April (T_{avg4}), maximum temperature in January (T_{max1}), minimum temperature in September (T_{min9})

	Coniferous Forest (G1)	Mixed Forest (G2)	Deciduous Forest (G3)
intercept	30.8451	34.5253	36.1119
T_{avg4}	2.9812	2.8371	2.2272
T_{max1}	1.4733	1.1565	1.1663
T_{min9}	−4.8134	−4.6894	−4.3645

2. Development of prediction model

▶ validated prediction model for sample area

  ▪ classification accuracy：56.8%

simulation / Forest types map	Coniferous Forest	Mixed Forest	Deciduous Forest	*Quercus myrsinaefolia*	Total
Coniferous Forest	456	533	937	–	1,926
Mixed Forest	322	894	3,127	2	4,345
Deciduous Forest	155	798	6,398	2	7,353
Quercus myrsinaefolia	1	–	7	–	7
Total	934	2,225	10,469	4	13,632

(units：㎢)

2. Development of prediction model

▶ considered limited range to improve prediction model

<actual distribution>

Mixed Forest

Deciduous
Forest

Coniferous
Forest

176   325   466   682   855   1,016

(elevation, m)

<limited range for distribution model>

Coniferous
Forest

Mixed Forest

Deciduous
Forest

2. Development of prediction model

▶ re-validated prediction model for sample area

▪ classification accuracy : 76.1%

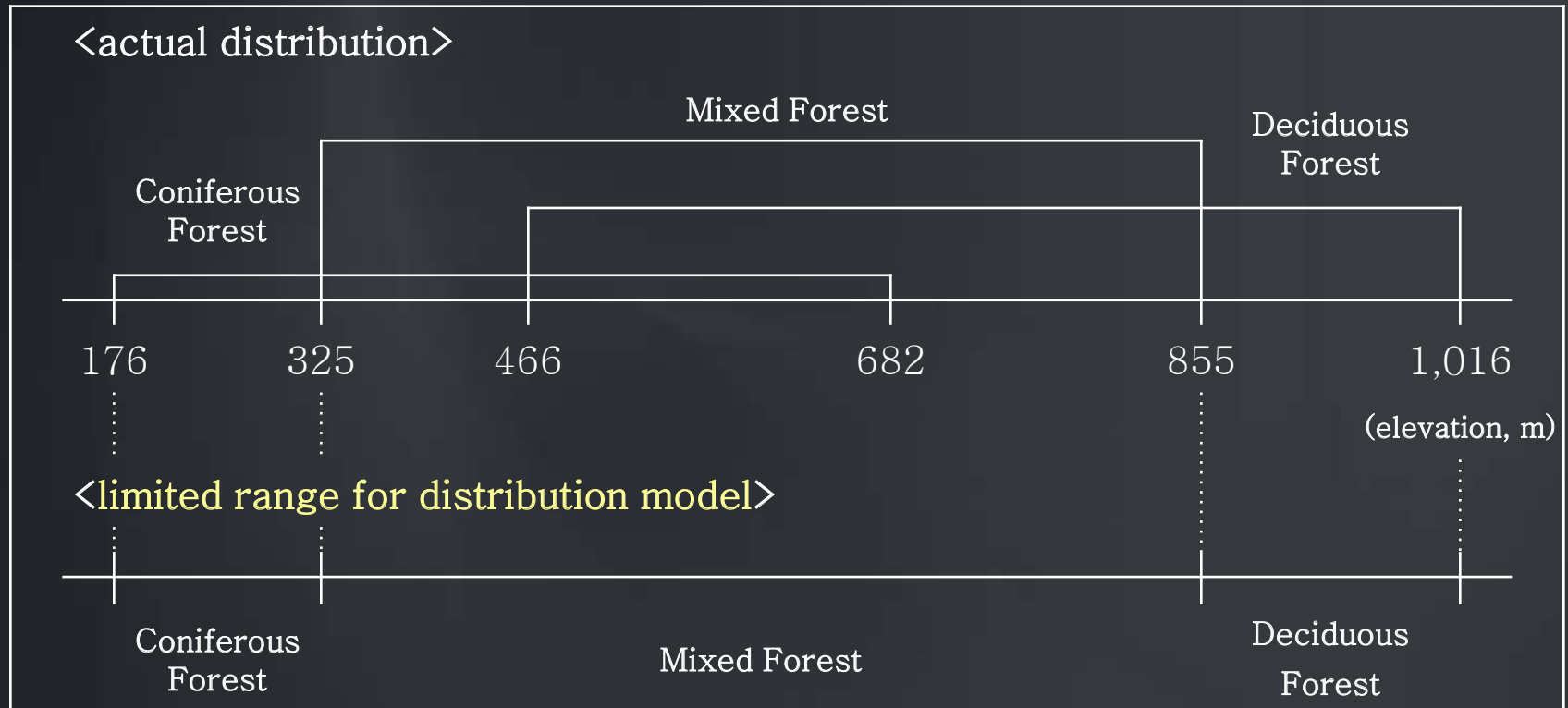| simulation / Forest types map	Coniferous Forest	Mixed Forest	Deciduous Forest	*Quercus myrsinaefolia*	Total
Coniferous Forest	644	396	886	–	1,926
Mixed Forest	275	3,328	740	2	4,345
Deciduous Forest	155	798	6,398	2	7,353
Quercus myrsinaefolia	1	–	–	7	8
Total	1,075	4,522	8,024	11	13,632

(units : ㎢)

Results

2. Development of prediction model

▶ re-validated prediction model for sample area

  ▪ classification accuracy : 76.1%

actual

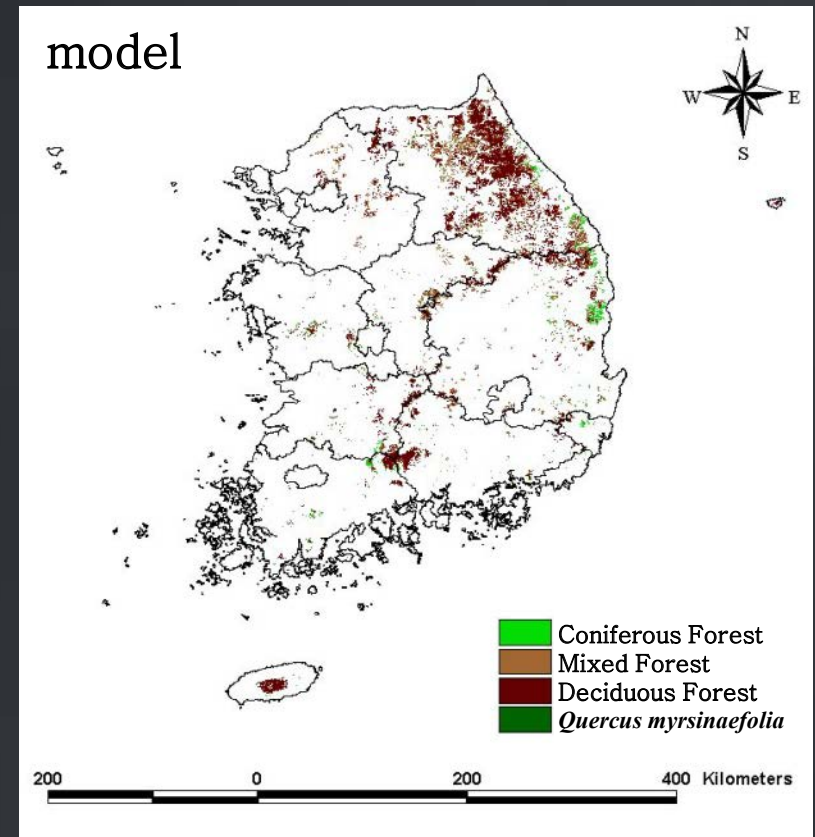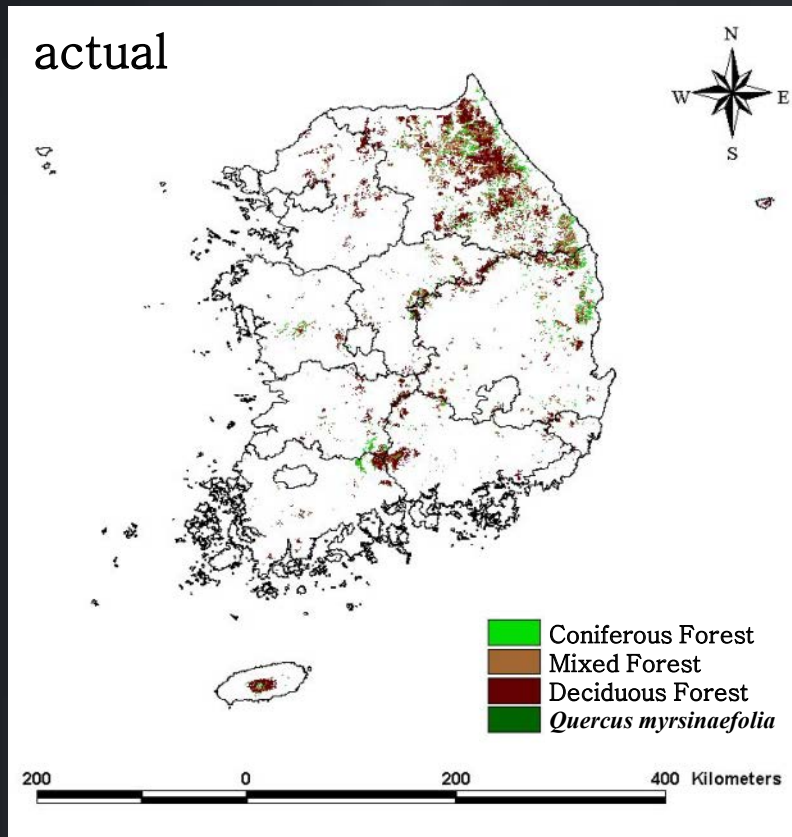Coniferous Forest
Mixed Forest
Deciduous Forest
Quercus myrsinaefolia

200 0 200 400 Kilometers

model

Coniferous Forest
Mixed Forest
Deciduous Forest
Quercus myrsinaefolia

200 0 200 400 Kilometers

Results

2. Development of prediction model

▶ applied prediction model for Korea

▪ limited range of elevation in forest types

	actual distribution	mean	1Std. Dev.	limited range
Coniferous Forest	0~1,883	249	193	56~99
Mixed Forest	0~1,705	337	238	99~575
Deciduous Forest	1~1,636	515	298	575~813

2. Development of prediction model

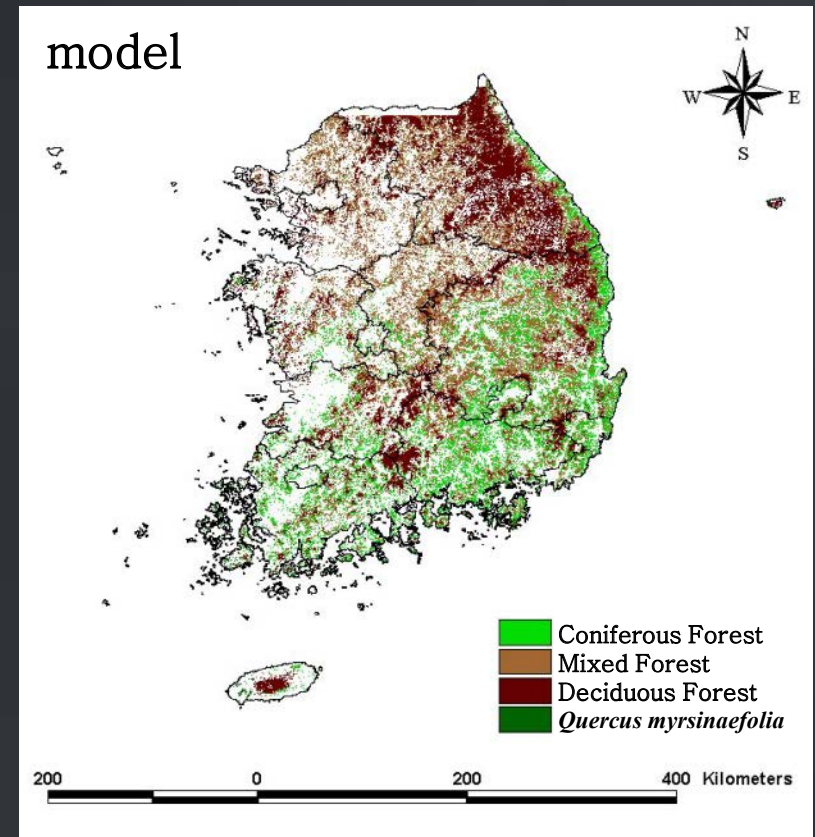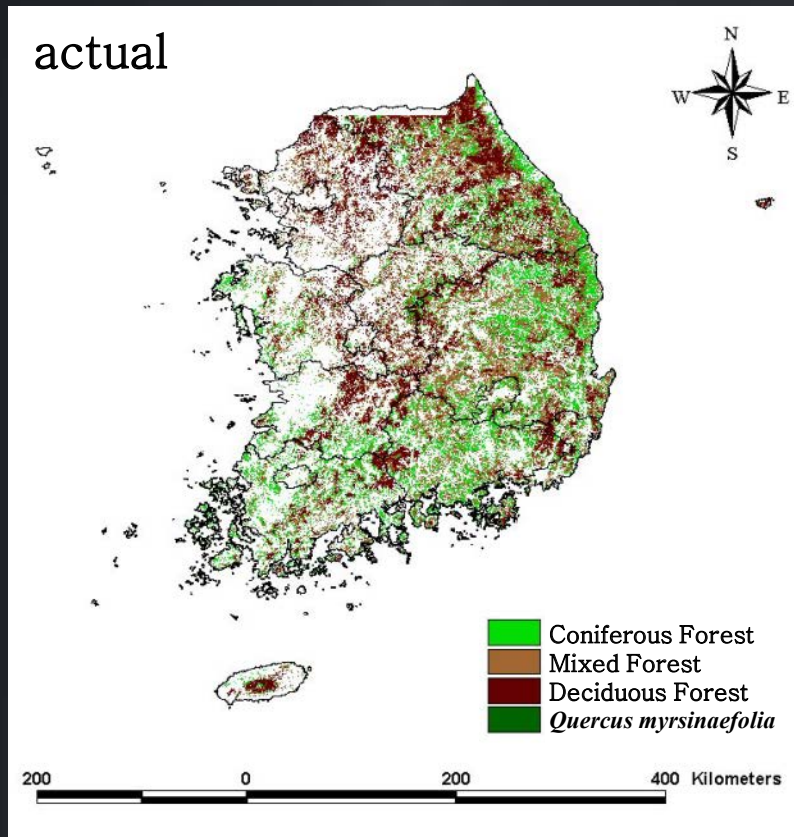▶ applied prediction model for Korea

▪ classification accuracy : 65.6%

simulation Forest types map	Coniferous Forest	Mixed Forest	Deciduous Forest	*Quercus myrsinaefolia*	Total
Coniferous Forest	11,978	4,275	3,861	294	20,408
Mixed Forest	2,203	19,722	4,578	52	26,555
Deciduous Forest	2,492	5,756	13,300	67	21,615
Quercus myrsinaefolia	1	–	–	7	8
Total	16,674	29,753	21,739	420	68,586

(units : ㎢)

2. Development of prediction model

▶ applied prediction model for Korea

▪ classification accuracy : 65.6%

3. Application of prediction model

▶ applied prediction model for Korea by 2030

  ▪ coniferous forest ： decreased 58.6%
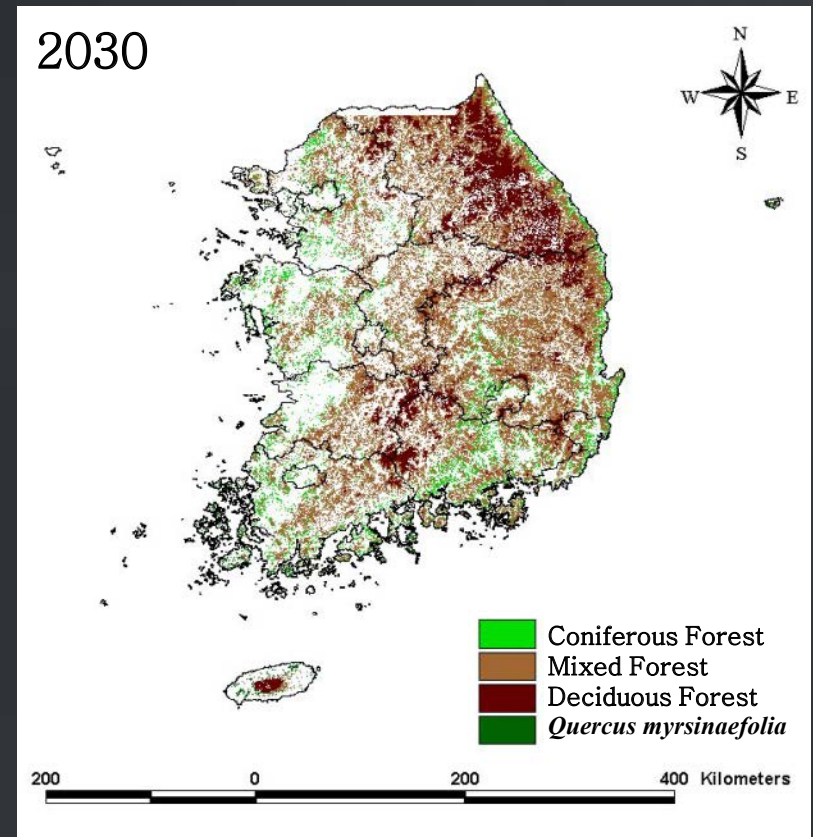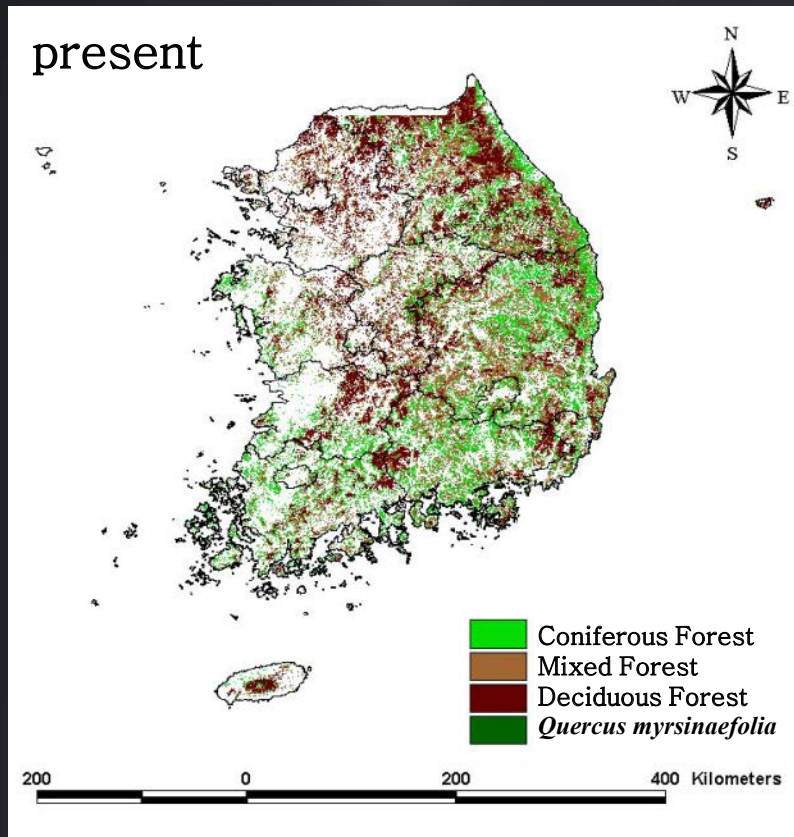
  ▪ mixed forest, *Quercus myrsinaefolia* ： increased

present 　2030	Coniferous Forest	Mixed Forest	Deciduous Forest	*Quercus myrsinaefolia*	Total
Coniferous Forest	6,601	9,760	–	294	16,655
Mixed Forest	1,135	28,175	256	144	29,710
Deciduous Forest	740	6,751	13,972	337	21,800
Quercus myrsinaefolia	–	–	–	421	421
Total	8,476	44,686	14,228	1,196	68,586

(units ： km^2)

3. Application of prediction model

▶ applied prediction model for Korea by 2030

- coniferous forest : decreased 58.6%

Results

3. Application of prediction model

▶ applied prediction model for Korea by 2050

▪ coniferous forest, deciduous forest, mixed forest : decreased

▪ *Quercus myrsinaefolia* : increased

2030 \ 2050	Coniferous Forest	Mixed Forest	Deciduous Forest	*Quercus myrsinaefolia*	Total
Coniferous Forest	7,908	–	–	568	8,476
Mixed Forest	190	43,937	–	559	44,686
Deciduous Forest	79	97	13,942	110	14,228
Quercus myrsinaefolia	–	–	–	1,196	1,196
Total	8,177	44,034	13,942	2,433	68,586

(units : km^2)
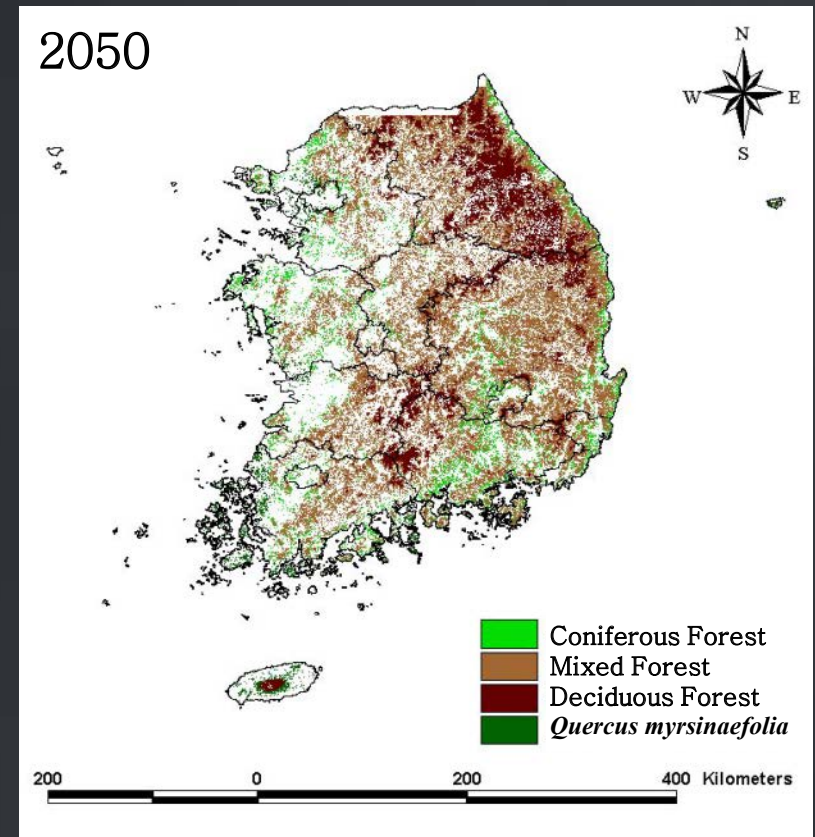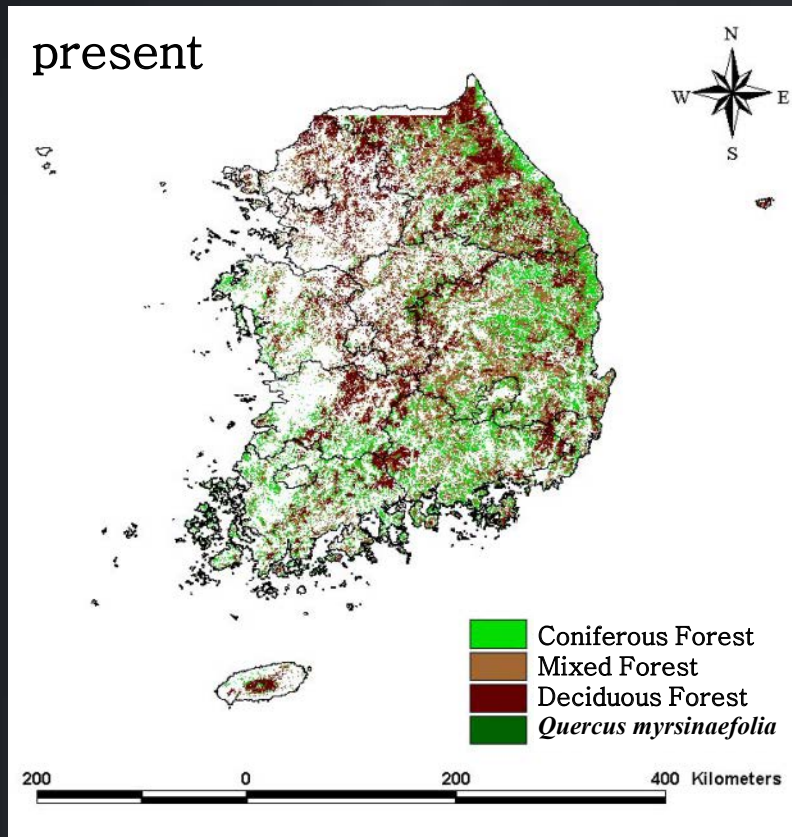
3. Application of prediction model

▶ applied prediction model for Korea by 2050

▪ *Quercus myrsinaefolia* : increased

3. Application of prediction model

▶ applied prediction model for Korea by 2070

- coniferous forest, mixed forest : decreased
- *Quercus myrsinaefolia* : increased

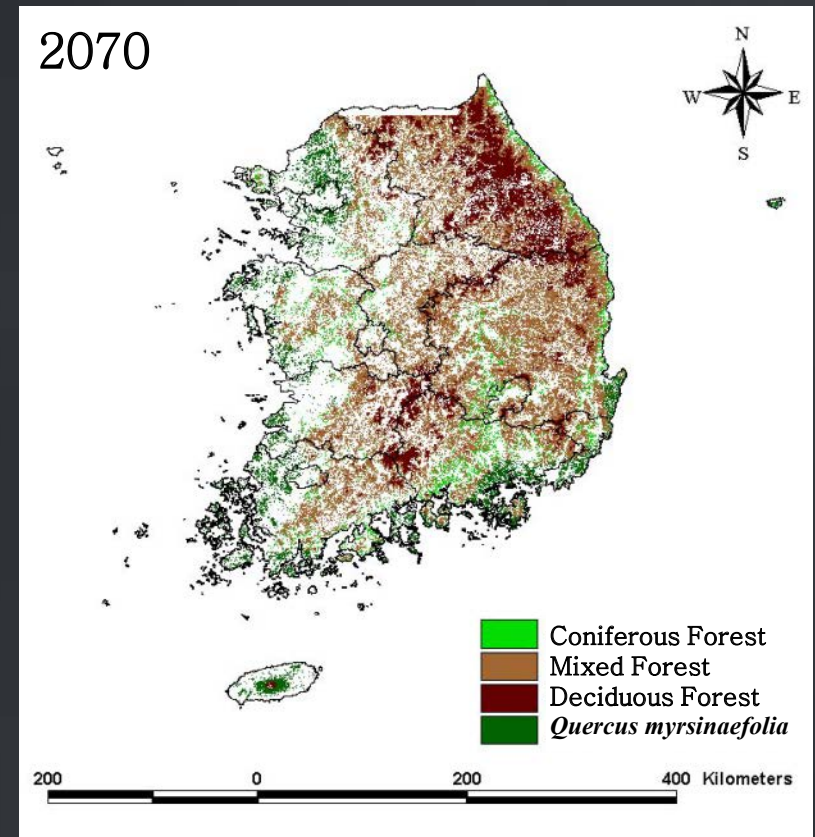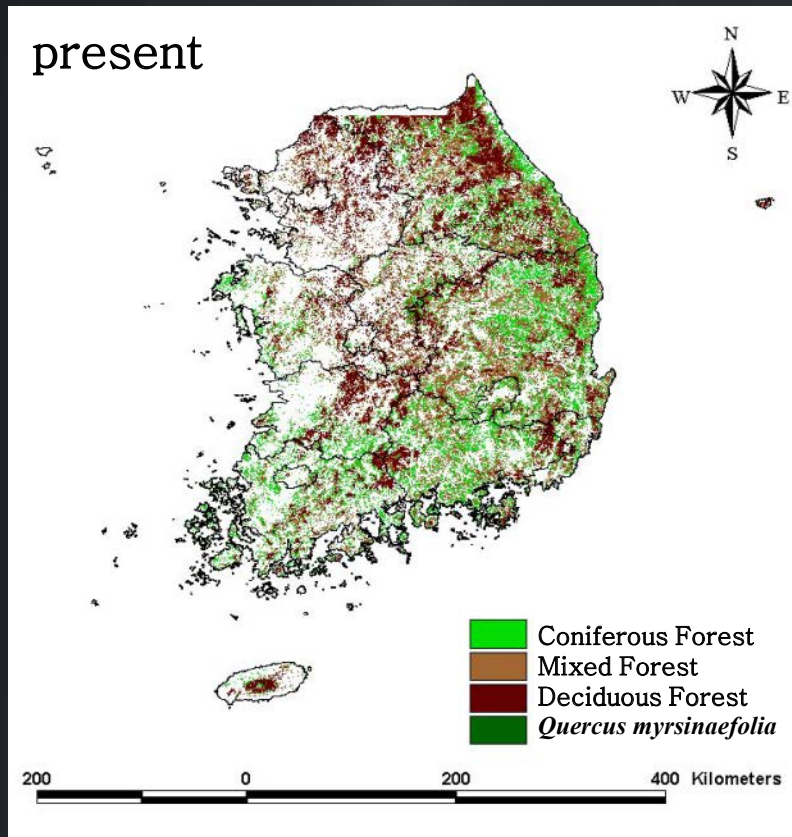| 2050 ＼ 2070	Coniferous Forest	Mixed Forest	Deciduous Forest	*Quercus myrsinaefolia*	Total
Coniferous Forest	5,371	–	–	2,806	8,177
Mixed Forest	21	40,848	74	3,091	44,034
Deciduous Forest	3	–	13,748	191	13,942
Quercus myrsinaefolia	–	–	–	2,433	2,433
Total	5,395	40,848	13,822	8,521	68,586

(units : km^2)

3. Application of prediction model

▶ applied prediction model for Korea by 2070

▪ coniferous forest, mixed forest : decreased

3. Application of prediction model

▶ applied prediction model for Korea by 2100

- deciduous forest, *Quercus myrsinaefolia* : decreased
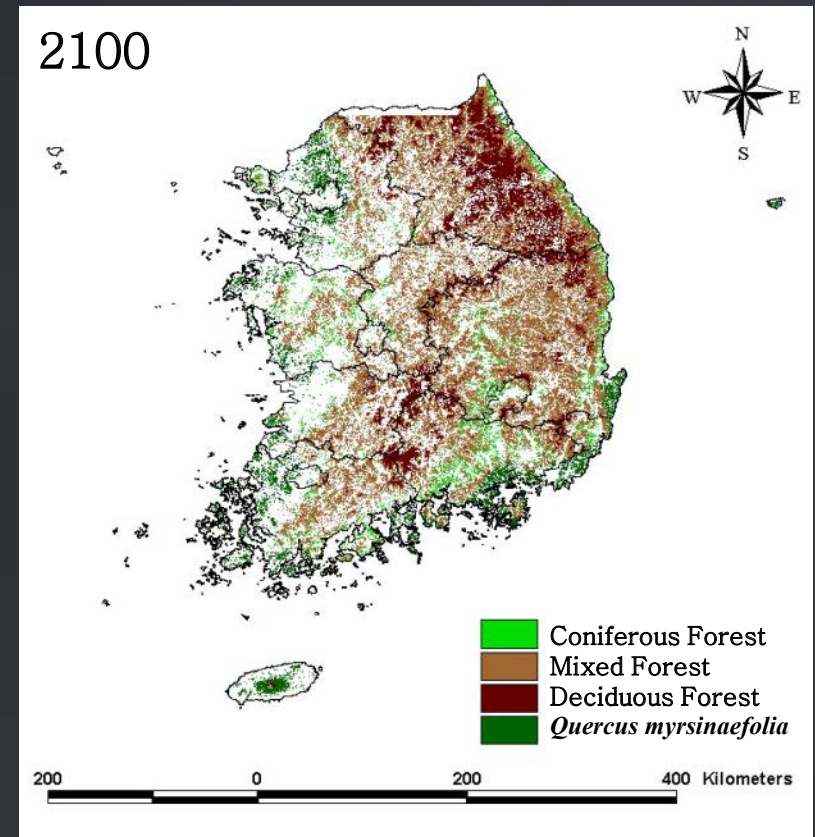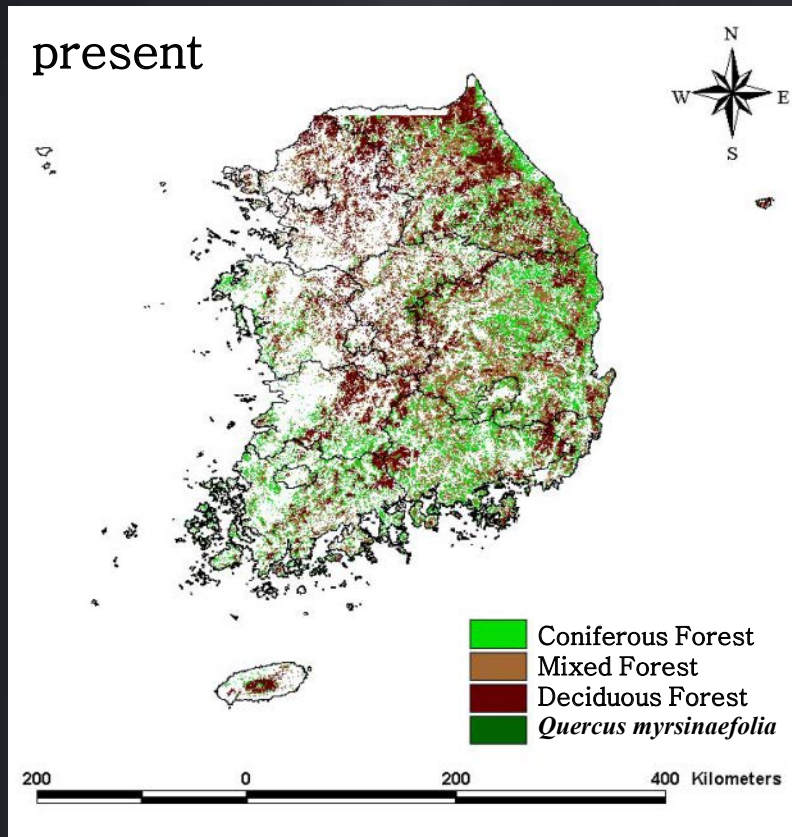- coniferous forest, mixed forest : increased

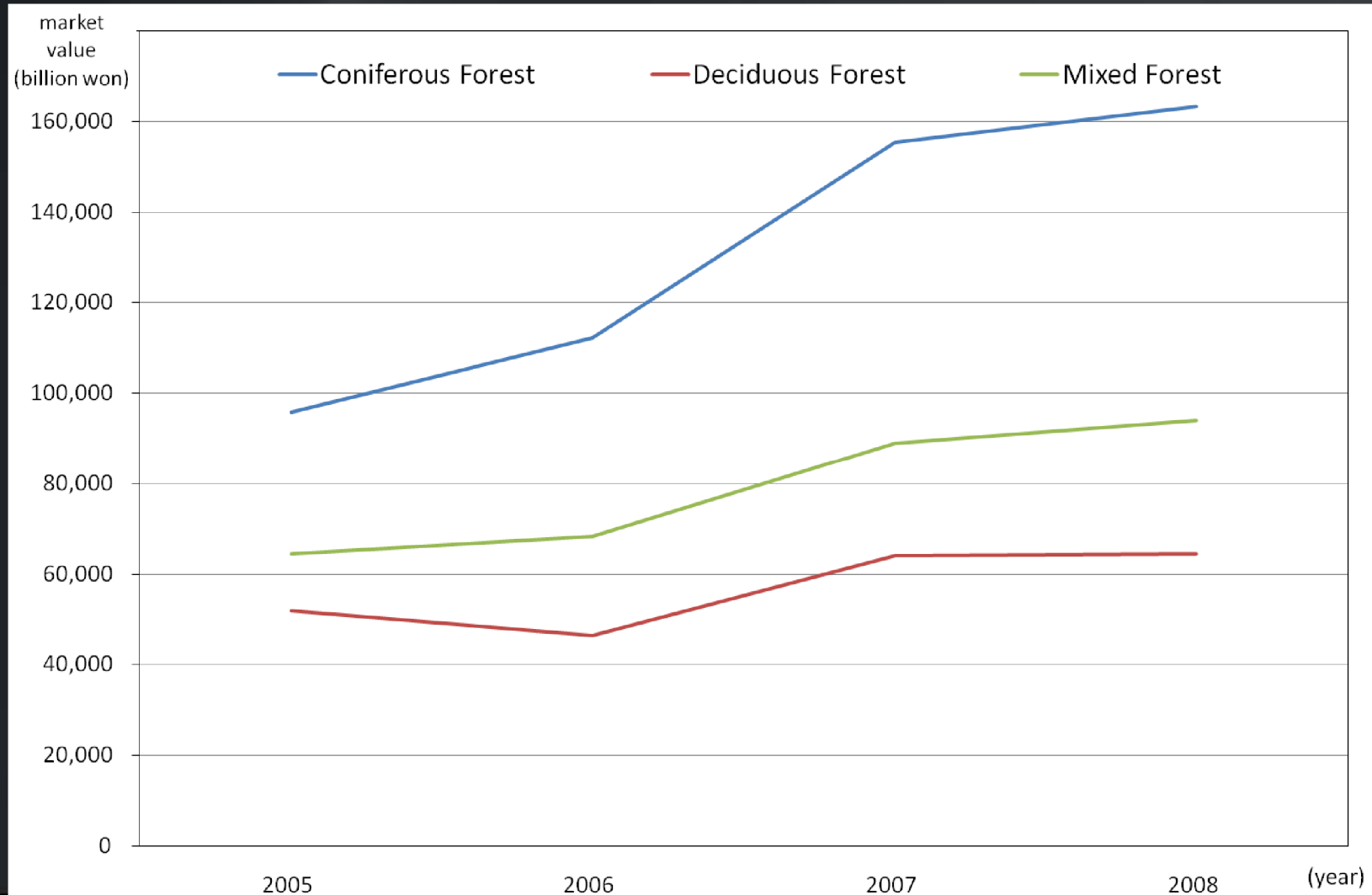| 2100 2070	Coniferous Forest	Mixed Forest	Deciduous Forest	*Quercus myrsinaefolia*	Total
Coniferous Forest	5,328	–	–	67	5,395
Mixed Forest	12	40,700	–	136	40,848
Deciduous Forest	34	52	13,715	21	13,822
Quercus myrsinaefolia	307	412	1	7,801	8,521
Total	5,681	41,164	13,716	8,025	68,586

(units : km^2)

3. Application of prediction model

▶ applied prediction model for Korea by 2100

▪ coniferous forest, mixed forest : increased

Results

4. Economic value of forest

4. Economic value of forest

▶ market value for forest types during the 2000 to 2008

- coniferous forest : 43.6 billon won/1000ha

- deciduous forest : 34.8 billon won/1000ha

- mixed forest : 38.7 billon won/1000ha

▶ verification of methods

|		Coniferous forest	Deciduous forest	Mixed forest	Total
2007	statistics	155,273 (43.0%)	63,995 (23.9%)	88,855 (33.1%)	268,123 (100%)
	results	117,153 (47.4%)	57,838 (23.4%)	72,059 (29.2%)	247,050 (100%)
2008	statistics	163,214 (50.7%)	64,496 (20.0%)	94,034 (29.2%)	321,744 (100%)
	results	116,848 (47.4%)	57,733 (23.4%)	71,711 (29.1%)	246,292 (100%)

(units : billion won)

4. Economic value of forest

|	Coniferous forest	Deciduous forest	Mixed forest	Total
present	72,638 (27.4%)	77,326 (29.2%)	114,978 (43.4%)	264,942 (100%)
2030	36,973 (14.0%)	53,662 (20.4%)	172,912 (65.6%)	263,547 (100%)
2050	35,665 (13.6%)	57,002 (21.7%)	170,396 (64.8%)	263,063 (100%)
2070	23,544 (9.1%)	77,743 (30.0%)	158,090 (60.9%)	259,377 (100%)
2100	24,765 (9.5%)	75,655 (29.1%)	159,289 (61.3%)	259,709 (100%)

(units : billion won)

Conclusion

▶ development of prediction model for forest types
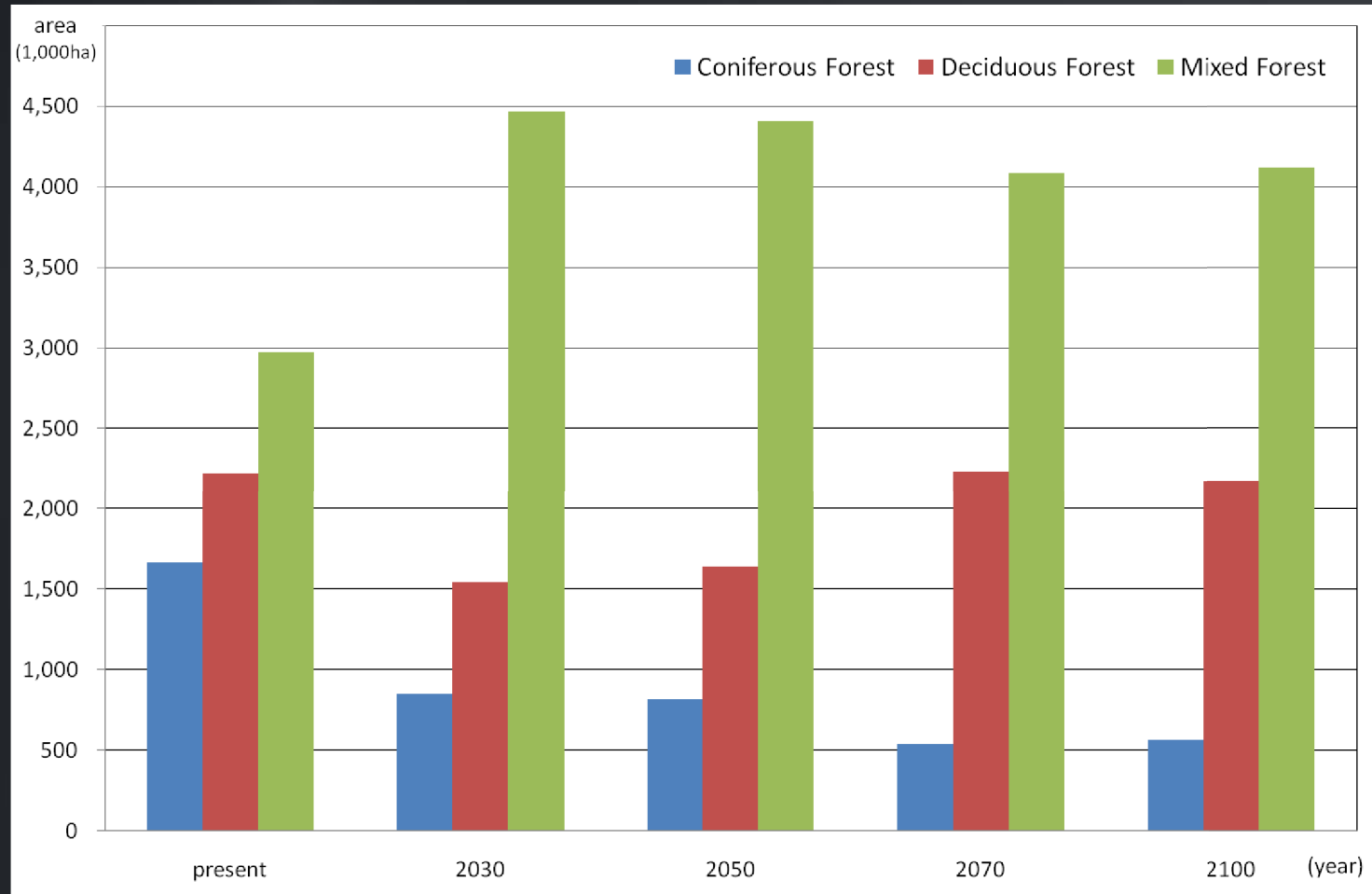
Conclusion

▶ assessment of economic value for forest types
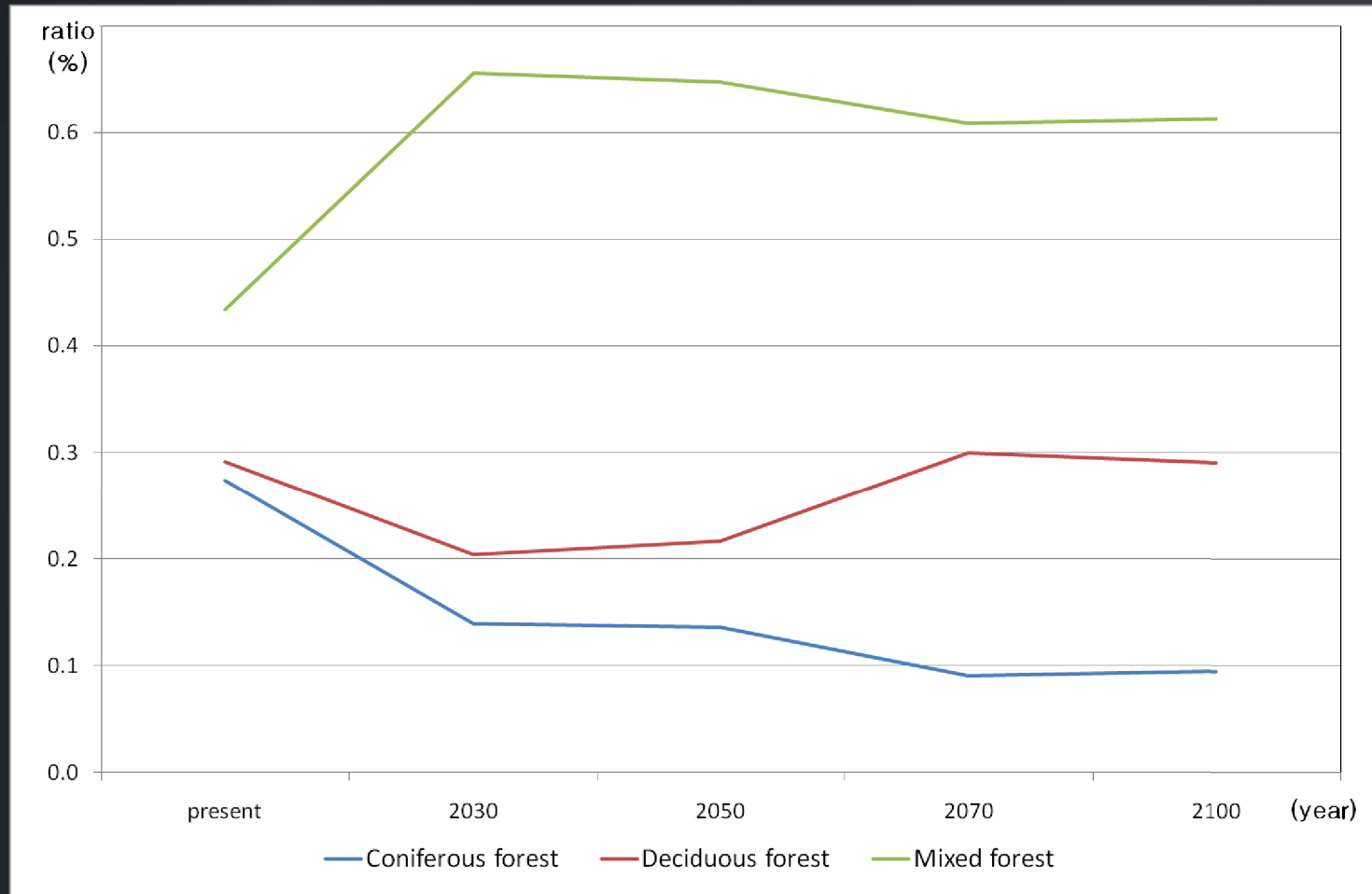
Conclusion

▶ Limitations and Considerations

- one regional climate model vs various climate models

- change in forest types vs change of forest based on landuse/cover change

- assessment of economic value by GDP ratio vs improvement of methods

Thank you for attention