The 13th AIM International Workshop
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NIES, Tsukuba, Japan

Impact assessment of vegetation by climate change in Korea

18 February, 2008

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(*Seoul National University · **Hanyang University, Korea)

Contents

Summary

Project Name

Development of an ecosystem model for change prediction and management technique of vulnerable areas by climate change

Terms of Totality Apr. 1st. 2007. ~ Mar. 31st. 2010. (3 years)

Term of this year Apr. 1st. 2007. ~ Mar. 31st. 2008.

Participant Seoul National University, Kyung Hee University, Hanyang University

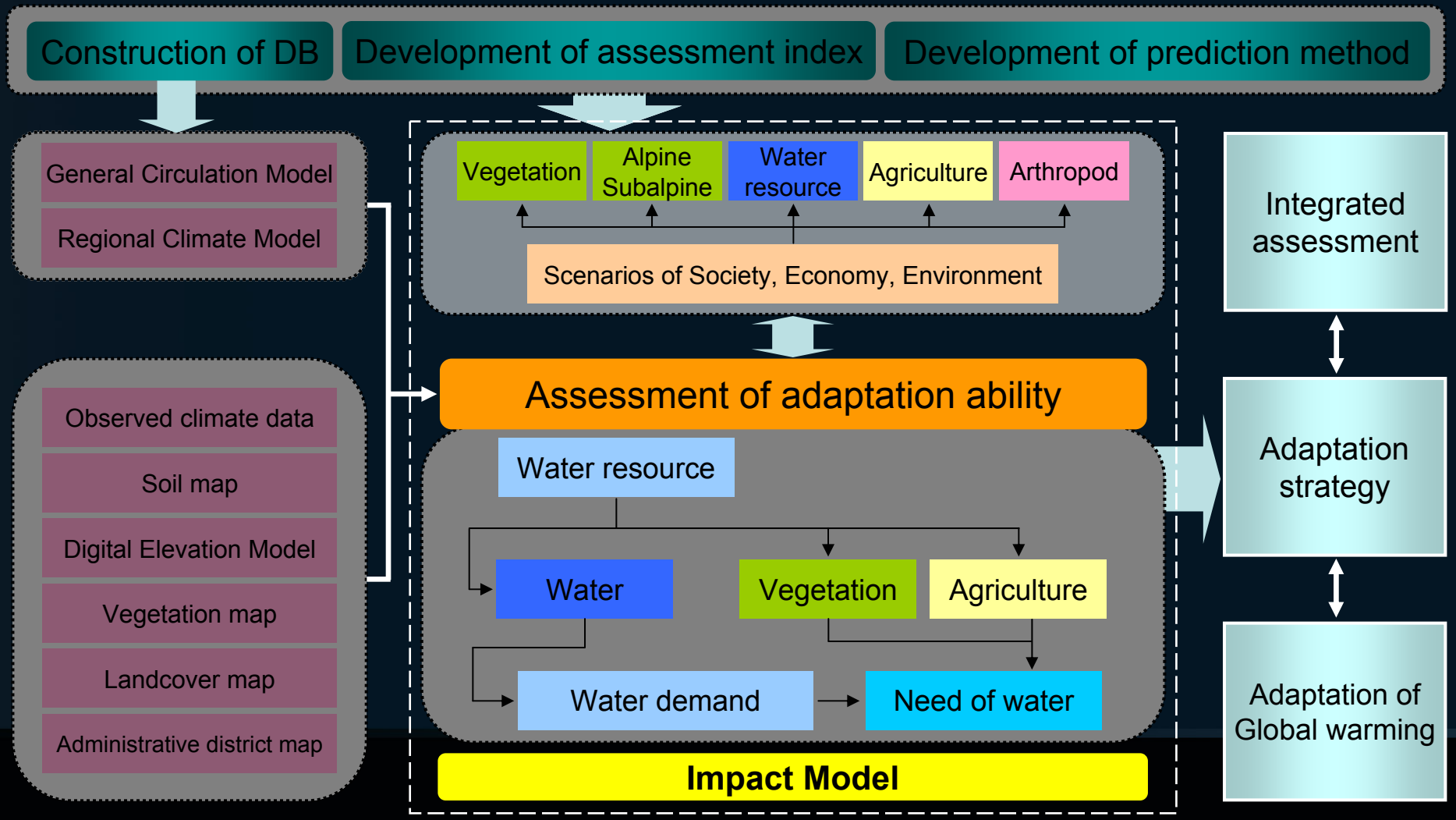
Objectives

To collect data and develop impact model of vulnerable fields (vegetation, alpine/subalpine, crop and arthropod) by climate change

To evaluate economic value in vulnerable fields

Summary

Flowchart



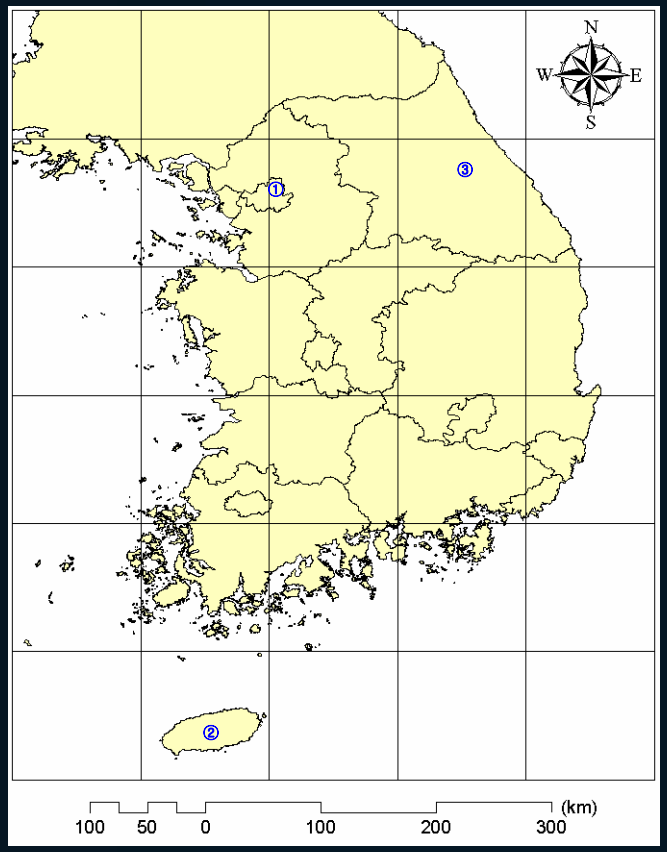
Backgrounds

Global mean temperature near the Earth's surface rose 0.74±0.18°C during the past century.

Climate models referenced by the IPCC project that global surface temperatures are likely to increase by 1.1 to 6.4 °C between 1990 and 2100.

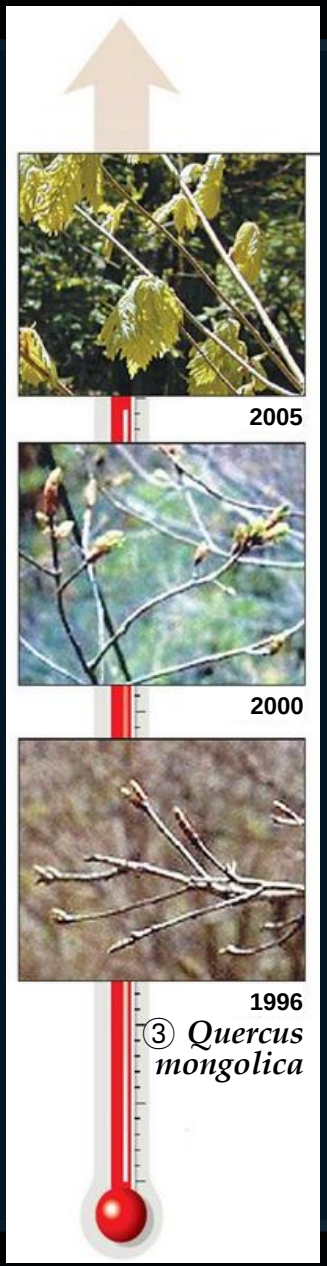
The effect of global warming is becoming more apparent on various parts of the world including dynamics in natural ecosystems.

Backgrounds



① *Camellia japonica L.*

② *Sasa quelpaertensis* Nakai



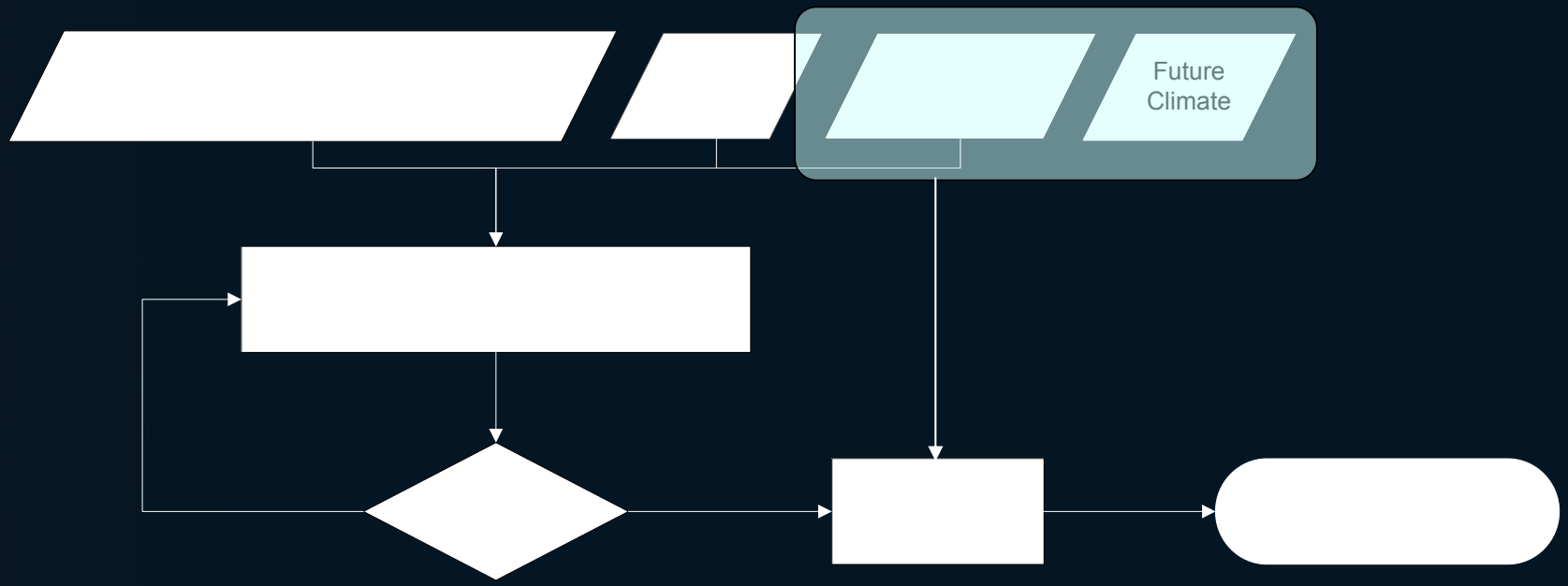
Objectives

To predict potential distribution of *Pinus densiflora*, *Quercus Spp.*, Alpine Plants and Evergreen Broad-Leaved Plants

To assess a vulnerable area in climate change

To measure economic value of change in vegetation due to climate change: focusing on pine and oak trees

Methods I



Methods II

Questionnaire design

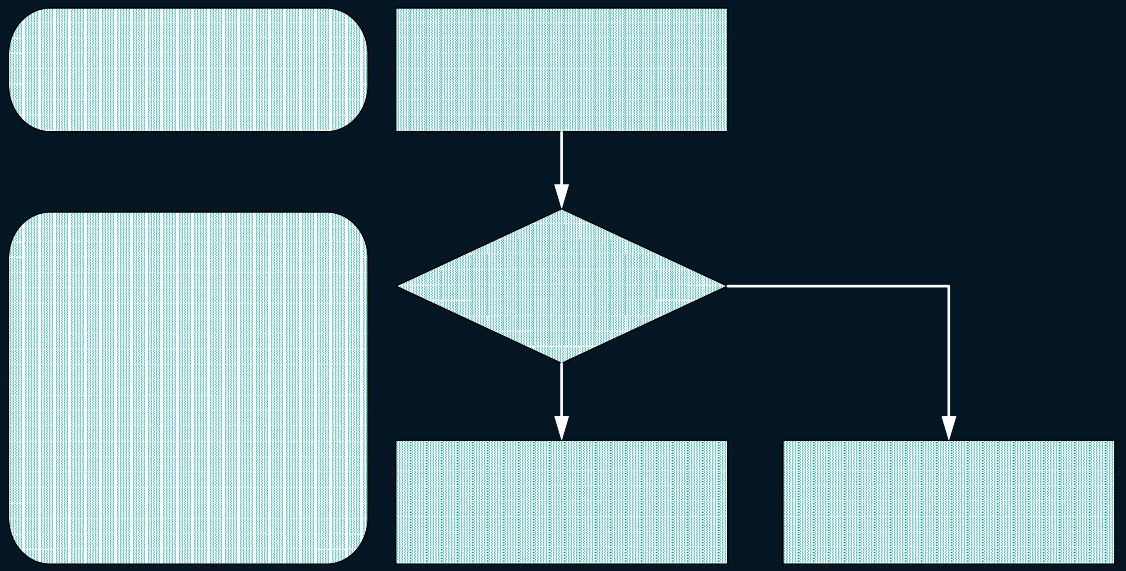
Sample design

Interview

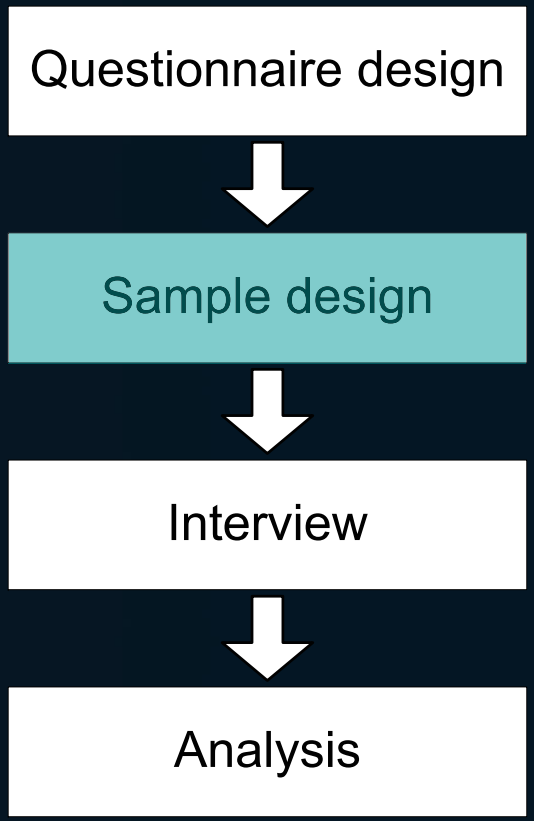
Analysis

Contingent valuation : double bounded referendum format

Virtual state : Conservation Fund for Pine and Oak trees

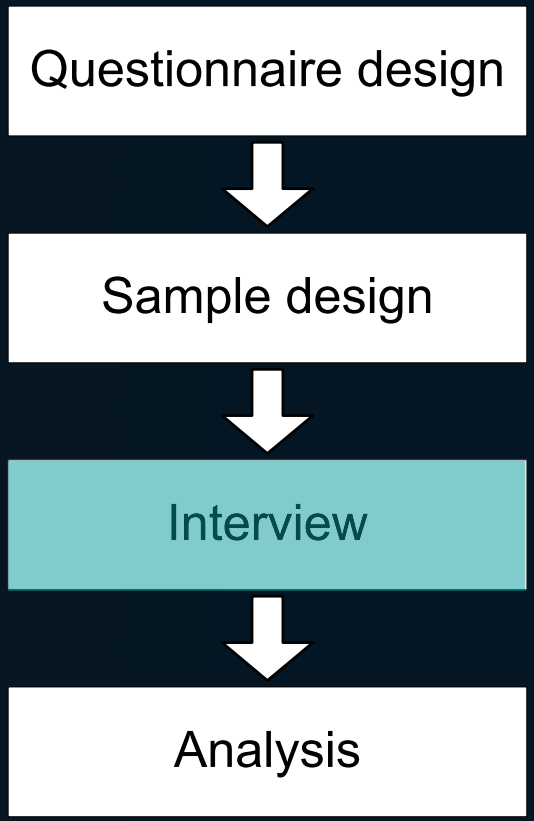


Methods II



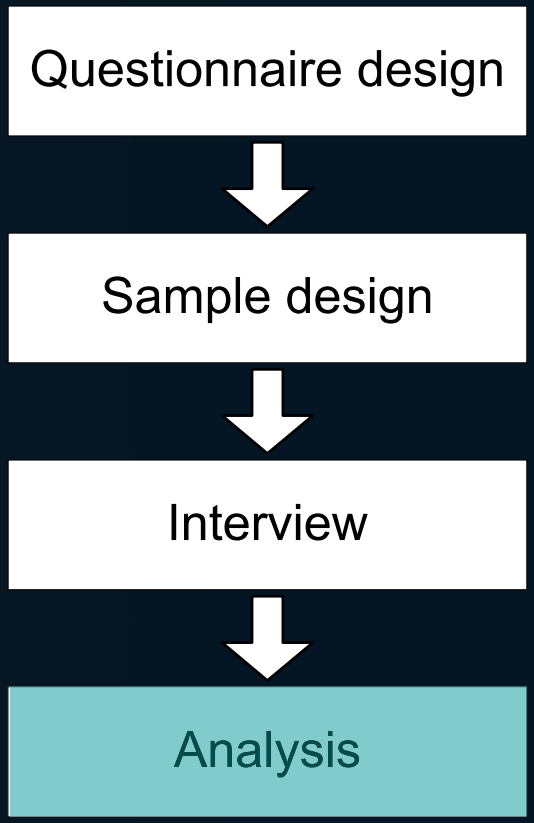
	Contents
Population	over 20 years old, nationwide
Sampling size	400 persons (general public)
Sampling methods	Proportionate Stratified Sampling
Sampling error	± 3.7% ($p < 0.05$)

Methods II



	Contents
Interview methods	Fax, E-Mail, Telephone
Data collection means	Structured Questionnaire
Interview period	30 November ~ 18 December, 2007

Methods II



Probability expressions for 4 types of responses

$$
\begin{aligned}
P((Q_{i,1}, Q_{i,2}) = (1,1)) &= P(\ln(WTP_i) \geq \ln(t^h_{i,2})) \\
&= P(\epsilon_i \geq -z_i'\gamma + \ln(t^h_{i,2})) \\
&= 1 - F\left(\frac{-z_i'\gamma + \ln(t^h_{i,2})}{\sigma}\right) \\
&= 1 - F(-z_i'\alpha + \delta\ln(t^h_{i,2})) \\
&= F(z_i'\alpha - \delta\ln(t^h_{i,2}))
\end{aligned}
$$

$$
\begin{aligned}
P((Q_{i,1}, Q_{i,2}) = (1,0)) &= P(\ln(t_{i,1}) \leq \ln(WTP_i) < \ln(t^h_{i,2})) \\
&= P(\ln(WTP_i) < \ln(t^h_{i,2})) - P(\ln(WTP_i) < \ln(t_{i,1})) \\
&= \{1 - F(-z_i'\alpha + \delta\ln(t^h_{i,2}))\} - \{1 - F(-z_i'\alpha + \delta\ln(t_{i,1}))\} \\
&= F(-z_i'\alpha + \delta\ln(t_{i,1})) - F(-z_i'\alpha + \delta\ln(t^h_{i,2}))
\end{aligned}
$$

$$
\begin{aligned}
P((Q_{i,1}, Q_{i,2}) = (0,1)) &= P(\ln(t^l_{i,2}) \leq \ln(WTP_i) < \ln(t_{i,1})) \\
&= P(\ln(WTP_i) < \ln(t_{i,1})) - P(\ln(WTP_i) < \ln(t^l_{i,2})) \\
&= \{1 - F(-z_i'\alpha + \delta\ln(t_{i,1}))\} - \{1 - F(-z_i'\alpha + \delta\ln(t^l_{i,1}))\} \\
&= F(-z_i'\alpha + \delta\ln(t^l_{i,1})) - F(-z_i'\alpha + \delta\ln(t_{i,1}))
\end{aligned}
$$

$$
\begin{aligned}
P((Q_{i,1}, Q_{i,2}) = (0,0)) &= P(\ln(WTP_i) < \ln(t^l_{i,2})) \\
&= 1 - F(z_i'\alpha - \delta\ln(t^l_{i,2}))
\end{aligned}
$$

Standard logistic distribution

Log - linear model

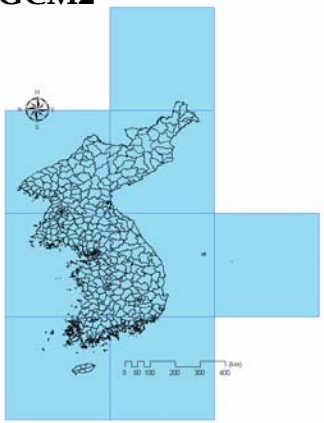
Estimate of WTP : median

Materials-Climate Models

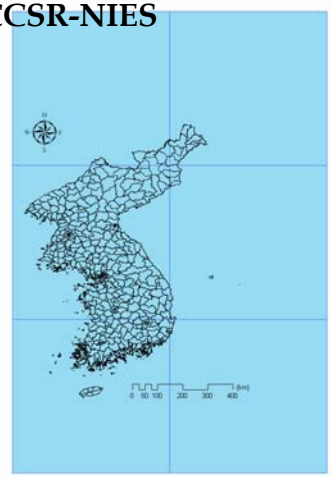
HadCM3

CSIRO-Mk2

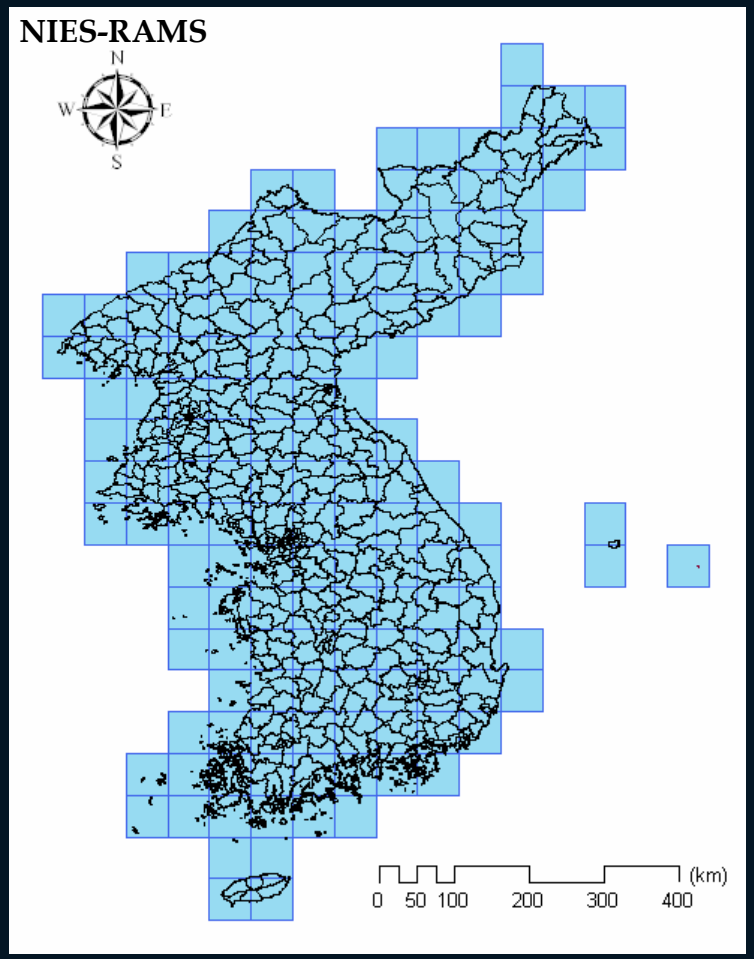
CGCM2



CCSR-NIES



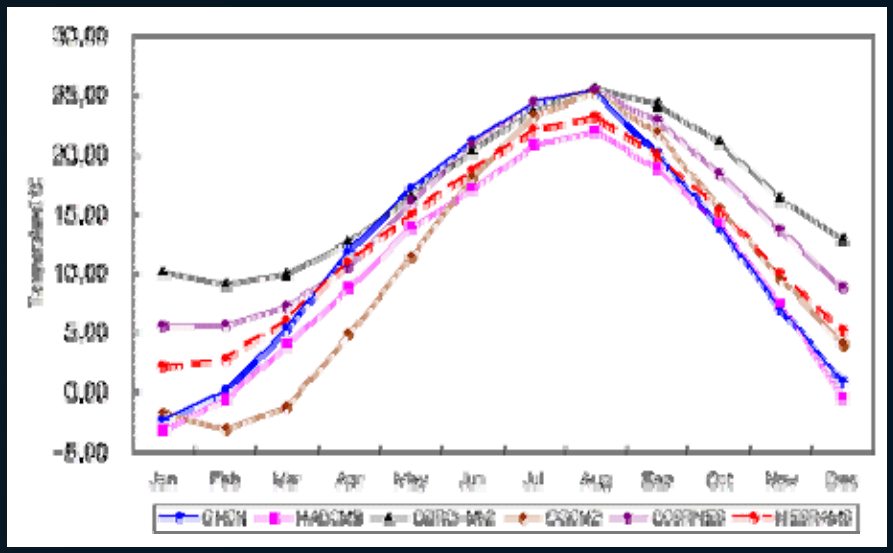
NIES-RAMS



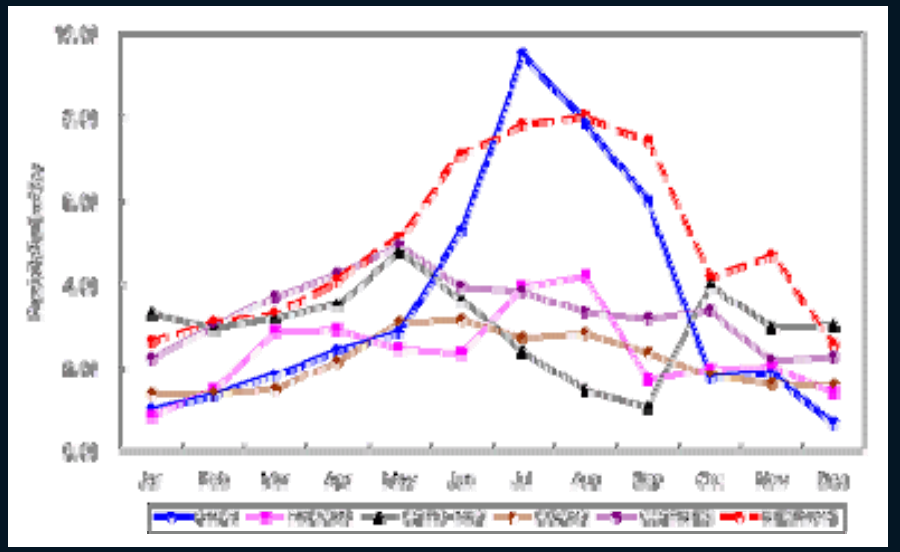
General Circulation Model

Regional Climate Model

Materials-Climate Models



Temperature



Precipitation

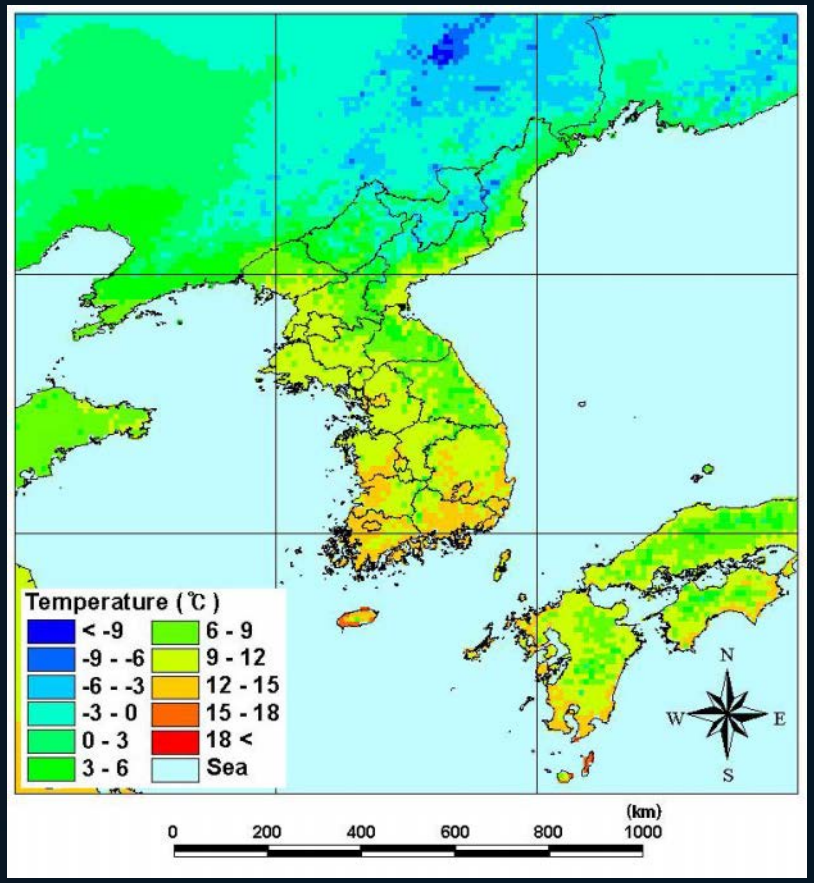
Materials-Plant communities

	Dominant communities
Pinus densiflora	*Pinus densiflora (1)*
Quercus Spp.	*Quercus acutissima, Quercus aliena, Quercus dentata, Quercus grosseserrata, Quercus mongolica, Quercus serrata, Quercus variabilis (7)*
Alpine Plants	*Abies holophylla, Abies koreana, Abies nephrolepis, Betula ermanii, Betula platyphylla, Empetrum nigrum var. japonicum, Juniperus chinensis var. sargentii, Juniperus rigida, Pinus koraiensis, Pinus pumila, Rhododendron mucronulatum var. ciliatum, Taxus cuspidata, Thuja koraiensis, Thuja orientalis L. (14)*
Evergreen Broad-Leaved Plants	*Castanopsis cuspidata var. sieboldii, Castanopsis cuspidata var. thunbergii, Camellia japonica L., Cinnamomum japonicum, Daphniphyllum macropodum, Elaeagnus macrophylla, Ilex integra, Litsea japonica, Machilus thunbergii, Quercus acuta, Quercus myrsinaefolia (11)*

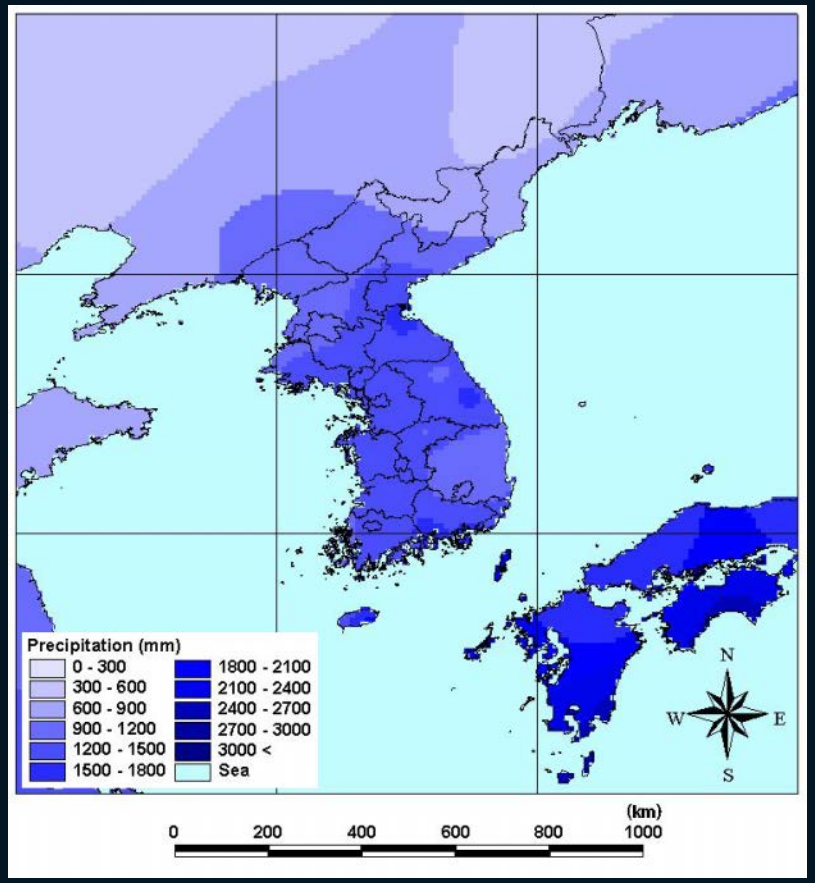
Materials-Environmental factors

Categories	Factors (16)
Climate	Mean temperature (yearly, January, August, Spring, Summer, Fall, Winter), Total precipitation (yearly, Spring, Summer, Fall, Winter)
Topography	Elevation
Index	Warmth index, Coldness index

Results-Current climate (1971~2000)

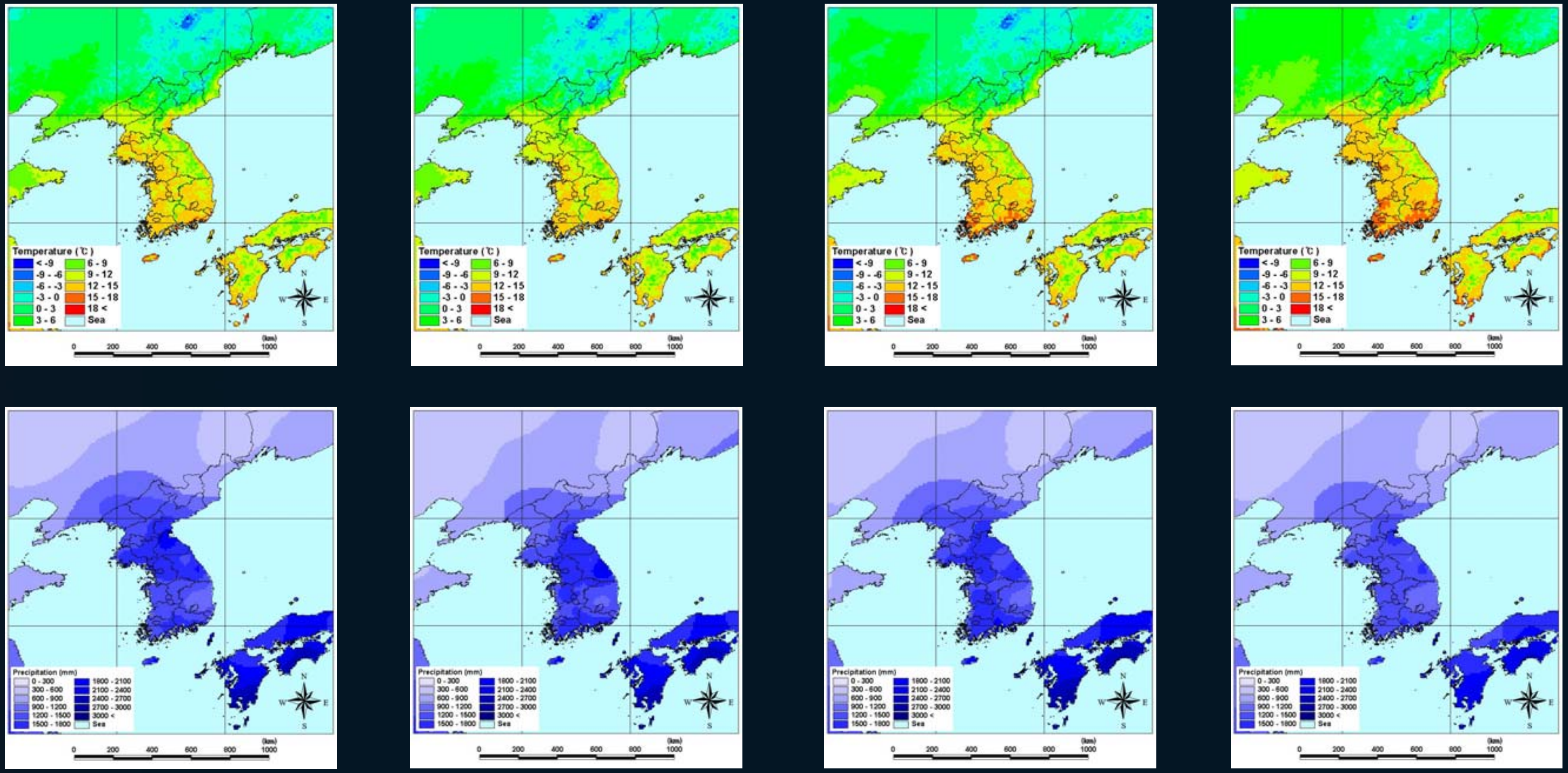


Temperature (10.1℃)



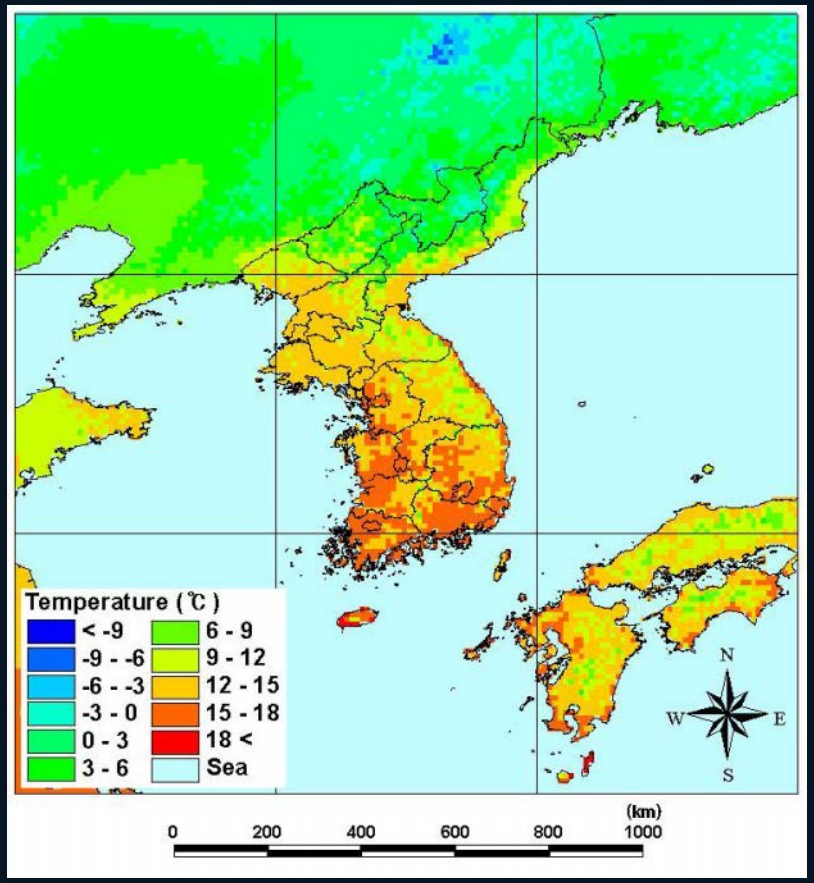
Precipitation (1,283mm)

Results-Future climate (2050)

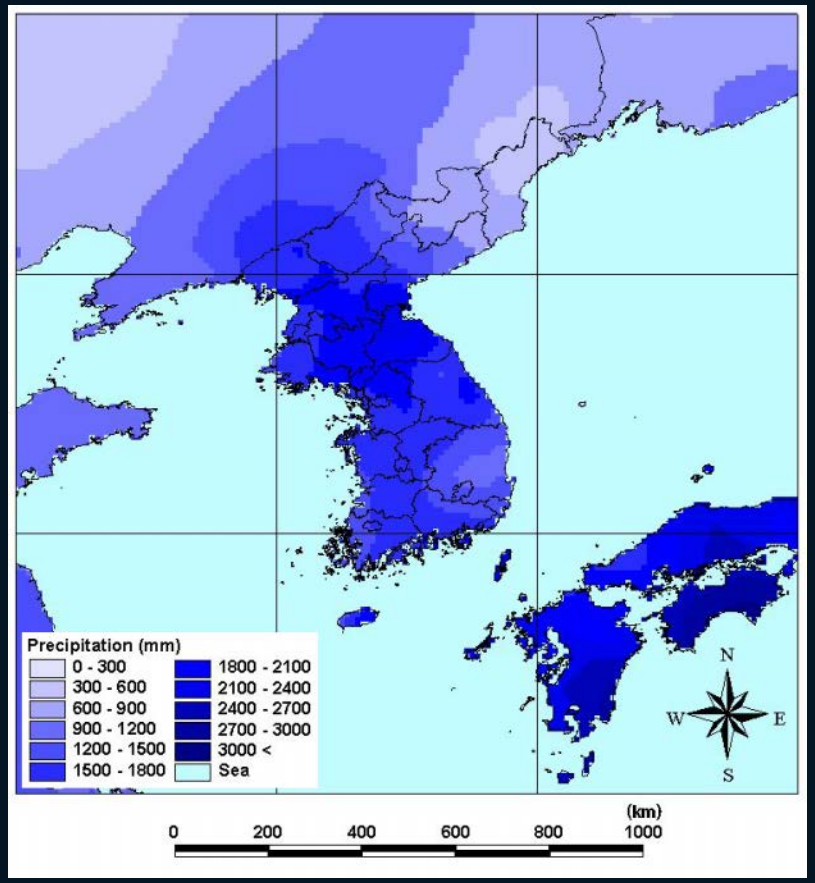


HADCM3 GCM | CSIRO-Mk2 GCM | CGCM2 GCM | CCSR/NIES GCM

Results-Future climate (2050)

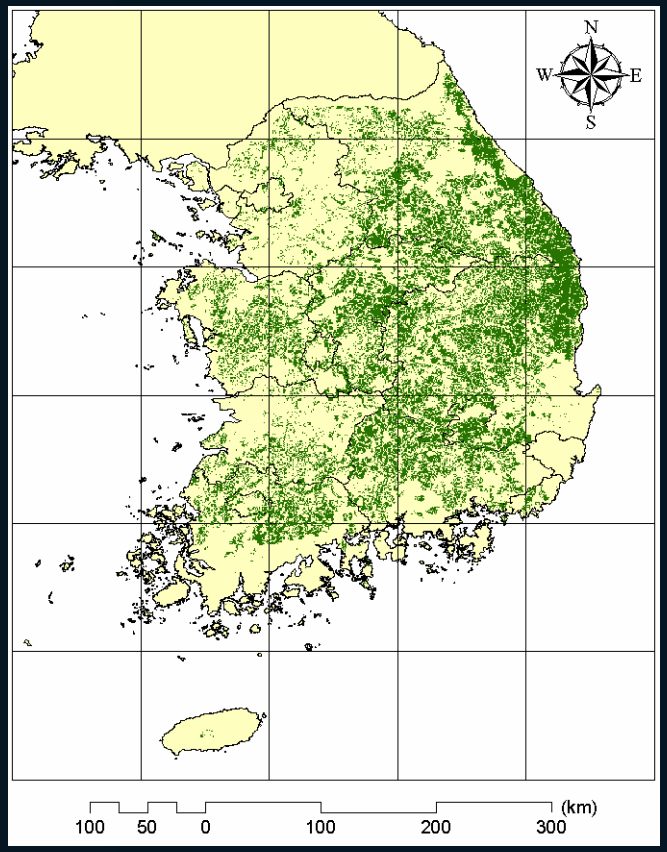


NIES/RAMS RCM (Temperature)



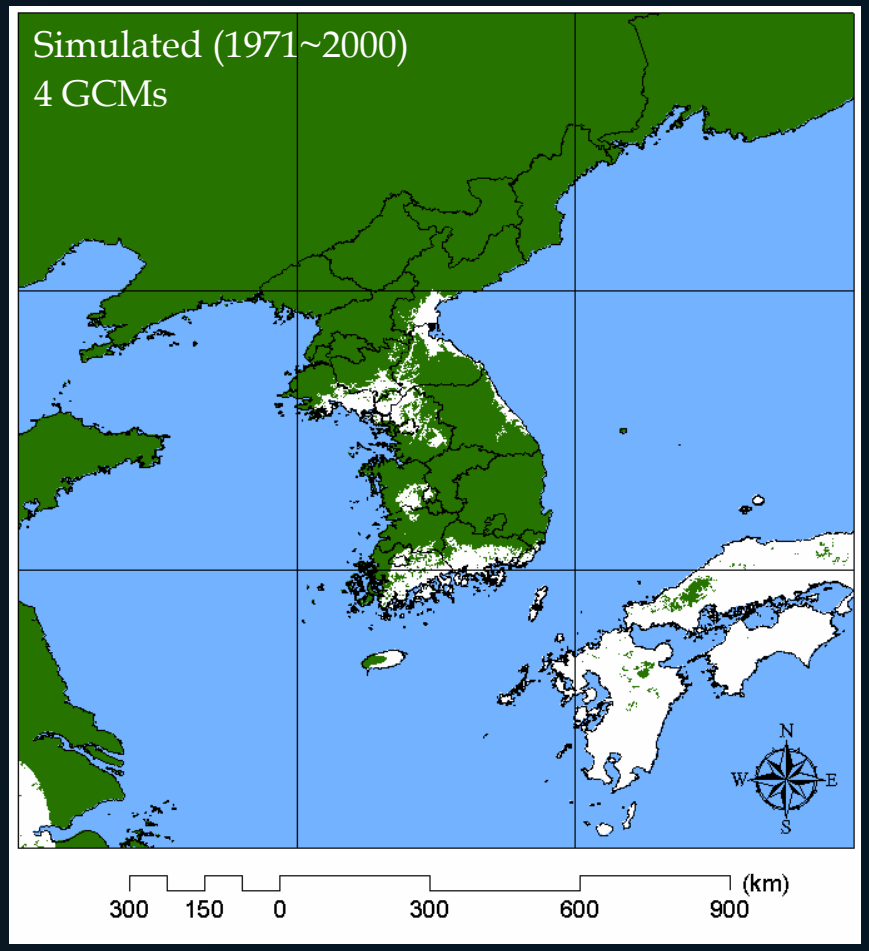
NIES/RAMS RCM (Precipitation)

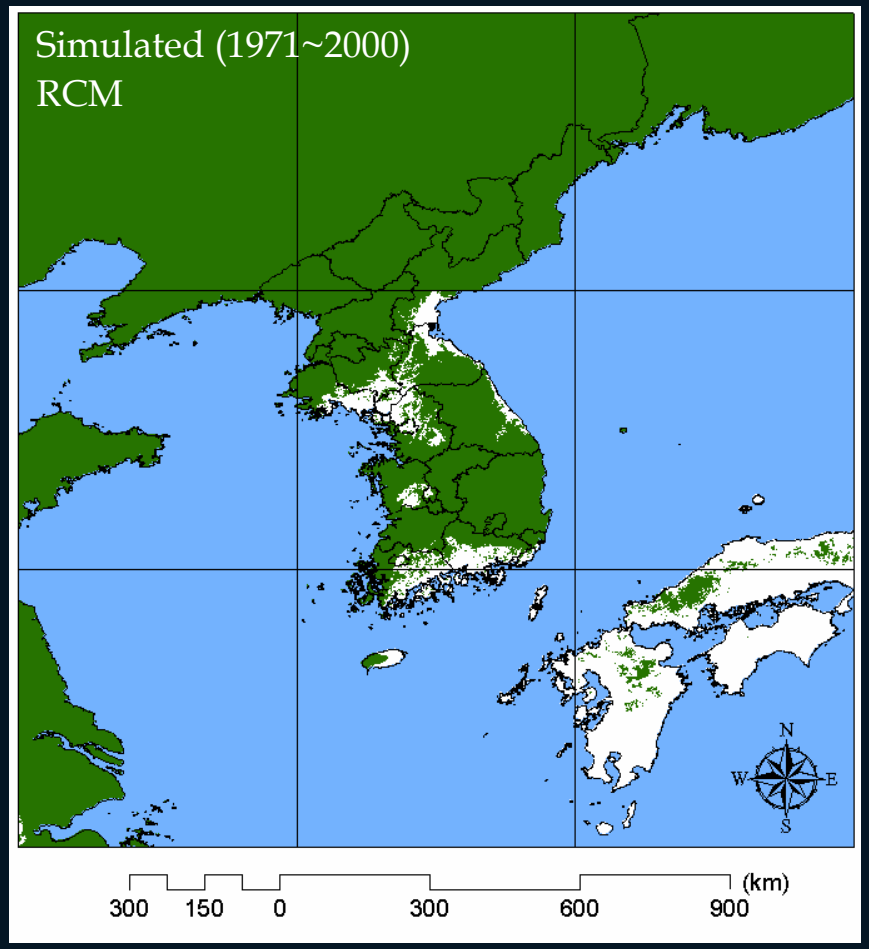
Results-*Pinus densiflora*



	Ranges	Mean
Area	56.2 %	
Elevation (m)	1~1,492	312
Mean temperature (℃)	1.5~14.8	10.5
Total precipitation (㎜)	971~1,741	1,252
Warmth index (month·℃)	34.3~120.3	89.3

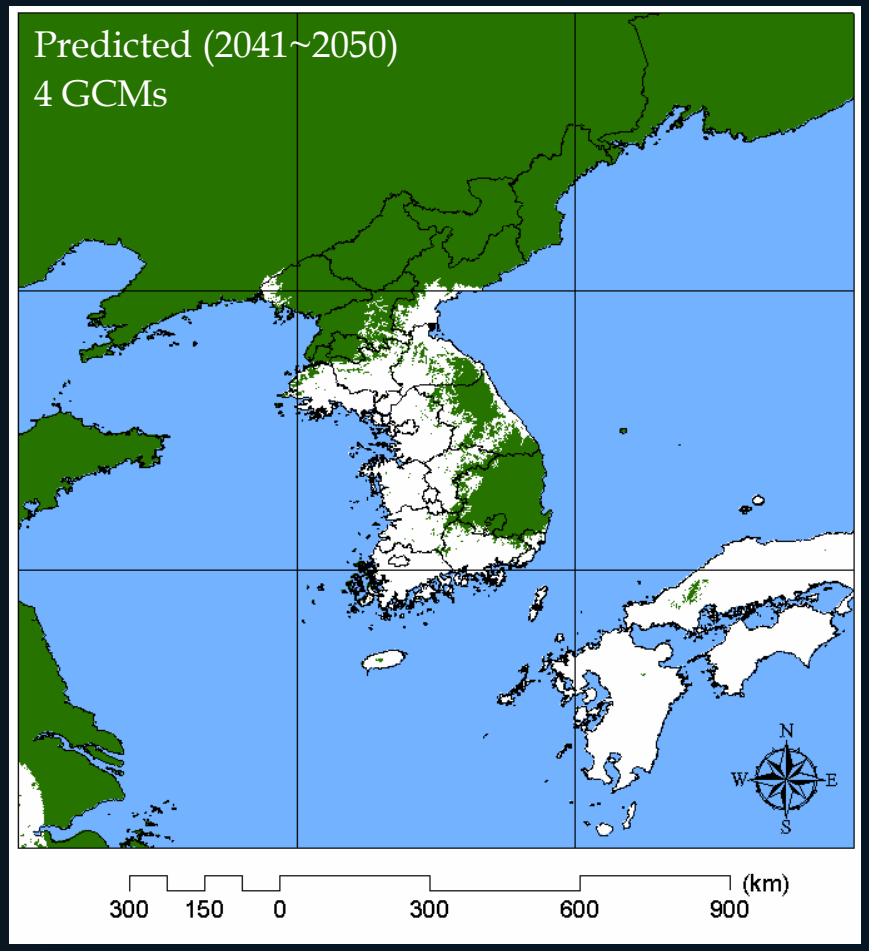
Results-*Pinus densiflora*

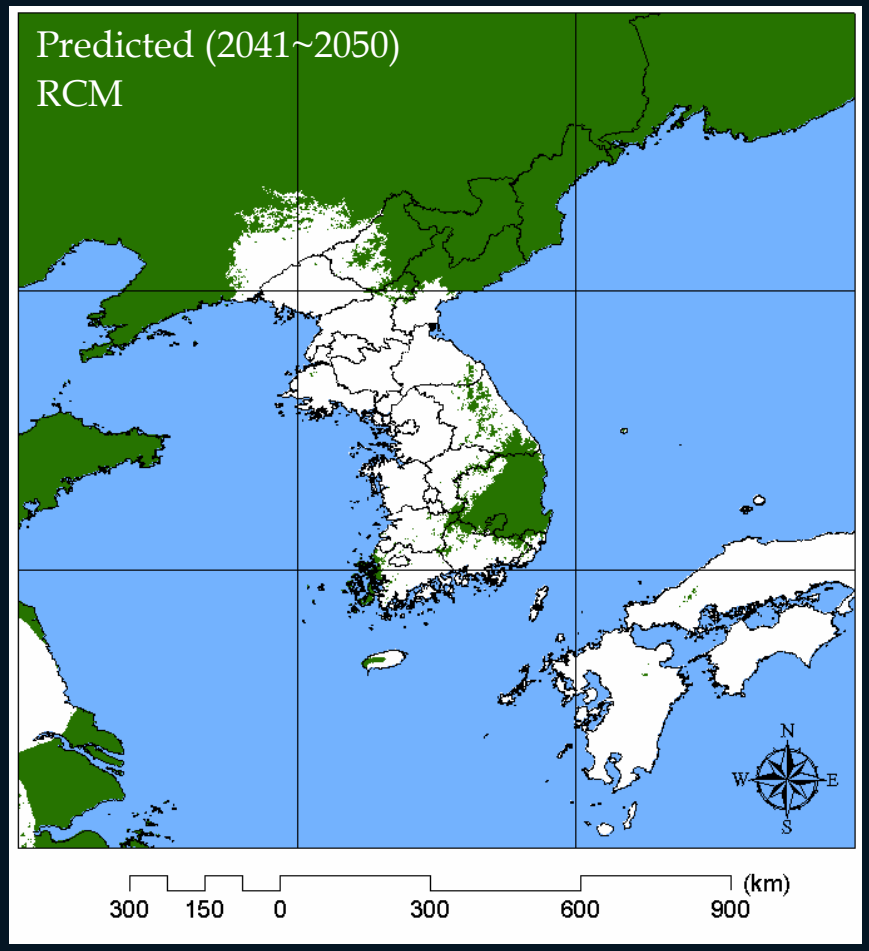




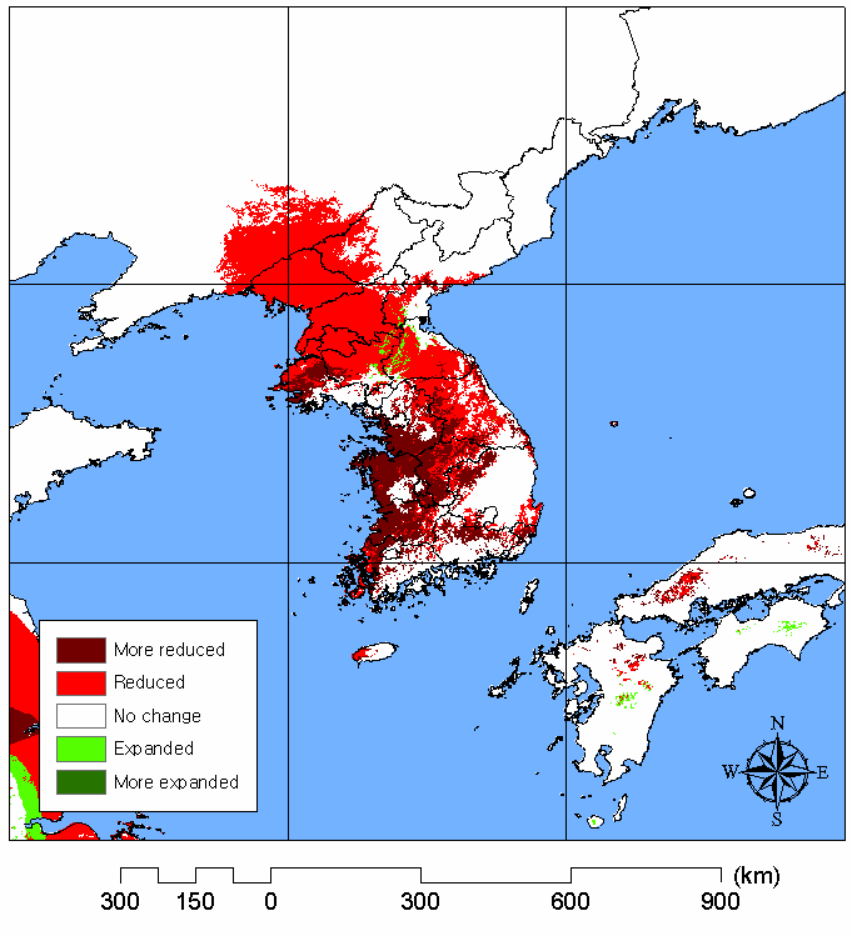
$$Pinus\ densiflora = 0.0015 \times DEM - 0.00252 \times P_{total} + 0.0175 \times T_{djf} + 1.8593$$

Results-*Pinus densiflora*



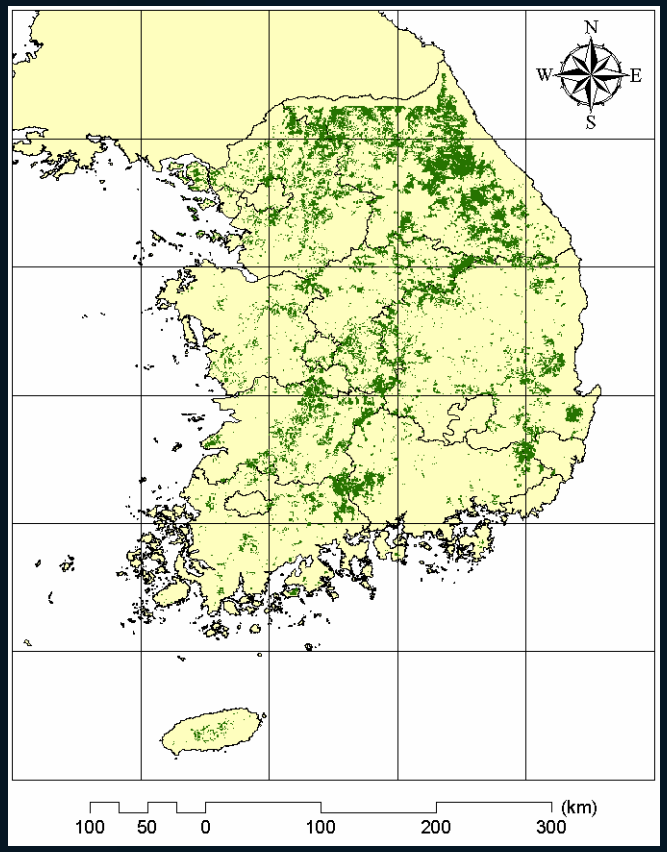


Results-*Pinus densiflora*



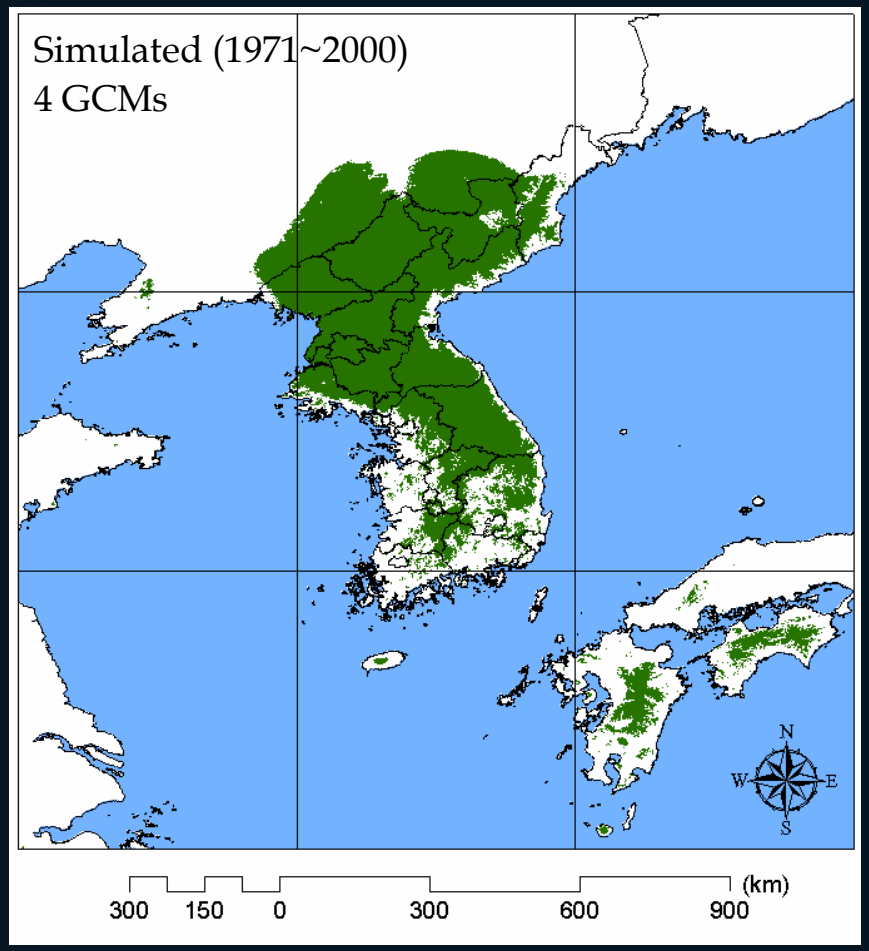
	Ratio (%)
More Reduced	17.5
Reduced	32.2
No change	49.6
Expanded	0.6
More Expanded	0.0

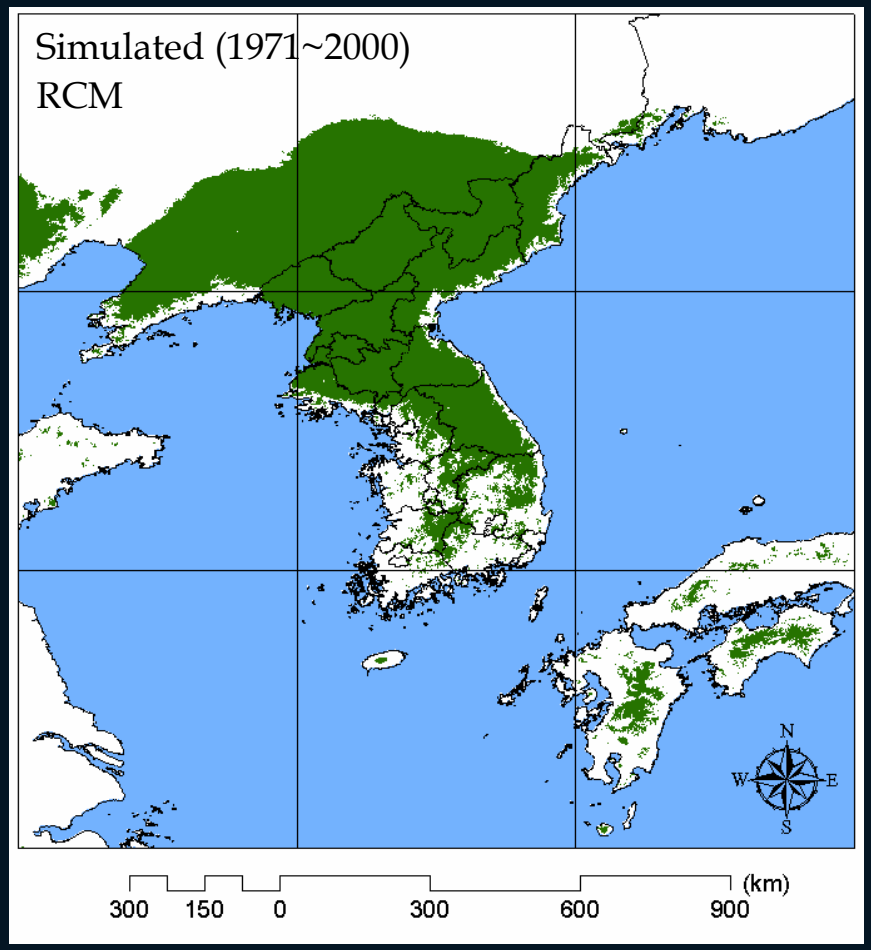
Results-*Quercus Spp.*



	Ranges	Mean
Area	30.4 %	
Elevation (m)	1~1,641	509
Mean temperature (℃)	2.0~15.9	9.0
Total precipitation (㎜)	974~1,810	1,298
Warmth index (month·℃)	36.8~130.7	79.4

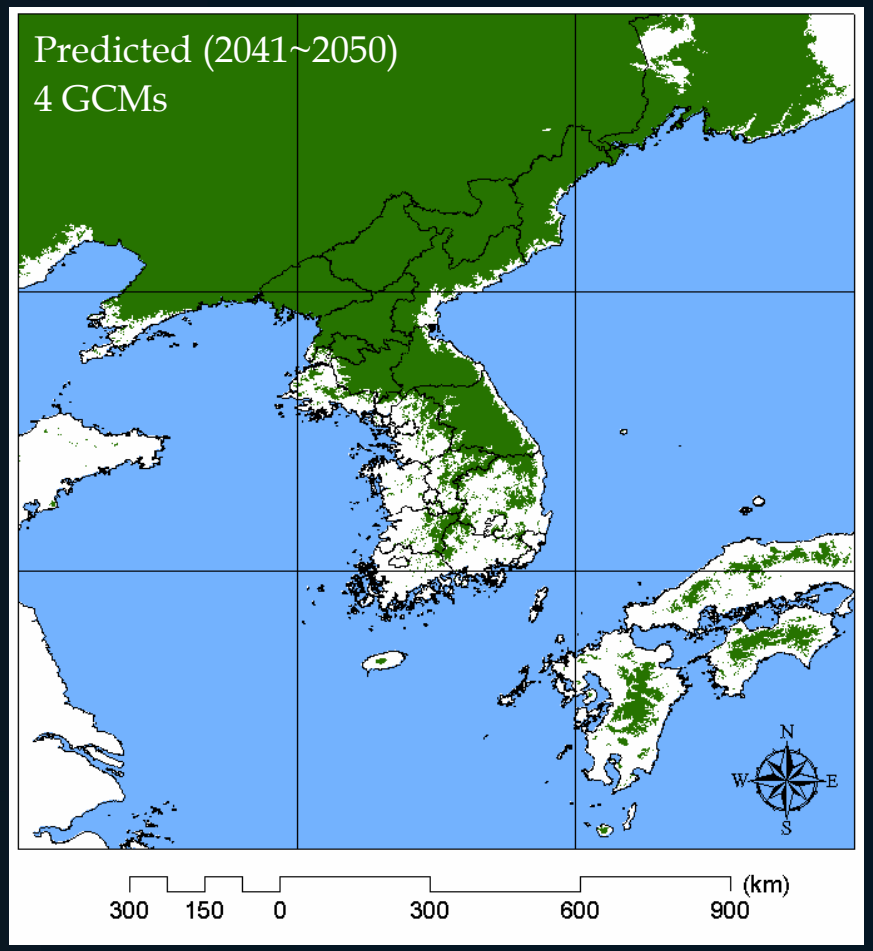
Results-*Quercus Spp.*

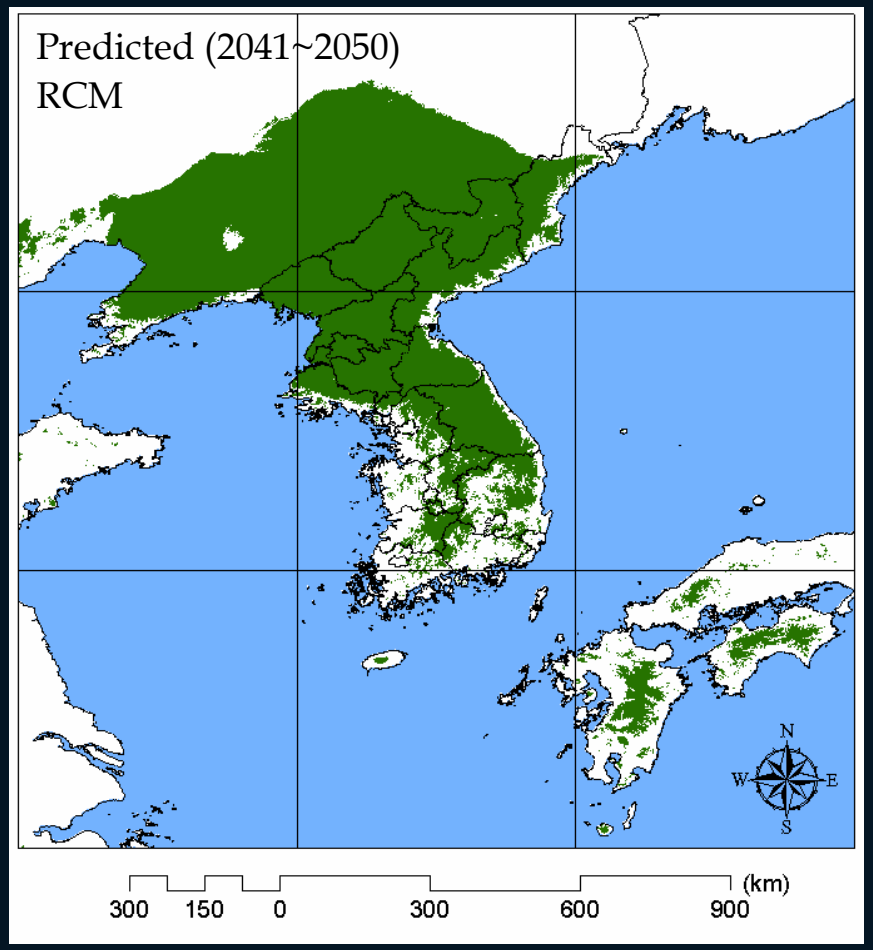




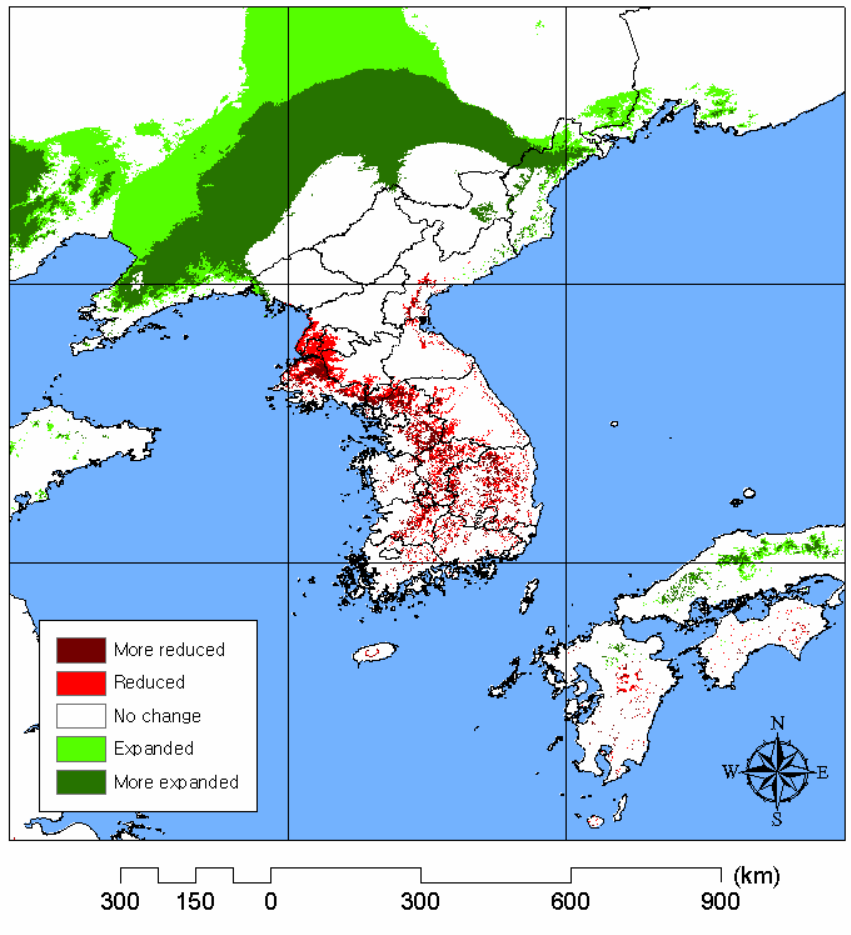
Quercus Spp. ; *CI, DEM,* T_{min}

Results-*Quercus Spp.*



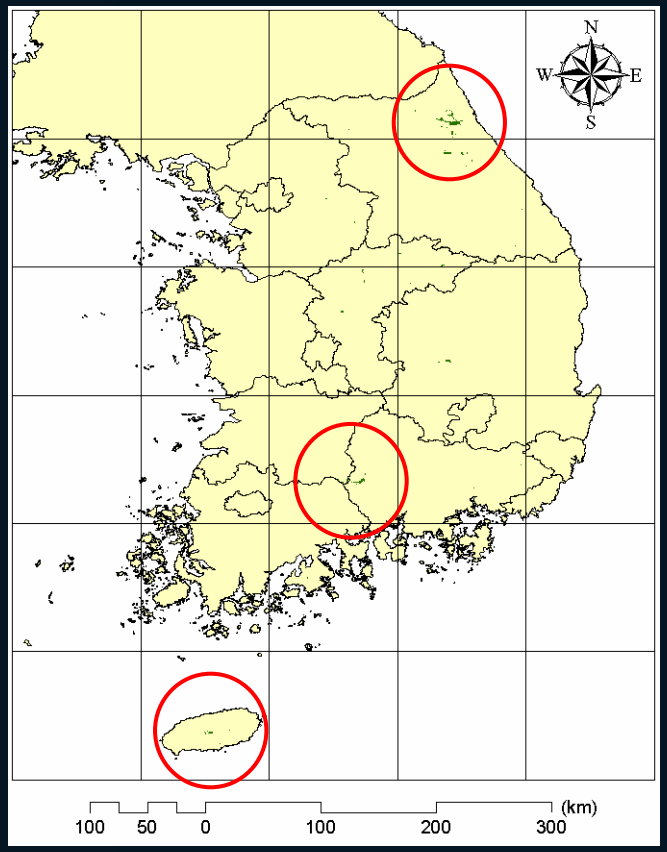


Results-*Quercus Spp.*



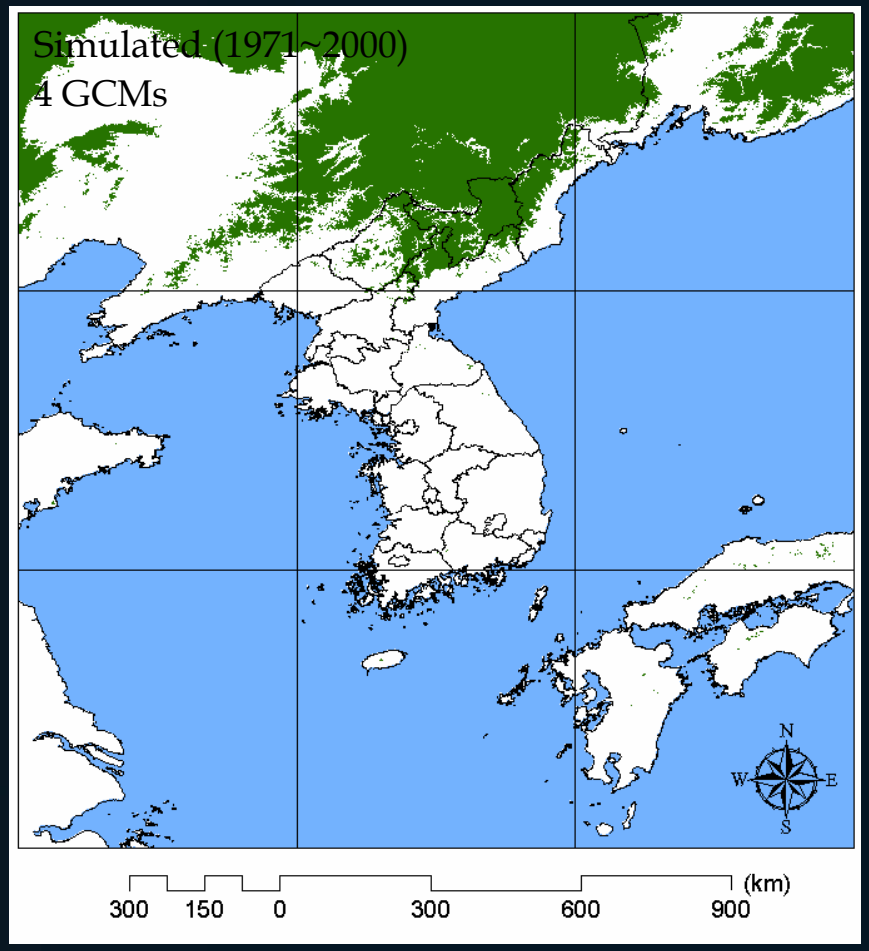
	Ratio (%)
More Reduced	5.7
Reduced	6.9
No change	83.4
Expanded	1.3
More Expanded	2.8

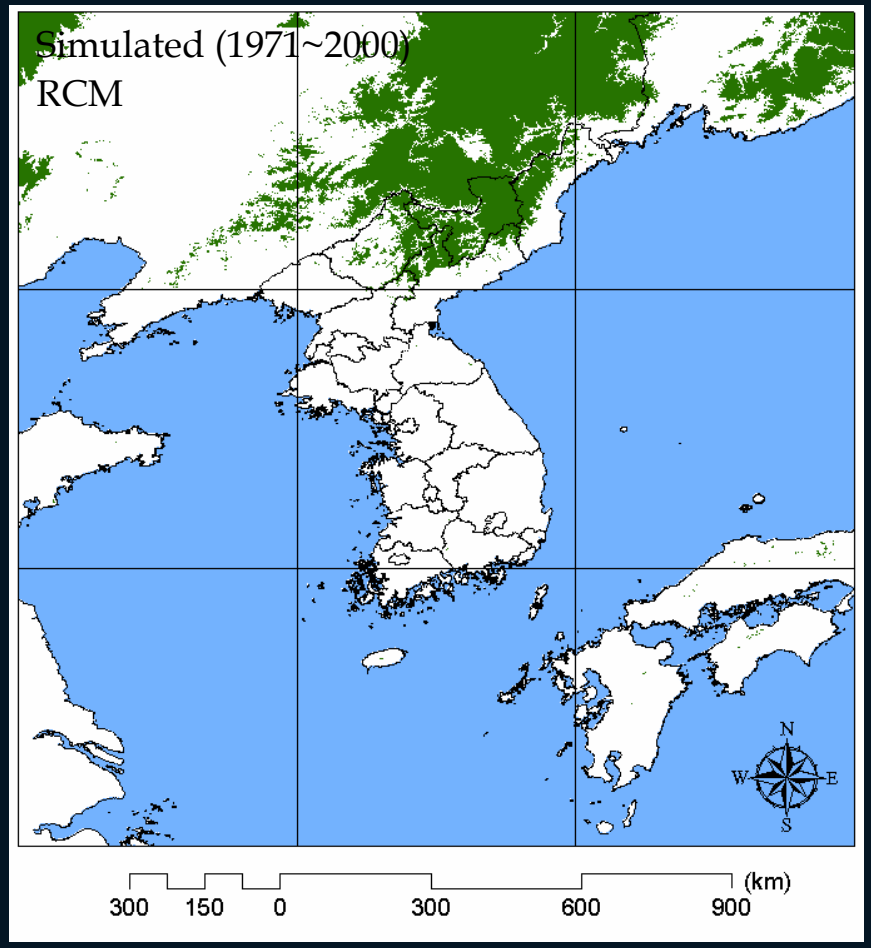
Results-Alpine Plants



	Ranges	Mean
Area	0.3 %	
Elevation (m)	86~1,824	1,024
Mean temperature (℃)	1.2~15.9	5.7
Total precipitation (㎜)	1,019~1,838	1,347
Warmth index (month·℃)	30.9~130.6	57.3

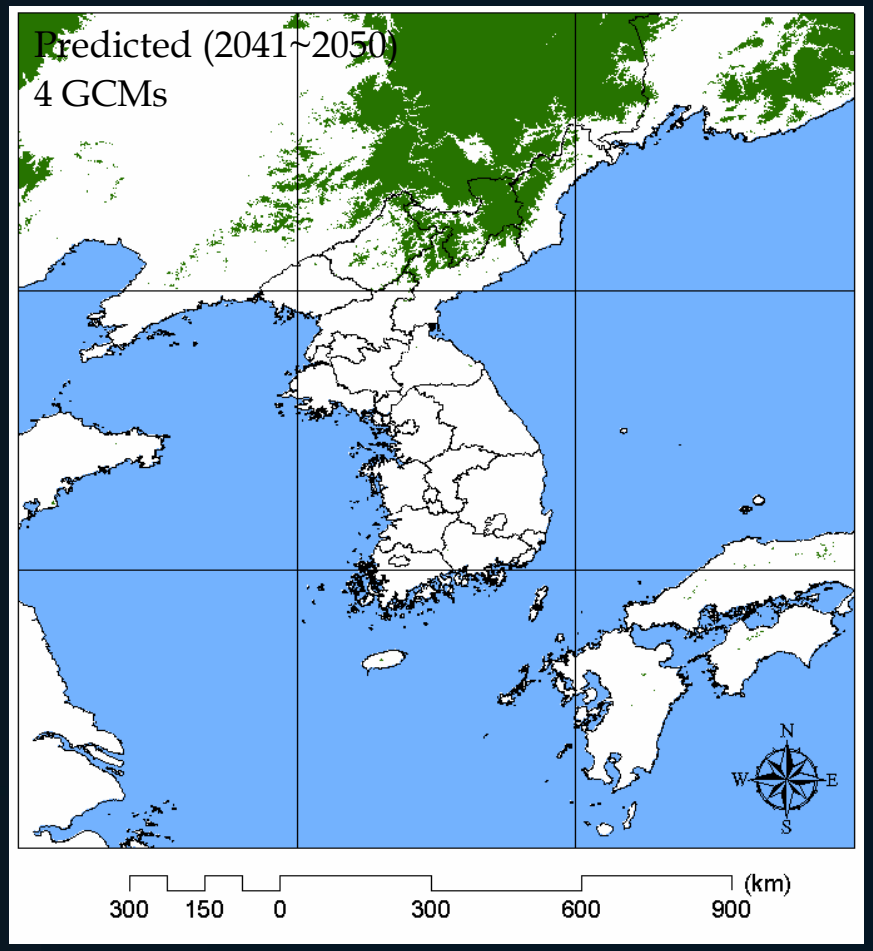
Results-Alpine Plants

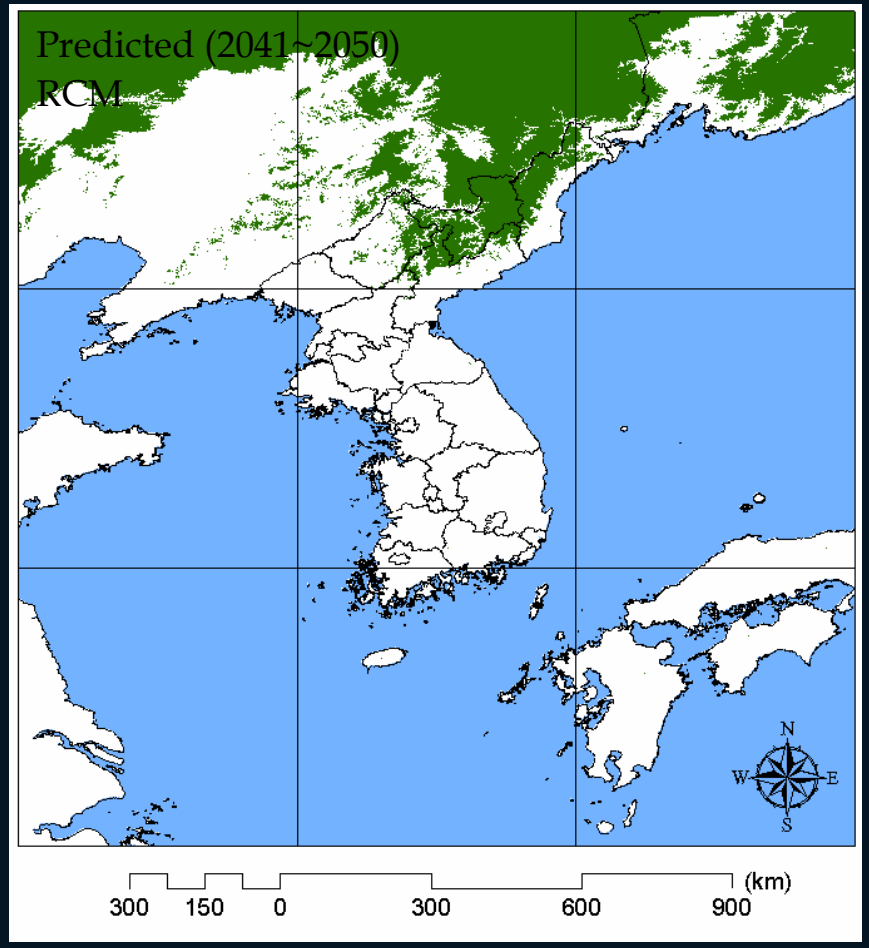




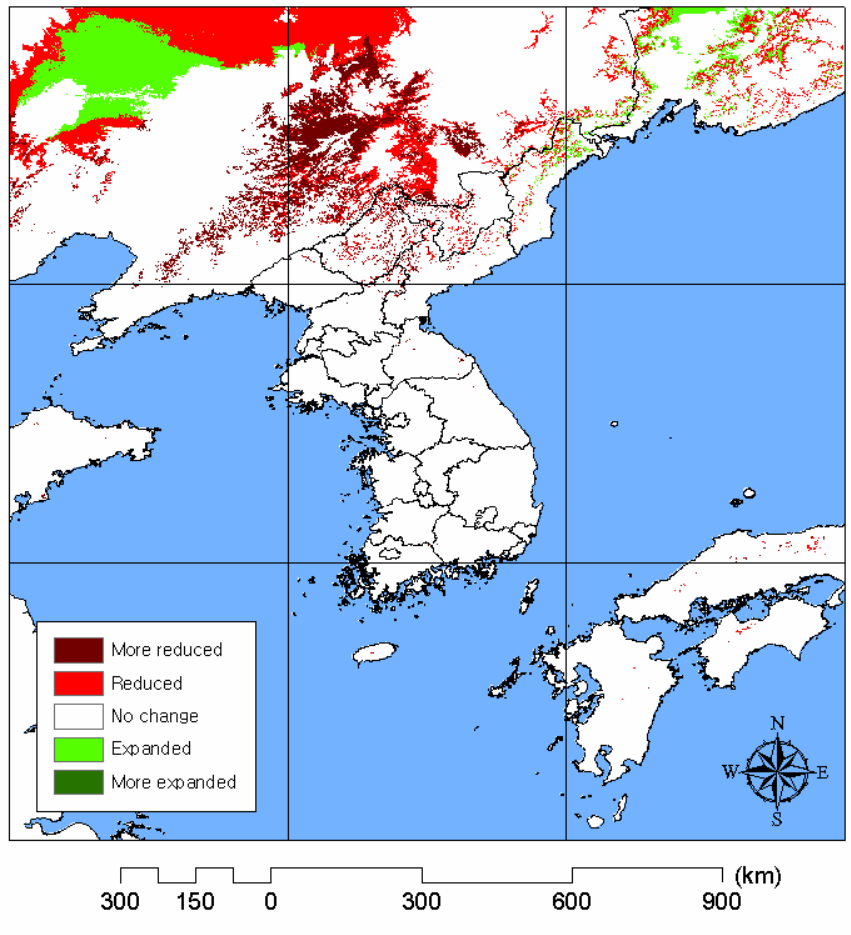
Alpine plants ; WI, DEM, T_{total}, T_{mam}

Results-Alpine Plants



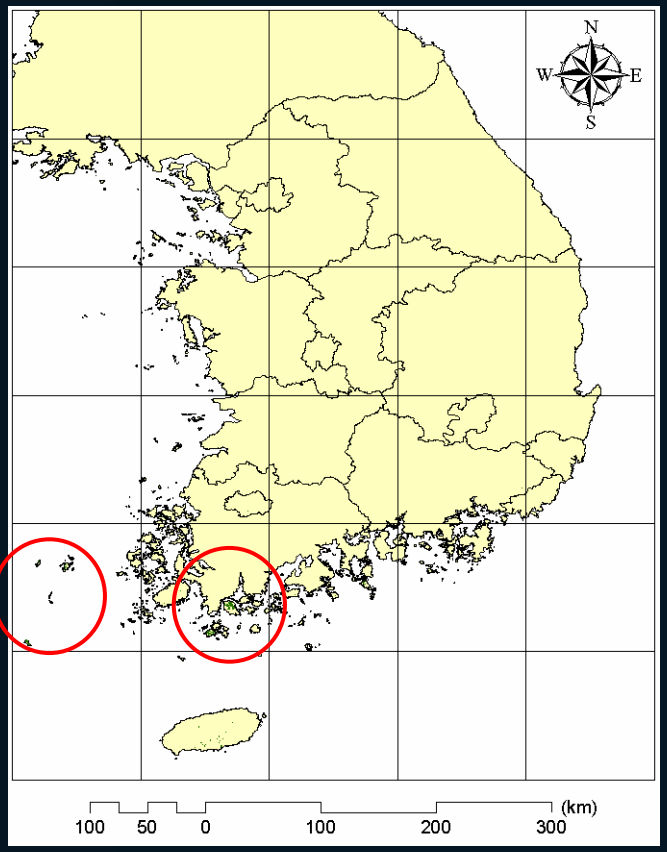


Results-Alpine Plants



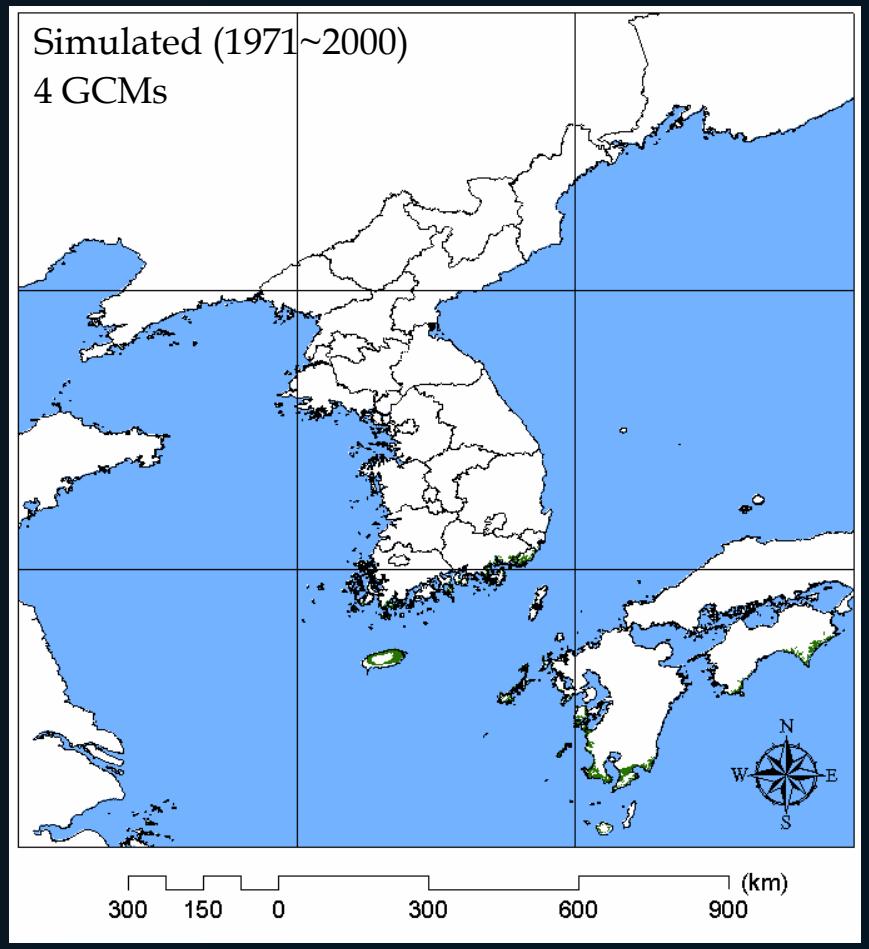
	Ratio (%)
More Reduced	1.5
Reduced	1.9
No change	96.0
Expanded	0.6
More Expanded	-

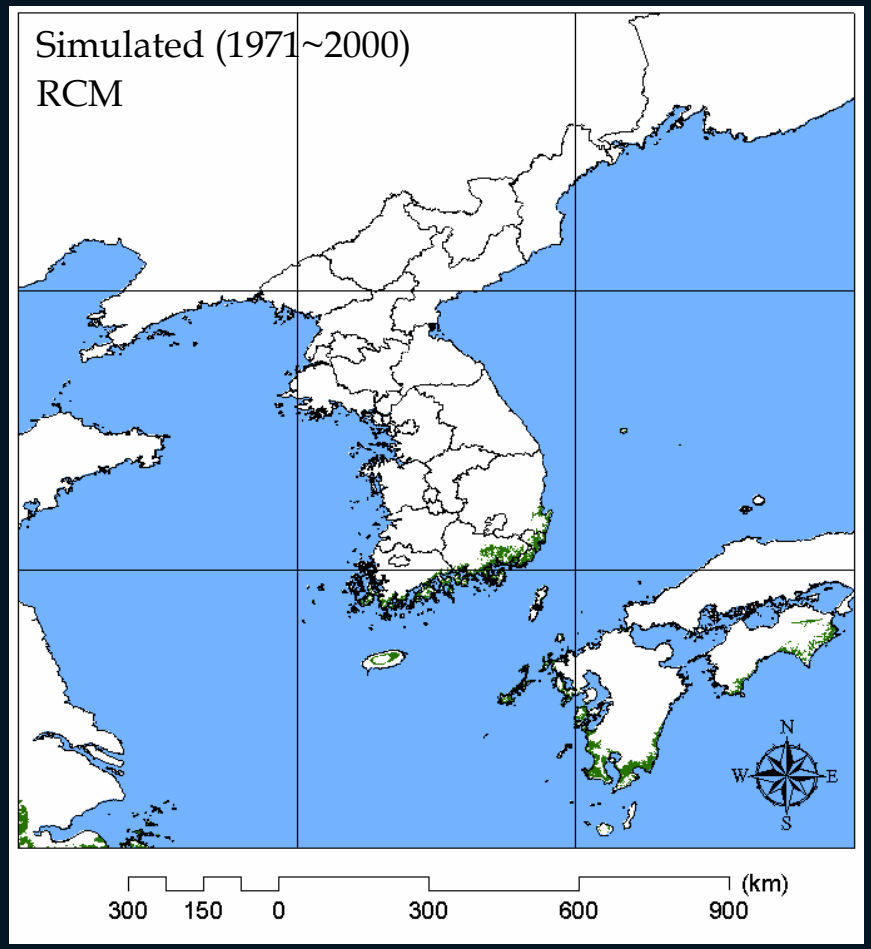
Results-Evergreen Broad-Leaved Plants



	Ranges	Mean
Area	0.2 %	
Elevation (m)	1~626	197
Mean temperature (℃)	10.9~16.3	13.4
Total precipitation (㎜)	961~1,853	1,375
Warmth index (month·℃)	84.9~135.4	106.1

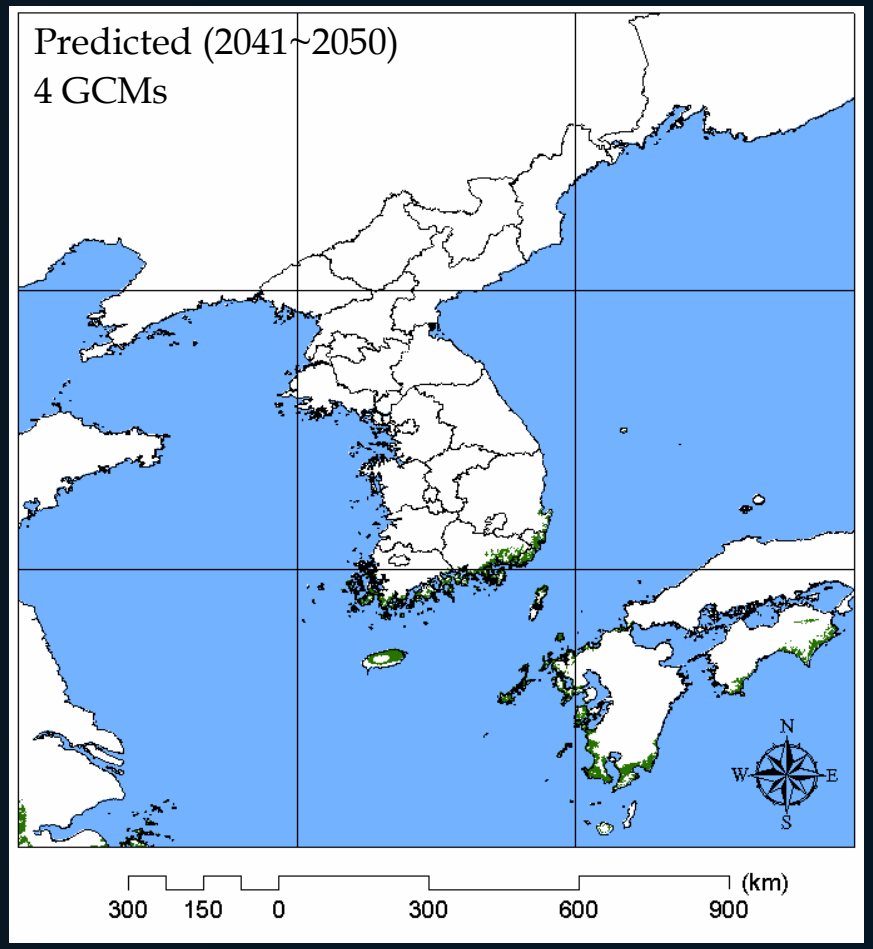
Results-Evergreen Broad-Leaved Plants

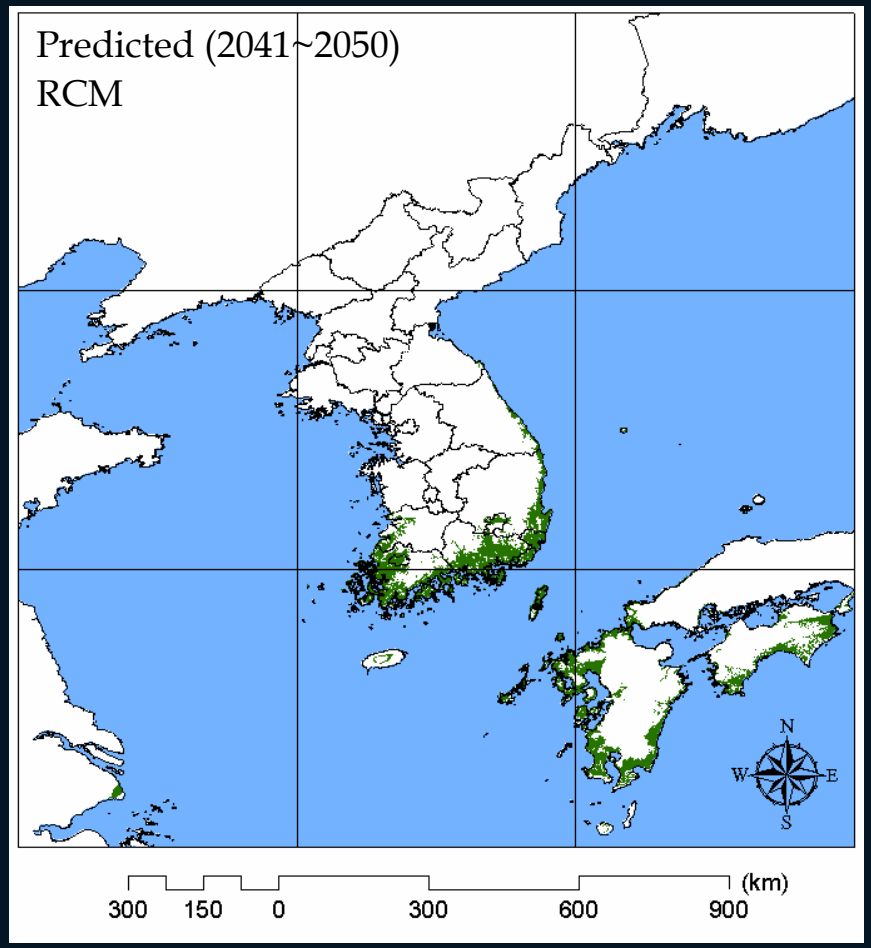




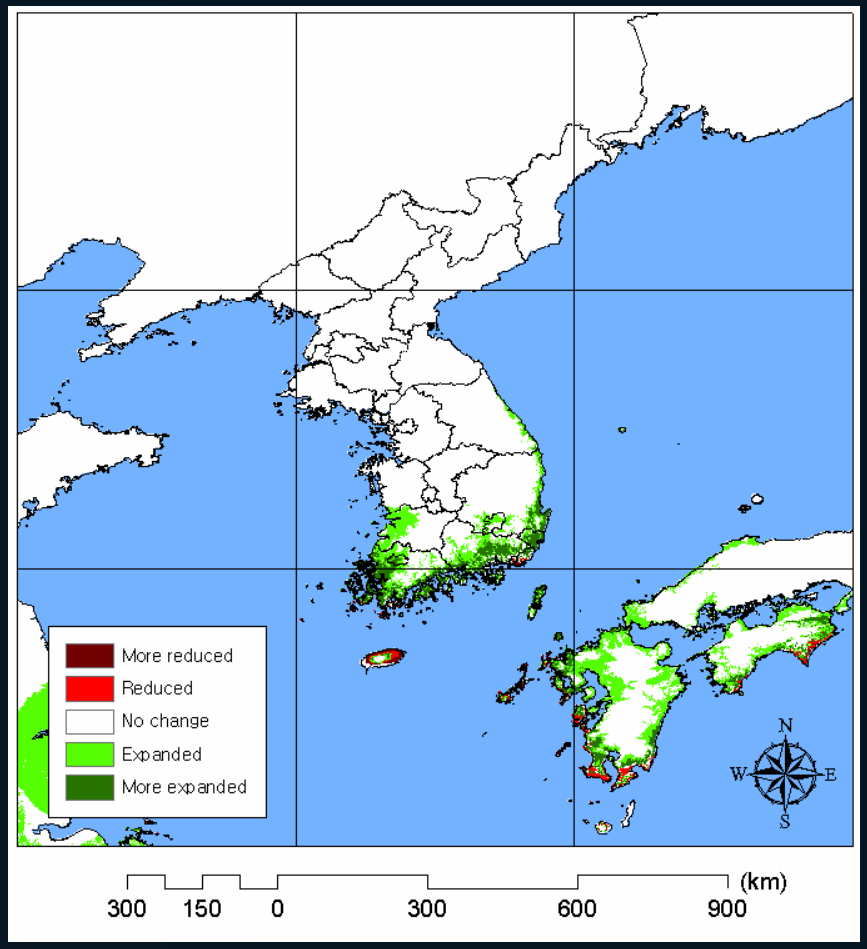
Evergreen Broad-Leaved Plants = $0.6503 \times CI - 0.7949 \times T_{min}$

Results-Evergreen Broad-Leaved Plants



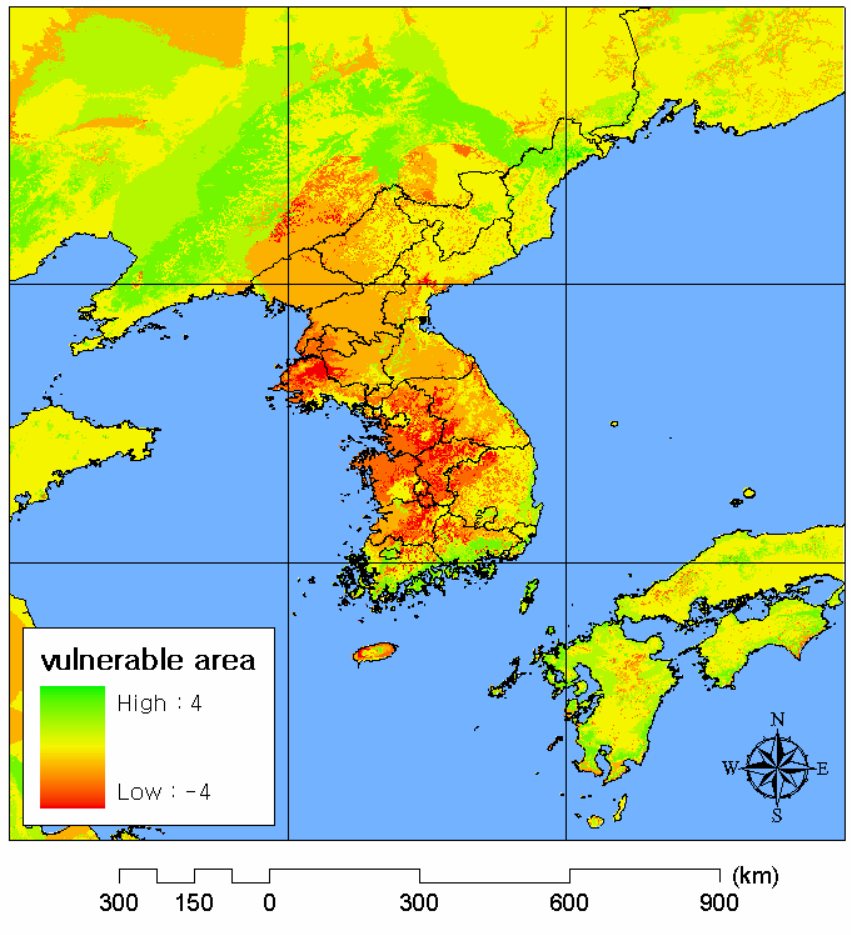


Results-Evergreen Broad-Leaved Plants



	Ratio (%)
More Reduced	0.3
Reduced	0.3
No change	89.7
Expanded	5.3
More Expanded	4.4

Results-vulnerable area



		Ratio (%)
More reduced	Grade 1	2.8
	Grade 2	3.3
	Grade 3	15.0
	Grade 4	33.9
No change	Grade 5	34.2
	Grade 6	5.6
	Grade 7	4.9
	Grade 8	0.2
More expanded	Grade 9	0.0

Results-Economic value assessment

Willingness to pay to Conservation Fund for Pine and Oak trees: raw data

amount of 1st offer	General public (% of willing payers)		
	2nd response (to half of 1st amount)	1st response	2nd response (to double of 1st amount)
Sampling	292 persons	400 persons	108 persons
$ 1	4.3 %	59.6 %	58.8 %
$ 3	19.5 %	28.1 %	31.3 %
$ 8	11.9 %	26.3 %	20.0 %
$ 10	19.5 %	28.1 %	12.5 %
$ 14	11.9 %	27.6 %	18.8 %
$ 18	16.7 %	15.8 %	11.1 %
$ 51	10.9 %	3.5 %	-
mean	14.0 %	27.0 %	31.5 %

Results-Economic value assessment

Median Estimates of Willingness-to-Pay (WTP): statistical analysis

Grouped by	Contents	WTP	*t*-value
Sex	male	$ 5.7/person	2.235
Age	20’s	$ 4.5/person	2.512
Occupation	self employed	$ 4.7/person	3.255
Annual income	$ 31,200~41,600	$ 6.0/person	1.995
overall	overall	$ 3.8/family	3.382

Results-Economic value assessment

Economic value of vegetation change by climate change
: median estimate for pine and oak trees

- Economic value (B) = \$ 3.8/family × 15,887,128 families (as of 2005)
  = \$ 60,371,086

- Present value = $\frac{(1+\delta)\times B}{\delta} = \frac{(1+0.05)\times B}{0.05}$ = \$ 1,267,792,806
  (δ = *discount rate*)

Results-Economic value assessment

Annual economic value and Present value

Value categories (share of the total)	Value criteria [subcategories(weight)]	Annual economic value	Present value
Use value (0.380)	Direct use value (0.177)	$ 10,685,682	$ 224,399,327
	Indirect use value (0.202)	$ 12,194,959	$ 256,094,147
Non-use value (0.620)	Bequest value (0.211)	$ 12,738,299	$ 267,504,282
	Option value (0.203)	$ 12,255,330	$ 257,361,940
	Existence value (0.206)	$ 12,436,444	$ 261,165,318
Total economic value (1.000)		$ 60,371,086	$ 1,267,792,806

Direct use value : Timber, Mushrooms cultivation etc.
Indirect use value : Water storage, Soil erosion prevention, Wildlife protection etc.
Bequest value : Forest inheritance
Option value : Saving for the possibility of unspecified future use
Existence value : Forest existence

Conclusion

Achievements

To challenges associated with predicting and assessing the future climate using climate models distribution of communities by climate change in Korea

To attempt economic value assessment of Natural ecosystem by climate change for the first time in Korea

Limitations and Considerations

To examine the potential distribution of communities by correlating the environmental factors without reflecting the natural succession processes

Variability of multiple RCM output results under various climate change scenarios were not sufficiently considered

Thank You