Impact Assessment of Forest Influenced by Changing Global Climate

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Contents

□ Objectives

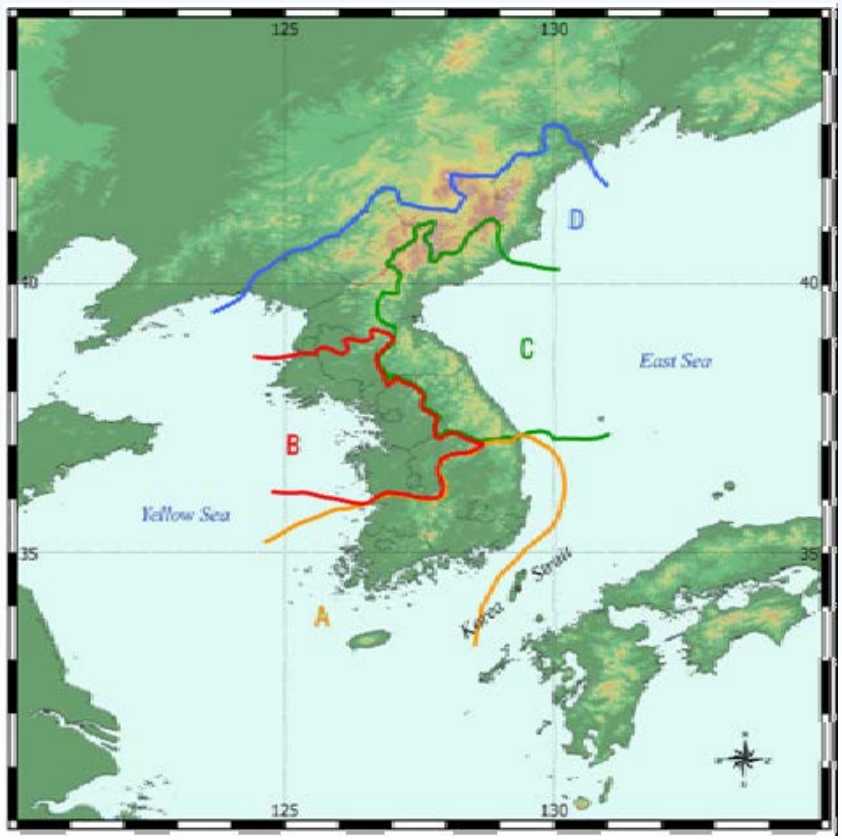
- To prepare primary data and conduct the modeling of the forest distribution assessment using AIM impact model
- To verify the validity of the modeling results
- To assess the change in economical efficiency of the forest through climate change

□ Results and Policy Proposals

- In case that the yearly mean movement growth rate of the forest is below than 0.25km/yr, it is estimated that there will be a loss of ***US$3.5billion annually*** due to the futility of forest adaptation in 2100.
- In the adaptation study of specific species, **the Pine (*Pinus densiflora*)** which has 1.5km/yr moving velocity is well adapted. but the **unsuitable plant area ratio** will increase to ***29%*** **.**
- The establishment of the integrated impact assessment is necessary to fully assess the impact of forest and other ecosystem fields. This includes a correspondence plan at national level and continuous establishment of the basic data.

2. Study area

The Korean peninsula is separated to 4 small regions regarding climate and forest Type.

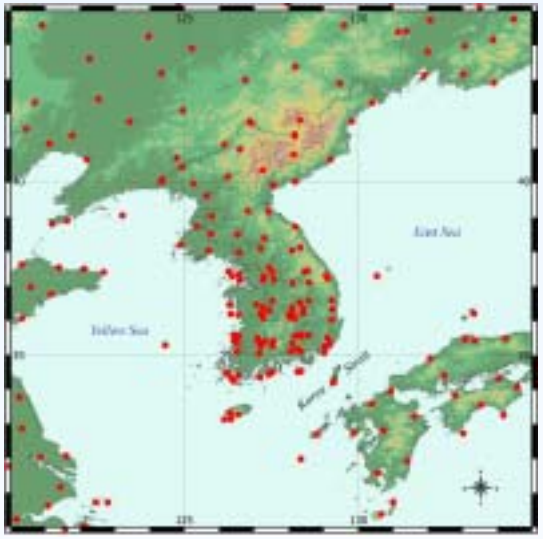


< Study area (longitude 120°~135°, latitude 30°~ 45°) >

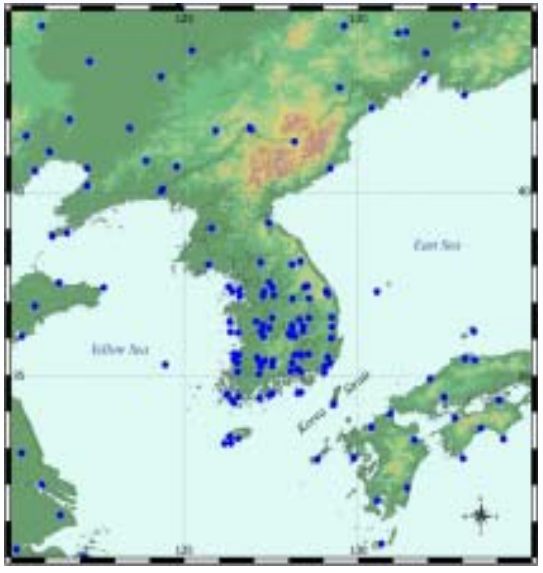
< Data >

- IPCC Data Distribution Center
- An IS92a-type forcing scenario
- Up to 2100 and forcing details are greenhouse gas only
- mean-monthly files , Time slice is 2070-2099
- GCM
  - CCSR /NIES
  - CCCma
  - CSIRO MK2
  - HadCM2
  - ECHAM4

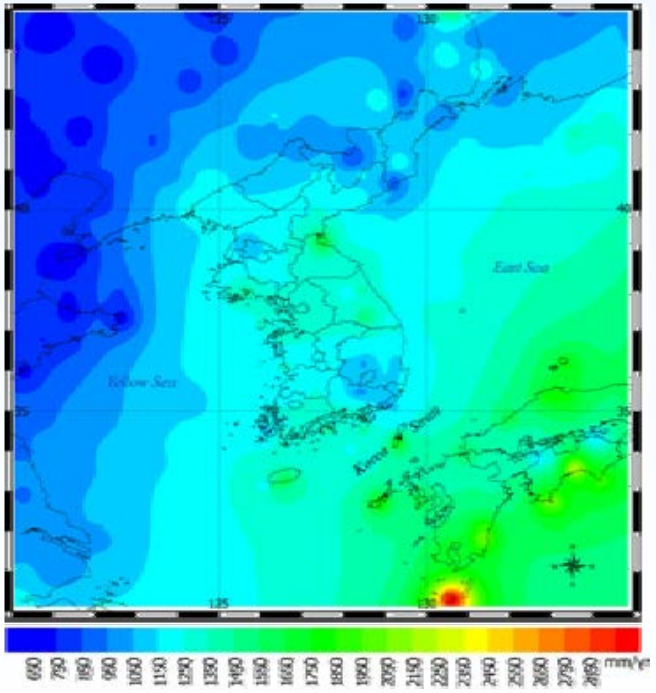
< Current Temperature & Precipitation >



Temperature measured stations,
227 stations
(UNEP/GHCN+KMA)

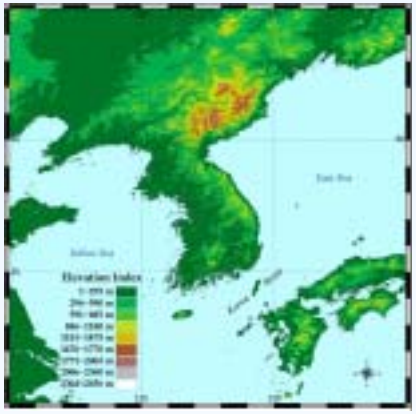


Precipitation, 199 stations
(UNEP/GHCN+KMA)

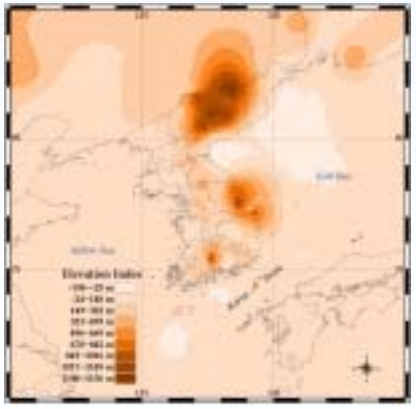


< Total precipitation in present day (mm/yr) >

< Temperature Correction using DEM & lapse rate >

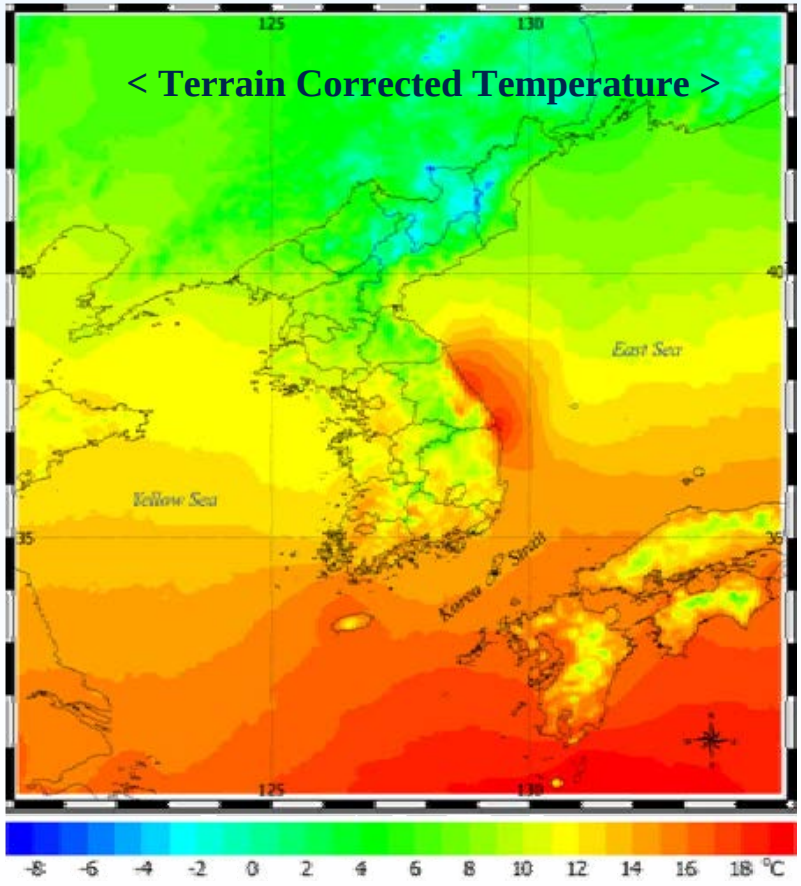


< 30 arc seconds DEM >



< Terrain height deviation distribution >

IDSW



< Measured monthly temperature lapse rate (C/m) >

Mon.	1	2	3	4	5	6	7	8	9	10	11	12
C/m	0.0080	0.0083	0.0083	0.0079	0.0073	0.0065	0.0058	0.0054	0.0055	0.0058	0.0065	0.0073

< Mean temperature & precipitation change in summer season, relation with ΔTasm >

	ΔTasm	0.5℃	1.0℃	1.5℃	2.0℃	2.5℃	3.0℃	3.5℃	4.0℃
Temp. (℃)	A	0.6	1.1	1.7	2.3	2.8	3.4	4.0	4.5
	B	0.6	1.2	1.8	2.4	3.0	3.6	4.1	4.7
	C	0.6	1.2	1.8	2.4	3.0	3.6	4.2	4.8
	D	0.6	1.2	1.8	2.4	3.0	3.7	4.3	4.9
Precip. (%)	A	3.0	6.0	9.0	12.0	15.0	18.0	21.0	24.0
	B	2.8	5.6	8.3	11.1	13.9	16.7	19.4	22.2
	C	2.9	5.8	8.6	11.5	14.4	17.3	20.2	23.1
	D	3.6	7.2	10.7	14.3	17.9	21.5	25.0	28.6

< Mean temperature & precipitation change in winter season, relation with Δtasm >

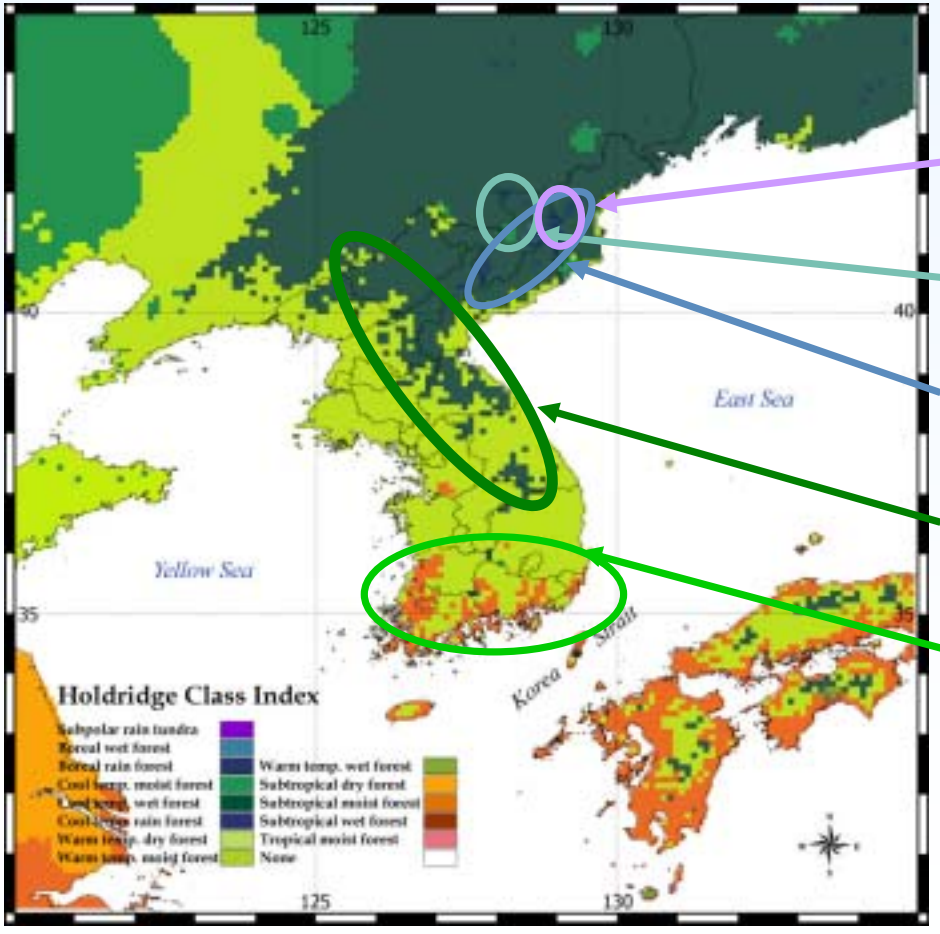
	ΔTasm	0.5℃	1.0℃	1.5℃	2.0℃	2.5℃	3.0℃	3.5℃	4.0℃
Temp. (℃)	A	0.7	1.3	2.0	2.7	3.4	4.0	4.7	5.4
	B	0.9	1.8	2.6	3.5	4.4	5.3	6.1	7.0
	C	1.0	1.9	2.9	3.9	4.9	5.8	6.8	7.8
	D	1.0	2.0	3.1	4.1	5.1	6.1	7.1	8.1
Precip. (%)	A	-0.4	-0.8	-1.2	-1.6	-2.0	-2.4	-2.8	-3.2
	B	1.2	2.5	3.7	4.9	6.2	7.4	8.7	9.9
	C	1.0	2.1	3.1	4.1	5.2	6.2	7.2	8.3
	D	2.8	5.6	8.4	11.2	14.0	16.7	19.5	22.3

< The climate change impact on the Korea peninsula(climate) >

ΔTasm	Temperature				Precipitation			
	1.0	1.5	2.0	2.5	1.0	1.5	2.0	2.5
A	O	O	++	+++	0	0	0	0
B	O	++	+++	+++	0	0	0	0
C	O	+++	+++	+++	0	0	0	0
D	O	+++	+++	+++	0	0	0	+

Sign	---	--	-	0	+	++	+++	Unit
Temp. change				< 2.25	2.25 ~2.5	2.5~ 2.75	> 2.75	℃, increase
Precip. change	< -45	-45~ -30	-30~ -15	-15~ 15	15~ 30	30~ 45	> 45	%, change

< Holdridge Class Change Result from 1990yr to 2100yr> (example of Scenario=IS92a,GCM=HadCM2)



Subpolar Tundra
: Top of the Mt. BAEKDU

Boreal Wet Forest
: Around of the Mt. BAEKDU

Boreal Rainforest
: GAEMA Highlands

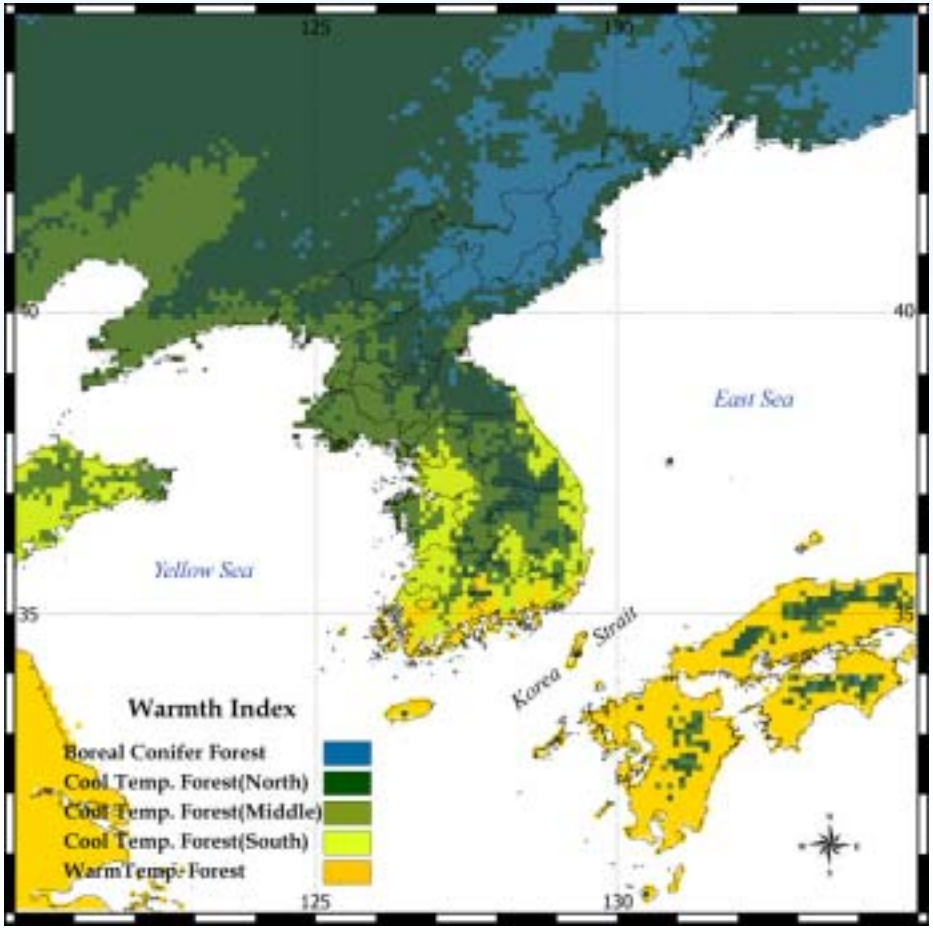
Cool Temperate Wet Forest
: From BAEKDU to JIRI Mountain Range, most parts in North Korea

Warm Temperate Moist Forest
: Middle and South Region

⇓

Subtropical Dry Forest
: South Region

< Bio-Climate Classification using Warmth Index >

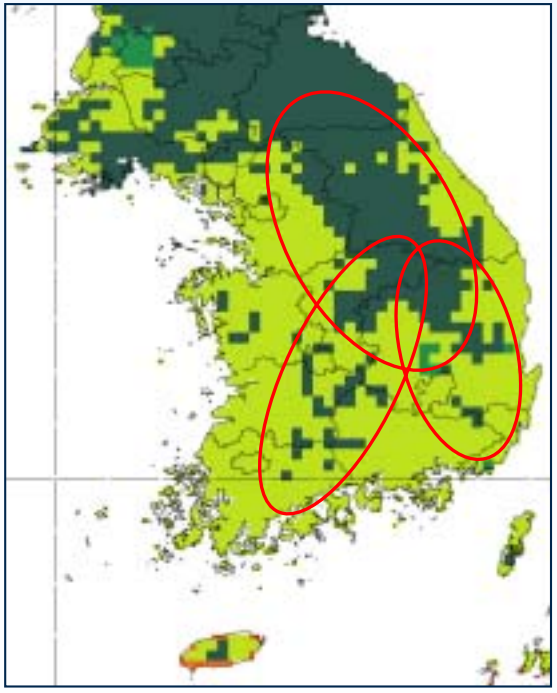


Warmth Index(WI) = $\Sigma(T_{mean,monthly} - 5)$, in monthly mean temp. is more than 5℃

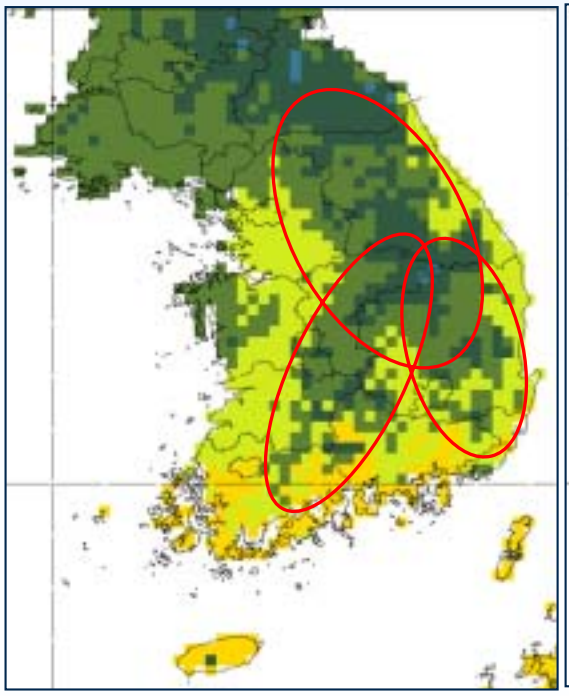
Coldness Index(CI) = $-\Sigma(T_{mean,monthly} - 5)$, in monthly mean temp. is more than 5℃

Forest Class	Range
Boreal Conifer Forest	WI < 55
Cool Temperate Forest Northern Part	55 ~ 85
Cool Temperate Forest Middle Part	85 ~ 110
Cool Temperate Forest Southern Part	WI > 110
Warm Temperate Forest	CI < 10

< Enlargement of Cool temperature middle part in each classification >



<Holdridge>



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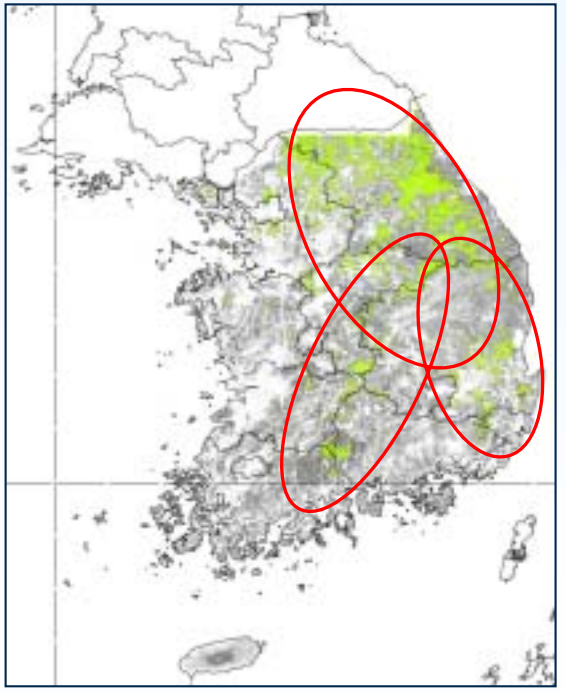
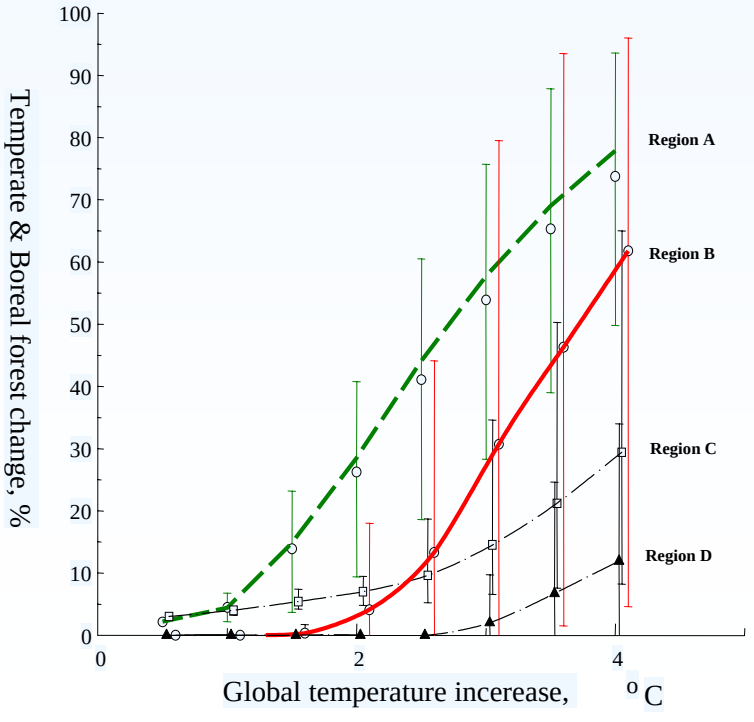


<Vegetation Map >
(Quercus mongolica)

< Decrease in temperature/boreal forest, relation with ΔTasm >

	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
A(%change)	2.2	4.4	14.8	28.5	44.1	57.7	69	77.9
B(%change)	0	0	0.3	4.1	13.3	30.7	46.3	61.8
C(%change)	3	4	5.4	7	9.6	14.5	21.2	29.4
D(%change)	0	0	0	0	0	2	6.7	11.9



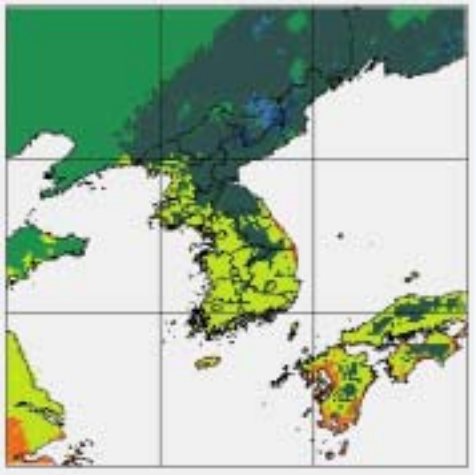
- South region
If ΔTasm=2℃, forest distribution change will be 30%
If ΔTasm=4℃, change rate will be more than 80%

- West region
If ΔTasm=2℃, forest distribution change will be 4%
If ΔTasm=4℃, change rate will be more than 60%
Forest type will be changed dramatically. If tree moving velocity is so fast, forest will be partly withered.

- East region
If ΔTasm=2℃, forest distributed change will be 7%
If ΔTasm=4℃, change rate will be more than 30%

- North region in the Korean peninsula
If ΔTasm=2℃, there will be no change in temperate /boreal forest
If ΔTasm=4℃, change rate will be 12% in western part

< Holdridge Classification Results in 2*CO2 >



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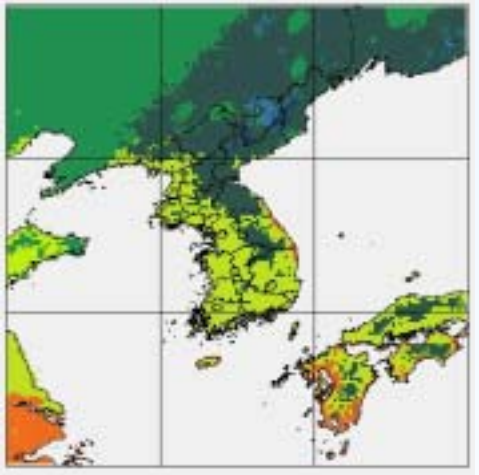

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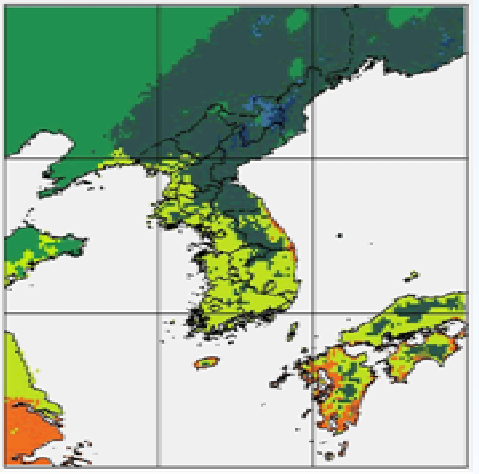

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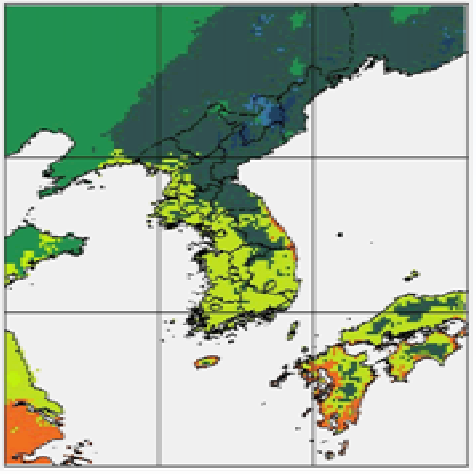
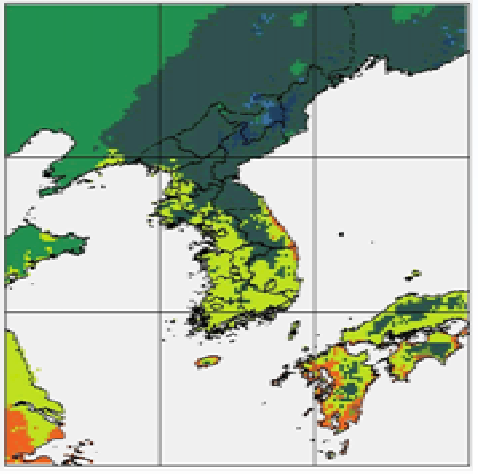


< HadCM2 >



< CCSR/NIES >

< The Climate Change Impact on the Korean peninsula(temperate/boreal forest) >

ΔTasm	Forest change(Temperate/Boreal)							
	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
A	0	0	0	-	--	--	---	---
B	0	0	0	0	0	-	--	---
C	0	0	0	0	0	0	-	-
D	0	0	0	0	0	0	0	0

<Legend>

notation	---	--	-	0	+	++	+++	Unit
Forest change	< -60	-60~ -40	-40~ -20	-20~ 0				% change

4. Data Analysis

The climate impact of the bio-climate classes and adaptation relation with tree moving velocity

IS92a Scenario
(climate sensitivity=2.5C,
mean temp. increase=2.08C)

HadCM2 GCM
(climate sensitivity=2.5C,
mean temp.increase=2.08C)

Holdridge Classification
(39 Classes)

Davis – Forest moving velocity
(0.25, 0.5, 1.0, 2.0 km/yr)

Cramer & Leemans Classification
(14 Classes)

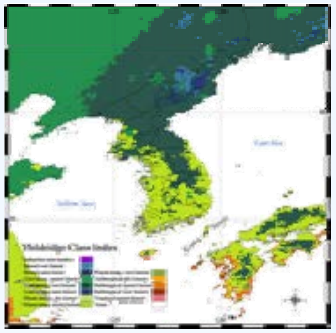
Geographic Information System

Impact prediction according to forest moving

Visualization of
area simulation

NCEAS Model

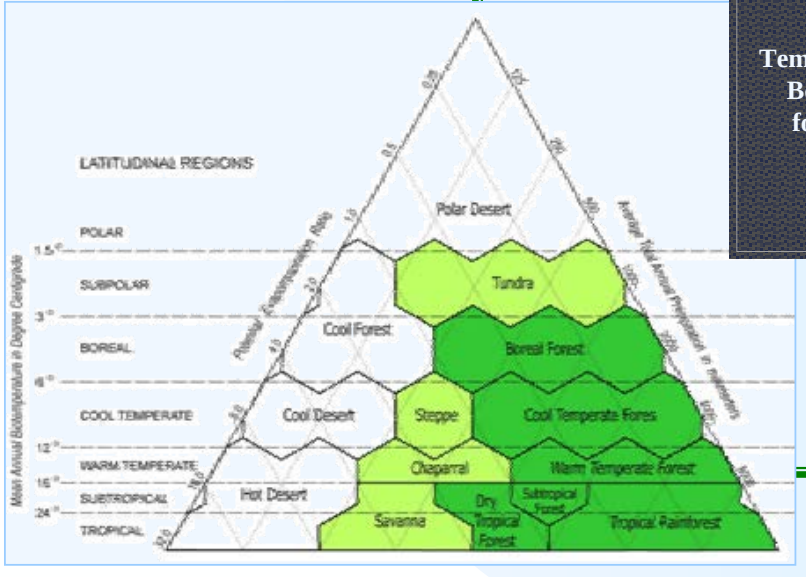
Estimation of Economic loss
according to forest distribution change



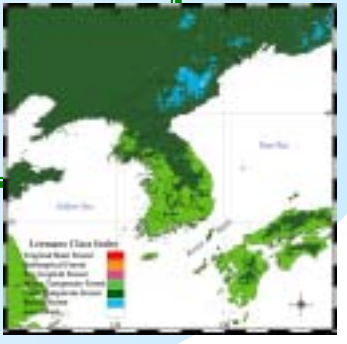
Holdridge classification Result

< Changing table of Bio-climate Classifications >

NCEAS Model	Cramer & Leemans classes (tree area)	Holdridge classes
Tropical forest	1. Tropical Rain Forest	30. Subtropical wet forest
		31. Subtropical rain forest
		37. Tropical moist forest
		38. Tropical wet forest
		39. Tropical rain forest
	2. Subtropical Forest	29. Subtropical moist forest
	3. Dry Tropical Forest	28. Subtropical dry forest
		36. Tropical dry forest
Temperate/ Boreal forest	4. Warm Temperate Forest	22. Warm temperal moist forest
		23. Warm temperal wet forest
		24. Warm temperal rain forest
	5. Cool Temperate Forest	15. Cool temperal moist forest
		16. Cool temperal wet forest
		17. Cool temperal rain forest
	6. Boreal Forest	9. Boreal moist forest
		10. Boreal wet forest
		11. Boreal rain forest



Cramer & Leemans classification scheme

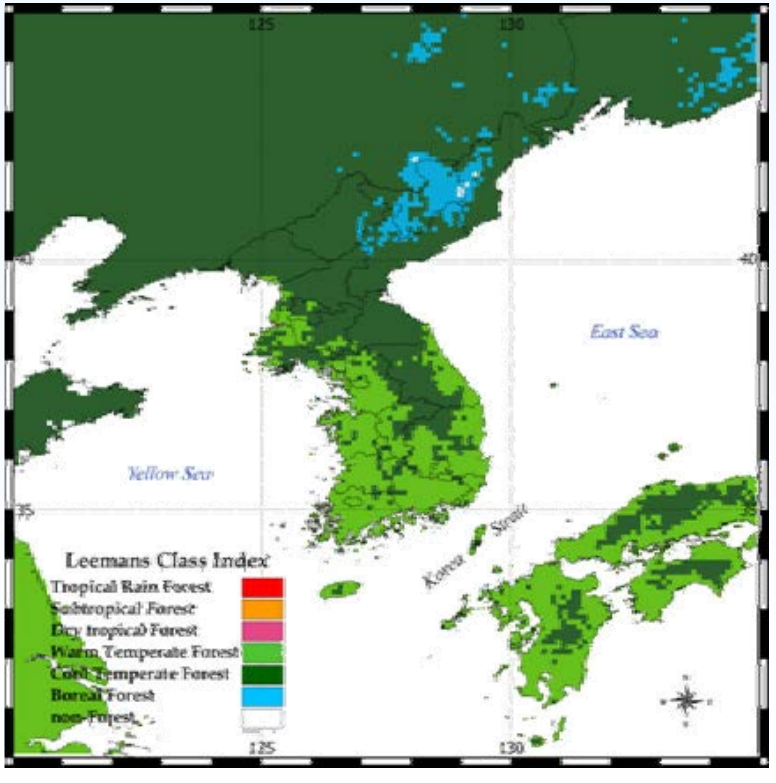


Leemans classification Result

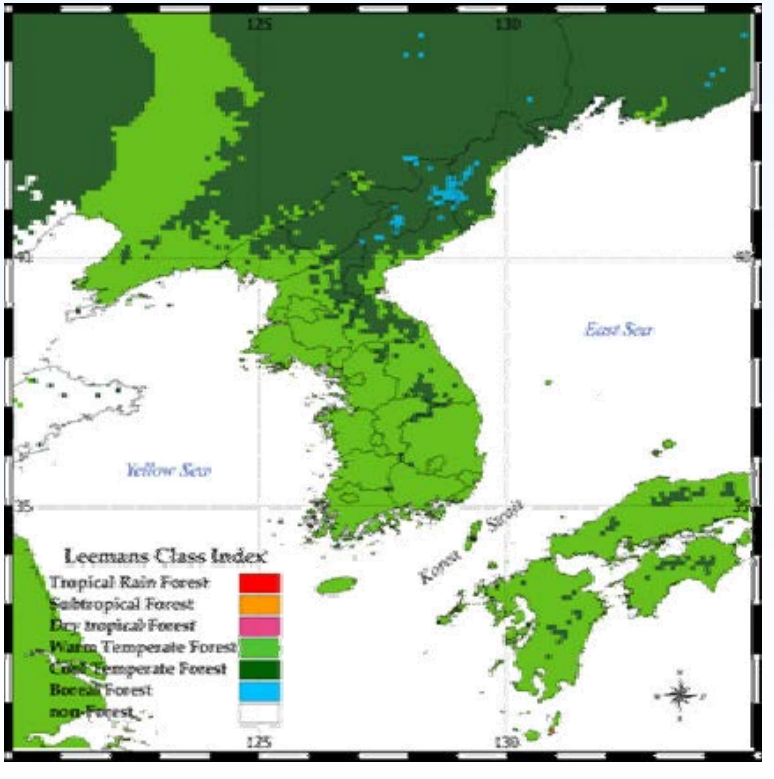
Tree

Grass

< Cramer and Leemans Classification(Scenario=IS92a, GCM=HadCM2) >

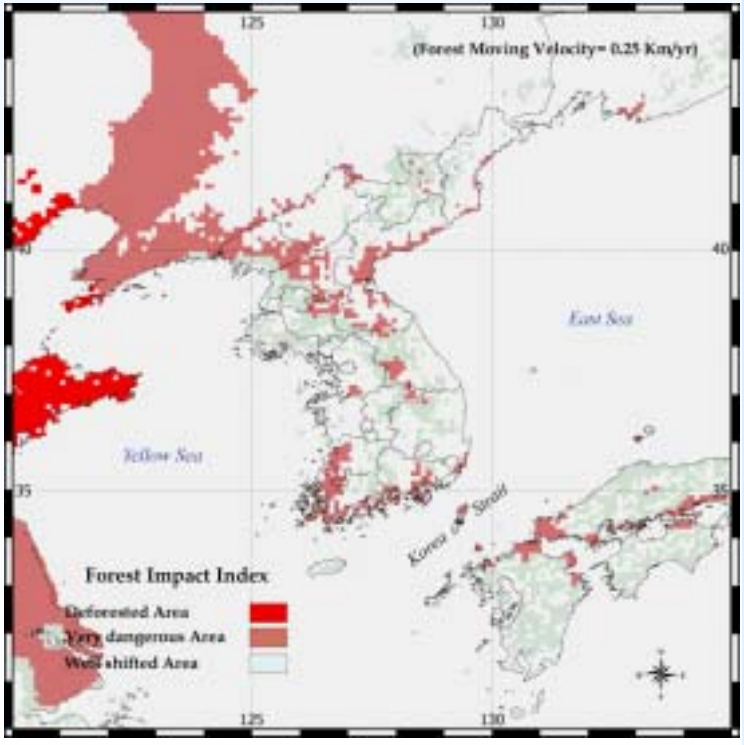


- 1990yr -



- 2100yr -

< Forest impact and change pattern relation with tree moving velocity >



Warm Temperate Forest and Cool Temperate Forest are mainly distributed the Korean peninsula in present day, and the whole place of GAEMA highlands is covered by Boreal Forest

Bio-climate class in 2100 will not be changed, but distribution and area of forest will be changed

According to mean moving velocity(0.25km/yr) of trees in 2100, there will be no place where forest withered in the Korean peninsula

High extinctive area

South Korea : 14% of 99,800㎢

;South coast and Western part of Cheonla-province, mostly Temperate forest

North Korea : 17.9% of 122,762㎢

; Inland of Pyungan-province and the borders, Eastern part of Hamkyung-province and so on, mostly Cool temperate forest

< Forest impact and change pattern in 2100, relation with tree moving velocity >

(Unit : area%)

Climate change pattern		South korea				North korea			
		0.25 km/yr	0.50 km/yr	1.0 km/yr	2.0 km/yr	0.25 km/yr	0.50 km/yr	1.0 km/yr	2.0 km/yr
a	Leemans class No.	61.3%	61.3%	61.3%	61.3%	57.7%	57.7%	57.7%	57.7%
	4	56.3	56.3	56.3	56.3	7.2	7.2	7.2	7.2
	5	5.0	5.0	5.0	5.0	47.5	47.5	47.5	47.5
	6	-	-	-	-	-	3.0	3.0	3.0
b	Leemans class No.	24.7%	33.6%	38.7%	38.7%	24.1%	35.3%	41.8%	42.0%
	4	4.1	10.1	15.3	15.3	-	-	-	-
	5	20.6	23.4	23.4	23.4	14.0	24.8	31.3	31.5
	6	-	-	-	-	10.1	10.5	10.5	10.5
c*	**Leemans class No.**	**14.0%**	**5.2%**	**-**	**-**	**17.9%**	**6.8%**	**0.2%**	**-**
	4	**11.2**	**5.2**	**-**	**-**	**-**	**-**	**-**	**-**
	5	**2.8**	**-**	**-**	**-**	**17.5**	**6.8**	**0.2**	**-**
	6	**-**	**-**	**-**	**-**	**0.4**	**-**	**-**	**-**
d		No impact				No impact			
e		No impact				0.3%	0.3%	0.3%	0.3%
f		No impact				No impact			
g		No impact				No impact			
Sum		100%	100%	100%	100%	100%	100%	100%	100%

Wither

Extinctive

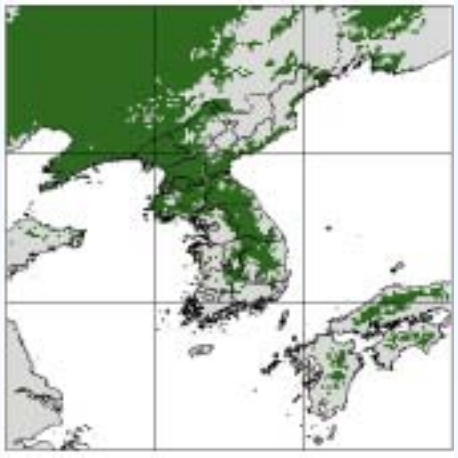
c : Bio-climate class is changed, but there is no invasion of an exotic plant from the out of moving range during 110yr*

< An Economic loss of tree region in NCEAS Model >

(Unit : 1994 U.S million$/yr)

	South korea				North korea			
Tree moving velocity	0.25 km/yr	0.50	1.0	2.0	0.25 km/yr	0.50	1.0	2.0
area	99,800㎢				122,762㎢			
Area % of c*	**14.0 %**	**5.2%**	**-**	**-**	**17.9 %**	**6.8%**	**0.2%**	**-**
loss	4225	1555	-	-	6636	2512	71	-
Increased grassland value	3246	1195	-	-	4144	1569	44	-
Net loss	**976**	**360**	**-**	**-**	**2492**	**943**	**27**	**-**

Ref : Costanza, R. et al.(1997), The Value of the the world's ecosystem services and natural capital. NATURE, 387, pp 253-260



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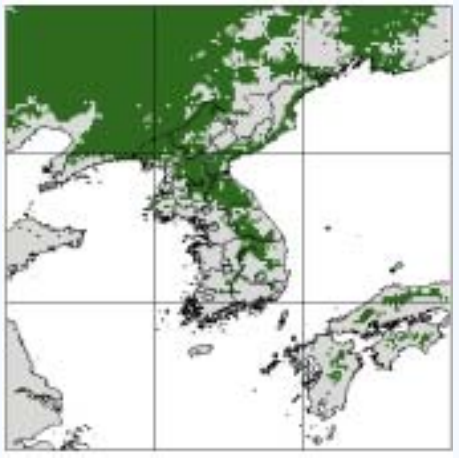

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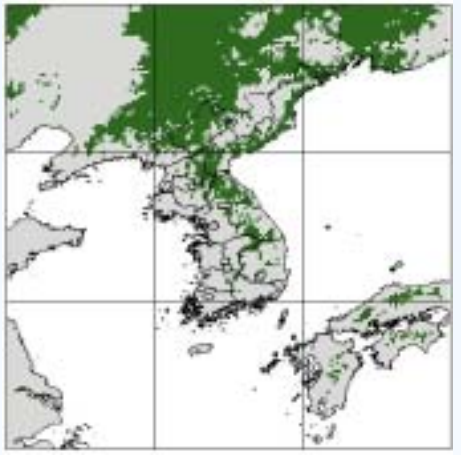
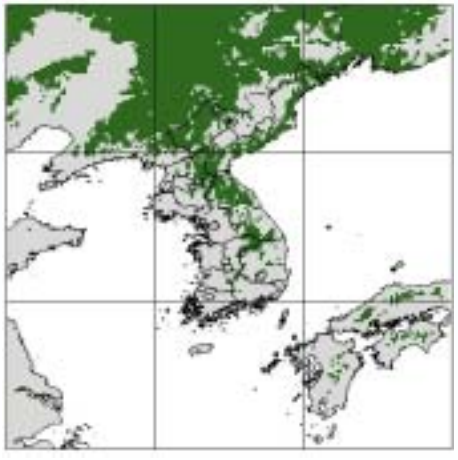


(CCCma)



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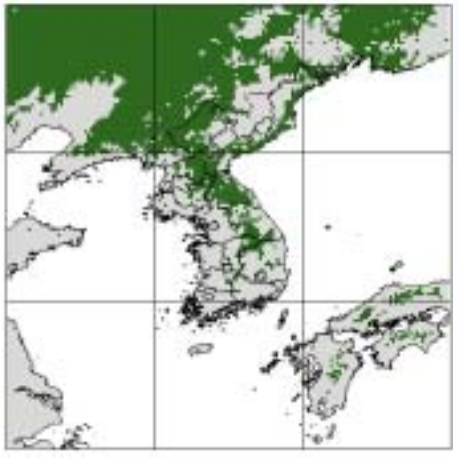
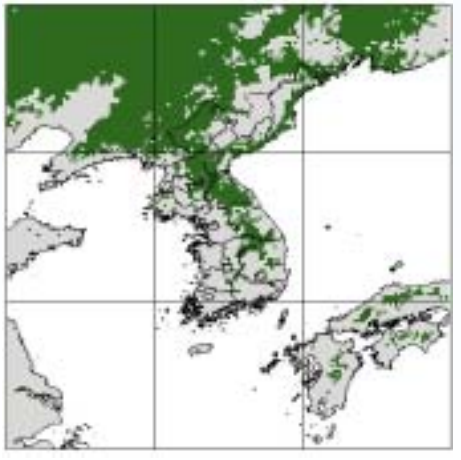
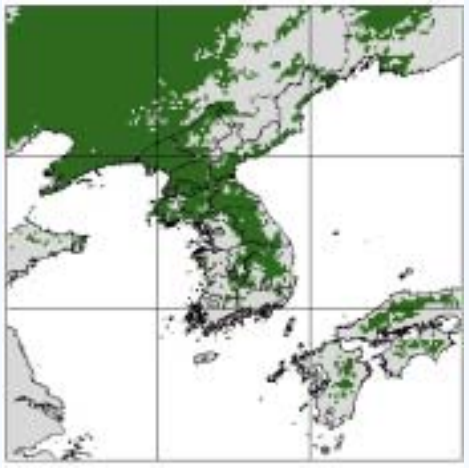


(HadCM2)



(CCSR/NIES)

< The green color shows suitable area for pine using WI in 2050 >



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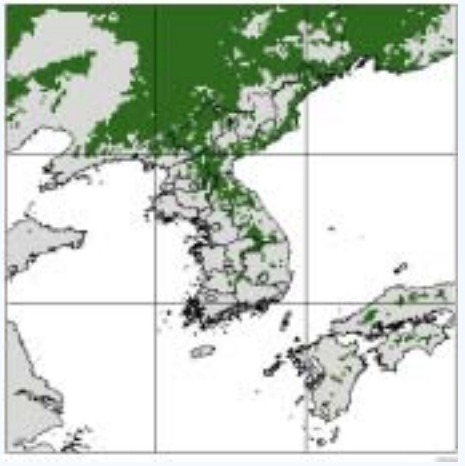

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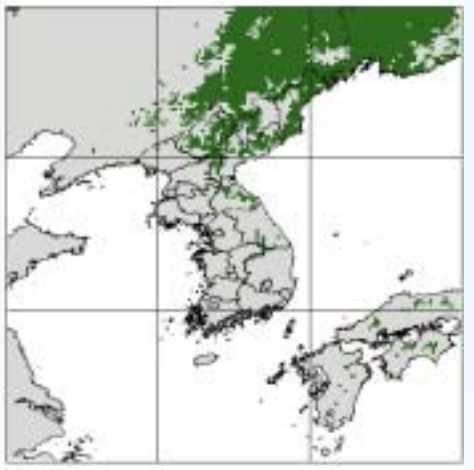

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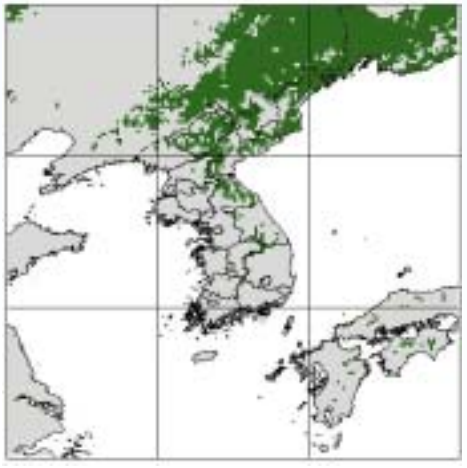
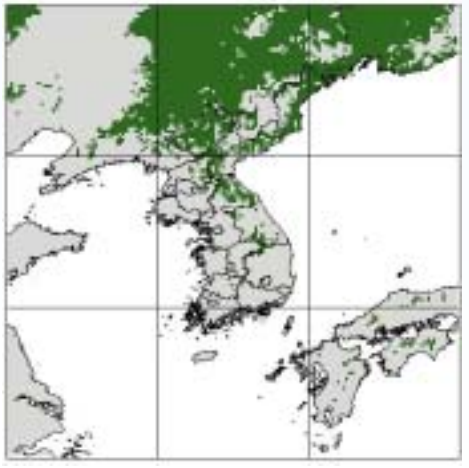


(ECHAM4)



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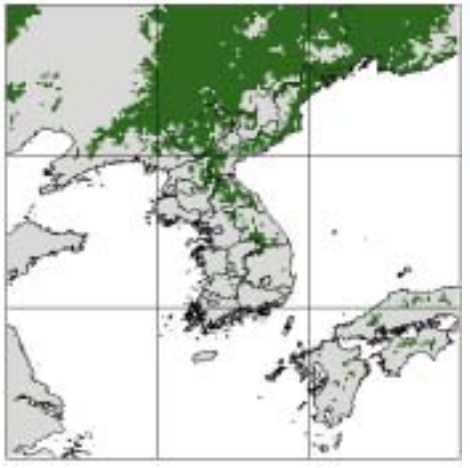


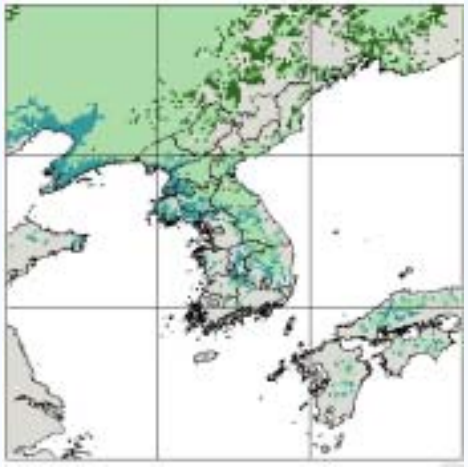
(CCSR/NIES)

< The green color shows suitable area for pine using WI in 2100 >

< The Adaptation Pattern of A Species by the Climate Change >

Plantable Possibility 樹種別 生育 可能性		Effect to forest(species) 地域 森林 影響	
current 現在氣候	future climate 未來 氣候		
suitable area 生育 適合 地域	suitable area 生育 適合 (Bio-climate class is not changed) (氣候帶 變化 無)	a) A species is not changed 樹種 變化 無	no change 自然適應
	unsuitable area 生育不適合地域	b) The concerned species is not able to grow up 該當樹種 生育 不可能 地域	change to the different species 樹種轉換 必要
unsuitable area 生育 不適合 地域	[illegible] 生育適合地域	c) The concerned species moves into the area naturally 移動可能地域	naturally adapted 自然適應
		d) The concerned species cannot move into the area naturally 移動不可能地域	artificial intervention is needed 人爲的 介入必要
	unsuitable area 生育不適合地域	e) Not a concerning species area 非關心地	-

< The Adaptation Pattern of the Pine in 2050 >



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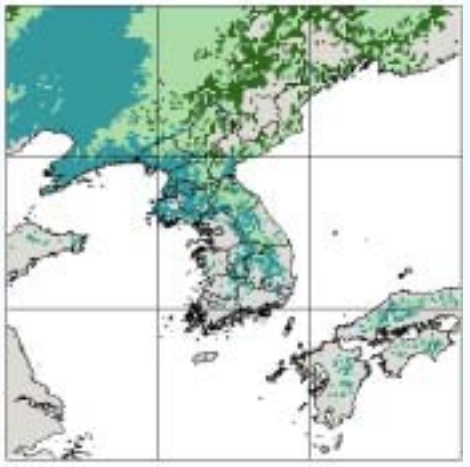

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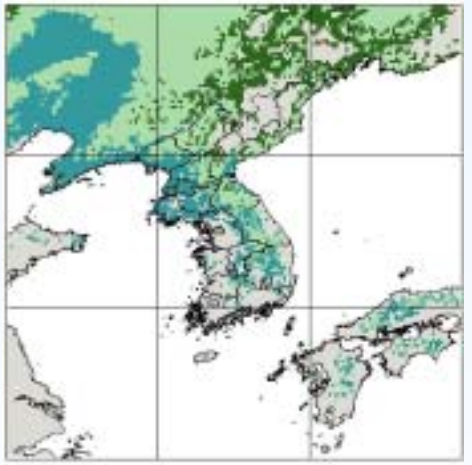
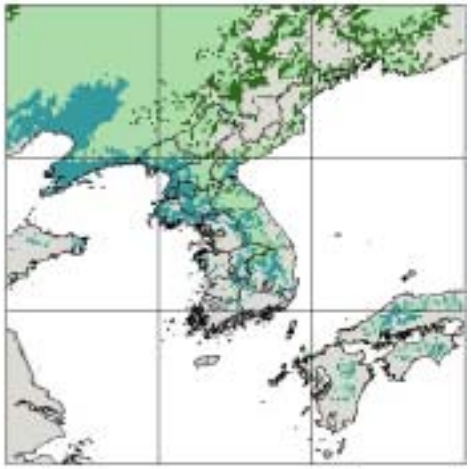
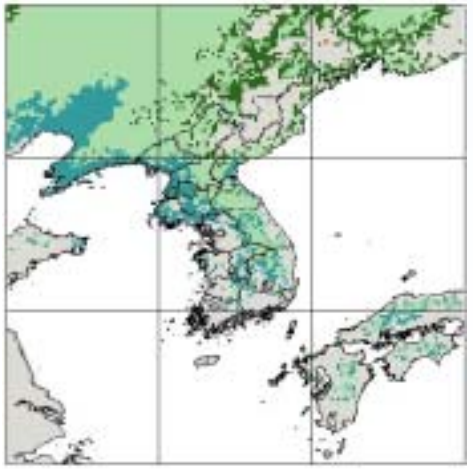


(ECHAM4)



(HadCM2)



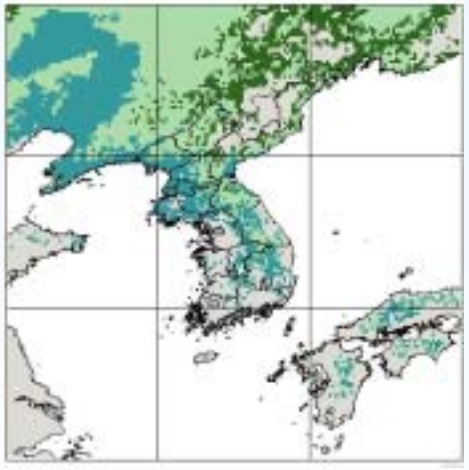
(CCSR/NIES)

a. Suitable ⇒ Suitable
b. Suitable⇒Unsuitable
c. Unsuitable⇒Suitable(Nat.)
d. Unsuitable⇒Suitable(A. I.)
e. Unsuitable⇒Unsuitable

< The adaptation result of pine tree in 2050 >

adaptation pattern		Areal ratio(%)						area(㎢)
		CSIRO MK2	CCCma	ECHAM4	HadCM2	CCSR /NIES	mean	
South korea	a	20.49	11.82	13.79	15.37	17.64	15.82	15,791
	b	14.88	23.55	21.58	20.00	17.73	19.55	19,508
	c	0.30	0.49	0.49	0.49	0.39	0.43	433
	d	-	-	-	-	-	-	-
	e	64.33	64.14	64.14	64.14	64.24	64.20	64,069
sum		100.00	100.00	100.00	100.00	100.00	100.00	99,800
North Korea	a	45.80	29.55	32.58	37.49	39.08	36.90	45,300
	b	13.68	29.93	26.91	22.00	20.41	22.59	27,726
	c	6.42	11.87	12.55	8.99	8.47	9.66	11,859
	d	-	-	-	-	-	-	-
	e	34.09	28.65	27.97	31.52	32.05	30.85	37,877
sum		100.00	100.00	100.00	100.00	100.00	100.00	122,762
Total Area								222,562

< The Adaptation Pattern of the Pine in 2100 >



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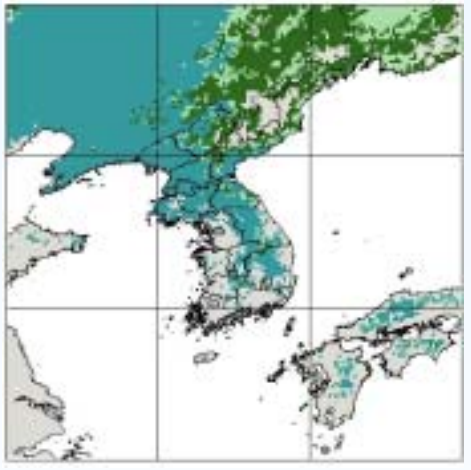

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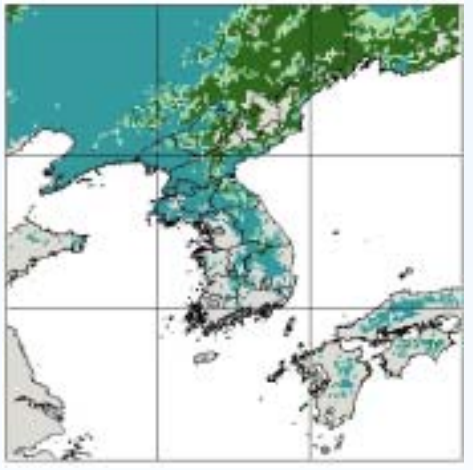

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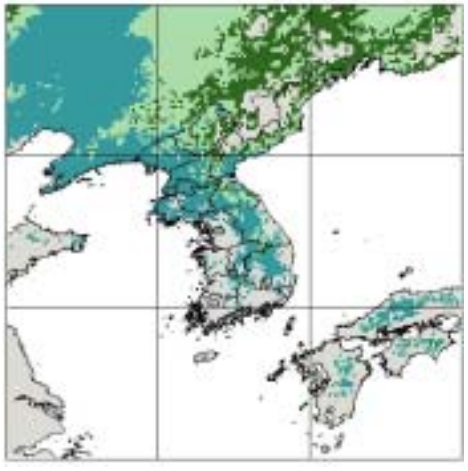

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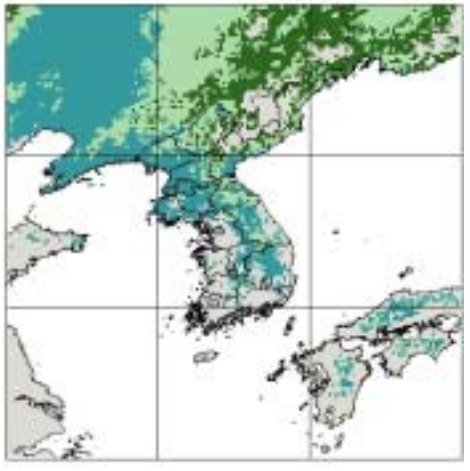

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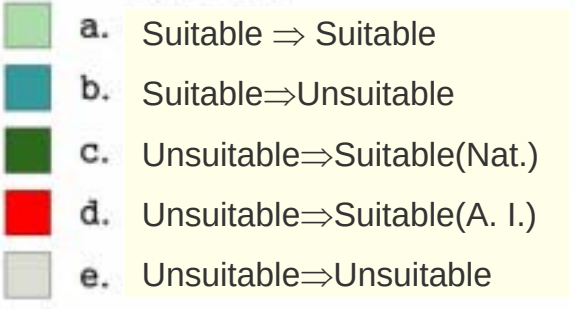


< The adaptation result of pine tree in 2100 >

adaptation pattern		Areal ratio(%)						area(㎢)
		CSIRO MK2	CCCma	ECHAM4	HadCM2	CCSR /NIES	mean	
South korea	a	11.13	2.66	4.14	5.12	7.39	6.09	6,076
	b	24.24	32.71	31.23	30.25	27.98	29.28	29,222
	c	0.49	0.49	0.49	0.49	0.49	0.49	492
	d	-	-	-	-	-	-	-
	e	64.14	64.14	64.14	64.14	64.14	64.14	64,010
sum		100.00	100.00	100.00	100.00	100.00	100.00	99,800
North Korea	a	30.84	9.07	12.85	20.71	23.73	19.44	23,866
	b	28.65	50.42	46.64	38.78	35.75	40.05	49,160
	c	13.08	23.05	23.43	17.99	17.01	18.91	23,216
	d	-	-	-	-	-	-	-
	e	27.44	17.46	17.08	22.52	23.51	21.60	26,520
sum		100.00	100.00	100.00	100.00	100.00	100.00	122,762
Total Area								222,562

5. Results & Proposals

❖ There is a big deviation by GCM, but IPCC IS92a scenarios shows that 12-32% of the forest until the year 2100 in Korean peninsula will be in danger.

❖ In case that the yearly mean movement growth rate of the forest is below than 0.25km per year, it is estimated that there will be a loss of 1.3-3.5billion US$ annually due to the futility of forest apatation.

❖ The establishment of the integrated impact assessment is necessary to fully assess the impact of forest and other ecosystem fields. This includes a correspondence plan at national level and continuous establishment of the basic data.

Korea Landuse/cover classification Project

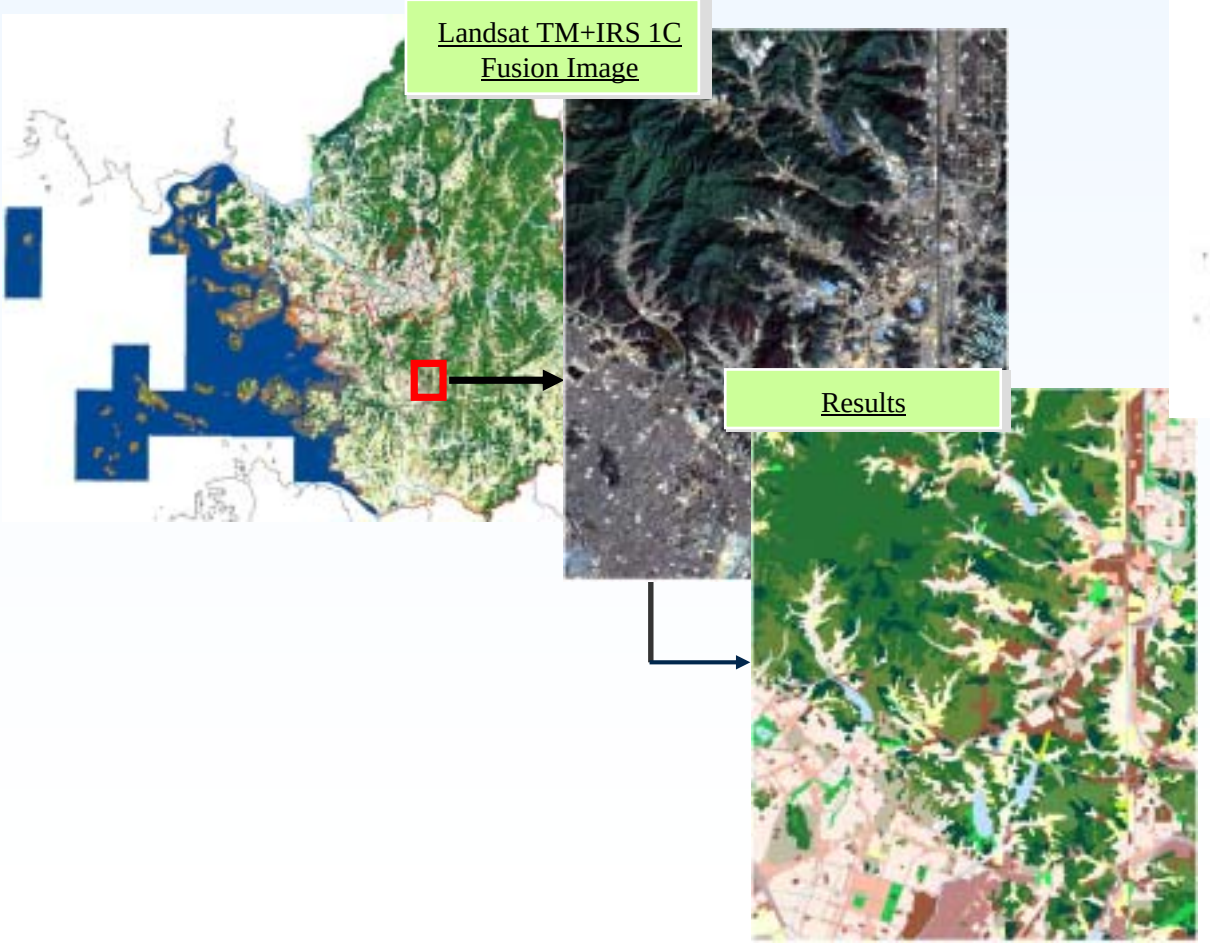
Classification Level

Level I (7 classes)		Level II (23 classes)		Level III (48 classes)	CODE
Urban or Built-up Land	100	Residential	110	Detached house areas	111
				Tenement house areas	112
				Apartment areas	113
		Industrial	120	Industrial areas	121
		Commercial And Services	130	Commercial areas	131
				Mixed com. & services area	132
				Gas & Oil station	133
		Recreation	140	Recreation facilities	141
				Gym. & Stadium	142
		Transport-ation	150	Airports	151
				Port areas	152
				Rail networks	153
				Road	154
				Other transportsion & communication area	155
		Public	160	Environmental Elementary facilities	161
				Electronic plant facilities	162
				Education & Miltary facilities	163
				Other public facilities	164
Agricultural Land	200	Rice Land	210	Permanently Irrigated land	211
				Non-irrigated land	212
		Field Land	220	Fileds	221
				산간지방의 밭	222
		Vinyl House	230	Vinyl house	231
		Orchard	240	Orchard	241
		Other Agri. Land	250	Tree planting areas	251
				Pasture lands	252

Level I (7 classes)		Level II (23 classes)		Level III (48 classes)	CODE
Forest Land	300	Broad-Leaved forest	310	Natural Broad leaved forest	311
				Planted Broad leaved forest	312
		Coniferous forest	320	Natural coniferous forest	321
				Planted coniferous forest	322
		Mixed	330	Mixed forest	331
Grass Land	400	Natural Grass	410	Natural Grassland	411
		Golf Area	420	Grassland in Golf-course	421
		Other Grass Land	430	Grassland in Cemetery park	431
				Avenue tress	432
				Other	433
Wetland	500	Inland Wetland	510	Inland Wetland	511
		Coastal Wetland	520	Intertidal flats	521
				Salines	522
Barren Land	600	Mining Area	610	Open pit areas of Industrial minerals	611
				Open areas mining of rock	612
				Open pit areas of other minerals	613
		Other Barren	620	Beaches	621
				River bank	622
				Other(construction etc.)	623
Water	700	Inland Water	710	Water courses	711
				Water bodies	712
		Marine Water	720	Sea & Ocean	721

Classification Level II

Classification Results in Seoul, kyonggi Povince



Classifying Area

Classified Area

To be Classified Area


Thank you!!