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Predicting distributions of coniferous forest and Japanese pine sawyer beetle (*Monochamus alternatus* Hope) to support climate change adaptation policy

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CONTENTS

Chapter 1

Introduction of project

Overview

Objectives

1. Development estimation methods considering uncertainty for supporting to adaptation policy
2. Impact, adaptation, and economic assessment by sectors

Period

2014. 05. 01. ~ 2017. 04. 30.
(650 million won/yr)

Target

- Regions: National, provincial and county-level scale
- Periods: 2040(2036~2045), 2090(2086~2095)
- Sectors: Forest, Health, Disaster, Agriculture, Ecosystem, Water Resources

Overview

Characteristics

1. **Scientific approach** to assess sector's impacts
2. **Probabilistic approach** to assess uncertainty of future projection
3. **Economic approach** to assess the feasibility of adaptation options
4. **Integrated approach** to support local adaptation decision-making

Overview

Contents (SNU)

1. Impact, adaptation option and economic assessment by sectors (forest, disaster, health, and agriculture)
2. Evaluation of adaptation strategy by sectors (forest, disaster, health, and agriculture)

Contents (KEI)

1. Construction of common scenarios
2. Impact, adaptation option and economic assessment by sector (water management and ecosystem)
3. Model development using impact response function for supporting of the adaptation policy
4. Visualization tool development for decision-making

Chapter 2

Case studies (Ecosystem sector)

Introduction

1st NCCAP

1. 1st National Climate Change Adaptation plan('10.12)
2. Sectoral plan
   - Forest: Measures to prevent from forest disaster, diseases and pests
   - Ecosystem: Damage prevention and management plan for alien species and unexpected outbreaks
3. Limitation
   - Difficulty in making a tangible outcome
   - Insufficient strategic framework for promoting adaptation

Introduction

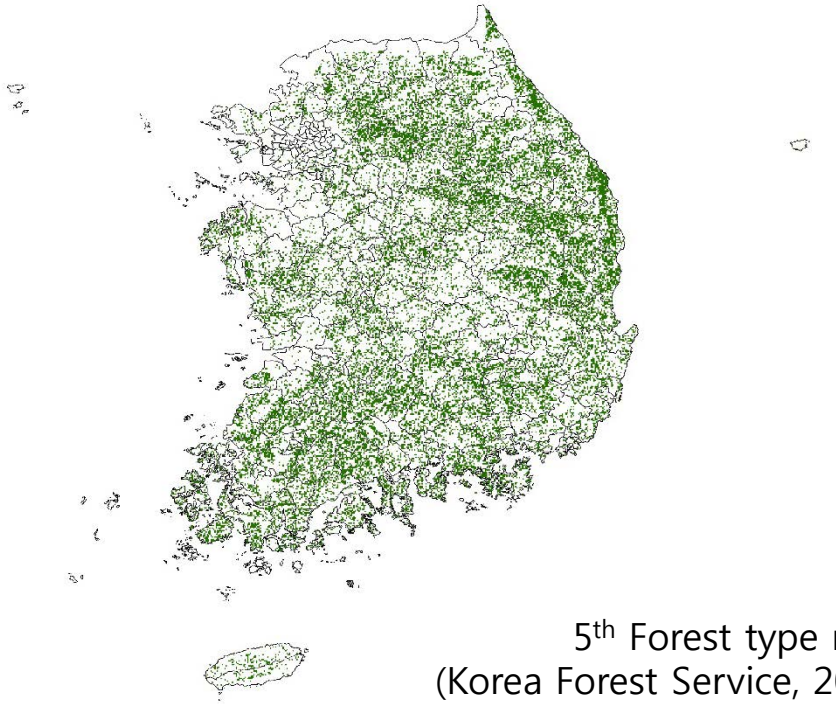
2nd NCCAP

1. 5 Visions
   - Cooperative adaptation
   - Science-based climate change risk management
   - Sound and Competitive economy
   - Sustainable conservation of natural resources
   - Establishing climate-safe society
2. Focused initiatives
   - Enhance climate change impact monitoring
   - Ecosystem climate risk management

Coniferous forest

Introduction

1. 2,581,000ha(41.9% of forest)
2. A host of pine wood disease (PWD)
   - Red pine (*Pinus densiflora*), Korean pine (*Pinus koraiensis*), Black pine (*Pinus thunbergii*)



5th Forest type map
(Korea Forest Service, 2010)

Coniferous forest

Methods

1. MaxEnt model (Maximum Entropy Modeling)
   - Input data: 5th Forest type map, Bioclim 1~19, Forest site map, DEM
   - Training points: 250
   - Random test points: 50
   - Replicates: 10 times
   - Threshold: Maximum training sensitivity plus specificity

Coniferous forest

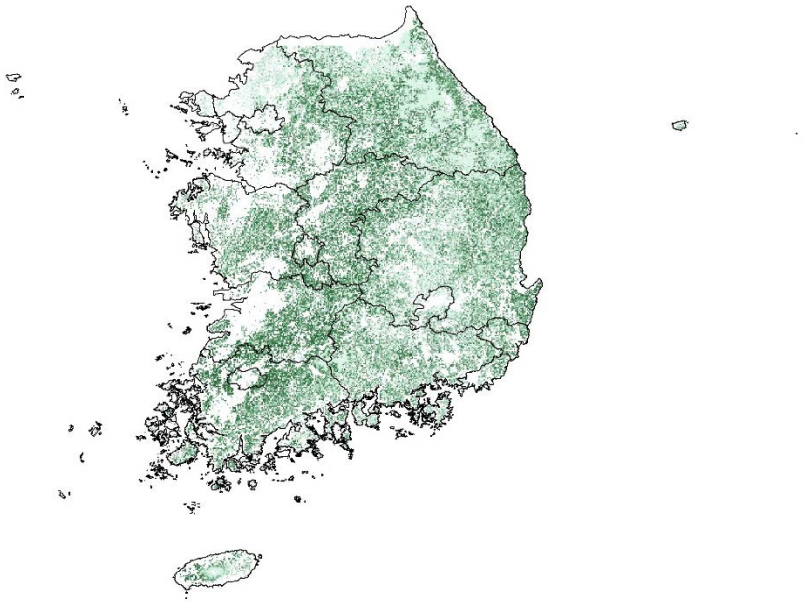
MaxEnt model

1. Selected variables
   - Bioclim(5): Annual Mean Temperature (BIO1), Max Temperature of Warmest Month (BIO5), Annual Precipitation (BIO12), Precipitation of Driest Month (BIO14), Precipitation of Coldest Quarter (Bio19)
   - Topography(1): Altitude
   - Forest site(7): Soil drainage, Wind exposure, Soil texture, Soil depth, Soil type, Topography type, Soil erosion

Coniferous forest

MaxEnt model

1. **AUC values**
   - **Training data: 0.667**
   - **Test data: 0.526**

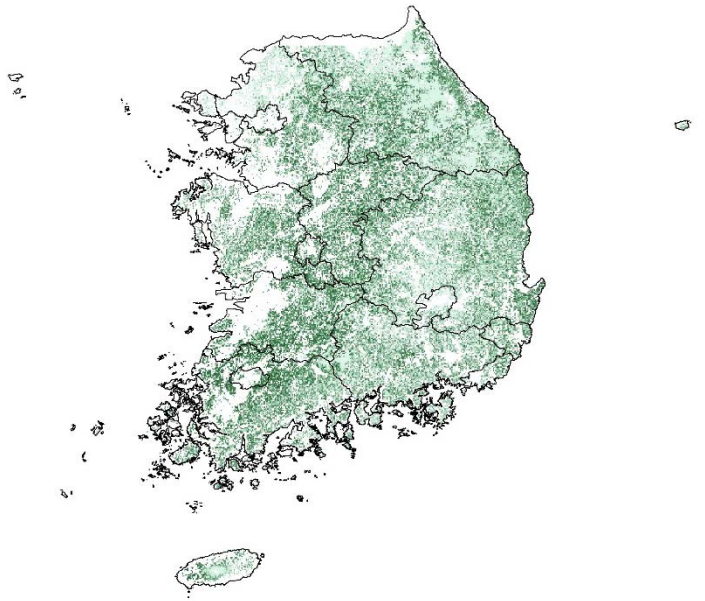


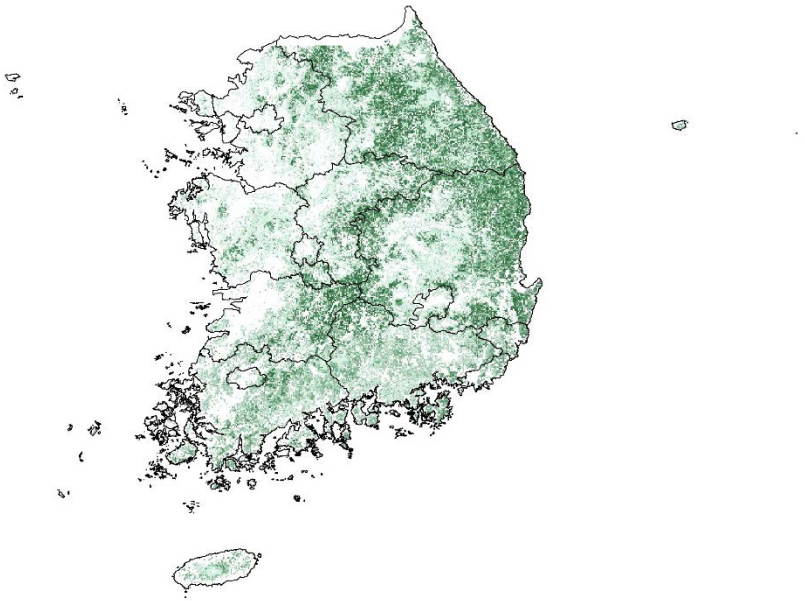
5th Forest type map (2010)	Area (ha)	Simulated coniferous (1971~2000)
2,667,600		1,823,100

Coniferous forest

MaxEnt model

1. **AUC values**
   - **Training data: 0.667**
   - **Test data: 0.526**



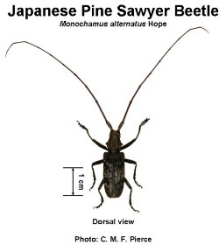


Simulated coniferous (1971~2000)	Area (ha)	Simulated coniferous (2021~2050)
1,823,100		1,138,600

Japanese pine sawyer beetle

Introduction

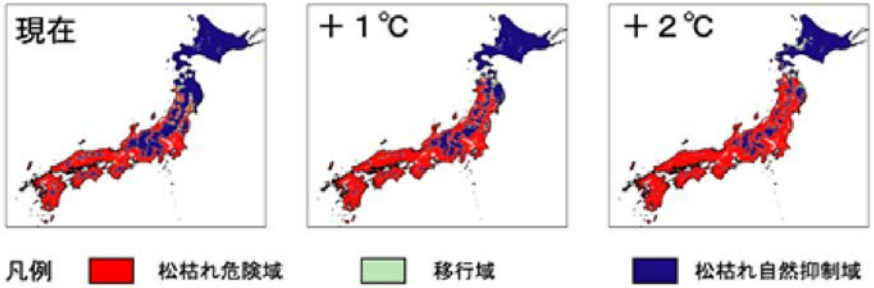
1. Major vector of pinewood nematode (PWN)
2. In the southern region of South Korea
3. Expanding rapidly to the northern area of S. Korea since 2000



Japanese pine sawyer beetle

Methods

1. **MB index (Taketani et al., 1975)**
   - **Annual summation of temperature values subtracted 15℃ from the mean monthly temperature exceeding 15℃**
2. **CLIMEX model (Sutherst and Maywald, 1985)**
   - **Environment of species life cycle (e.g. temperature, moisture, degree day etc.)**



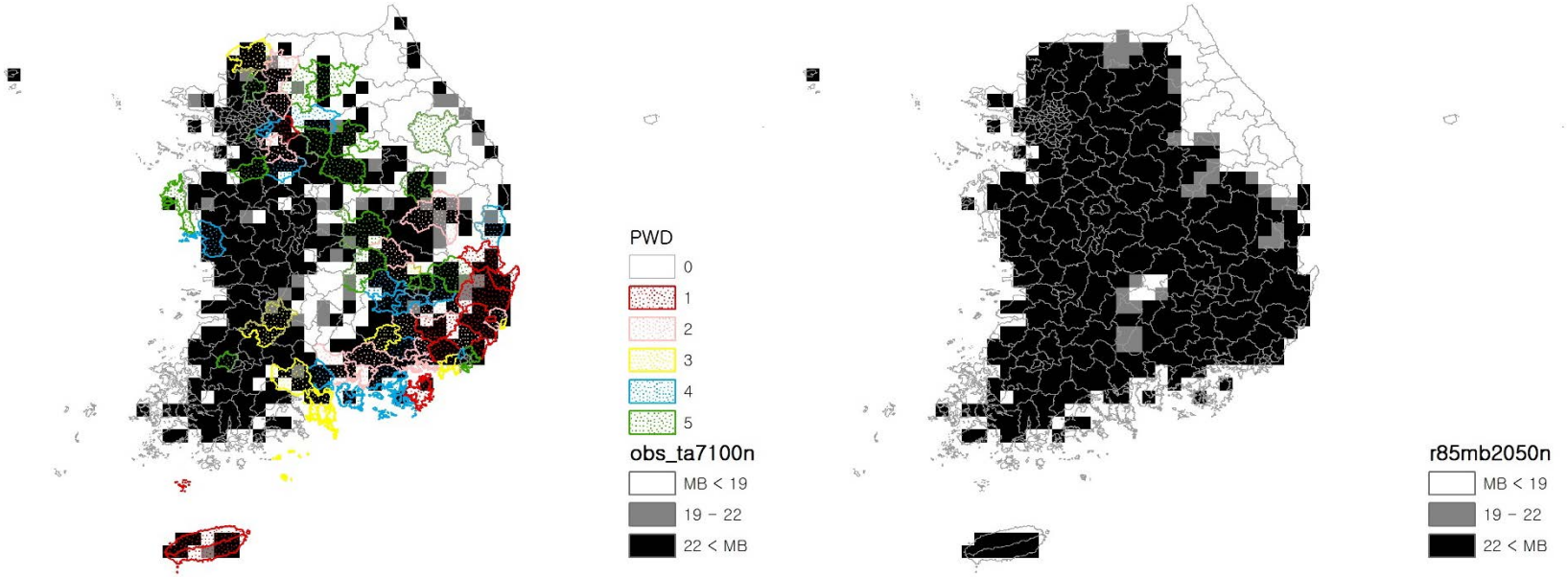
MB index (Hiromu and Nakamura, 2008)

CLIMEX model (Park et al., 2014)

Japanese pine sawyer beetle

MB index

1. **T-test: p < 0.05**
   - **Presence area(MB): 21.9±13.2**
   - **Absence area(MB): 16.1±14.2**

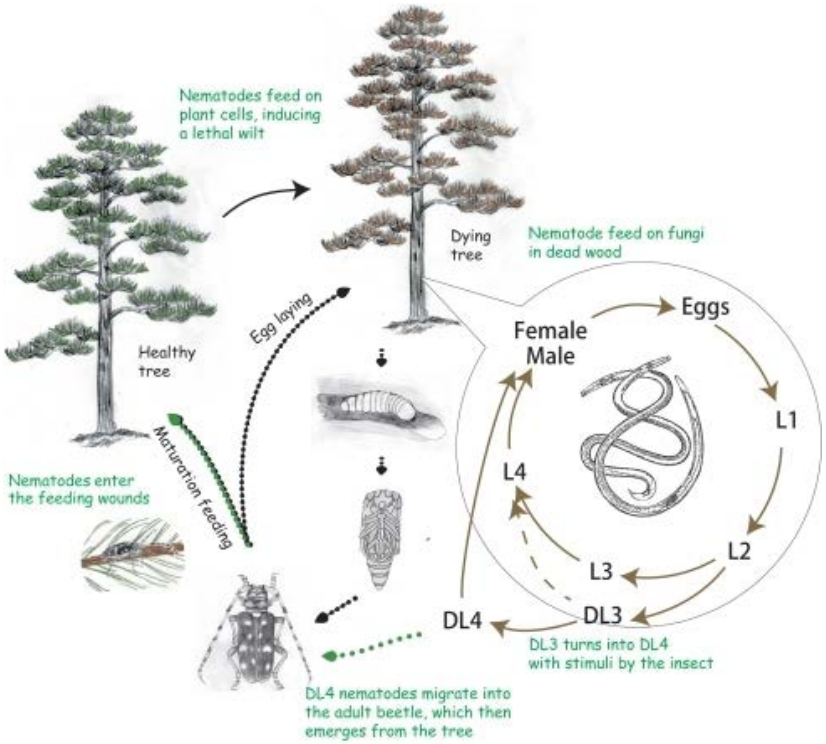


1971~2000	Area (ha)	2021~2050
625,000	19 < MB < 22	500,000
6,140,625	22 < MB	7,984,375

Japanese pine sawyer beetle

CLIMEX model

1. **Parameter values**
   - **Moisture index**
   - **Temperature index**
   - **Stress index: cold, heat, dry, wet**



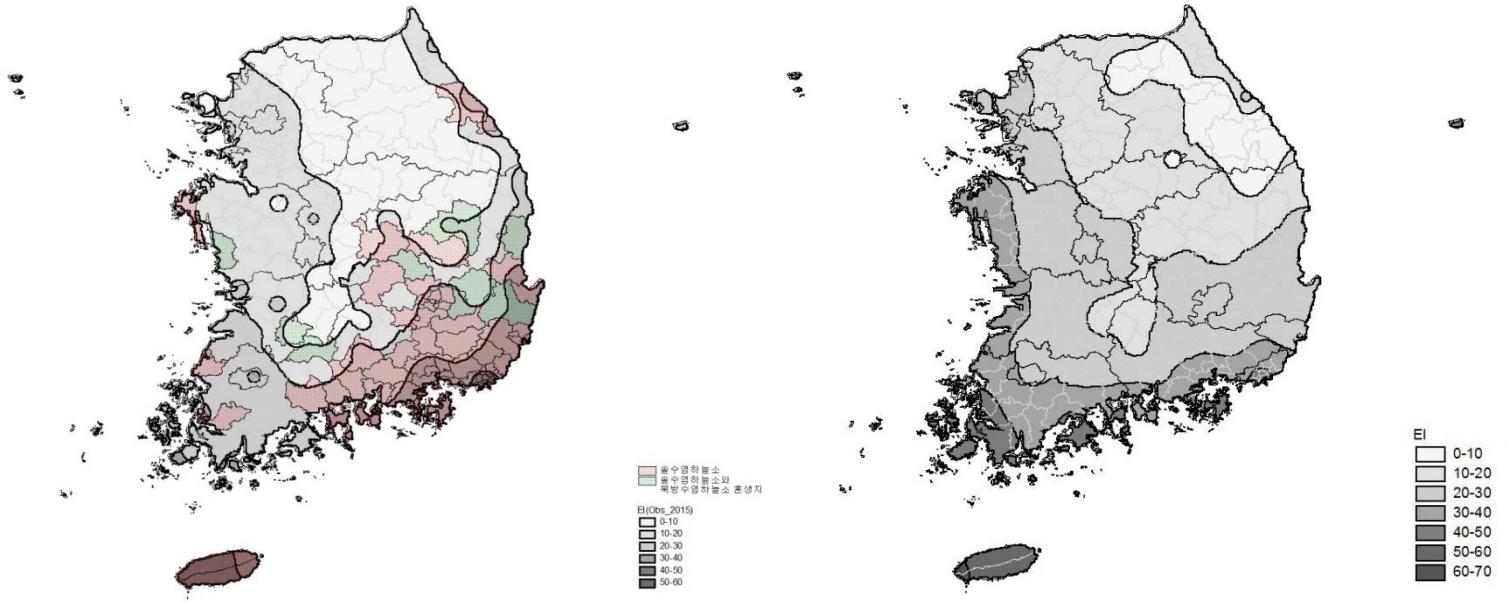
(source: https://openi.nlm.nih.gov/imgs/512/353/3164644/3164644_ppat.1002219.g002.png)

☑ Moisture Index					
SM0	SM1	SM2	SM3		
0.1	0.55	1.35	4		
☑ Temperature Index					
DV0	DV1	DV2	DV3		
10.8	15	30	33		
☐ Light Index					
☐ Diapause Index					
☑ Cold Stress					
TTCS	THCS	DTCS	DHCS	TTCSA	THCSA
8	-0.00013	15	-0.0001	0	0
☑ Heat Stress					
TTHS	THHS	DTHS	DHHS		
33	0.0001	0	0		
☑ Dry Stress					
SMDS	HDS				
0.25	-0.001				
☑ Wet Stress					
SMWS	HWS				
4	0.0001				
☐ Cold-Dry Stress					
☐ Cold-Wet Stress					
☐ Hot-Dry Stress					
☐ Hot-Wet Stress					
Day-degree accumulation above DV0					
DV0	DV3	MTS			
10.8	33	7			
Day-degree accumulation above DVCS					
DVCS	*DV4	MTS			
8	100	7			
Day-degree accumulation above DVHS					
DVHS	*DV4	MTS			
28	100	7			
Degree-days per Generation					
PDD					
1690					

Japanese pine sawyer beetle

CLIMEX model

1. **T-test: $p < 0.05$**
   - **Presence area(EI): 23.7±12.1**
   - **Absence area(EI): 17.4±7.8**

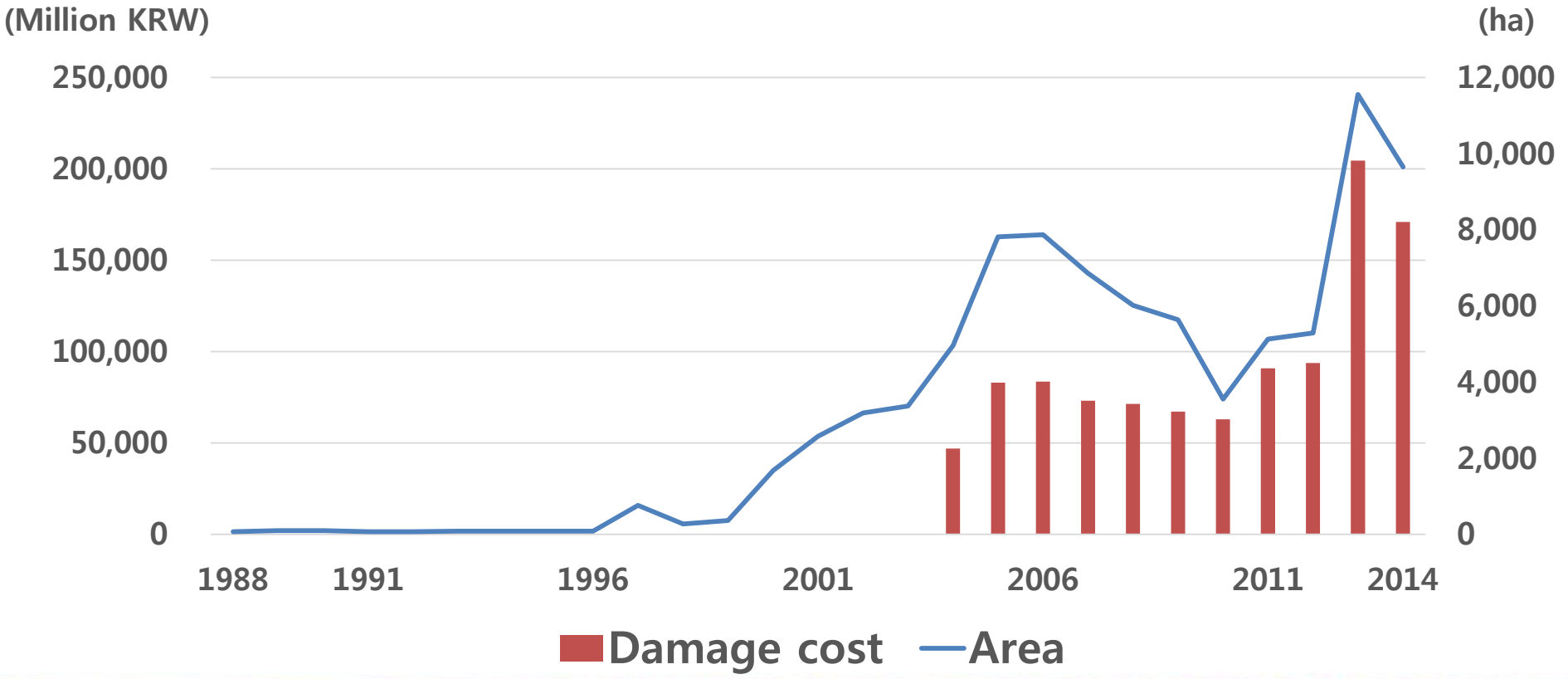


2006~2014	Area (ha)	2046~2055
937,500	10 < EI < 25	1,531,250
2,296,875	25 < EI	4,359,375

Pine wood diseases (PWD)

Introduction

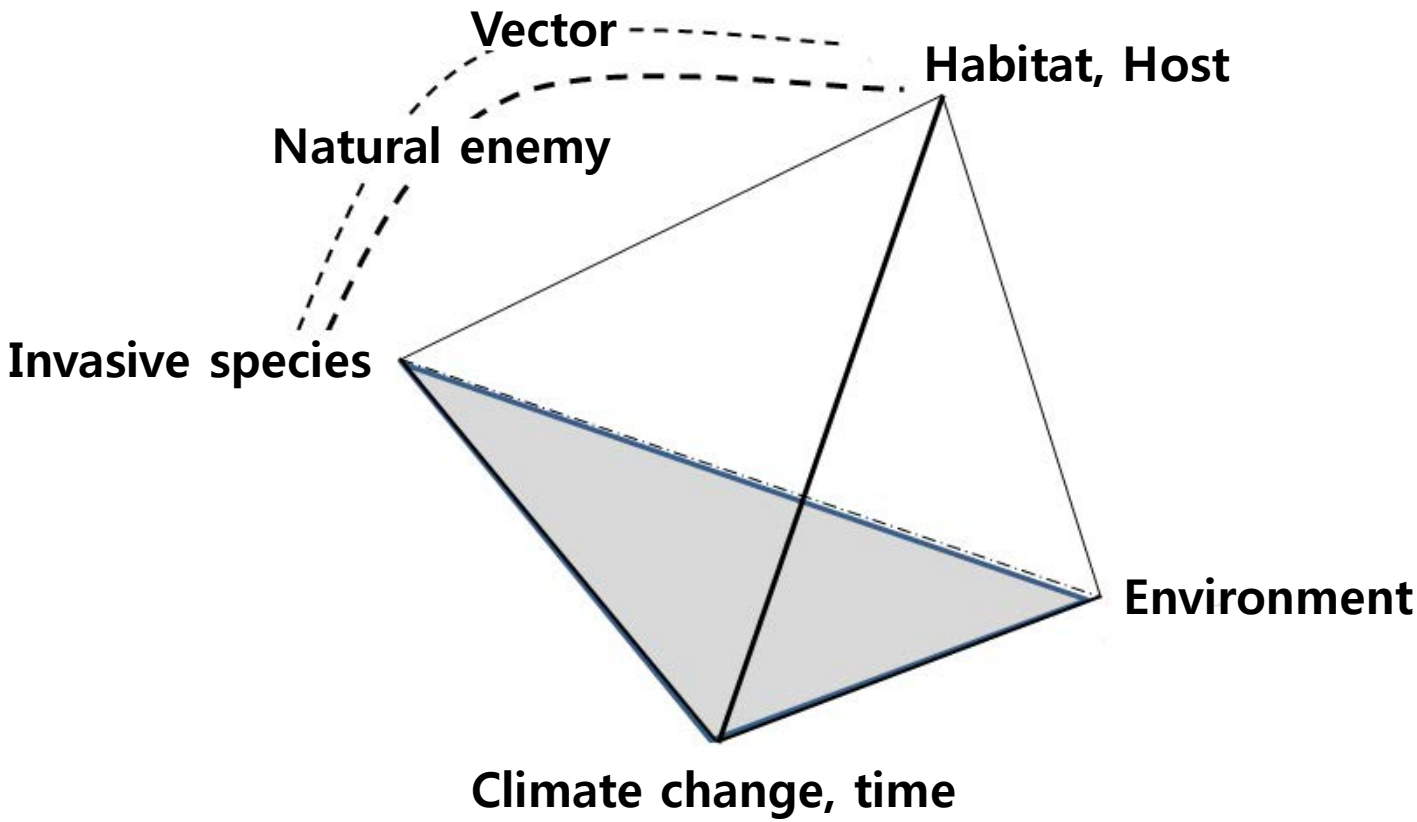
1. First infection in Busan(1988)
2. Area: 9,644 ha(2014)
3. Damage cost: 170 billion KRW(2014)



Pine wood diseases (PWD)

Introduction

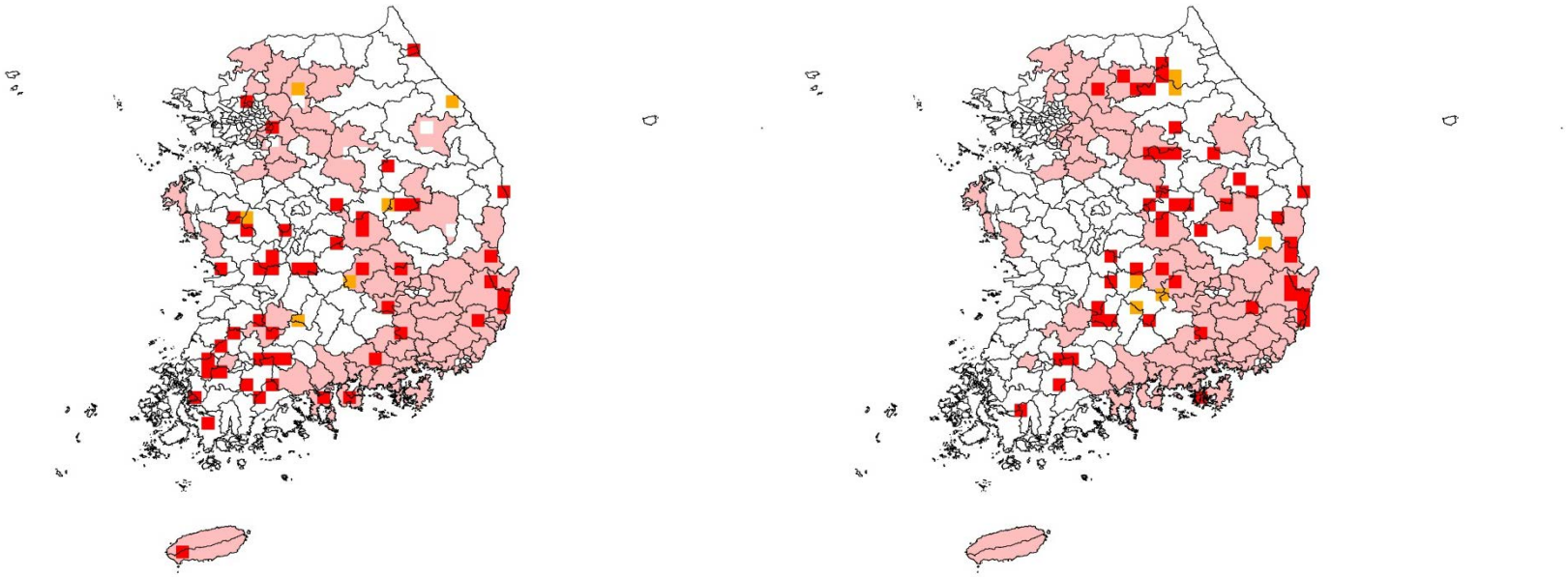
1. Host: Coniferous forest
2. Invasive species: Pine wood nematode
3. Vector: Japanese pine sawyer beetle



Pine wood diseases (PWD)

MB index

1. Quite similar to reality
2. Moving towards inland area

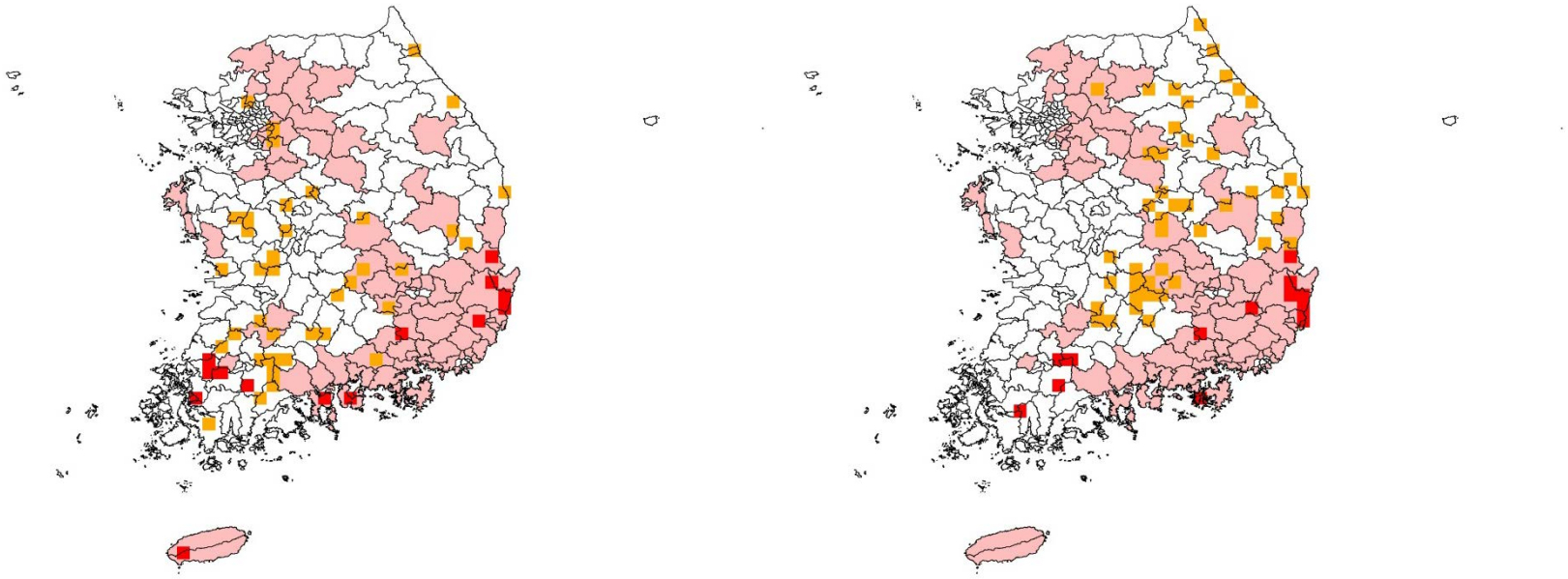


1971~2000	Area (ha)	2021~2050
93,750	19 < MB < 22	93,750
750,000	22 < MB	718,750

Pine wood diseases (PWD)

CLIMEX model

1. **Under estimation than MB index**
2. **Moving towards high ground and coast area**



2006~2014	Area (ha)	2046~2055
593,750	10 < EI < 25	687,500
218,750	25 < EI	203,125

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