Predicting potential habitats for plants under climate change and assessing vulnerability in Japan: especially referring to buna (*Fagus crenata*) forests

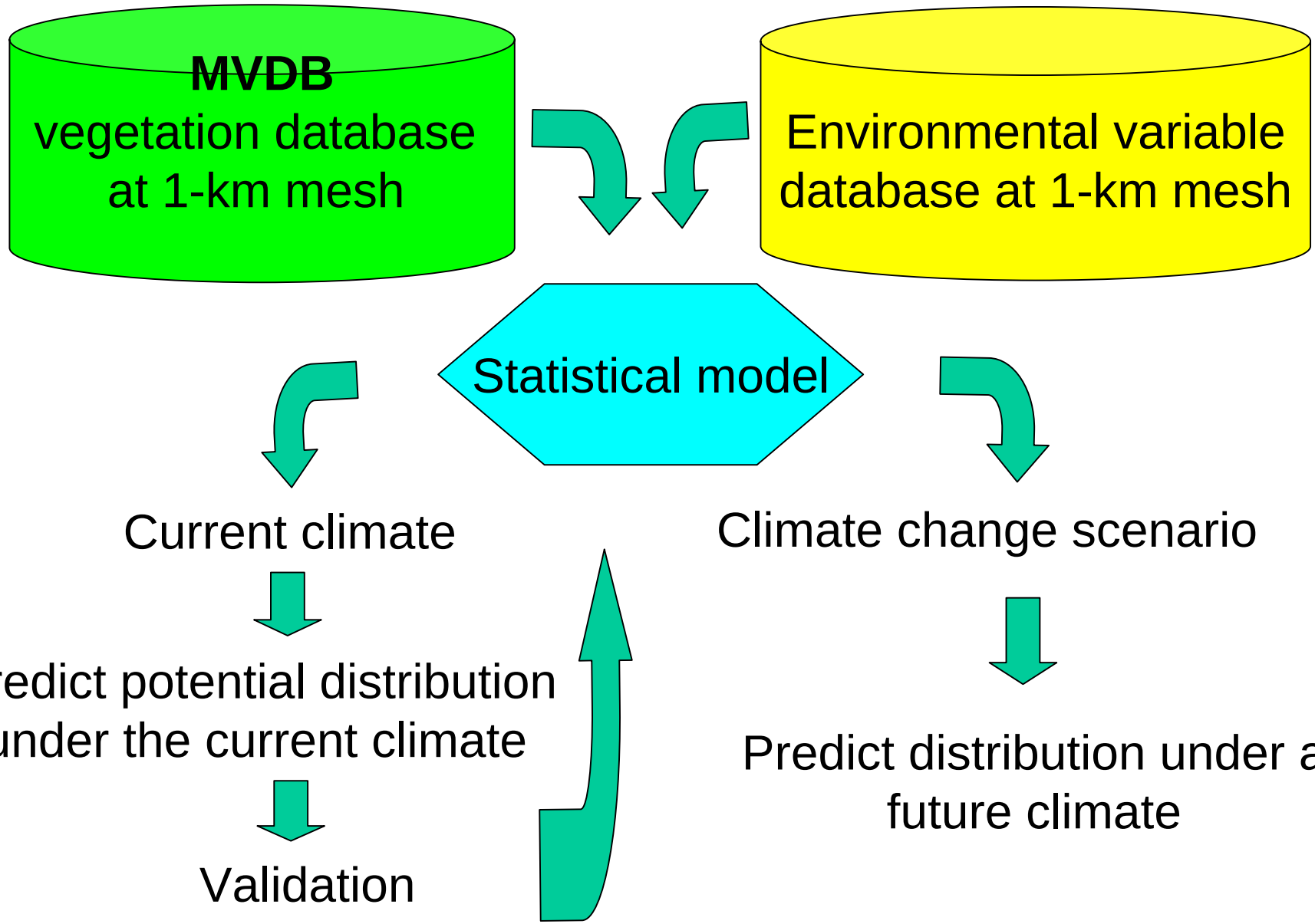
Tanaka, N., Matsui, T., Yagihashi, T., Taoda, H.

Forestry and Forest Products Research Institute (FFPRI), Tsukuba, Japan

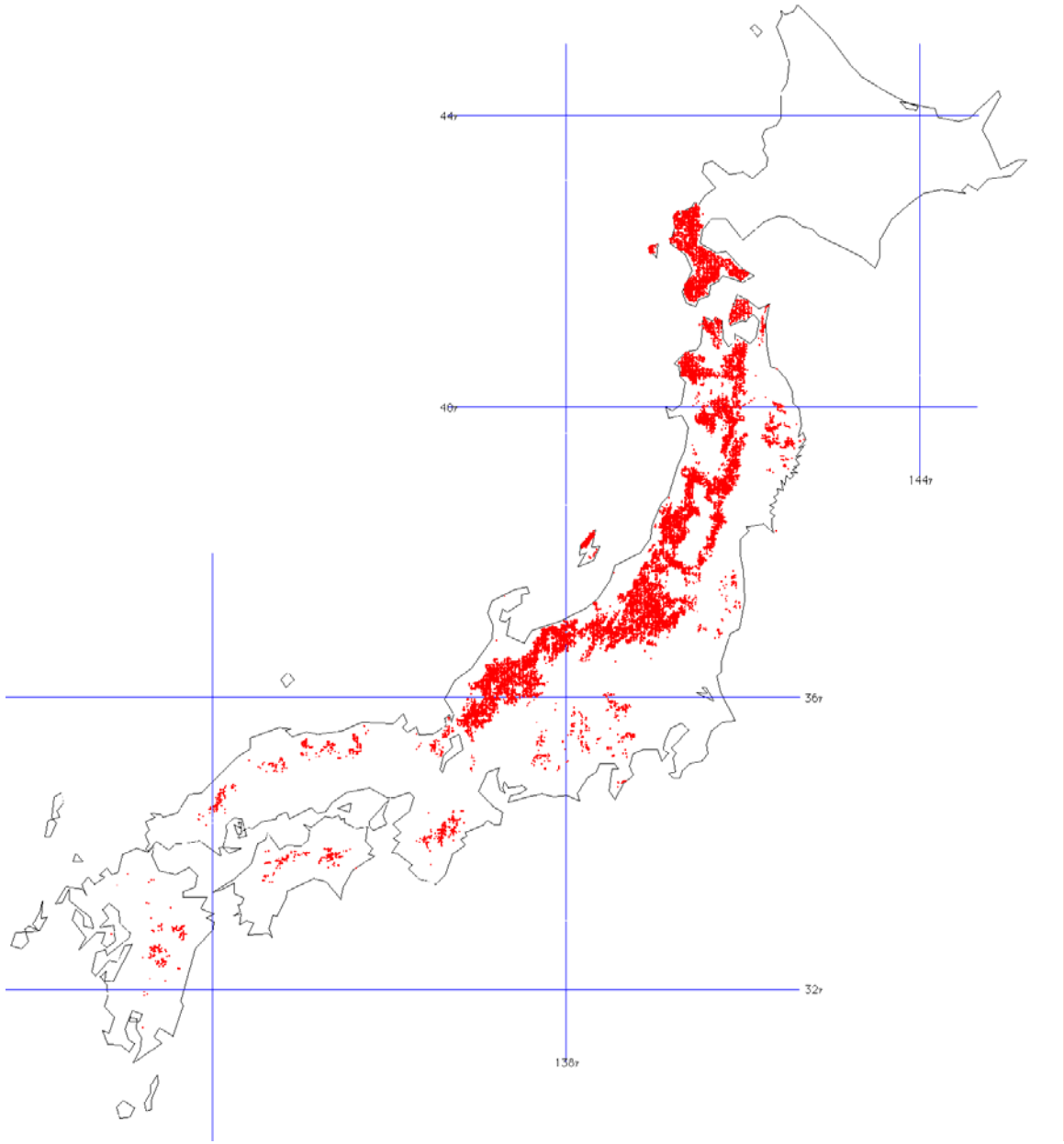
Topics

1. Predicting potential habitats for buna forests
2. Predicting potential habitats for a dwarf-bamboo species
3. Monitoring to detect effects of climate change

Studies using the NSNE 3rd (1-km) mesh vegetation database (MVDB)




Buna (*Fagus crenata*)



Actual distribution of buna forests

Data

Vegetation data

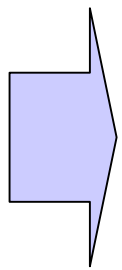
3rd (1-km) mesh vegetation data (MVDB)

Anthropogenic vegetation and lands: 188,363 cells ----- Excluded

Natural vegetation: 156,804 cells

Buna forests: 23,432 cells

Other vegetation types: 133,372 cells



Analysis

Environmental data

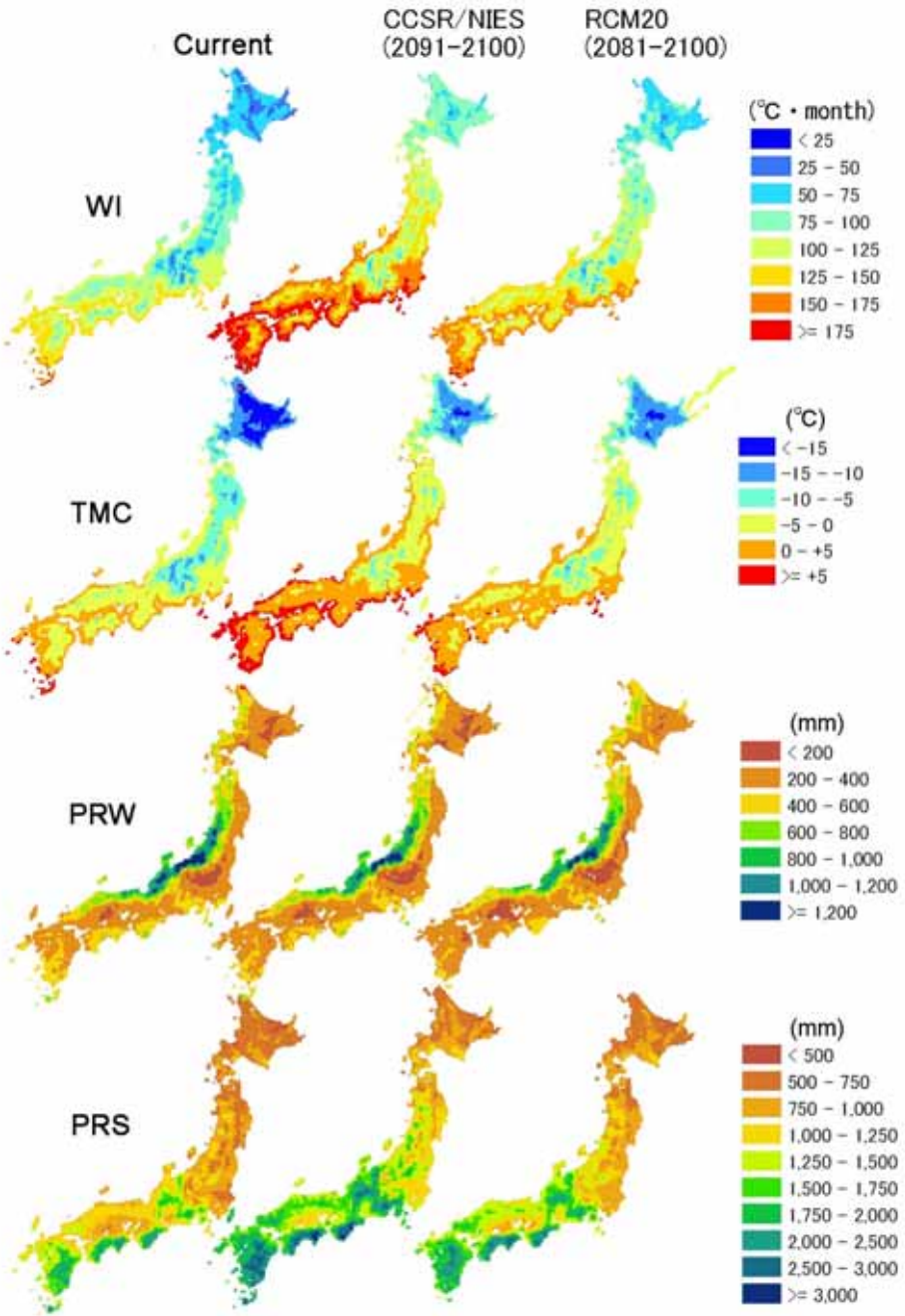
3rd (1-km) mesh climate data (Average for 30 years, Japan Meteorological Agency)

WI: warmth index (˚C·month)

TMC: mean minimum daily temperature of coldest month (˚C·month)

PRW: winter precipitation (Dec. to March; mm)

PRS: summer precipitation (May to September; mm)



Maps of four climatic variables under the current climate and future climates,

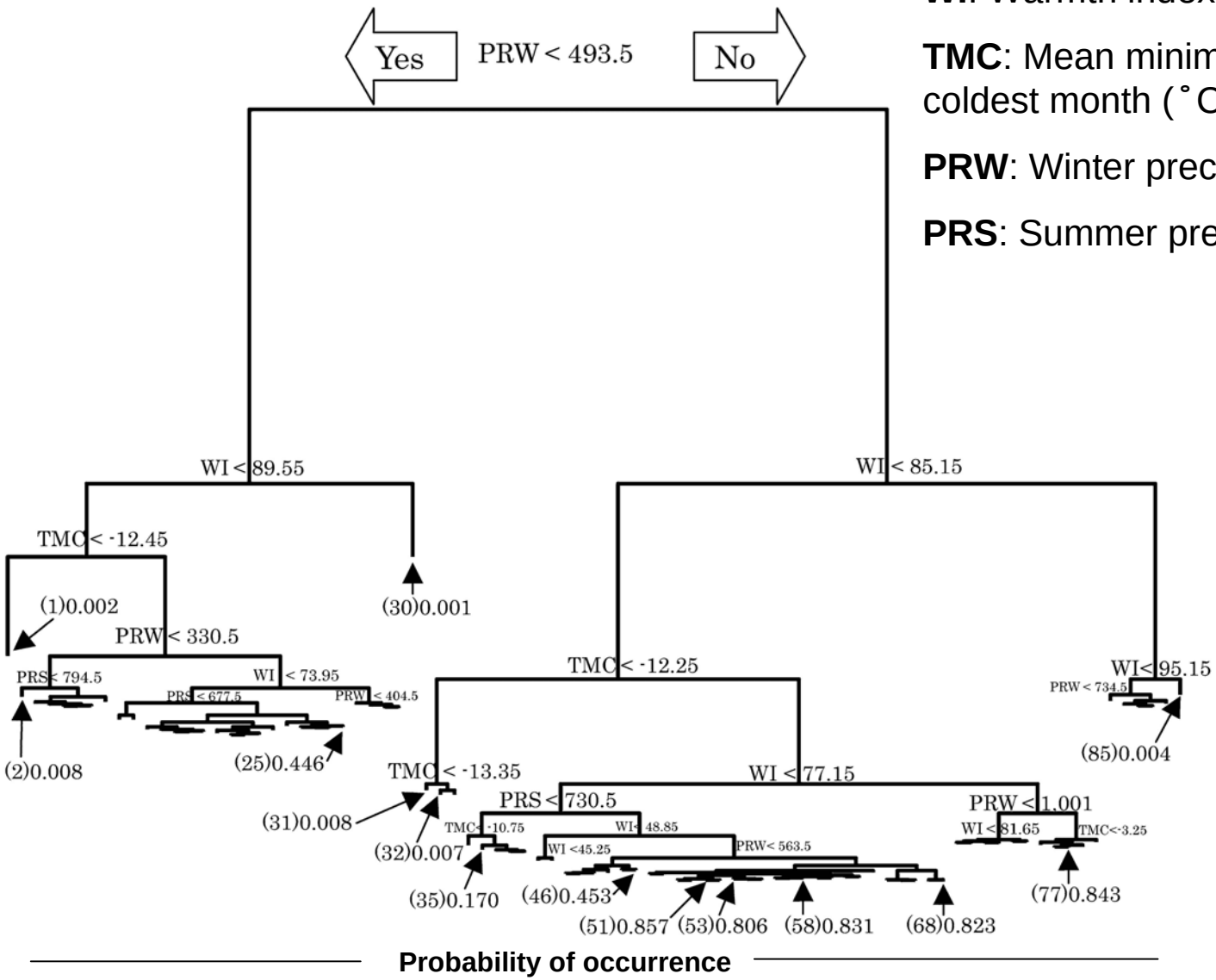
i.e. the CCSR/NIES scenario in 2091-2100 and the RCM20 scenario in 2081-2100.

WI: Warmth index (˚C·month)

TMC: Mean minimum temperature of coldest month (˚C·month)

PRW: Winter precipitation (mm)

PRS: Summer precipitation (mm)



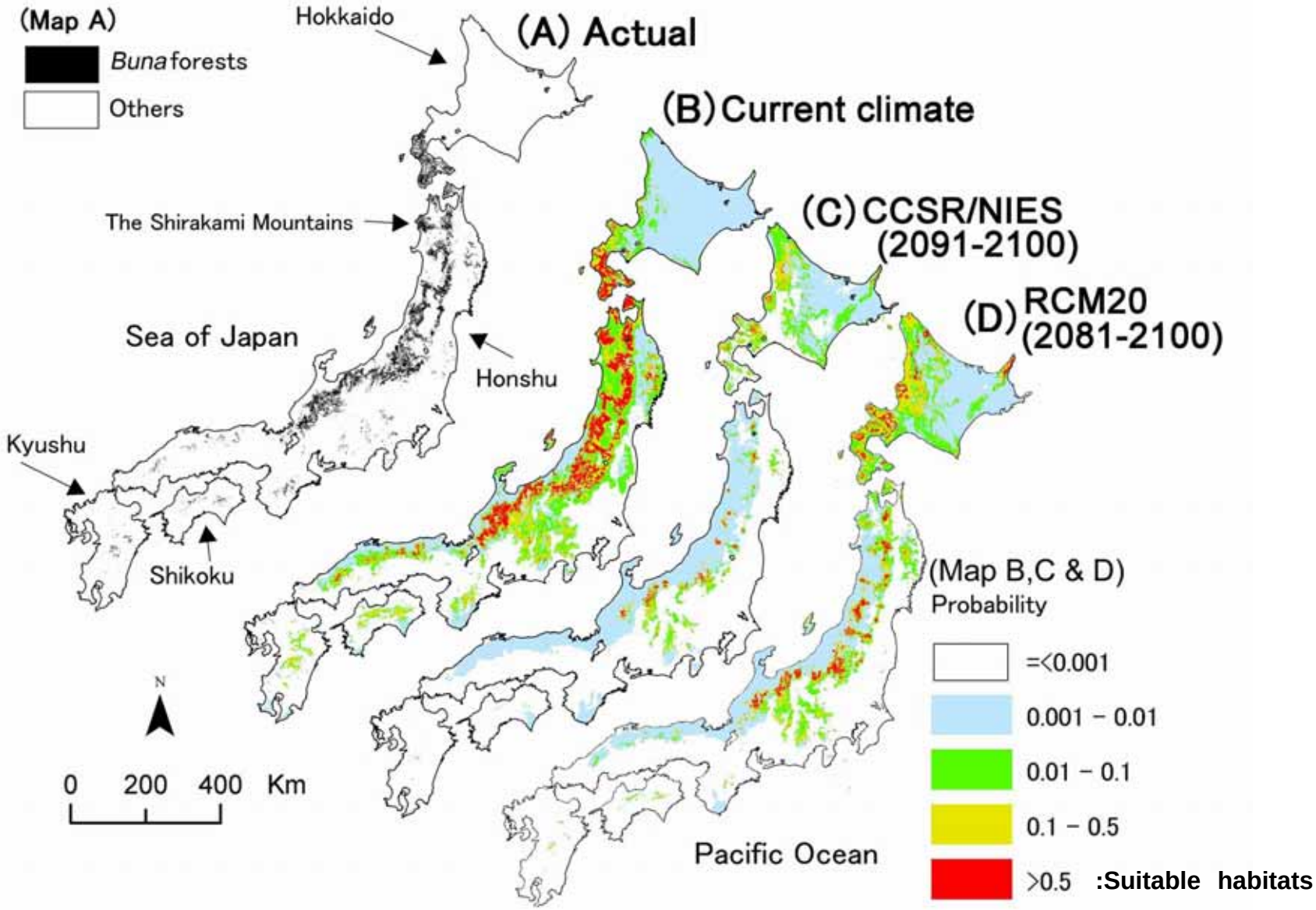
Classification tree model for buna forests

Suitable habitat conditions for buna forests

Where probability of occurrence is more than 0.5

The Sea of Japan side of northern Honshu and the southern Hokkaido

- High precipitation both in winter and summer (564<PRW, 731<PRS)
- Moderate WI (48.9<WI<77.2)
- Moderate coldness in winter (-12.3<TMC)



Buna forest distribution maps:

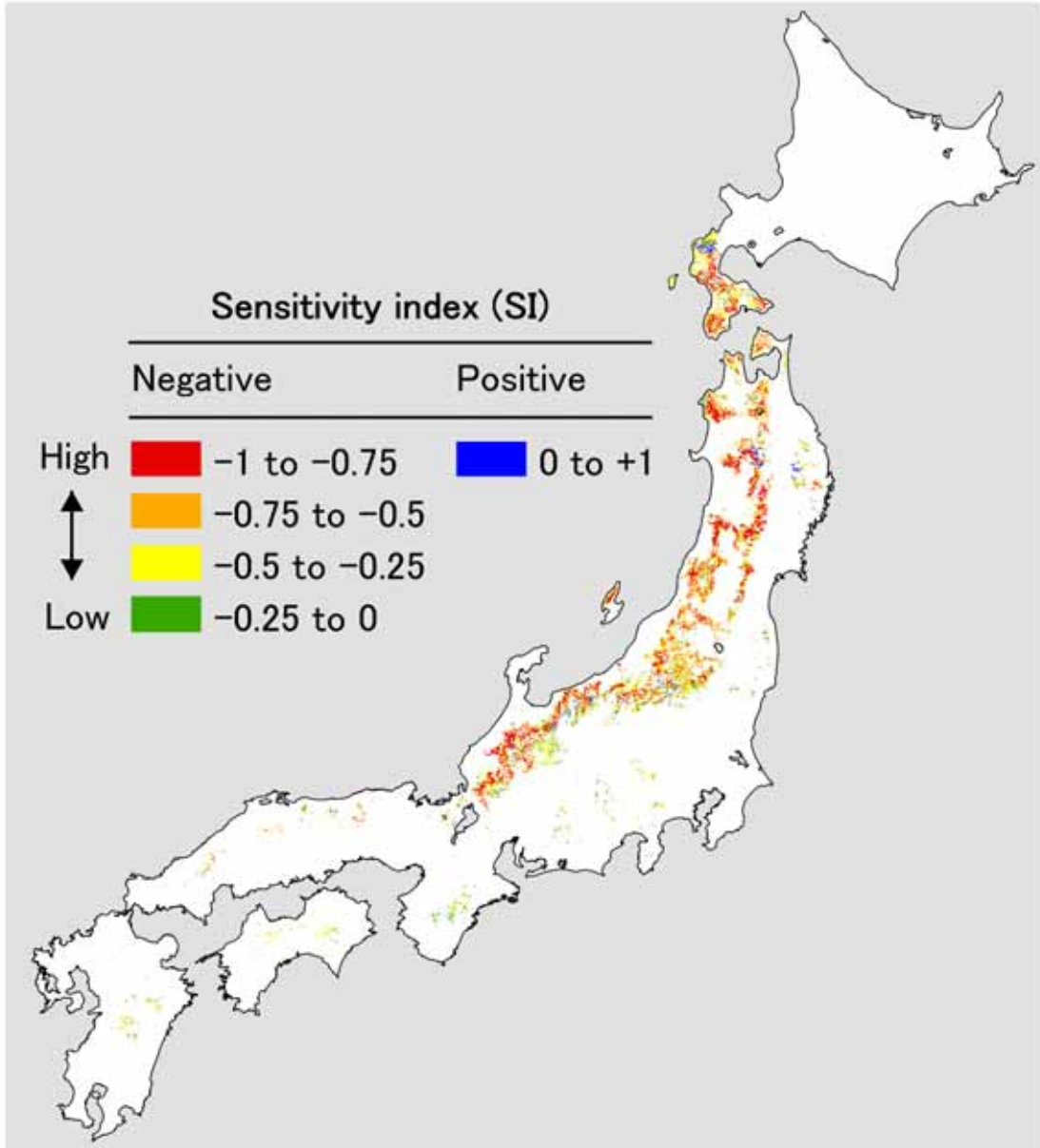
(A) Actual distribution and predicted probability distributions of buna (*Fagus crenata*) under (B) the current climate and (C) the CCSR/NIES climate change scenario in 2091-2100 (D) that under the RCM20 scenario in 2081-2100.

Distribution of sensitivity index (SI) of buna forests

SI = PS – PC

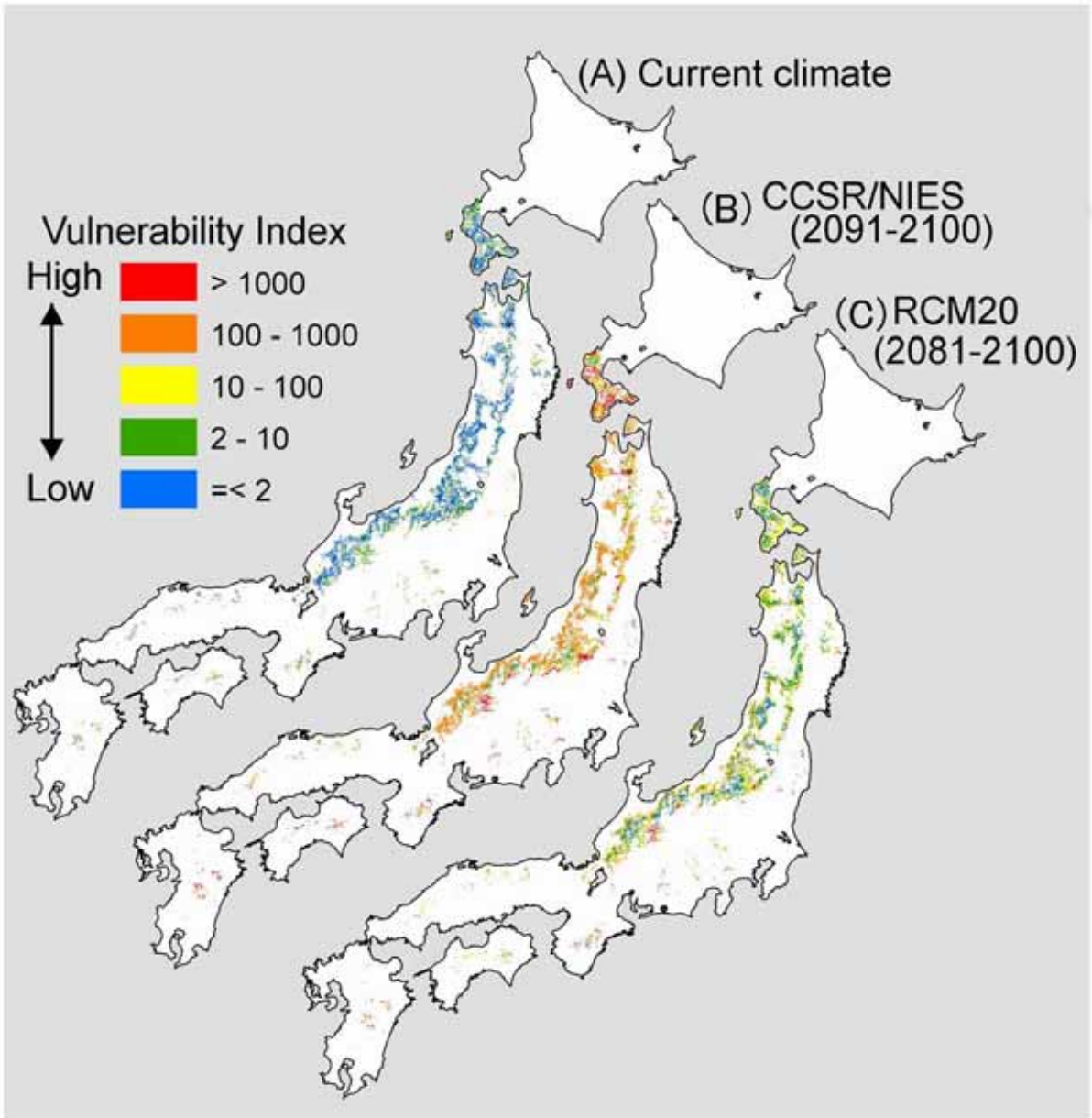
PS = probability of the CCSR/NIES scenario

PC = probability of the current climate



Vulnerability Index for buna forests (VI)

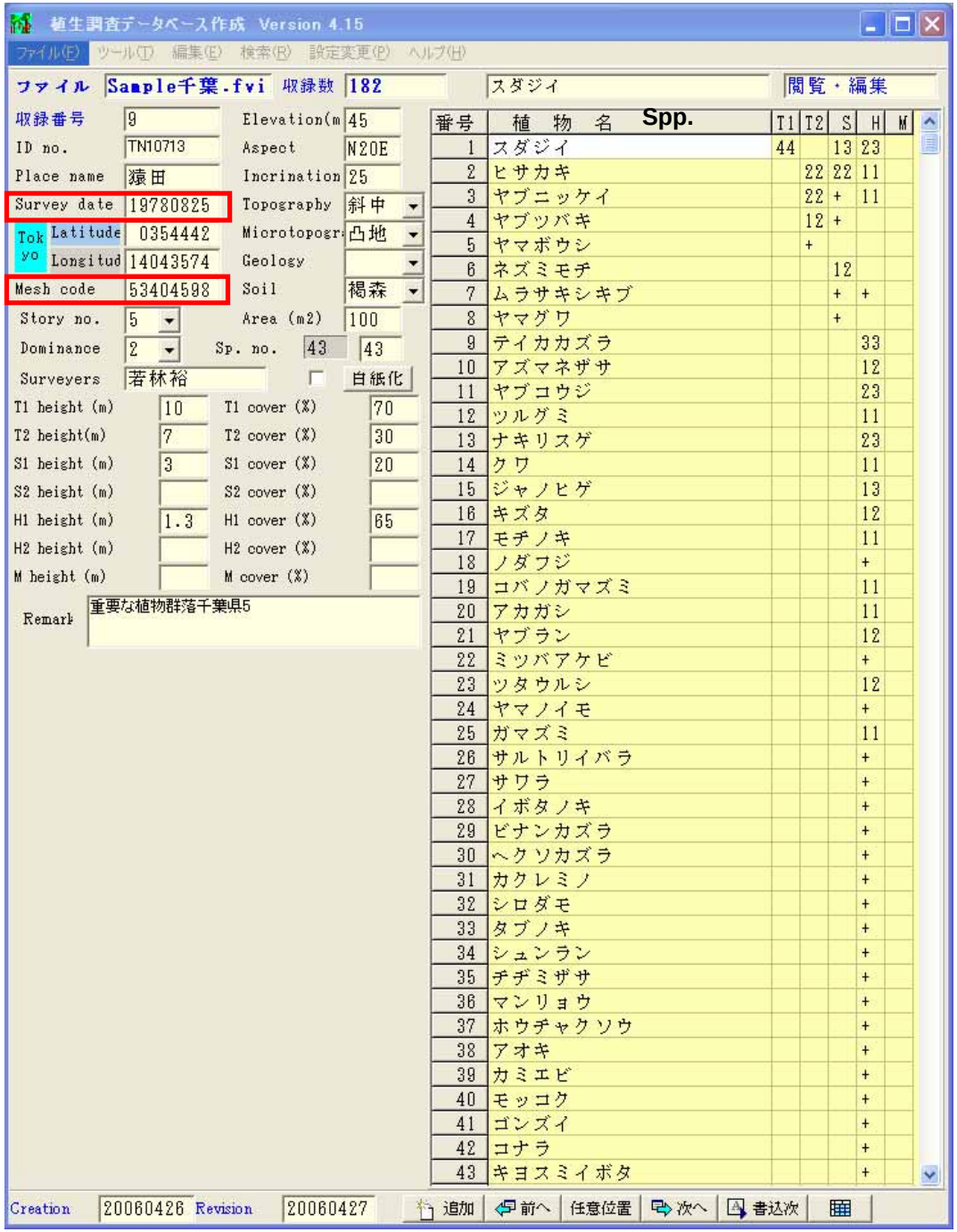
VI = 1 / Occurrence probability



The MVDB (NSNE 3rd mesh vegetation database) provides the distribution data on vegetation types, **but lacks the species distribution data.**

In order to predict habitats of a variety of species, it is necessary to construct databases on plant species distribution.

A relevé data sheet of **Phytosociological Relevé Database (PRDB)**



Survey date

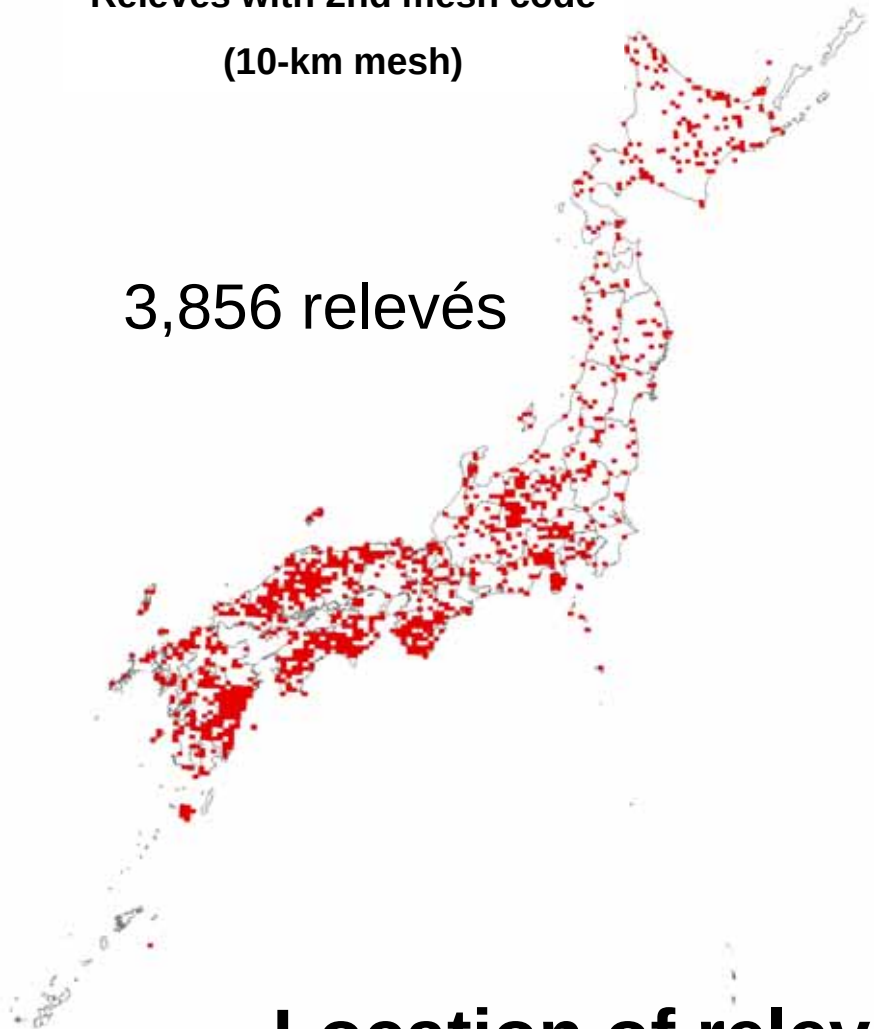
Mesh code

Key data for temporal and spatial analysis

Relevés with 2nd mesh code

(10-km mesh)

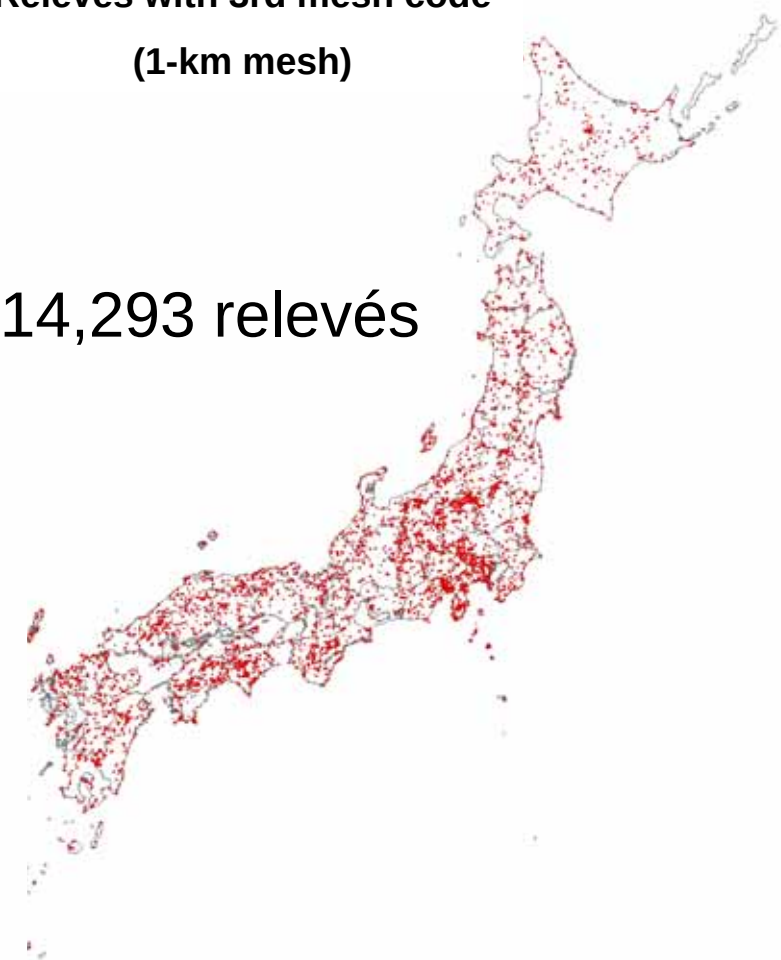
3,856 relevés



Relevés with 3rd mesh code

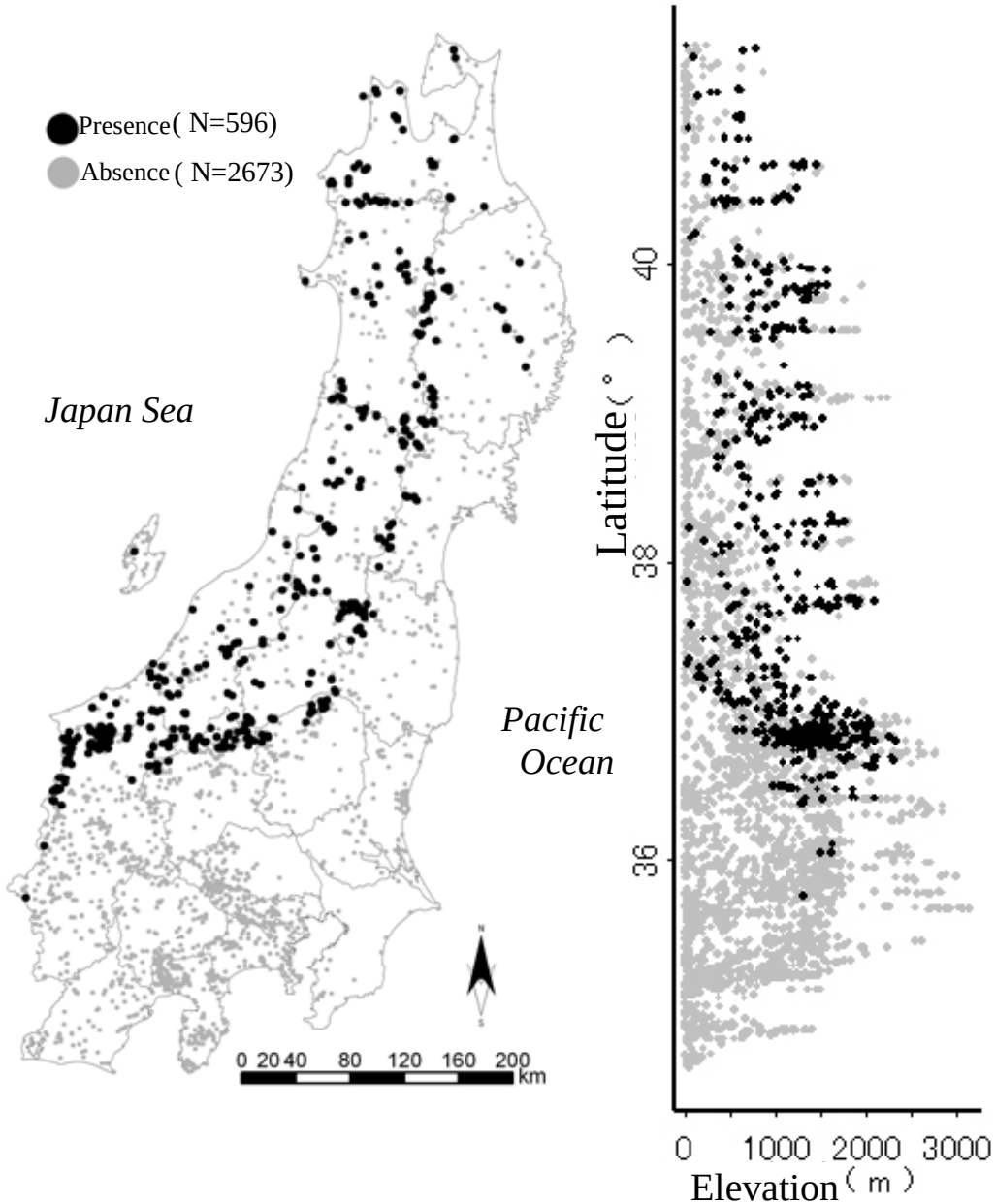
(1-km mesh)

14,293 relevés

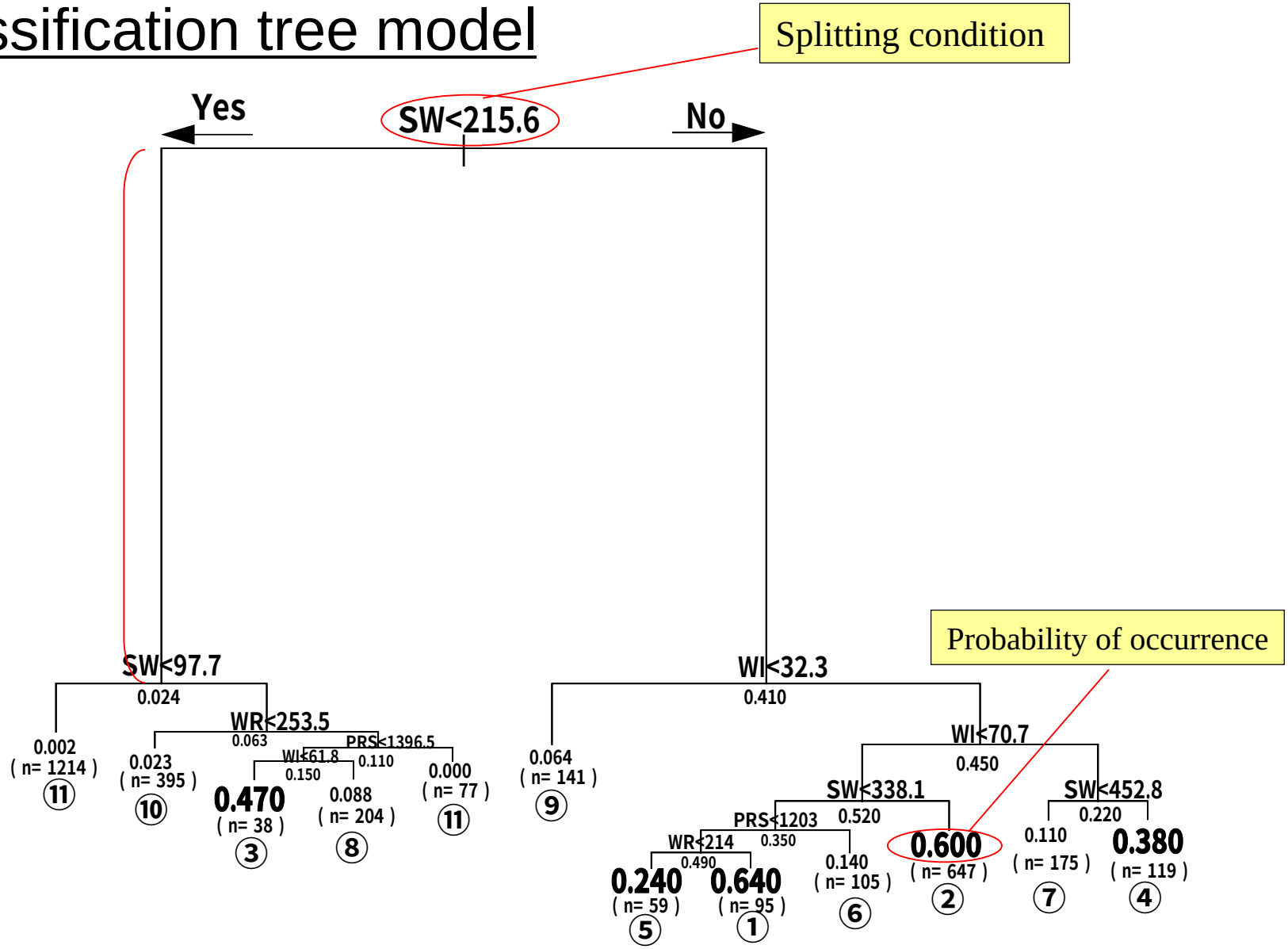


Location of relevés in the PRDB

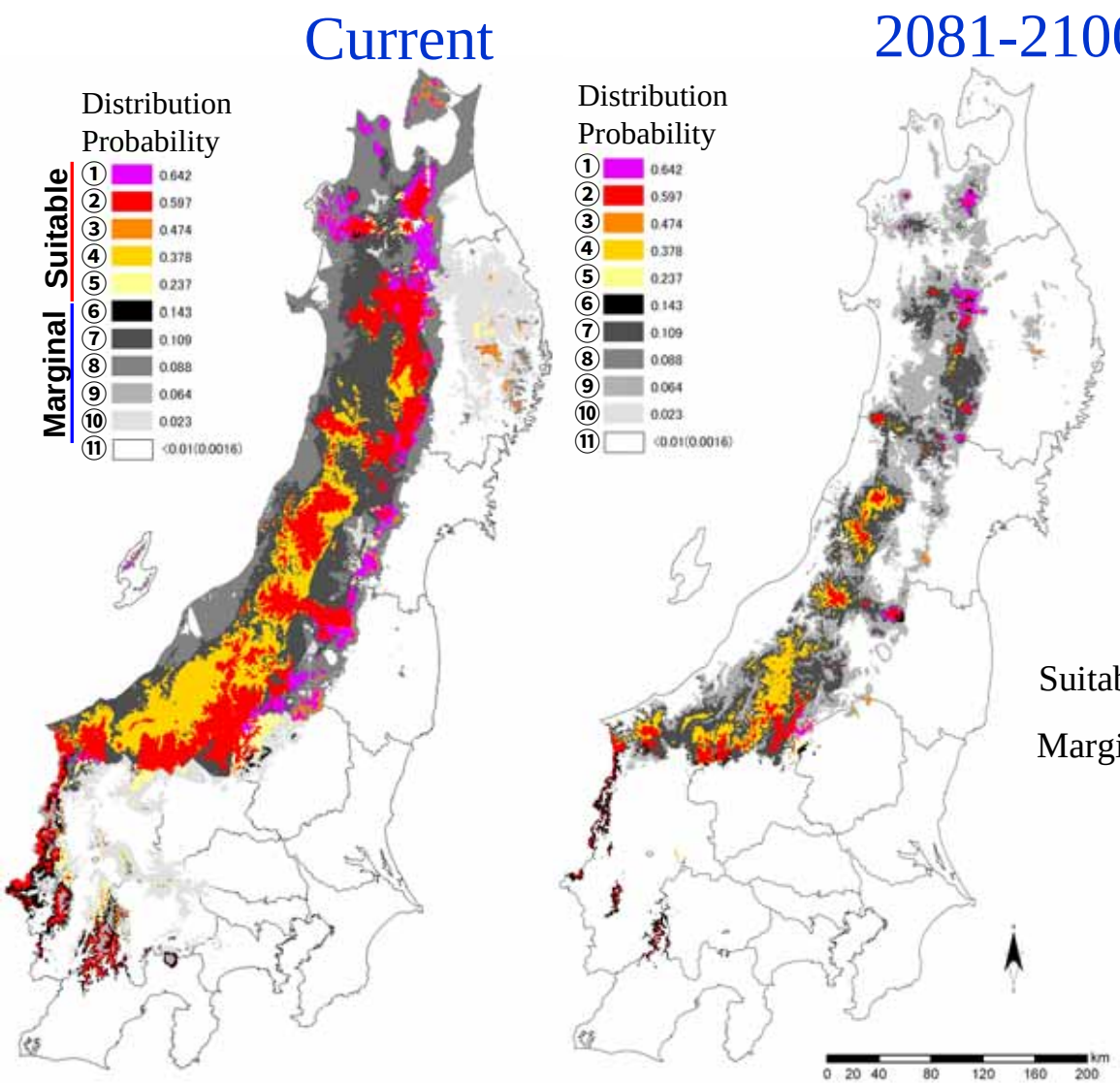
Sasa kurilensis Dominant undergrowth plant species in snowy areas



Classification tree model



Predicted probability distributions of *Sasa kurilensis* under the climate change scenario, RCM20 (2081-2100)



	Current		2081-2100	
Suitable habitat	26,067	→	5,657	(21.7%)
Marginal habitat	46,217	→	31,010	(66.3%)

Monitoring to detect effects of climate change

- Suitable places for monitoring:

  Vulnerable and/or sensitive areas

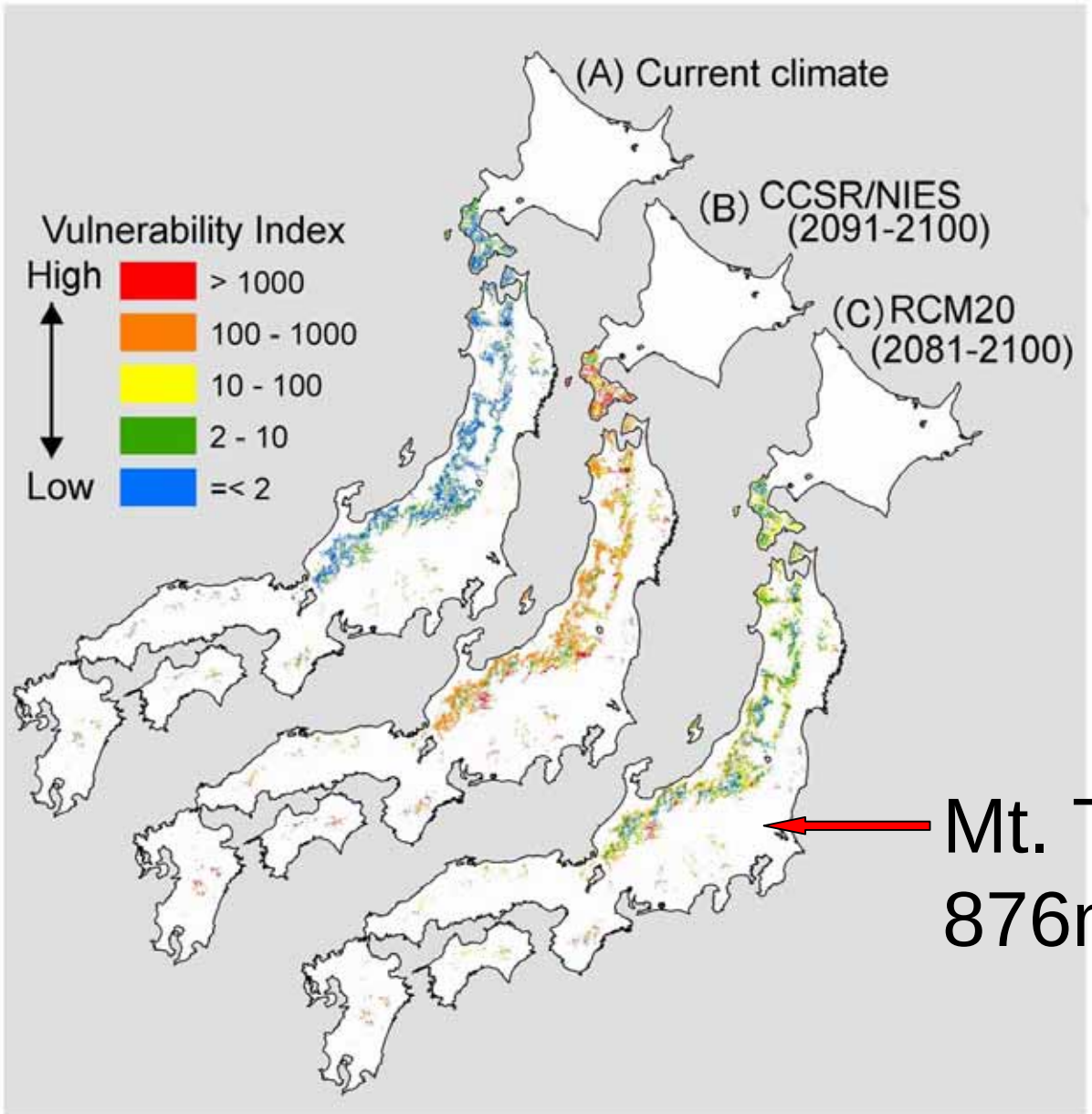
- Methods of monitoring:

  Permanent plots: less than 10 ha

  Remote sensing techniques: more than 10 ha

Vulnerability Index for buna forests (VI)

VI = 1 / Occurrence probability



A declining buna forest in Mt. Tsukuba, located in a marginal habitat with low precipitation in winter and high temperature.

Monitoring of buna trees by ortho air photos in Mt. Tsukuba

Ortho air photo

Date: April 30, 2004

Area: 820 ha

Spatial resolution: 12.5cm

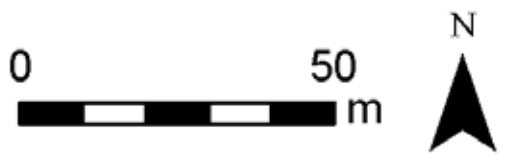
Mt. Tsukuba in autumn

Identifying buna canopies

Buna trees have new leaves on April 30, 2004

Identifying buna canopies

Buna: polygons of red lines
Estimated no. of buna trees: 1,915



Monitoring of a buna forest by 1-ha permanent plot

Census of all trees with DBH>5cm

Conclusion

- The tree model using the MVDB and four climatic variables could predict the distribution of buna forests.
- The area of suitable habitats for buna forests decreases into 9 % under the CCSR/NIES scenario (2091-2100) and 37 % under the RCM20 scenario (2081-2100). Buna forests in Pacific side of Honshu, Shikoku, Kyusyu will be most vulnerable.
- The MVDB lacks the information on plant species distribution. In order to predict habitats of a variety of species, it is necessary to construct databases on plant species distribution such as the PRDB.
- In order to Monitor effects of climate change on plant species, it is necessary to place monitoring sites in areas vulnerable and/or sensitive to climate change.

Thank you

This studies have been supported by the grants:

the Global Environmental Research of Japan (B-11 and S-4) program, the Ministry of the Environment

Influential variables of climate

Deviance weighted score (DWS) in the model shows

PRW>WI>TMC>PRS

Unsuitable habitats

Distribution of cells with low probability of occurrence (<0.01)

(D) Terminal node no. 31

Predicted score = 0.008
Number of squares = 5,492
PRW >= 493.5
WI < 85.15
TMC < −13.35

(E) Terminal node no. 32

Predicted score = 0.007
Number of squares = 1,377
PRW >= 493.5
WI < 85.15
TMC >= −13.35 and < −12.25
PRS < 758.5

(F) Terminal node no. 85

Predicted score = 0.004
Number of squares = 28,809
PRW >= 493.5
WI >= 95.15

Unsuitable habitats

Distribution of cells with low probability of occurrence (<0.01)

USDA United States Department of Agriculture

Forest Service

Northeastern Research Station

General Technical Report NE-265

Atlas of Current and Potential Future Distributions of Common Trees of the Eastern United States

Louis R. Iverson
Anantha M. Prasad
Betsy J. Hale
Elaine Kennedy Sutherland

Index of Scientific Names

Page number in **bold** is for map information; number in *italics* is for life history information.

Fagus grandifolia American Beech Fagaceae

Life History Section, Page 185

Current Status and Rank Among 80 Species

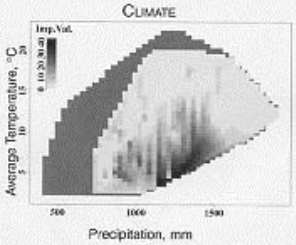
	Amount	Rank		Amount	Rank
Area (FIA), km² x 10⁶	1.64	16	Σ Area x IV x 10³	0.91	21
Area (Little), km² x 10⁶	1.92	29	IV, Average (FIA)	5.01	46

Potential Change from Climate Change

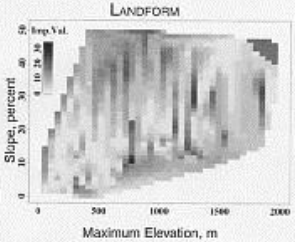
	GISS	GFDL
Weighted IV, %	-75	-88
Area, %	-83	-90
Optimal latitude, km	210S	280S

FIA distributions (1101 counties) quartiles:	Min	1st	Mean	Median	3rd	Max	Rank
Diameter, cm (8909 plots)	0.3	7.6	24.2	21.0	36.4	142.7	38
Growth Rate, cm²/yr (3728 plots)	0.2	13.2	25.1	20.7	32.5	231.8	20
Annual Temperature, °C	2.2	9.3	12.2	12.2	15.3	20.4	44
January Temperature, °C	-12.5	-4.1	0.1	0.0	4.4	12.5	38
Precipitation, mm	710	1020	1160	1160	1310	1930	33
Potential Evapotranspiration, mm/month	12.6	49.6	60.6	61.4	71.3	104.0	58
Maximum Elevation, m	5	188	432	320	548	2000	38
Slope, percent	0.0	4.8	12.2	9.7	16.1	51.0	20
pH	2.1	3.9	4.6	4.5	5.0	7.4	63
Permeability, cm/hr	0.3	1.2	2.5	1.7	2.8	14.2	30
Organic Matter, percent	0.8	1.6	3.3	2.2	3.5	34.5	37
Clay, percent	2.5	16.6	21.4	22.0	27.0	46.7	60
Water-Holding Capacity, cm/152 cm	3.1	6.0	7.1	6.9	8.3	11.5	53

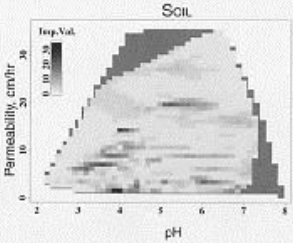
Climate



Landform

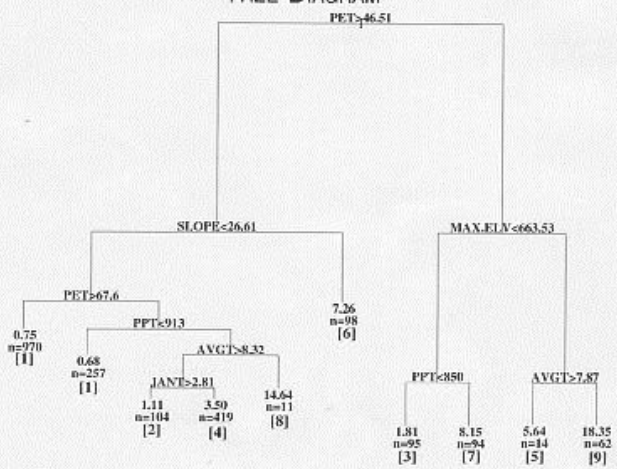


Soil

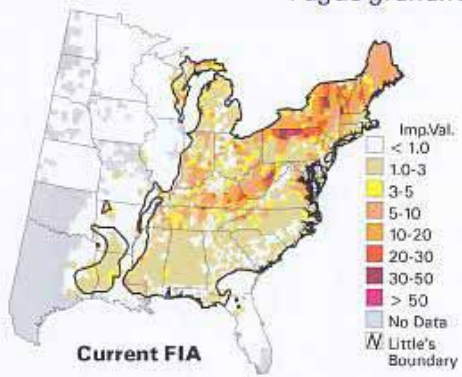


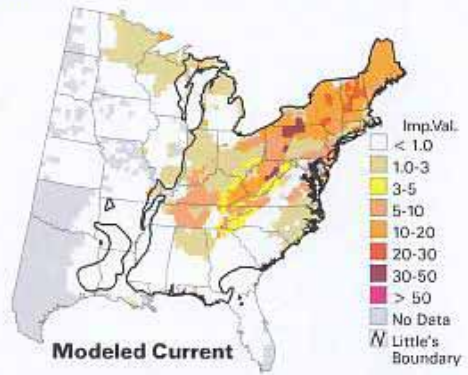
Tree Diagram

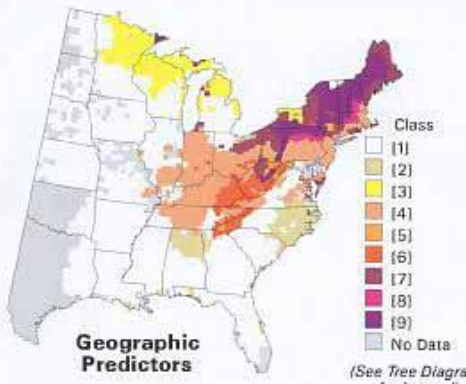
$R^2 = 0.75$

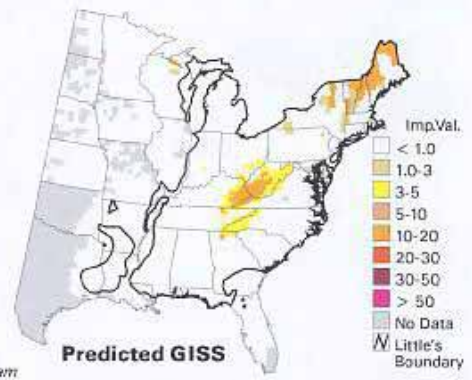


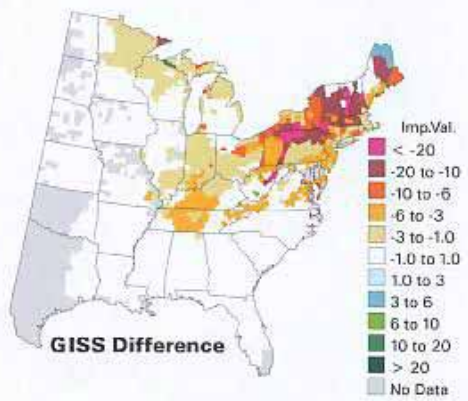
Fagus grandifolia











Phytosociological Relevé Database (PRDB) operated by FVD