2026年1月22日

Forests as regulators of water and carbon:
Can management enhance these ecosystem functions?

2026 NTNU × Glasgow × Kyushu Winter Institute

Kyushu University Forest, Professor, Tomonori Kume

Who am I?

Kyushu University Forest

Former faculty member at National Taiwan University

A forest you decided not to use

Is “not using” always the best strategy?
不使用　一定是最好的策略嗎？

There is no single correct answer in forest management

Japan: when forests started to be underused

Decline of forest use

Decline of hunting

Underuse can lead to silent degradation

Silent degradation under forest underuse

Loss of understory vegetation

The forest looks green, but it is losing its function

森林看起來綠色的，但正在逐漸失去功能。

Deer are not the cause, but the consequence
鹿不是原因，而是結果。

Loss of forest ecosystem services

How can we detect and correct this silent decline?

Today’s contents

- Part 1: Why forests matter — social and management perspectives
- Part 2: Forests and water — myth vs. science
- Part 3: Forests and carbon — how to evaluate carbon balance
- Part 4: Evidence-based forest management for sustainability

Forest as regulator of water

HOW WE MANAGE FORESTS? : MYTH VS. SCIENCE

Kyushu University Forest
Professor Tomonori Kume

QUESTION

If your income increases, are you richer?

Income ↑
Expenses ↑ ↑

FOREST & WATER BALANCE

Income→ **Precipitation**

Expenses→ **Evapotranspiration**

FOREST & WATER BALANCE

Translation

Income – Expense = Saving

Precipitation – Evapotranspiration = ?

FOREST & WATER BALANCE

In hydrology,

Precipitation – Evapotranspiration = Runoff

Runoff → Water resources

MYTH OF FOREST

Many people believe that **forests** offer a more favorable environment than other land uses.

1. Forests increase water resources
2. Cutting trees cause water resource problem
3. Evapotranspiration is “loss”

What is supported by evidence, and what is a myth?

TOPIC TODAY

Water balance

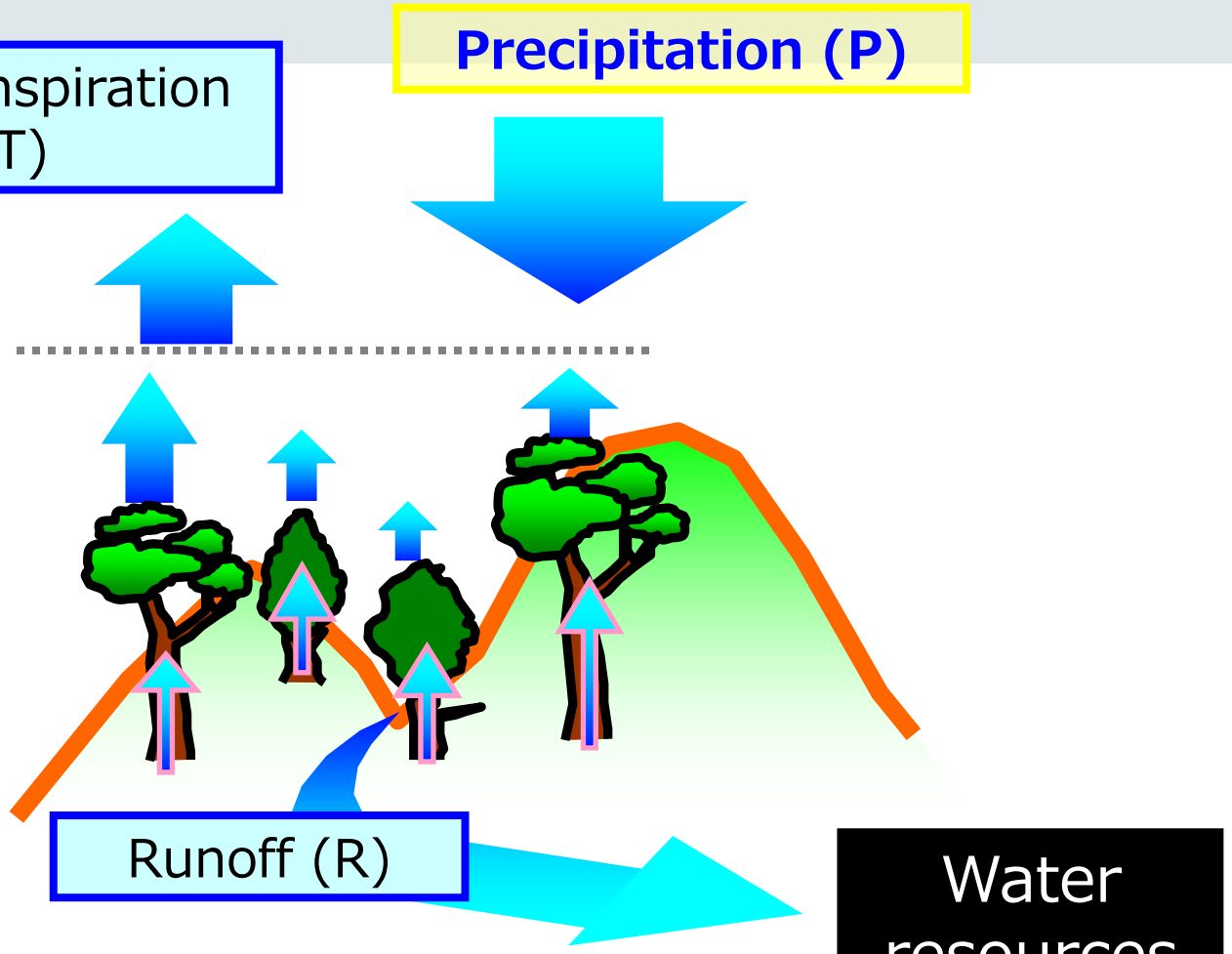
Forest and water resources

WATER BALANCE

Water balance

$$P = ET + R \pm \Delta S$$

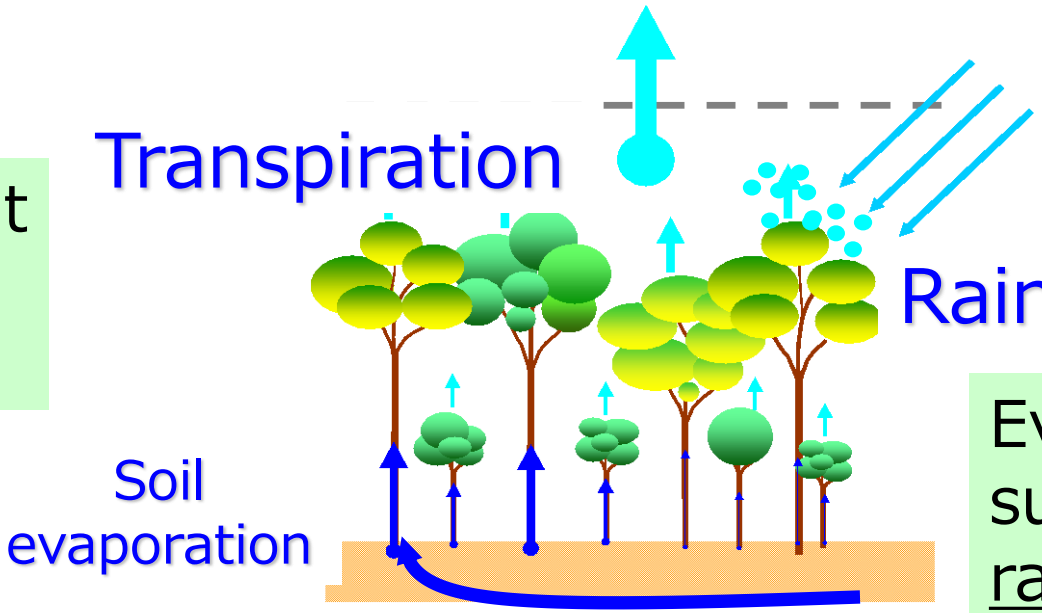
Changes in soil water (ΔS)≒0
under stable conditions



EVAPOTRANSPIRATION (ET) ?

This（Evapotranspiration:ET)

Water movement through soil (Dry-canopy)



Evaporation from free water surface during and after rainfall (Wet-canopy)

HOW DO WE MEASURE ?

Weighing lysimeters

Sap flow measurements

Eddy covariance techniques

Catchment water balance

Spatial scale

QUESTION

How large is an daily water use of an individual tree?

1. <100 L/day
2. 100–500 L/day
3. >1000 L/day

34 Litter

500 Litter

1000 Litter

QUESTION

How large is an daily water use of an individual tree?

1. <100 liter

2. 100-500 liter

3. >1000 liter

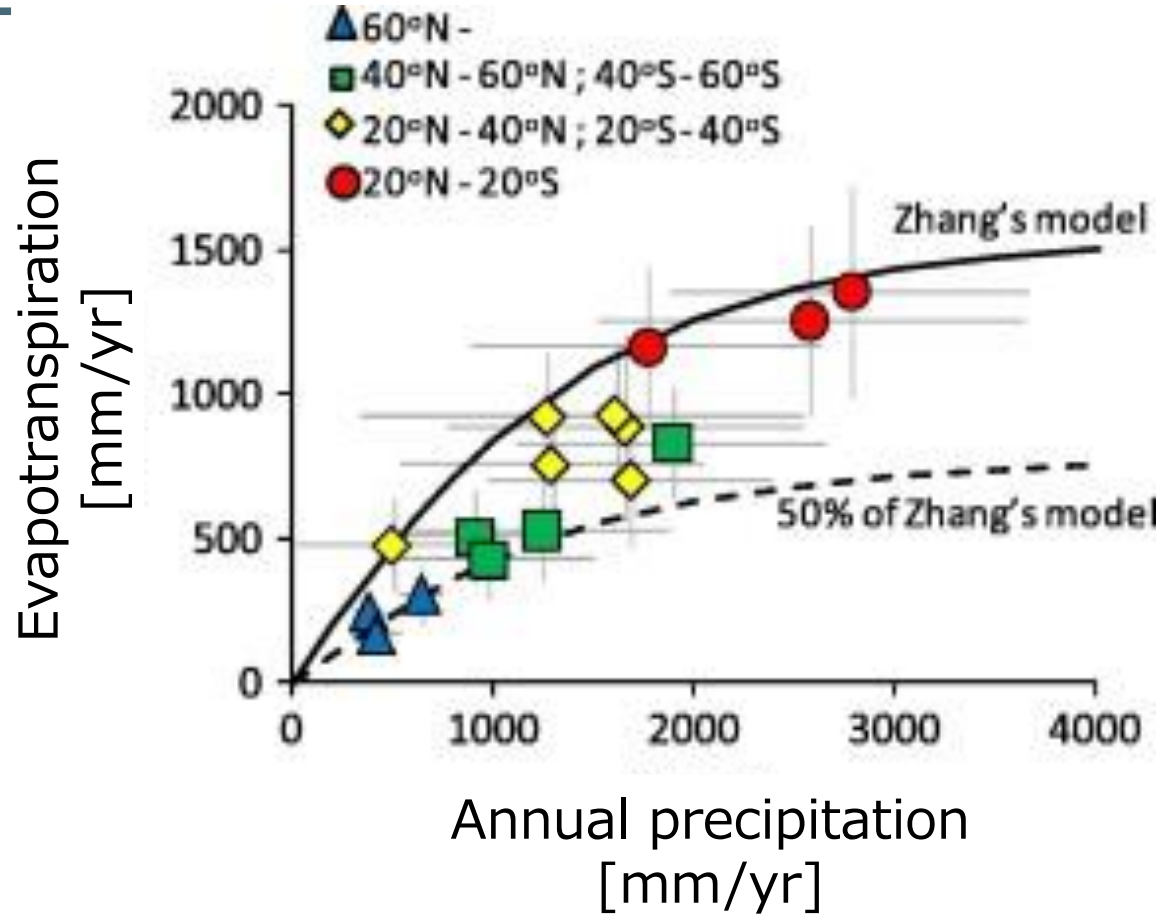
FOREST EVAPOTRANSPIRATION AT THE GLOBAL SCALE

Komatsu et al. 2010

Boreal ＜500 mm/yr

Temperate・Cool temperate
500-1000 mm/yr

Tropical ＞ 1000 mm/yr

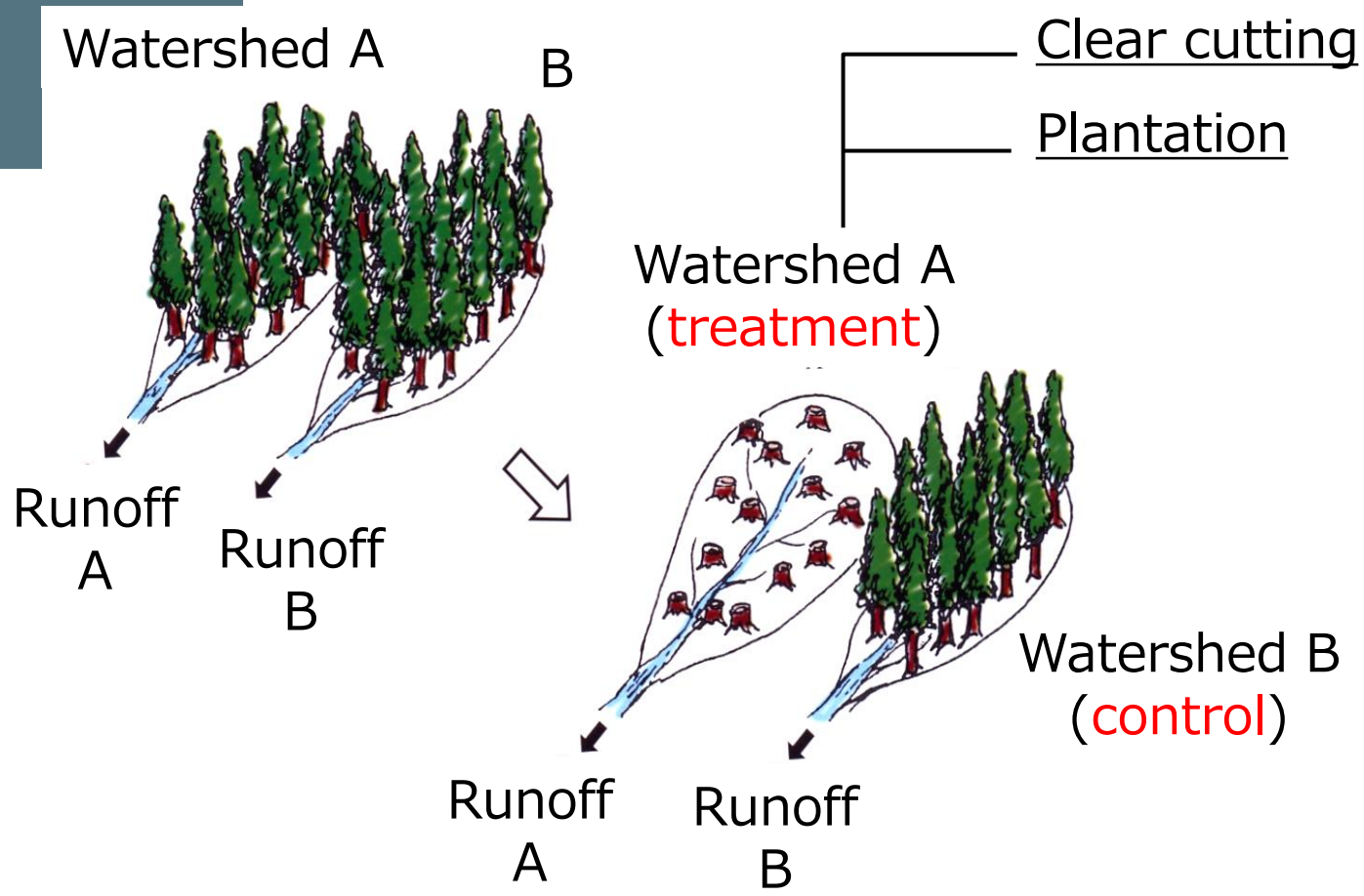


QUESTION

When we conduct clear-cut in a forested catchment, runoff will increase or decrease?

1. Increase
2. Decrease
3. Case by case

PARED WATERSHED TREATMENT

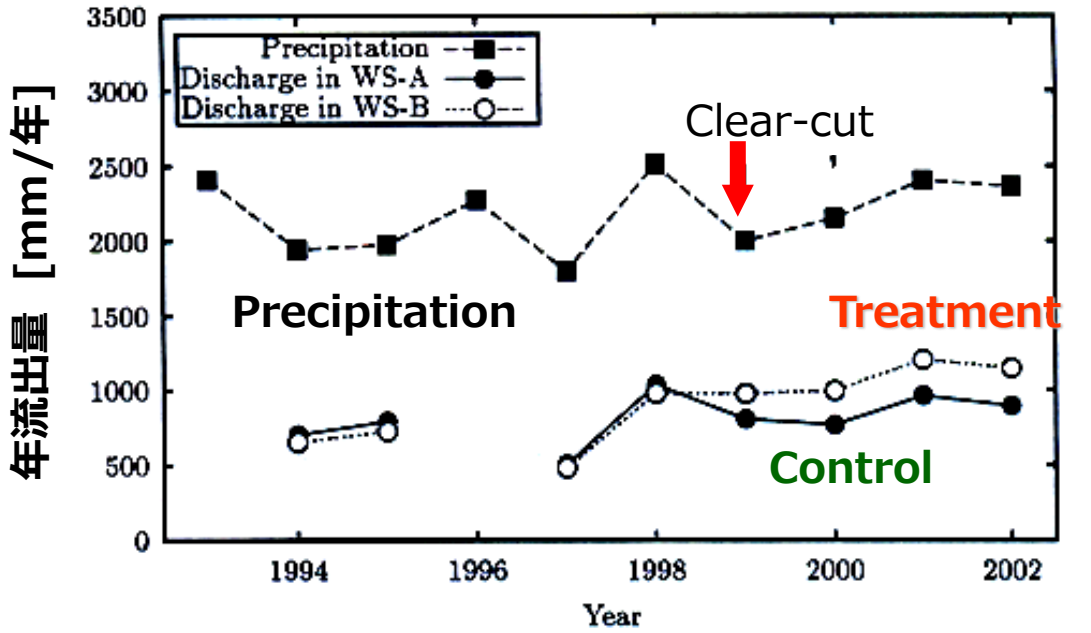


We can examine impacts of treatments on water balance by the difference runoff A and B.

RESULTS

A case in Tokyo University Forest, Chiba.

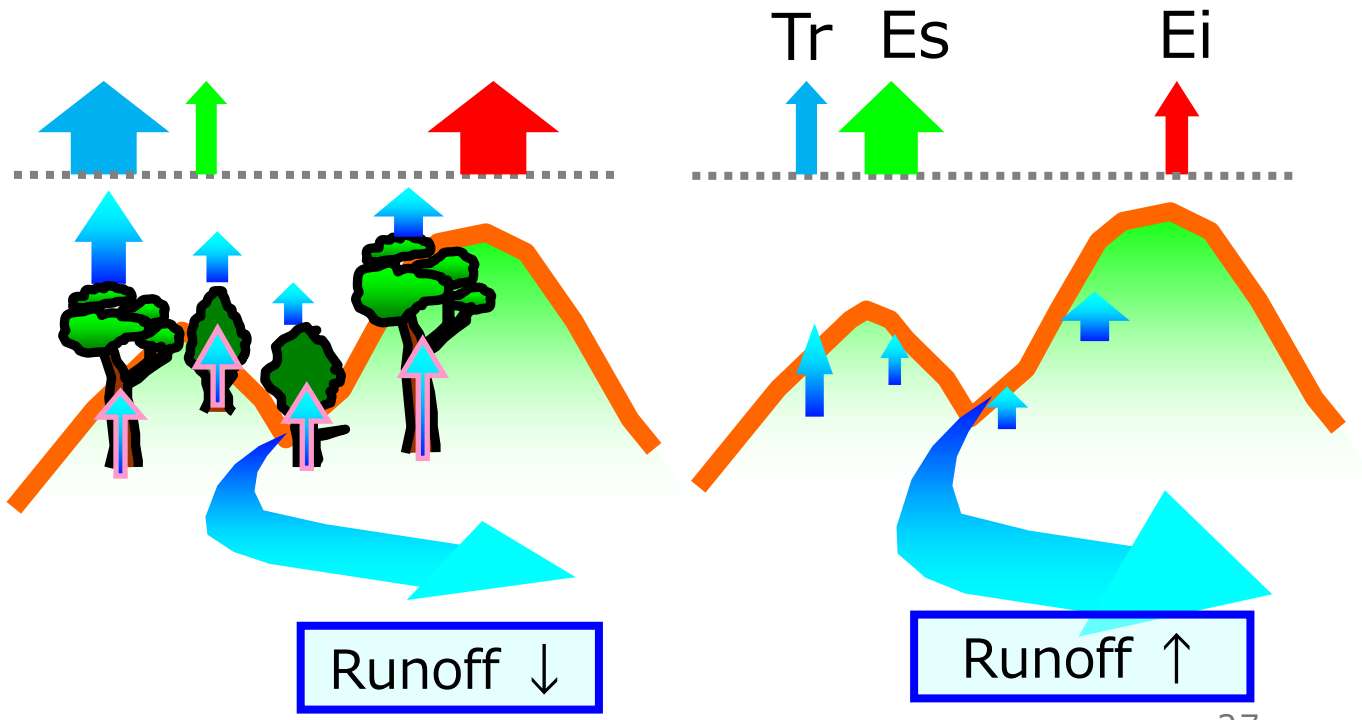
真板 (2005)



Runoff increased after cutting.
It can happen globally.

WHAT HAPPEN AFTER CLEAR CUTTING ?

Water balance components before and after clear cutting



Decreases in ET

- Transpiration (Tr) ↓
- Soil evaporation (Es) ↑
- Interception (Ei) ↓

AT CONTINENTAL SCALE

If we could cut all trees in Amazonian basin ?

Forested area

Deforested area

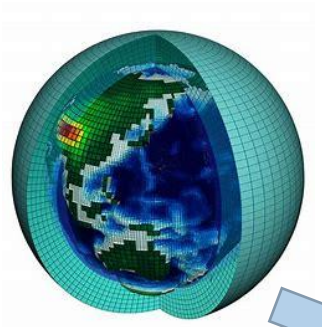
QUESTION

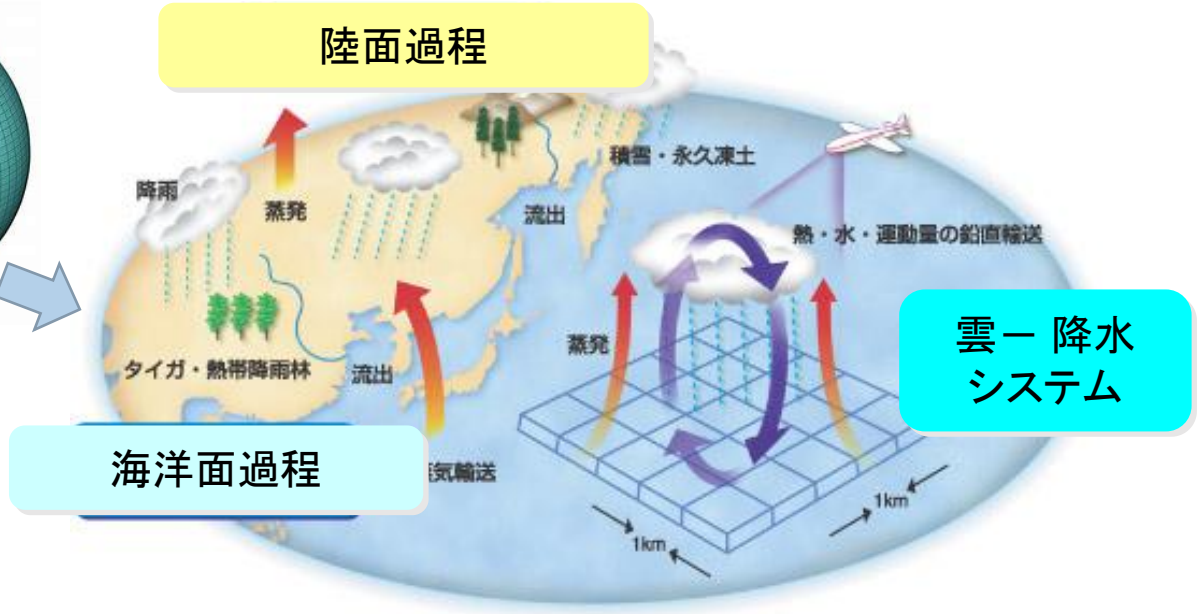
If we could cut all trees at the continental scale, runoff would increase or decrease?

1. Increase
2. Decrease
3. Unclear

GLOBAL CIRCULATION MODEL

MODEL SIMULATION



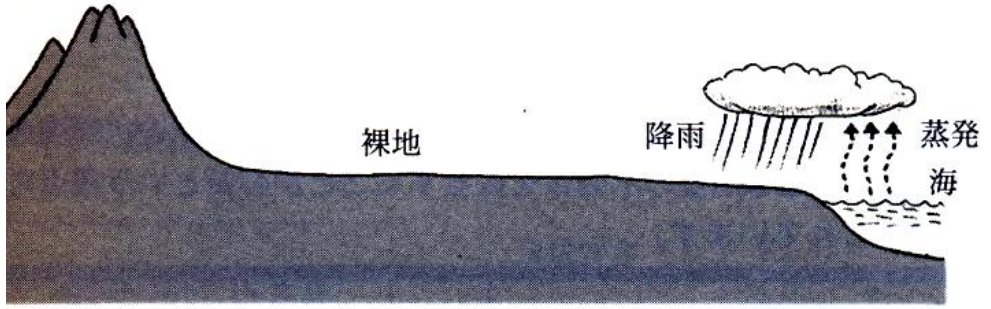


Precipitation could decrease, thus, runoff also could decrease.

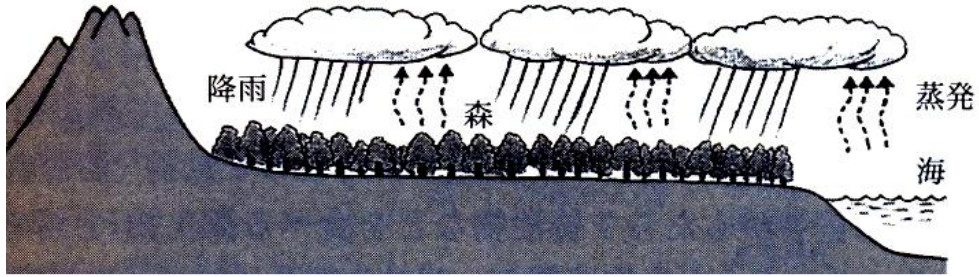
FEED BACK TO ATMOSPHERE

Less active cloud formation

Degraded



Vegetation



Active cloud formation

Forest can impact on climate system at the large scale.
→ One of the keys for predicting climate changes.

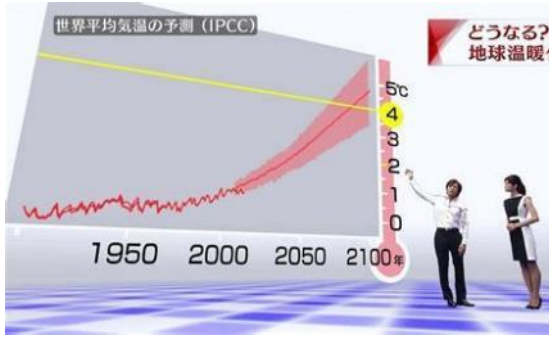
Lean & Walilow 1995、Kanae et al. 2000

CURRENT ISSUES : LOCAL TO GLOBAL

CLEAR-CUTTING

UN-MANAGEMENT

INVASIVE SPECIES



CLIMATE CHANGE

Still, we need scientific evidence.

WHAT DID WE LEARN TODAY?

1. Water responses depend on scale & context
2. Common sense ≠ Truth
3. Forest management is not black-or-white

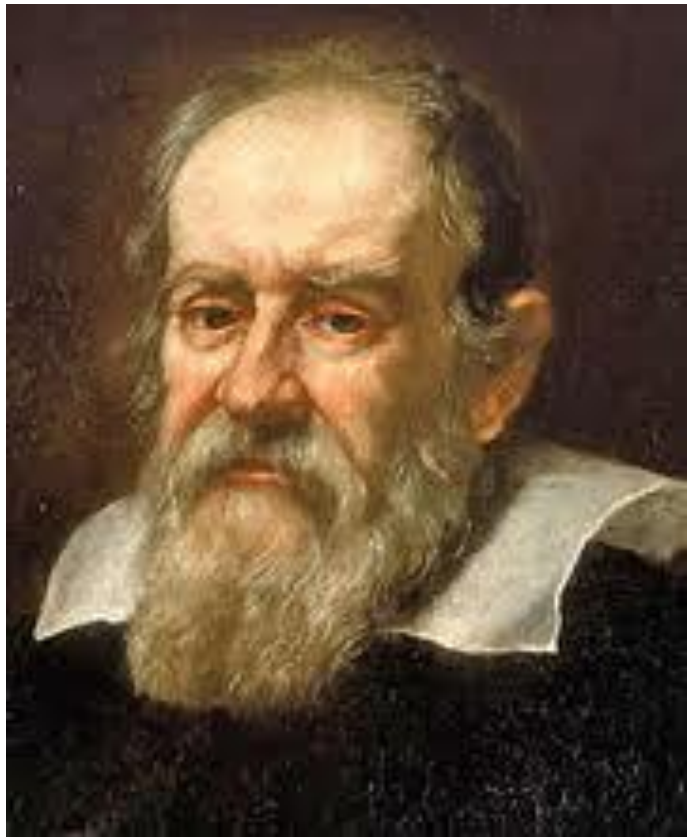
2025年12月12日

Forest as regulator of carbon

Building a Society for Sustainable Coexistence

Kyushu University Forest, Professor, Tomonori Kume

Common sense ≠ Truth



Italian physicist, mathematician, astronomer, and philosopher (16th century).

Heliocentrism (地動説)

Galileo Galilei (1564－1642AD)

A great figure who challenged myths based on scientific evidence.

Myth of forests

Many people believe that **forests** offer a more favorable environment than other land uses (農地、草地、都市等)

1. Water resources: Mitigate drought/flood risk
2. Water quality: Improve water quality
3. Carbon sink: Reduce atmospheric CO_2 levels

etc.

What is true, and what is a myth?

Calder 2005 in *Blue Revolution*

Question: Which can have largest CO2 emission?

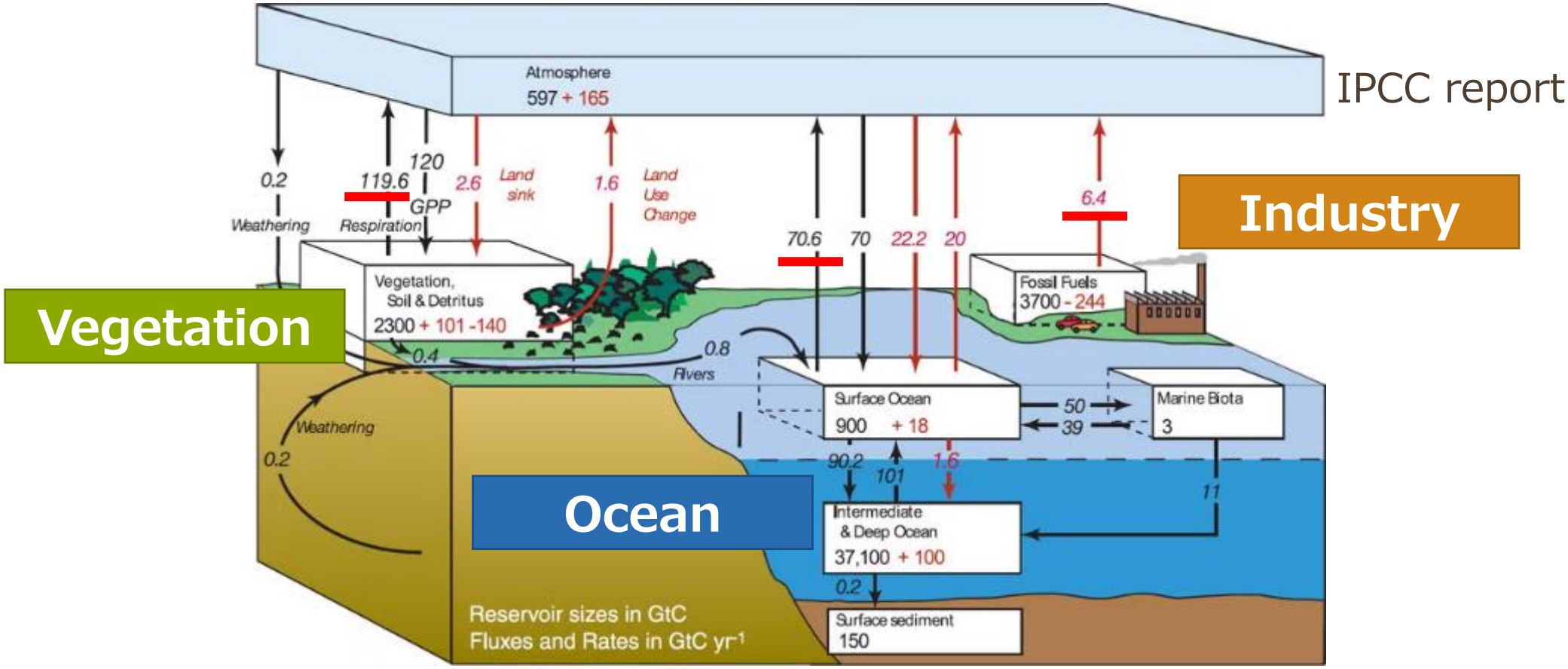
1 . Vegetation

2. Ocean

3 . Industry

Click “clicker”!

Global C cycling

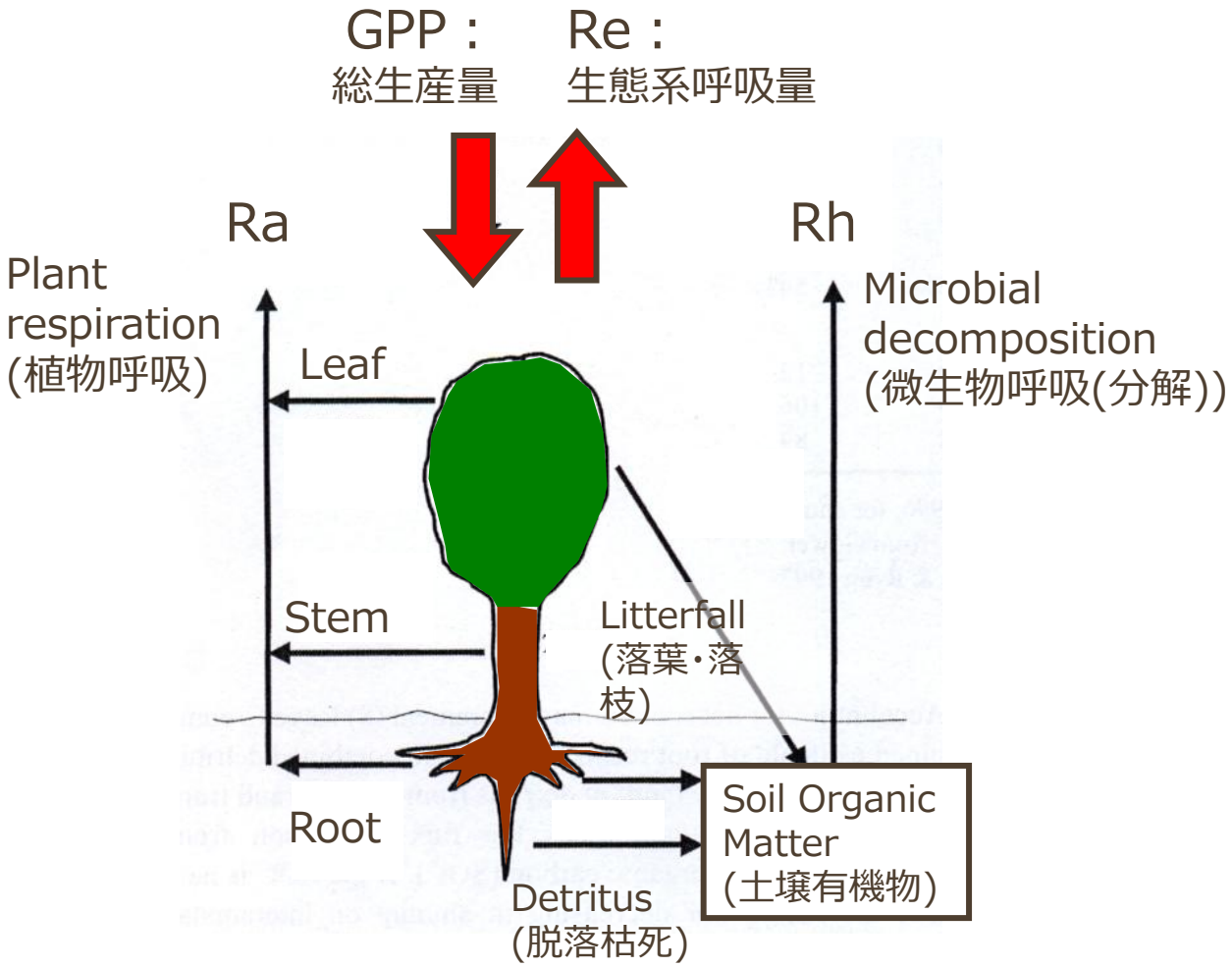


Vegetation has the largest C emission! But…

Forest C balance

Measurements

Forest C cycling: Not for memorization



NPP ：Net Primary Production (純生産量)

= GPP－Ra

NEP：Net Ecosystem Production (純生態系生産量)

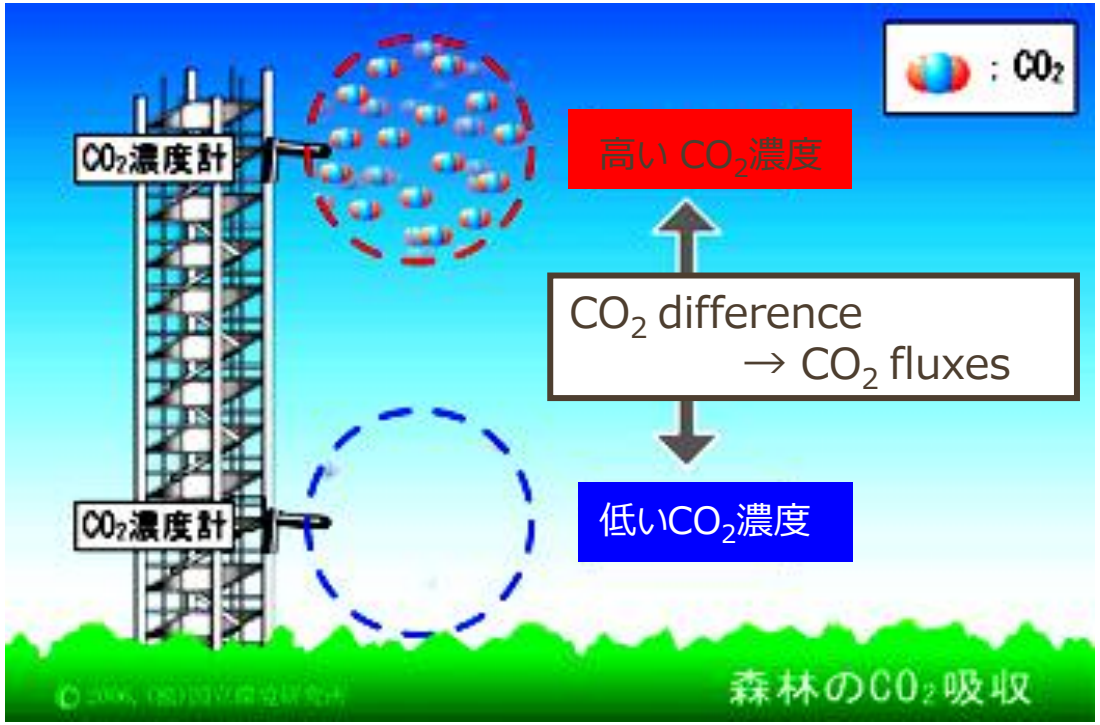
= NPP－Rh

= GPP－Ra－Rh

NEP＞0 → C Sink (C 吸収)

NEP＜0 → C Source (C 放出)

The top-down approach (微気象学的方法)



Direct measurement for GPP、Re、NEP

乱流変動法のプローブ

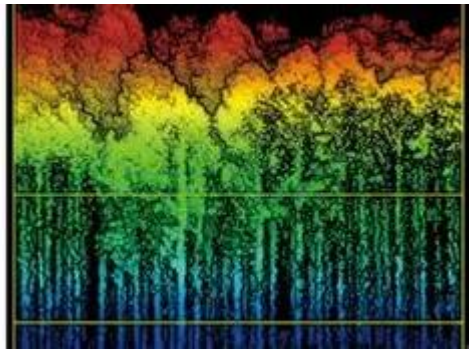
The bottom-up approach

NEP = GPP- Ra -Rh = NPP – Rh

NPP = ΔB + L (枯死量) +H (被食量)

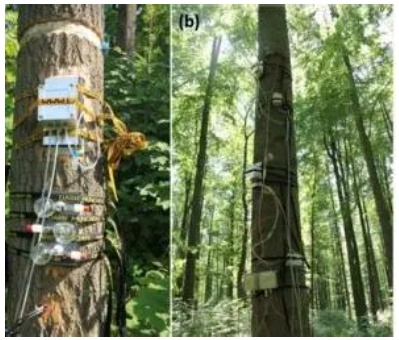
Inventory measurements :

Biomass increases



Chamber methods

Ecosystem respiration



Flux network project world-wide:

Long-term observational studies have been conducted across various ecosystems, leading to the establishment of a global flux observation network (FLUXNET).

Tropical rain forest in Borneo

93-m のクレーン

植物 – 動物 – 環境の相互作用 に関する研究

Long-term monitoring has been conducted for water & C cycling (>15yr).

Forest C balance

Characteristics of the data

Question: Which forests have higher carbon sequestration capacity?

① Boreal forest

② Temperate forest

③ Tropical rain forest

Question: Which forests have higher carbon sequestration capacity?

① Boreal forest

② Temperate forest

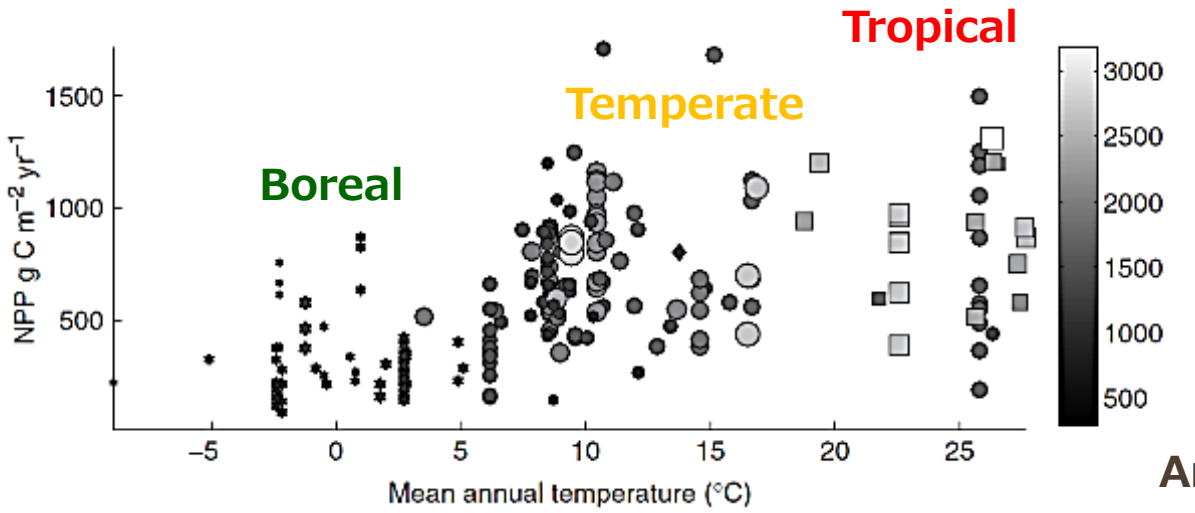
③ Tropical rain forest

Boreal forests « Temperate forests « tropical rainforests

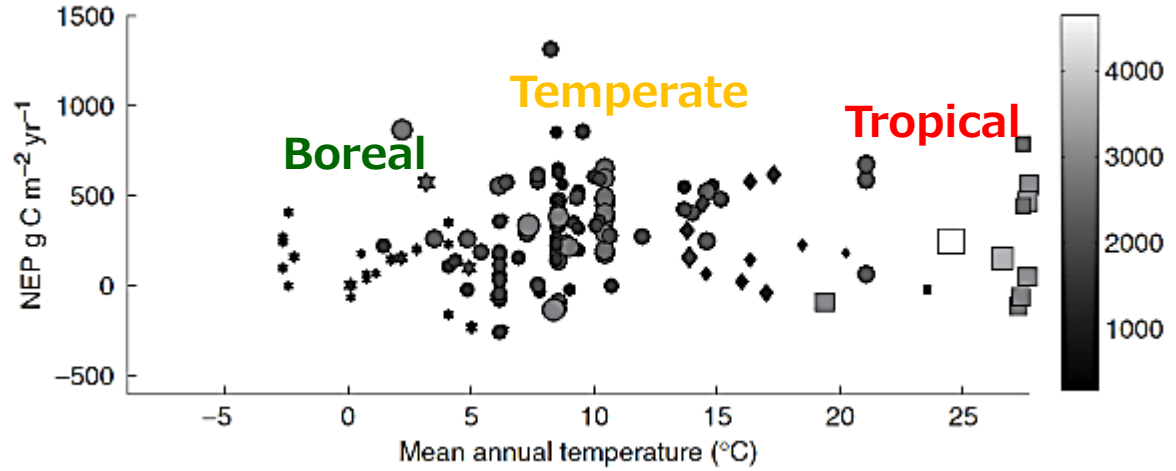
— is this really true?

Forest NPP and NEP in response to cliamte

Productivity (NPP) increase with temperature.

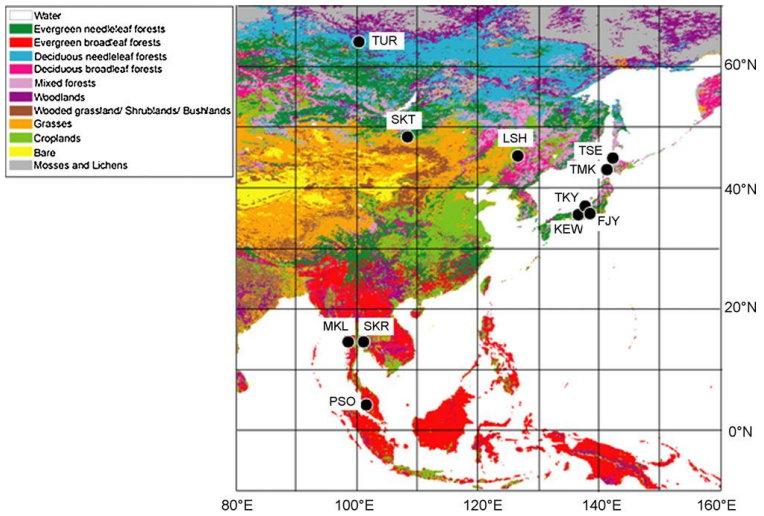


Net ecosystem C balance (NEP) also increase with temperature?

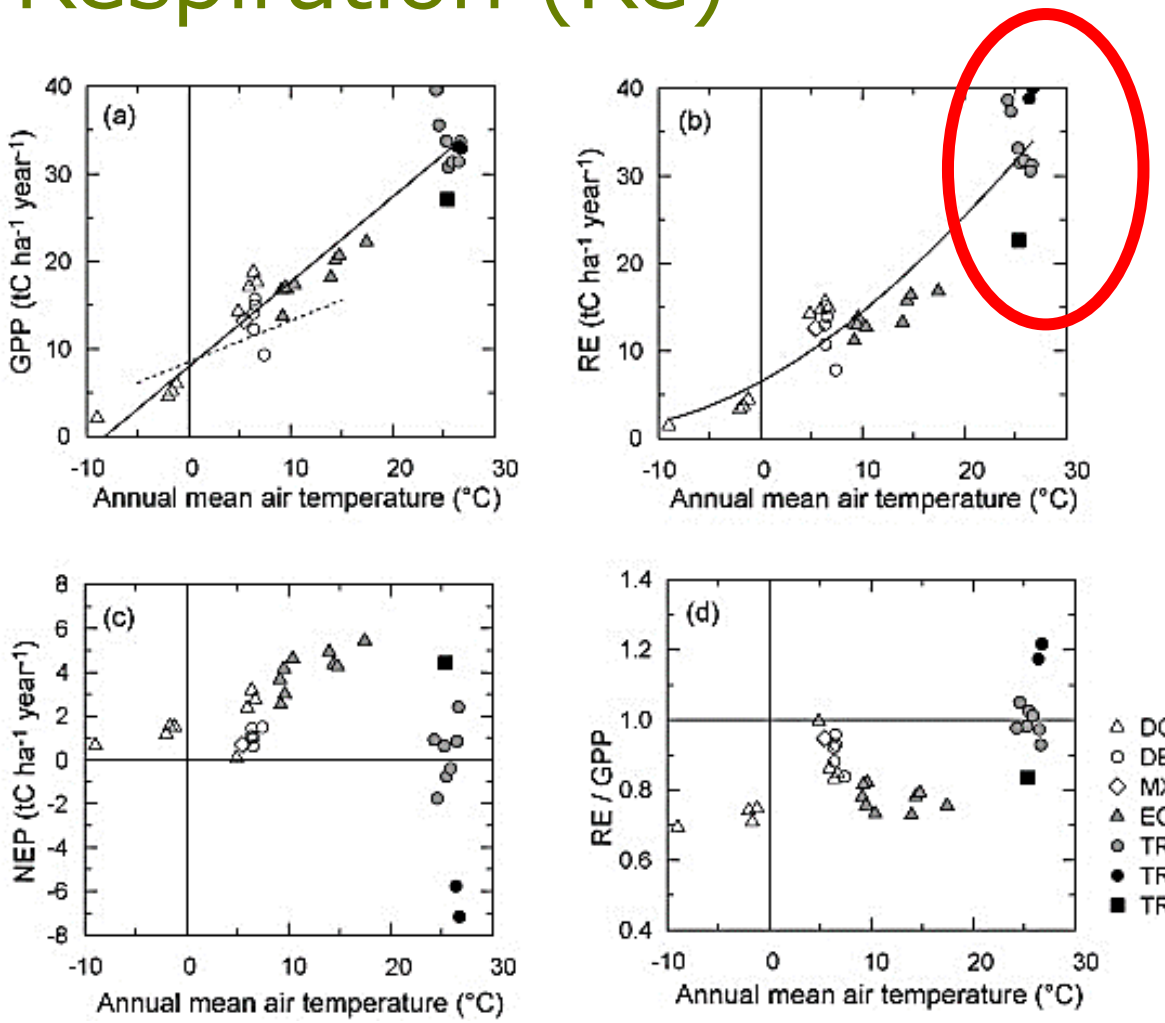


Luyssaert et al. 2007

C assimilation (GPP) and Respiration (Re)



Saigusa et al., 2008



Hirata et al., 2008

Large ecosystem respiration in **tropical forests**.

-> Not always C sink!

Question: Which forests have higher carbon sequestration capacity?

Young forest

スギ林 (約40年 宮城県)

Old growth forest

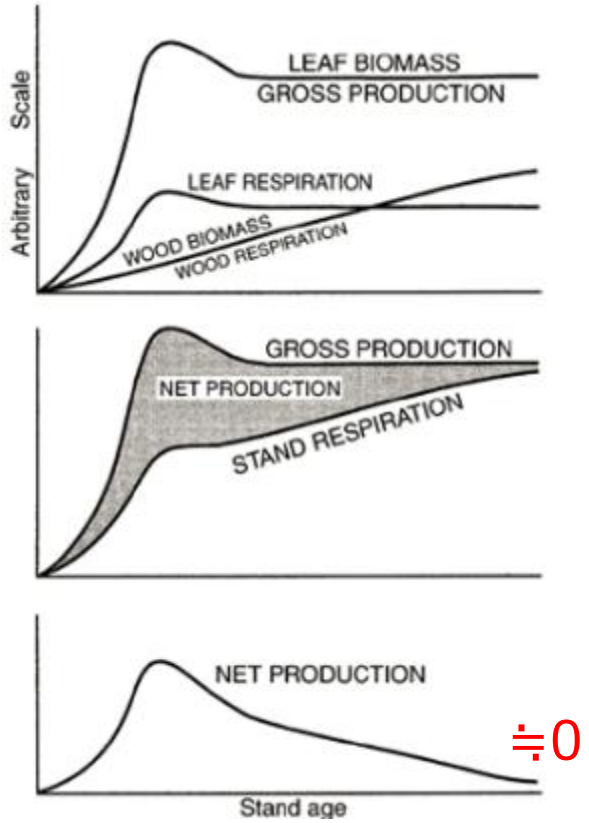
スギ林 (110年 東大千葉演習林)

Yong >> Old growth

— is this really true?

Traditional idea and new evidence

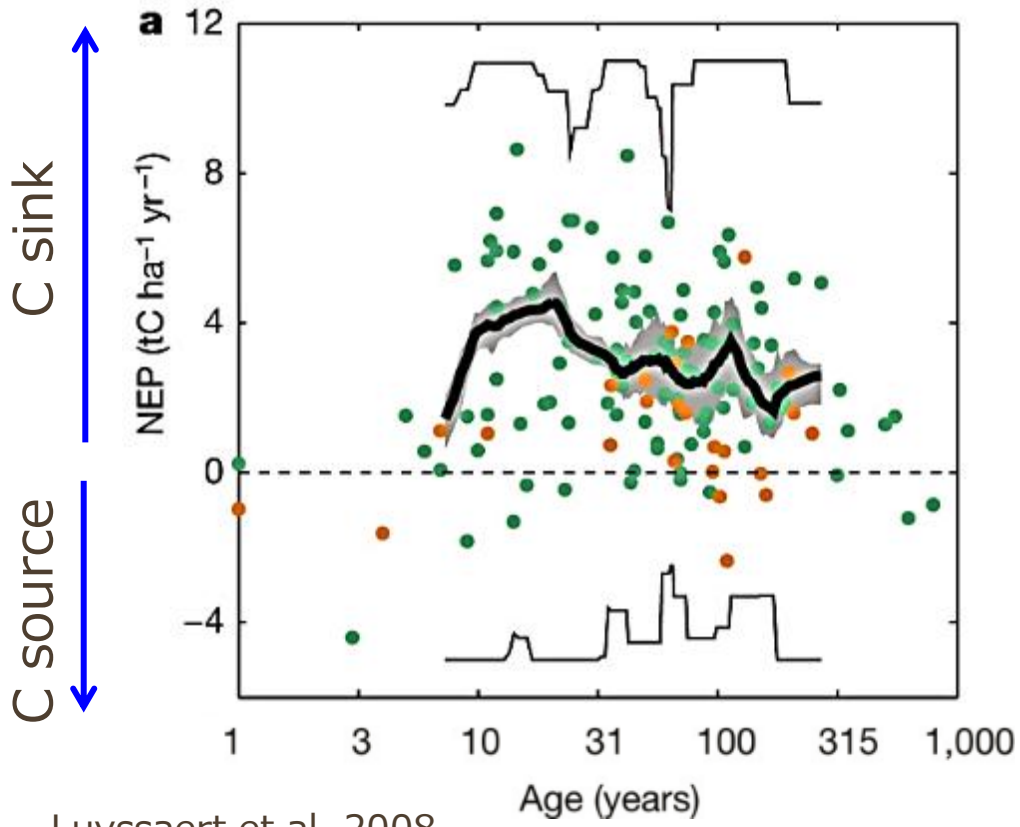
Traditional



From Kira & Shidei et al. 1967

Newer idea

Old growth (>100yr) still strong C sink!



Luyssaert et al. 2008

A recent issues in Japan

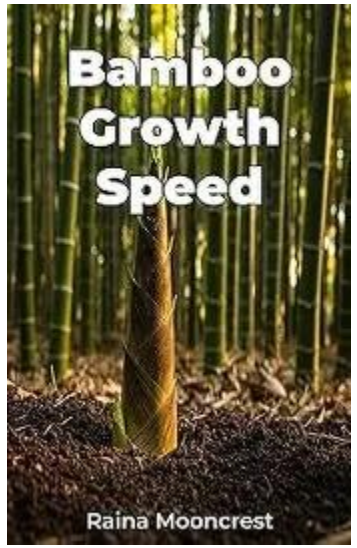
Expansion of Moso bamboo forests

Moso bamboo: native to southern China; introduced for food and materials

Lifestyle changes since 1980s → **land abandonment**

Expansion of bamboo forests → ecological impacts?

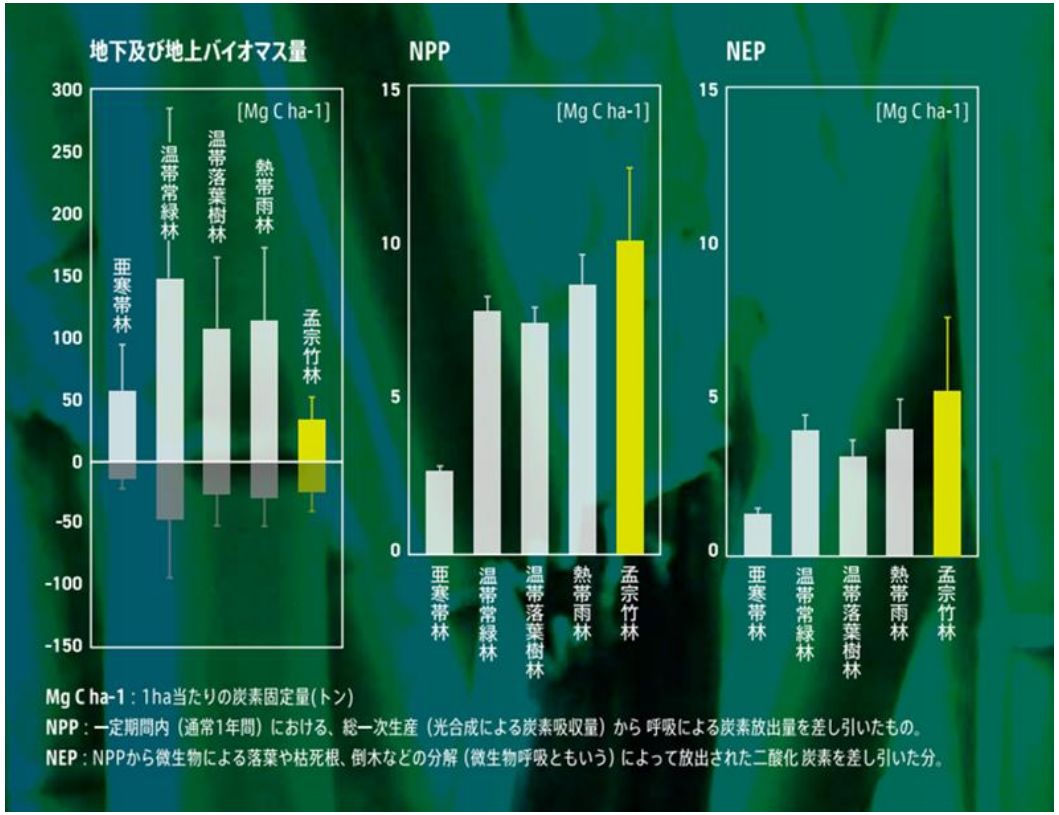
Bamboo forests as strong C sink?



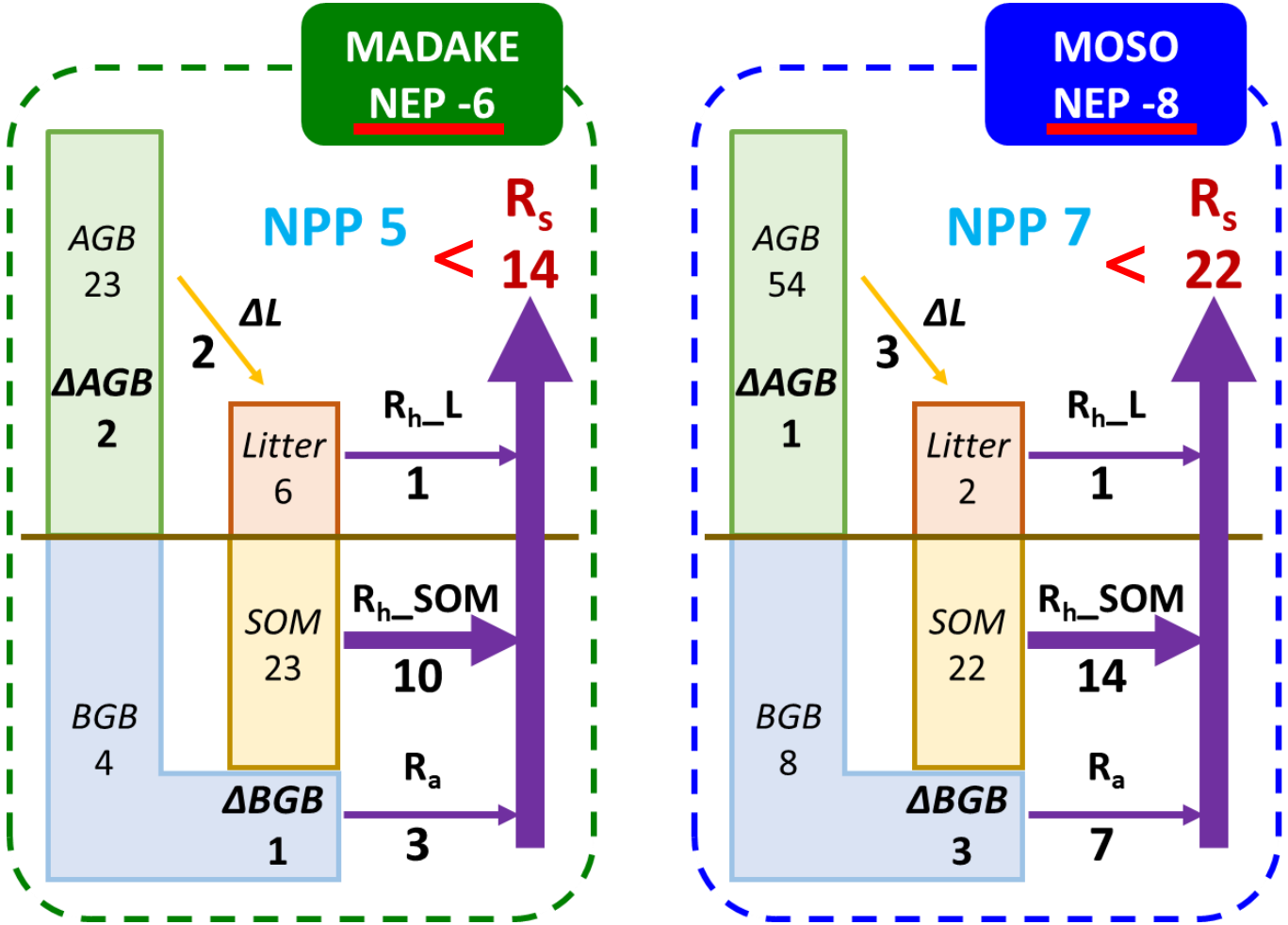
Very fast growing species

https://lewisbamboo.com/pages/how-bamboo-grows

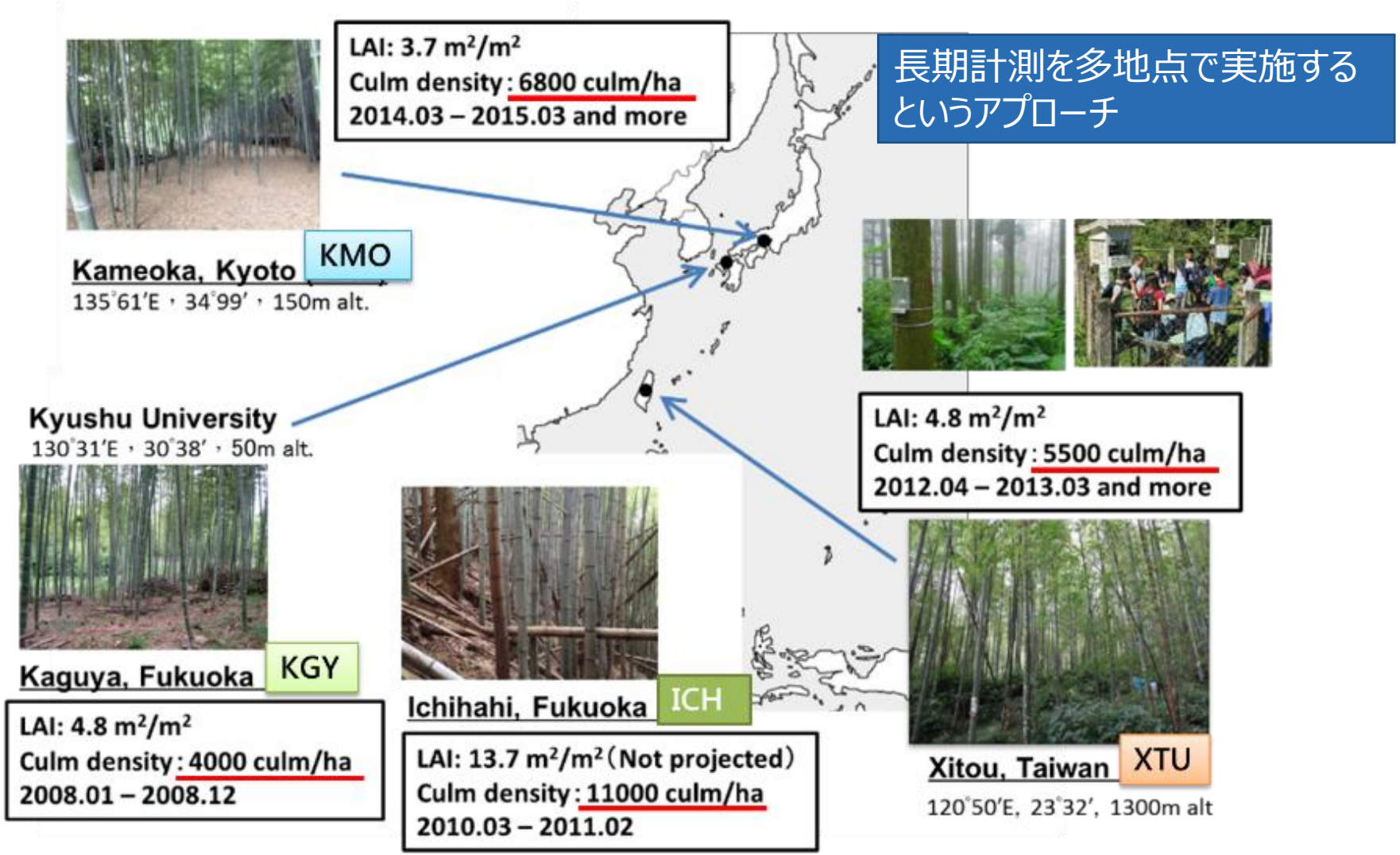
Largest NEP in the world-forests!



Bamboo forests not always C sink?



Still on-going research



What did we learn today ?

1 Common sense is not always true

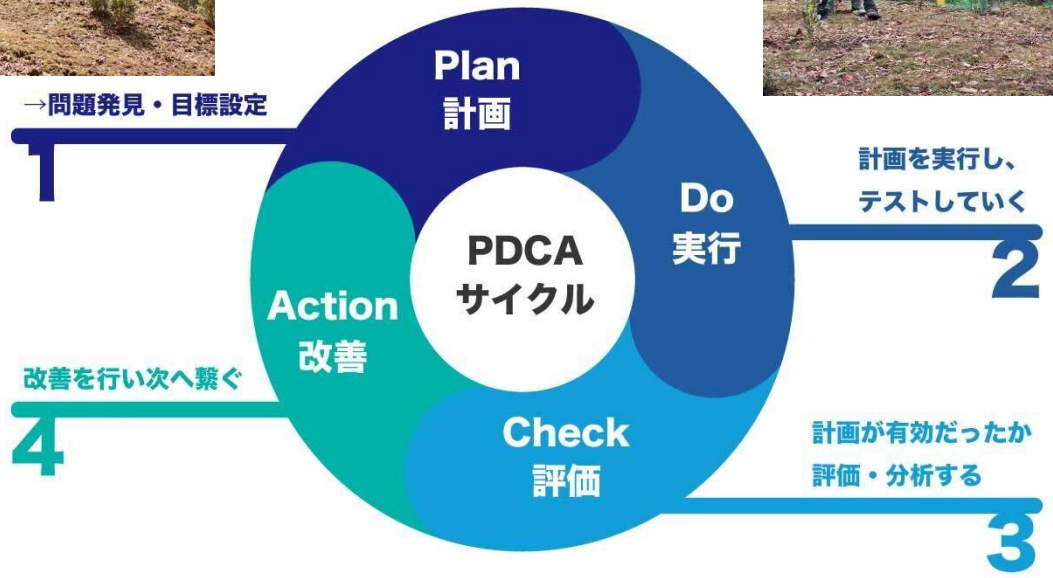
2 How we evaluate matters

3 Answers depend on conditions and perspectives

Finally

How should we manage forests in our country?

Why University Forests matter?



Satoyama as a living laboratory

Previous situations

Less human activity

What is optimal strategy？

Current situations

Forest ecosystem services can deteriorate due to underuse.
森林的生態系服務，可能因為「不使用」而退化。
Doing nothing is also a decision.
什麼都不做，也是一種選擇。
We need to decide,
based on science, history, and social context.