



A proposal for indicators to detect signs of soil erosion

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Outline

- I. Enhancement of Criterion 4 concept
- II. Geography and forests, and erosion in Japan
- III. New erosion indicators for Criterion 4 in national forest inventory (NFI), Japan
- IV. Preliminary analysis of the erosion indicators in NFI monitoring data
- v. Applications for policy measures

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I. Enhancement of Criterion 4 concept

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Review of Criterion 4: Conservation and Maintenance of Soil and Water Resources (1)

Indicators under Criterion 4 of MP in 1995

Just listing wide range of indicators related, but most of them are difficult to measure

- a. Area and percent of forest land with significant soil erosion-(b);
- b. Area and percent of forest land managed primarily for protective functions, e.g. watersheds, flood protection, avalanche protection, riparian zones-(a);
- c. Percent of stream kilometers in forested catchments in which stream flow and timing has significantly deviated from the historic range of variation-(b);
- d. Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties-(b);
- e. Area and percent of forest land with significant compaction or change in soil physical properties resulting from human activities-(b);
- f. Percent of water bodies in forest areas (e.g. stream kilometers, lake hectares) with significant variance of biological diversity from the historic range of variability-(b);
- g. Percent of water bodies in forest areas (e.g. stream kilometers, lake hectares) with significant variation from the historic range of variability in pH, dissolved oxygen, levels of chemicals (electrical conductivity), sedimentation or temperature change-(b);
- h. Area and percent of forest land experiencing an accumulation of persistent toxic substances-(b).

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Review of Criterion 4: Conservation and Maintenance of Soil and Water Resources (2)

Indicators of Criterion 4 of MP in 2009

Grouping into soil and water (and protective function), but still hard to measure

- 4.1 Protective function
 - 4.1.a Area and percent of forest whose designation or land management focus is the protection of soil or water resources
- 4.2 Soil
 - 4.2.a Proportion of forest management activities that meet best management practices or other relevant legislation to protect soil resources
 - 4.2.b Area and percent of forest land with significant soil degradation
- 4.3 Water
 - 4.3.a Proportion of forest management activities that meet best management practices, or other relevant legislation, to protect water related resources.
 - 4.3.b Area and percent of water bodies, or stream length, in forest areas with significant change in physical, chemical or biological properties from reference conditions

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Proposal for enhancement

Proposal for enhanced understanding of protective functions

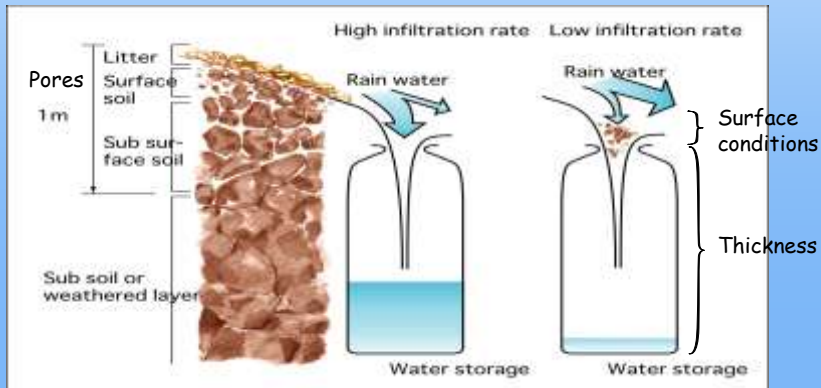
Focusing **soils**, which support water and other functions

Justification of this proposal will be made by the following slides.

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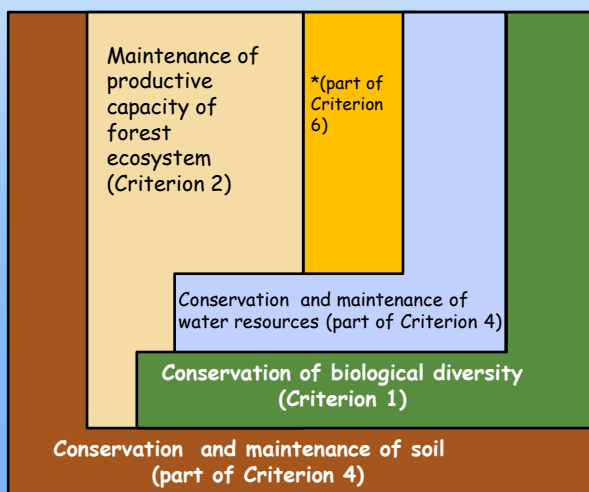
Medium (soil) or substance (water)

- Pores, thickness, surface conditions of soils determine the capacity of water storage and infiltration rate
- Consumers/end-users only care about water



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Hierarchic structure of ecosystem services of forests



- Soils are cultivated by biota, **which takes forever** - basic concept of soil science
- Soils provide a basis for all other services

* Maintenance and enhancement of public recreation, tourism, cultural needs and values

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Suzuki (2007), partly modified

I. Enhancement of Criterion 4 concept (summary)

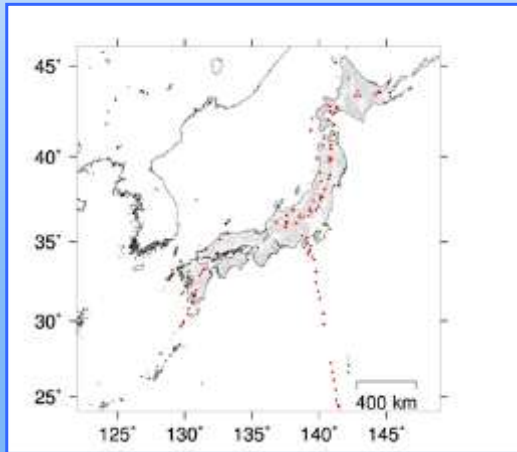
1. Soil formulates a baseline of ecosystem services
2. Prevention of soil erosion and soil conservation should be a basis of protective functions under Criterion 4
3. The problem is how we achieve it through forest management - actual state in Japan
 - How it goes under different climate zones or different regions?

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II. Geography and forests, and erosion in Japan

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Distribution of volcanoes



The Japanese Archipelago lying on the Ring of Fire



- ▣ Fresh soil materials
- ▣ Volcanic ash soils

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Mountainous steep slopes

Located on Pacific tectonic belt

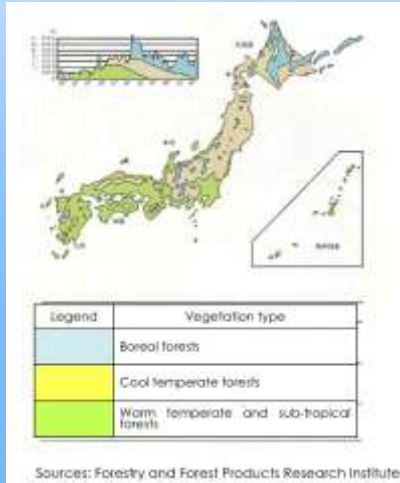
- ▣ Very steep slopes
- ▣ High erosion rate, 0.1 - 1.0 mm/y
- ▣ Frequent disasters by mass movement



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Materials in ICG 2001

Forests covers 2/3 of the country (25/37 million ha)



Four climatic zones:

- Sub-boreal
- Cool temperate
- Warm temperate and Subtropical

Rainfall ca. 1,700 mm

→ Luxuriant growth of forests covers, i.e. 67% of terrain

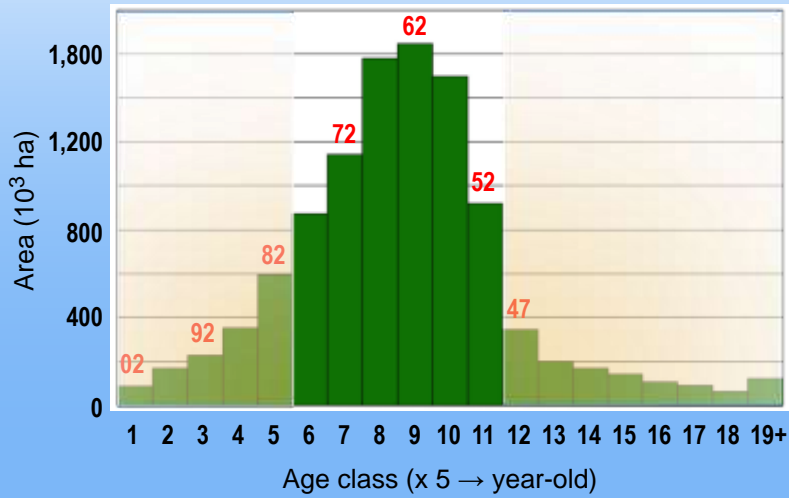
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Luxuriant forest development - quick recovery of forest covers



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Planted forests by age class as of 2007

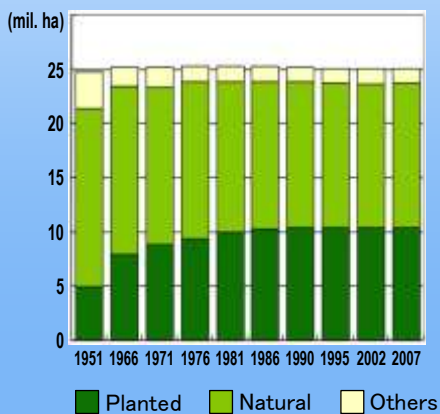


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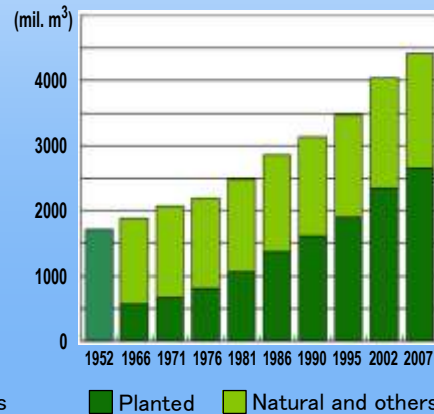
Forestry Agency (2009)

Change in forest area and growing stock

Forest area



Growing stock



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Forestry Agency (2009)

II. Geography and forests in Japan (mini summary)

1. Steep slope and high rainfall leads to be vulnerable to soil erosion and mass movement
2. However, cool to warm, and humid climate provides luxuriant forests of high biodiversity and large growing stock of planted forests



In spite of these favorable conditions for forest growing, we still have various threats of soil degradations

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Recent threats to soil erosion in Japanese forests (1)



Cedar



Cypress

Effect of tree species

- Vulnerable Cypress vs Cedar
(*Chamaecyparis obtusa* vs *Cryptomeria japonica*)
- Low protective effect of scaly needles of Cypress

Browsing damage by deer:
Deer excluded (left) vs
not excluded (right)



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Recent threats to soil erosion in Japanese forests (2)



Severe rill erosion on volcanic ash deposition



Strong soil disturbance by forestry machines

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Historical forest soil degradation by human impacts in Japan (1) Ashio mine

Bald mountains, forests completely destroyed by sulfurous acid gas from Ashio copper mine in 1960s

Forests recovered in 2000s with high reforestation costs. Do functions of soils and other services recover or not?

1960s (began in 19th century)



2012



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Historical forest soil degradation by human impacts in Japan (2) Tanakami mountains near Kyoto

Bald mountains, forests severely damaged by continuous utilization of litters and roots from Edo era, in Tanakami mountains

Forests recovered in 2000s with high reforestation costs. Do functions of soils and other services recover or not?

1948(began in 17-18th century) →

2000s



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II. Geography and forests, and erosion in Japan (summary)

1. Steep slope
→ High rate of erosion and mass movement
2. Cool to warm, and humid
→ Luxuriant forests and high biodiversity
3. Rapid increase of growing stock of planted forests
4. Under these favorable conditions, we still have various threats of soil degradations
5. Rehabilitation of soil degradation needs cost and time
→ Monitoring **signs of erosion** should be effective and cost saving

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III. New soil erosion indicators for Criterion 4 in National Forest Inventory, Japan

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Monitoring method for soil erosion in NFI

1st and 2nd rounds for NFI 1999-2008

Reported in 2nd Country Report of Japan 2009



3rd round for NFI 2009-2014

Localized indicators, quantitative, reproducible

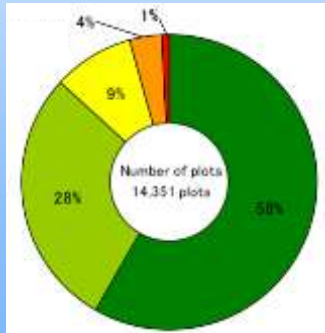
Two new indicators :

- ▣ Percentage of floor cover (FCP)
(cover by litter or understory) and percentage of boulders } **floor cover**
- ▣ **Evidence** of erosion

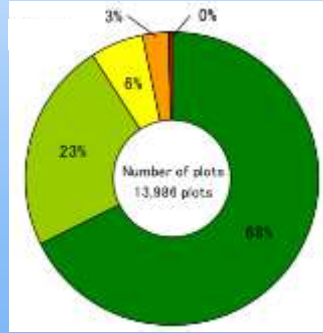
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Previous monitoring method for soil erosion in NFI

NFI 1st Round survey



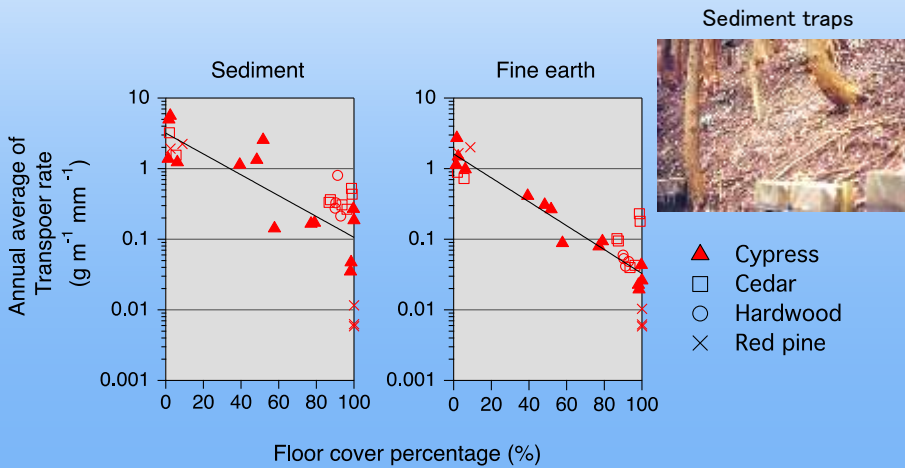
NFI 2nd Round survey



	0	A0[O] horizons (Organic material layers) covers all over the area >> 100% cover	} only severe erosion
	1	A part of A0[O] horizons (Organic material layers) is lost, no gully >> 50 - 100% cover	
	2	A0[O] horizons (Organic material layers) covers <50%, no gully >> 0 - 50% cover	
	3	Gullies are found partially	
	4	Gullies are found all over the area	

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Floor cover determines erosion rate



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Miura et al. (unpublished)

New monitoring method for soil erosion in NFI

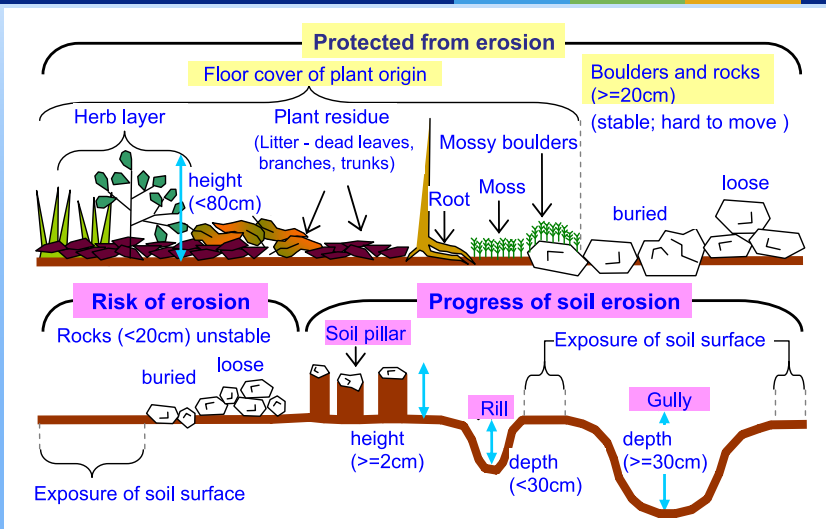
3rd round

Two types of indicators at two 4x6 m plots in one site :

- ▣ Percentage of floor cover (FCP) and percentage of boulders
 - protective function (\approx detecting signs of erosion)
- ▣ Appearance of Pedestal (Soil pillar) / Rill / Gully
 - evidence of erosion

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Schematic model and definitions of two new indicators



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Forestry Agency (2009)

Example of field survey



Field note

Percentage floor cover *	90	%
Percentage boulders *	0	%
Evidence of erosion	Soil pillar / Rill / Gully	

* Soil protective effect; visual judgment in 10% increments



Soil pillar



Rill



Gully

slightly severe < moderately severe < extremely severe

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Duration, cost and reproducibility of new soil survey method

1. A few minutes for one plot survey
→ Almost no additional cost under NFI field survey
2. Reproducibility between contracted consultant surveys and control surveys by JAFTA in 2010 is as follows:

▣ Percentage floor cover	94%
▣ Percentage boulders	98%
▣ Evidence of erosion	87%

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III. New erosion indicators for Criterion 4 in NFI, Japan (summary)

1. **Forest floor cover** (percentage of floor cover and percentage of boulders) will represent the function of soil conservation.
2. Monitoring a **percentage of floor cover** (FCP) and **evidence of erosion** would likely warn signs of erosion before facing serious situation.
3. It requires only very low cost compared to monitoring the magnitude of erosion itself.
4. New methodology indicates high accuracy and reproducibility as well.

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IV. Preliminary analysis of erosion indicators in NFI monitoring data

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Framework of NFI in Japan (1)

Legal basis

- Forest planning system under Forest Act

Sampling design

- 14,500 nation-wide permanent points at 4 x 4 km grid

Frequency of survey

- Once in every five years

Items of survey

- Geographical information, site conditions, forest conditions, dead wood, floor vegetation

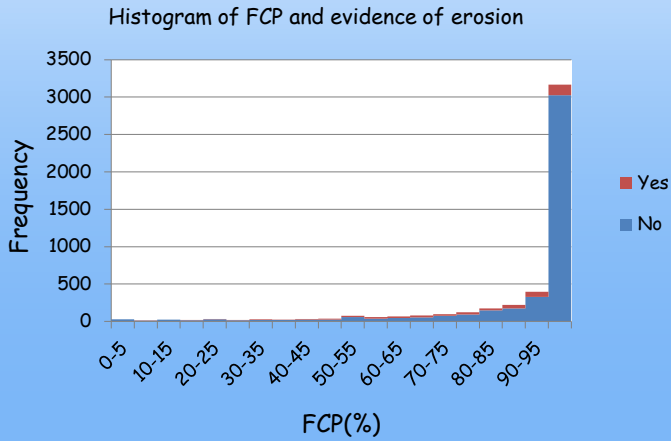
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Framework of NFI in Japan (2)

- MP Indicators
 - Biological Diversity
 - 1.1.a: Area and percent of forest by forest ecosystem types, successional stage, age class and forest ownership or tenure
 - 1.1.b: Area and percent of forest in protected areas by forest ecosystem type, and by age class or successional stage
 - 1.2.a: Number of native forest-associated species
 - Health and Vitality
 - 3.a : Area and percent of forest affected by biotic process and agents (e.g. disease, insects, invasive species) beyond reference condition
 - Soil and Water
 - 4.2.b: Area and percent of forest land with significant soil degradation

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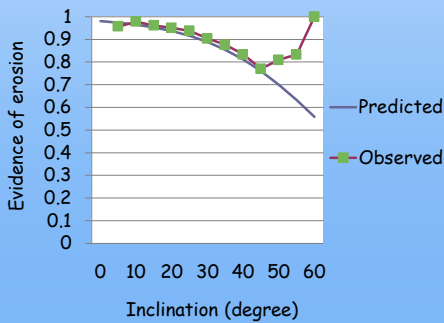
**FCPs of $\frac{3}{4}$ plots are >90%,
evidence of erosion in 90% plots are none**



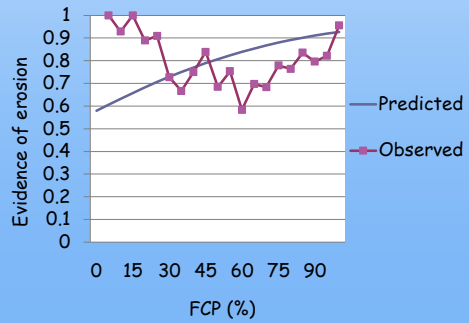
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**Evidence of erosion increases with slope,
but decreases with FCP**

Logistic regression between
Inclination vs evidence of erosion

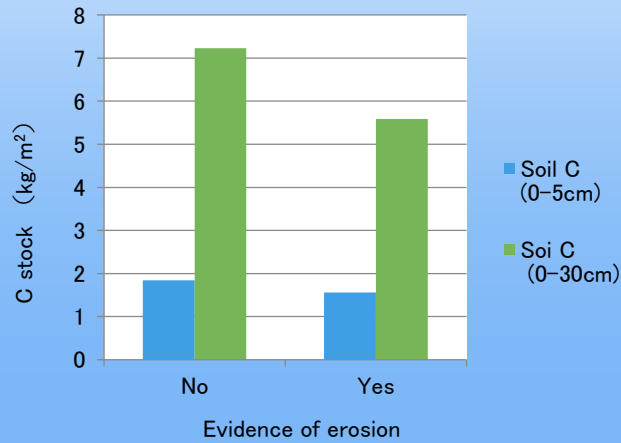


Logistic regression between
FCP vs evidence of erosion



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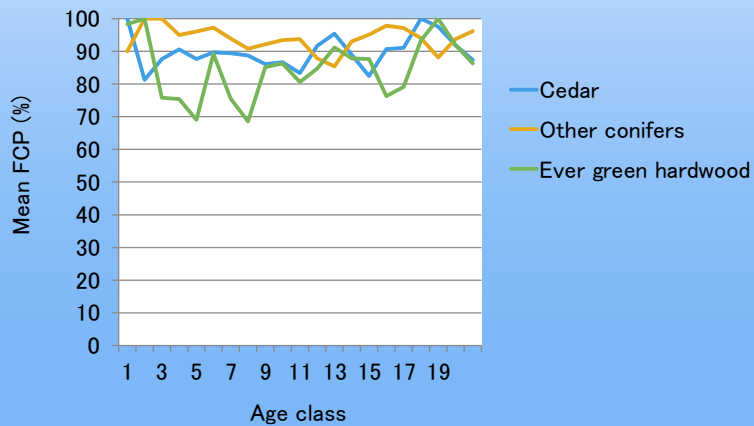
Soil carbon stock (Criterion 5) vs Evidence of erosion



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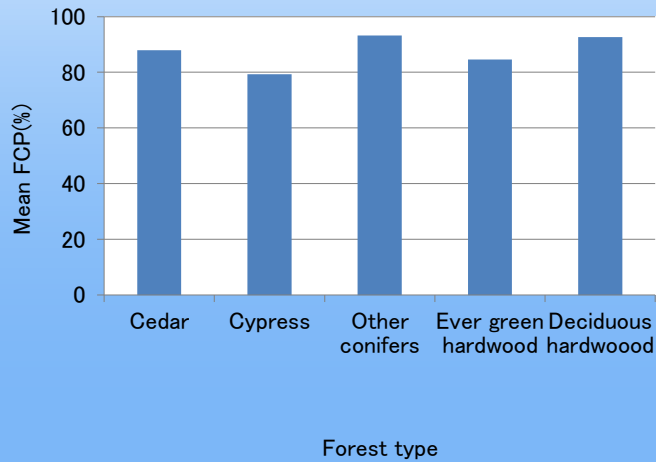
Forest carbon inventory, Forestry Agency (2010)

FCP varies with age classes



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FCPs also varies with forest types, which implies that we can control erosion monitoring through FCP by forest management



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Possible evidence of historical erosion by human impacts



Seikei zusetu (1804)

Removal of litter, foliage, root might cause severe erosion and decrease of soil carbon stock



Walter Weston (1922)

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IV. Preliminary analysis of NFI monitoring data (summary)

1. Existence of forest is pre-condition of soil conservation, however soil erosion could progress even under forest cover in humid temperate regions.
2. Recent forest soil carbon inventory also revealed possible long-term soil erosion.
3. We found percentage of floor cover (FCP) would influence soil erosion.
4. Better to detect signs of erosion before we found evidence of erosion itself.
5. FCP would be an effective and essential indicator for conservation and maintenance of soil which forms a basis for all other services.

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V. Applications for policy measures in Japan

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Applications for policy measures in Japan

- Firstly, finishing the five-year 3rd round survey of NFI by 2014.
- Secondly, extracting threshold values of indicators for judging critical progress of erosion.
- Then, distinguishing forest management effect from natural effect on amount of change with signs of erosion.

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V. Applications for policy measures (concluding remarks) (1)

1. Experience of erosion studies in humid temperate regions indicates that the basis of Criterion 4 could be placed and focused on soil conservation rather than on water status.
2. Direct observation of the magnitude of erosion tend to take high-cost. Monitoring floor cover (FCP) is low cost and effective for detecting signs of erosion before facing serious situation.
3. **Cover**, not only forest canopy cover but also **floor cover**, is a clue for grasping forest degradation. Loss of floor cover triggers succeeding disasters.
4. Primary threat for forest degradation is human interventions. It also changes along social circumstances.

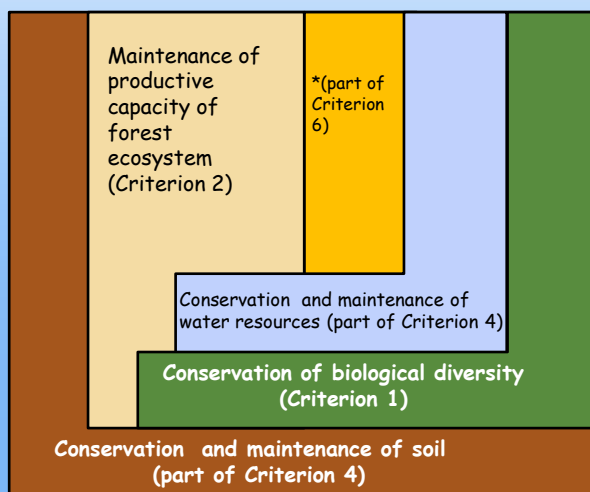
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V. Applications for policy measures (concluding remarks) (2)

5. We know the high cost of rehabilitation of various functions of ecosystem services in degraded forest.
6. We would like to propose to pay more attention to the indicators detecting signs of erosion.
7. Monitoring covers of crown and floor is effective.
8. Applications for policy measures would vary by forest types, forestry and societies' needs.
9. However, prevention is better than rehabilitation for all the countries.
 - we would pay due attention to the concept of **cover** for further refinement of the concept under Criterion 4.

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Again, hierarchic structure of ecosystem services of forests



- Forests provide various services
- Soils are essential for maintaining forests
- **Floor cover** is a measurable indicator for keeping soils

* Maintenance and enhancement of public recreation, tourism, cultural needs and values

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Suzuki (2007), partly modified



Japan Forest Technology Association



Thank you for your attention!



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