A Proposal of New Indicator for Soil Erosion
- How implement Forest Floor Cover Management?

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Outline

I. Soil erosion of forested area in Japan
II. Why is “forest floor cover” so important?
III. Monitoring soil erosion in NFI
IV. Forest Floor Cover Management for SFM
I. Soil erosion of forested area in Japan
Raindrop splash, quick progress

Consequence of floor cover removal treatment

Splash

Pedestal
Recent threats of soil erosion (1) forest type, deer

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)

(Copyright by H. Furusawa)
Recent threats of soil erosion (2) associated with harvesting

- Improper managed un-afforested stands
- Mainly in south-western part of Japan
- Severe erosion along skid trails

(Photograph by S. Sasaki)

Strong soil disturbance by forestry machines
Recent threats of soil erosion (3) natural disturbance

Severe rill erosion on volcanic ash deposition (Miyake island)
Historical forest soil degradation by human impacts (1) Ashio copper mine

Bald mountains, forests were completely destroyed by sulfurous acid gas from Ashio copper mine

Forests recovered in 2000s with high reforestation costs. Have soils fully developed, or not?

1960s (begun in 19^{th} century) \rightarrow 2000s

(Photos by Forest Agency)
Historical forest soil degradation by human impacts (2) Tanakami mountains near Kyoto

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

1948 (began in 17-18th century) ➔ 2000s

Forests recovered in 2000s by much efforts. Have functions of soils and other services recovered or not?

(Photos by GSI, Japan)
Summary

'Canopy' or 'Floor'

• Loss of floor cover accelerates soil erosion quickly

• Erosion worsens:
  Splash -> Surface flow -> rills and gullies

• Excessive human activities will devastate forests and soils
II. Why is “forest floor cover” so important?
Why ... cause foundational functions

Because,

• forest soil supports ecosystem services

and,

• **soil** is a primary *regulating factor* (RF) of most ecosystem services

• **floor cover** protects **soils** from erosion
RF for water holding capacity, regulation, filtering

Medium

Pores

Surface conditions

Thickness

Substance

RF for water holding capacity, regulation, filtering
Susceptive erosion response to change of floor coverage

(Miura et al. 2003)
What factor? - floor cover percentage

Annual average of Transpoer rate (g m$^{-1}$ mm$^{-1}$)

Fine earth

FCP, Floor Cover Percentage (%)
What factor? - Slope inclination, forest type
What factor? - Forest type and age

Miura (2000)

- FCP
  - Young cypress: 40 ~ 80%
  - Others: 90 ~ 100%
Soil is a regulating factor for ecosystem functions
Losing floor cover, soil is quickly eroded
Floor cover can be controlled by forest conditions

Base on these facts,

I am proposing a new concept of 'Forest Floor Cover Management' to protect soil from erosion

(→ this requires us to care about forest floor conditions along with crown cover of forests)

(→ measurable indicators should be introduced to national monitoring)
III. Monitoring soil erosion in National Forest Inventory (NFI)
Monitoring method for soil erosion in NFI

- 1999-2008: 1\textsuperscript{st} and 2\textsuperscript{nd} rounds for NFI
- 2009-2014: 3\textsuperscript{rd} round for NFI
  - Quantitative, reproducible indicators
Location of plots in NFI and NFSCI

**NFI**, 4x4 km grid, 0.1ha
14,700 in Japan

(Akita pref.)
Definition of floor cover percentage

On 3rd round survey (2009), two new indicators were introduced:

- **Floor cover percentage (FCP)**
  (cover by litter or understory)
  and percentage of boulders

- **Evidence of erosion**
Scheme and definitions of two new erosion indicators in forest floor

Protected from erosion

Floor cover of plant origin

Herb layer
Plant residue (Litter - dead leaves, branches, trunks)

Mossy boulders (stable; hard to move)
Boulders and rocks (>=20cm)

Risk of erosion

Rocks (<20cm) unstable

Soil pillar
Exposure of soil surface

Progress of soil erosion

Exposure of soil surface

Rill

Gully

height (>=2cm)

depth (>=30cm)

height (<80cm)

Forestry Agency (2009)
Example of field survey

Field note

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Percentage floor cover *</td>
<td>90 %</td>
</tr>
<tr>
<td>Percentage boulders *</td>
<td>0 %</td>
</tr>
<tr>
<td>Evidence of erosion</td>
<td>Soil pillar / Rill / Gully</td>
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</tbody>
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* Protective effect; visual judgment in 10% increments

Very low cost

Soil pillar

Rill

Gully

slightly severe < moderately severe < extremely severe
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%
FCPs >90% at 3/4 of plots

evidence of erosion appeared in 10% plots

Histogram of FCP and evidence of erosion

(obs. = 4725)
FCP varies with forest types

Mean FCP (%)

<table>
<thead>
<tr>
<th>Forest type</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Cedar</td>
<td>95</td>
</tr>
<tr>
<td>Cypress</td>
<td>80</td>
</tr>
<tr>
<td>Other conifers</td>
<td>90</td>
</tr>
<tr>
<td>Evergreen hardwood</td>
<td>85</td>
</tr>
<tr>
<td>Deciduous hardwood</td>
<td>90</td>
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</table>

(obs. = 4725)
Evidence of erosion increases with slope, but decreases with FCP.

Logistic regression between Slope inclination vs evidence of erosion.

"FCP signs erosion"
Summary of preliminary analysis of erosion data of NFI

1. New indicators were introduced into NFI
2. FCP was affected by forest type and age
3. Evidence of erosion was increased as increase of inclination and as decrease of FCP
4. A relationship likely exists among FCP, evidence of erosion
IV. Forest Floor Cover Management for Sustainable Forest Management
SOIL FORMATION:
• Dead organic matters and living organisms are indispensable to soil formation
  -> Soils must be preserved

TIME SCALE/SPAN RELATED SOIL
• We should remember the unbalanced time scale between formation and erosion of forest soil
Hierarchic structure of ecosystem services of forests

- **Conservation of biological diversity** (Criterion 1)
- **Maintenance of productive capacity of forest ecosystem** (Criterion 2)
- **Conservation and maintenance of water resources** (part of Criterion 4)
- **Conservation and maintenance of soil** (part of Criterion 4)
- ***(part of Criterion 6)***

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

Suzuki (1994, 2007), partly modified
Conclusion

- Forest soil should be protected from erosion because it regulates functions of ecosystem services.

- Floor cover percentage (FCP) is a good indicator because it detects signs of soil erosion as a precautionary principle;
  - decrease of FCP triggers erosion
  - we can control FCP by management

- Accumulated data of FCP will be utilized to maintain forests sustainable.
The forest floor is undoubtedly the most distinctive feature of a forest soil.

(Fisher and Binkley, 2000)