Comparative long-term forest ecosystem study among circumpolar regions.

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Today’s contents

- Circumpolar region: revised view
- Multi-disciplinary interpretation
  - Permafrost, geological history, vegetation,
  - Soil, Nutrient cycling
- Long-term cooperative research
  - Stand reconstruction, fire, climate
Today’s contents

- Circumpolar region: revised view
Vegetation map in circumpolar region

Discrepancy between vegetation zone and permafrost boundary.
Climate conditions among circumpolar regions

**Kajaani (64N-28E)**
- MAT: -3.4°C
- AP: 287 mm
- C-index: 57

**Tura (64N-100E)**
- MAT: -9.2°C
- AP: 317 mm
- C-index: 80

**Yakutsk (62N-129E)**
- MAT: -10.1°C
- AP: 213 mm
- C-index: 97

**Fort-Smith (60N-112W)**
- MAT: -3.1°C
- AP: 353 mm
- C-index: 62

**Nizhne-Kolymsk (69N-161E)**
- MAT: -14.5°C
- AP: 177 mm
- C-index: 74

**Fairbanks (65N-147W)**
- MAT: -10.1°C
- AP: 213 mm
- C-index: 97

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**MAT:** Mean Annual Temperature  
**AP:** Annual Precipitation  
**C-index:** Continentality-Index
<table>
<thead>
<tr>
<th>Permafrost type</th>
<th>Dominant conifers</th>
<th>Regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuous</td>
<td><em>Larix</em></td>
<td>Central Siberia, Eastern Siberia, NWT, Canada</td>
</tr>
<tr>
<td></td>
<td><em>Picea</em></td>
<td></td>
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<tr>
<td>Discontinuous</td>
<td><em>Picea</em></td>
<td>NWT, Canada Interior Alaska</td>
</tr>
<tr>
<td>Sporadic/Isolated</td>
<td><em>Pinus, Picea</em></td>
<td>NWT Canada West Mongolia</td>
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<tr>
<td></td>
<td><em>Larix</em></td>
<td></td>
</tr>
<tr>
<td>Permafrost free</td>
<td><em>Pinus, Picea</em></td>
<td>Fennoscandia N. Europe</td>
</tr>
</tbody>
</table>
Surveyed in 1993-2001
Surveyed from 90’s / continuing
Surveyed in recent 5 years

Comparative forest ecosystem research sites in circumpolar region (2016)
Varrio (68N-29E)  
Permafrost-free

Cherskiy (69N-160E)  
Continuous permafrost

Inuvik (68N-133W)  
Continuous permafrost

Tura (64N-100E)  
Continuous permafrost

Yakutsk (62N-130E)  
Continuous permafrost

Fairbanks (65N-147W)  
Discontinuous permafrost
Today’s contents

- Multi-disciplinary interpretation
  Permafrost, geological history, vegetation, Soil, Nutrient cycling
Schematic diagram of circumpolar forest biome development (modified from Matsuura 2004)
Carbon storage in larch ecosystems on continuous permafrost in Siberia

High allocation rate to belowground part

Yakutsk 62N-130E

Tura 64N-100E

Cherskiy 69N-160E

C in aboveground part
C in belowground part
C in forest floor
C in active layer (SOC)

Unit: MgC/ha

Data sources of forest biomass: Kanazawa et al. 1994, Kajimoto et al. 1999a, 1999b

Matsuura et al. (2005)
Old root system was packed in frozen soil.

Surviving trees have
1) Ability and chance to extend new root system to non-frozen soil, when the old root system was packed in frozen soil.
2) Ability and chance to extend new root system to the area where neighbor trees do not reach.
Carbon budget monitoring study by ecological methods
CO_2 flux measurements during growing season
Osawa et al. (2010)
Forest fire, Permafrost degradation, Shallow root system
Monitoring study on 2004 fire in Alaska
Schematic diagram of regeneration processes on permafrost and non-permafrost soils

Permafrost Subsidence after disturbances

Nutrient release after disturbances

Recovery of forest floor and permafrost re-rising

Self-thinning process starts

Anomaly self-thinning under strong nutrient limitation and root competition

Stand development along normal self-thinning rule trajectory

Permafrost

Non-permafrost

20-40 yrs

100 yrs
Larch forests in continuous permafrost region of Siberia.

- *Larix cajanderi* (Eastern Siberia)
- *Larix gmelinii* (Central Siberia)

Black spruce forests in discontinuous permafrost region of Caribou Poker Creek, Interior Alaska.

- *Picea mariana*
Soils in eastern Siberia

Tree limit

Thermokarst

Cryoturbation

Erathhummock

Ice wedge
Soils in Central Siberia
SOC - C/N relationship in permafrost larch forests in eastern and central Siberia.
Soil profiles in NWTC Canada
Soil profiles in interior Alaska
SOC - C/N relationship among boreal forests in NWT, Canada and Interior Alaska.
1) SOC storage regime in NE Eurasia was larger at one order of magnitude than that in North America. (Mann-Whitney U test, p=0.0000)

2) Soil C/N ratios in eastern Siberia were lower than those in central Siberia. (Mann-Whitney U test, p=0.0021)

3) Soil C/N ratios in NWT Canada were lower than those in Interior Alaska. (Mann-Whitney U test, p=0.0164)

Soil C/N ratio varied site to site. Soils derived from weathered rock fragment have higher C/N than those of deposit origin soils.
**Similarity**
1) Bedrock
2) Glaciation / deglaciation
3) Lake formation
4) Histosol / Podosol

**Difference**
1) Present climate
2) E-W gradient
3) Species niche
Soil organic carbon (SOC) kgC m$^{-3}$ vs. Soil C/N ratio

- E-Siberia
- C-Siberia
- Interior Alaska
- NWT Canada
- Kalina (peat soil)
- Varvio

The diagram shows a scatter plot with data points representing different regions and soil types. The x-axis represents soil organic carbon (SOC) in kgC m$^{-3}$, while the y-axis represents the soil C/N ratio.
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Several-decadal oscillation noted in Arctic air temperature variation.

Figure 2: Red – global average change (IPCC Reports). Blue – data from stations along the coastline of the Arctic Ocean (Polyakov et al., 2002). The figure shows also the amount of various sources of energy used during the last century; gas, oil, and coal all release CO₂.
Black spruce B44 (Osawa unpublished)
Fort Smith, Canada
Gmelin larch L14  (Osawa unpublished)
Tura, Siberia
Summary

◆ More field survey dataset is necessary to improve our knowledge of circumpolar region.

◆ Multi-disciplinary research has much advantages.

◇ Bilateral and multi-lateral cooperative research should be accelerated among Arctic countries and non-Arctic countries.
Thank you for your attention.
If you have a question, send e-mail to orijoy@ffpri.affrc.go.jp