

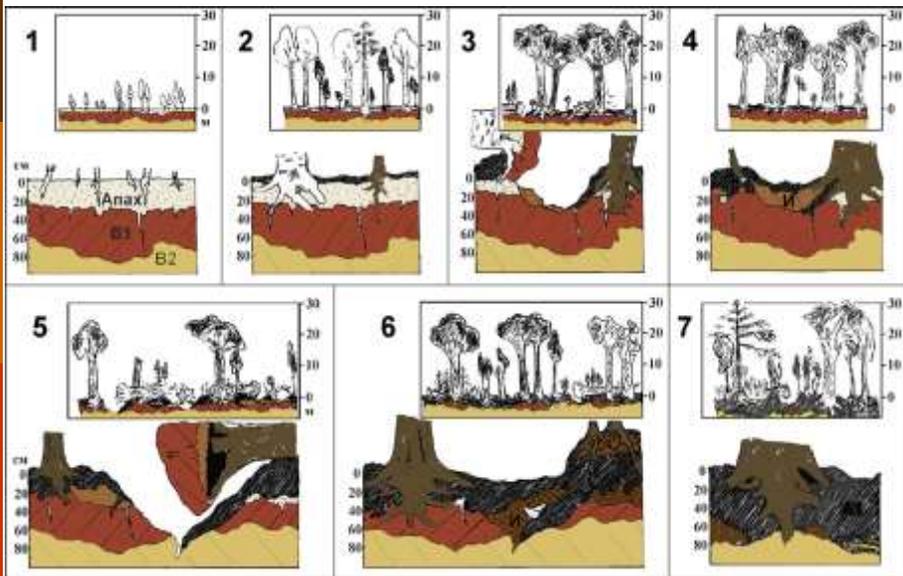
Forest soil in European Russia: biotic and anthropogenic factors in pedogenesis

Maxim Bobrovsky



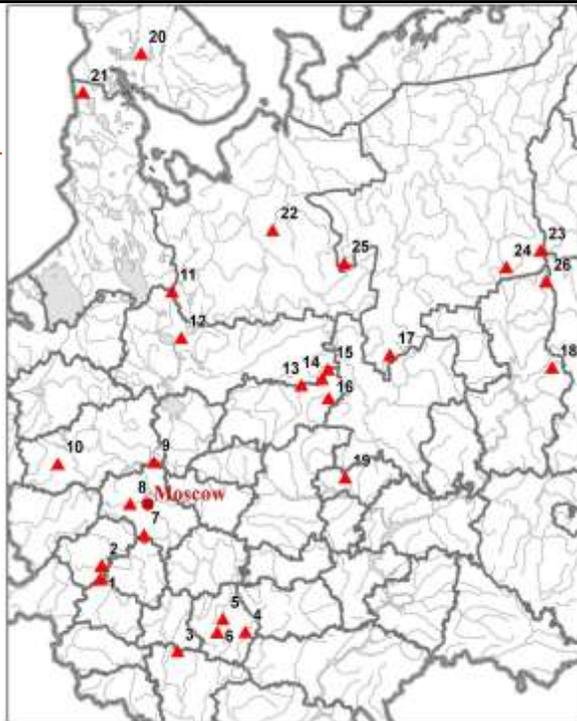
Institute of Physicochemical and Biological Problems of
Soil Sciences of Russian Academy of Science
Pushchino (Russia)

Схема сукцессии после распашки при долговременном развитии леса
The scheme of succession after plowing and long term development of forest ecosystem



Study areas

Forest selection:
Forest inventory
data
Remote sensing data



Objects of the investigation

↓
Vegetation



↓
Soil



↓
Pedofauna



Study areas – boreal forests

All areas are situated in the taiga, in the **hard-accessible parts of forestry** enterprises located in

Karelia republic	Vodlozersly Leshoz, Kostomukshsky Rezerve
Komi republic	Pechoro-Ilychskij Reserve, Udorskij, Priluzskij and Koigorodokskij Leshozes
Perm region	Visherskij Reserve
Kostroma region	Mezhevskij, Paviskij and Vokhomskij Leshozes
Vologda region	Andomsky Leshoz, National park 'Russkij sever'

Main objects of the investigation

Old-growth spruce and spruce-fir forests

age of spruce ranged from 150 to 400 years old

Different forest types:

domination in ground vegetation

- **dwarf shrubs and green mosses**
- **small herbs and ferns**
- **tall herbs and ferns**

Study areas – subboreal and temperate forests

Kaluga region	Reserve 'Kaluzskie zaseki' National Park 'Ugra'
Voronez region	Rezerve 'Voronezsky'
Tambov region	Reserve 'Voroninsky' Perkinsky forest
Moscow region	Rezerve "Prioksko- terrasny'
Tver region	Central forest reserve

Objects of the investigation

Old-growth broad-leaved (hardwood) forests
age of oak ranged from 150 to 400 years old

Different types of
softwood (birch, aspen) forests
coniferous (spruce, pine) forests

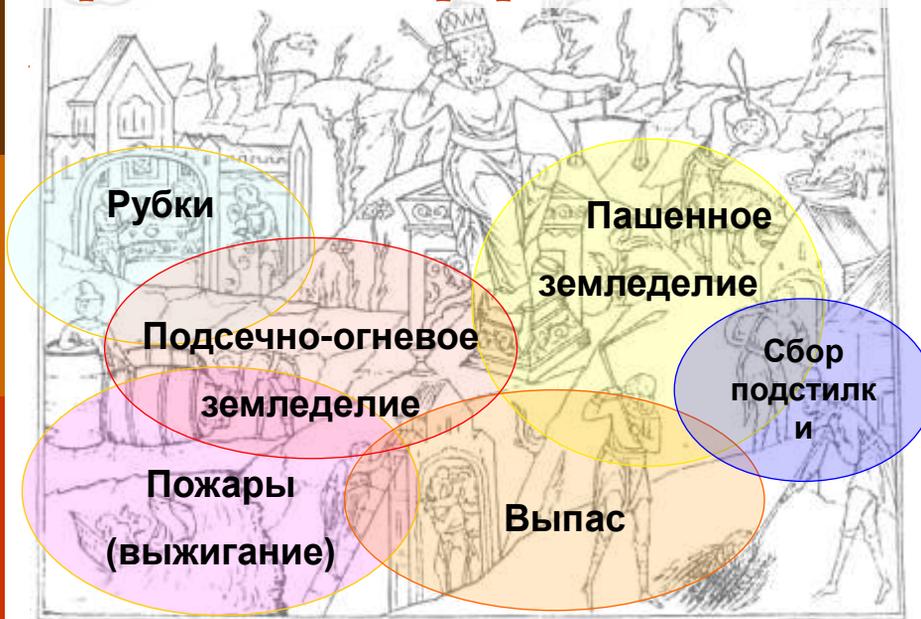
Results

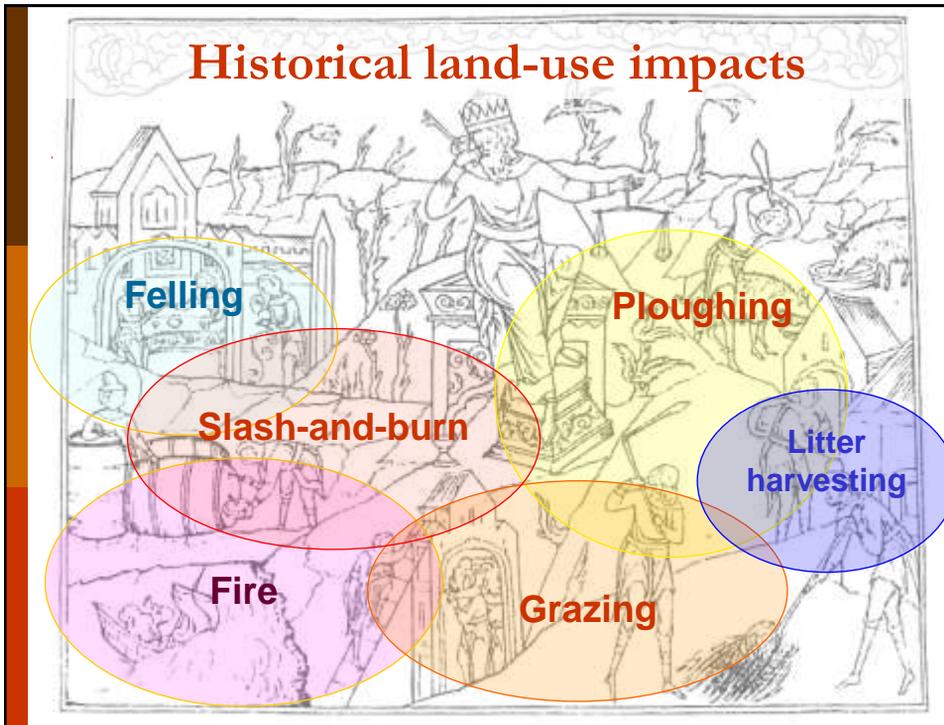
More than 4000 vegetation relevés

Morphological analysis of more than 1000 soil profiles (depth 1.5-3 m)

Historical/archival data for key regions

Традиционное природопользование





Традиционное природопользование

□ **Выпас**
Преобладание лесного выпаса

Лицевой свод, XVI в. Москва

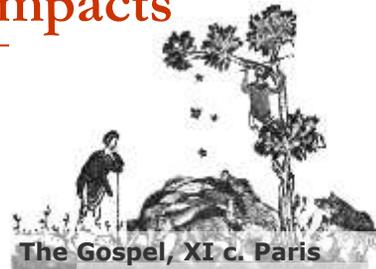
The Gospel, XI c. Paris

XVIII в. Москва

Historical land-use impacts

- **Stock-breeding**
Forest grazing prevailed

Licevoj svod, XVI c. Moscow



The Gospel, XI c. Paris

Miniature, XVIII c. Moscow



Традиционное природопользование

- **Рубки, сбор хвороста**



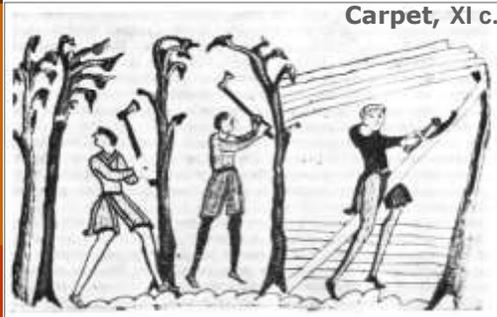
Carpet, XI c.



Engraving by
Kallo, 1620. France

Historical land-use impacts

□ Felling, brushwood harvesting



Engraving by
Kallo, 1620. France



Традиционное природопользование

- Сбор подстилки
- Сенокосение ... и др.



“Лекарство душевное”,
XVII в.
Москва

“Деревенское зеркало”,
1798, Тула



Большинство воздействий связаны с
традиционными системами земледелия

Historical land-use impacts

- ❑ Branches, litter harvesting
- ❑ Mowing ... etc.



"Derevenskoe zerkalo",
1798, Tula

"Lekarstvo
duschevnoe", XVII c.
Moscow



The important part of impacts was connected with **historical agriculture systems**

Традиционные системы земледелия

- ❑ Подсечно-огневая
- ❑ Переложная
- ❑ Трехполье
(вариант паровой системы)



Traditional agriculture systems

- ❑ **Slash-and-burn system**
- ❑ **Shifting agriculture (forest-shifting system)**
- ❑ **Three-field system (type of fallow system)**

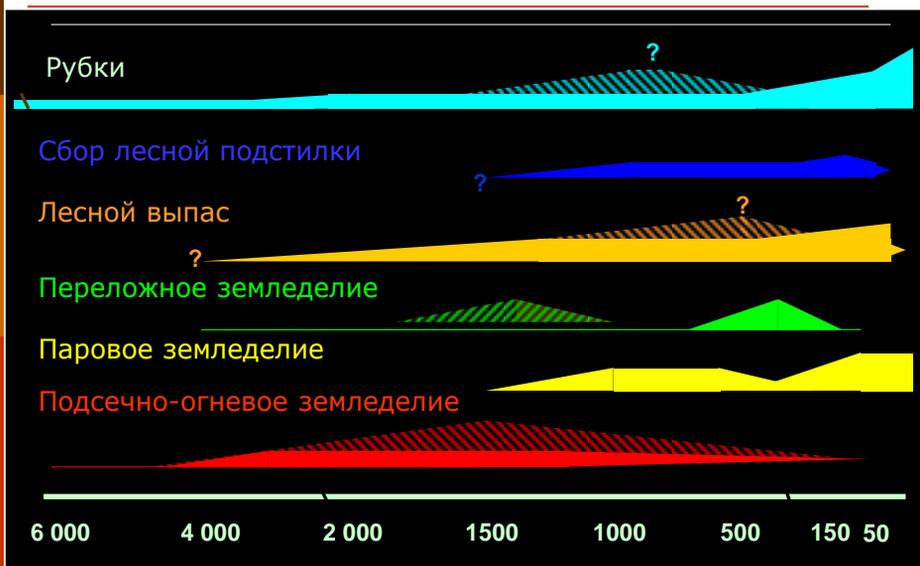
Pic. by Lindholm, XVIII c. Finland



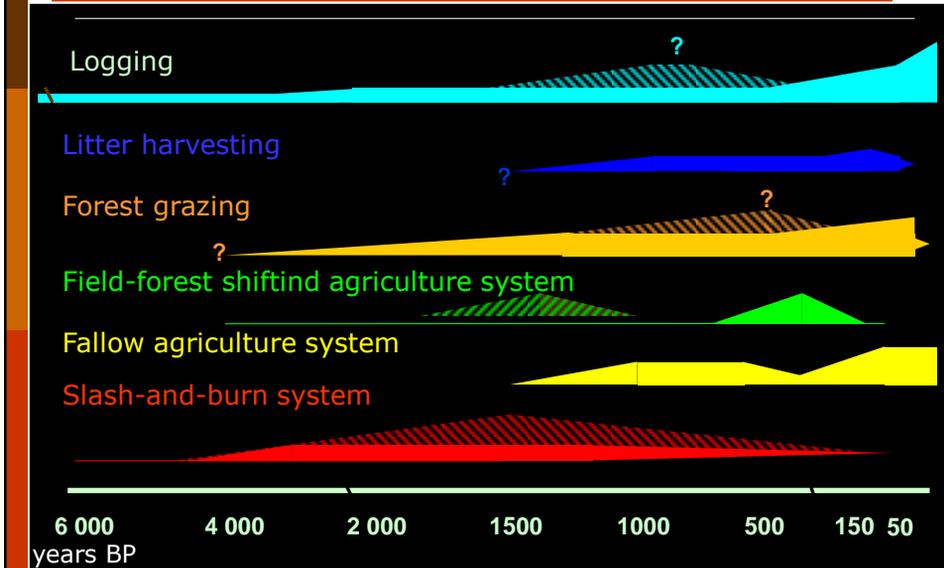
Licevoj svod, XVI c. Moscow



Хронология традиционного природопользования для территории центральной России



Chronology of traditional land-use



Macromorphological analysis of soil

What is the **soil macromorphological structure**?

that we can see without special instruments

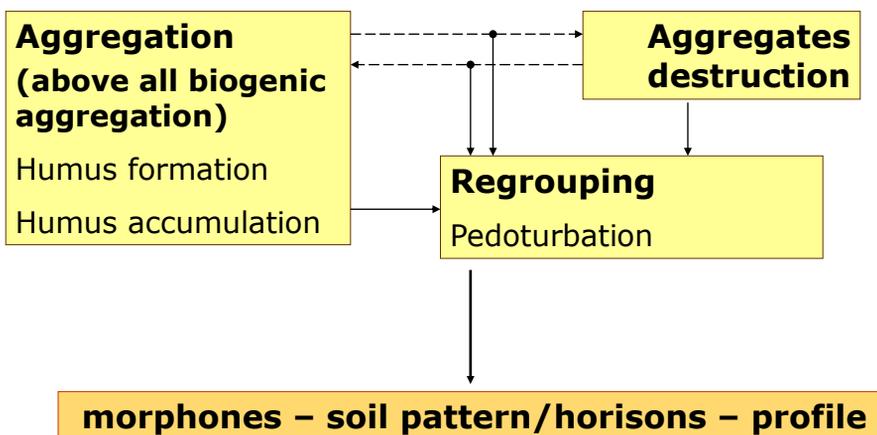
What do we **see** in a soil profile?

- Homogeneous elements = **morphones**
- Complex / Combination of elements = **soil pattern**

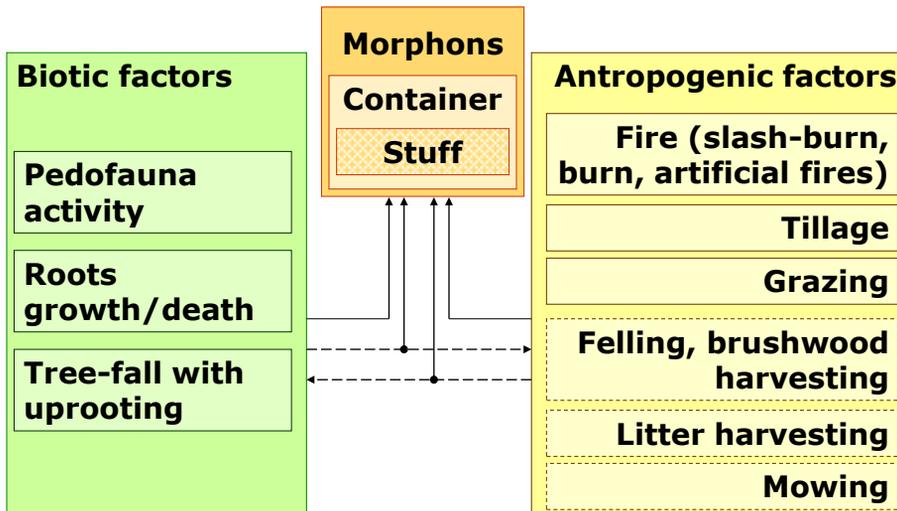
Macromorphological analysis of soil

- ▣ A soil profile is a pattern of different morphones
- ▣ The morphones are formed in result of natural and anthropogenic impacts on the ecosystem
- ▣ Sequence and strength of the impacts can be distinguished by the analysis of soil matter filled the morphones of different age

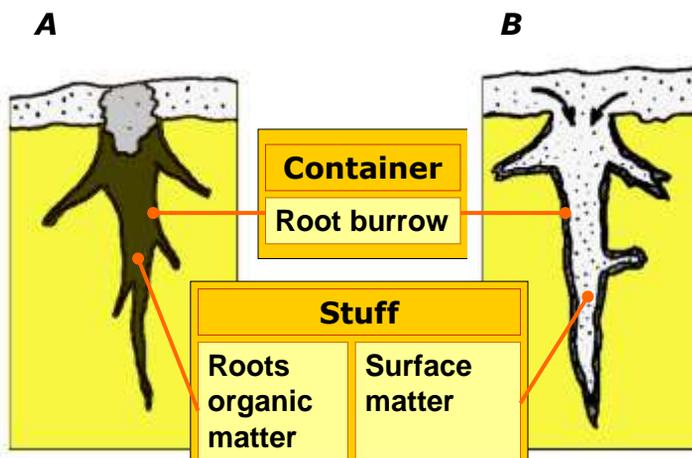
Processes of morphones forming



Factors of morphones formation



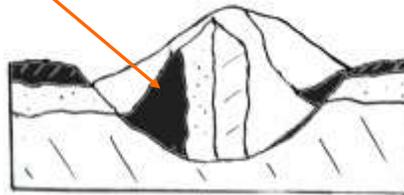
Difference between traces of hardwood (*A*) and softwood (*B*) roots after wind-break or logging



Pits after tree-fall is the main “depots” of the surface soil matter

Surface matter is kept mainly in peripheral parts of the pit

The main “depot” of surface matter is in a front part of pits formed after tree-fall with back shifting



If we can show and make out soil morphological signs

a sequence of various impacts and their intensity may be followed up

Traces of soil macrofauna activity

Coprolites, organo-mineral aggregates



Burrows, voids



Shifted and mixed soil matter in burrows



Results of biogenic sorting of mineral matter is the immersion of stones

Pedofauna activity

It was **well expressed** only in forests with **tall herbs domination** (Schaschkov, Bobrovsky, 2008)

Brown soil with **moder or mull humus** dominated in tall herb spruce and spruce and fir forests



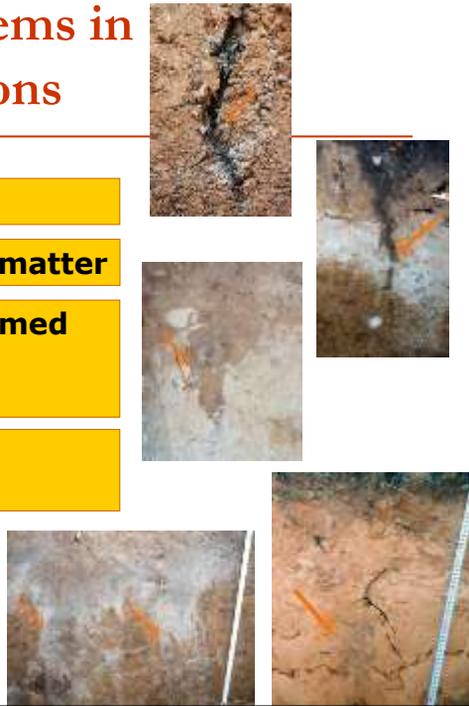
Traces of root systems in different soil horizons

Voids in a soil after roots

Root burrows with organic matter

Root burrows with transformed organic matter (after mineralization, oxidation)

Root burrows with mineral matter



Traces of root systems

Sometimes we can reconstruct:

- Tree species or species group
- Cause of tree death:
 - wind-break
 - logging
 - grubbing
 - tree-fall with uprooting

Tree-fall mosaic

Now well-expressed (occurred at different times) tree-fall mosaics attend at tall herb forests



Solitary or catastrophic tree-falls attend at other forest types



Следы ветровалов в почве

Следы западин старых вывалов
в большинстве почвенных
профилей
во всех типах леса



Traces of tree-falls

Past (“buried”) pits after tree-falls
were presented

in majority soil profiles

in all soil types

in all studied forest types



Следы ветровалов в почве



Протяженные
комплексы структур в
виде слоев, котлов, чаш



Traces of past tree-fall



long stripes or cauldrons



Traces of tree-fall

Striped structure



**Spotted structure
(«floating clods»)**

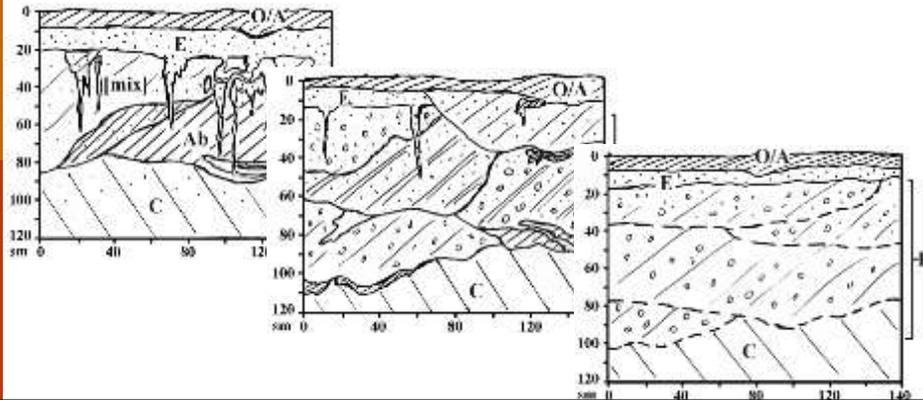


**Buried matters
(charcoals, litter etc.)**



Traces of tree-fall

Middle and bottom layers of soil profiles were presented by matters in pits and root burrows



Traces of tree-fall

Prevailing depth of pits was between 30 and 80 sm.
There were pits to 200 sm depth

There were **several levels of uneven-aged pits** in one soil profile (till 8 levels in trench)



Main impacts were similar in boreal, subboreal and temperate forests:

- ▣ **Fire (slash-burn, burn, artificial fires)**
- ▣ **Tillage**
- ▣ **Felling**
- ▣ **Grazing / wood pasture**

Boreal and subboreal+temperate forests differences

Boreal forests - alone major factor of human impact – **fire**

Traces of fires

Traces of **fires** are presented in all forest types, and they **maximal** in the dwarf shrub or green moss types



Следы пожаров в почве

Формы
углей

Окатанные
(трансформированные
на поверхности почвы)

Пластинчатые
(типичные
древесные угли)

Дисперсные,
угольная пыль



Traces of fire - Charcoals

Charcoal forms

rounded
(transformed on the soil surface)

lamellar (typical charry wood)

dispersed, coal fines



Traces of fire - Charcoals

Charcoal frequency

single

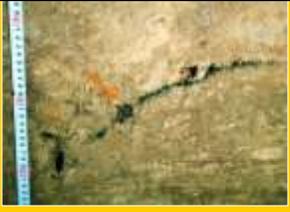
group

layer



Угли в материале отсыпки вывалов

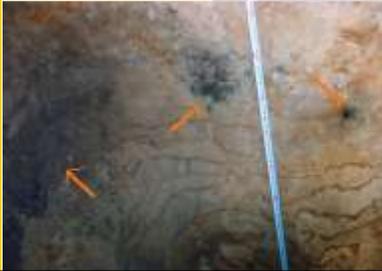
«слой»



единичные

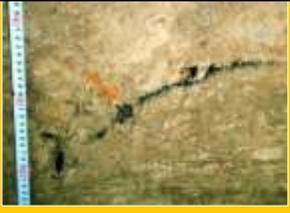


«пятно», «котел»



Charcoals in the past pits

“layer”



single



“cauldrons”



We can range different forest ecosystems by fires scale/frequency

Traces of fires		Spruce and spruce-fir forest with domination		
		Tall herbs	Small herbs	Dwarf shrubs or green mosses
Traces of fires on pine trunks		no	rarely	usually
Char-coals in a soil	Form (shape)	lamellar	rounded or lamellar	rounded, lamellar, dispersed
	Frequency	single or agglomeration	single or agglomeration	agglomeration or layers (up to 7 layers)
	location	in past pits matter	in past pits matter, at the border litter/mineral horizon (rarely)	at the border litter/mineral horizon, in past pits matter

Экстенсивное природопользование

= интенсивное, «на пределе»,
использование ресурсов без активной
заботы об их возобновлении =>

=> большая площадь освоения /
воздействий



Ландшафты Центральной России
Миниатюры из "Альбома Мевверберга", 1661

Extensive nature management

intensive use of free goods without well care for good renewal =>

=> large area of impacts



Распашка Plowing



The most important factor – agriculture

All present-day forest ecosystem had deforestation phases in past most often they were arable land



Следы распашки в почве

Старопахотный горизонт
в песчаной почве

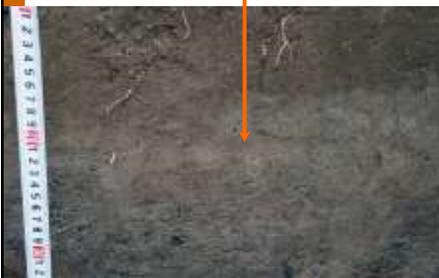
Подпахотный горизонт в
суглинистой почве



Traces of tillage/ploughing – in most part of soil profiles

Old-arable horizon
(sandy soil)

Subarable horizon =
undercrust (loamy soil)



Plows traces

Burned fertilizers matter

Soil profiles of different history



without agricultural use



**after agricultural use,
mainly slash-and-burn**

Komi republic, European Russia

Soil profiles of different history



without agricultural use



**after long-term
agricultural use, mainly
shifting agriculture**

Vologda region, European Russia

Soil profiles of different history



without agricultural use



**after long-term
agricultural use, mainly
three-field system
without fertilization**

Kaluga region, European Russia

Особенности воздействий на экосистемы, связанные с экстенсивным природопользованием

- **разнообразие воздействий и их сочетаний**
- **многократность воздействий на каждый участок**
- **периодичность нарушений часто меньше продолжительности оборота поколений деревьев**

Features of human impacts on ecosystems under extensive nature management

- Diversity of impacts and their combinations
- Multiple impacts on the same plot
- Periodicity of forest disturbances often less of tree life
less than time of trees generations rotation

In soil:

Multiple alternation of soil surface transformation,
illuviation, and tree-fall pedoturbations

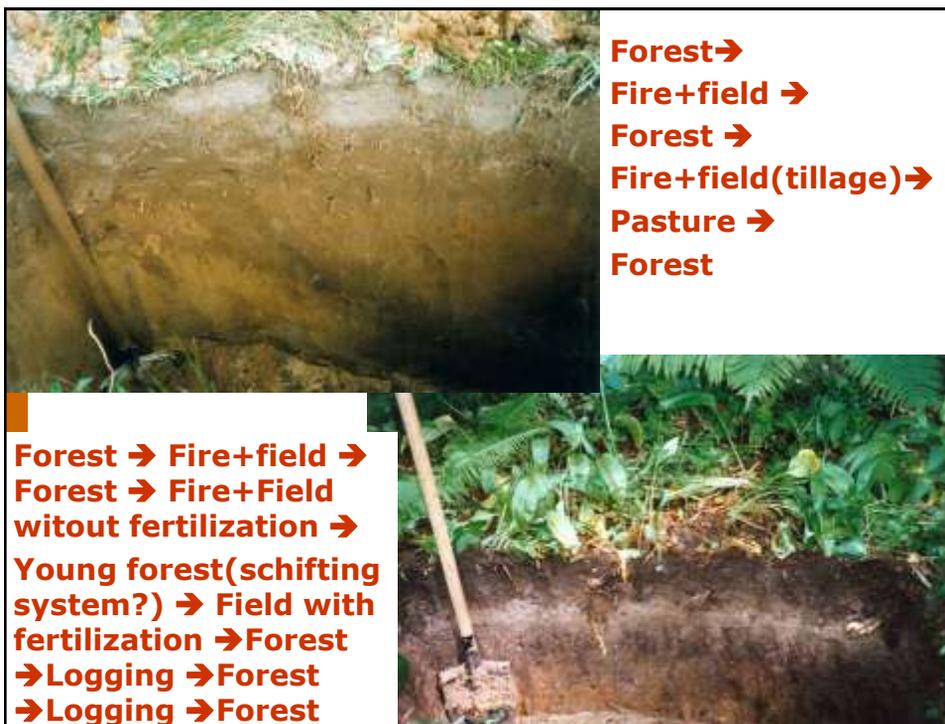
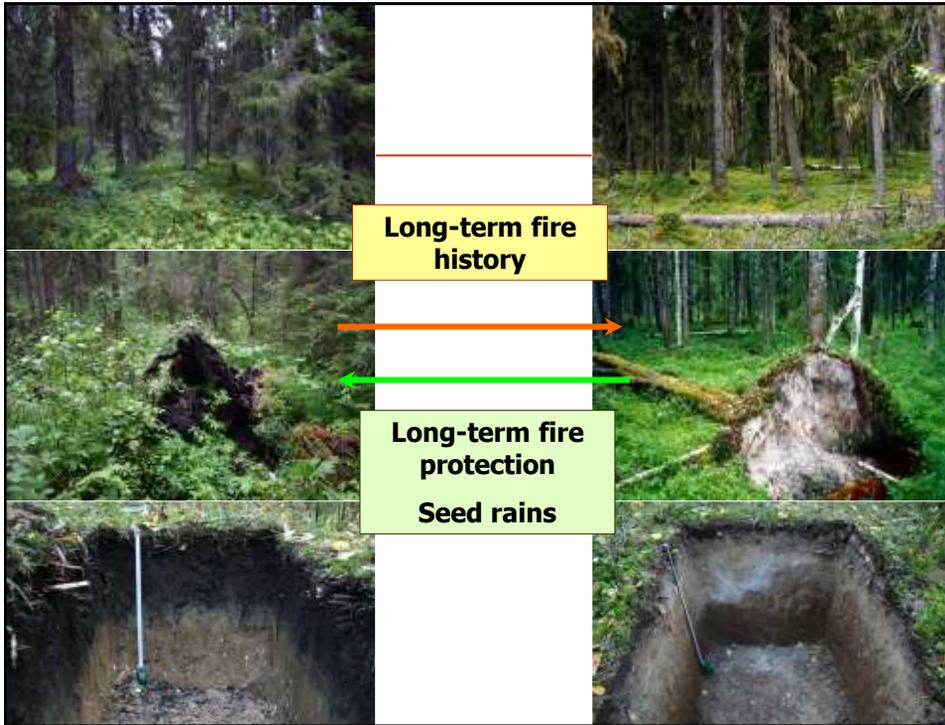
Slash-burn cultivation and fires were the
main factors of boreal soil degradation led
to uncolored mineral horizon E evolution

Horizon B is mainly developed by **multiple
bioturbation of degraded soils** and by
attendant soil processes (gleyzation,
mineralization, hydromorphy etc.)



<p>Гар-мозаика</p> <p>Разновозрастные ветровалы</p> <p>Высокое видовое разнообразие растений</p> <p>Активность почвенной мезофауны</p> <p>Модер/муль гумус</p> <p>Нет подзолистого горизонта</p> <p>...</p>		<p>Слабо развита гар-мозаика</p> <p>Единичные или массовые ветровалы</p> <p>Низкое видовое разнообразие растений</p> <p>Низкая активность почвенной мезофауны</p> <p>Мор/модер гумус</p> <p>Подзолистый горизонт</p> <p>...</p>
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<p>Tall herb forests</p> <p>Tree-fall mosaics</p> <p>High plant diversity</p> <p>Many tree uprooting</p> <p>Pedofauna activity</p> <p>Moder/mull humus</p> <p>No E horizon</p> <p>...</p>		<p>Dwarf shrub or green moss forests</p> <p>Low expression of tree-fall mosaics</p> <p>Low plant diversity</p> <p>Rarely tree uprooting</p> <p>Pedofauna incomplete</p> <p>Moor/moder humus</p> <p>E horizon</p> <p>...</p>
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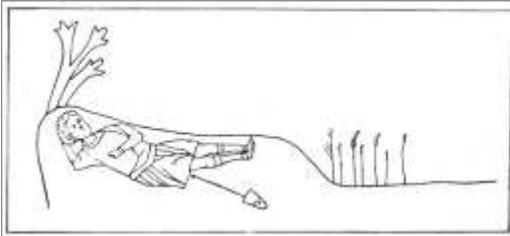
Homogeneous profile with A/H horizon is a result of **long-term free development** of spruce or spruce-fir forests



**Thank You
for Your Attention!**



Licevoj svod, XVI c. Moscow



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