Influence of land-use and land cover changes on iron oxides in boreal soils

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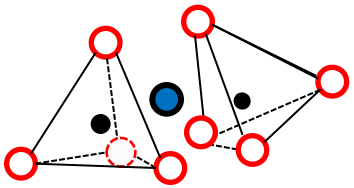
Chemical processes of iron in a soil system

Primary Rocks



Oxygen

Silica

Weathering

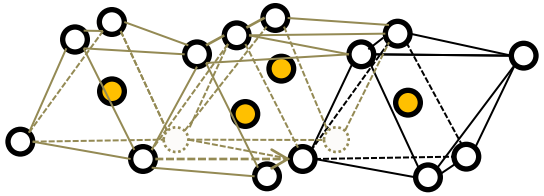
Fe^{2+}

Oxidation

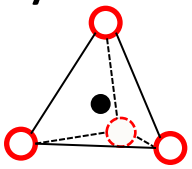
Fe^{3+}

Precipitation as oxides or hydroxides

Iron oxides (hydroxides) (Secondary minerals)

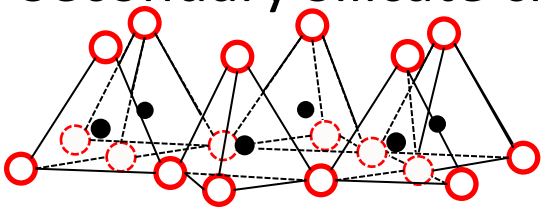


Silicate crystal unit

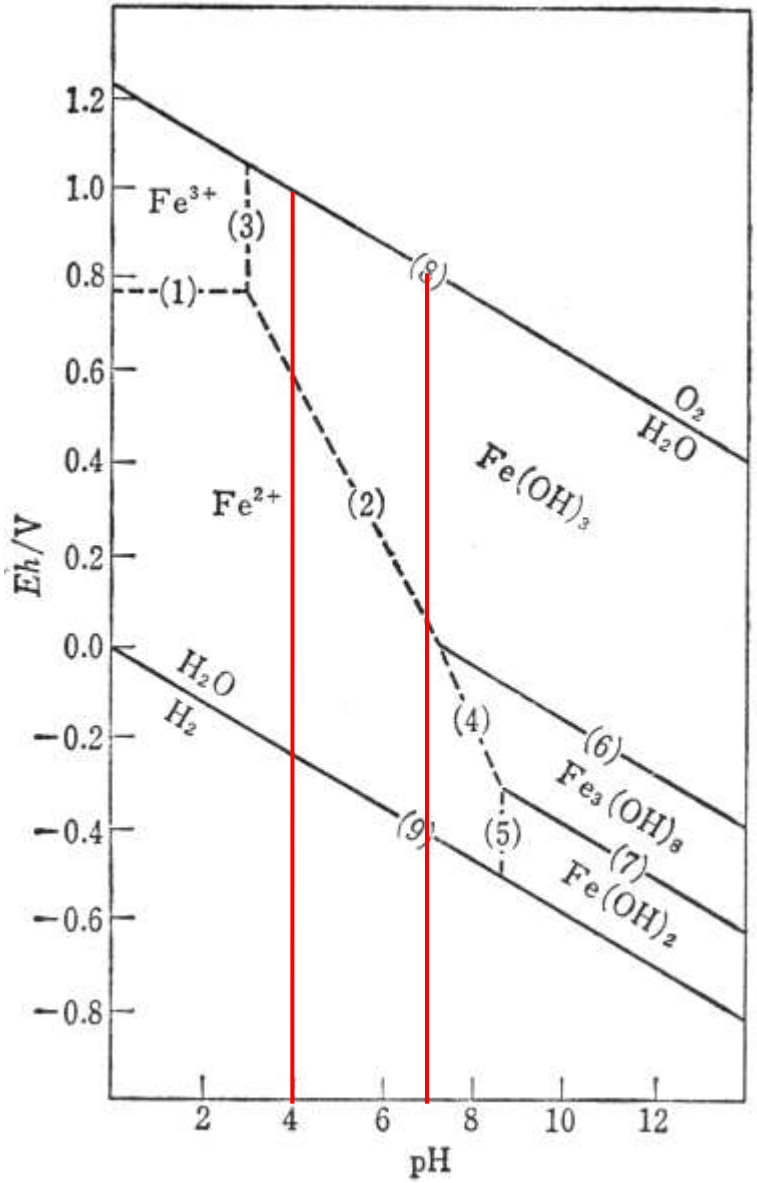


Re-crystalization

Secondary Silicate crystals



Chemcial process of iron in a soil system



Type of the secondary iron oxides indicates **soil conditions** controlled by **land-use**.

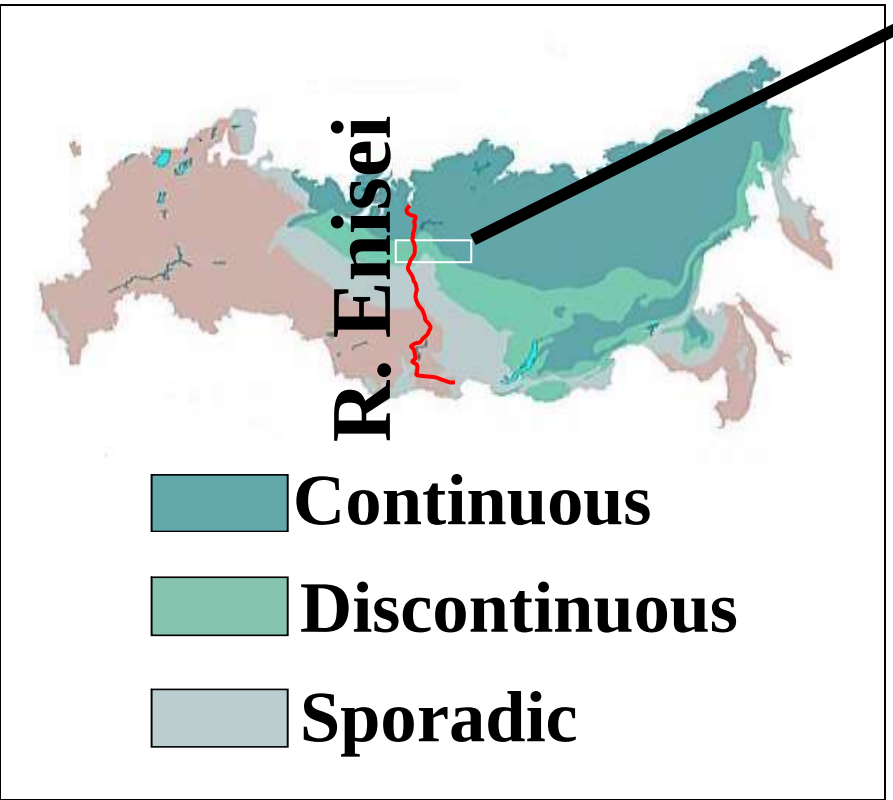
I.Implications for forest fires controlling soil surface cover.

II.Implications for land-use controlling soil moisture conditions.

Burned sites in permafrost distributing area

(64° N、100° E)

ca. 860km from Enisei



Forest Fire and Deforestation

- Changes in albedo
- Deepening permafrost table
- Thinning surface vegetation cover
- Decrease in organic horizons
- Increasing soil temperature

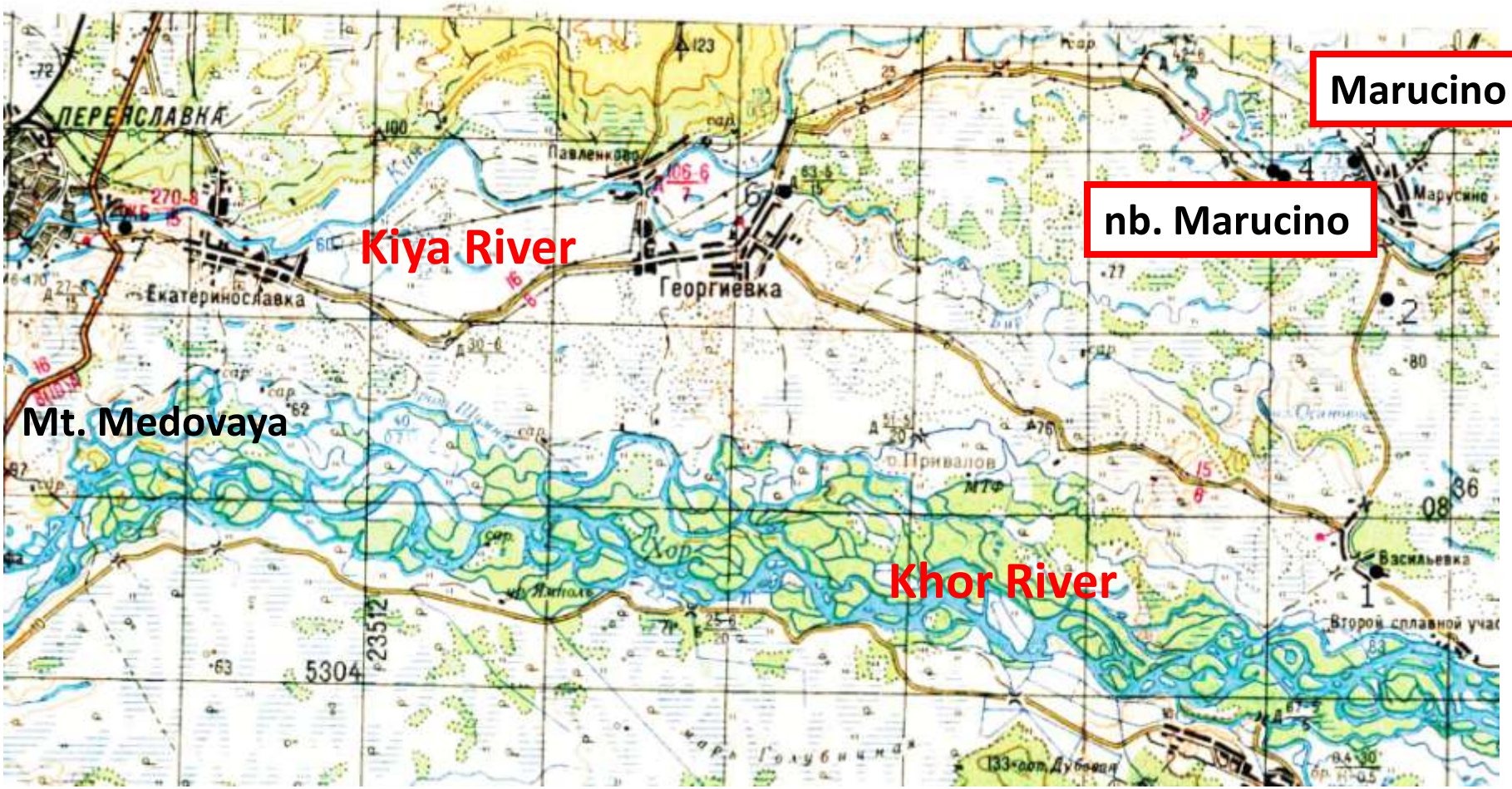
→ **Oxidative conditions in soils**

Soil Profiles

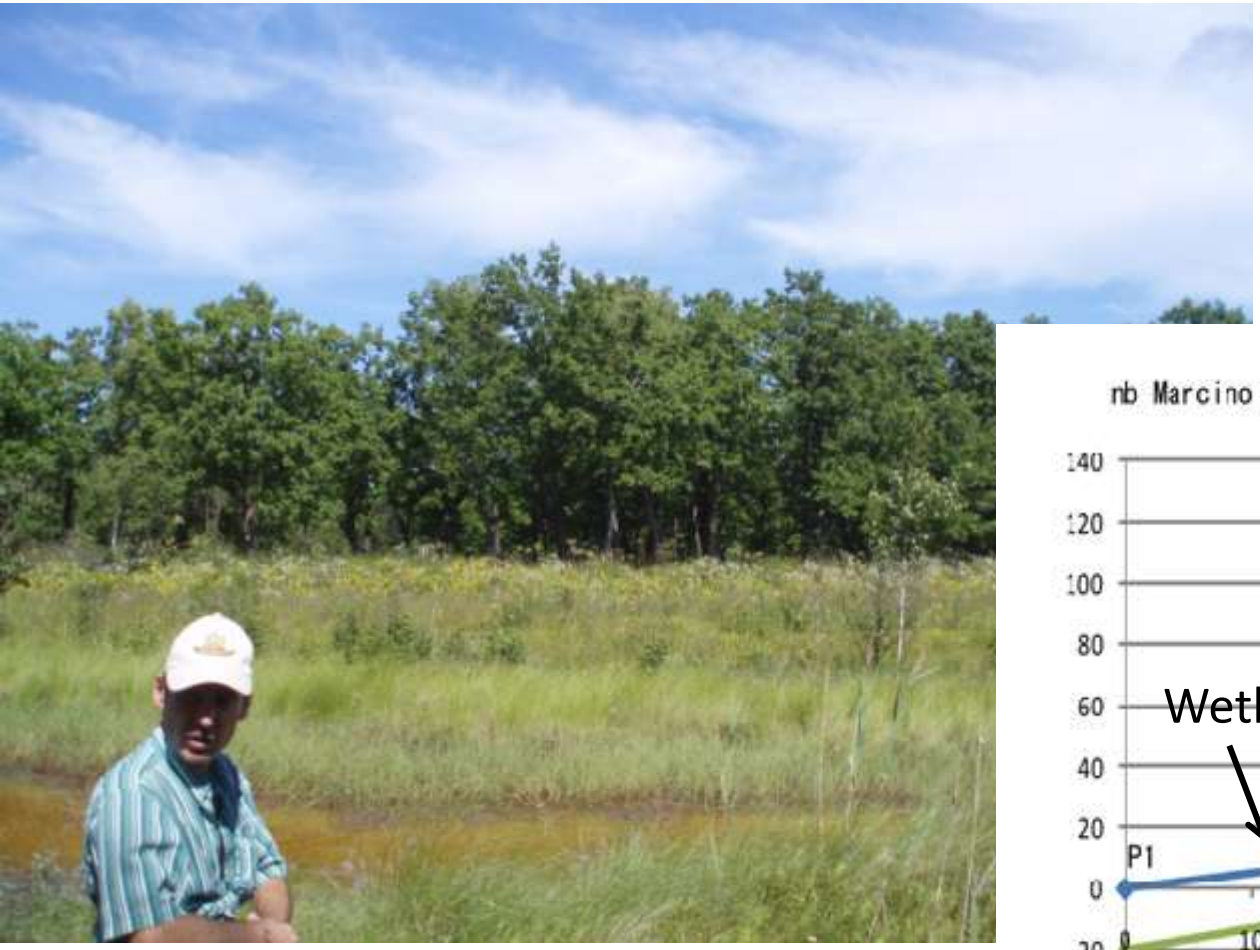
- Deepening the permafrost tables
- Soil color changed into brownish

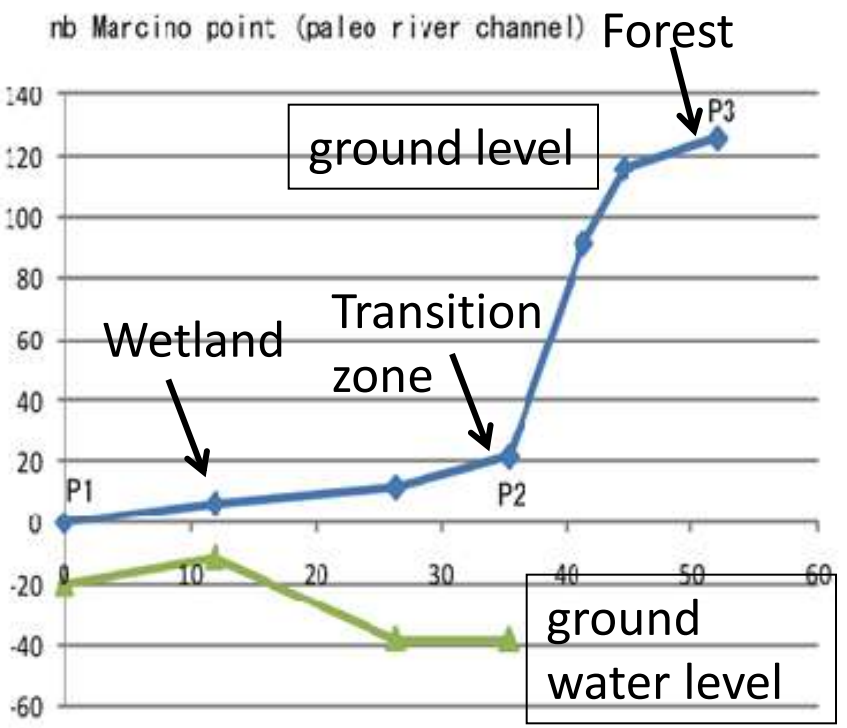
Location of research sites near Khabarovsk

Sampling sites along Kiya River



Vegetation change with topography





Produced by Dr. Yamagata

Soil profiles

nb. Marcino site

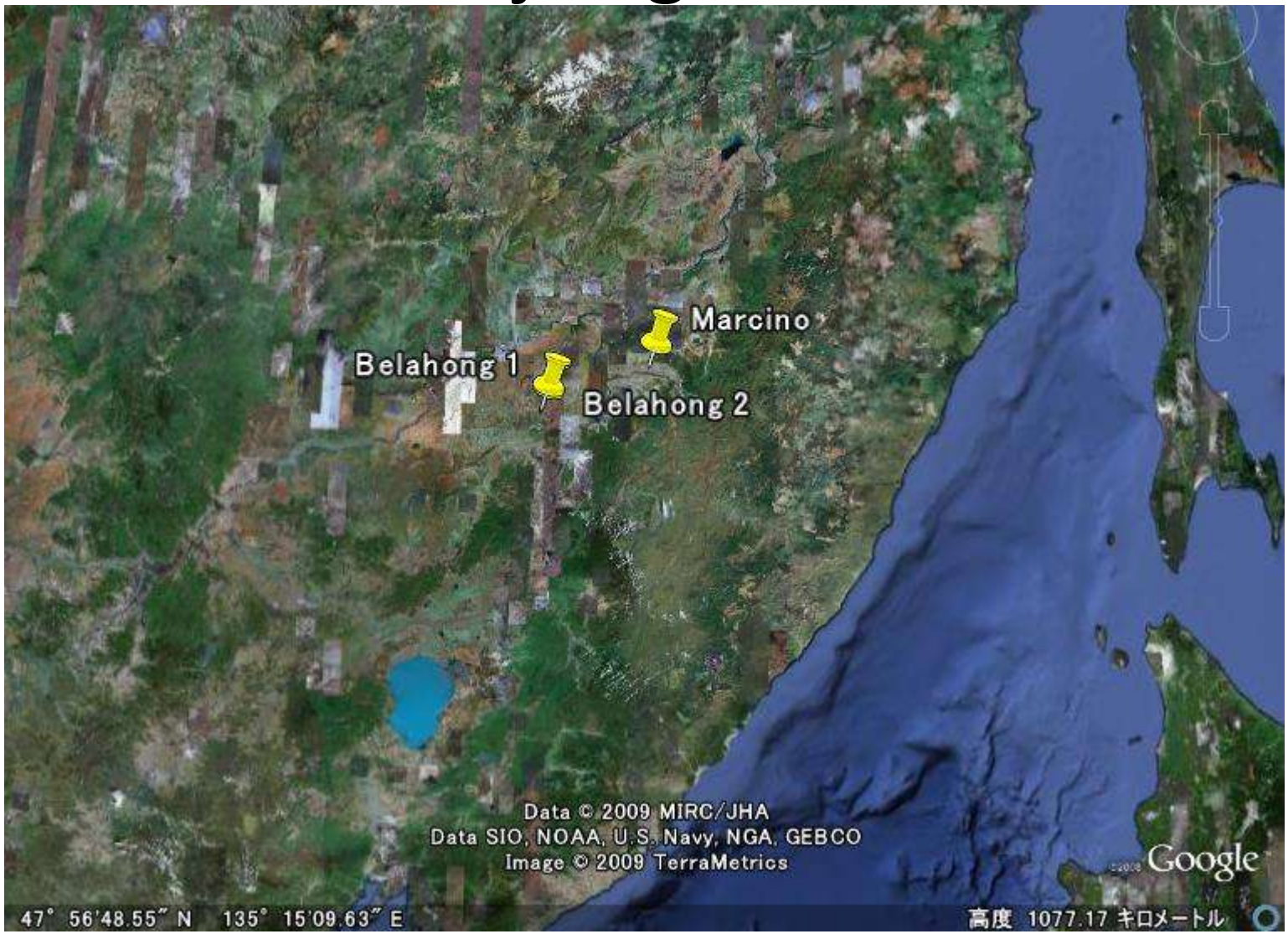
Brownish and oxidative

Soil profiles

Marcino site

Brownish and oxidative

Location of research sites in the Sanjiang Plain



Land-use change

- Changes in ground water level
- Periodical Water drainage control
- Changes in soil moisture conditions

Oxidative conditions

Iron species based on solubility

Free Iron oxides (Iron oxides composed of crystallized & amorphous Fe)

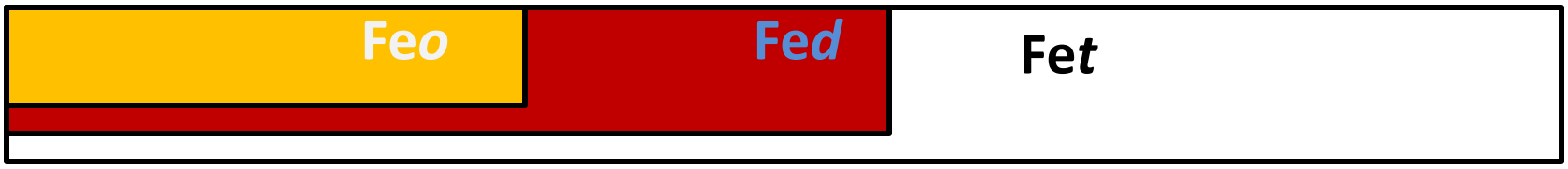
Fe*d* : **Extracted using citrate buffer solution with dithionite. After reducing soil samples with dithionite, Fe^{2+} extracted by chelating action of citrate.**

Amorphous Iron oxides

Fe*o* : **Extracted using oxalate buffer solution under acidic condition (pH 3.0). Under acidic condition, amorphous iron oxides can be extracted by chelating action of oxalic acids.**

Fe*o*/Fe*d*: **Reactivity of iron oxides.**

(Fe*d*-Fe*o*)/Fe*t*: **Indicator for crystallization of iron oxides.**



Methods for determination of types of Fe

Feo:

A 0.3g of air-dried soil

↓

Falcon tube (50mL)

← 30mL of Oxalate buff. (pH 3.0)

↓

Shaking for 4 hours (under a dark condition)

↓

Filtration (filter paper)

↓

Filtrate is collected In a falcon tube (15mL)

Fed:

A 0.6g of air-dried soil

↓

Falcon tube (50mL)

← 30mL of Citrate buff. (with 0.6 g ditionite powder)

↓

Shaking for 16 hours

↓

Filtration (filter paper)

↓

Filtrate is collected In a falcon tube (15mL)

Fet:

A 0.5g of air-dried soil

← Na_2CO_3

↓

Pt crucible

↓

Heating in the muffle furnace at 920C

← HCl conc.

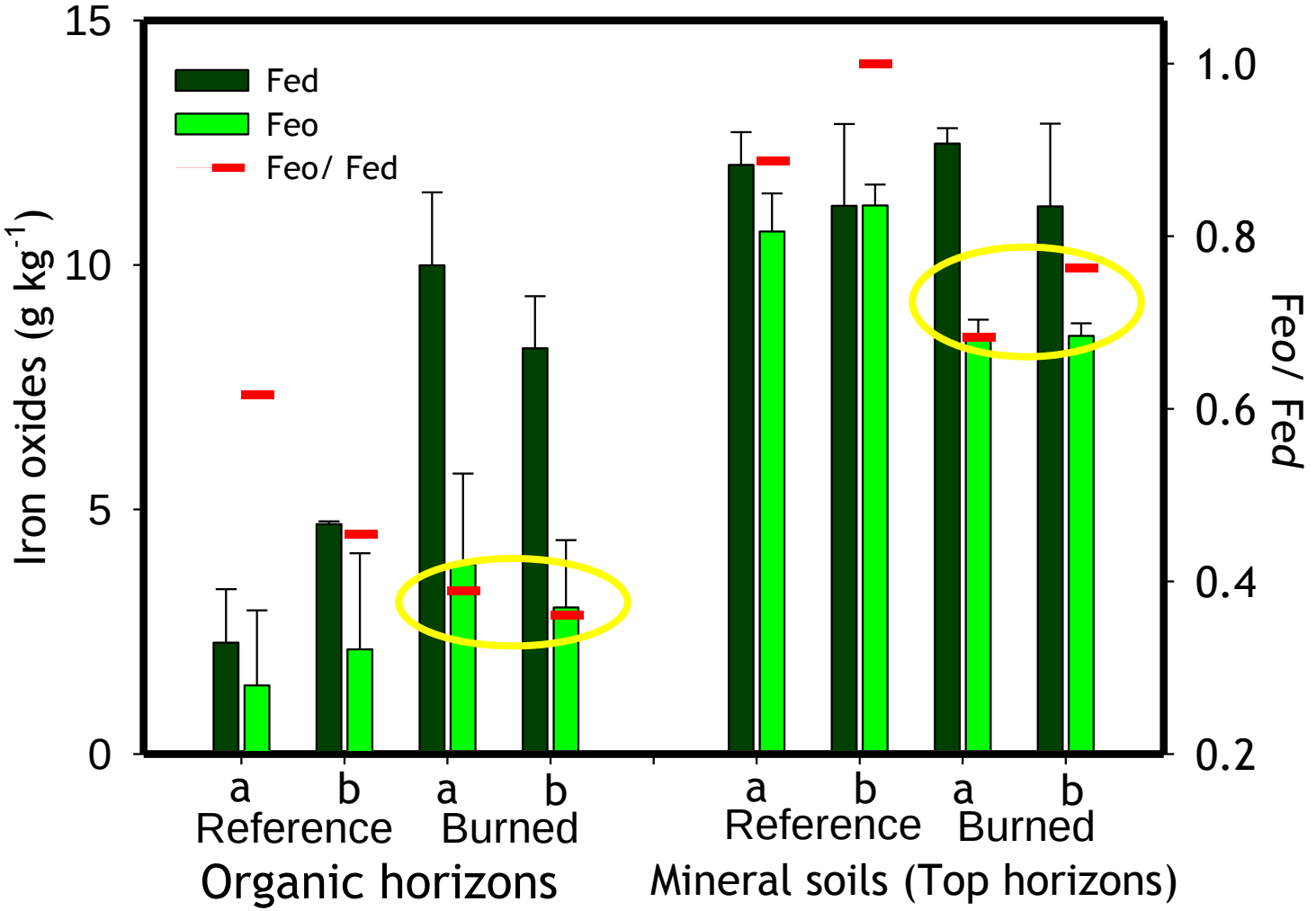
↓

Heating in the water bath at 70C

↓

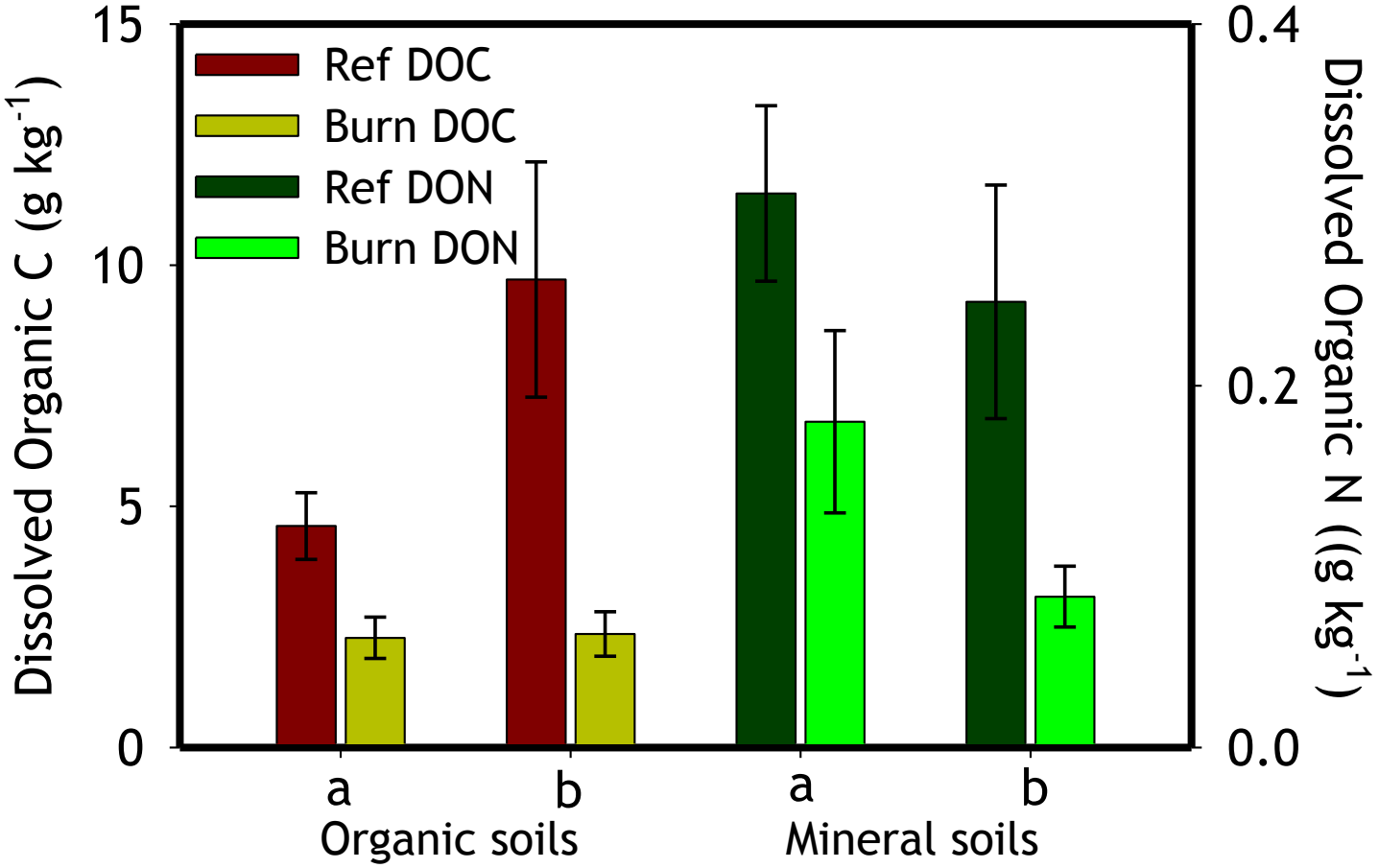
Filtrate is collected in a volumetric flask

Iron oxides in soils at burned sites



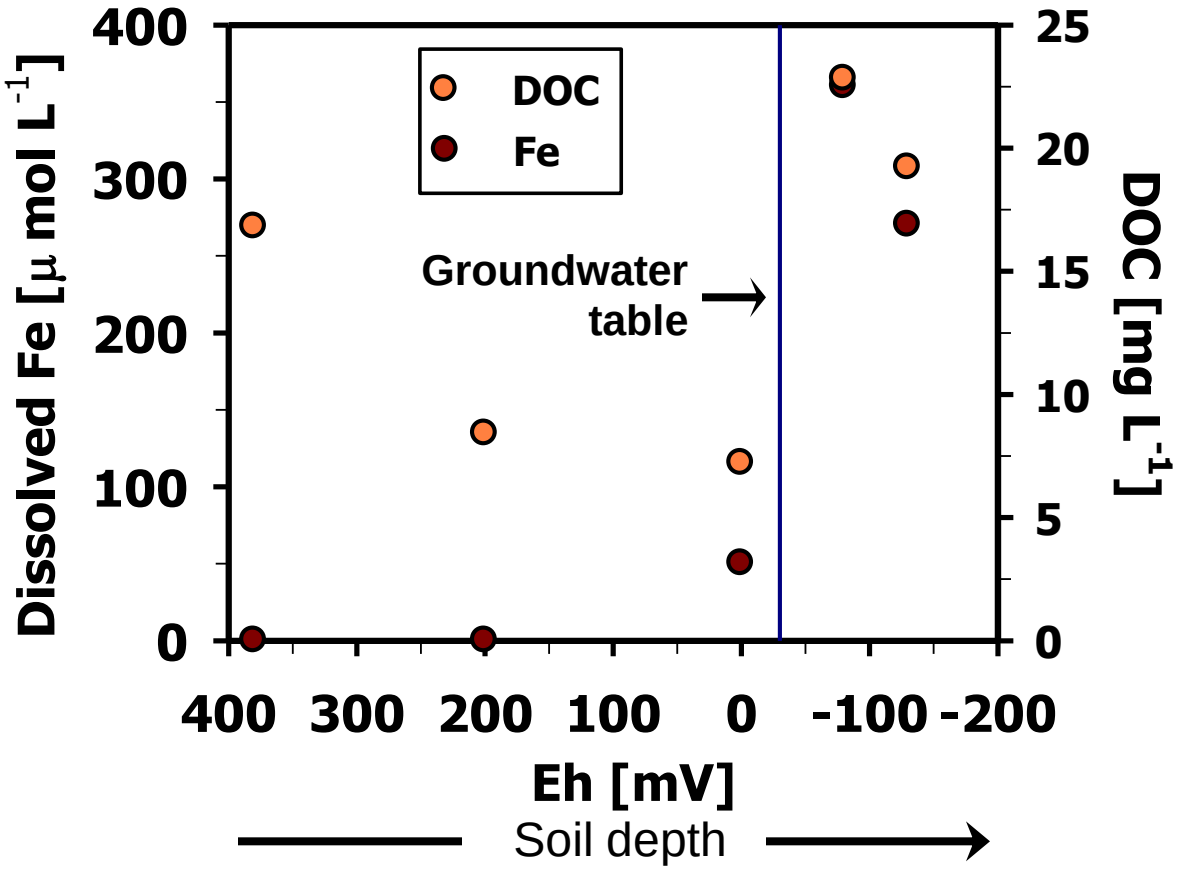
a: after 10 years b: after 25 years since last forest fires.

Soluble organic matter released from organic horizons



a: after 10 years b: after 25 years since last forest fires.

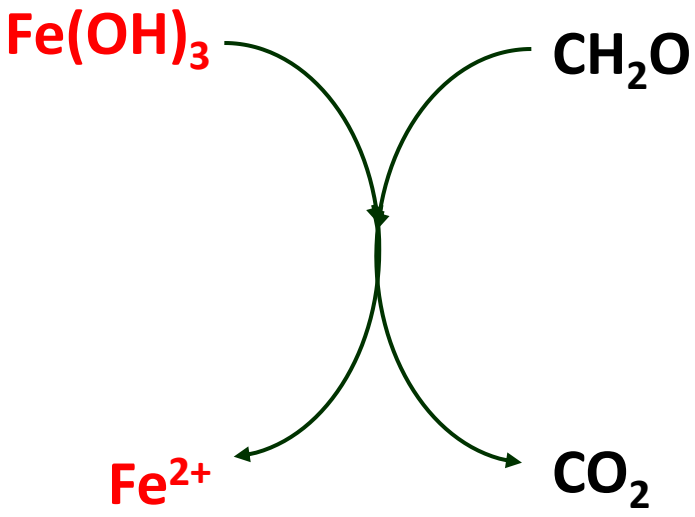
DOC concentrations and dissolved (ferric) Fe in a Gleysol



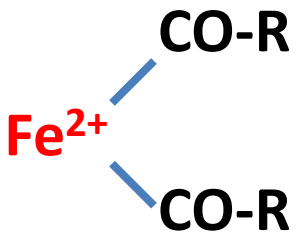
Hagedorn et al. (2000)

Contribution of labile DOM for Fe dynamics

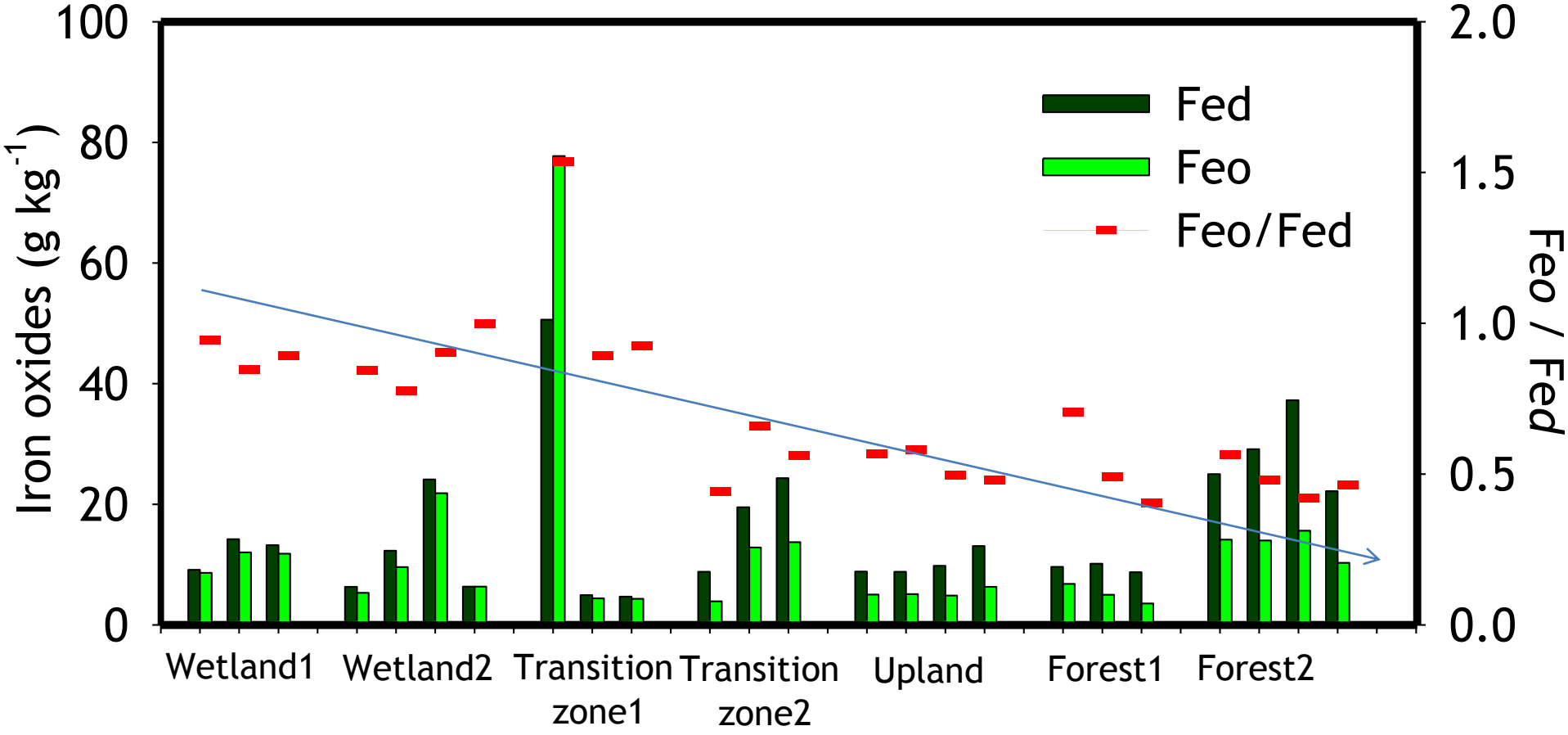
Reduction by labile DOM (Sugars, Amino acids..)



Chelation and transportation by refractory DOM (humic substances)

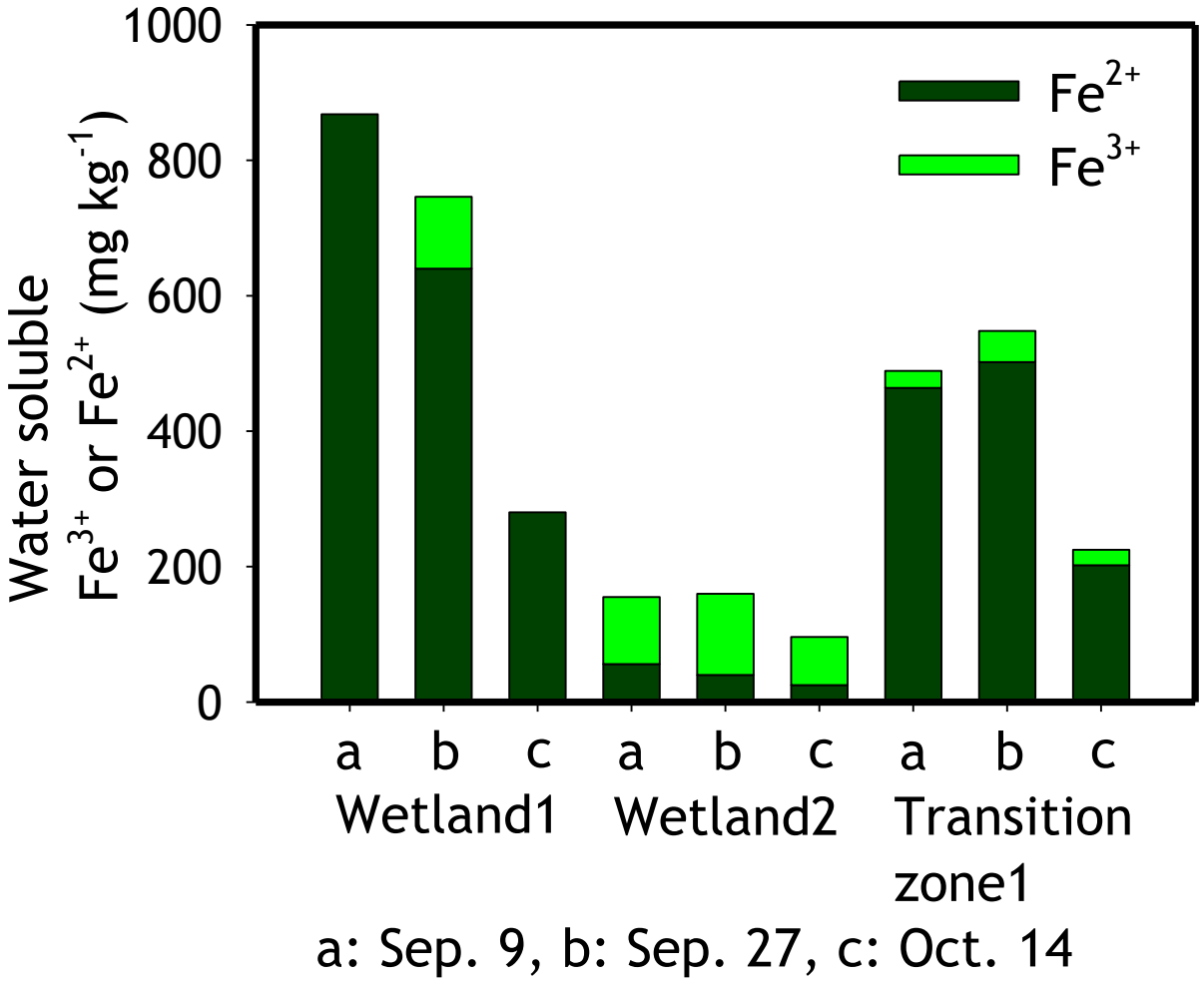


Iron oxides in different land-uses along the Kiya River near Khabarovsk



From left to right in a test site each bar is the surface to the bottom horizons.

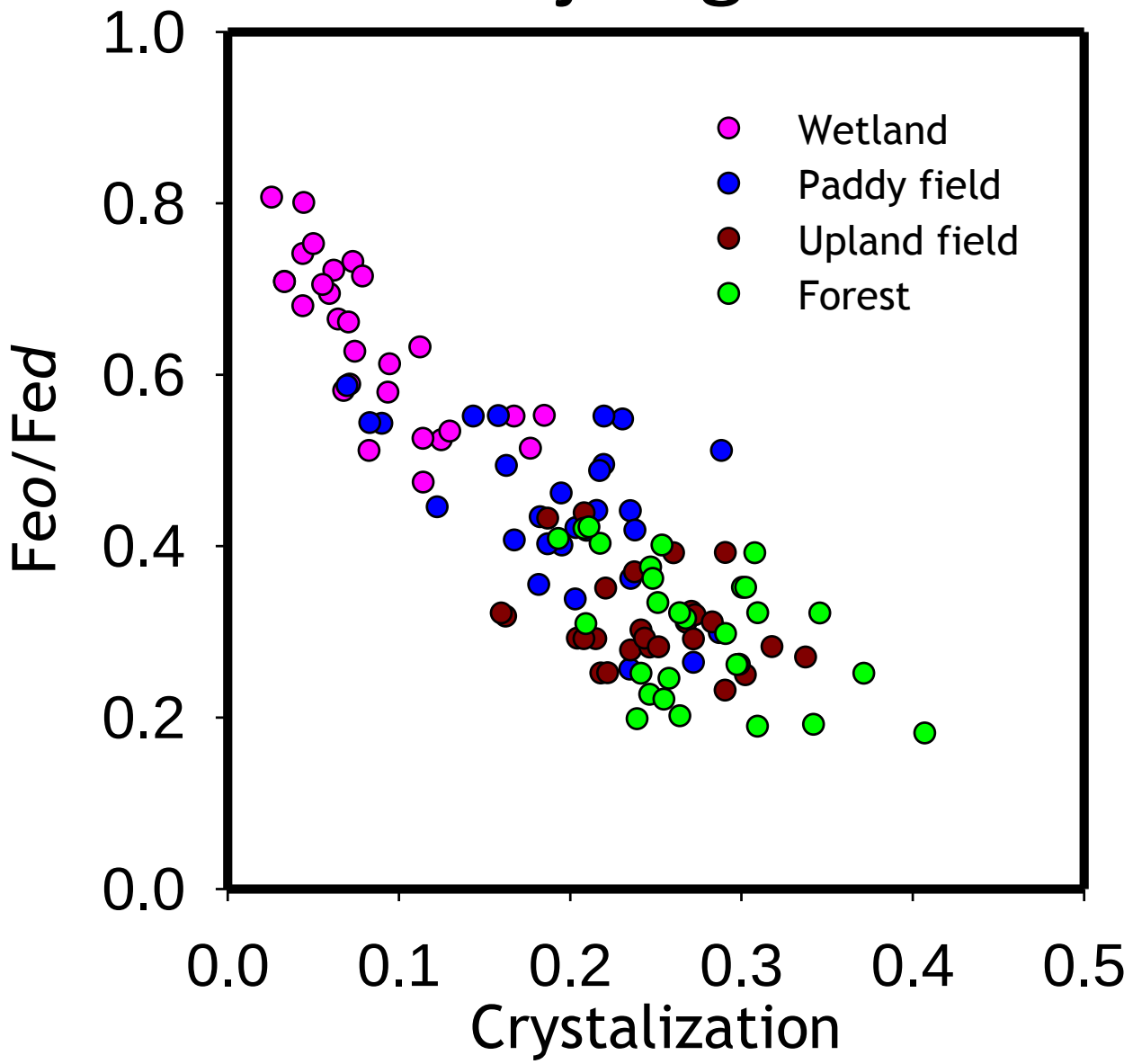
Dissolved Fe in surface waters



a: Sep. 9, b: Sep. 27, c: Oct. 14

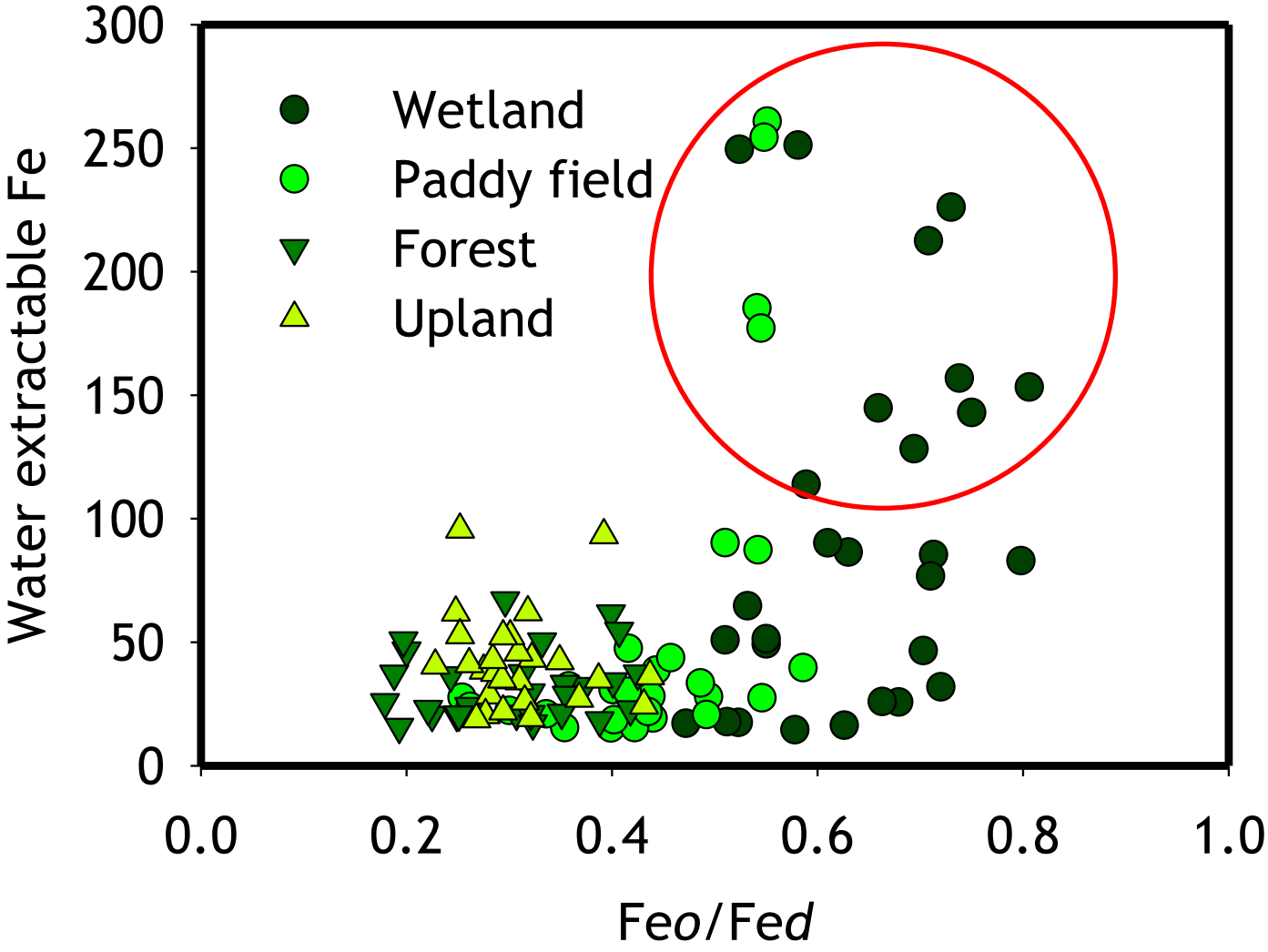
Data from "Report on the research in the Amur Basin, Amur Liman and Sakhalin bay in 2008"

Type of iron oxides in different land-uses in the Sanjinag Plain



Data from "Research on the Distribution of Soil Chemistry and Fe Dynamics in Sanjian Plain for 2008"

Water soluble Fe from soils in the Sanjiang Plain



Data from "Research on the Distribution of Soil Chemistry and Fe Dynamics in Sanjian Plain for 2008"

Conclusion

- The rate of amorphous iron oxides was lower in burned forest sites.

↓

Forest fire makes soils oxidative due to deepening permafrost table and decreasing dissolved organic matter as a reductant or chelater for Fe.

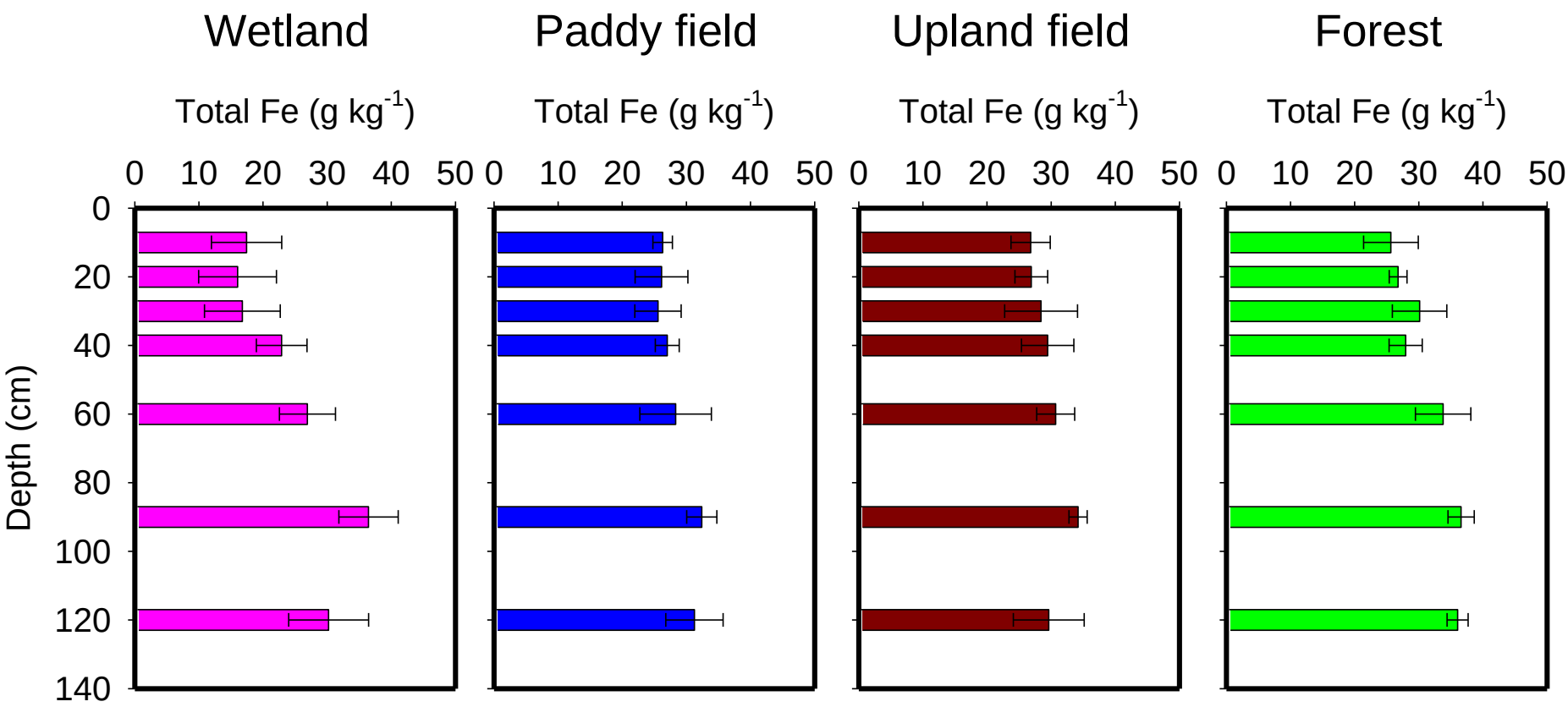
- Wetlands distributing along the Amur River contained greater amount of amorphous iron oxides as compared with other land-uses.
- Some wetlands and paddy fields showing high Feo/Fed can release lots of water soluble Fe.

↓

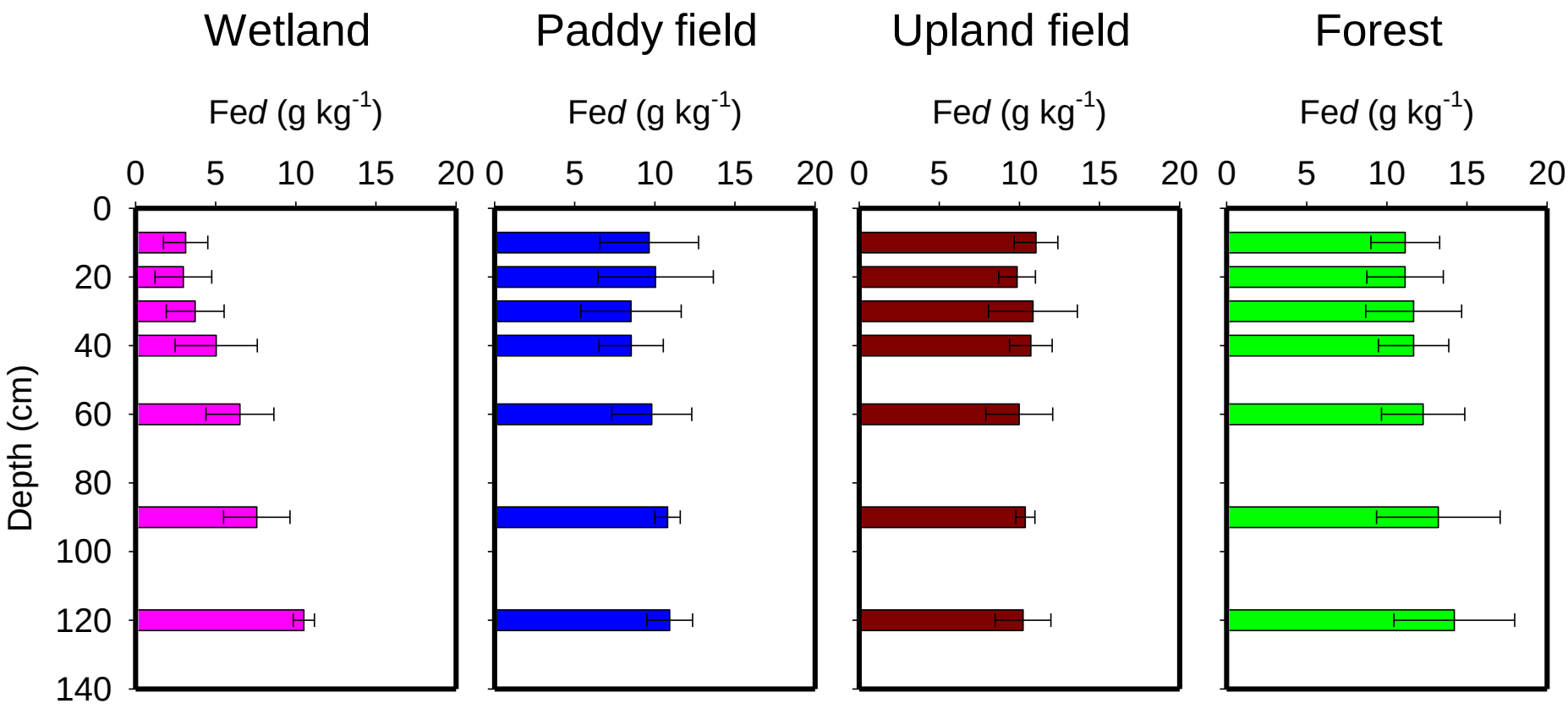
Reduced soil condition in wetlands and paddy fields can keep greater rate of amorphous irons. Concurrently those reduced soils can provide dissolved Fe to surrounding aquatic environment.


Thank you for your attention!

Total Fe


Wetland
Paddy field
Upland field
Forest
Total Fe (g kg-1)
0 10 20 30 40 50
Depth (cm)
0
20
40
60
80
100
120
140

Free Fe


Wetland
Paddy field
Upland field
Forest
Fed (g kg-1)
0
5
10
15
20
Depth (cm)
0
20
40
60
80
100
120
140

Amorphous Fe