International Conference | October 30 - 31 2017, Riga

BALTIC PATHWAY
TOWARDS LOW CARBON AND
CLIMATE RESILIENT DEVELOPMENT

Reducing, Mitigating and Adapting to Climate Change with Increasing Carbon Stock in Soils: Lithuanian Experience

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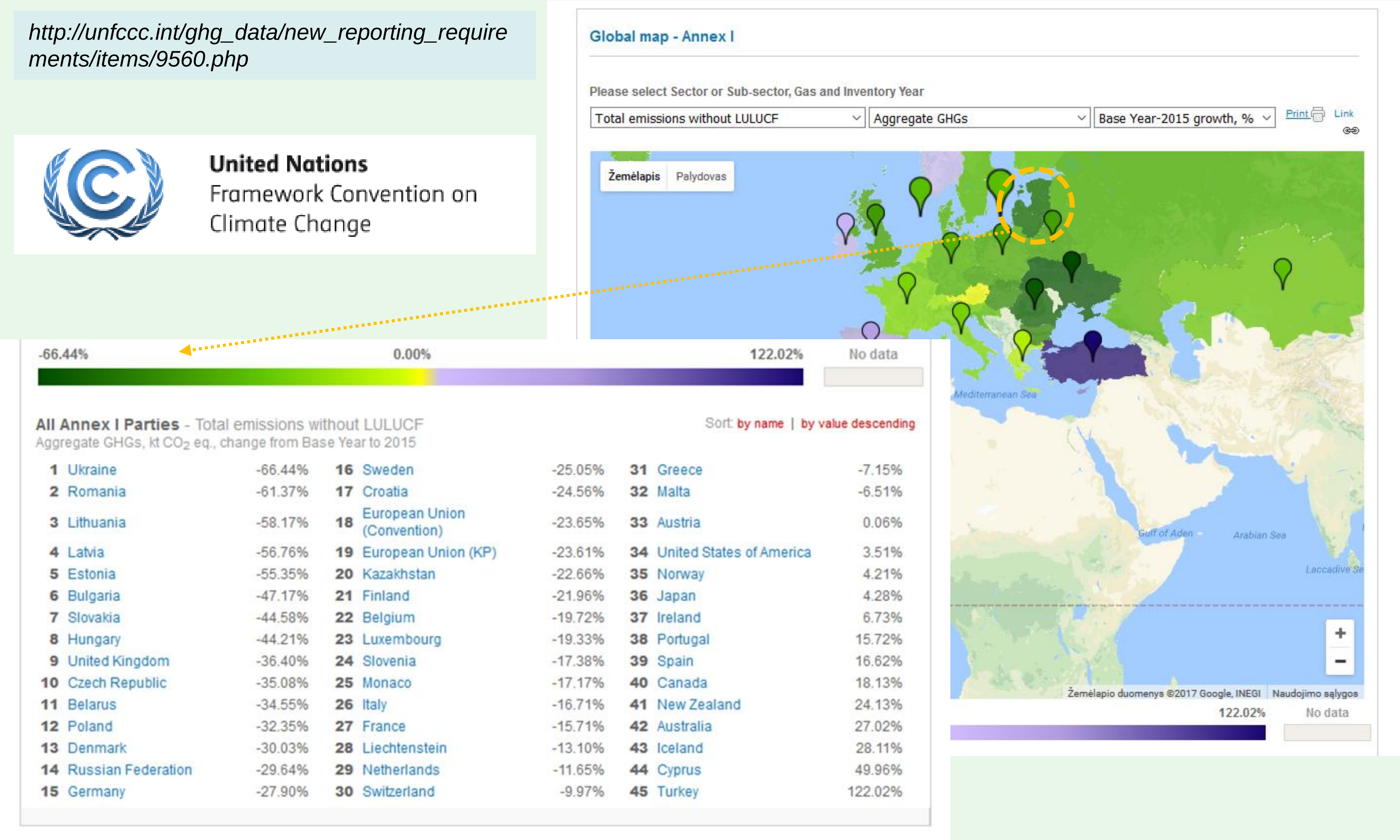
http://unfccc.int/ghg_data/new_reporting_requirements/items/9560.php

United Nations
Framework Convention on
Climate Change



Global map - Annex I

Please select Sector or Sub-sector, Gas and Inventory Year

Total emissions without LULUCF | Aggregate GHGs | Base Year-2015 growth, %

All Annex I Parties - Total emissions without LULUCF
Aggregate GHGs, kt CO$_2$ eq., change from Base Year to 2015

Sort: by name | by value descending

1	Ukraine	-66.44%
2	Romania	-61.37%
3	Lithuania	-58.17%
4	Latvia	-56.76%
5	Estonia	-55.35%
6	Bulgaria	-47.17%
7	Slovakia	-44.58%
8	Hungary	-44.21%
9	United Kingdom	-36.40%
10	Czech Republic	-35.08%
11	Belarus	-34.55%
12	Poland	-32.35%
13	Denmark	-30.03%
14	Russian Federation	-29.64%
15	Germany	-27.90%
16	Sweden	-25.05%
17	Croatia	-24.56%
18	European Union (Convention)	-23.65%
19	European Union (KP)	-23.61%
20	Kazakhstan	-22.66%
21	Finland	-21.96%
22	Belgium	-19.72%
23	Luxembourg	-19.33%
24	Slovenia	-17.38%
25	Monaco	-17.17%
26	Italy	-16.71%
27	France	-15.71%
28	Liechtenstein	-13.10%
29	Netherlands	-11.65%
30	Switzerland	-9.97%
31	Greece	-7.15%
32	Malta	-6.51%
33	Austria	0.06%
34	United States of America	3.51%
35	Norway	4.21%
36	Japan	4.28%
37	Ireland	6.73%
38	Portugal	15.72%
39	Spain	16.62%
40	Canada	18.13%
41	New Zealand	24.13%
42	Australia	27.02%
43	Iceland	28.11%
44	Cyprus	49.96%
45	Turkey	122.02%

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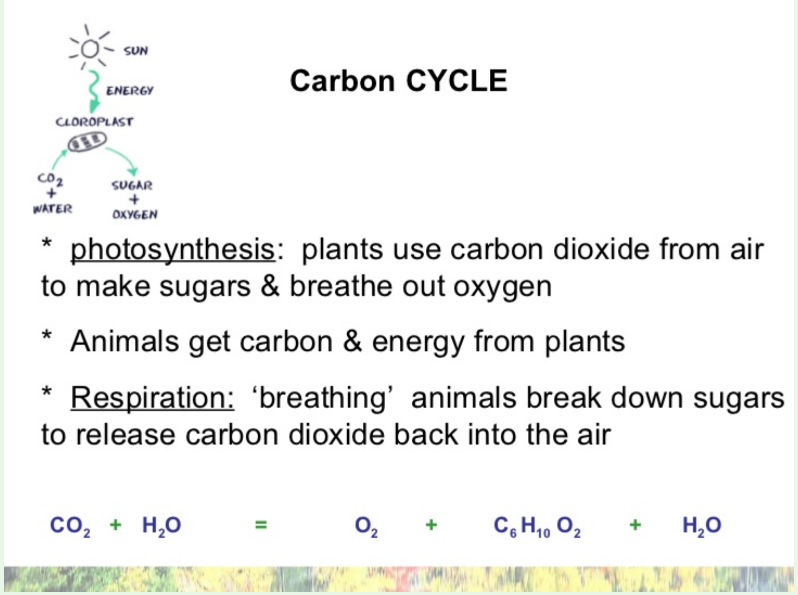


Carbon CYCLE

- photosynthesis: plants use carbon dioxide from air to make sugars & breathe out oxygen
- Animals get carbon & energy from plants
- Respiration: 'breathing' animals break down sugars to release carbon dioxide back into the air

$$CO_2 + H_2O = O_2 + C_6H_{10}O_2 + H_2O$$

Plant Biology Europe
EPSO/FESPB 2016 Congress
Prague, Czech Republic | June 26–30, 2016

DO WHEAT YIELD-POTENTIAL AND STRESS-RESILIENCE GO HAND-IN-HAND?

João Paulo Pennacchi[1,2], P John Andralojc[2], Tracy Lawson[3], Christine Raines[3], Martin AJ Parry[1,2], Elizabete Carmo-Silva[1,2]

[1]Lancaster Environment Centre, Lancaster University, UK, [2]Plant Biology and Crop Science, Rothamsted Research, UK; [3]School of Biological Sciences, University of Essex, Colchester, UK

ORGANIC CARBON CYCLE

P : Photosynthesis - incorporation of carbon into plants

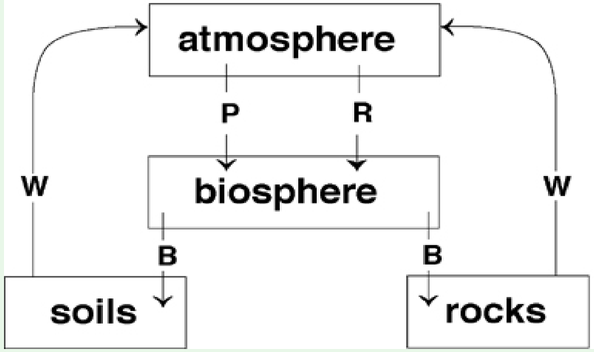
R : respiration and decay - oxidation of organic matter

B : burial of matter

W : exposure and weathering of buried organic matter (involves oxidation)

$$P : CO_2 + H_2O \xrightarrow[\text{sunlight}]{} CH_2O + O_2$$

$$R,W : CH_2O + O_2 \xrightarrow[\text{energy released}]{} CO_2 + H_2O$$



atmosphere
P
R
biosphere
W
W
B
B
soils
rocks

Improving land management and checking degradation and deforestation are *win-win* options: they are desirable for the purpose of alleviation and sustainability and measures increasing C sequestration in soils, thus making investments in the agricultural/rural sector more beneficial to farmers.

REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS The implementation of the Soil Thematic Strategy and ongoing activities (COM/2012/046 final).

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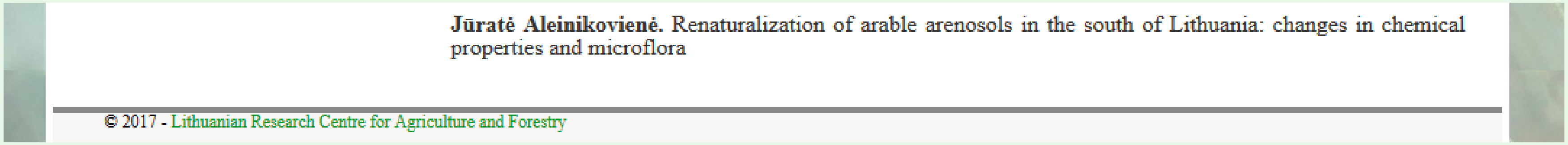
Study was financially supported by the research programme “Productivity and sustainability of agricultural and forest soils” implemented by Lithuanian Research Centre for Agricultures and Forestry 2005-2009.



Jūratė Aleinikovienė. Renaturalization of arable arenosols in the south of Lithuania: changes in chemical properties and microflora

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PROJECT AIM... The natural or artificial afforestation is mostly common in <u>*unsuitable for agriculture or in abandoned former arable land*</u>. Such afforestation of inappropriate farming and unused state land could be relevant with the focus on carbon sequestration. This is especially important for the European Union countries committed to reduce CO_2 emissions following the Kyoto Protocol and reducing the negative effects of the climate change (Feller, Bernoux, 2008).

Due to the formation of a thin humus horizon in the surface of mineral soil, <u>*carbon stock increases in the surface 0–5 cm mineral soil layer but decreases in the deeper (5–25 cm) layer*</u>. Therefore, the initial carbon pools in 20–30 cm thick mineral topsoil tend to decrease during the first 5–10 years following afforestation of arable land. Such an increase is especially considerable in the nutrient-poor sandy soils with a low carbon stock (Armolaitis et al., 2007; Xiong et al., 2014).

ALEINIKOVIENĖ J., ARMOLAITIS K., ČESNULEVIČIENĖ R., ŽĖKAITĖ V., MURAŠKIENĖ M., 2017. The status of soil organic matter decomposing microbiota in afforested and abandoned arable *Arenosols.* Zemdirbyste-Agriculture, vol. 104, No. 3 (2017), p. 195-202.

Table 1. Mean parameters of *Arenosol* in Scots pine plantations and adjacent abandoned former arable land of the Perloja experiment (adopted from Armolaitis et al., 2007)

Horizon	Biotope (depth)	pH_{CaCl2}	SOC g kg^{-1}	N g kg^{-1}	P_2O_5 mg kg^{-1}	K_2O mg g^{-1}
OL	plantations	3.7 ± 0.2	**545.7 ± 6.0**	9.4 ± 1.1	325 ± 37	584 ± 49
	arable land	**5.6 ± 0.2**	360.6 ± 17.2	10.9 ± 0.7	**650 ± 30**	**2593 ± 101**
OF + OH	plantations	3.6 ± 0.2	**386.7 ± 26.0**	8.1 ± 1.7	247 ± 6	384 ± 5
	arable land	**5.0 ± 0.1**	252.5 ± 16.5	9.3 ± 0.4	**660 ± 35**	**2815 ± 142**
Ap (0–2 cm)	plantations	3.6 ± 0.2	**28.7 ± 1.6**	**2.3 ± 0.2**	58 ± 8	146 ± 18
	arable land	**5.5 ± 0.2**	8.4 ± 1.0	1.3 ± 0.1	**136 ± 8**	179 ± 4
Ap (2–10 cm)	plantations	4.7 ± 0.4	**6.5 ± 0.3**	0.5 ± 0.1	50 ± 5	51 ± 2
	arable land	**6.0 ± 0.2**	5.7 ± 0.3	**1.0 ± 0.1**	**148 ± 11**	**114 ± 4**

Note. OL – litter horizon of organic layer, OF + OH – fragmented + humus horizons of organic layer (OH horizon was not found in abandoned arable land), Ap – former ploughed mineral horizon; means (n = 3) ± standard errors are given; significantly ($p < 0.05$) outstanding parameters are shown in bold.

ARMOLAITIS K., ALEINIKOVIENĖ J., BANIŪNIENĖ A., LUBYTĖ J., ŽĖKAITĖ V. 2007. Carbon sequestration and nitrogen status in *Arenosols* following afforestation or following abandonment of arable land. Baltic Forestry, 13, 2 (25): 169–178.

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The partnership project between Norway and Lithuania
“THE PARTNERSHIP PROJECT ON GREENHOUSE GAS INVENTORY“

The studies in LULUCF sector: Organic carbon stock values research in national forest, non-forest land and forest products

1. Study for evaluation of carbon stocks in forest land and non-forest land in soil and forest litter.

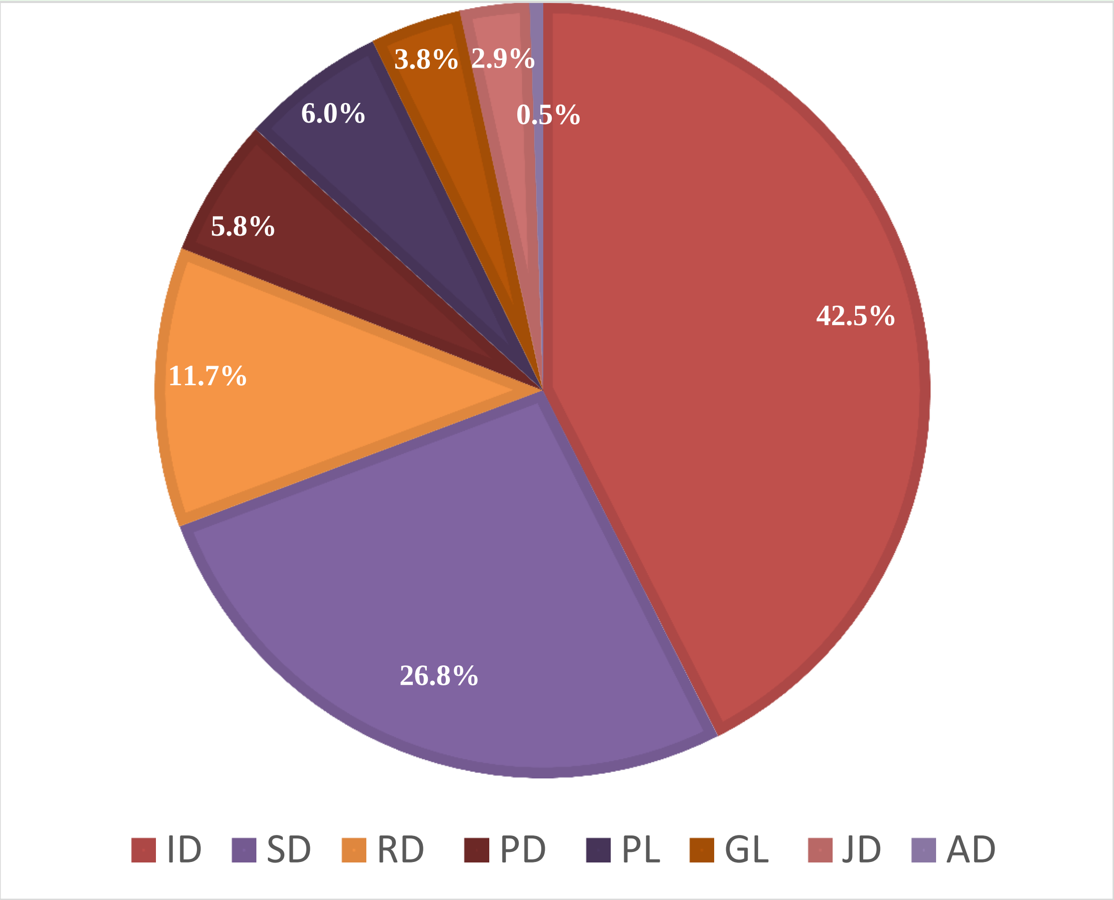
2. Study for evaluation of carbon stocks in soil and forest litter in forests that were afforested and reforested on non-forest land.

3. Study for evaluation of carbon stocks in dead organic matter (dead wood) analyzing various degrees of dead wood decomposition rates.

4. Study for development of the harvested wood products (HWP) accounting system and preparation of relevant accounting methodology.

- **PROJECT AIM... – to estimate soil organic carbon (SOC) stocks in Lithuanian forests, croplands and grasslands:**
  - **in forest floor (OL+OF+OH soil organic horizons) and plant litter (OL) of perennial grassland;**
  - **in surface 0-30 cm mineral or peat layer of major soil groups (LTDK-99; WRB, 2014);**
  - **in forest floor and surface 0-30 cm layer of different forest sites (according to Lithuanian classification, Vaičys et al., 2006);**
  - **in forest stands of different species composition and different age.**

ARMOLAITIS K., VARNAGIRYTĖ-KABAŠINSKIENĖ I., STAKĖNAS V., ŽEMAITIS P., ARAMINIENĖ V., MURAŠKIENĖ M., 2017. ASSESSMENT OF CARBON STOCKS IN MINERAL AND ORGANIC SOILS IN FOREST AND AGRICULTURAL LAND IN LITHUANIA. 6th International Symposium on Soil Organic Matter, 3-7 September 2017, Harpender (UK).



9 major soil groups*:*

ID - Luvisols + Retisols **(n=324)**
SD – Arenosols **(n=204)**
RD – Cambisols **(n=89)**
PD – Histosols **(n=44)**
PL – Planosols **(n=46)**
GL – Gleysols **(n=29)**
JD – Podzols **(n=22)**
AD – Fluvisols **(n=4)**

Figure 1. Distribution of major soil groups (WRB, 2014) in sample plots

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ARMOLAITIS K., VARNAGIRYTĖ-KABAŠINSKIENĖ I., STAKĖNAS V., ŽEMAITIS P., ARAMINIENĖ V., MURAŠKIENĖ M., 2017. ASSESSMENT OF CARBON STOCKS IN MINERAL AND ORGANIC SOILS IN FOREST AND AGRICULTURAL LAND IN LITHUANIA. 6th International Symposium on Soil Organic Matter, 3-7 September 2017, Harpender (UK).

SOC stocks

Table 2. Mean stocks of soil organic carbon (SOC) in surface 0-30 cm layer of major soil groups in forests

Major soil groups (WRB, 2014)	**Average in Europe, (de Vos et al., 2015)**	**LULUCF default values* (IPCC, 2006)**	**Average in Lithuania (2016 m.; number of plots, n)**
Cambisols	**75**	**95**	**118 (n=8)**
Luvisols+Retisols	**73**	**95**	**96 (n=130)**
Planosols	**45**	**95 (?)**	**81 (n=26)**
Arenosols	**50**	**71**	**58 (n=92)**
Podzols	**63**	**115**	**100 (n=21)**
Gleysols	**94**	**87**	**106 (n=20)**
Histosols	**181**	**-**	**154 (n=37)**
Fluvisols	**64**	**-**	**80 (n=3)**

Cold temperate, moist region

ARMOLAITIS K., VARNAGIRYTĖ-KABAŠINSKIENĖ I., STAKĖNAS V., ŽEMAITIS P., ARAMINIENĖ V., MURAŠKIENĖ M., 2017. ASSESSMENT OF CARBON STOCKS IN MINERAL AND ORGANIC SOILS IN FOREST AND AGRICULTURAL LAND IN LITHUANIA. 6th International Symposium on Soil Organic Matter, 3-7 September 2017, Harpender (UK).

Pan-European demonstration project, part of the programme of the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests
Research funded by a grant (No. MIP-038/2010) from the Research Council of Lithuania.

BioSoil Project and SOC in Lithuanian Forests (2006-2008; 2010)

PROJECT LEADER dr. Ričardas BENIUŠIS,
Lithuanian Forest Service

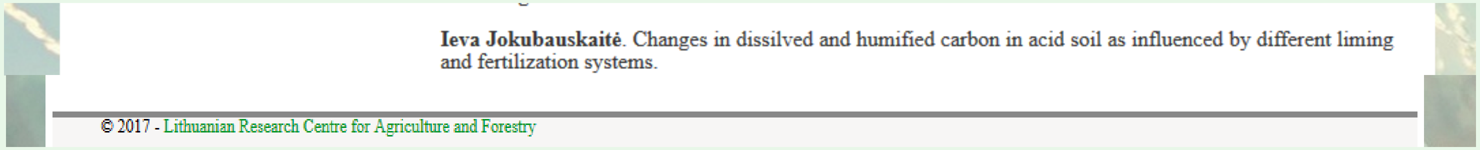
PROJECT AIM... was to assess the stability of soil organic carbon (SOC) in *Arenosols* within three different arable land use: (1) continuous arable land; (2) abandonment; and (3) afforestation with Scots pine (*Pinus sylvestris* L.) or silver birch (*Betula pendula* Roth).

Soil organic matter refers to a complex of large and amorphous organic molecules and particles derived from the humification of aboveground and belowground litter, and incorporated into the soil, either as free particles or bound to mineral soil particles. It also includes organic acids, dead and living microorganisms, and the substances synthesized from their breakdown products (IPCC, 2003, Chapter 3).

Photo by D.Karčauskienė, 2015

BENIUŠIS R., ARMOLAITIS K., ALEINIKOVIENĖ J., LUBYTĖ J., ŽĖKAITĖ V., GARBARAVIČIUS P., 2012. Comparative Study on Stability of Soil Organic Carbon in Forest and Agro Ecosystems. International IUFRO&APW&COST&ENV Conference “Biological Reactions of Forests to Climate Change and Air Pollution”, Aleksandras Stulginskis University, 18-26 May, 2012, Kaunas, Lithuania

Figure 2. Sampling and cooperation Lithuania-Denmark-Finland.



Ieva Jokubauskaitė. Changes in dissolved and humified carbon in acid soil as influenced by different liming and fertilization systems.

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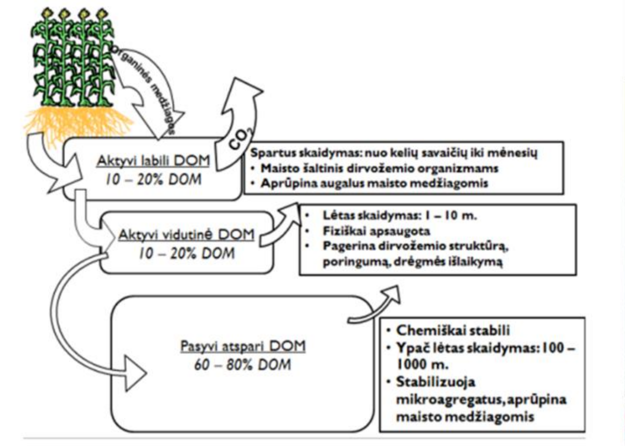
PROJECT AIM... *determine the changes of soil organic carbon chemical fractions and to estimate their relationship with the other soil chemical properties as influenced by different liming and fertilization systems in a naturally acid soil.*



*•In general **3 main mechanisms of SOM stabilization** have been defined (Six et al., 2002):*
1)Physical protection (OC occluded/protected in 53–250 μm sized soil microaggregates).
2)Chemical stabilization (OC associated with silt and clay).
3)Biochemical stabilization (OC biochemically protected in non-hydrolyzable SOM including stabile humus fractions)

SOC stability

•Various types of SOM have different turnover time: from < 10 years (active SOM pools) to > 500 years for OC resistant to the oxidation (von Lützow et al., 2007; Guggenberger, 2010).

•Dissolved and water extractable SOC, soil microbial biomass C, and SOC in light fraction (SOC not occluded in 53-250 μm sized microaggregates) reflect active SOC pool (Six et al., 2002; von Lützow et al., 2007).

•The silt and clay content and the microaggregation in mineral soils protect SOM from the microbial decomposition.

The results obtained in this study highlight the special relevance of limed and organic fertilizer – applied soils to the environmental quality, because organic carbon is sequestered and stored in stable forms in these soils.

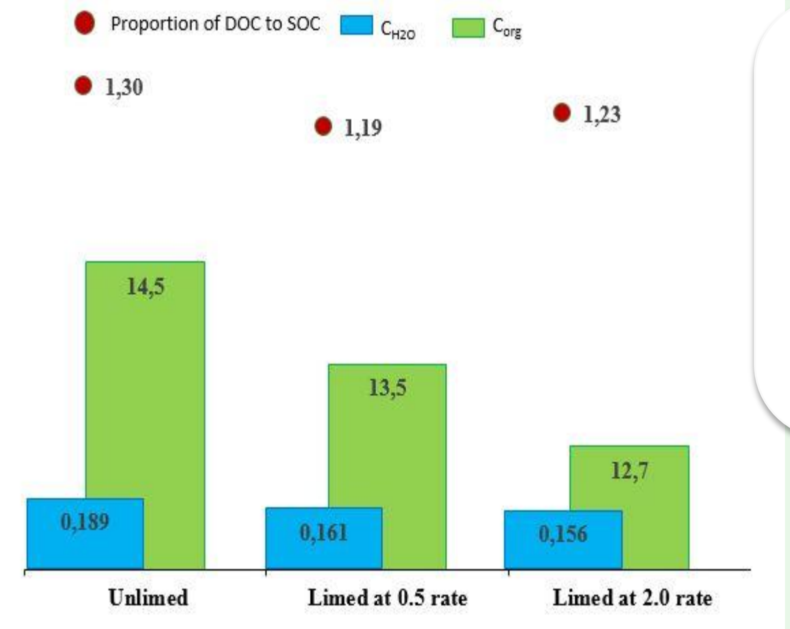


Figure 3. The interaction between soil organic carbon (g kg^{-1}), dissolved organic carbon and the DOC share from SOC under different liming.

The pH is an important chemical factor for the solubility and production of DOC and the relationship between pH and DOC is generally thought to be a complex one, partly because of the influence on charge density of the humic compounds, partly because of stimulation of the microbial activity. The amount of DOC in soil increased with increasing soil pH. This relationship could be attributed to differences in decomposition rates (higher at elevated pH), differences in DOC sorption to the soil complexes and complex formation with aluminium, and differences in DOC quality (phenol content lower at high pH and therefore more readily decomposable DOC)

An important consistent pattern of carbon transformation was identified – the changes in labile fraction of carbon were influenced by the land use. Application of lime, promotes the increase of the share of DOC in SOC, leading the decline of stability of SOC and the soil becomes more prone nutrient leaching, degradation and erosion. Fertilization promotes carbon transformation processes (changes in humified carbon fractions influencing intensive organic matter humification processes) in the soil.

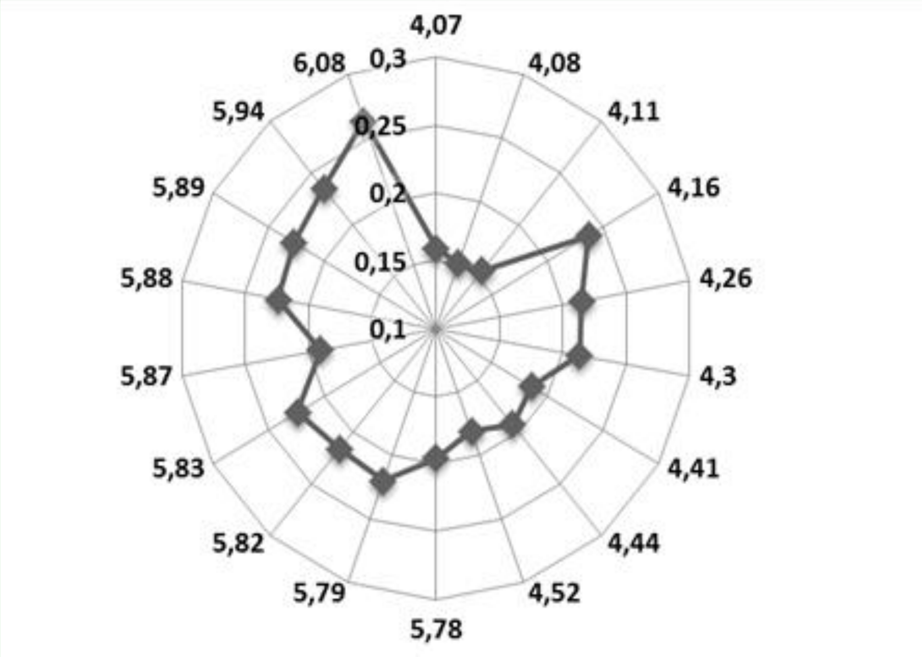


Figure 4. Changes of dissolved organic carbon content (g kg $^{-1}$) in soil at different pH levels. External graph axis displays different pH levels, internal graph axis - dissolved organic carbon content (g kg $^{-1}$) in soil.

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Research was done on the project "The influence of long-term contrasting intensity resources management on genesis of different soils and to other agro-ecosystems components” (SIT-9/2015) of the National Scientific Programme “Sustainability of Agro-Forest and Water Ecosystems” financed by Research Council of Lithuania (2015-2020)

As an important part of the carbon cycle, atmospheric concentrations of CO_2 are naturally regulated through ecosystem respiration and uptake by photosynthesis. With increased anthropogenic emissions, the ability of terrestrial ecosystems to sink carbon dioxide is of high importance.

When studying C stocks and fluxes in agriculture, forest, and peatland ecosystems, it is often helpful to consider the C stored in the basic components of biomass and soil.

KLIMATO KAITA DURPYNUOSE: HALOCENO ŽENKLAI IR DABARTINĖS TENDENCIJOS; ĮTAKA BIOĮVAIROVEI IR ANGLIES DEPONAVIMUI DURPĖSE (CLIMPEAT, WWW.CLIMPEAT.LT).

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Figure 5. Influence of soil water content on CO$_2$ efflux in loam

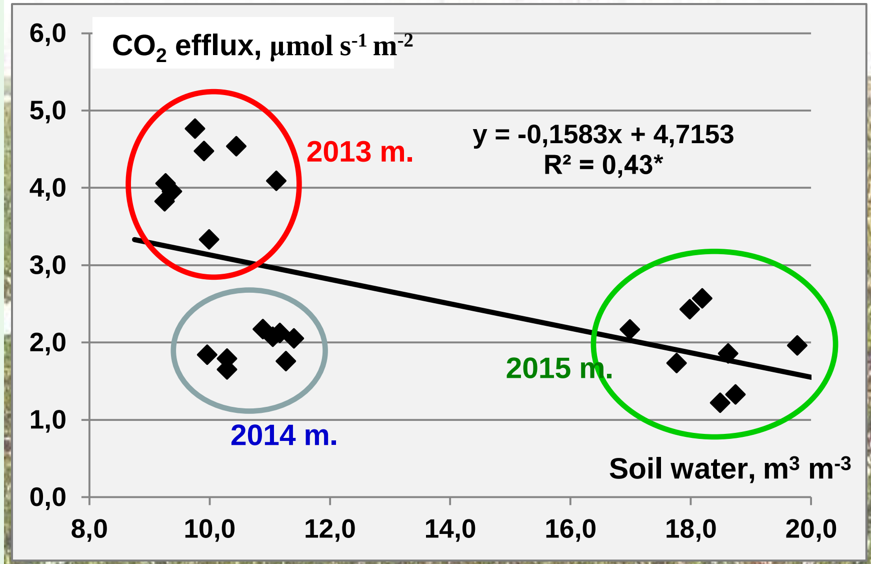
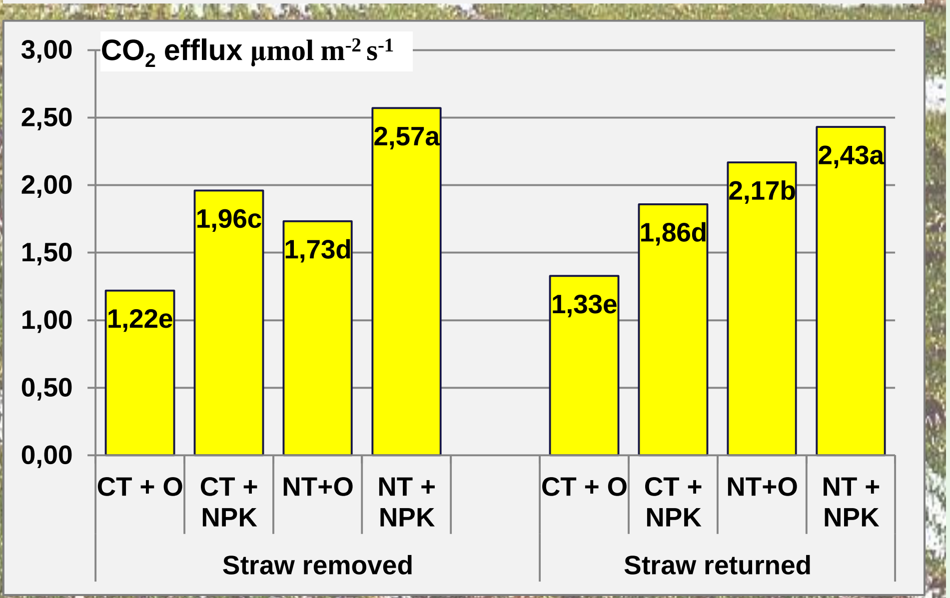


Figure 6. Influence of soil tillage, fertilization and residue handling on mean soil CO2 efflux during winter wheat growing period in loam



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This research was supplemented in the frame of the support from the Research Council of Lithuania (grant number: SIT-8/2015; research project "Composite impact of climate and environmental change on productivity, biological diversity and sustainability of agro-ecosystems" in the frame of National Research Program "Sustainability of Agro, Forest and Water Ecosystems").

- even while over the **16 years** the mean annual temperature increased on average by 1.14 °C and mean annual precipitation expanded on average by 113 mm, soil tillage systems as well as steady plant rotation and cover crop treatment **have influenced the accumulation of SOC.**
- along the conventional tillage the pools of SOC were not increasing, while shallow rotovating, cover cropping and no-tillage have been processed, the accumulation of **SOC have increased on average by 1.5 folds in ploughed (0-20 cm) horizon.**

- in uppermost (0-10 cm) mineral soil layer along the minimized tillage **the C:N ratio and microbial biomass accumulation have been increasing**.
- **minimized soil tillage system** following the climate change **intensifies the accumulation of SOC as well as humification**.

Project „Optimal catch crop solutions to reduce pollution in the transboundary Venta and Lielupe river basins“ LLI-49 (2017-2019)

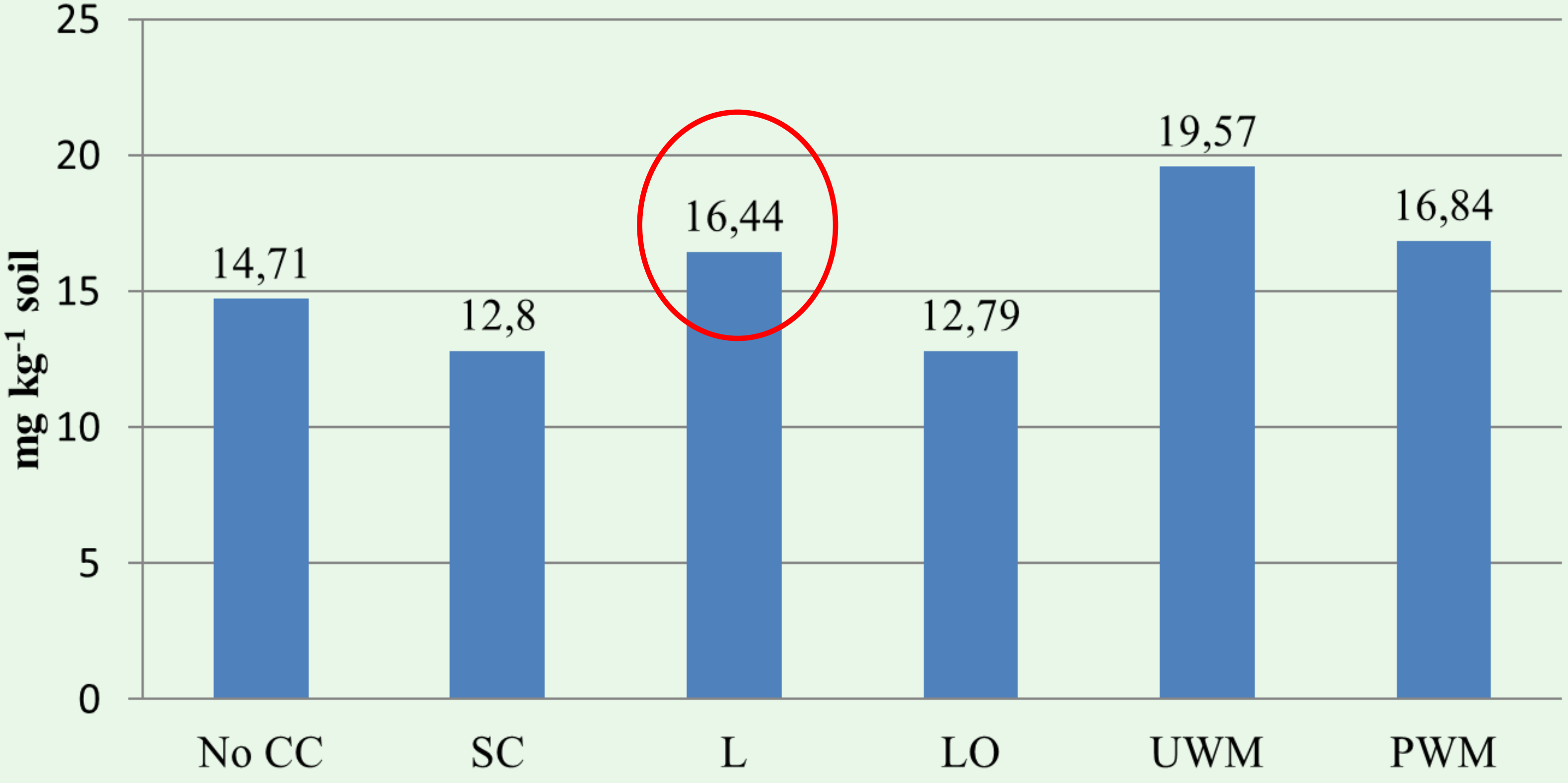
PROJECT AIM... is to increase efficiency in management of the transboundary Venta and Lielupe river basins by providing a joint concept for the reduction of agricultural pollution. Assessment of ***potentials and economic aspects of catch-crop solutions*** as prominent agro-environmental measures of catch crop growing in Lithuania and Latvia.

- By applying economic analysis to identify optimal catch-crops for reduction of agricultural pollution;
- To elaborate a decision support tool which would include information on costs and benefits of various catch crop and help to select the optimal catch crop strategies benefiting the farmer and the environment;
- To elaborate recommendations and action plans for policy makers regarding implementation of catch crop solutions in the Venta and Lielupe river basins.

Data from „LT Fund of Nature“: The once pristine Baltic Sea waters have become strongly eutrophicated, i.e. saturated with nutrient components. That is a serious problem threatening the sea's ecosystem as well as the Baltic Sea coastal inhabitants.

Interreg Latvija–Lietuva European Regional Development Fund EUROPEAN UNION

Figure 7. Content of mineral nitrogen in spring in the soil after catch crop incorporation (0-40 cm soil layer)



No CC - without catch crop; SC – soil cultivation; L – narrow-leaved lupin; LO - mixture of narrow-leaved lupin and oat; UWM - undersowed white mustard; PWM – post harvest white mustard

Thank You for the attention

We are open to share our experience