# Project “Sustainable use of soil resources in the changing climate (SUCC)”: Overview of activities by the Lithuanian team (LAMMC).

Dr. Jelena Ankuda and Dr. Kęstutis Armolaitis

EEA (European Economic Area) Grants, Baltic Research Programme.

SUCC spring 2023 meeting, 30.05.2023.

**2023 m. gegužės 27 d.**

# Lithuanian team

- ✓ The PostDoc Dr. **Jelena Ankuda** acted as a Principal investigator (PI) on the Lithuanian side.

Since 2011, her research has involved energy plant cultivation for solid biofuel (including using of sewage sludge compost as fertilizer of energy crops) in context of decreasing of greenhouse gas emissions into the atmosphere and of improving soil chemical properties.

**Her functions were:** project coordination and administration, participation in field expeditions for soil sampling, analyzing literature on the topic of the project, project data analysis, and planning and writing scientific and other publications.

- ✓ Dr. **Kęstutis Armolaitis** acted as a Co-Principal Investigator (Co-PI) and the Chief researcher.

He has studied the impact of different land-use (forest and afforested land, cropland, abandoned arable land and grassland) on soil chemical condition and sustainability, including carbon allocation in plants and carbon sequestration in soil for over 15 years. He continued his work in this field.

**His functions were:** search of soil sampling plots, participation in field expeditions for soil sampling, scientific consultations to PhD students, and other participants (Lithuanian partner), analyzing literature on the topic of the project, and planning and writing scientific publications.

# Lithuanian team

**Other participants:**

- ✓ Project senior researcher **Dr. Jūratė Aleinikovienė**. She is implementing soil organic carbon and mineral nitrogen analyses, estimating soil microbial biomass carbon and microbial biomass nitrogen content. She is measuring the potential of organic matter decomposition and determining the ecological sustainability of afforestation of former agricultural land.

**Her functions were:** estimating of soil microbial biomass carbon and microbial biomass nitrogen content, analyzing literature on the topic of the project, and writing scientific publications.

- ✓ Project junior researcher **Dr. Karolina Gvildienė.** She specialized on chemical analysis of soil, water and compost.

**Her functions were:** perform chemical analyzes on soil samples, analysis of data, and analyzing literature on the topic of the project.

# Lithuanian team

**In our project the Lithuanian partner included 5 PhD students:**

**1. Audrius Jakutis** is focused on restoration of soil fertility in croplands of different management regimes, especially from the perspective of soil microbiota.

**2. Diana Sivojienė.** She studies successions of soil microbial communities in light textured soil using various organic fertilizers.

**3. Valeriia Mishcherikova.** She is focused on the functional diversity of microbial communities in Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* (L.) H. Karst) forests in the process of climate change.

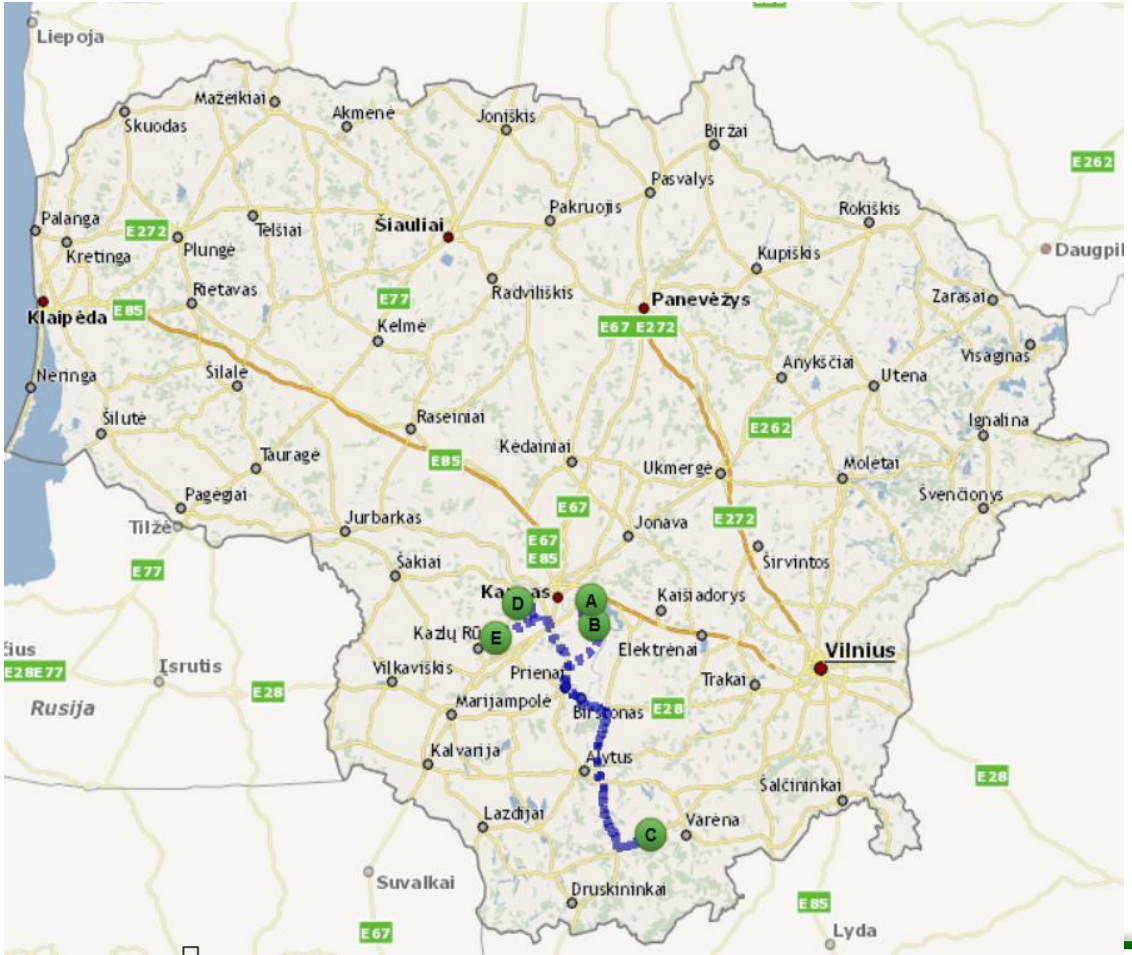
**4. Vaiva Kazanavičiūtė** is specialized on the impact of land-use change and biomass use for climate change mitigation.

**5. Donata Drapanauskaitė** is focused on the effect of chemical composition and structure of liming materials for neutralizing soil acidity. She tests the influence of soil pH and its regulators on the distribution of organic C in soil and C in plants.

**Their functions were:** search of soil sampling plots, participation in field expeditions for soil sampling, prepare the soil for chemical and metagenomic analysis, perform chemical analyzes on soil samples, data analysis, and also writing scientific publications.

# We sampled soil samples of:

- Type I - North-to-South transects.
- Type II - Land abandonment / afforestation chronosequence.
- Type III - Soil depth gradient.




# Locations of sampling plots in 2020:

A –Žiegždriai (Type I and Type II)

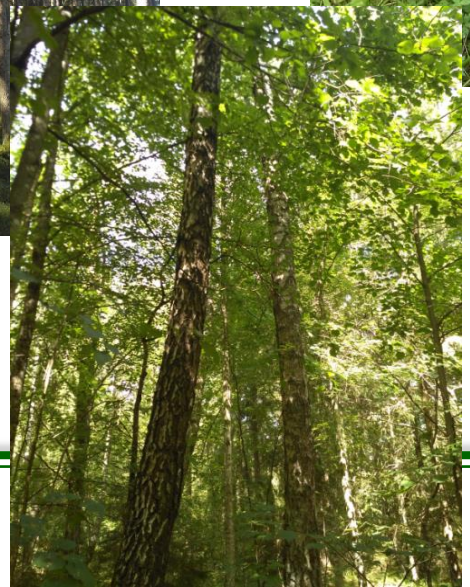
B – Dubrava (Type I)

C – Perloja (Type I and Type II)

D – Near Kačerginė (Type I)

E – Jūrė small town near Kazlų Rūda (Type I and Type III)

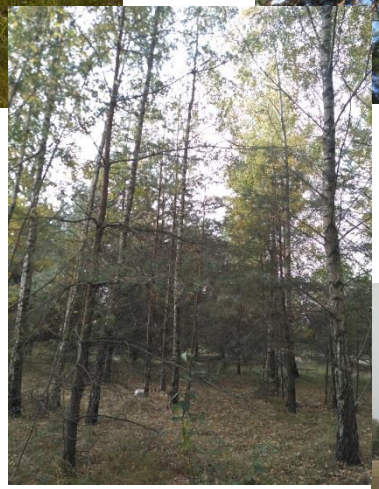
# Dubrava (Type I)

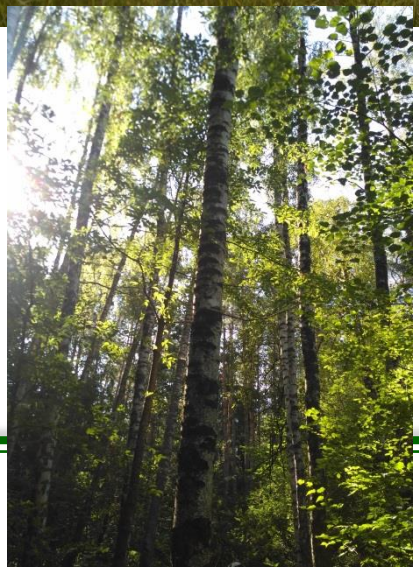




LAMMC

# Žiegždriai (Type I and Type II)

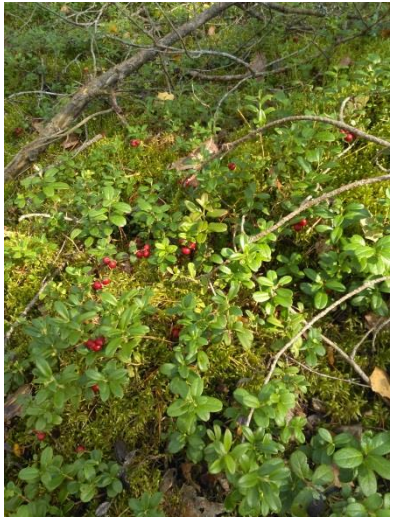




# Perloja (Type I and Type II)

# Near Kačerginė (Type I)

# Jūrė small town near Kazlų Rūda (Type I and Type III)



# Type I - North-to-South transects in 2020

- ✓ In August and September (2020), in total 20 soil samples from 15 plots in Lithuania were collected for the latitudinal gradient study of silver birch (*Betula pendula*) and Scots pine (*Pinus sylvestris*) forests and grasslands. Mainly these were Arenosols and Luvisols.

- ✓ Ecosystems:

1) Scots pine forest (5 plots) – 60 – 100-year-old
2) Silver birch forest (5 plots) – 48 – 68-year-old
3) Permanent grassland (5 plots)

- ✓ Depth of soil sampling: 0-5 cm
- ✓ Locations of plots:

-Dubrava (2020.08.11.)
-Žiegždriai (2020.08.13.)
-Perloja (2020.08.19.)
-Near Kačerginė (2020.08.27.)
-Jūrė small town near Kazlų Rūda (2020.09.05.)

Chemical and microbiological analyses of these soil samples were performed.

# Type II - Land abandonment/afforestation chronosequence in 2020

- ✓ In September and October (2020), in total 15 samples from 14 plots in Lithuania were collected to assess abandonment / afforestation chronosequence. Mainly these were Arenosols and Luvisols.

- ✓ Ecosystems:

1) Croplands (2 plots)

2) Grasslands (2 plots)

3) Abandoned croplands=fallows (2 plots)

4) Coppicing grasslands (tree coverage 10-50%, height 2-6 m) (1 plot) 6-year-old

5) Coppice (tree coverage >80%, height >6 meters (1 plot) 20-year-old

6) Planted forest of deciduous trees (3 plots): silver birch (59-year-old), pedunculate oak (*Quercus robur*) (61-year-old), small-leaved linden (*Tillia cordata*) (61-year-old).

7) Planted conifers (2 plots): Scots pine (59-year-old) and Norway spruce (60-year-old).

8) „Mature forest“ (deciduous trees, preferably as natural as possible) (1 plot): silver birch - natural – mature (66-year-old).

- ✓ Depth of soil sampling: 0-10 cm
- ✓ Locations of plots:

-Perloja (2020.09.17.)

-Žiegždriai (2020.10.01.)

Chemical and microbiological analyses of these soil samples were performed.

# Type III – Soil depth gradient in 2020

- ✓ In October (2020), in total 21 soil samples (3 pits, 7 depths) from 1 plot in Lithuania were collected for the soil depth gradient study in Scots pine forests (Arenosol).
- ✓ Ecosystem:
  - Scots pine forest – 60-year-old
- ✓ Sampling depth intervals:

1) 0-5 cm,
2) 10-15 cm,
3) 20-25 cm,
4) 50-55 cm,
5) 100-105 cm,
6) 150-155 cm,
7) 195-200 cm.

- ✓ Location of plot:
  - Jūrė small town near Kazlų Rūda (2020.10.16. and 2020.10.22.) (3M plot of ICP Forests, Level II; Arenosols).

- ✓ Chemical and microbiological analyses of these soil samples were performed.
- ✓ In this plot we had extra measurement: sampling soil for bulk density analysis.

# Type III – Soil depth gradient in 2021

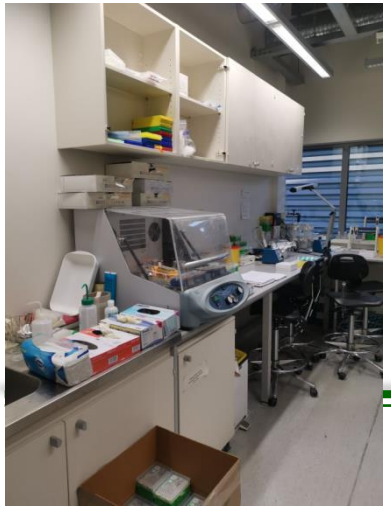
- In the autumn (2021), 42 samples were collected from 6 soil profiles up to 2 m depth (0-5 cm; 10-15 cm; 20-25 cm; 50-55 cm; 100-105 cm; 150-155 cm and 195-200 cm) (Type III - Soil depth gradient).
- Locations of plots:

1. Norway spruce forest in Vaišvydava (11M plot of ICP Forests, Level II, Luvisol) – 3 pits;
2. Scots pine forest in Dubrava (former 6M plot of ICP Forests, Level II, Luvisol) – 3 pits.

- Chemical and microbiological analyses of these soil samples were performed.
- All these samples were prepared for the high-throughput sequencing analysis during an internship at Tartu university.

# Activities in 2021:

- In October (2021), SUCC Lithuanian participants dr. Jūratė Aleinikovienė, Ph.D. students Diana Sivojienė and Audrius Jakutis did an internship at the Institute of Ecology and Earth Sciences of the University of Tartu.
- Trainees were introduced to the protocols of molecular work, high-throughput sequencing analysis, and the basics of bioinformatics.
- They learned methodology and performed deoxyribonucleic acid (DNA) extraction, polymerase chain reaction (PCR), and electrophoresis.
- In total of 117 Lithuanian soil samples were prepared for the high-throughput sequencing analysis.
- High-throughput sequencing analysis was subsequently performed on these samples.





# Activities in 2021:

**In total 42 samples that belong to Type III, and 75 samples from 3 experiments were analyzed during the internship.**

**Generalized schemes of experiments:**

- **I experiment:**
1. Cropland fertilized
2. Meadow
3. Mixed forest

- **II experiment:**
1. Clear cutting
2. Forest control (unfertilized)
3. Forest fertilized
4. Managed meadow

- **III experiment:**
1. Cropland unfertilized
2. Cropland fertilized
3. Cropland fertiliezed + biological product

- The sites were selected to evaluate the soil management (forest - fertilization and clear-cutting, meadow - meadow cutting and biomass removal; cropland - organic matter (biological implementation), mineral fertilization and biological product) sustainability on carbon balance / sequestration.

- It is expected to predict the soil management impact on soil carbon mineralization, stabilization, or accumulation according to the bacteria and fungi metagenomic analyses, bridging of soil bacteria and fungi functional potentials to carbohydrate or nitrogen metabolism.

# Activities in 2021:

- In the second year of the project (2021), together with a colleague from Estonia dr. Martin Maddison, in various land uses $CO_2$ emission concentrations were measured at 25 plots, and soil samples were collected to determine emissions of other GHG ($N_2O$, $CH_4$) at the University of Tartu.
- Selected sites were of Type I, Type II and Type III: forests and croplands, abandoned croplands, perennial grasslands, agroforestry.




# Activities by Lithuanian team in 2020

- ✓ Results were presented:

At the 3rd International Scientific Virtual Conference „AGROECOSYSTEM SUSTAINABILITY: Links between Carbon Sequestration in Soils, Food Security and Climate Change (AgroEco2020)“ during oral presentation „Land use change response on an allocation of organic carbon in the uppermost mineral soil layers“. Authors: Jūratė Aleinikovienė, Kęstutis Armolaitis, Jelena Ankuda, Audrius Jakutis, Diana Sivojienė, Valeriia Mishcherikova (2–3 December, 2020. http://agroeco.vdu.lt/).

VYTAUTAS MAGNUS UNIVERSITY Faculty of Agronomy

AGRO ECO 2020

CERTIFICATE

Hereby we confirm that

Jūratė Aleinikovienė, Kęstutis Armolaitis, Jelena Ankuda, Audrius Jakutis, Diana Sivojienė, Valeriia Mishcherikova

has participated at the International Scientific Virtual Conference AgroEco2020 and has given an oral presentation

Land use change response on an allocation of organic carbon in the uppermost mineral soil layers

Prof. Aušra Blinstrubienė
Chairperson of the International Scientific Conference Committee
Vytautas Magnus University Agriculture Academy

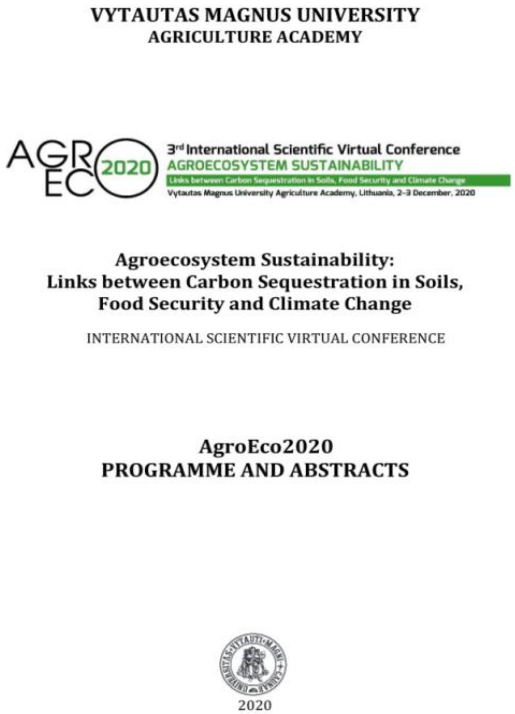
2-3 December, 2020 in Akademija, Kaunas distr., Lithuania

MCMXXII
VYTAUTO DIDŽIOJO UNIVERSITETAS

# Activities by the Lithuanian team in 2020

- ✓ Results were presented:

In the abstract, which was published in the abstracts book of 3rd International Scientific Virtual Conference „AGROECOSYSTEM SUSTAINABILITY: Links between Carbon Sequestration in Soils, Food Security and Climate Change (AgroEco2020)“. „Land use change response on an allocation of organic carbon in the uppermost mineral soil layers“. Authors: Jūratė Aleinikovienė, Kęstutis Armolaitis, Jelena Ankuda, Audrius Jakutis, Diana Sivojienė, Valeriia Mishcherikova (17 p.).



VYTAUTAS MAGNUS UNIVERSITY
AGRICULTURE ACADEMY

AGROECO 2020
3rd International Scientific Virtual Conference
AGROECOSYSTEM SUSTAINABILITY
Links between Carbon Sequestration in Soils, Food Security and Climate Change
Vytautas Magnus University Agriculture Academy, Lithuania, 2–3 December, 2020

**Agroecosystem Sustainability:
Links between Carbon Sequestration in Soils,
Food Security and Climate Change**

INTERNATIONAL SCIENTIFIC VIRTUAL CONFERENCE

**AgroEco2020
PROGRAMME AND ABSTRACTS**

2020

17

## LAND USE CHANGE RESPONSE ON AN ALLOCATION OF ORGANIC CARBON IN MINERAL TOPSOIL

**Jūratė Aleinikovienė[1], Kęstutis Armolaitis[2], Jelena Ankuda[2], Audrius Jakutis[1], Diana Sivojienė[2], Valeriia Mishcherikova[2]**

*[1]Vytautas Magnus University, Agriculture Academy, Studentų Str. 11, Akademija, Kaunas Distr., Lithuania*
*[2]Lithuanian Research Centre for Agriculture and Forestry*
*jurate.aleinikoviene@vdu.lt*

Land-use change drives both the turnover of soil organic matter (SOM) and the changes in soil organic carbon (SOC) storage. Meanwhile, the objective of this study was to determine SOM allocation into the SOC and into the soil microbial biomass (SMB) along the land use change. Composite soil samples were collected from the mineral topsoil (in 0-10 cm of the depth) of cropland, abandoned agricultural land, managed and unmanaged grassland and adjacent middle-aged and premature forest stands of different tree species, mainly Scots pine (*Pinus sylvetris* L.) and silver birch (*Betula pendula* Roth). It was estimated, that mean allocation of decomposed SOM into the SOC was higher in the silver birch stands (22.0–4.2 mg C $g^{-1}$ of dry soil) and were significantly decreasing in Scots pine stands (10.1–14.4 mg C $g^{-1}$ DS) and cropland (9.8–13.7 mg C $g^{-1}$ DS). However, the SOC in abandoned agricultural land and in grassland was varying in relatively high extent, respectively, from 15.6 to 20.5 mg C $g^{-1}$ DS and from 15.0 to 23.5 mg C $g^{-1}$ DS and was higher than in cropland. There were estimated the significant link between the SOM allocation into the SMB and the vegetation composition in the land use change experimental sites. Thus, SMB carbon was significantly increasing mainly in the mineral topsoil of managed and unmanaged grassland (449–496 µg C $g^{-1}$ DS) and were by 1.6-2.3 folds higher than in cropland (217–280 µg C $g^{-1}$ DS) and 1.4–1.7 times higher than in the Scots pine stands (289–314 µg C $g^{-1}$ DS) This research work was carried out to obtain the results funded by the EEA Financial Mechanism Baltic Research Programme in Estonia.

***Key words:*** *soil, land-use change, organic matter, organic carbon, soil microbial biomass.*

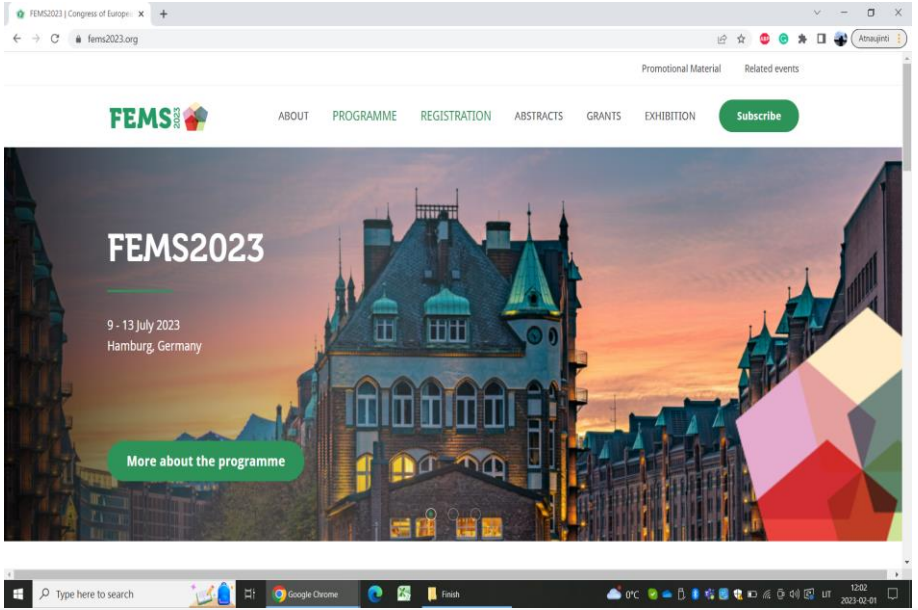
# Activities in 2022 and 2023:

In 2023, we plan to participate with 2 poster presentations in **FEMS2023** (Federation of European Microbiological Societies) Congress, which will be 9-13 July in Hamburg (Germany). https://www.fems2023.org/

2 abstracts were prepared and sent:

- ***Soil fungi and soil organic carbon stocks in Arenosol profile on Scots pine stand.***

- ***Influence of the afforestation process on soil fungi and soil organic carbon stocks in Arenosols.***



# Activities by the Lithuanian team in 2020 and in 2021

- ✓ Information about the project was prepared in Lithuanian and English and inserted in the website of Lithuanian Research Centre for Agriculture and Forestry lammc.lt: https://www.lammc.lt/data/public/uploads/2020/09/succ_lt.pdf and https://www.lammc.lt/data/public/uploads/2020/09/succ_en-1.pdf.

- ✓ Information about the project was inserted in the facebook.com page of Lithuanian Research Centre for Agriculture and Forestry:

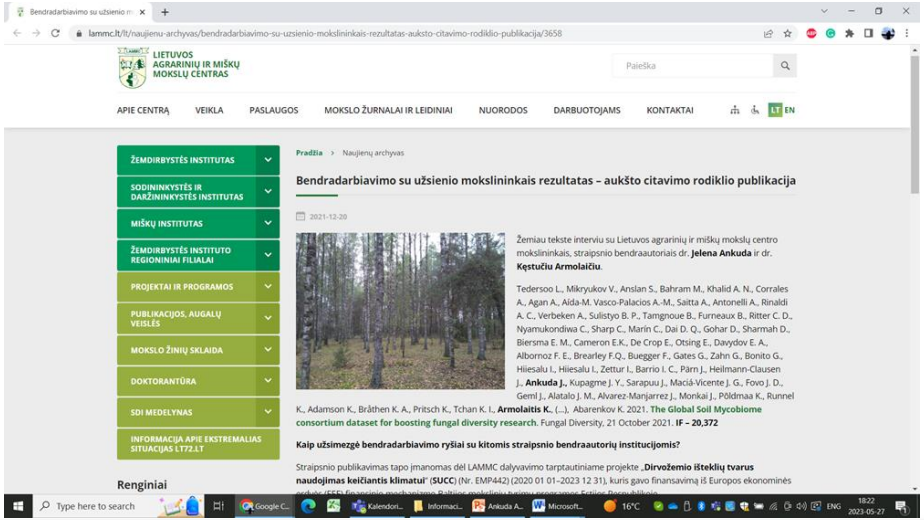
https://www.facebook.com/permalink.php?story_fbid=4367816963233855&id=149047625110831 (2021.02.08.)

- ✓ Information about the project was presented during the online event "Living and Healthy Soil" („Gyvas ir sveikas dirvožemis“) (in Lithuanian). Oral presentation "The potential of Lithuanian soils to achieve climate neutrality" ("Lietuvos dirvožemių potencialas siekiant klimato neutralumo") (in Lithuanian). Authors: Kęstutis Armolaitis, Jūratė Aleinikovienė, Vaiva Kazanavičiūtė (December 4, 2020.

https://www.lammc.lt/data/public/uploads/2020/11/seminaras-2020-12-04.pdf).

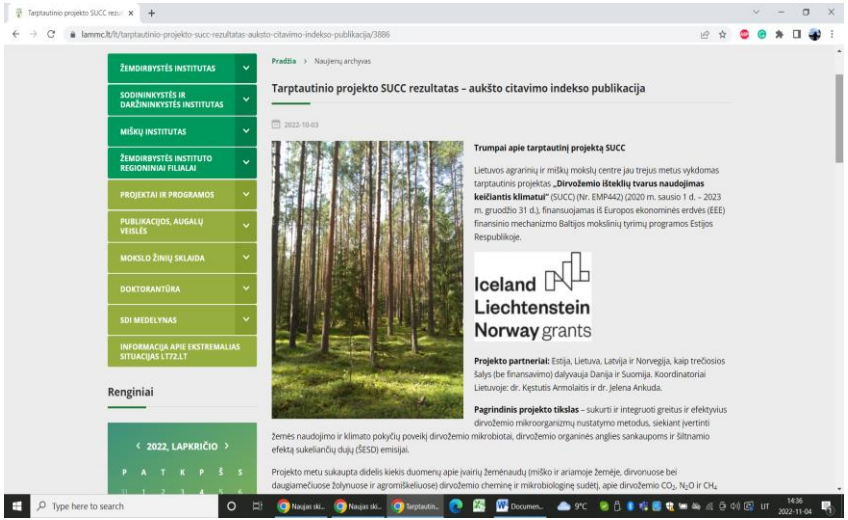
# Activities in 2021:

- One article was written and published on the lammc.lt page and on the facebook.com page of Lithuanian Research Centre for Agriculture and Forestry (LAMMC). This article was about the SUCC project and the scientific article published together with the project partners (Tedersoo, L., Mikryukov, V., Anslan, S. et al. 2021. The Global Soil Mycobiome consortium dataset for boosting fungal diversity research. *Fungal Diversity*, 111: 573–588. IF – 24,902.)




# Activities in 2022:

- One article was written and published on the lammc.lt page and on the facebook.com page of Lithuanian Research Centre for Agriculture and Forestry (LAMMC). This article was about the SUCC project and the scientific article published together with the project partners (Tedersoo et al., 2022. Global patterns in endemicity and vulnerability of soil fungi. *Global Change Biology*, 28 (22): 6696–6710. IF – 13.211.) .




# Activities

**Thanks to our Estonian partner, we are the co-authors of 3 excellent scientific publications:**

- Anslan S, Mikryukov V, Armolaitis K, Ankuda J, Lazdina D, Makovskis K, Vesterdal L, Schmidt IK, Tedersoo L. 2021. Highly comparable metabarcoding results from MGI-Tech and Illumina sequencing platforms. PeerJ 9:e12254. https://doi.org/10.7717/peerj.12254. IF – 3,061.

- Tedersoo, L., Mikryukov, V., Anslan, S. et al. The Global Soil Mycobiome consortium dataset for boosting fungal diversity research. Fungal Diversity 111, 573–588 (2021). https://doi.org/10.1007/s13225-021-00493-7. IF – 24,902.

- Tedersoo L., Mikryukov V., Zizka A., Bahram M., Hagh-Doust N., Anslan S., Prylutskyi O., Delgado-Baquerizo M., Maestre F. T., Pärn J., Öpik M., Moora M., Zobel M., Espenberg M., Mander Ü., Khalid A. N., Corrales A., Ahto A., Vasco-Palacios A. M., Saitta A., Rinaldi A. C., Verbeken A., Sulistyo B. P., Tamgnoue B., Furneaux B., Ritter C. D., Nyamukondiwa C., Sharp C., Marín C., Gohar D., Klavina D., Sharmah D., Dai D. Q., Nouhra E., Biersma E. M., Rähn E., Cameron E. K., De Crop E., Otsing E., Davydov E. A., Albornoz F. E., Brearley F. Q., Buegger F., Zahn G., Bonito G., Hiiesalu I., Barrio I. C., Heilmann-Clausen J., Ankuda J., Kupagme J. Y., Maciá-Vicente J. G., Fovo J. D., Geml J., Alatalo J. M., Alvarez-Manjarrez J., Põldmaa K., Runnel K., Adamson K., Bråthen K. A., Pritsch K., Tchan K. I., Armolaitis K., Hyde K. D., Newsham K. K., Panksep K., Lateef A. A., Tiirmann L., Hansson L., Lamit L. J., Saba M., Tuomi M., Gryzenhout M., Bauters M., Piepenbring M., Wijayawardene N., Yorou N. S., Kurina O., Mortimer P. E., Meidl P., Kohout P., Nilsson R. H., Puusepp R., Drenkhan R., Garibay-Orijel R., Godoy R., Alkahtani S., Rahimlou S., Dudov S. V., Põlme S., Ghosh S., Mundra S., Ahmed T., Netherway T., Henkel T. W., Roslin T., Nteziryayo V., Fedosov V. E., Onipchenko V. G., Yasanthika W. A. E., Lim Y. W., Soudzilovskaia N. A., Antonelli A., Kõljalg U., Abarenkov K. 2022. Global patterns in endemicity and vulnerability of soil fungi. Global Change Biology, 28 (22): 6696–6710. IF – 13.211.

# Activities in 2022

- Data part of Lithuanian Type III soil samples (Soil depth gradient), that were taken in Southwestern Lithuania, near Jūrė small town near Kazlų Rūda in Scots pine stand (Arenosol) is with the bioinformatics in this moment.
- Samples were collected from 3 soil profiles up to 2 m depth (0-5 cm; 10-15 cm; 20-25 cm; 50-55 cm; 100-105 cm; 150-155 cm and 195-200 cm).
- These and other data were analyzed and used for the writing of the scientific article "Soil microbiological parameters and soil organic carbon stocks in profile of forest Arenosol“.
- Our research showed that in Arenosol on Scots pine stand to the depth up to 2 meters it is possible to detect a relatively large number and diversity of soil fungi.
- We are currently looking for a journal to submit our article.

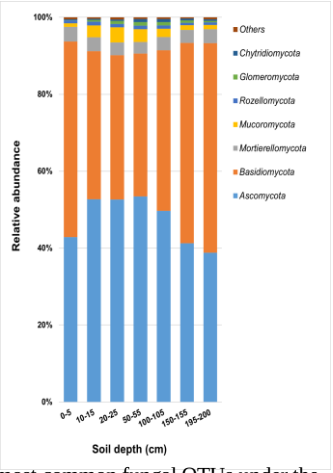




Figure 1. Relative abundance of most common fungal OTUs under the phylum level.

# Plans for 2023:

- We plan to publish article "Soil microbiological parameters and soil organic carbon stocks in profile of forest Arenosol“ in journal with IF.

- We plan to finish a scientific article about soil microbiological and chemical parameters in different land use (“Soil bacteria and fungi related organic matter and nitrogen turnover in soils with different soil management practices”**?**) using data of Lithuanian Type II samples (Land abandonment / afforestation chronosequence). We plan to publish this article in a journal indexed in the *Clarivate Analytics Web of Science database* (with impact factor (IF)).

- We plan to prepare bioinformatics of the remaining metagenomic data and to write and publish 2 scientific articles.

# Thank You for Your attention

**Additional information:** jelena.ankuda@lammc.lt or kestutis.armolaitis@lammc.lt

The research work carried out to obtain the results has been funded by the EEA Financial Mechanism Baltic Research Programme in Estonia (grant EMP442).