# Development of biocovers for mine waste sites

NATURAL RESOURCES INSTITUTE FINLAND/LUKE

MARLEENA HAGNER, MARJA UUSITALO, KIMMO RASA

Funded by the European Union

BIOPEITTO 3

Luke NATURAL RESOURCES INSTITUTE FINLAND

GTK

KAMK Kajaani University of Applied Sciences

REGIONAL COUNCIL OF KAINUU

Centre for Economic Development, Transport and the Environment

# Luke in brief

**79** M€ State budget funding

**148** M€ **Turnover**

**69** M€ External funding

**22** **Locations** head office in Helsinki, Viikki



**1298** **employees**

**630** **Scientists**

**616** **Experts***

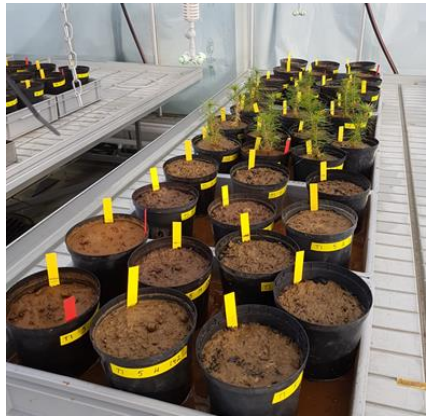
**52** **Professors**

*Employees in service groups and research infrastructure servicesas well as directors


Annual financial report of the Natural Resources Institute for the year 2024, number of staff 31.12.2024

# Background

Time & Scale



**Biocover**
Use of biochar in mineral waste cover materials (2017-2020)

**Biocover 2**
New regional operating models and biocoverage solutions promoting the circular economy in the aftercare of mines (2021-2023)

**Biocover 3**
Biocover solutions to promote ecosystem recovery in post-mining (2024-2026)

**Biocover Kainuu**
(2024-2026)

Funded by the European Union

BIOPEITTO 3

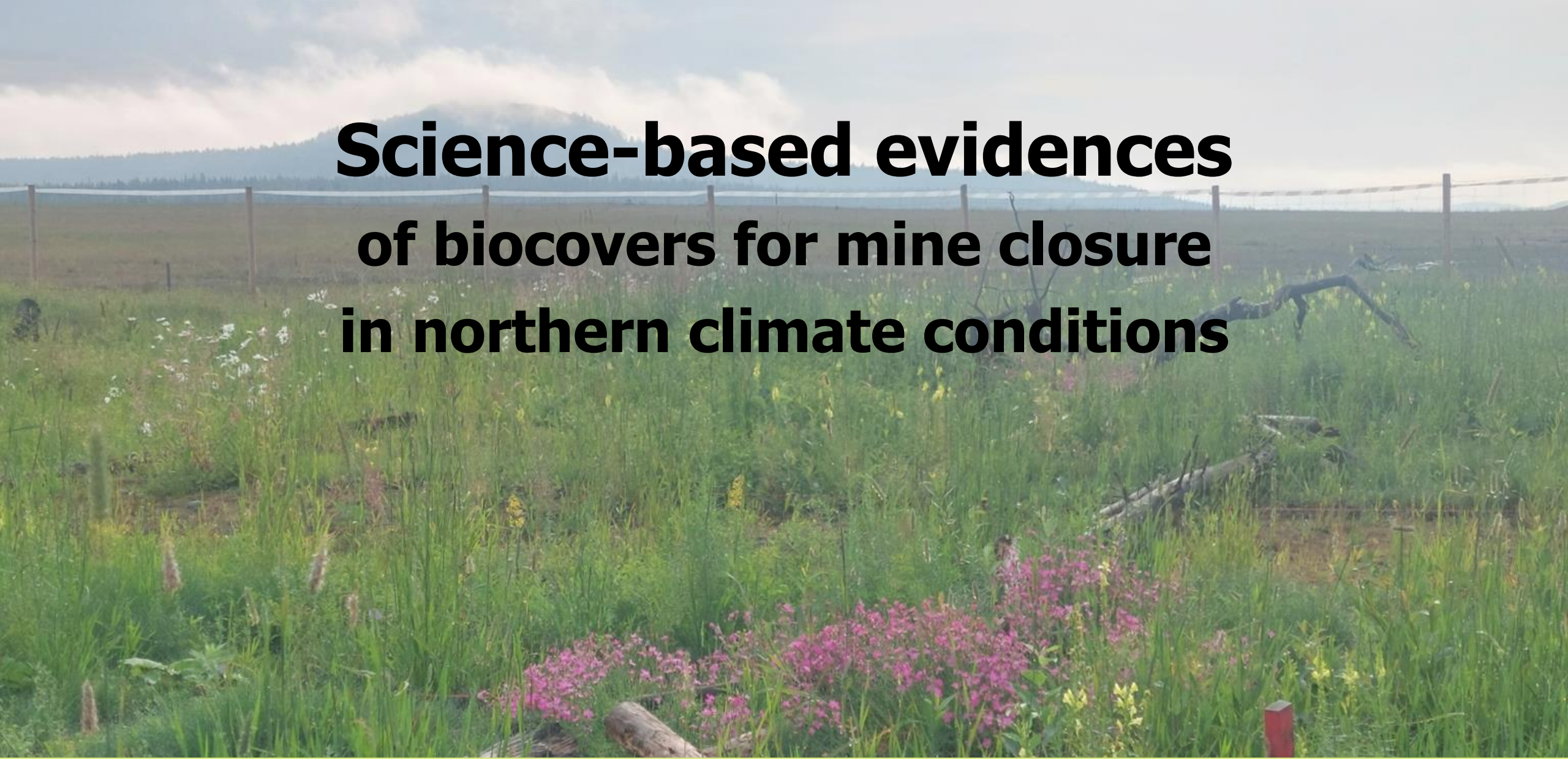
Luke NATURAL RESOURCES INSTITUTE FINLAND

GTK

KAMK Kajaani University of Applied Sciences

REGIONAL COUNCIL OF KAINUU

Centre for Economic Development, Transport and the Environment



# Science-based evidences

## of biocovers for mine closure in northern climate conditions

Funded by the European Union

BIOPEITTO 3

Luke NATURAL RESOURCES INSTITUTE FINLAND

GTK

KAMK Kajaani University of Applied Sciences

REGIONAL COUNCIL OF KAINUU

Centre for Economic Development, Transport and the Environment

# Effect of different biocover solutios on plant growth


**Vegetation studies in Rautuvaara tailing (2018-2025)**

**Biochar including growth media:**

**20-200% higher plant growth**

https://doi.org/10.1007/s12665-020-09154-5

Environmental Earth Sciences (2020) 79:422
https://doi.org/10.1007/s12665-020-09154-5

ORIGINAL ARTICLE

**Addition of recyclable biochar, compost and fibre clay to the growth medium layer for the cover system of mine tailings: a bioassay in a greenhouse**

Juha Heiskanen[1] · Marleena Hagner[2,3] · Hanna Ruhanen[4] · Kari Mäkitalo[5]

Received: 23 August 2019 / Accepted: 27 August 2020 / Published online: 15 September 2020
© The Author(s) 2020

**Abstract**
Mine closures require landscape reclamation to reduce the environmental risks of tailings fields. However, information about the feasibility of recyclable waste materials as a growth medium layer for the cover systems of mine tailings and their effects on vegetation restoration and reforestation success is scant especially in the boreal climate. This study examines the use of various recyclable by-products in improving vegetation success on reclaimed mine tailings. The physical and chemical properties of two wood biochar types, fibre clay, compost, tailings soil and forest till soil as well as their effects as growth media on the growth of several plant species during one growing period in a greenhouse were examined. Marked differences in the properties (e.g. pH, element concentrations, water retention) as well as in plant growth among the growth media were found. Fresh non-oxidized tailings soil showed high salt contents and electrical conductivity which together with fine soil texture provided the poorest or nonexistent plant growth. Fibre clay was the coarsest and driest material and also showed poor plant growth. Root and shoot growth was greatest in pure compost. All media without compost additive showed relatively poor growth which indicates the lack of nitrogen. The results suggest that forest till soil and biochar are the most suitable growth media for the cover systems of mine tailings when added with compost or another nitrogen source. Scots pine container seedlings, willow cuttings and sown red clover showed to be the most feasible plant species to be grown on boreal tailings covers.

**Keywords** Land reclamation · Mine closure · Recyclates · Reforestation · Soil · Vegetation restoration

**Introduction**
After post ore-extracting activities, mine closures require landscape reclamation to reduce the environmental risks of tailings fields. As tailings fields store large amounts of mining waste, they can pose threats to the environment such as uncontrolled spills of tailings or the release of hazardous substances. In Europe, such devastating effects on humans and the environment have been following past accidents such as the aluminium sludge spill in Kolontar, Hungary, in 2010 (Thorpe 2010) or the accident at the Talvivaara Mining Company in Finland in 2012 (Kotilainen 2015; Leppänen et al. 2017).
Typically mine tailings are covered with low-permeability materials to prevent sulphide oxidation and minimize outflow of harmful effluents from reactive mine wastes into the surrounding environment (O'Kane and Wels 2003; MEND 2012; Kauppila et al. 2013). Commonly the most hazardous wastes are covered with geosynthetic clay liners (GCLs) to

https://doi.org/10.1007/s11356-021-14865-8

Environmental Science and Pollution Research (2021) 28:59881–59898
https://doi.org/10.1007/s11356-021-14865-8

RESEARCH ARTICLE

**Amending mine tailing cover with compost and biochar: effects on vegetation establishment and metal bioaccumulation in the Finnish subarctic**

Marleena Hagner[1,2] · Marja Uusitalo[3] · Hanna Ruhanen[4] · Juha Heiskanen[4] · Rainer Peltola[3] · Kari Tiilikkala[1,5] · Juha Hyvönen[3] · Pertti Sarala[6,7] · Kari Mäkitalo[3]

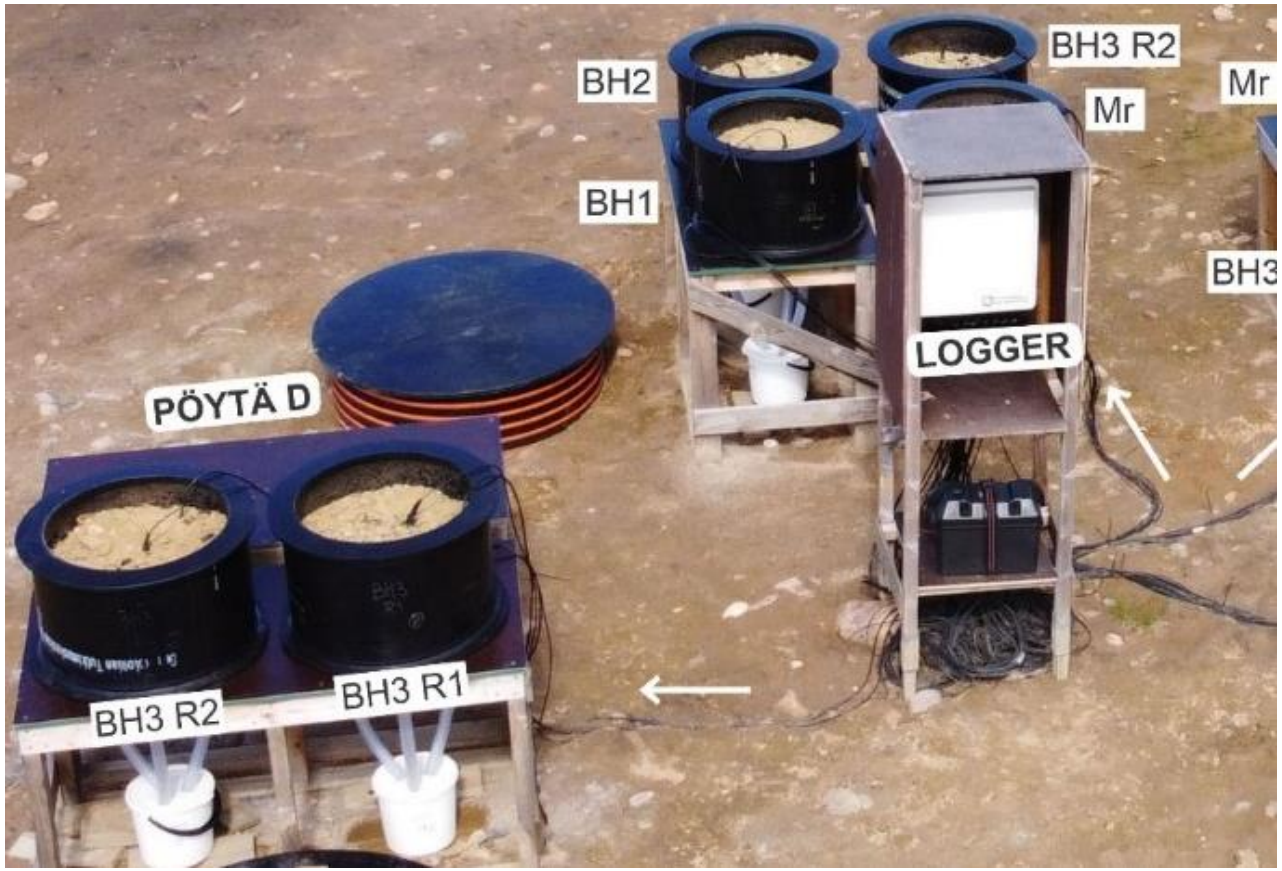
Received: 12 February 2021 / Accepted: 8 June 2021 / Published online: 20 June 2021
© The Author(s) 2021

**Abstract**
In the northern boreal zone, revegetation and landscaping of closed mine tailings are challenging due to the high concentrations of potentially toxic elements; the use of nutrient-poor, glacigenic cover material (till); cool temperatures; and short growing period. Recycled waste materials such as biochar (BC) and composted sewage sludge (CSS) have been suggested to improve soil forming process and revegetation success as well as decrease metal bioavailability in closed mine tailing areas. We conducted two field experiments in old iron mine tailings at Rautuvaara, northern Finland, where the native mine soil or transported cover till soil had not supported plant growth since the mining ended in 1989. The impacts of CSS and spruce (*Picea abies*)-derived BC application to till soil on the survival and growth of selected plant species (*Pinus sylvestris*, *Salix myrsinifolia*, and grass mixture containing *Festuca rubra*, *Lolium perenne*, and *Trifolium repens*) were investigated during two growing seasons. In addition, the potential of BC to reduce bioaccumulation of metals in plants was studied. We found that (1) organic amendment like CSS markedly enhanced the plant growth and is therefore needed for vegetation establishment in tailing sites that contained only transported till cover, and (2) BC application to till soil-CSS mixture further facilitated the success of grass mixtures resulting in 71–250% higher plant biomass. On the other hand, (3) no effects on *P. sylvestris* or *S. myrsinifolia* were recorded during the first growing seasons, and (4) accumulation of metals in cover plants was negligible and BC application to till further decreased the accumulation of Al, Cr, and Fe in the plant tissues.

**Keywords** Sewage sludge · Revegetation · Bioavailability · Tailing repositories · Carbon · Metal uptake

**Introduction**
In order to minimize the release of the harmful effluents from mine wastes into the immediate environment, closed mine tailings are usually covered with low permeability materials (Kauppila et al. 2013). According to international guidelines, mine sites must be landscaped not only after closing (i.e., rehabilitation) but also during production (EC 2012). A good tailing cover retains water, prevents erosion, increases evapotranspiration, and reduces oxygen flow to mine waste layers, reducing the oxidation and leaching of sulfide minerals into the environment (Lottermoser 2007). As vegetation enhances these processes, the rapid establishment of vegetation after covering is important. Vegetation also increases soil carbon content, which further favors natural vegetation succession.
The properties of tailings depend on the mineralogy and ore type of mine, and the enrichment process used to separate

# Effect of cover media and vegetation on water quantity and quality




**Biochar enhances plant growth and reduces water leaching**

**Leachate water studies in Rautuvaara: field work and modelling**

# Enhancing circular bioeconomy solutions

## Use of local side-streams and creation of new value chains

Funded by the European Union

BIOPEITTO 3

Luke NATURAL RESOURCES INSTITUTE FINLAND

GTK

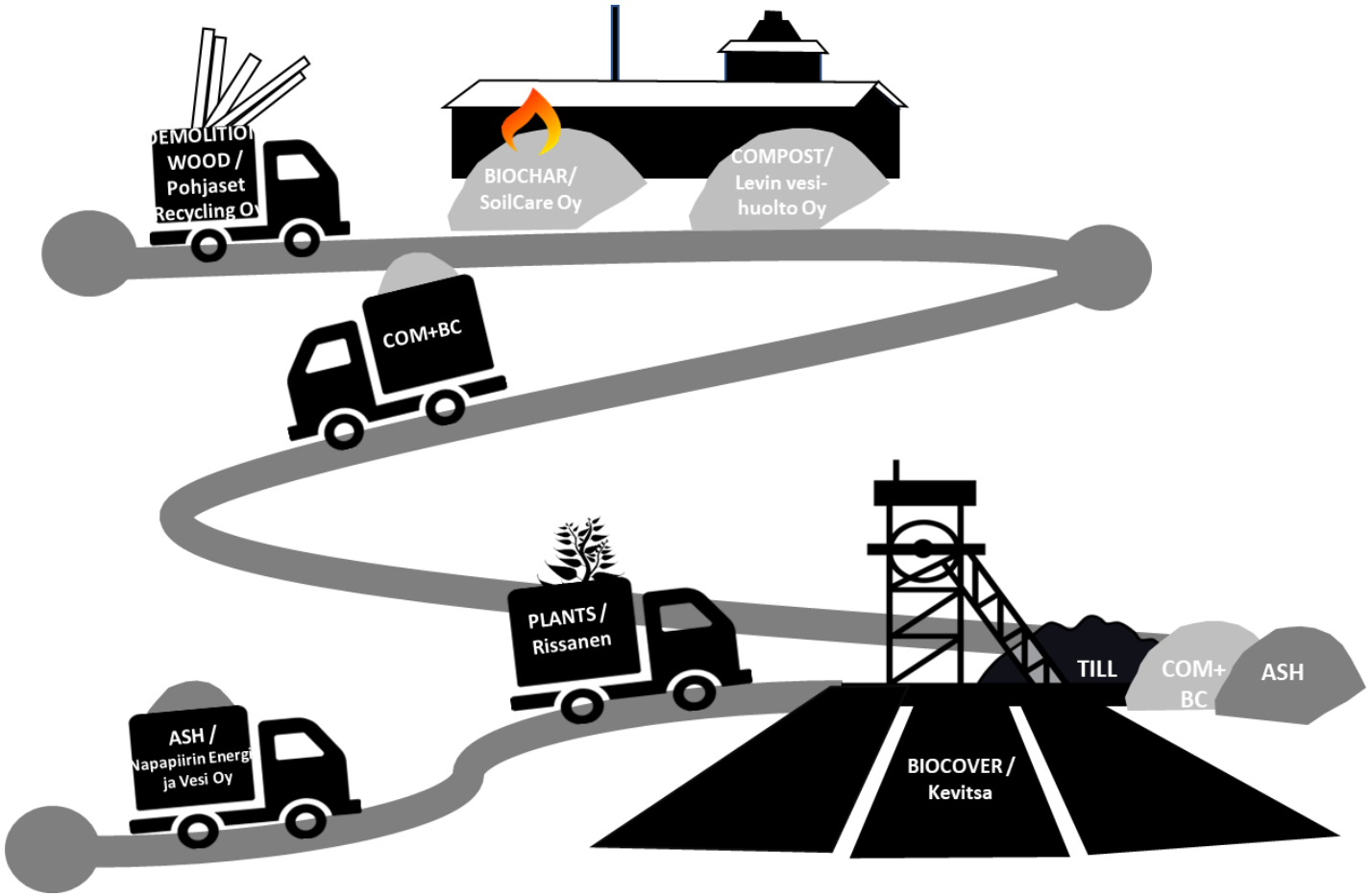
KAMK Kajaani University of Applied Sciences

REGIONAL COUNCIL OF KAINUU

Centre for Economic Development, Transport and the Environment

# The role of regional circular bioeconomy

- Practical pilot in Kevitsa mine 2022
- 0.1 hectar biocover solution established
- Based on regional side streams and local companies
- LCA and LCC to analyze costs and benefits



# Biochar production and value chain
## COM-BC-TILL scenario





**7. Post-shredding**
**8. Transportation to composting site**

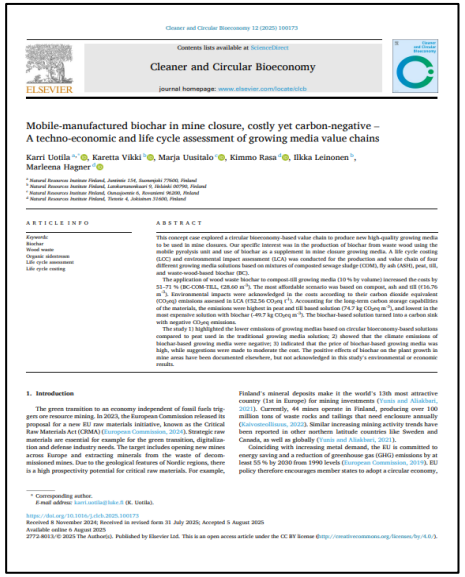

Photos: Karri Uotila / Luke

https://www.sciencedirect.com/science/article/pii/S2772801325000417

# LCA and LCC for biocover solutions

**Moderation of price difference:**

- Biochar price (productivity, technology)
- Labor cots (automation)
- Emission price (increase?)



Cleaner and Circular Bioeconomy 12 (2025) 100173

Contents lists available at ScienceDirect

Cleaner and Circular Bioeconomy

journal homepage: www.elsevier.com/locate/clcb

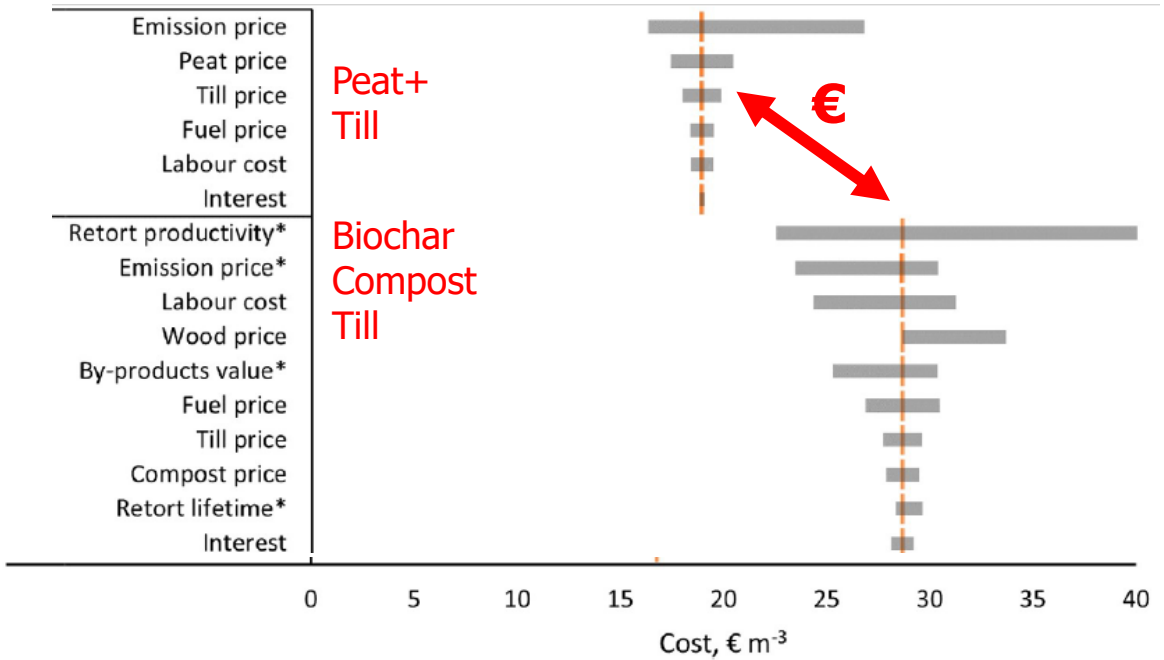
Mobile-manufactured biochar in mine closure, costly yet carbon-negative – A techno-economic and life cycle assessment of growing media value chains

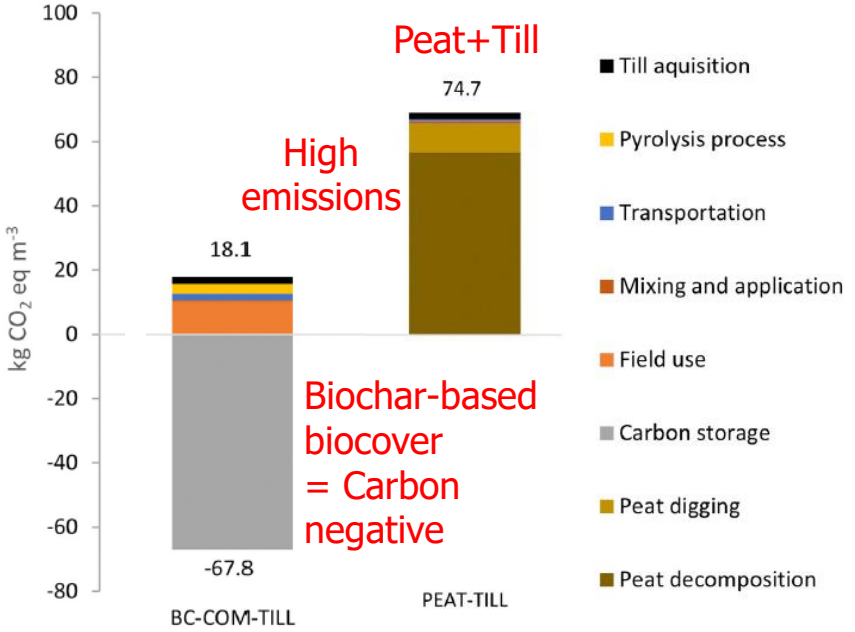
Karri Uotila, Karetta Vikki, Marja Uusitalo, Kimmo Rasa, Ilkka Leinonen, Marleena Hagner

ARTICLE INFO

ABSTRACT

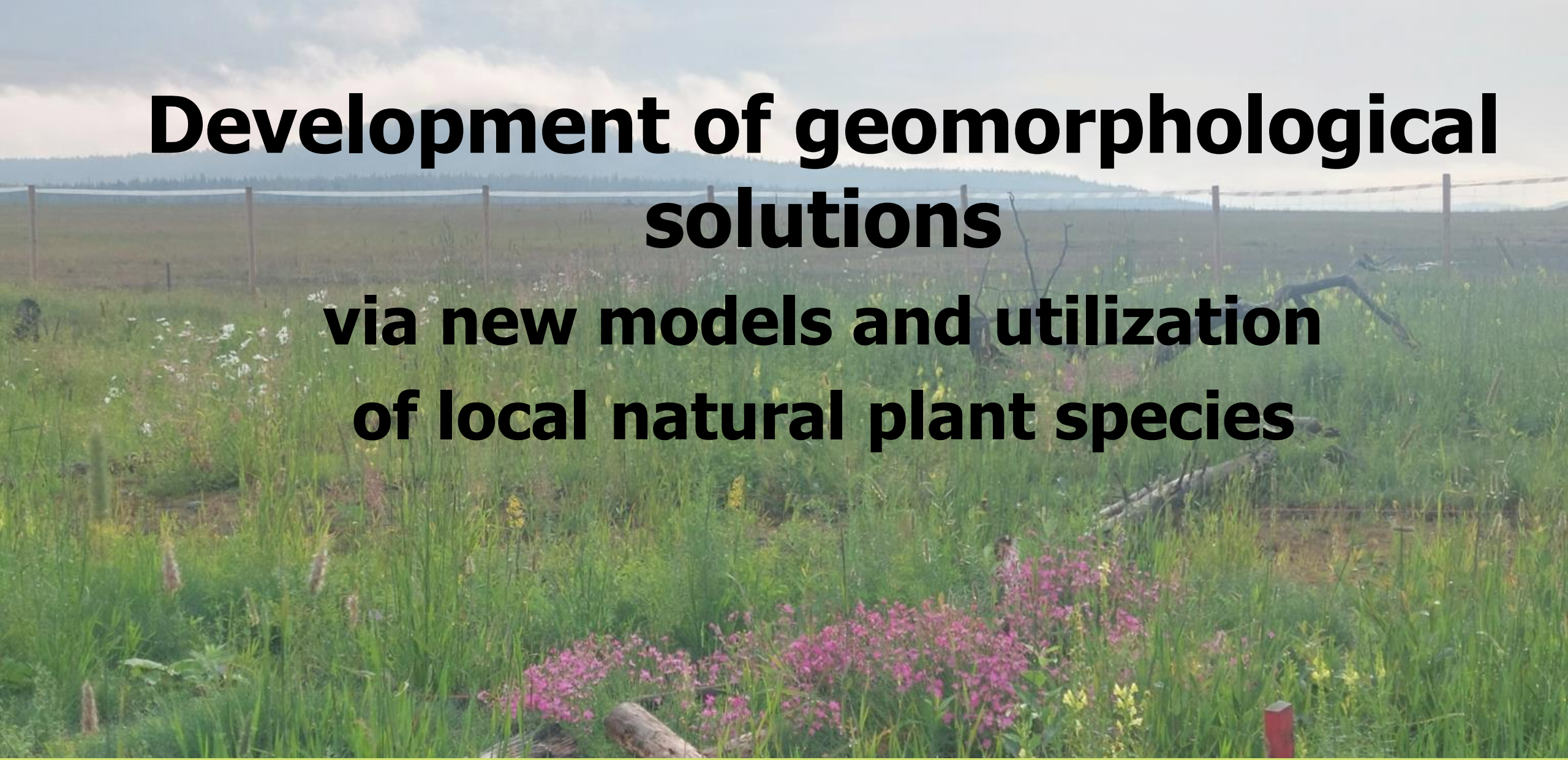
1. Introduction



# Development of geomorphological solutions

## via new models and utilization of local natural plant species



Funded by the European Union

BIOPEITTO 3

Luke NATURAL RESOURCES INSTITUTE FINLAND

GTK

KAMK Kajaani University of Applied Sciences

REGIONAL COUNCIL OF KAINUU

Centre for Economic Development, Transport and the Environment

# Ecosystem Restoration in Mine Closures

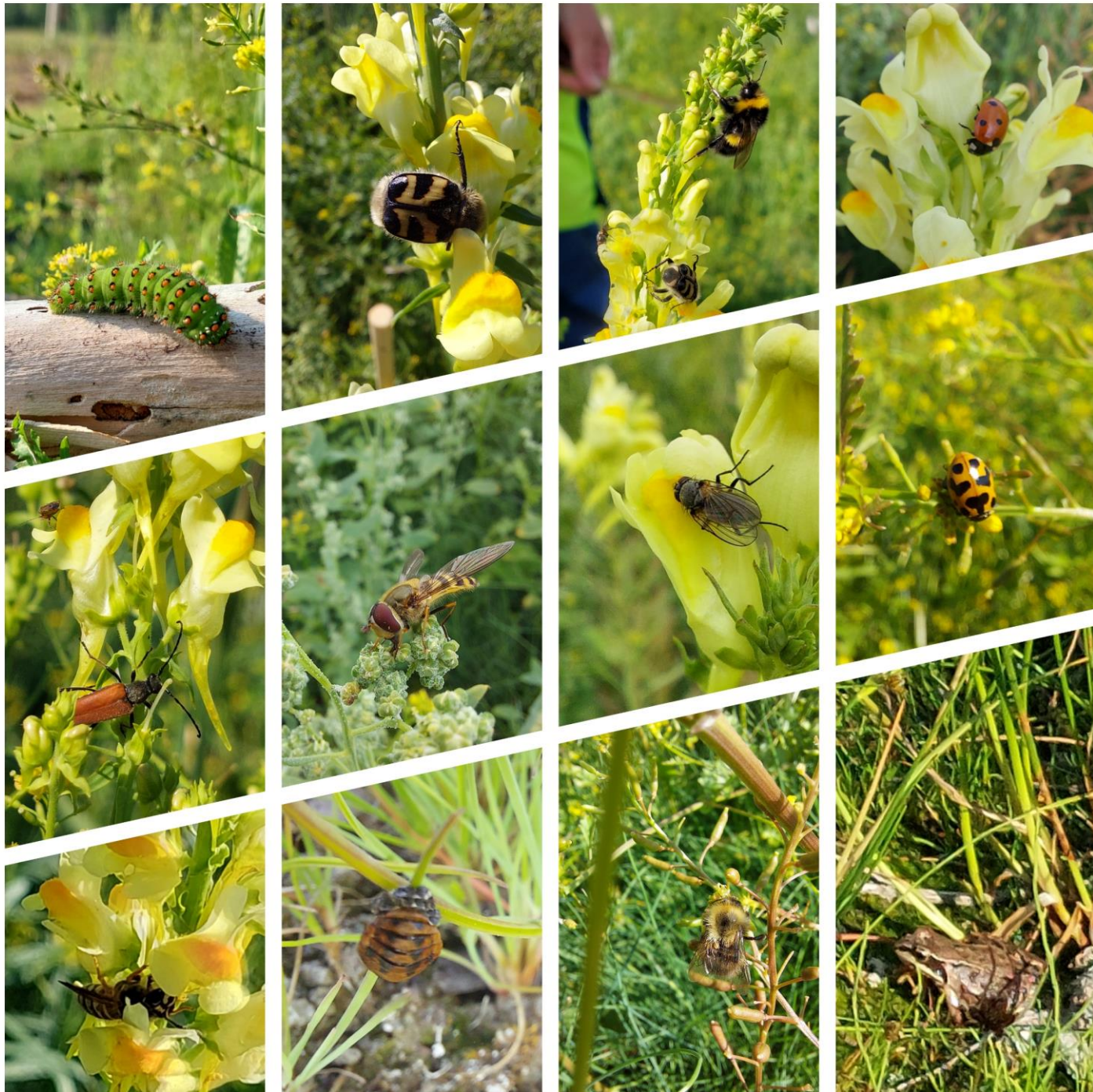
## Aims

- Plant species adaption to northern conditions
- Establishment methods: seedlings, seeds, meadow clippings, and mor


# Ecosystem Restoration in Mine Closures

## Results so far

- The biocover solution improve plant germination, growth, and spread
- Successful restoration and increased biodiversity with geomorphology, micro-topography and dynamic vegetation planning



# Co-operators & funders

**Lapland (EAKR), Kainuu (JTF)**

## Mining companies

**Boliden Kevitsa Mining Ltd, Hannukainen Mining Ltd, Rupert Finland Ltd, Mawson Ltd, AA Sakatti Mining Ltd, Angnico Eagle Ltd, Terrafame Ltd, Elementis Minerals Ltd**

## Other companies and organizations

**GRK Ltd, Neve Ltd, Sodankylä municipality, Kittilä municipality, Sodankylä municipality, Levin Vesihuolto Ltd, Inergia Ltd, Rissasen Taimisto Ltd, Taaleri Ltd, Kajaani municipality, Sotkamo municipality**

Funded by the European Union

BIOPEITTO 3

Luke NATURAL RESOURCES INSTITUTE FINLAND

GTK

KAMK Kajaani University of Applied Sciences

REGIONAL COUNCIL OF KAINUU

Centre for Economic Development, Transport and the Environment

# Luke´s expertise relevant for mining industry

- Science-based development of biocover solutions for mine closure in northern climate conditions
- Enhancing regional circular bioeconomy together with local companies
  - Utilization of side-streams
  - Value chain evaluation
- Development of geomorphological solutions
  - New models
  - Utilization of local natural plant species and dynamic vegetation planning

Funded by the European Union

BIOPEITTO 3

Luke NATURAL RESOURCES INSTITUTE FINLAND

GTK

KAMK Kajaani University of Applied Sciences

REGIONAL COUNCIL OF KAINUU

Centre for Economic Development, Transport and the Environment

marleena.hagner@luke.fi
pasi.laajala@luke.fi
raija.pietia@gtk.fi

Funded by the European Union

BIOPEITTO 3

Luke NATURAL RESOURCES INSTITUTE FINLAND

GTK

KAMK Kajaani University of Applied Sciences

REGIONAL COUNCIL OF KAINUU

Centre for Economic Development, Transport and the Environment