

# Soil carbon stock in fertilized forest stands with mineral soils

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Forest mineral soil is one of the terrestrial carbon pools, and changes in forest management practices can affect the carbon stock in forest soil.

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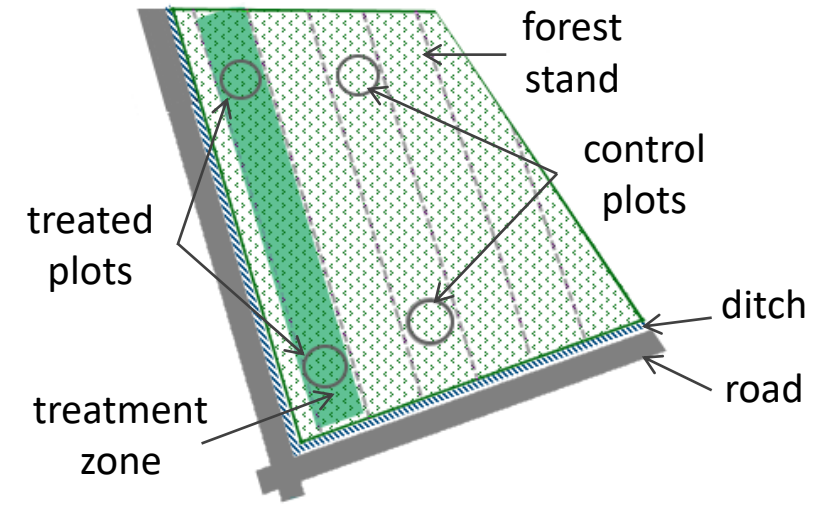
The aim of the study is to estimate temporal fertilization impact on mineral soil organic carbon stock.

# Research objects and fertilization

Experiment	Soil type and moisture conditions	Dominant tree species	Number of forest stands	Age of stands	Dose: t WA or $\text{NH}_4\text{NO}_3 \text{ ha}^{-1}$	Date of treatment
Wood ash	Dry min. soil	Norway spruce	3	50-54	2; 3 t WA	11.2014; 05.2017
	Drained min. soil	Norway spruce	3	44-53	3; 4; 6; 8 t WA	10.2016; 12.2016; 05.2017
WA+ $\text{NH}_4\text{NO}_3$	Drained min. soil	Norway spruce, Scots pine, birch	7	34-67	3 t WA + 0.44 t $\text{NH}_4\text{NO}_3$	10.2016; 02.2017; 06.2017; 07.2017
$\text{NH}_4\text{NO}_3$	Dry min. soil	Norway spruce, Scots pine, birch	31	24-130	0.44 t $\text{NH}_4\text{NO}_3$	09.2015; 06.2017; 07.2017
	Wet min. soil	birch	2	23-48	0.44 t $\text{NH}_4\text{NO}_3$	05.2017; 06.2017
	Drained min. soil	Norway spruce	2	28-37	0.44 t $\text{NH}_4\text{NO}_3$	09.2015; 06.2017

# Soil sample collection

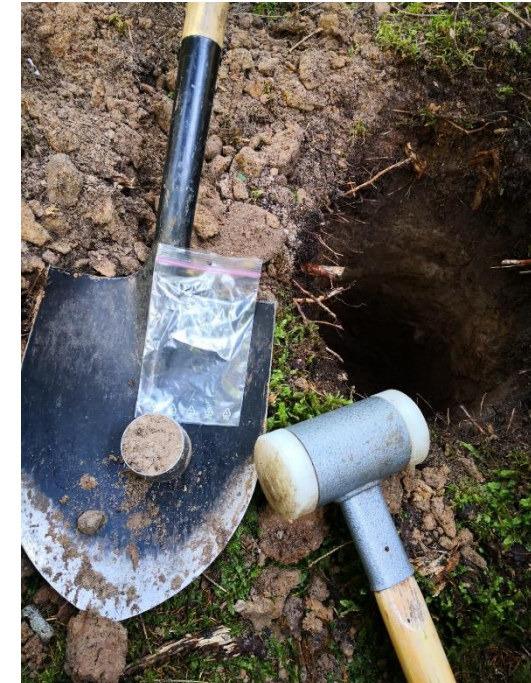
- Soil samples (0-10 cm, 10-20 cm, 20-40 cm, 40-80 cm) and O horizon samples - 2 replicates per plot.
- Samples were collected in 2019 (2-5 years after the forest soil fertilization).



**Scheme of trial object**



**Sample of O horizon**



**Sample of mineral soil**

# $C_{\text{ORG}}$ stock ( $\text{t ha}^{-1}$ ) in O horizon

Fertilizer	WA		WA+ $\text{NH}_4\text{NO}_3$		$\text{NH}_4\text{NO}_3$	
	dry min. soil	drained min. soil	drained min. soil	dry min. soil	wet min. soil	drained min. soil
control	14.0±6.5	6.4±2.4	12.9±1.6	13.3±0.9	7.8±2.3	7.2±0.9
fertilized	12.5±3.0	11.2±3.0	9.9±1.3	11.6±0.7	8.8±2.3	8.2±1.3

Types of fertilizers:

WA – wood ash

WA +  $\text{NH}_4\text{NO}_3$  – wood ash and ammonium nitrate

$\text{NH}_4\text{NO}_3$  – ammonium nitrate

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*Biosoil*: **21 t ha<sup>-1</sup>** (Bārdule *et al.*, 2009)

European forests: **22.1 t ha<sup>-1</sup>** (De Vos *et al.*, 2015)

# Correlations between $C_{\text{ORG}}$ and $N_{\text{TOT}}$ stock in O horizons

Fertilizer	WA		WA+ $\text{NH}_4\text{NO}_3$		$\text{NH}_4\text{NO}_3$	
	dry min. soil	drained min. soil	drained min. soil	dry min. soil	wet min. soil	drained min. soil
control	<sup>b</sup> 0.73	-	<sup>a</sup> 0.89	<sup>a</sup> 0.85	<sup>b</sup> 0.94	<sup>a</sup> 0.98
fertilized	<sup>b</sup> 0.76	-	<sup>a</sup> 0.54	<sup>a</sup> 0.58	-	<sup>a</sup> 0.79

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$\text{NH}_4\text{NO}_3$  – ammonium nitrate

<sup>a</sup>  $p < 0.01$

<sup>b</sup>  $p < 0.05$



# Mean soil C<sub>ORG</sub> stock (t ha<sup>-1</sup>) in different soil layers

Layer	Plot	WA		WA+ NH <sub>4</sub> NO <sub>3</sub>		NH <sub>4</sub> NO <sub>3</sub>	
		dry min. soil	drained min. soil	drained min. soil	dry min. soil	wet min. soil	drained min. soil
0-10 cm	control	40.5±6.7	66.7±15.4	62.9±5.1	30.7±2.3	<sup>a</sup> 44.4±5.3	63.8±9.8
	fertilized	38.4±9.2	43.8±16.2	54.5±4.8	30.9±2.1	<sup>a</sup> 29.6±4.1	61.9±6.7
10-20 cm	control	22.5±5.2	30.6±9.3	36.3±6.7	15.7±1.3	<sup>a</sup> 19.4±3.8	32.8±2.3
	fertilized	18.1±2.7	41.1±5.4	36.0±6.7	12.8±0.8	<sup>a</sup> 11.0±1.6	45.7±5.7
20-40 cm	control	16.2±4.6	19.0±6.3	29.3±9.9	12.1±1.0	7.1±2.4	14.6±4.1
	fertilized	17.5±5.4	31.8±5.7	34.6±14.5	12.4±1.0	8.9±3.1	32.7±8.8
40-80 cm	control	15.5±5.5	52.3±12.2	41.1±16.1	16.8±2.3	12.6±3.7	15.2±3.8
	fertilized	18.2±3.3	33.1±5.1	25.3±6.4	15.4±1.7	29.0±10.8	21.2±5.3

Types of fertilizers: WA – wood ash; WA + NH<sub>4</sub>NO<sub>3</sub> – wood ash and ammonium nitrate; NH<sub>4</sub>NO<sub>3</sub> – ammonium nitrate

<sup>a</sup> p < 0.05

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Layer	Plot	WA		WA+ NH <sub>4</sub> NO <sub>3</sub>		NH <sub>4</sub> NO <sub>3</sub>	
		dry min. soil	drained min. soil	drained min. soil	dry min. soil	wet min. soil	drained min. soil
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# Mean soil $C_{\text{ORG}}$ stock ( $\text{t ha}^{-1}$ ) in different soil layers

Layer	Plot	WA		WA+ $\text{NH}_4\text{NO}_3$		$\text{NH}_4\text{NO}_3$	
		dry min. soil	drained min. soil	drained min. soil	dry min. soil	wet min. soil	drained min. soil
0-10 cm	control	40.5±6.7	66.7±15.4	62.9±5.1	30.7±2.3	<sup>a</sup> 44.4±5.3	63.8±9.8
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<sup>a</sup>  $p < 0.05$

# Cumulative soil C<sub>ORG</sub> stock (t ha<sup>-1</sup>) in different soil layers

Layer	Plot	WA		WA+ NH <sub>4</sub> NO <sub>3</sub>		NH <sub>4</sub> NO <sub>3</sub>	
		dry min. soil	drained min. soil	drained min. soil	dry min. soil	wet min. soil	drained min. soil
0-20 cm	control	63.0	97.3	99.2	46.4	63.8	96.6
	fertilized	56.5	84.8	90.5	43.7	40.7	107.5
0-40 cm	control	79.2	116.2	128.5	58.5	71.0	111.2
	fertilized	74.0	116.7	125.1	56.2	49.5	140.2
0-80 cm	control	94.7	168.6	169.6	75.3	83.6	126.4
	fertilized	92.2	149.8	150.4	71.6	78.6	161.4

Types of fertilizers:

WA – wood ash

WA + NH<sub>4</sub>NO<sub>3</sub> – wood ash and ammonium nitrate

NH<sub>4</sub>NO<sub>3</sub> – ammonium nitrate

European forests: **108 t ha<sup>-1</sup>** at  
0-100 cm depth (De Vos *et al.*,  
2015)

# Correlations between relative C<sub>ORG</sub> and N<sub>TOT</sub> (in comparison to the control plots, %) stock in soil layers

Experiment	Soil type and moisture conditions	0-10 cm	10-20 cm	20-40 cm	40-80 cm	0-20 cm	0-40 cm	0-80 cm
WA	Dry min. soil	-	-	-	-	-	<sup>b</sup> 0.94	<sup>a</sup> 0.95
	Drained min. soil	-	-	-	-	<sup>b</sup> 0.94	<sup>a</sup> 0.86	<sup>b</sup> 0.61
WA+ NH <sub>4</sub> NO <sub>3</sub>	Drained min. soil	-	-	-	<sup>b</sup> 0.89	<sup>a</sup> 0.85	<sup>a</sup> 0.83	<sup>a</sup> 0.84
NH <sub>4</sub> NO <sub>3</sub>	Dry min. soil	<sup>a</sup> 0.92	<sup>a</sup> 0.86	<sup>a</sup> 0.53	<sup>a</sup> 0.53	<sup>a</sup> 0.90	<sup>a</sup> 0.78	<sup>a</sup> 0.72
	Wet min. soil	-	-	-	-	-	-	<sup>a</sup> 0.88

Types of fertilizers:

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WA + NH<sub>4</sub>NO<sub>3</sub> – wood ash and ammonium nitrate;

NH<sub>4</sub>NO<sub>3</sub> – ammonium nitrate

<sup>a</sup> p < 0.01; <sup>b</sup> p < 0.05

# Conclusions

- No significant trends were found in average carbon stock in O horizon among experimental groups or different growth conditions.
- In comparison to the control plots, a smaller  $C_{\text{ORG}}$  stock in 0-10 cm mineral soil layer was detected in the most of the fertilized plots. A statistically significant difference between control and fertilized plots was found in upper soil layers (0-10 cm and 10-20 cm) of birch stands with wet mineral soil, indicating a possible impact of ammonium nitrate on mineralization of organic matter.
- There is no significant difference between soil  $C_{\text{ORG}}$  stock in control plots and plots fertilized with wood ash and nitrogen.
- On average, forest fertilization with wood ash and/or ammonium nitrate does not have a significant impact on  $C_{\text{ORG}}$  stock in mineral soil 2-5 years after the fertilization.
- A relationship between  $C_{\text{ORG}}$  and  $N_{\text{TOT}}$  stock in mineral soil was found practically in all plots – both control and fertilized, and in most of the plots – a relationship between the stock in O horizon.

***Thank you for your attention!***

Research program on forest fertilization 2015-2021

The study is implemented within the scope of the memorandum between LSFRI “Silava” and Joint Stock Company “Latvia’s State Forests” from 11.10.2011