GLOBE Estonia Learning Expedition

WOODLANDS NEAR THE SHORE OF THE BALTIC SEA IN MATSI

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Abstract

Due to the active forest harvesting in Estonia, there is a heated discussion about its effects on climate and natural habitats. Because of that we wanted to study the biomass and vegetation of forests in different growth stages.

The aim of the study is to note the vegetation and biomass of the forest and find how the formerly cut recovering forest is recovering by comparing its vegetation to an older pine forest. For that we did fieldwork in five different study sites on the shore of the Baltic sea in Matsi, Pärnu County, where we measured tree height, trunk circumference, and studied the vegetation.

According to the research, the biomass and the amount of stored carbon does not vary a lot in one forest; the biomass in a forest can be up to 26 times more than in a herbaceous field, and that formerly cut recovering forests have mostly deciduous species even if the cut forest used to be mostly evergreen.

To extend the study, the methods should be improved by making them more clear and concrete. In addition, the fieldwork can be carried out in other forests in Estonia and if a few more measurements were added, conclusions could also be made on the topic of forest recovery and that can help to make even better decisions about cutting or preserving forests.

1. Introduction

In the European Union, forests are currently treated as a renewable resource. They are intensively cut and used in wood-based heat and power production, construction and for the production of everyday wood-based items such as kitchenware, office supplies etc.

Due to the active forest harvesting in Estonia, there is a heated discussion about its effects on climate and natural habitats. Strategies for sustainable forest management have been made in the EU, specifically the New EU Forest Strategy for 2030 which "...recognises the central and multi-functional role of forests, and the contribution of foresters and the entire forest-based value chain for achieving by 2050 a sustainable and climate-neutral economy while ensuring that all of the ecosystems are restored, resilient, and adequately protected.” (European Commission, 2021).

The aim of the study is to note the vegetation and biomass of the forest and find how the formerly cut recovering forest is recovering near the shore of the Baltic Sea in Matsi, by comparing its vegetation to an older pine forest. The project can help make better decisions on whether to cut or preserve forests.

Our research questions were:

- What are the differences in vegetation in forests of different growth stages?
- How much does the amount of the assessed biomass and stored carbon vary in the pine forest?
- Compared to a herbaceous field, how much more biomass per square meter is deposited in the forest?

Our hypotheses were:

- Recovering and older woodlands in the same area have little to no differences in species.
- The biomass is of a higher value in the study site “Pine forest 2”, because there the average circumference of a tree is wider than in study site “Pine forest 1”.
- Compared to a “Herbaceous field”, the biomass is 10 times higher in value in the pine forest (average of study sites “Pine forest 1” and “Pine forest 2”).

The most used sources and materials in conducting the study are The GLOBE Program’s protocols and methods as well as the Modified UNESCO Classification system (MUC) (The GLOBE Program, 2021).

2. Study sites

We studied four different research locations near the shore of the Baltic Sea in Matsi (Figure 1).

Figure 1. Research locations near the shore of the Baltic Sea in Matsi. Source of background aerial image: The Estonian Land Board

The first two study sites were pine forests - "Pine forest 1" and "Pine forest 2", of which the latter had fewer deciduous specimens in the understory layer than the former one. The average tree circumference in site "Pine forest 2" was of higher value than in site "Pine forest 1". Both study sites were dominated by tall pine trees (*pinus sylvestris*) and the land cover class was the same in both study sites – MUC 1121. The coordinates of the first site, "Pine forest 1", are 58°22'12.7"N 23°44'21.9"E and the coordinates of the second site are 58°22'06.7"N 23°44'30.5"E (Figure 2). According to The State Forest Management Centre's forestry works map, the age of the forest covering both sites is about 204 years (The State Forest Management Centre, 2021).

Figure 2. Study site “Pine forest 2”. Author: Anastassija Belaja

The third study site was a “Meadow with trees and bushes”, the purpose of which was to assess the general age of trees in that area (including the age of pine forest 1 and pine forest 2). It was mainly covered by broad-leaved deciduous species whose coverage was under 10%. The land cover class of the site was MUC 4323 and the coordinates were 58°22'02.8"N 23°44'34.6"E.

The fourth site, the “Formerly cut recovering forest”, had a thick canopy layer that consisted mainly of deciduous trees. The most common species were *populus tremula, betula pendula, grey alder* etc. The land cover class was MUC 2232 and the coordinates are 58°22'08.2"N 23°44'33.2"E. (Figure 3 and 4)

Figure 3. The “Formerly cut recovering forest”. Author: Anastassija Belaja

Figure 4. The pine forest next to the “Formerly cut recovering forest”. Author: Anastassija Belaja

The fifth site was a “Herbaceous field”. Its land cover class was MUC 4422 and the vegetation consisted mostly of herbaceous species that were no taller than 0.5 m as well as a few shrubs and saplings. The coordinates of the site are 58°22'29.3"N 23°44'05.2"E.

3. Methods

In all study sites we registered the precise research locations' coordinates using a GPS extension on Google Maps and identified the MUC code using The GLOBE Program's MUC Field Guide. We marked the research areas using measuring tapes and flags. Each area was 30 x 30 m (900 m2). To assess the age of trees we counted the tree rings of a stump and for more accurate results we compared our results to data on the Forestry Map by the State Forest Management Centre. To assess the age of small trees we took branch samples using a handsaw. We measured the height of trees using a handmade clinometer and the circumference of the trees using a tape measure. (Figure 5)

Figure 5. Used measuring tools. Author: Johanna Tammist

To assess the age of trees in the pine forest (sites "Pine forest 1" and "Pine forest 2"), we found the stump that was closest to the pine forest (it was located in study site three, meadow with trees and bushes) and counted its tree rings, which are usually equal to the age of the tree. Although when analyzing the data we realized that the used method is not accurate enough to assess the age of trees in the pine forest, because of the difference in land cover (between study sites "Pine forest 1", "Pine forest 2" and the "Meadow with trees and bushes") and because the age of the deciduous trees has probably little to no correlation with the age of evergreen pine trees that are located a couple hundred meters away. Therefore to check the accuracy of our data we compared it to the Forestry Map created by the State Forest Management Center (The

State Forest Management Centre, 2021). To assess the age of trees in the "Formerly cut recovering forest" we picked suitable branches, took branch samples and counted the tree rings.

To calculate the height of trees (Figure 6) we used a clinometer to find the angle of elevation (A) and measured the horizontal distance from the tree (AB) and the height of the clinometer from the ground (1.35 m) (The GLOBE Program 2014). The formula used was as followed:

$$\textbf{Tree height} = \textbf{AB} \cdot \tan \angle A + 1.35\ \text{m}$$

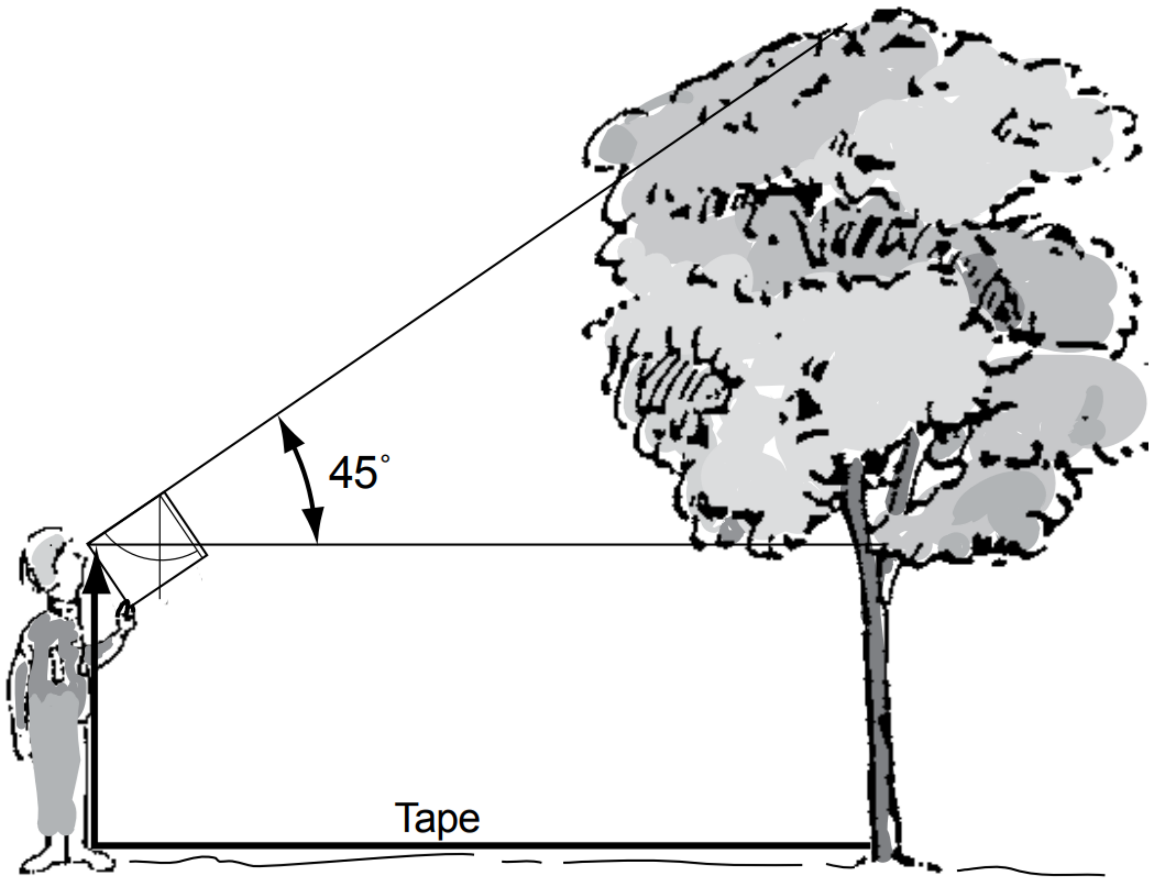


Figure 6. Measuring tree height using a clinometer. Source: The GLOBE Program's biometry protocol (The GLOBE Program, 2014)

When assessing the aboveground biomass in study sites "Pine forest 1" and "Pine forest 2", we identified the tree species and measured the circumference of all individual trees in the previously marked 30 x 30 m area. To find the biomass of the trees, we calculated the trunk diameter based on the measured circumference using the following formula:

diameter = circumference / π

To assess the biomass we used the predicted biomass graph (Figure 7) and to get the total biomass in the study site, we added up the biomass of all individual trees in the marked area. The amount of biomass in 1 m^2 was calculated by dividing the total biomass data by 900 because the total biomass was calculated on a 900 m^2 sized area.

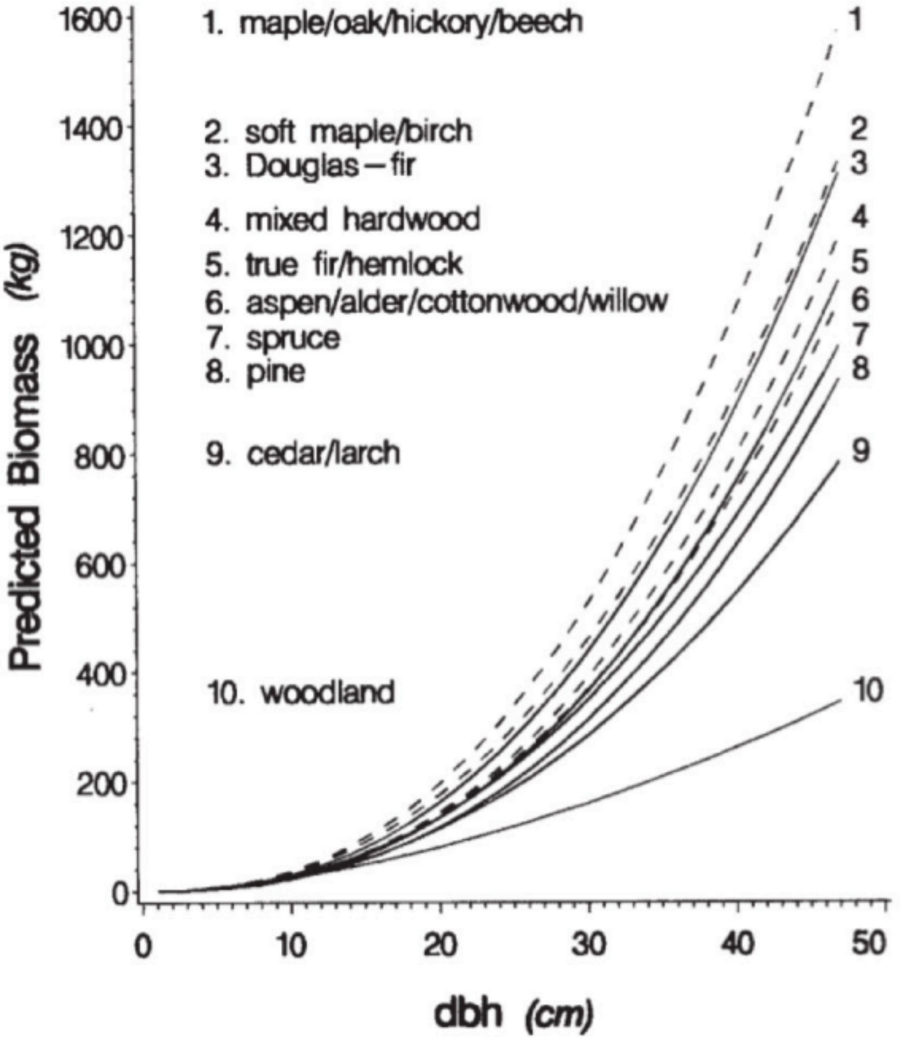


Figure 1. Graphs of ten equations for predicting total aboveground biomass by species group. Hardwoods are represented by dashed lines, softwoods by solid lines.

Figure 7. Allometric graph used to assess the predicted aboveground biomass based on trunk diameter and species. Source: The GLOBE Program Tree Biomass and Carbon Analysis protocol (The GLOBE Program, 2017a)

To calculate the biomass of vegetation we used The GLOBE program's Herbaceous Protocol Standard (The GLOBE Program, 2017b). To measure the biomass of the vegetation in study site 5, "Herbaceous field", we collected the samples of herbaceous vegetation on a random 1 x 1 m area. The area was randomly selected by one group member by throwing a rock somewhere in the study site with their back to the area. Next, we clipped all the vegetation close to the ground within the marked square. We let the samples dry and weighed the dry mass which was equal to the biomass.

To calculate the amount of stored carbon in trees we used The GLOBE program's Tree Biomass & Carbon Analysis protocol (The GLOBE program, 2017c). The formula used was:

$$\textbf{biomass (kg/m}^2\textbf{)} \cdot \textbf{50\% = amount of stored carbon (gC/m}^2\textbf{)}$$

4. Results

To get a better overview of the collected data we gathered it into tables and graphs.

Table 1 shows the most common tree species in study sites "Pine forest 1", "Pine forest 2" and "Formerly cut recovering forest". It is important to note that the deciduous species found in "Pine forest 1" and "Pine forest 2" had a low coverage and did not reach into the canopy layer. The formerly cut recovering forest site was mostly covered by deciduous species.

Table 1. Most common tree species in study sites "Pine forest 1", "Pine forest 2" and "Formerly cut recovering forest".

Pine forest 1 and 2		**Formerly cut recovering forest**	
English plant name	**Scientific plant name**	**English plant name**	**Scientific plant name**
scots pine	*pinus sylvestris*	common aspen	*populus tremula*
(mountain ash) rowan	*sorbus aucuparia*	European white birch	*betula pendula*
European spruce	*picea abies*	willow	*salix*

European white birch	*betula pendula*	Norway maple	*acer platanoides*
common aspen	*populus tremula*	(mountain ash) rowan	*sorbus aucuparia*
		European spruce	*picea abies*
		grey alder	*alnus incana*

Table 2 and 3 show the trunk circumference, diameter and biomass of individual trees in study sites "Pine forest 1" and "Pine forest 2". The tree species with the most coverage in both sites are scots pine (*pinus sylvestris*) and European spruce (*picea abies*). The data shown also supports the previous statement that the deciduous trees in sites "Pine forest 1" and "Pine forest 2" have a low coverage.

Table 2. The trunk circumference, diameter and biomass of individual trees in "Pine forest 1".

Pine forest 1				
English plant name	**Scientific plant name**	**Trunk circumference (cm)**	**Trunk diameter (cm)**	**Biomass, kg**
scots pine	*pinus sylvestris*	150	47.8	960
scots pine	*pinus sylvestris*	83	26.4	210
scots pine	*pinus sylvestris*	151	48.1	945
scots pine	*pinus sylvestris*	116	36.9	480
European spruce	*picea abies*	89	28.3	320
European spruce	*picea abies*	51	16.2	60
scots pine	*pinus sylvestris*	154	49.0	1040
scots pine	*pinus sylvestris*	151	48.1	945
European spruce	*picea abies*	44	14.0	60
European spruce	*picea abies*	65	20.7	150
scots pine	*pinus sylvestris*	65	20.7	150
scots pine	*pinus sylvestris*	75	23.9	165
scots pine	*pinus sylvestris*	30	9.6	30
scots pine	*pinus sylvestris*	39	12.4	40
scots pine	*pinus sylvestris*	49	15.6	60
scots pine	*pinus sylvestris*	47	15.0	55

scots pine	*pinus sylvestris*	42	13.4	40
European spruce	*picea abies*	32	10.2	30
European spruce	*picea abies*	15	4.8	10
European spruce	*picea abies*	10	3.2	10
(mountain ash) rowan	*sorbus aucuparia*	10	3.2	10
Average trunk circumference (cm)		69.905		

Table 3. The trunk circumference, diameter and biomass of individual trees in "Pine forest 2".

Pine forest 2				
English plant name	**Scientific plant name**	**Trunk circumference (cm)**	**Trunk diameter (cm)**	**Biomass, kg**
scots pine	*pinus sylvestris*	86	27.4	270
scots pine	*pinus sylvestris*	146	46.5	960
scots pine	*pinus sylvestris*	125	39.8	600
scots pine	*pinus sylvestris*	106	33.8	400
scots pine	*pinus sylvestris*	62	19.7	115
scots pine	*pinus sylvestris*	66	21.0	121
scots pine	*pinus sylvestris*	84	26.8	220
scots pine	*pinus sylvestris*	70	22.3	150
scots pine	*pinus sylvestris*	77	24.5	195
scots pine	*pinus sylvestris*	57	18.2	100
European spruce	*picea abies*	25	8.0	10
scots pine	*pinus sylvestris*	48	15.3	60
scots pine	*pinus sylvestris*	68	21.7	120
European white birch	*betula pendula*	107	34.1	560
scots pine	*pinus sylvestris*	104	33.1	485
common aspen	*populus tremula*	137	43.6	920
scots pine	*pinus sylvestris*	60	19.1	120

scots pine	*pinus sylvestris*	37	11.8	45
scots pine	*pinus sylvestris*	75	23.9	160
scots pine	*pinus sylvestris*	45.5	14.5	60
Average trunk circumference (cm)		79.275		

Table 4 shows the total biomass, biomass in 1 m^2 and deposited carbon (kg/m^2) in study sites "Pine forest 1", "Pine forest 2" and also the average of the two sites. The biomass in 1 m^2 in "Pine forest 1" was 6.41 kg and in"Pine forest 2" was 6.30 kg, the average of the two sites was 6.356 kg.

Table 4. The total biomass, biomass and deposited carbon (kg/m^2) 1 m^2 in study sites "Pine forest 1", "Pine forest 2" and the average of the two sites.

	Pine forest 1	**Pine forest 2**	**Average of the two sites**
Total biomass (kg)	5770	5671	5720.5
Biomass in 1 m^2 (kg)	6.41	6.30	6.356
Deposited carbon kg/m^2	3.21	3.15	3.18

The following graph (Figure 8) illustrates the difference in biomass between study sites "Pine forest 1" and "Pine forest 2". It is evident that the difference is small.

Figure 8. Biomass in study sites "Pine forest 1" and "Pine forest 2".

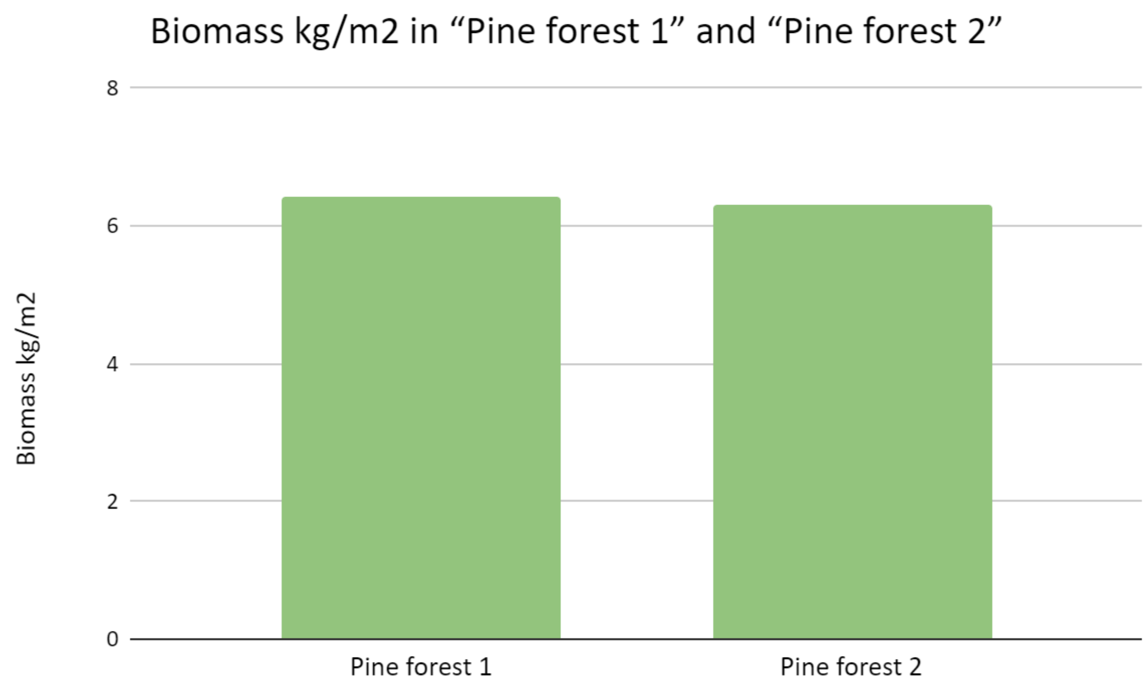


Figure 9 shows that the difference in the amount of deposited carbon in study sites "Pine forest 1" and "Pine forest 2" is also small.

Figure 9. Deposited carbon in study sites "Pine forest 1" and "Pine forest 2".

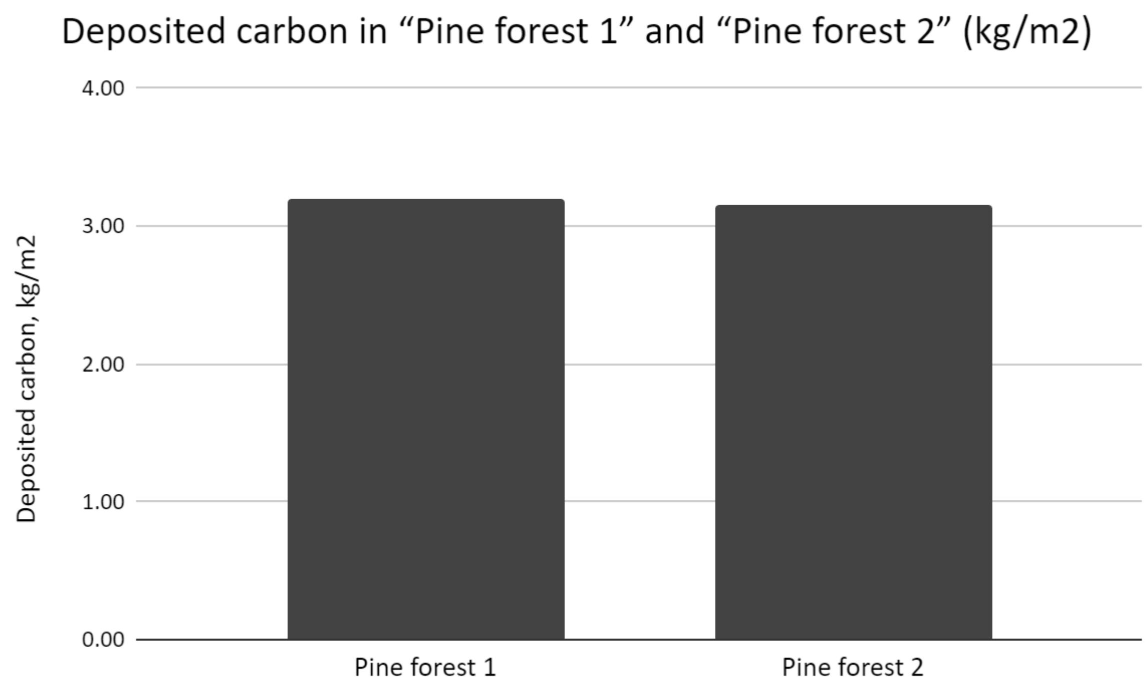
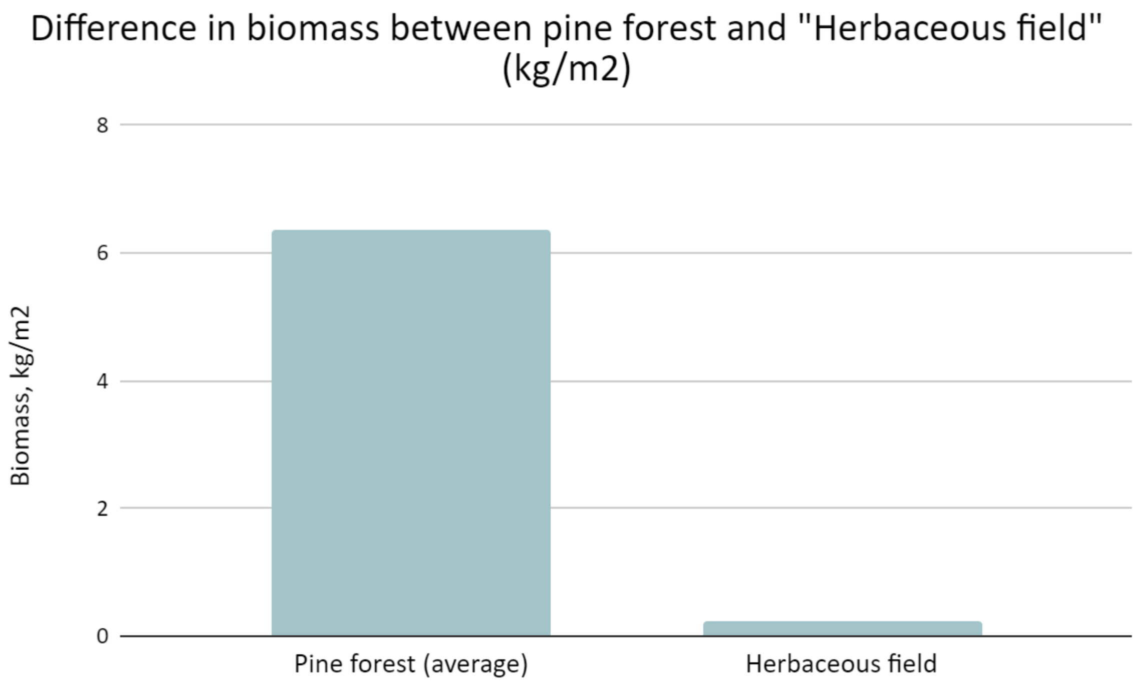


Table 5 and Figure 10 show the difference in biomass (kg/m^2) between pine forest (average of study sites “Pine forest 1” and “Pine forest 2”) and “Herbaceous field”. The biomass in the “Herbaceous field” is as low as 0.246 kg/m^2. The amount of biomass in the pine forest was 25.8 times more than the biomass of the “Herbaceous field”.

Table 5. The difference in biomass (kg/m^2) between pine forest (average) and “Herbaceous field”.

	Pine forest (average)	**Herbaceous field**
Biomass, kg/m^2	6.356	0.246

Figure 10. The difference in biomass (kg/m^2) between pine forest (average) and “Herbaceous field”.



5. Discussion

Based on the collected data, the “Formerly cut recovering forest” has mostly deciduous trees (*populus tremula, betula pendula, grey alder* etc.) which was not expected and not shown in our hypothesis. Therefore the first hypothesis we set, that stated that recovering and older woodlands in the same area have little to no differences in species, was not supported. The differences in our case were in fact evident, yet based on the data we collected to be able to say as a fact that recovering and older woodlands in the same area have many differences in species, is not possible. To be able to say for sure, similar fieldwork should be carried out in other different types of forests in Estonia as well. The dominating species in "Pine forest 1" and "Pine forest 2" were *pinus sylvestris* and *picea abies*.

Hypothesis 2 – the biomass is of a higher value in the study site "Pine forest 2", because there the average circumference of a tree is wider than in study site "Pine forest 1" – was not supported. The biomass was of a higher value in the study site "Pine forest 1", being 6.41 kg/m^2 compared to the 6.30 kg/m^2 in "Pine forest 2" . If the two study sites had the same amount of trees and the average circumference of a tree in study site "Pine forest 2" was still wider than in the site "Pine forest 1", the hypothesis would be correct. However in our case the site "Pine forest 1", that had narrower trees, also had more trees resulting in a slightly higher total biomass. Based on the research question and the collected data it can be said that the amount of the assessed biomass and stored carbon varies very little.

Our third hypothesis was not supported. Compared to the "Herbaceous field", the biomass was not only 10 times, but about 25.8 times higher in value in the pine forest (average biomass of study sites "Pine forest 1" and "Pine forest 2"). The biomass of the "Herbaceous field" was 0.356 kg/m^2 and the average in the pine forest was 6.356 kg/m^2.

6. Conclusions

According to the conducted research, there are differences in vegetation in forests of different growth stages. Formerly cut recovering forests have mostly deciduous species even if the cut forest used to be mostly evergreen. The research also shows that the amount of biomass and stored carbon does not vary a lot in different parts of a pine forest. A grown forest's biomass can be as much as 25-26 times more than the biomass of a herbaceous field.

To extend the study, the methods should be improved by making them more clear and concrete. In addition, to get better, more accurate results, the fieldwork should become more structured and then be carried out in other forests in Estonia. Studying also the biomass of the formerly cut recovering forest and comparing the data to that of an older forest in the same area, conclusions could also be made on the topic of forest recovery. That can help to make even better decisions about cutting or preserving forests.

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