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Soil fertility rather reduces potential productivity of silver birch at the early stage of natural regeneration of post-agricultural lands

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Abstract

The study aimed to investigate the effect of soil fertility on the growth potential of naturally regenerated silver birch (*Betula pendula* Roth.) stands growing on the post-agricultural lands in Mazowieckie region (central Poland). We selected 10 locations with birch renewals of age ranging from 2 to 17 years. At each place we established a 4-plot chronosequence and determined the following features in the upper 50-cm-thick soil layer: soil texture, pH, total carbon and nitrogen level, and base cations content. These characteristics were later on used for soil fertility index calculation. Based on the height measurements, we determined the site index (height at the base age of 25 years) for the analysed stands using previously developed formula. Trees height as well as chemical properties of soils under silver birch regeneration varied with regard to the age, whereas soil physical attributes turned to be rather stabile. We found out that both soil fertility index and site index values were not significantly correlated with stand age ($r = -0.043$, $p = 0.919$ and $r = -0.053$, $p = 0.748$, respectively) indicating that site productivity potential during the initial phase of secondary succession is rather stable. However, the soil fertility turned to have the negative and significant impact on the site index of birch renewals ($r = -0.372$, $p = 0.018$). This might have probably resulted from the similar type of relationship we observed between site index and base cations content ($r = -0.317$, $p = 0.046$).

Introduction

Stable elements of the environment (e.g. soil conditions) determine the site productive potential in the great measure.

Recognition of the production potential of the post-agricultural lands intended for afforestation is important from the point of view of their sustainable forest management.

Silver birch (*Betula pendula* Roth.) is a pioneer species that very often itself colonises former arable lands or is used to afforest them.

Objectives

We investigated the selected attributes of soils covered by natural regeneration of silver birch on post-agricultural lands as well as determined the growth potential of this vegetation.

We hypothesised that soil fertility enhance the growth potential of naturally regenerated silver birch and the site index of such stands is the higher the more fertile soils are.

Material & methods: study sites

10 locations in central Poland where we established 4-plot chronosequences of silver birch secondary succession stands.

The age of analysed stands ranged from 2 to 17 years.

At each plot, soil samples and stand parameters measurements were taken.

	GPS
Mińsk Mazowiecki	52°10' N, 21°40' E
Łochów 1	52°33' N, 22°02' E
Łochów 2	52°34' N, 20°01' E
Kozienice	51°24' N, 21°26' E
Dobieszyn 1	51°35' N, 21°10' E
Dobieszyn 2	51°33' N, 21°09' E
Siedlce	52°03' N, 21°56' E
Ostrołęka	53°03' N, 21°29' E
Kampinoski Park Narodowy 1	52°21' N, 20°43' E
Kampinoski Park Narodowy 2	52°19' N, 20°40' E

Gawęda et al. 2018

Material & methods: soil properties

At each plot, from the upper soil horizons we took samples (0-5, 5-15 and 15-50 cm layers) and their further analyses included:

- soil texture
- pH
- total carbon
- total nitrogen
- exchangeable base cations content (Ca, Mg, Na and K)

Material & methods: soil fertility

We used forest soil trophic index (ITGL; Brożek 2001) to quantify the soil fertility.

ITGL is a sum of sub-indices values (silt content, clay content, sum of exchangable base cations, pH and C:N ratio) calculated for each layer and weighted with layer thickness.

The higher ITGL value, the more eutrophic (fertile) soil.

Material & methods: site index

SI – site index: height of the stand at the base age of 25 years

$$SI = H_L \frac{25^{1,41} \cdot (T^{1,41} \cdot R + 16640,57)}{T^{1,41} \cdot (25^{1,41} \cdot R + 16640,57)}$$

$$R = H_L + 21,77 + \left((H_L + 21,77)^2 + \frac{2 \cdot 16640,57 \cdot H_L}{T^{1,41}} \right)^{0,5}$$

Bijak et al. 2014

T – age [yrs], H_L – average height [m]

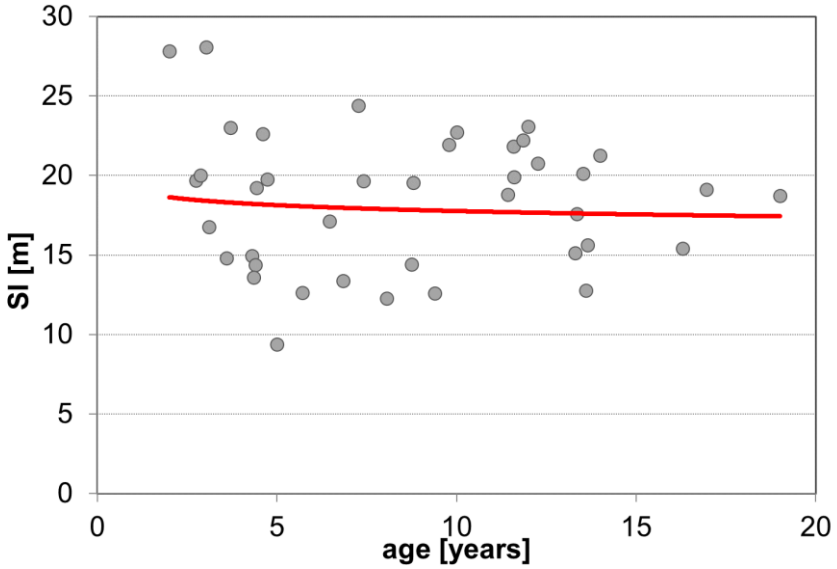
Material & methods: analyses

Pearson correlation coefficient used to track the relationship between site index and soil fertility

Calculations performed with PAST 4.06 software (Hammer et al. 2001)

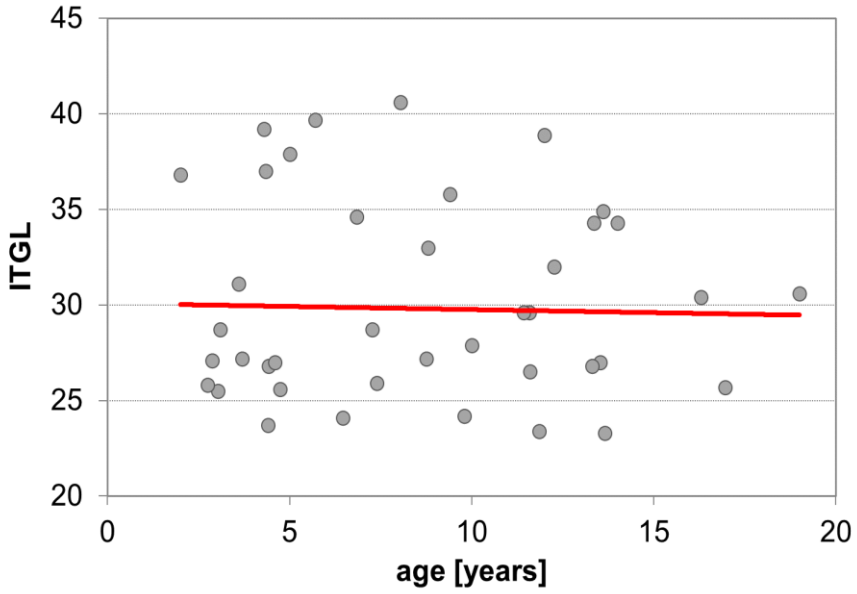
	ITGL	SI
mean	30.2	18.4
median	28.7	19.2
min	23.3	9.4
max	40.6	28.1
CV	17%	23%

Results: (in)dependence on age



$r_{SIvsAGE}$ -0.053

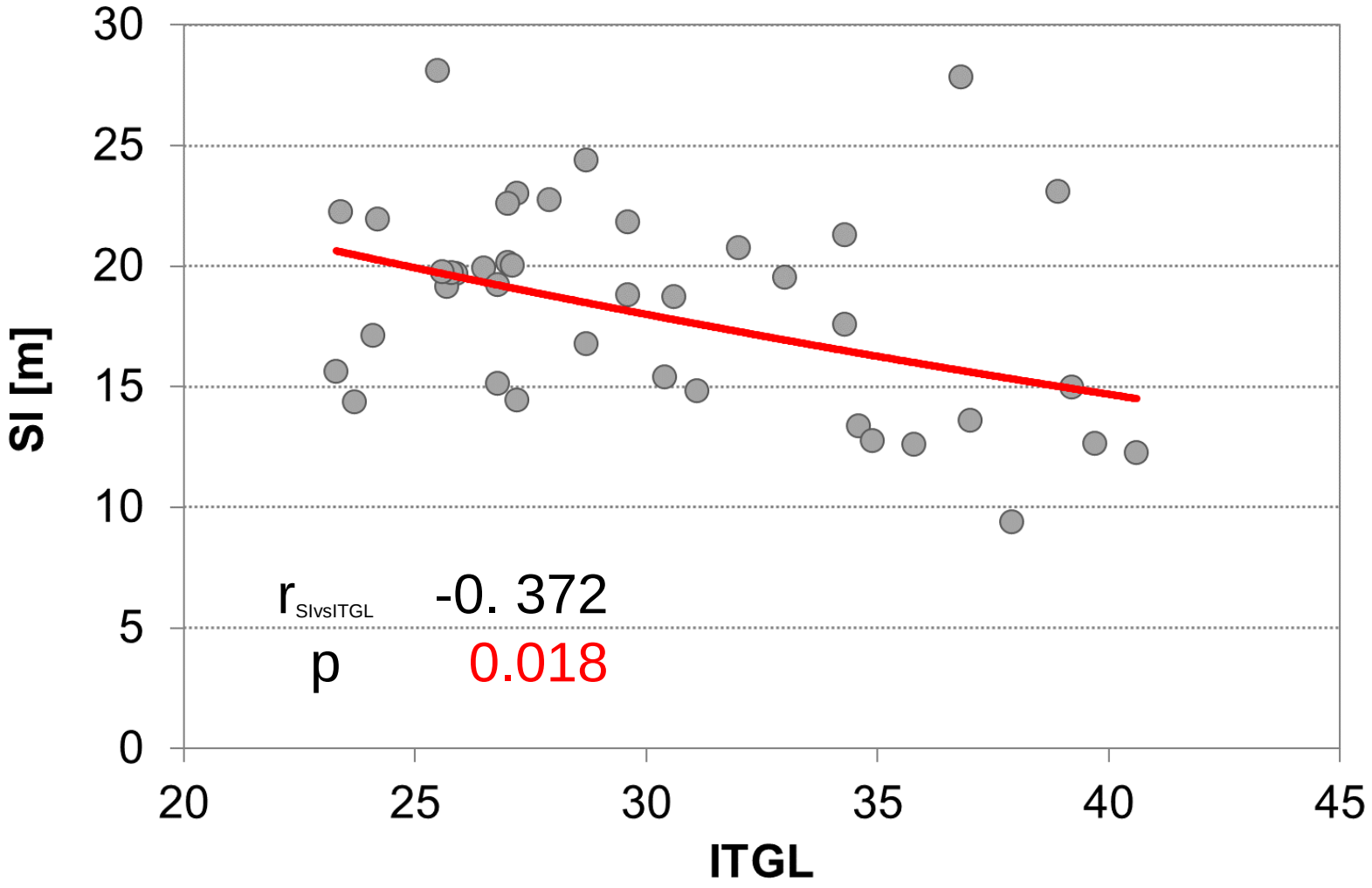
p 0.748



$r_{ITGLvsAGE}$ -0.043

p 0.919

Results: overfertility gives no productive effect



Results: looking for a cause

Out of analysed soil properties, base cations content had significant negative impact on site index of silver birch secondary succession stands

	r_{vsSI}	p
base cat.	-0.317	0.046
pH	-0.238	0.140
N	-0.276	0.085
C	-0.167	0.304
C:N	0.018	0.911
silt	-0.189	0.243
clay	-0.194	0.231

Conclusions

- Both soil fertility and site indices were not significantly correlated with the stand age, which indicates that the site productivity potential during the initial phase of secondary succession is rather stable.
- Soil fertility turned to have significant negative impact on the site index of birch renewals, which might have resulted from the similar type of relationship between site index and base cations content.
- High fertility of post-agricultural soils seems not to be fully exploited by the silver birch secondary succesion.

References

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