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Distribution, composition and structure of forest communities with non-native *Sambucus* species in Lithuania

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Abstract. In the last two hundred years, forest managers introduced non-native woody species. Such species can negatively impact ecosystems by invading and disrupting communities and ecosystems, changing biodiversity, nutrients and water cycling. The aim of this study was to determine the distribution of *Sambucus* species in different age *Pinus sylvestris* forests and the impact of *Sambucus* sp. on forest communities composition and structure. The data on the characteristics of pine forest stands with *Sambucus* sp. and dynamics of *Sambucus* sp. were retrieved from Standwise Forest Inventory and National Forest Inventory databases. Species composition and structure of forest stands with *Sambucus nigra*, *Sambucus racemosa* shrub species and natural forests stands were recorded in 43 sample plots. In each plot stand dendrometric characteristics, soil chemical properties and abundance of vascular plant and moss species were recorded in 2016. Data were analysed using ordination and GLM method. *Sambucus* sp. were mostly spread in fertile, fresh humidity sites in *Pinus sylvestris* and *Picea abies* dominated forest stands of 0.7-0.8 stocking level and 41-80 years old. The abundance of *Sambucus sp.* increased from 1998 to 2015 in all height and different age stands. The highest increase of *Sambucus sp.* stems was recorded in 2013-2015 in the stands dominated by deciduous *Quercus robur* and *Alnus incana* species. Conditionally natural pine forest and pine forest communities with *Sambucus racemosa* and *Sambucus nigra* were different in terms of species composition and soil parameters. The highest number of species was recorded in forest communities with *Sambucus racemosa*, but forests communities with *Sambucus nigra* were associated with higher amount of soil organic carbon and total nitrogen.
Keywords: impact; communities composition; distribution; *Sambucus racemosa*; *Sambucus nigra*.

Distribución, composición y estructura de las comunidades forestales con especies no nativas de Sambucus en Lituania

Resumen. En los últimos doscientos años los responsables del manejo forestal han introducido en los bosques lituanos especies leñosas no nativas. Estas especies pueden impactar negativamente en los ecosistemas al invadir y desorganizar las comunidades, ya que introducen cambios en la biodiversidad, los nutrientes y el ciclo del agua. El objetivo de este estudio fue determinar la distribución de las especies de *Sambucus* en diferentes bosques de *Pinus sylvestris* y su impacto sobre la composición y estructura de las comunidades forestales. Los datos sobre las características florísticas y la dinámica del bosque de pinos con *Sambucus* sp. se obtuvieron de las Bases de Datos del Inventario Forestal y del Inventario Nacional de Bosques. Se registraron la composición de especies y la estructura de los rodales forestales con *Sambucus nigra*, *Sambucus racemosa* en 43 parcelas. Además para cada una de las parcelas, se muestrearon en 2016 las características dendrométricas, las propiedades químicas del suelo y la abundancia de especies de plantas vasculares y briófitos. Los datos se analizaron mediante ordenaciones, así como GLMs. Las distintas especies de *Sambucus* se encontraron principalmente en sitios de humedad fresca y fértil en bosques de *Pinus sylvestris* y *Picea abie*s, en rodales forestales de 0,7 a 0,8 de altura media y de 41 a 80 años de edad. La abundancia de *Sambucus* aumentó de 1998 a 2015 en todas las alturas y a diferentes edades. El mayor incremento de *Sambucus* se registró en 2013-2015 en los rodales dominados por *Quercus robur* y *Alnus incana*. Las comunidades de bosque de pino condicionalmente natural y de bosque de pino con *Sambucus racemosa* y *Sambucus nigra* fueron diferentes en términos de composición de especies y parámetros del suelo. El mayor número de especies se registró en aquellas comunidades forestales con *Sambucus racemosa*, pero las comunidades forestales con *Sambucus nigra* se asociaron con una mayor cantidad de carbono orgánico en el suelo y nitrógeno total.
Palabras clave: impacto; composición florística; distribución; *Sambucus racemosa*; *Sambucus nigra*.

Introduction

Natural barriers in the natural environment are decreasing because of increasing processes of globalization. The issue that is often debated nowadays is the distribution of new species and the change of species in ecosystems. In fact, the changes in ecosystems take place continuously, they are of different directions and intensity, and those changes will take place in the future (Hansen *et al.*, 2010).

During the last two hundred years, forest managers introduced non-native woody species seeking new products and increased stand yield. Thus, non-native species have become numerous and even have partly replaced native forests in some countries in Europe. In the same way, non-native species move into anthropogenic, disturbed, or natural habitats and start changing not only the composition of communities but also environmental conditions. Non-native tree and other woody species can negatively affect ecosystems in many ways. After naturalization, non-native

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species can become invasive and may disrupt or transform communities and ecosystems. They may also affect native forest biodiversity through hybridization, changed nutrient cycling and water filtration, and decreased water supplies for nearby communities (Dickie *et al.*, 2014; Blackburn *et al*., 2015).

Some studies (Mooney & Hobs, 2006; Brang *et al*., 2014; Schlaepfer *et al*., 2015; Bonnano, 2016) reported the benefits of non-native species. Non-native species could become increasingly appreciated for their tolerance and adaptability to novel ecological conditions and their contribution to ecosystem resilience and to future speciation events. Non-native species could fill important ecosystem and aesthetic functions, particularly in places where native species cannot persist due to environmental changes. Indeed, some non-native species may be preadapted or adapt rapidly to novel ecological conditions. Furthermore, the ability of non-native species to tolerate and adapt to a broad range of biotic and abiotic conditions, as well as to expand their ranges rapidly, suggests that they may persist under a variety of future climate scenarios (Mooney & Hobbs, 2000; Richardson & Pyšek, 2006; Zerebecki & Sorte, 2011; Rejmanek, 2014).

The research of non-native species in Lithuania has been mostly dedicated to tree species such as *Quercus rubra* L.*, Robinia pseudoacacia* L. and *Prunus serotina* Ehrh. (Riepšas & Straigytė, 2008; Marozas *et al*., 2009, 2015; Janušauskaitė & Straigytė, 2011; Straigyte *et al*., 2012, 2015). Meanwhile, studies on non-native shrub species are lacking. In Lithuanian forests, the most spread alien shrub species are *Sambucus racemosa* L. and *S. nigra* L. The effects of these non-native species on plants reproductive potential and impact on human health were investigated (Abe *et al*., 2008; Cunha *et al*., 2016), whereas there is a lack of studies on the dispersal potential of non-native species or their impact on soil conditions, natural ecosystems, interactions with existing species.

The aim of this study was to determine the distribution of *Sambucus* sp. in different forests and investigate the impact of these species on the composition and structure of forest communities.

Materials and Methods

Data collection from databases

Data on distribution of *Sambucus* sp. and forest stand characteristics (with *Sambucus* sp.) were extracted from Standwise Forest Inventory database, which contains data on all forest stands in Lithuania. We retrieved data on the characteristics (dominant tree species, age, stocking level, and site type) of forest stands with *Sambucus* sp. The proportional distribution of area of stands with *Sambucus* sp. according forest type, dominant tree species, stocking level and age was calculated.

Data on the dynamics of *Sambucus* sp. were extracted from National Forest Inventory database of Lithuania. National Forest Inventory (NFI) possesses the data of four inventory cycles: 1998-2002, 2003-2007, 2008-2012, and 2013-2015. We used data of *Sambucus* sp. abundance expressed as number of stem units per ha according various categories: shrub height classes (0-0.5, 0.6-1.5, 1.6-3.0, and >3.0), stand age and dominant tree species.

Data sampling for the assessment of species composition

To analyse species composition, the circular plots (500 m^2) were established in *Pinus sylvestris* stands, where *Sambucus racemosa* and *S. nigra* shrub species were present (Figure 1, Table 1). In total, 19 plots were selected in pine stands with *S. nigra*, 14 plots in pine stands with *S. racemosa*. Within each plot stand, dendrometric characteristics (site type, dominant tree height, diameter, age and stocking level) were recorded. All vascular plants and moss species were recorded in the summer of 2016 (June-August). Species abundance was estimated using the scale of Braun-Blanquet (1965). Percentage cover of different stand layers (tree, shrub, herb and moss) was estimated visually. The nomenclature of vascular plants followed Gudzinskas (1999). The 10 relevés were selected form natural pine forest to compare species composition of forests with *Sambucus* sp.

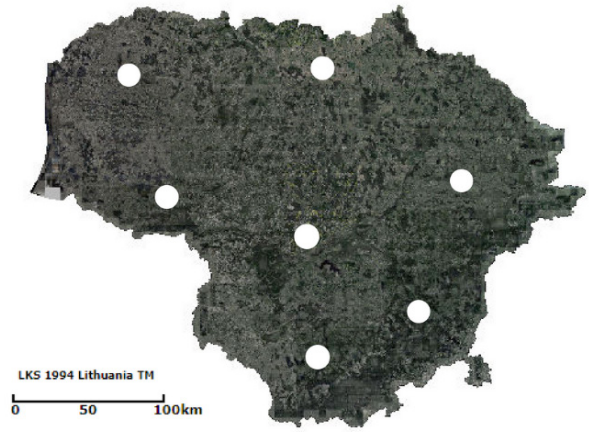


Figure 1. Locations of studied forests in Lithuania.

Soil chemical properties analyses

To evaluate soil chemical properties with *Sambucus* sp., composite soil samples of the 0-10 cm mineral topsoil were collected at nine systematically distributed points in each plot. Soil samples were dried at 40 °C and were sieved through a 2×2 mm sieve. The mobile potassium (K_2O) and mobile phosphorus (P_2O_5) were determined in soil samples using the Egner-Riehm-Domingo (A-L) method (Egner *et al*., 1960); pH was potentiometrically measured in a 1 M KCl suspension (Anon., 2005). The organic carbon (C) concentration was determined with a Heraeus apparatus (Anon., 1995, dry combustion at 900°C), total nitrogen (N) was analysed using the Kjeldahl method (Anon., 1995). The analyses were conducted at the Agrochemical Research Laboratory of LRCAF.

Table 1. Characteristics of forest with *Sambucus* sp. and natural pine forest stands. Abbreviations are: Nb, fresh poor soils; Nc, fresh fertile soils; Lc, moisture fertile soils.

Forest stands	Site type	Dominant tree species	Age			Stocking level		
			Average	Min.	Max.	Average	Min.	Max.
Sambucus nigra	Nb, Nc, Lc	*Pinus sylvestris*	94	37	150	0.7	0.5	0.8
Sambucus racemosa	Nb, Nc, Lc	*Pinus sylvestris*	90	50	130	0.8	0.5	1.2
Natural pine forests	Nb, Nc	*Pinus sylvestris*	100	90	110	0.8	0.7	0.9

Data analysis

Data on plant species were analysed using ordination methods, Detrended correspondence analysis (DCA), Canonical-correlation analysis (CCA), and Principal component analysis (PCA). Significance of variables at $p>0.05$ level was evaluated using normal distribution Monte Carlo test of 499 permutations. Generalized linear model (GLM) was used to assess non-native *Sambucus* sp. relation to forest site type and stand variables (Jongman *et al.*, 1987; Kent & Coker, 1992; Sokal & Rolhf, 1997). Statistical analysis included six explanatory variables (age, stocking level, height, bonitet of forest stand and site types) and species as response variables. The analyses were carried out using CANOCO5 software (Leps & Smilauer, 2014).

To compare forest with *Sambucus* sp. and natural pine forests only species composition was recorded for natural pine forests, so we used for analyses only species data. An indicator species analysis (Dufrêne & Legendre, 1997) was carried out to determine the indicator species for the groups (*Sambucus racemosa*, *S. nigra* and natural *Pinus sylvestris* dominated stands). The analysis takes into account both the frequency and abundance of species in a particular group and produces an indicator value for each species. The indicator value ranges from zero (no indication) to 100 (perfect indication). We tested the significance using the Monte-Carlo procedure (999 permutations). Analyses were carried out with PC-ORD software (McCune & Mefford, 2011).

Results and Discussion

Distribution of *Sambucus* sp. in forest stands

Sambucus sp. were spread in 4382.8 ha of forest stands. *Sambucus* species were mostly spread in *Pinus sylvestris* dominated forest stands, where these species occupied 1883.0 ha. Non-native *Sambucus* sp. occupied 996.7 ha in *Picea abies* dominated stands. In *Alnus glutinosa* dominated stands, *Sambucus* grew in 469.2 ha area; in *Betula pendula* dominated stands it grew in 324.9 ha. (Figure 2).

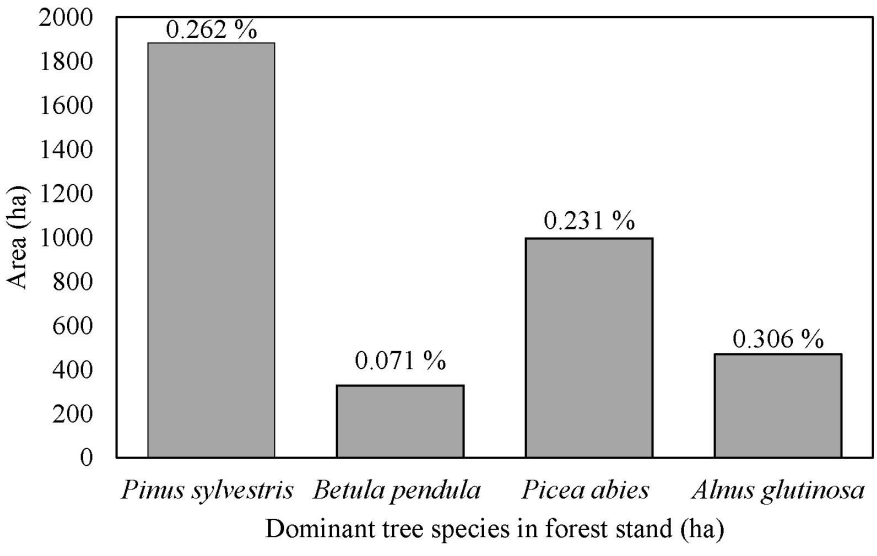


Figure 2. The distribution of *Sambucus* sp. in different Lithuanian forests stands (ha) and proportion of total dominated tree stands, in percentage.

According data of Lithuanian Statistical Yearbook of Forestry (Butkus *et al*., 2016), stands dominated by *P. sylvestris* occupied 715.9 ha, stands dominated by *P. abies*, 430.0 ha, stands dominated by *B. pendula*, 457.7 ha, and stands dominated by *A. glutinosa*, 153.0 ha. Proportional distribution of *Sambucus* sp. occupied 0.262% of total *P. sylvestris* dominated stands in Lithuania, 0.231% appeared in *P. abies* dominated stands, 0.071% in *B. pendula* dominated stands, and 0.306% in *A. glutinosa* dominated stands (Figure 1). The largest area of forests stands with *Sambucus* sp. (2159.3 ha) was in fertile, fresh humidity sites (0.67% of the total area of the site). In fresh poor sites, forests stand with *Sambucus* sp. occupied 808.7 ha (0.019% of the total area of the site; Figure 3).

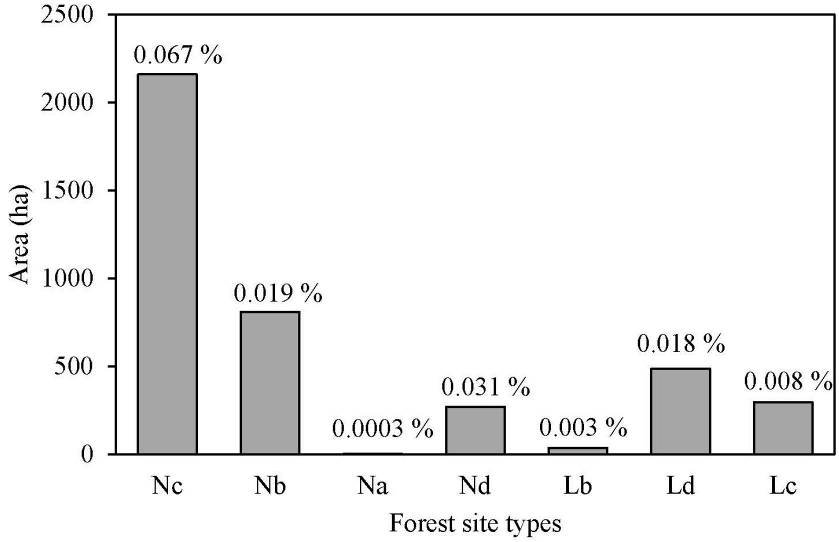


Figure 3. Distribution of *Sambucus* sp. in different sites respect to the area (ha) and proportion in percentage of total site types. Abbreviations for the degree of soil humidity are: N, fresh soils; L, moisture soils; abbreviations for the degree of soil fertility are: a, very poor; b, poor; c, fertile; d, very fertile.

In *P. sylvestris* dominated stands, *Sambucus* sp. were mostly spread in stands of 0.7-0.8 stocking level (1064.0 ha) and were rare in sparse and dense stands. In *P. abies* dominated stands, *Sambucus* species were also mostly spread in stands of 0.7-0.8 (639.9 ha) stocking level. In *P. abies* dominated stands of low density (0.3-0.5 stocking level), *Sambucus* sp. were rare and occupied only 110.2 ha. In *B. pendula* and *A. glutinosa* dominated stands, *Sambucus* species were spread mostly in 0.7-0.8 stocking level stands (Figure 4).

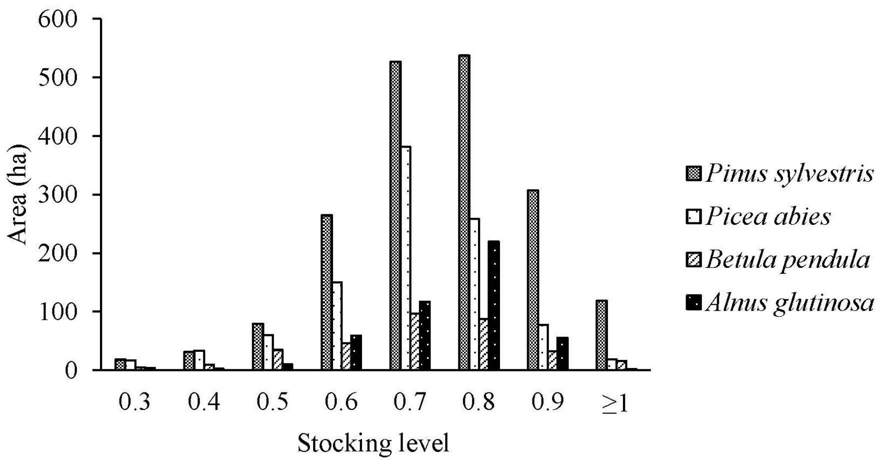


Figure 4. Distribution of *Sambucus* sp. in stocking level classes according different dominant tree species in the stand (ha).

In *P. sylvestris* dominated stands *Sambucus* sp. occupied the largest area in 31-90 age pine forests. *Sambucus* sp. were spread sporadically in young, mature and over-mature stands. In *Picea abies* dominated stands, *Sambucus* sp. were mostly spread in stands to 10 years old (390.8 ha) and in stands 51-80 years old (392.1 ha). In *Alnus glutinosa* and *Betula pendula* dominated stands, *Sambucus* sp. were mostly spread in stands of 31-60 years old (Figure 5).

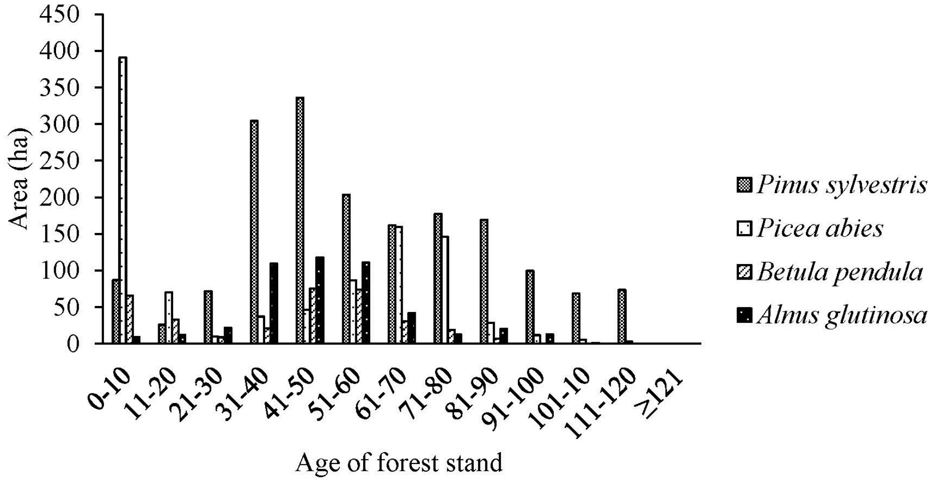


Figure 5. Distribution of *Sambucus* sp. according to the age of the different dominant tree in the stands (ha).

Dynamics of non-native *Sambucus* sp. abundance

Results of NFI data analyses showed an increase of *Sambucus* species abundance in all of the height classes. The highest increase of *Sambucus* sp. stems were recorded in 2008-2012 period, in 0.6-1.5 m, 1.6-3.0 m and >3.0 m height of shrubs. In 0-0.5 m height of shrubs the biggest growth were recorded in 2013-2015 inventory period (Figure 6).

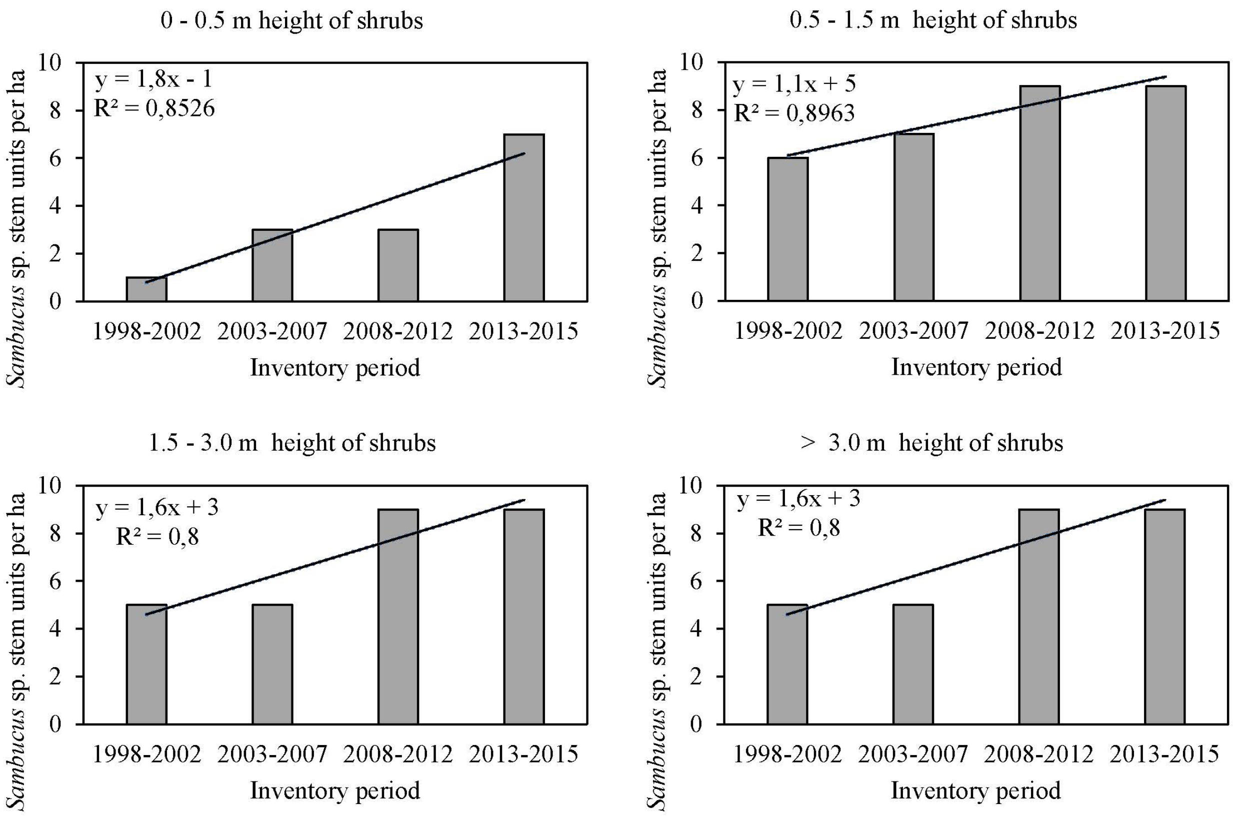


Figure 6. Dynamics of *Sambucus* sp. abundance in 1998-2015 years according different height groups of shrub layers and number of individuals per ha. The abundance of *Sambucus* species was highest in the stands to 20 years old. In the period of 2013-2015 they reached more than 60 stem units per ha. The abundance of *Sambucus* sp. was lower in the 20-60 years old stands (up to 30 stem units per ha). The lowest abundance of *Sambucus* was in mature stands (61-120 years old). The abundance of *Sambucus* sp. has increased in different age stands since 1998. The highest increase was observed in 2012-2015 in young stands (0-20 years old; Figure7).

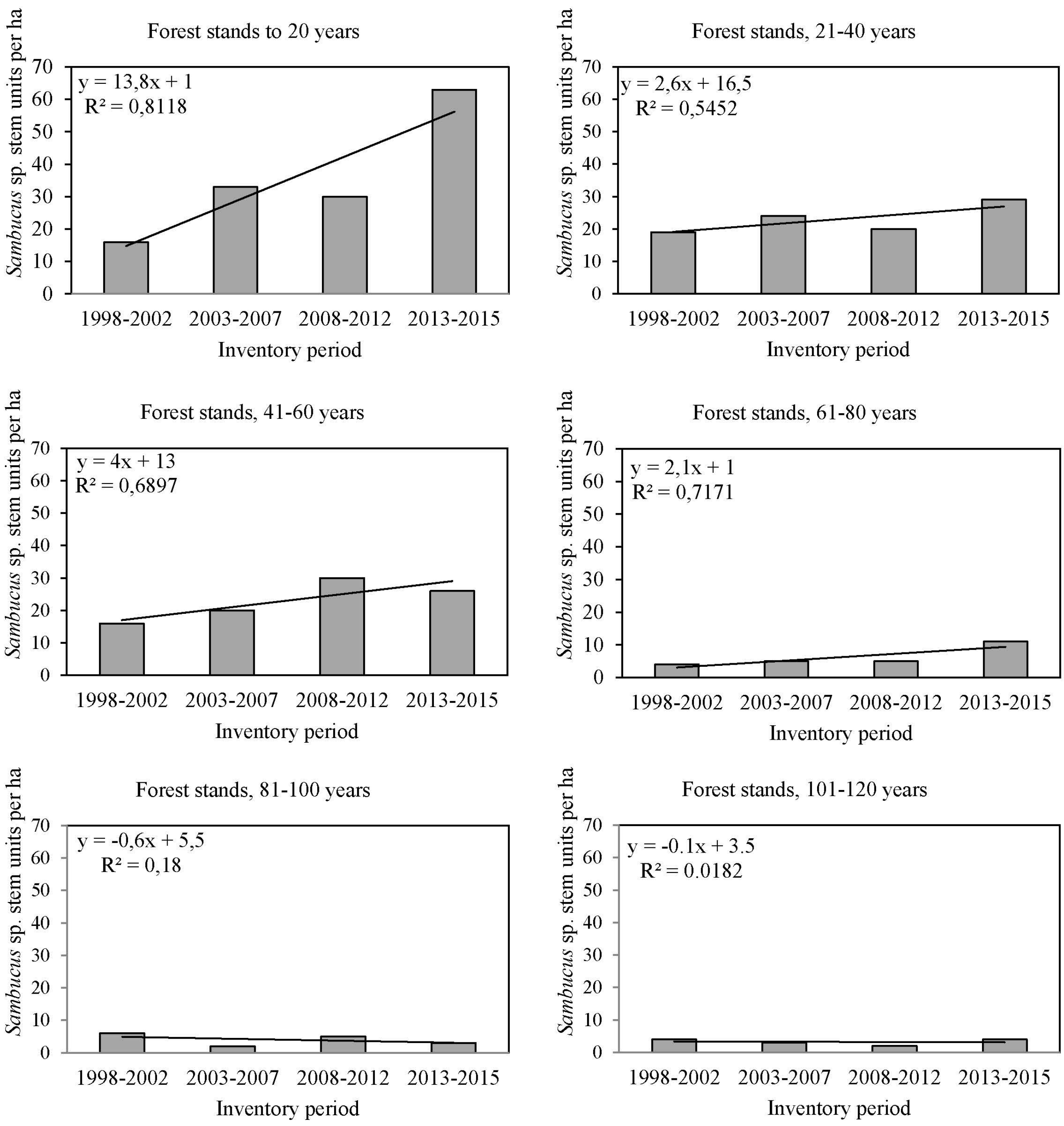


Figure 7. Dynamics of *Sambucus* sp. abundance in 1998-2015 years according the age of different stands and number of individuals per ha.

Dynamic of the abundance of *Sambucus* sp. in stands dominated by different tree species showed increase or no trend (Figure 8). *Sambucus* sp. abundance did not change in *Pinus sylvestris* dominated stands, while is increased in other stands. The highest increase was observed in *Quercus robur* dominated stands.

Composition and structure of forest communities with Sambucus *racemosa* and *Sambucus nigra*

In communities with *S. nigra* (in 19 plots) 100 different plant species were recorded, in communities with *S. racemosa* (in 14 plots) 105 plant species were recorded and 27species were recorded in natural pine communities (10 plots). In communities with *S. nigra* 12 tree species, 18 shrub species, 62 vascular plants and 8 moss species were recorded. In communities with *S. racemosa* 12 tree species, 22 shrub species, 65 vascular plant species, 6 moss species were found. In natural forests 3 tree species, 3 shrub species, 10 vascular plant species, 6 moss species were recorded. Detrended correspondence analyses indicated differences in species composition among selected groups. (Figure 9).

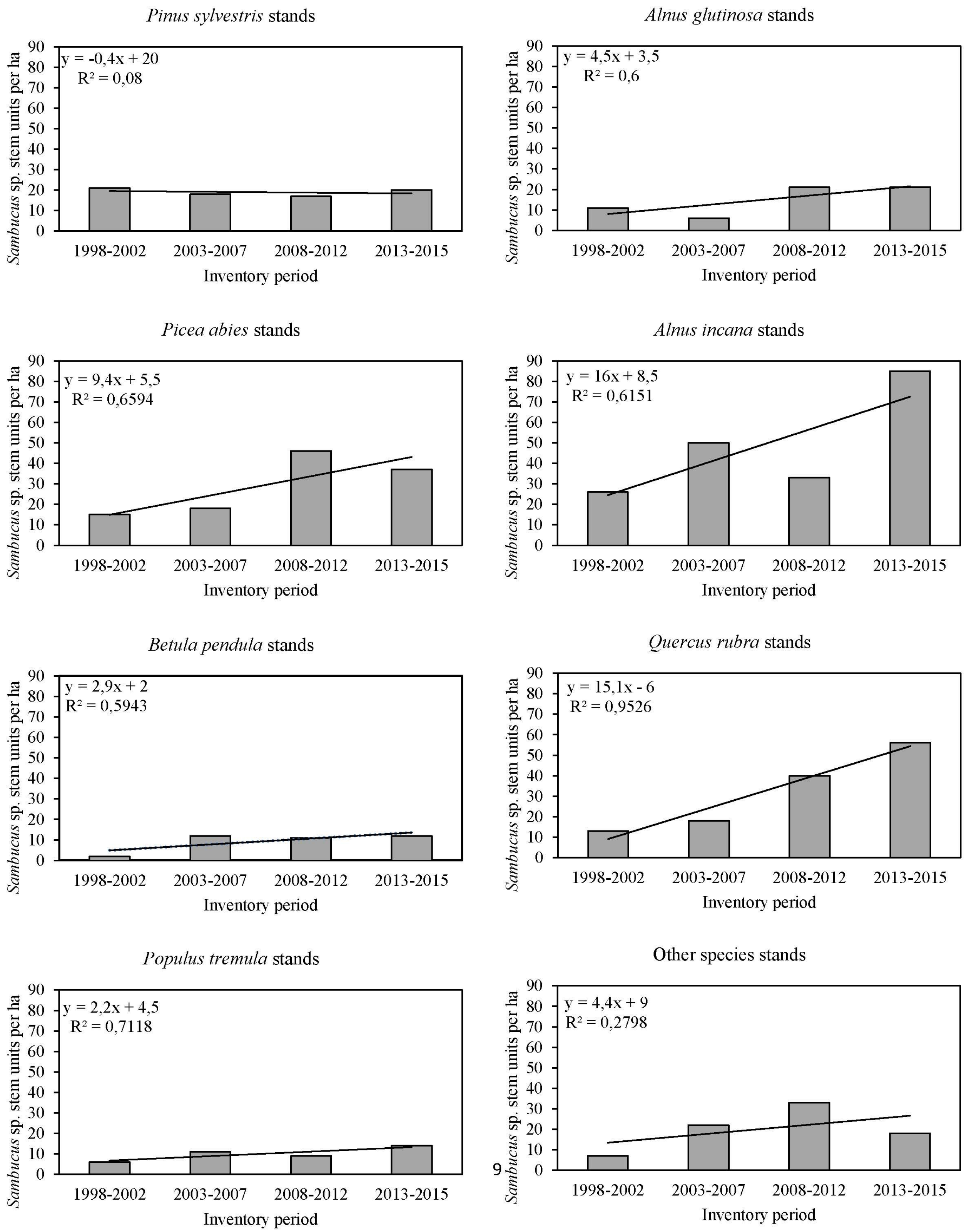


Figure 8. Dynamics of *Sambucus* sp. abundance in 1998-2015 years according the different dominated tree species, and number of individuals per ha.

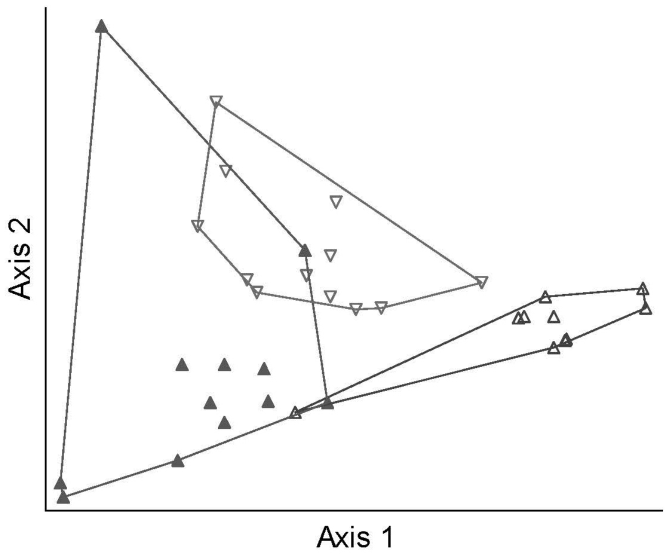


Figure 9. Detrended correspondence analyse (DCA) analysis of plot composition; up empty triangles indicate natural pine forest communities; up solid triangles indicate pine communities with *Sambucus nigra*; down empty triangles indicate *Sambucus racemosa* communities.

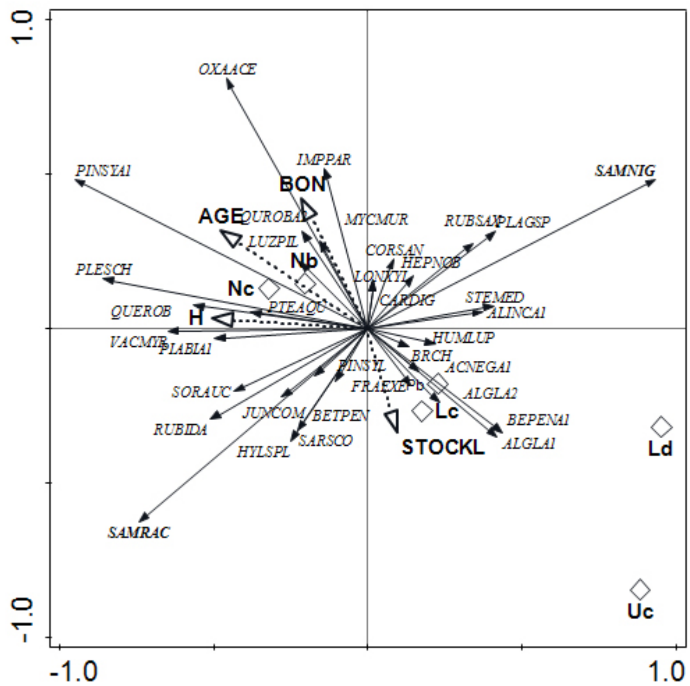


Figure 10. Principal correspondence analyses (PCoA) of non-native *Sambucus racemosa*, *S. nigra* communities; triplot showing species (arrows), dendrometric stand parameters (dashed arrows) and site types (empty diamonds). Abbreviations are: Dendrometrical parameters: STOCKL, forest stocking level; H, height; AGE, the age of forest stand; BON, bonitet (site class) of forest stands. Forest site types: Nb, fresh poor soils; Nc, fresh fertile soils; Lc, moisture fertile soils; Ld, moisture fertile soils; Uc, wet fertile soils. Tree species in undergrowth: QUEROB, *Quercus robur*; BETPEN, *Betula pendula*; FRAEXE, *Fraxinus excelsior.* Tree species in the 1st stand layer: PINSYA1, *Pinus sylvestris;* BETPENA1, *Betula pendula*; PIABIA1, *Picea abies*; ALGLA1, *Alnus glutinosa*; ACNEG1, *Acer negundo*. Tree species in the 2nd stand layer: QUEROBA2, *Quercus robur*; PIABIA2, *Picea abies*; ALGLA2, *Alnus glutinosa*; ACPLA2, *Acer platanoides.* Shrub species: SAMRAC, *Sambucus racemosa*; SAMNIG*, Sambucus nigra;* SARSCO*, Sarothamnus scoparius*; FRAAL, *Frangula alnus*; SORAUC, *Sorbus aucuparia*; CAORAVE, *Corylus avellanae*; RIBRUB*, Ribes rubrum*; CORSAN, *Cornus sanguinea*; JUNCOM, *Juniperus communis.* Herb species: OXAACE, *Oxalis acetosella*; MYCMUR, *Mycelis muralis*; PTEAQU, *Pteridium aquilinum*; LUZPIL, *Luzula pilosa*; VACMYR, *Vaccinium vitis-idaea*; HUMLUP, *Humulus lupulus*; CONMAJ, *Convallaria majalis*; RUBSAX, *Rubus saxatilis*; IMPPAR, *Impatiens parviflora*; CHEMA, *Chelidonium majus.* Moss species: BRCH, *Brachythecium sp.*; PLESCH, *Pleurozium schreberi*.

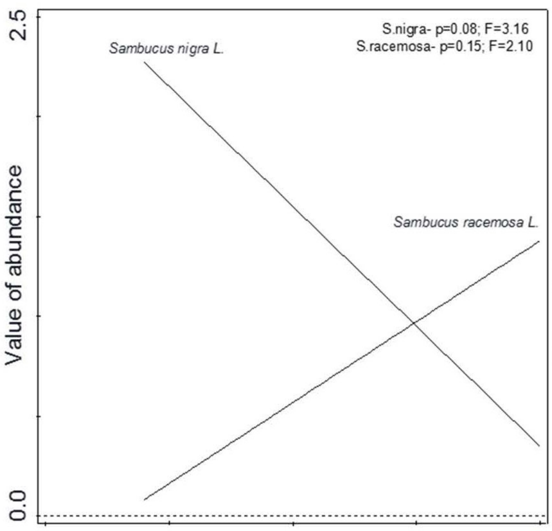
Table 2. Plants species indicator values of the analysed groups of forest communities: Natural forests (1); *Sambucus racemosa* (2); *Sambucus nigra* (3) and significance (*p*).

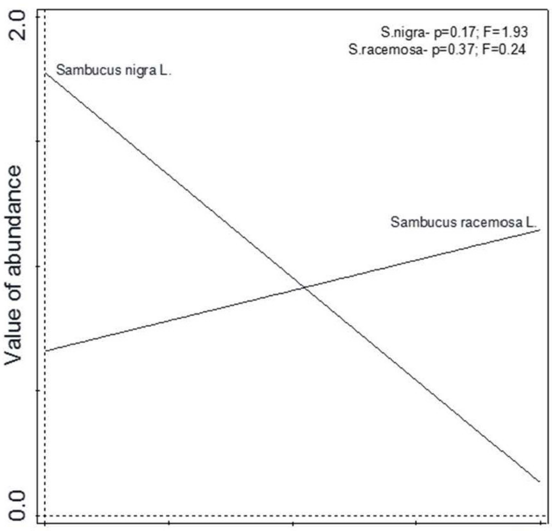
Species	1	2	3	*p*
Sambucus nigra	0	0	100	0.0002
Rubus saxatilis	0	0	67	0.0002
Impatiens parviflora	0	9	62	0.002
Chelidonium majus	0	6	56	0.002
Tilia cordata	0	1	39	0.0122
Mycelis muralis	0	5	30	0.0424
Stellaria media	0	1	38	0.0242
Acer platanoides	0	17	47	0.0366
Rubus idaeus	0	53	39	0.0106
Sorbus aucuparia	3	62	24	0.0072
Rubus idaeus	0	33	8	0.023
Pteridium aquilinum	0	49	4	0.0054
Frangula alnus	1	68	2	0.0022
Quercus robur	4	70	8	0.0018
Betula pendula	0	63	0	0.0006
Sambucus racemosa	0	85	4	0.0002
Pleurozium schreberi	44	23	17	0.0414
Vaccinium myrtillus	48	16	1	0.0116
Impatiens noli-tangere	30	0	0	0.0216
Calluna vulgaris	30	0	0	0.0196
Hylocomium splendens	49	7	1	0.0108
Vaccinium vitis-idaea	47	1	0	0.013
Polytrichum spp.	49	0	0	0.0034

Principal correspondence analysis showed differences between communities of *S. nigra* and *S. racemosa* and no clear association with dendrometric stand parameters (Figure 10). *Sorbus aucuparia, Aegopodium podagraria, Polygonatum odoratum, Maianthemum bifolium, Acer platanoides* species were characteristic for communities with *Sambucus nigra* and occurred in more fertile forest sites. *Sambucus nigra* more often occurred with ruderal plant species (*Impatiens parviflora*, *Chelidonium majus*, *Acer negundo, Rubus idaeus, Cornus sanguinea, Urtica dioica* and *Ribes rubrum),* some of these are invasive species in Lithuania.

In the indicator species analysis (ISA), 23 vascular species showed a significant preference for three analysed groups (Table 2). Six species were strongly associated with forest communities with *S. racemosa*, eight species were characteristic to forest communities with *S. nigra*; two species (*Rubus idaeus* and *Sorbus aucuparia*) were associated with forest communities with both non-native shrubs - *S. racemosa* and *S. nigra* species. Seven species were associated with natural forest communities.

The results of generalized linear model analysis showed that height, stocking level and age of forest stands had different influence on the distribution of both *Sambucus* species. With increasing height and age of forest stand the abundance of *S. nigra* decreased, but abundance of *S. racemosa* increased with these two stand parameters. Only bonitet (site class) of forest stand had similar impact on the distribution of both *Sambucus* species. *Sambucus nigra* was widely spread in dense and young forests. *Sambucus racemosa* grew in rare, mature and overmatured stands Dendrometric parameters (height, age and bonitet of forests stands) had no significant effect on the distribution of *Sambucus* sp. (Figure 11).





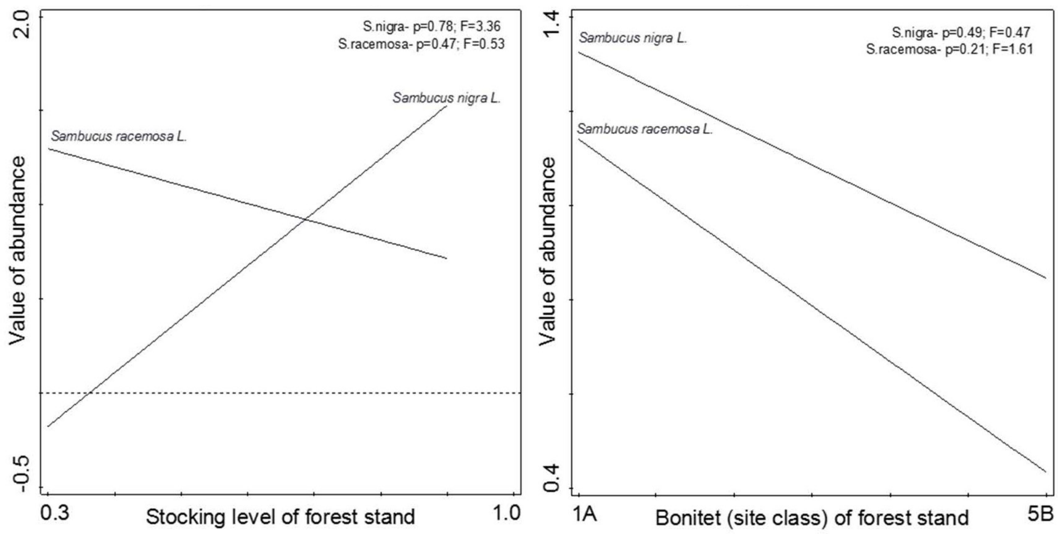


Figure 11. The results of generalized linear regression method (GLM) analysis between *Sambucus racemosa, S. nigra* and stand dendrometric parameters (height, stocking level, bonitet and age of forest stand)

Canonical correspondence analysis (CCA) revealed differences in species composition and soil parameters between forest communities with *S. racemosa* and *S. nigra* (Figure 12).

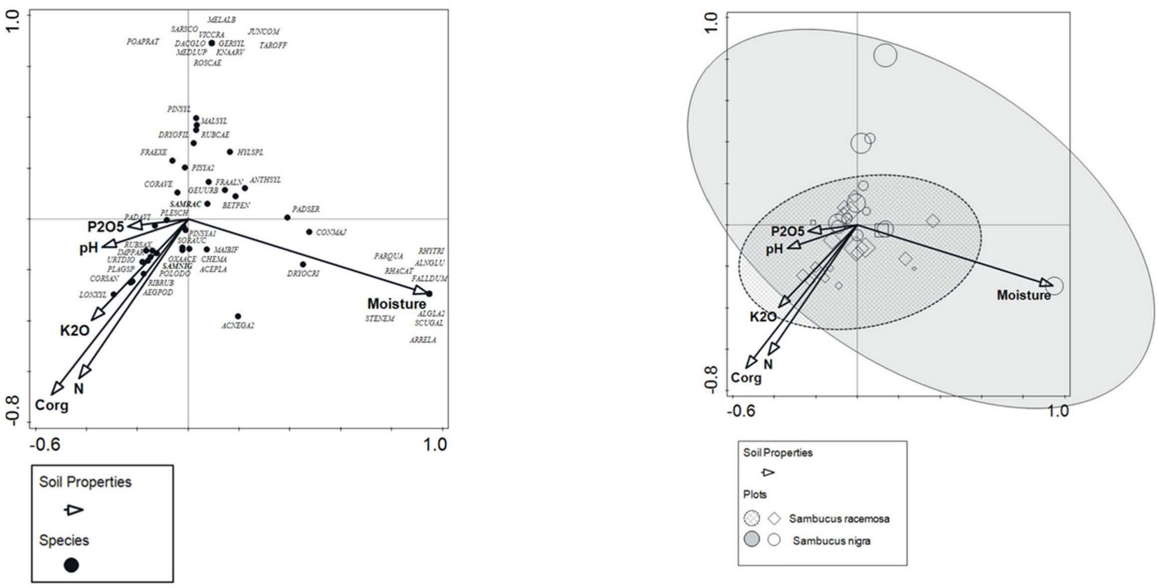


Figure 12. Canonical correspondence analyses (CCA) of *Sambucus racemosa* and *S. nigra* forest plots*,* soil fertility and moisture parameters. Tree species in undergrowth: QUEROB*, Quercus robur*; BETPEN*, Betula pendula*; FRAEXE, *Fraxinus excelsior*; ACEPLA*, Acer platanoides*; ALNGLU*, Alnus glutinosa.* Tree species in 1st stand storey: PINSYA1*, Pinus sylvestris*; BETPENA1*, Betula pendula*; PIABIA1*, Picea abies*; ACNEG1, *Acer negundo*. Tree species in 2nd stand storey: QUEROBA2*, Quercus robur*; PIABIA2, *Picea abies*; ALGLA2*, Alnus glutinosa*; ACPLA2, *Acer platanoides.* Shrub species: SAMRAC*, Sambucus racemosa*; SAMNIG*, Sambucus nigra*; SARSCO*, Sarothamnus scoparius*; FRAAL*, Frangula alnus*; SORAUC, *Sorbus aucuparia*; CAORAVE, *Corylus avellana*; RIBRUB*, Ribes rubrum*; CORSAN*, Cornus sanguinea*; JUNCOM, *Juniperus communis*; ROSCAE*, Rosa caesius*; TAROFF*, Taraxacum officinale*; PADSER, *Padus serotina*; CORSAN, *Cornus sanguinea*; LONXYL, *Lonicera xylosteum*; RUBSAX*, Rubus saxatilis*; PADAVI*, Padus avium.* Herb species: OXAACE, *Oxalis acetosella*; MYCMUR, *Mycelis muralis*; PTEAQU, *Pteridium aquilinum*; LUZPIL, *Luzula pilosa*; VACMYR, *Vaccinium vitis-idaea*; HUMLUP, *Humulus lupulus*; CONMAJ, *Convallaria majalis*; IMPPAR, *Impatiens parviflora*; CHEMA, *Chelidonium majus*; POAPRA*, Poa pratensis*; MAIBIF*, Maianthemum bifolium*; DACGLO*, Dactylis glomerata*; MEDLUP*, Medicago lupulina*; KNAARV*, Knautia arvensis*; GERSYL*, Geranium sylvaticum*; MELALB*, Melilotus albus*; VICCRA*, Vicia cracca*; DRYOFIL*, Dryopteris filix-mas*; DRYOCRI*, Dryopteris cristata*; FALLDUM, *Fallopia dumetorum*; ARRELA*, Arrhenatherum elatius*; GEUURB*, Geum urbanum*; PARQUA*, Paris quadrifolia*; RHACAT, *Rhamnus cathartica*; URTDIO*, Urtica dioica*; ANTHSYL*, Anthriscus sylvestris*; POLODO*, Polygonatum odoratum*; STEMED*, Stellaria media*; SCUGAL*, Scutellaria galericulata.* Moss species: BRCH, *Brachythecium sp.*; PLESCH, *Pleurozium schreberi*; HYLSPL, *Hylocomium splendens*; PLAGSP, *Plagiomnium* spp.

The first axes explained the 12.56 % and the second the 23.38 % of total variance. Monte Carlo permutation test showed that the analysis was significant (p=0.0062). Variation of forest communities with *Sambucus racemosa* and *S. nigra* was explained by two complex environmental parameters – soil fertility and moisture. Forests communities with *S. racemosa* were associated with higher amounts of soil organic carbon and total nitrogen. Other parameters such as soil acidity (pH_{KCl}), and P_2O_5 did not show preference for forest communities with different *Sambucus* sp. (Figure 12).

Sambucus sp. occupied about the 0.2 % of total forest area in Lithuania. They were more frequent in fertile, fresh humidity soils and coniferous tree species dominated forests of middle age and stocking classes. We reported increase of non-native *Sambucus* sp. in Lithuanian forests from 1998 to 2015 years. The highest increase of *Sambucus* sp. abundance was in young forest stands dominated by deciduous trees, *Alnus* and *Quercus* tree species, and thus we can consider such forests as the most sensitive to the invasion of non-native *Sambucus* sp. Our results correspond to the study by Dobravolskaite (2010) who reported the rapid increase of number of invasive species in the forests of Lithuania.

Non-native *S. nigra* is light tolerant species preferably growing in open areas, woodland edges and disturbed nitrogen-rich soils (Kollmann & Reiner, 1996; Atkinson & Atkinson, 2002). Usually *S. nigra* very hardly grows in shaded areas. On the other hand, *S. nigra* has ruderal characteristics and broad ecological plasticity; it can grow under different conditions. *S. nigra* spreads very fast in disturbed habitats and it can colonize natural forests, forest plantations and shrublands (Kollmann & Reiner, 1996; Atkinson & Atkinson, 2002; Charlebois *et al.*, 2010). Atkinson (2002) showed that optimal soil pH was 4.2-8.0 for *S. nigra* and it grows in soils with a wide range of nitrogen (N), phosphorous (P) and potassium (K) levels. Under suitable soil conditions, this species can grow fast and produce new stems of 2 meters height every year.

Sambucus racemosa is widely spread in many forest communities, it usually grows in forest gaps or as separate individuals, and rarely becomes dominant species (Gonzalves & Darris, 2017). Numerous studies showed that this species are rare in forests communities, because it is not shade tolerant species (Kollmann & Reiner, 1996; Rutkovska *et al.*, 2017). Although *S. racemosa* can grow in wide variety of conditions, it mostly prefers rich soils, full sun, and pH of 6.0-7.5 (Gonzalves & Darris, 2017).

Our results showed that there are differences in species composition and stand structure between the natural forest and the forest with *Sambucus* spp. These findings confirm the impacts of *Sambucus* species in natural forest communities.

Conclusions

In the investigated region, *Sambucus* sp. were spread mostly in fertile, fresh humidity sites in *Pinus sylvestris* and *Picea abies* dominated forest stands of 0.7-0.8 stocking level and 41-80 years old. From 1998 to 2015, the abundance of *Sambucus* sp. increased in all height and age stands. The highest increase of *Sambucus* sp. stems was recorded in 2013-2015 inventory period in the stands dominated by deciduous trees *Quercus robur* and *Alnus incana*. The lowest increase of *Sambucus* species was in *Pinus sylvestris* dominated stands.

Natural forest and forest with *Sambucus racemosa* and *S. nigra* differed in terms of species composition and soil parameters. The highest number of species was identified in forest communities with *S. racemosa,* but *S. nigra* more often occurred with ruderal vascular plants such as *Impatiens parviflora*, *Chelidonium majus*, *Acer negundo, Rubus idaeus, Cornus sanguinea, Urtica dioica* and *Ribes rubrum*.

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