Acta Sci. Pol.
Silv. Colendar. Rat. Ind. Lignar. 10(4) 2011, 17-27

THE LIST OF PLANTS, FUNGI AND INVERTEBRATES OF NOBLE FIR (*ABIES PROCERA* REHDER) EXPERIMENTAL STANDS IN ROGÓW ARBORETUM (POLAND)

Marek Kasprowicz[1], Andrzej M. Jagodziński[2,3], Maciej Skorupski[2], Maria Wojterska[1], Tomasz Dobies[2], Izabela Kałucka[4], Małgorzata Sławska[5], Anna Wierzbicka[2], Andrzej Łabędzki[2], Mirosław Nowiński[2], Piotr Karolewski[3], Jacek Oleksyn[3], Piotr Banaszczak[6], Stanisław Małek[7]

[1]Adam Mickiewicz University in Poznań
[2]Poznań University of Life Sciences
[3]Institute of Dendrology of Polish Academy of Sciences, Kórnik
[4]University of Lodz
[5]Warsaw University of Life Sciences – SGGW
[6]Rogów Arboretum of Warsaw University of Life Sciences – SGGW
[7]University of Agriculture in Krakow

Abstract. The paper gives a survey of biodiversity of noble fir (*Abies procera*) stands in Rogów Arboretum on the background of environmental data. Noble fir is native to the mountains of north-western United States. During the study in the Rogów Arboretum we have found 53 taxa of vascular plants and mosses, 51 taxa of macrofungi and 112 of invertebrates in *Abies procera* stands. The documented biodiversity of planted *Abies procera* stands has been commented with respective data from natural habitats.

Key words: *Abies procera*, noble fir, biodiversity, vascular plants, macrofungi, nematodes, mites, insects

INTRODUCTION

Noble fir (*Abies procera* Rehder) is an upper-elevation and long-lived conifer forest tree species. It is found in the western North America, i.e. in the mountains of northern

Corresponding author – Adres do korespondencji: Dr hab. Maciej Skorupski, Department of Game Management and Forest Protection of Poznań University of Life Sciences, Wojska Polskiego 71 C, 60-625 Poznań, Poland, e-mail: maskorup@up.poznan.pl

Oregon and Washington between the McKenzie River and Stevens Pass (44° to 48°N). Most of its distribution is within the Cascade Range, predominantly on the western slopes and along the crest [Franklin 1964]. In general, it is found at elevations between 1070 and 1680 m in the Cascade Range in Oregon and 910 and 1520 m in the Cascade Range in central Washington [Franklin 1982, Filip and Schmitt 1990]. However, noble fir is occasionally found at much lower elevations and shows excellent growth on such sites. Throughout its native range, its distribution exhibits the structure of one mainland consisting of 2 disjunct submainlands, and many islands which are scattered on isolated peaks in the Oregon Coast Ranges and in the Willapa Hills of southwestern Washington [Franklin 1990, Yeh and Hu 2005]. The natural range of this species lies within a maritime climate characterized by cool summers and mild, wet winters. Annual temperatures average 4.4 to 7.2°C, and the annual precipitation averages 1960 to 2650 mm. Most of the precipitation (ca. three-fourths) occurs between October and March [Franklin 1983, 1990, Grier and Lee 1983, Jagodziński and Banaszczak 2010].

Noble fir is considered a seral or pioneer tree species and one of the most shade intolerant of the American firs [Franklin 1990]. It grows well on a variety of sites; for example it inhabits rugged, steep slopes, on all landforms, from valley bottom to ridge top. However, it grows best on gentle slopes and warm southern aspects. In the northern part of its natural range, it shows a preference for warm and moist exposures. Water supply is more important for noble fir growth than soil quality [Fowells 1965, Tumiłowicz 1977, Gessel and Olivier 1982, Franklin 1983]. This species is associated with most other Pacific Northwest conifers at some point within its natural range.

Noble fir can regenerate abundantly after a severe disturbance (often with Douglas-fir), for example it is an early colonizer after stand-replacing fires, but under a dense closed canopy it cannot regenerate [Franklin et al. 1978, Franklin 1983, 1990]. It begins to produce seeds at age 25 to 30 years, however abundant crop of seeds is produced after age 50 at 3- to 6-year intervals. Noble fir seeds germinate in the spring; mineral seedbed in large gaps is favorable to seedling establishment and successful juvenile growth [Franklin et al. 1978]. Moreover, Franklin [1990] showed that the most common factors that inhibit regeneration of noble fir are competing vegetation and frosts. The initial juvenile growth of this species is slow as with other firs and it requires 5-12 years to reach breast height (depending on site condition) [Franklin 1982, 1983, Harrington and Murray 1982, Jagodziński and Banaszczak 2010]. Harrington and Murray [1982] and Stewart [1986] showed that growth from a sapling stage to maturity is rapid, allowing noble fir to attain site dominance, although as the tree ages, the growth slows. Noble fir grows more frequently in mixed stands with other species, such as Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and Pacific silver fir (*Abies amabilis*) [Franklin and Dyrness 1973, Brockway et al. 1985]. It is valuable tree species both for timber and greenery products [Betts 1945, Tumiłowicz 1977, Rasmussen et al. 2005]. Noble fir attains the largest dimensions of any of the true fir species and has a greater volume for a given diameter and height than any of its associates and dominates such stands, contributing volume out of proportion to the number of trees. It grows in nearly pure stands and is able to produce high standing timber volumes over a wide range of ages and site qualities [Fujimori et al. 1976, Franklin 1983, Maze and Parker 1983, Doede and Adams 1998, Jagodziński and Banaszczak 2010]. For example in a mixed stand of the Cascade Range in northern Oregon, the average size of noble fir trees grown under favorable conditions was as follows: 10 years – ca. 1.2 m tall, 20 years – ca. 3.6 m tall and 8 cm diameter at breast height, 50 years – ca. 16.1 m tall

and 52 cm diameter and 200 years – 44.3 m tall and 84.3 cm in diameter [Hanzlik 1925].

Noble fir is also cultivated as an exotic tree species in Europe and Canada, where numerous provenance experiments have been established in the Great Britain, Germany, and British Columbia [Fletcher and Samuel 1990, Ying 1992, Xie and Ying 1994, Ruetz et al. 1998]. For example, Jagodziński and Banaszczak [2010] studied stem volume and aboveground woody biomass in noble fir stands (39- and 43-years old) in the Rogów Arboretum (Poland). The cited study showed that the mean DBH of trees was 20.14 cm in the younger stand and 22.25 cm in the older stand. The basal area of the 39-year-old stand was 49.01 m^2/ha and 43-year-old stand was 47.53 m^2/ha. Based on the developed equation, stem volume over bark was 374.87 m^3/ha and 356.24 m^3/ha in the 39- and 43-year-old stands, respectively. Moreover, based on the developed site-specific allometric equations they found that total aboveground woody biomass in the 39-year-old stand was 189 Mg/ha whereas in the 43-year-old stand it was 184 Mg/ha.

MATERIAL AND METHODS

The study was conducted in two noble fir (*Abies procera*) stands with ages of 42 and 38 years, situated in the Rogów Arboretum of the Warsaw University of Life Sciences (SGGW), Poland (51°49'N, 19°53'E). The study plots (site A and B) were located in the central part of the Arboretum. The detailed information for both stands is shown in Table 1.

Table 1. Characteristics of *Abies procera* experimental plots (2009) [Hotała 2010]
Tabela 1. Charakterystyka powierzchni doświadczalnych z *Abies procera* (2009) [Hotała 2010]

Characteristics Charakterystyka	Study site A Powierzchnia doświadczalna A	Study site B Powierzchnia doświadczalna B
Year of stand establishment Rok założenia drzewostanu	1970	1975
Year of seed sprouting Rok skiełkowania nasion	1967	1971
Area of experimental plot Powierzchnia poletek badawczych	0.04 ha	0.04 ha
Seed origin Pochodzenie nasion	Wirty Arboretum, Poland, 53°54'N, 18°23'E	(Washington USDA Forest Ser.) Oregon, Bear Spring Ranger Distr. of Mt. Hood Nat. Forest, USA
Stand density, trees·ha^{-1} Zagęszczenie, drzewa·ha^{-1}	1 275	1 550
Stand age Wiek drzewostanu	42	38

According to long-term meteorological observations (55 years) from the closest meteorological station in Strzelna, mean annual temperature is 7.2°C (January: –3.2°C, July: 17.3°C), mean annual precipitation is 596 mm (404-832 mm, ca. 70% of annual

precipitation is in the growing season), and mean growing season length (calculated as the number of days with mean temperature ≥5°C) is 212 days [Bednarek 1993, Jagodziński and Banaszczak 2010].

The study plots are located on a flat terrain ca. 189 m a.s.l. The soils were developed on a postglacial formation, in the region of a ground moraine. The soils are rich, mesic, with the groundwater level beyond the reach of tree roots [Czępińska-Kamińska et al. 1991, Jagodziński and Banaszczak 2010]. Soil unit is haplic luvisol. Soil texture in the A horizon was sandy silt. The content of sand fraction was 47%, silt fraction 48.5%, clay fraction 4.5%. Soil reaction was strongly acidic, pH measured in M KCl in particular horizons was as followed: Oll 4.01, Ol 4.68, Ofh 3.97 and A 3.58. Total acidity was respectively: Oll 37.45 cmol(+)/kg, Ol 34.60 cmol(+)/kg, Ofh 61.03 cmol(+)/kg and A 11.59 cmol(+)/kg.

During the three-year study (2007-2010), vascular plants, mosses, macrofungi and soil invertebrates (nematodes, mites and insects) were determined on the experimental plots. The subject of mycological examination were mycorrhizal, saprotrophic and parasitic species, excluding corticioid taxa; traditionally, Myxomycetes were also considered. Observations were carried out in 2008-2010. Identification of sporocarps was based on standard methods used in mycological studies. The nomenclature follows Index Fungorum (indexfungorum.org/Names/Names.asp). Vouchers of dried fungal materials have been deposited in the Herbarium Universitatis Lodziensis (LOD).

The list of the taxa found in *Abies procera* plots were compared with the list of taxa found in the subcontinental oak-hornbeam forest *Tilio-Carpinetum* Traczyk 1962 *calamagrostietosum*, situated in the western part of the Arboretum. The oak-hornbeam forest was dominated by native tree species. The upper stand layer is formed by *Quercus petraea* and *Pinus sylvestris* as well as *Populus tremula*. The lower tree layer of the stand and undergrowth were dominated by *Carpinus betulus*.

RESULTS

During the study 216 taxa of plants, fungi and invertebrates were found. There are 53 taxa of vascular plants and mosses, 51 taxa of fungi and 112 of invertebrates. In the control sites (*Tilio-Carpinetum*) 281 taxa of the organisms studied were found. There are 52 taxa of vascular plants and mosses, 67 taxa of fungi and 162 taxa of invertebrates (Fig. 1). Below is the list of organisms recorded in the plots of *Abies procera*.

Vascular plants cultivated in the Arboretum, spontaneous in the investigated plots

Abies procera Rehder, *Acer tataricum* L., *Amelanchier spicata* (Lam.) K. Koch, *Castanea sativa* Mill., *Kalopanax septemlobus* (Thunb.) Koidz., *Thuja plicata* Donn ex D. Don in Lamb., *Acer* sp.

Spontaneous vascular plants

Acer platanoides L., *Acer pseudoplatanus* L., *Agrostis capillaris* L., *Anemone nemorosa* L., *Carex digitata* L., *Carex pilulifera* L., *Carpinus betulus* L., *Chamaenerion angustifolium* (L.) Scop., *Convallaria majalis* L., *Dryopteris carthusiana* (Vill.) H. P.

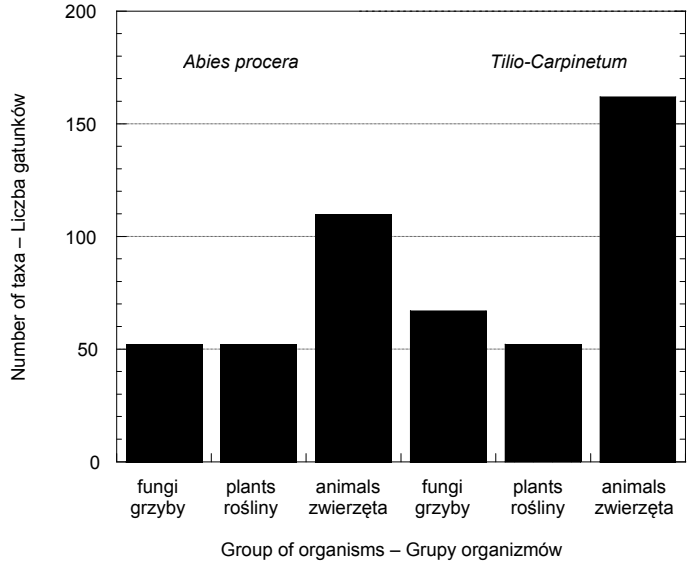

Fig. 1. Number of fungi, plants and animals taxa found in *Abies procera* stands and *Tilio-Carpinetum* sites (control)
Rys. 1. Liczba gatunków grzybów, roślin i zwierząt stwierdzonych w drzewostanach *Abies procera* i na powierzchni kontrolnej *Tilio-Carpinetum*

Fuchs, *Dryopteris filix-mas* (L.) Schott, *Euonymus europaea* L., *Euonymus verrucosa* Scop., *Fagus sylvatica* L., *Frangula alnus* Mill., *Galeopsis pubescens* Besser, *Galium schultesii* Vest, *Hieracium lachenalii* C. C. Gmel., *Hieracium murorum* L., *Hypochoeris radicata* L., *Luzula pilosa* (L.) Willd., *Maianthemum bifolium* (L.) F. W. Schmidt, *Melica nutans* L., *Moehringia trinervia* (L.) Clairv., *Mycelis muralis* (L.) Dumort., *Oxalis acetosella* L., *Padus serotina* (Ehrh.) Borkh., *Poa nemoralis* L., *Quercus petraea* (Matt.) Liebl., *Quercus robur* L., *Rubus hirtus* Waldst. & Kit. Agg., *Rubus idaeus* L., *Sambucus nigra* L., *Sorbus aucuparia* L., *Taraxacum officinale* F. H. Wigg., *Vaccinium myrtillus* L., *Veronica officinalis* L., *Viola riviniana* Rchb.

Mosses

Atrichum undulatum (Hedw.) P. Beauv., *Dicranella heteromalla* (Hedw.) Schimp., *Plagiomnium affine* (Funck) T. Kop., *Plagiothecium curvifolium* Schlieph. ex Limpr., *Pleurozium schreberi* (Brid.) Mitt., *Pohlia nutans* (Hedw.) Lindb., *Polytrichastrum formosum* (Hedw.) G. L. Smith, *Sciuro-hypnum oedipodium* (Mitt.) Ignatov & Huttunen.

Mycorrhizal fungi

Amanita muscaria (L.) Lam., *Amanita rubescens* Pers., *Chalciporus piperatus* (Bull.) Bataille, *Cortinarius* sp. 3, *Cortinarius* sp. 4, *Hebeloma* sp. 2, *Inocybe* sp. 1, *Inocybe* sp. 2, *Lactarius quietus* (Fr.) Fr., *Lactarius rufus* (Scop.) Fr., *Lactarius tabidus* Fr., *Paxillus involutus* (Batsch) Fr., *Rhodocollybia butyracea* f. *asema* (Fr.) Antonín

Halling & Noordel., *Ramaria abietina* (Pers.) Quél. *Russula ochroleuca* (Pers.) Fr., *Russula puellaris* Fr., *Russula risigallina* Secr., *Russula vesca* Fr., *Russula* sp. 2, *Russula* sp. 4, *Xerocomus badius* (Fr.) E.-J. Gilbert, *Xerocomus chrysenteron* (Bull.) Quél.

Saprotrophic and parasitic fungi

Agaricus sp. 2, *Ampulloclitocybe clavipes* (Pers.) Redhead, Lutzoni, Moncalvo & Vilgalys, *Armillaria* sp., *Calocera viscosa* (Pers.) Fr., *Chlorophyllum rhacodes* (Vittad.) Vellinga, *Clitocybe* spp., *Cystoderma amianthinum* (Scop.) Fayod, *Dacrymyces stillatus* Nees, *Entoloma* spp., *Gymnopilus penetrans* (Fr.) Murrill, *Gymnopus dryophilus* (Bull.) Murrill, *Gymnopus peronatus* (Bolton) Antonín, Halling & Noordel., *Hygrophoropsis aurantiaca* (Wulfen) Maire, *Hypholoma fasciculare* (Huds.) P. Kumm., *Lepista flaccida* (Sowerby) Pat., *Lycoperdon nigrescens* Wahlenb., *Lycoperdon perlatum* Pers., *Lyophyllum connatum* (Schumach.) Singer, *Mycena epipterygia* (Scop.) Gray, *Mycena zephirus* (Fr.) P. Kumm., *Mycena* spp., *Postia caesia* (Schrad.) P. Karst., *Ramaria* sp., *Rhodocollybia butyracea* f. *asema* (Fr.) Antonín, Halling & Noordel., *Rhodocollybia butyracea*
f. *butyracea* (Bull.) Lennox, *Ripartites tricholoma* (Alb. & Schwein.) P. Karst., *Sparassis crispa* (Wulfen) Fr, *Stereum sanguinolentum* (Alb. & Schwein.) Fr., *Trametes versicolor* (L.) Lloyd, *Tricholomopsis rutilans* (Schaeff.) Singer.

Nematodes

Aphelenchoides spp., Araeolaimida spp., *Cephalenchus hexalineatus* (Geraert) Geraert et Goodey, *Ditylenchus anchilisposomus* (Tarjan) Fortuner, *Ditylenchus* spp., *Filenchus discrepans* (Andrásssy) Raski et Geraert, *Filenchus misellus* (Andrássy) Raski et Geraert, *Lelenchus leptosoma* (de Man) Mezl, *Malenchus acarayensis* Andrássy, *Mesocriconema curvatum* (Raski) Loof et De Grisse., Rhabditida spp.

Acari (Oribatida)

Achipteria coleoptrata (L.), *Acrotritia duplicata* (Grandjean), *Adoristes ovatus* (C.L. Koch), *Banksinoma lanceolata* (Michael), *Camisia spinifer* (C.L. Koch), *Carabodes coriaceus* C.L. Koch, *Carabodes subarcticus* Trägårdh, *Chamobates voigtsi* (Oudemans), *Damaeus verticillipes* (Nicolet), *Eueremaeus oblongus* (C.L. Koch), *Galumna lanceata* (Oudemans), *Lauroppia falcata* (Paoli), *Licneremaeus licnophorus* (Michael), *Liochthonius tuxeni* (Forsslund), *Metabelba pulverulenta* (C.L. Koch), *Micreremus gracilior* Willmann, *Minunthozetes semirufus* (C.L. Koch), *Moritzoppia keilbachi* (Moritz), *Neobrachychthonius marginatus* (Forsslund), *Neoliochthonius occultus* (Niedbała), *Nothrus silvestris* Nicolet, *Oppiella nova* (Oudemans), *Oribatula tibialis* (Nicolet), *Phauloppia rauschenensis* (Sellnick), *Phthiracarus longulus* (C.L. Koch), *Porobelba spinosa* (Sellnick), *Quadroppia quadricarinata* (Michael), *Ramusella insculpta* (Paoli), *Scheloribates latipes* (C.L. Koch), *Scheloribates pallidulus* (C.L. Koch), *Sellnickochthonius jacoti* (Evans), *Steganacarus carinatus* (C.L. Koch), *Suctobelbella acutidens* (Forsslund), *Suctobelbella sarekensis* (Forsslund), *Suctobelbella subcornigera* (Forsslund), *Suctobelbella subtrigona* (Oudemans),

Tectocepheus velatus (Michael), *Trichoribates berlesei* (Jacot), *Xenillus tegeocranus* (Hermann).

Acari (Mesostigmata)

Arctoseius brevichelis Karg, *Arctoseius semiscisus* (Berlese), *Heteroparasitus* sp., *Hypoaspis lasiomyrmecophilus* Hirschamann, *Leptogamasus suecicus* Trägårdh, *Prozercon kochi* Sellnick, *Rhodacarus coronatus* Berlese, *Rhodacarus reconditus* Athias-Henriot, *Trachyuropoda poppi* Hirschmann et Zirngiebl-Nicol, *Urodiaspis tecta* (Kramer), *Uropoda minima* Kramer, *Zercon peltatus* C.L. Koch, *Zercon* sp. 1, *Zercon triangularis* C.L. Koch.

Insects (Collembola)

Anurida granulata Agrell, *Anurophorus septentrionalis* (Pallisa), *Ceratophysella denticulata* (Bagnall), *Ceratophysella* sp. juv., *Desoria germanica* (Huther & Winter), *Desoria* sp. juv., *Dicyrtoma fusca* (Lucas), *Entomobrya nivalis* (L.), Entomobyidae spp. juv., *Folsomia manolachei* Bagnall, *Folsomia penicula* Bagnall, *Friesea truncata* Cassagnau, *Isotomiella minor* (Schaffer), *Lepidocyrtus lanuginosus* (Gmelin), *Lepidocyrtus lignorum* gr juv., *Lipotrix lubbocki* (Tullberg), *Megalothorax minimus* Willem, *Mesaphorura hylophila* Rusek, *Mesaphorura macrochaeta* Rusek, *Micraphorura absoloni* (Borner), *Neanura muscorum* (Templeton), *Parisotoma notabilis* (Schaffer), *Pogonognatellus flavescens* (Tullberg), *Proisotoma minima* (Tullberg), *Protaphorura* sp. juv., *Pseudachorutes corticicolus* (Schaffer), *Pseudachorutes parvulus* Borner, *Pseudachorutes* sp. juv., *Pseudosinella alba* (Packard), *Pseudosinella horaki* Rusek, *Schoetella ununguiculata* (Tullberg), *Sminthurinus* sp. juv., *Spatulosminthurus flaviceps* (Tullberg), *Sphaeridia pumilis* (Krausbauer), Symphypleona juv., Tomoceridae spp. juv., *Willowsia buski* (Lubbock), *Xenylla* sp. juv.

Insects (Coleoptera)

Apion sp., *Coccinella septempunctata* L., *Propylea quatuordecimpunctata* L., *Selatosomus aeneus* L., *Carabus violaceus* L., *Nebria brevicollis* (Fabr.), *Pterostichus cupreus* (L.), *Pterostichus niger* (Schall.), *Calathus erratus* (Sahlb.), Staphylinidae spp.

DISCUSSION

Noble fir is within its natural range a component of five forest cover types [Forest... 1980], but it is significant only within Coastal True Fir-Hemlock type. In the understory occur ericaceous shrubs represented by several species from the genus *Vaccinium* and *Rhododendron* as well as currants (*Ribes* spp.) and among herbs most often *Xerophyllum tenax* [Franklin 1990].

There is hardly any information about fungi associated with *Abies procera*, neither within its natural occurrence limits nor in the plantations in novel places. In an extensive review of works on the taxonomy and ecology of fungi claiming mycorrhizal fun-

gus-host associations published by Trappe [1962] only one species – *Russula delica* (the species known also from Poland, not found in the present study) – was reported for that tree [Trappe 1961]. In a contemporary review of all available publications published since 1961 and providing 1244 descriptions of ectomycorrhizas no single record concerning *Abies procera* is mentioned [De Roman et al. 2005].

Most of the fungal species recorded in the present study in the examined stands of noble fir are typical of mixed and coniferous forests and are rather widespread in Poland and Central Europe [Ławrynowicz et al. 2004]. Majority of them are also cosmopolitan species of holarctic distribution. None of the species recorded is alien for Europe.

In the course of the present study no sporocarps of *Heterobasidion annosum* were found in the noble fir plots; however, the species has been reported from *Abies procera* in Poland [Dominik and Grzywacz 1998 and the literature cited therein]. High susceptibility of that tree species to *H. annosum* was also reported from experimental stands in northern Denmark [Ronnberg et al. 1999]. The presence of another severe fungal parasite – *Armillaria* sp. was observed. Species of that genus were reported on this tree by Grzywacz as well [Dominik and Grzywacz 1998 and the literature cited therein].

The presence of week parasite *Sparassis crispa* is worth mentioning as this species is strictly protected by law in Poland. The species is also red-listed as rare in the country [Wojewoda and Ławrynowicz 2006].

The studied noble fir (*Abies procera*) plots in the Rogów Arboretum had the lowest number of plants in comparison with other two fir species (*A. cephalonica*, *A. grandis*) plots. On the other hand the noble fir plots were much more diverse as concerns invertebrates. Halaj et al. [1998] in their research on habitat structure and prey availability of spiders in different forests found that the highest numbers of spiders were collected in tree stands with noble fir and Douglas fir. This tree species had also the highest species richness. But there are not many papers on other aspects of biodiversity of noble fir tree stands. The data already published are focused on records of particular species of invertebrates or are connected with research in the field of plant protection [Pratt et al. 2002].

ACKNOWLEDGMENTS

The authors are indebted to Dr. Anna Rusińska for verification of bryophyte determinations. This research was supported by the Polish Ministry of Science and Higher Education (grant No. N304 071 32/2761).

REFERENCES

Betts H.S., 1945. Noble fir (*Abies procera*). American Woods. U.S. Depart. Agric. For. Serv. 6.

Bednarek A., 1993. Klimat [Climate]. In: Warunki przyrodnicze lasów doświadczalnych SGGW w Rogowie. Ed. R. Zielony. Wyd. SGGW Warszawa, 24-41 [in Polish].

Brockway D.G., Topik C., Hemstrom M.A., Emmingham W.H., 1985. Plant association and management guide for the Pacific silver fir zone: Gifford Pinchot National Forest. R6-Ecol-130a. Portland, OR: U.S. Depart. Agric. For. Serv., Pacific Northw. Region 122.

Czępińska-Kamińska D., Janowska E., Konecka-Batley K., 1991. Gleby Arboretum w Rogowie [Soils of the Rogów Arboretum]. Arboretum Rogów [manuscript in Polish].

De Roman M., Claveria V., de Miguel A.M., 2005. A revision of the descriptions of ectomycorrhizas published since 1961. Mycol. Res. 109 (10), 1063-1104.

Doede D.L., Adams W.T., 1998. The genetic of stem volume, stem form, and branch characteristics in sapling Noble fir. Silvae Genet. 47, 4, 177-183.

Dominik I., Grzywacz A., 1998. Zagrożenie obcych gatunków drzew iglastych ze strony rodzimej entomofauny oraz mikoflory [Threats to alien species of coniferous trees from inoligenous entomofauna and micoflora]. Fund. Rozwój SGGW Warszawa [in Polish].

Filip G.M., Schmitt C.L., 1990. Prescription for *Abies* silvicultural options for diseased firs in Oregon and Washington USA. U.S. For. Serv. General Techn. Rep. PNW.

Fletcher A.M., Samuel C.J.A., 1990. Early height growth in the seed origins of noble fir in Britain. In: 1990 joint meeting of Western Forest Genetics Association and IUFRO Working Parties S2.02-05, 06, 12, and 14 on Douglas-fir, contorta pine, Sitka spruce, and *Abies* breeding and genetic resources. 20 to 24 August 1990. Olympia, WA. Weyerhaeuser Tacoma, WA, 2.98-2.113.

Forest cover types of the United States and Canada. 1980. Ed. F.H. Eyre. Soc. Am. For. Washington, DC, 148.

Fowells H.A., 1965. Silvics of forest trees of the United States. Agricultural Handbook 271. U.S. Depart. Agric. Washington, DC, 762.

Franklin J.F., 1964. Some notes on the distribution and ecology of noble fir. Northw. Sci. 38, l, 1-13.

Franklin J.F., 1982. The true fir resource. In: Proceedings of the Biology and Management of True Fir in the Pacific Northwest Symposium. 24 to 26 February 1981, Seattle-Tacoma, WA. Contribution No. 45. Eds C.D. Oliver, R.M. Kenady. Coll. For. Res. Univ. Washington, 1-6.

Franklin J.F., 1983. Ecology of noble fir. In: Proceedings of the Biology and Management of True Fir in the Pacific Northwest Symposium. 24 to 26 February 1981, Seattle-Tacoma, WA. Contribution No. 45. Eds C.D. Oliver, R.M. Kenady. Coll. For. Res. Univ. Washington, 59-69.

Franklin J.F., 1990. *Abies procera* Rehd. Noble fir. In: Silvics of North America. Vol. 1. Conifers. Agricultural Handbook 654. Eds R.M. Burns, B.H. Honkala. U.S. Depart. Agric., For. Serv. Washington, DC, 80-87.

Franklin J.F., Dyrness C.T., 1973. Natural vegetation of Oregon and Washington. Gen. Tech. Rep. PNW-8. Portland, OR: U.S. Depart. Agric., For. Serv., Pacific Northw. Forest Range Exper. Stat.

Franklin J.F., Sorensen F.C., Campbell R.K., 1978. Summarization of the ecology and genetics of the noble and California red fir complex. In: Proceedings of the IUFRO Joint Meeting of Working Parties. Vol. 1. Ministry of Forestry, Inform. Serv. Branch, Victoria, B.C., 133-139.

Fujimori T., Kawanabe S., Saito H., Grier C.C., Shidei T., 1976. Biomass and primary production in forests of three major vegetation zones of the Northwestern United States. J. Japan. For. Soc. 58, 10, 360-373.

Gessel S.P., Oliver C.D., 1982. Soil-site relationships and productivity of true firs. In: Proceedings of the Biology and Management of True Fir in the Pacific Northwest Symposium. 24 to 26 February 1981, Seattle-Tacoma, WA. Contribution No. 45. Eds C.D. Oliver, R.M. Kenady. Coll. Forest Res. Univ. Washington, 177-184.

Grier C.C., Lee K.M., 1983. Primary production in *Abies amabilis* zone ecosystems. In: Proceedings of the Biology and Management of True Fir in the Pacific Northwest Symposium. 24 to 26 February 1981, Seattle-Tacoma, WA. Contribution No. 45. Eds C.D. Oliver, R.M. Kenady. Coll. Forest Res. Univ. Washington, 139-144.

Hanzlik E.J., 1925. A preliminary study of the growth of noble fir. J. Agric. Res. 31, 10, 929-934.

Halaj J., Ross D.W., Moldenke A.R., 1998. Habitat structure and prey availability as predictors of the abundance and community organization of spiders in western Oregon forest canopies. J. Arachnol. 26, 2, 203-220.

Harrington C.A., Murray M.D., 1982. Patterns of height growth in western true fir. In: Proceedings of the Biology and Management of True Fir in the Pacific Northwest Symposium. 24 to

26 February 1981, Seattle-Tacoma, WA. Contribution No. 45. Eds C.D. Oliver, R.M. Kenady. Coll. Forest Res. Univ. Washington, 209-214.
Hotała S., 2010. Sezonowa zmienność warunków świetlnych w drzewostanach obcych gatunków drzew leśnych [Seasonal variation of light conditions in stands of exotic tree species]. MSc Thesis. Depart. Game Manag. Forest Prot. Pozn. Univ. Life Sci. Poznań [manuscript in Polish].
Jagodziński A.M., Banaszczak P., 2010. Stem volume and aboveground woody biomass in Noble fir (*Abies procera* Rehder) stands in Rogów Arboretum (Poland). Acta Sci. Pol., Silv. Colendar. Rat. Ind. Lign. 9 (2), 9-24.
Ławrynowicz M., Bujakiewicz A., Mułenko W., 2004. Mycocoenological studies in Poland 1952-2002. Monogr. Bot. 93, 1-102.
Maze J., Parker W.H., 1983. A study of population differentiation and variation in *Abies procera*. Canad. J. Bot. 61, 1094-1104.
Pratt P.D., Rosetta R., Croft B.A., 2002. Plant-related factors influence the effectiveness of *Neoseiulus fallacis* (Acari: Phytoseiidae), a biological control agent of spider mites on landscape ornamental plants. J. Econ. Entomol. 95, 6, 1135-1141.
Rasmussen H.N., Nielsen C.N., Jørgensen F.V., 2005. Crown architecture and dynamics in *Abies procera* as influenced by cutting for greenery. Trees 19, 619-627.
Ronnberg J., Vollbrecht G., Thomsen I.M., 1999. Incidence of butt rot in a tree species experiment in northern Denmark. Scand. J. For. Res. 14 (3), 234-239.
Ruetz W.F., Svolba J., Rau H.-M., 1998. Der IUFRO *Abies procera* Provenienzversuch in der Bundesrepublik Deutschland. Forst-u. Holz 53, 22, 672-675.
Stewart G.H., 1986. Population dynamics of a montane conifer forest, western Cascade Range, Oregon, USA. Ecology 67, 2, 534-544.
Trappe J.M., 1961. Some probable mycorrhizal associations in the Pacific Northwest. III. Northw. Sci. 35, 91-94.
Trappe J.M., 1962. Fungus associates of ectotrophic mycorrhizae. Bot. Rev. 28, 538-606.
Tumiłowicz J., 1977. Jodła szlachetna – *Abies procera* Rehd. [Noble fir – *Abies procera* Rehd.] In: Obce gatunki drzew w gospodarstwie leśnym. Eds S. Bellon, J. Tumiłowicz, S. Król. PWRiL Warszawa, 53-60 [in Polish].
Wojewoda W., Ławrynowicz M., 2006. Red list of the macrofungi in Poland. In: Red list of plants and fungi in Poland. Eds Z. Mirek, K. Zarzycki, W. Wojewoda, Z. Szeląg. W. Szafer Inst. Bot. Polish Acad. Sci. Kraków, 53-70.
Xie C.Y., Ying C.C., 1994. Adaptedness of Noble fir (*Abies procera* Rehd.) beyond its northern limit. For. Sci. 40, 3, 412-428.
Yeh F.C., Hu X.-S., 2005. Genetic structure and migration from mainland to island populations in *Abies procera* Rehd. Genome 48, 461-473.
Ying C.C., 1992. Effect of sites and provenances on 6th-year performance of noble fir in coastal British Columbia. Research Note 112. B.C. Ministry of Forestry, Victoria, BC.

WYKAZ GATUNKÓW ROŚLIN, GRZYBÓW I BEZKRĘGOWCÓW NA POWIERZCHNIACH DOŚWIADCZALNYCH Z JODŁĄ SZLACHETNĄ (*ABIES PROCERA* REHDER) W ARBORETUM SGGW W ROGOWIE (POLSKA)

Streszczenie. W pracy przedstawiono różnorodność gatunkową stwierdzoną na powierzchniach doświadczalnych jodły szlachetnej (*Abies procera*), założonych na terenie Arboretum SGGW w Rogowie. Jodła szlachetna jest gatunkiem rodzimym dla obszarów górskich północno-zachodnich Stanów Zjednoczonych. W wyniku badań wykonanych

w Arboretum SGGW w Rogowie na powierzchniach doświadczalnych z jodłą szlachetną wykazano obecność 53 gatunków roślin naczyniowych i mchów, 51 gatunków grzybów wielkoowocnikowych oraz 112 gatunków bezkręgowców. Dane te porównano z wynikami innych autorów dotyczącymi jodły szlachetnej rosnącej w granicach naturalnego zasięgu występowania oraz z bogactwem gatunkowym stwierdzonym w rodzimym zbiorowisku leśnym (*Tilio-Carpinetum*), występującym w bliskim sąsiedztwie powierzchni doświadczalnych.

Słowa kluczowe: *Abies procera*, jodła szlachetna, różnorodność biologiczna, rośliny naczyniowe, grzyby wielkoowocnikowe, nicienie, roztocze, owady

Accepted for print – Zaakceptowano do druku: 22.12.2011

For citation – Do cytowania: Kasprowicz M., Jagodziński A.M., Skorupski M., Wojterska M., Dobies T., Kałucka I., Sławska M., Wierzbicka A., Łabędzki A., Nowiński M., Karolewski P., Oleksyn J., Banaszczak P., Małek S., 2011. The list of plants, fungi and invertebrates of noble fir (Abies procera Rehder) experimental stands in Rogów Arboretum (Poland). Acta Sci. Pol., Silv. Colendar. Rat. Ind. Lignar. 10(4), 17-27.