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SOILS CHARACTERISTICS OF FOREST PHYTOCOENOSES OCCUPIED BY SELF-REGENERATING POPULATIONS OF *Quercus rubra* IN SILESIAN UPLAND

WŁAŚCIWOŚCI FIZYKOCHEMICZNE GLEB NA STANOWISKACH Z ODNOWIENIEM DĘBU CZERWONEGO NA WYŻYNIE ŚLĄSKIEJ

Abstract: Northern Red Oak is a tree species native to North America. In Polish flora it has status of invasive plants. In the years 2008-2011 autoecological studies were conducted aiming at examination on what type of soils the species tends to regenerate *ie* appearance of seedlings in the vicinity of maternal trees. In total 250 phytosociological relevés and 100 soil samples (400 soil subsamples) were collected. It was observed that majority stands (almost 80%) of Northern Red Oak occupy sites very strongly acid and strongly acid. In reference to pH in KCl results are a little different, however, sites with soil very strongly acid (pH = 4.1-5.0) and stronly acid (pH < 4.1) also predominate. The investigated soils were typified by very low values of magnesium (< 10 mg/1000 g), phosphorus (< 3 mg/100 g) and potassium (< 7 mg/100 g). Total nitrogen in studied sites dominated in two the lowest classes (> 0.25%). The sites of *Q. rubra* are rich in organic carbon. Almost 50% of all sites covers two highest classes of concentration of this element *ie* 4.0-8.0% and > 8.0%. Soils where seedlings of Northern Red Oak were encountered, were characterized by humus medium for mezotrophic and eutrophic broad-leaved forests and mixed coniferous forests - more than 60% had ratio of carbon and nitrogen CN > 25. In several sites this ratio reached 50. The lower values in case of content of calcium and loss on ignition dominate. The studies showed that soils on which species grows and also spontaneously regenerates are typical for coniferous and mixed coniferous forests, however, in natural range *Q. rubra* is component of deciduous forests. It could be associated with the fact of more frequent introduction of Northern Red Oak into poorer sites than the consequence of its habitat requirements.

Keywords: biological invasions, neophyte, biotopic requirements

Introduction

Northern Red Oak *Q. rubra* L is a tree species native to North America. The species has status of invasive plant in Poland [1], Czech Republic [2], Germany [3], Lithuania [4] and Belgium [5, 6]. In other European countries mainly in northern part of the continent it is common and established species [7]. This tree was introduced to Europe in 1691 [1] and to Poland in 1806 [8]. Northern Red Oak is preferred over the indigenous oaks as *Q. robur* and *O. petraea* by European foresters because of its faster growth (even up to 60% higher)

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when compared with native oaks, which yields earlier profits for forestry [9, 3]. Northern Red Oak is frequently used in the silvopasture [10, 11] because this tree possesses an open crown that allows light to reach the pasture surface, making it compatible with pasture production. Furthermore, as a broad-leaved species, it allows better light penetration than coniferous trees during the autumn and early spring, and it provides shading during the summer. Thus, evapotranspiration is reduced, leading to enhanced pasture production as compared to pasture under conifers or on open pasture sites [12]. Both in the Netherlands, and Poland it was introduced as a good timber producing tree species on poor and sandy soils [1, 3, 13]. However, quality of timber in comparison with native oaks, especially for furniture production is lower [3, 14]. In its homeland *ie* eastern North America its spread is dispersed by birds especially quirrels or jays [15]. Natural regeneration of *Q. rubra* typically depends on periodic fires, which increase light penetration through the canopy and reduce interspecific competition in the understorey. Stands of *Q. rubra* are undergoing successional replacement by shade-tolerant competitors *eg Acer rubrum*, *A. saccharum* [16] however, the processes of regeneration occur faster and easier in alien range [17]. In invasive range the presence of the tree species is a result of cultivation and further spontaneous spread also depends on birds [18], whereas regeneration of the tree species is not fully known. Regeneration may be a crucial factor in invasion success of Northern Red Oak and consequently enhances reduction of native biodiversity by this species. The causes of regeneration of the tree, spread and establishment and as a consequence - threat to native biodiversity, can be of biotic and abiotic nature. As regards the latter, one of most important factor is so-called habitat compatibility. For plants soil environment, among others, its physical and chemical properties enables seedling recruitment, growth and reproduction of plants. The similar soils in secondary range can contribute to the invasion success of alien species. In this study the main goal of research was to examine chemical and physical properties of soil in sites with the regeneration of *Quercus rubra,* exemplified by Silesian Upland, and to discuss them with soil preferences in North America.

Study area

The Silesian Upland is a physical-geographical region, covering an area *ca* of 4,000 km^2, situated in the southern part of Poland 50°15′N, 19°0′E (Fig. 1). The region is heavily transformed due to human activity *ie* mainly industry and coal mining. The plant and soil cover has been substantially altered since 16th century [19, 20]. The cover of forested area is low and in some towns it is estimated to *ca* 1.5% (for Katowice urbanization - about 17%). Cabała [21] distinguished there 17 forest associations and 26 syntaxa of lower rank.

Material and methods

During fieldwork conducted in the years 2008-2011 in the Silesian Upland soil samples were taken randomly across forest associations. The soil was sampled in sites where phytosociological relevés were taken. The methods of sites selection for study of Northern Red Oak was described in detail in previous works [22, 23]. One hundred soil samples included four soil sub-samples (in total 400) which were collected from 0-10 cm depth and mixed into one composite sample. After air-drying and sieving over 2 mm, they were analysed for: pH, measured potentiometrically in H_2O (ph_aqua) and in 1N KCl, total organic C [%], according to the Tiurin method (C_org). Loss on ignition in muffle furnace [%] (LOS), total N content [%] with the application of the Kjeldahl method (N_T), available Mg using FAAS (Flame Atomic Absorption Spectrometry), available phosphorus P using colorimetry method, sodium Na and potassium K were detected using flame emission spectroscopy, and Ca by spectrophotometry in 1 N ammonium acetate [mg/kg]. The granulometric composition of soils was characterized by the Proszynski method. The scales of available nutrient contents (P, K, M), pH in water and KCL solution as well as C/N ratio were adopted after [24] and literature cited there. However, scale of organic carbon, total nitrogen and scale of slope follow [25]. The 7-degree scale of percentage of floatable fraction and division of soils into groups, due to granulometric composition, were employed according to [26].

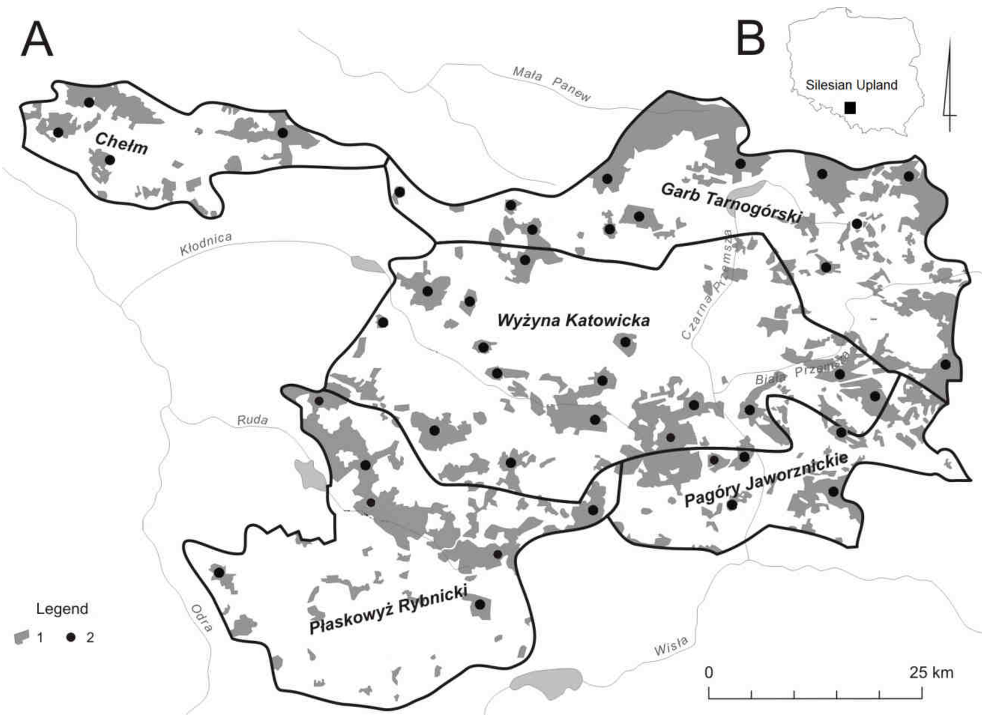

Fig. 1. Localization of the study area (the Silesian Upland) with investigated forest complexes: 1 - forest area, 2 - study site

Results

It was observed that majority stands (almost 80%) of Northern Red Oak occupy sites very strongly acid and strongly acid, whereas alkaline sites there are lower than 4% (Fig. 2).

In reference to pH in KCl results are a little different, however, sites with soil very strongly acid (pH = 4.1-5.0) and stronly acid (pH < 4.1) also predominate (Fig. 2).

The investigated soils were typified by very low values of magnesium (< 10 mg/1000 g) (90.2%), phosphorus (< 3 mg/100 g) (82.7%) and potassium

(< 7 mg/100 g) (69.1%). Total nitrogen in studied sites dominated in two the lowest classes (> 0.25%) (Fig. 3).

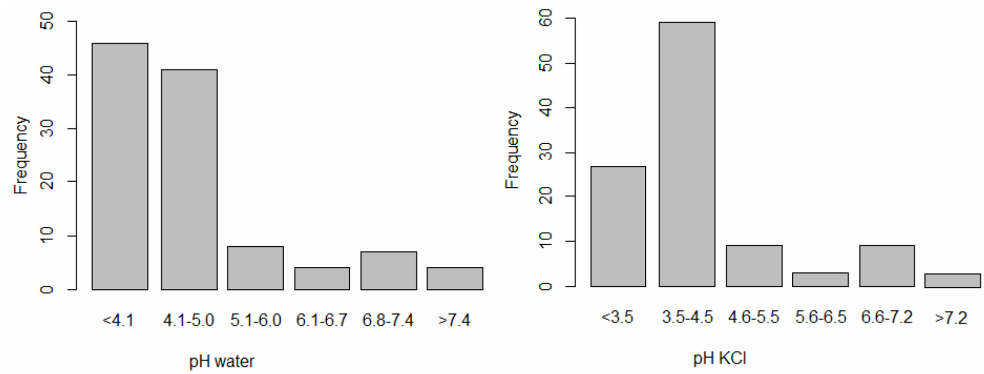

Fig. 2. The soil range of sites with the occurrence of *Quercus rubra*

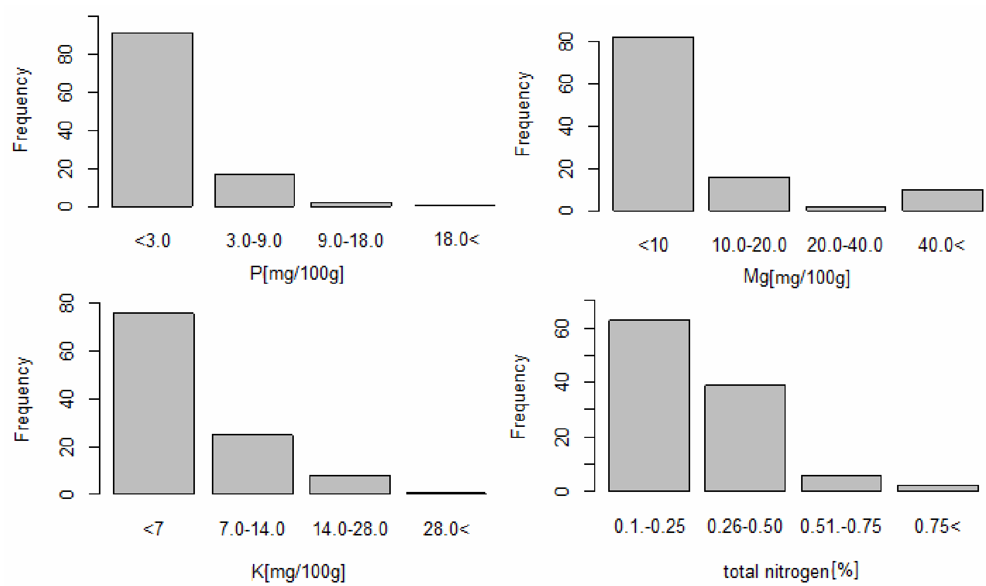

Fig. 3. Distribution of sites of *Quercus rubra* in various classes of phosphorus, magnesium, potassium and total nitrogen

The sites of *Q. rubra* are rich in organic carbon. Almost 50% of all sites covers two highest classes of concentration of this element *ie* 4.0-8.0% and > 8.0% (Fig. 4). Soils where seedlings of Northern Red Oak were encountered, were characterized by humus medium for mezotrophic and eutrophic broad-leaved forests and mixed coniferous forests - more than 60% had ratio of carbon and nitrogen CN >25. In several sites this ratio reached 50 (Fig. 4). The lower values in case of content of calcium and loss on ignition dominate (Fig. 5).

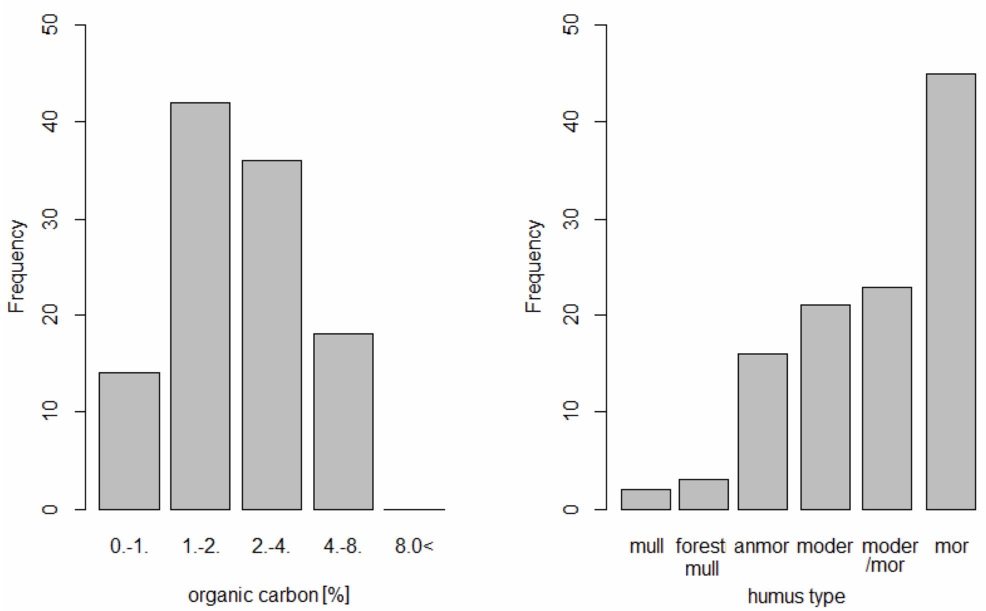

Fig. 4. Distribution of sites of *Quercus rubra* in various classes of organic carbon and types of humus

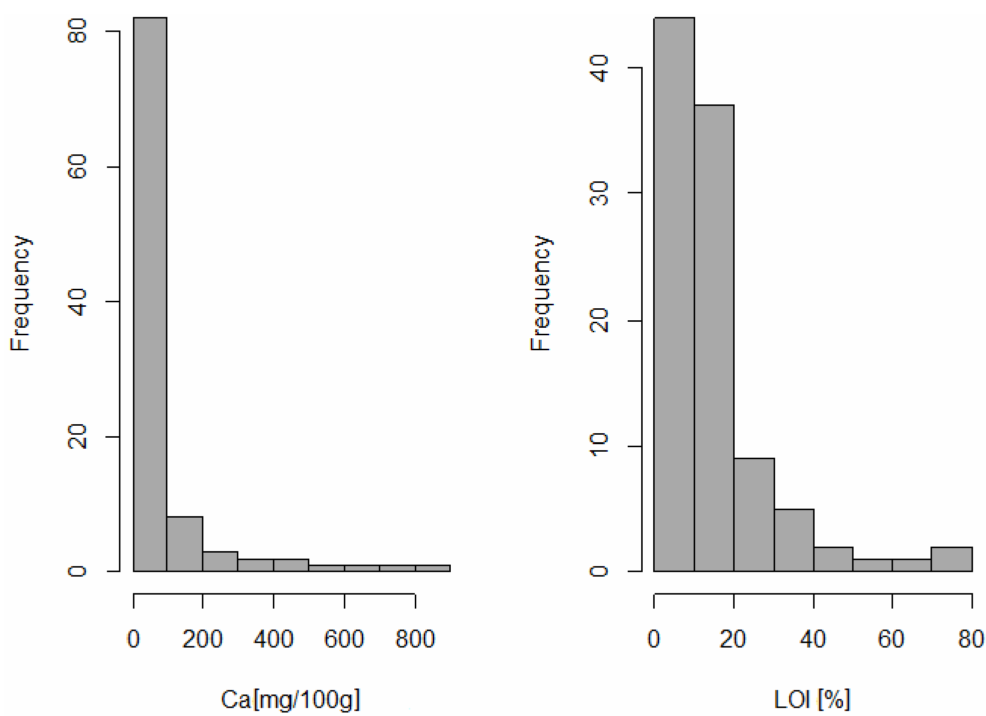

Fig. 5. Histograms of calcium content and percentage of loss on ignition LOI in *Quercus rubra* sites

Taking into account particular granulometric fractions it was revealed that fractions for sand and dust dominate (Fig. 6). About 71% of all soil samples represented very light soils (< 5% of floatable fractions), 21% light soils (5.0-10.0%) and almost 7% - medium soils (10.1-15.0%).

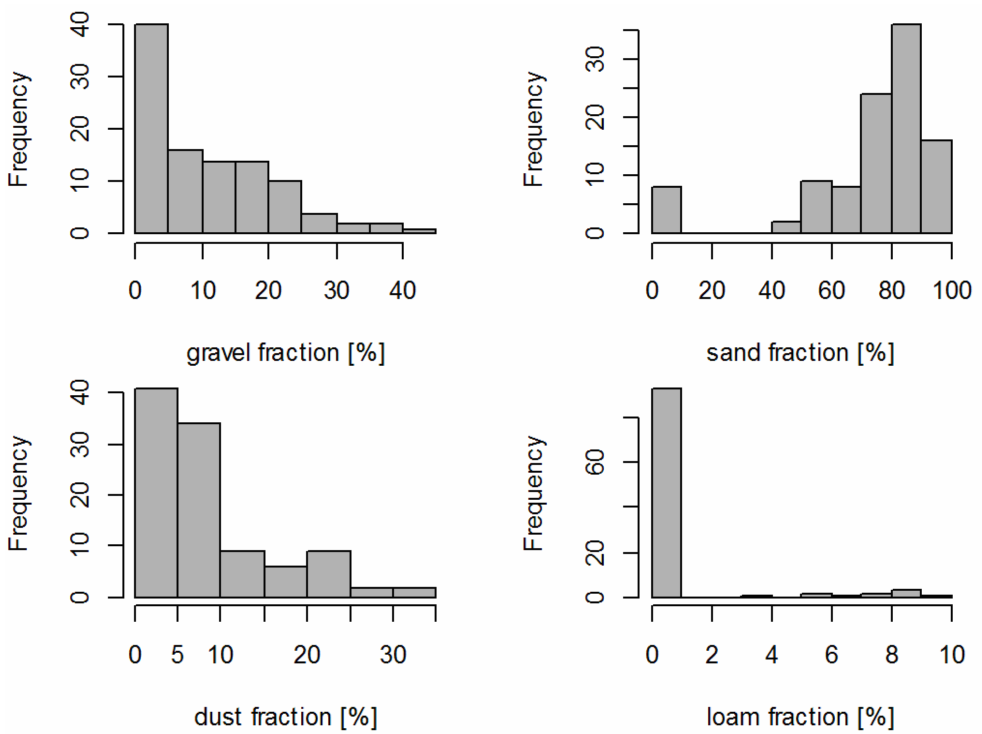

Fig. 6. Histograms of chosen granulometric fractions in *Quercus rubra* sites

Discussion

The study showed that majority of soils grown by Northern Red Oak are rather acidic. Such soils are chiefly occupied by coniferous and mixed coniferous forests. This is the effect of choice of foresters who cultivated Northern Red Oak on sandy soils in pine plantations in whole Europe [3]. What interesting in natural range the species occurs in first of all in broad-leaved and mixed coniferous forests. Northern Red Oak grows best on deep, welldrained loam to silty, clay loam soils. It also prefers north- and east-facing slopes [27]. This study demonstrated that fractions which prevailed were sand and dust, however, in native range it was reported that *Q. rubra* also grows on sandy soils. The soils which were occupied by Northern Red Oak were typified by low fertility. Major et al [17] showed that *Q. rubra* regeneration was optimal at lower soil nutrient (P, K, Mg and Ca) concentrations. Therefore, the species is considered as stress-tolerant plant which can survive highly reduced soil fertility. The present study confirmed these results because Northern Red Oak was found most frequently in lower classes of aforementioned elements. The study conducted in Niepołomice Forest by [28] revealed that Red Oak tended to occur on moderately poor soils. Chmura [22] also showed negative correlations between abundance of Northern Red Oak in herb layer and total nitrogen and loss on ignition. According to [29] more frequent presence of *Q. rubra* on poor sites in mixed and coniferous forests is result of intentional introduction of this tree into these types of habitats. It does not reflect biotopic requirements of the species.

Conclusions

Despite different policy of foresters in Europe and cultivation rather on habitats of coniferous forests, the species regenerates on soils similar in terms of physical-chemical properties to those encountered in native range. Attention should be paid to stands of Northern Red Oak occurring in mixed coniferous and deciduous forests characterized by low fertility. The experiences from native and secondary range showed that in such habitats *Q. rubra* is quite effective competitive tree.

Acknowledgements

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WŁAŚCIWOŚCI FIZYKOCHEMICZNE GLEB NA STANOWISKACH Z ODNOWIENIEM DĘBU CZERWONEGO NA WYŻYNIE ŚLĄSKIEJ

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Abstrakt: Dąb czerwony *Quercus rubra* L. to gatunek północnoamerykański, introdukowany do Polski na początku XIX w. W polskiej florze ten gatunek drzewa ma status rośliny inwazyjnej. W latach 2008-2011 na obszarze Wyżyny Śląskiej prowadzono badania autoekologiczne m.in. w celu sprawdzenia, na jakich typach gleb gatunek ten ma tendencję do odnawiania się (tzn. w miejscach, gdzie pojawiają się siewki w sąsiedztwie drzew macierzystych). Zebrano ogółem ok. 250 zdjęć fitosocjologicznych oraz ok. 100 próbek glebowych. Stwierdzono, że pod względem odczynu gleby (pH w wodzie) stanowiska z dębem czerwonym prawie w 80% zajmują miejsca bardzo silnie kwaśne i silnie kwaśne. W stosunku do pH w KCl wyniki się różnią, ale wciąż przeważają miejsca o odczynie silnie kwaśnym (pH = 4,1-5,0) i bardzo kwaśnym (pH < 4,1) na korzyść tych pierwszych. Stanowiska z *Q. rubra* są zasobne w organiczne związki węgla. Prawie 50% stanowisk mieści się w dwóch ostatnich klasach zawartości tego pierwiastka, tj. 4,0-8,0% oraz > 8%. Azot ogólny wśród badanych miejsc dominował w niższej i średniej klasie (> 0,25%). Gleby, na których odnotowano siewki dębu czerwonego, charakteryzowały się humusem pośrednim dla mezotroficznych i eutroficznych lasów liściastych i mieszanych, a borów i borów mieszanych - blisko 70% stanowisk miało stosunek węgla do azotu > 25. Na kilku stanowiskach stosunek C/N był bliski 50. Badane gleby odznaczały się wyjątkowo niskimi zawartościami magnezu (< 10 mg/100 g), fosforu (< 3 mg/100 g) oraz potasu (< 7 mg/100 g). Około 69-90% wszystkich stanowisk znajdowało się w najniższej klasie. Badania pokazują, że gleby na jakich rośnie, a także spontanicznie odnawia się dąb czerwony są typowe dla borów i lasów mieszanych, natomiast w naturalnym zasięgu *Q. rubra* jest głównie składnikiem lasów liściastych. Może to być związane z tendencją do częstszego wprowadzania dębu na uboższe siedliska przez leśników niż odzwierciedlać jego rzeczywiste preferencje.

Słowa kluczowe: inwazje biologiczne, kenofit, wymagania siedliskowe