

JÓZEF K. KUROWSKI<sup>1</sup>, EWELINA KOCZYWAŚ<sup>2</sup> & MICHAŁ PIEŃKOWSKI<sup>3</sup>

Department of Geobotany and Plant Ecology, University of Łódź, Banacha 12/16,  
90-237 Łódź, Poland, <sup>1</sup>kurowski@biol.uni.lodz.pl, <sup>2</sup>e.koczywas@wp.pl,  
<sup>3</sup>pieniek@toya.net.pl

**ESTIMATION OF POPULATION SIZE OF *DENTARIA ENNEAPHYLLOS*  
IN THE VICINITY OF THE BEŁCHATÓW BROWN COAL MINE AND  
THE ATTEMPT OF ITS METAPLANTATION**

**Abstract:** The impact of anthropopressure on the flora in the vicinity of the Bełchatów Brown Coal Mine in Central Poland has been substantially strong. Consequently, certain changes in habitat conditions have been observed, leading to a decline in particular species stands. Mechanical damage, as well as the mine and power plant expansion have contributed to further species decline in the area. *Ex situ* conservation, e.g. metaplantation from native to secondary localities seems an efficient method of ensuring the species survival in the local flora. One of the species is to be found in Wola Wydrzyna (under the Forest District Administration of Bełchatów) is Drooping Bittercress *Dentaria enneaphyllos*. Its population was first recorded in the area in 1979. However, since 2009 the forest complex has undergone a regular expansion of the Bełchatów Brown Coal Mine. The forest area is to be utilised for the future Szczerców coal deposit. Therefore, in 2000 the method of *Dentaria enneaphyllos* metaplantation was applied.

**Key words:** metaplantation, *Dentaria enneaphyllos*, Central Poland, the Bełchatów Brown Coal Mine

## 1. INTRODUCTION

Rising of widespread industrial areas is often related to destruction of valued ecosystems or causes negative, irreversible changes in habitat conditions. In that kind of areas there is a necessity of *ex situ* conservation of valuable and rare species. Transferring them to secondary habitats ensure their survival and gene pool. One of the efficient method is a metaplantation experiment. This instrument ought to be obligatory for investors as a nature compensation. At the beginning of investments some rare and endangered species should be taken away from planned industrial areas. The procedure, terms and conditions of metaplantation, its purposefulness were described (ŁUKASIEWICZ 1984; OLACZEK 1986; KLASA 1991; TESKE 1992). PAWLACZYK and JERMACZEK (2008) payed attention to sources of difficulty and hazard related to creating new, artificial stands of important species. Suitable rules of law which would regulate problem of transferring valuable species or endangered populations from industrial areas haven't been created so far.

An example of the area where the impact of anthropopressure has been substantially strong, resulting in irreversible changes in forest ecosystems, is the vicinity of the open-pit Bełchatów Brown Coal Mine. The main causes of such transformations include: drainage of the brown coal deposit, large area felling facilitating the spread of the mine's and power plant's infrastructure, dust and gaseous pollution, peat exploitation, construction of canals replacing natural river sections and leading away the drained water (KUROWSKI 1984, 1993, 2007a, b). In the vicinity of the coal mine there are situated stands of *Dentaria enneaphyllos* which is rare in Central Poland.

Drooping Bittercress is a geophyte blooming in April and May (SZAFER *et al.* 1988; RUTKOWSKI 2006). In Poland it chiefly occurs in the Sudety Mountains, the West Carpathians, the Kraków-Częstochowa Upland and the Świętokrzyskie Mountains (ZAJĄC, ZAJĄC 2001). The species is characteristic for fertile mountain beech forests *Dentario enneaphylli-Fagetum* and *Dentario glandulosae-Fagetum* (MATUSZKIEWICZ 2007). As for the lowlands, the main places of its occurrence are the oak-hornbeam and beech forests (ZAJĄC 1996).

In Central Poland *Dentaria enneaphyllos* occurs in rare and isolated populations. Furthermore, the species is categorised as VU (vulnerable) in the List of Threatened Species of the area (JAKUBOWSKA-GABARA, KUCHARSKI 1999). Drooping Bittercress has been recorded in four stands, two of which are situated in the vicinity of the Bełchatów Brown Coal Mine, i.e. in the forest complexes of Wola Wydrzyna and Stróża in Forest District Administration of Bełchatów (KUROWSKI 1984; JAKUBOWSKA-GABARA 1989). Two other stands are to be found in the Spała Forests, i.e. in the Sługocice forest-floristic reserve (OLACZEK 1978) and in the Forest District of Białobrzegi (KIEDRZYŃSKI 2000).

The population in Wola Wydrzyna is to be destroyed in the near future. The outset of mining activity in the Szczerców coal deposit will lead to annihilation of the forest complex. Consequently, the flora's gene pool in the region will be impoverished. Wola Wydrzyna is one of the most valued areas in the vicinity of the open-pit mine, not only due to occurrence of the investigated population of *Dentaria enneaphyllos*, but also to the forest's remarkably rich flora and significant variety of its phytocoenoses. If it were not to be destroyed, the area should be classified as a nature reserve (KUROWSKI 1984). What is also worth mentioning, Drooping Bittercress co-exist there with *D. bulbifera*, which is also rare in Central Poland. Furthermore, the forest complex of Wola Wydrzyna is home to such species as: *Corydalis cava* (with an area of ca. 1 ha), *Lathraea squamaria*, *Viburnum opulus*, *Ribes nigrum*, *Asarum europaeum*, *Daphne mezereum* and *Hepatica nobilis*. Patches of *D. enneaphyllos* are spread over the area of above 0.9 ha (KIEDRZYŃSKI, KUROWSKI 2011), and the individuals total coverage amounts to ca. 0.13 ha. In the face of the future annihilation of the Drooping Bittercress stand, the method of metaplantation has been applied in the forest complex of Wola Wydrzyna since 2000. Problem of metaplantation were presented for such species as *Cochlearia polonica* (KWIATKOWSKA 2001), *Aldrovanda vesiculosa* (KAMIŃSKI 1995), *Dianthus gratianopolitanus* (WĘGLARSKI, JAŃCZYK-WĘGLARSKA 2000), *Echium russicum* and *Irys aphylla* (DĄBROWSKA *et al.* 1995), *Polemonium coeruleum* (DĄBROWSKA *et al.* 2011). The method has already been successfully applied in the Łódź region, e.g. with regard to *Linnaea borealis* (KUROWSKI 2004; WITOSŁAWSKI 2004). There are

also known examples of metaplantation from industrial areas (JERMACZEK 2007; KRASICKA-KORCZYŃSKA, KORCZYŃSKI 2007; ŻÓŁKOŚ *et al.* 2010).

The main goals of this work include:

- estimating population size of *D. enneaphyllos* in its native stands,
- describing the condition of *D. enneaphyllos* new population in its secondary stand,
- pointing to practical problems regarding *ex situ* conservation and discussing difficulties concerning the application of metaplantation method, as well as emphasizing lack of any programmes that would enable the transfer of particular populations of rare and endangered species away from areas of future widespread investigations.

## 2. MATERIALS AND METHODS

In 2009, in the forest complex of Wola Wydrzyna were conducted observations of *Dentaria enneaphyllos* in its native stand. Estimating the population size involved both assessing the area of particular patches and determining the species percent coverage in each of them. Furthermore, individual stances of Drooping Bittercress have been distinguished in a number of representative areas, all characterised by varying density. The area of a single study plot was 1 m<sup>2</sup> (FALIŃSKA 2002).

In the year 2000 metaplantation was attempted by transferring *D. enneaphyllos* 10 km away from its native stand, situated in the forest complex of Wola Wydrzyna, to the projected Kluki nature reserve (named after Henryk Baksalerski). In the spring, separate soil lumps with *D. enneaphyllos* are transferred to a new location in the phytocoenosis of moist oak-hornbeam forests *Tilio-Carpinetum stachyetosum*. The metaplantation of Drooping Bittercress involves both measuring the total area covered by the species, and estimating the number of its flowering shoots. Since 2008 sterile shoots have also been taken into account.

### 3. RESULTS

It has been estimated that *Dentaria enneaphyllos* covered the area of 1280 m<sup>2</sup> in the forest complex of Wola Wydrzyna (including 430 m<sup>2</sup> in the 156 forest section and 850 m<sup>2</sup> in the 157 forest section; Phot. 1, Fig. 1, 2). The population size of *D. enneaphyllos* in the 156 forest section amounted to 57300 shoots (including 24400 flowering and 32900 sterile ones), while the number of shoots in the 157 forest section amounted to ca. 72400 (including respectively 24500 flowering and 47900 sterile ones).



Photo 1. *Dentaria enneaphyllos* in the forest complex of Wola Wydrzyna (photo E. Koczywas).

The stand of *Dentaria enneaphyllos* is situated in such phytocoenoses that undergo transformations (mainly resulting from habitat drainage). These are the phytocoenoses of *Carici remotae-Fraxinetum* and *Tilio cordatae-Carpinetum betuli* characteristic for the Maopolska region (their subdivisions are: *Tilio-Carpinetum stachyetosum sylvaticae* and *Tilio-Carpinetum corydaletosum*). *Dentaria*

*enneaphyllos* occupies only 1 m<sup>2</sup> in the Stróża forest complex, located to the west from the Wola Wydrzyna, belonging to the above mentioned phytocoenosis of *Tilio-Carpinetum stachyetosum sylvaticae*.

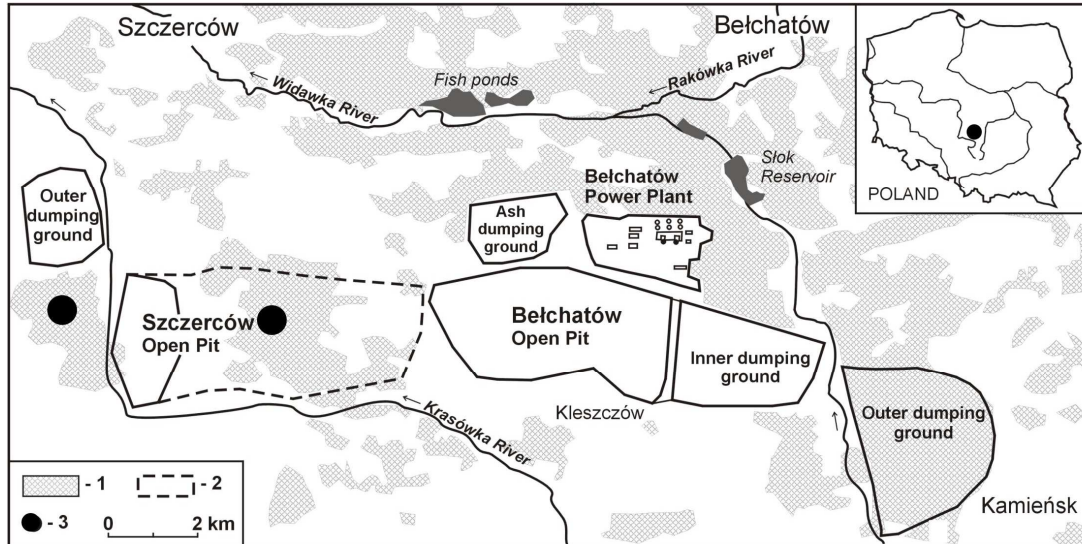


Fig. 1. The vicinity of the Bełchatów Brown Coal Mine (KUROWSKI 2007b, modified) 1 – forests, 2 – future area of the Szczerców Open Pit, 3 – *Dentaria enneaphyllos* stands.

Metaplantation of Drooping Bittercress was conducted in the years 2000–2009, in the phytocoenosis of moist oak-hornbeam forests *Tilio-Carpinetum stachyetosum*. To a secondary stand (forest complex of Kluki near Bełchatów) were transferred 33 soil lumps of *D. enneaphyllos*, amounting to a total area of 6.6 m<sup>2</sup> (Tab. 1).

Table 1. The spread of *Dentaria enneaphyllos* patches over a new territory after metaplantation into the projected Kluki nature reserve.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
The area of transferred soil lumps (m <sup>2</sup> ) in a given year	1.0	0.4	0.6	1.0	1.0	1.0	0.4	0.4	0.4	0.4
The total area of transferred soil lumps (m <sup>2</sup> )	1.0	1.4	2.0	3.0	4.0	5.0	5.4	5.8	6.2	6.6
The size of <i>Dentaria enneaphyllos</i> patches (m <sup>2</sup> ) in the new stand	1.0	0.6	0.7	1.7	2.5	1.4	1.2	1.4	1.8	1.1

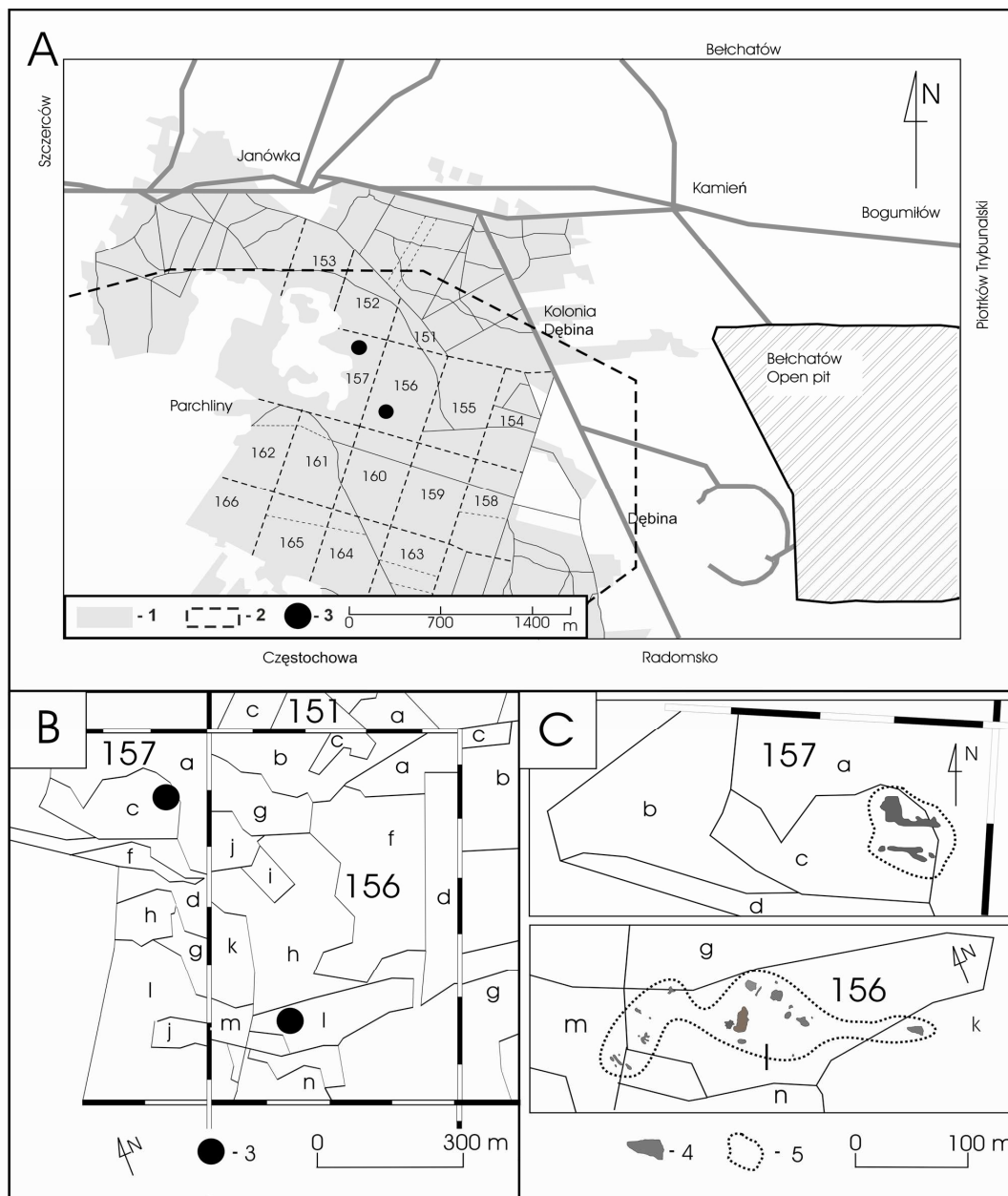


Fig. 2. *Dentaria enneaphyllos* stands in the Wola Wydrzyna. A – localization in forest complex; B – localization in the forest sections; C – distribution of patches; 1 – forests, 2 – future area of the Szczerców Open Pit, 3 – *D. enneaphyllos* stands, 4 – *D. enneaphyllos* patches, 5 – range of *D. enneaphyllos* population.

In 2009 the new territory of *Dentaria enneaphyllos* after metaplantation amounted to ca. 1m<sup>2</sup>. The population numbered 261 individuals (including 49

flowering and 222 sterile ones). On the basis of the yearly monitoring it has been estimated that the new population area oscillates between 1 and 2.5 m<sup>2</sup>. Since 2005, despite yearly transferring of new soil lumps, the population's expanse has not advanced, the area amounting to more or less 1m<sup>2</sup> (Fig. 3). In comparison with the total amount of transferred soil lumps, 20% of *D. enneaphyllos* has been successfully located into its secondary stand (the situation has been stable since 2004). The 2005 transfer of soil lumps of the same size as in the years 2002-2004 did not cause (opposed to the previous transfers) any expanse in the population's area (Fig. 4).

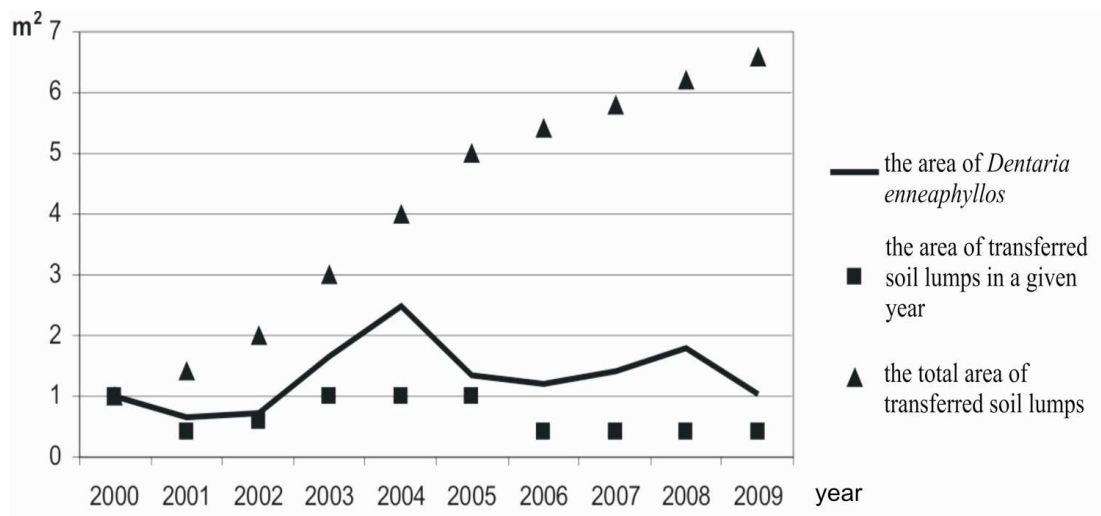


Fig. 3. The dynamics of *Dentaria enneaphyllos* secondary stand after metaplantation in a projected Kluki nature reserve.

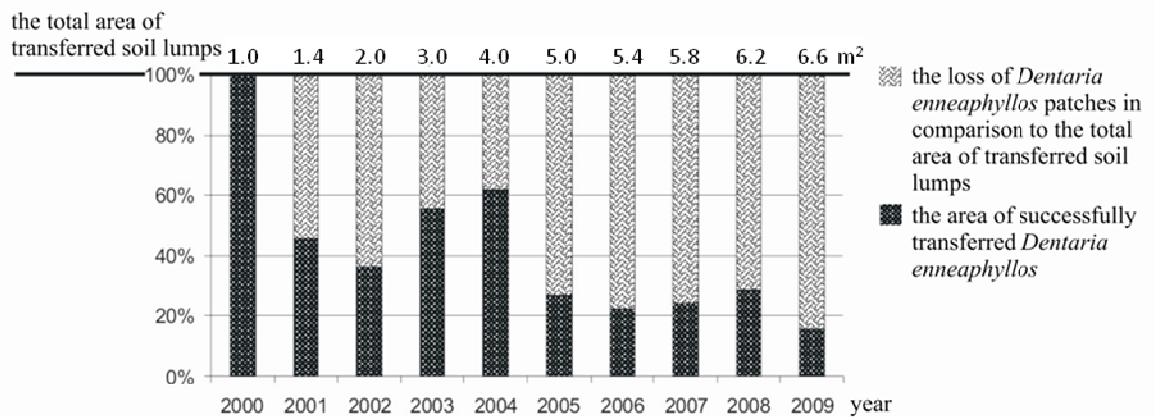


Fig. 4. The percentage of successfully transferred *Dentaria enneaphyllos* area (stable since 2004) in comparison with the total amount of transferred soil lumps.



#### 4. SUMMARY

- The stand of *Dentaria enneaphyllos* in the forest complex of Wola Wydrzyna was first recorded at the end of the 1970s. It took place during investigations carried out by the geobotanists of the University of Łódź (KUROWSKI 1984; JAKUBOWSKA-GABARA 1989). The stand has been monitored on a regular basis ever since. Currently, the species population covers the largest area ever. Throughout the years, the habitat conditions have changed as a result of the area's drainage (KUROWSKI 1993, 2007a, b). Soil moisture in the area deteriorated, peat decay and extinction of hygrophilous plants have been observed. However, those factors have so far facilitated the growth of *D. enneaphyllos* in Wola Wydrzyna. The decision to begin brown coal extraction in the Szczerców Open Pit made it necessary to transfer Drooping Bittercress to new, secondary stands.
- In the projected Kluki nature reserve *Dentaria enneaphyllos* population covers the area of ca. 1m<sup>2</sup>. During the blooming phase particular individuals of the species suffer from the attacks of leaf beetles (*Chrysomelidae*) that feed on their leaves. The leaves also bear signs of animal bites. All the factors contributing to the species shoot destruction severely inhibit its ability of generative reproduction.
- Drooping Bittercress should remain under monitoring, its scope widened *via* investigations on the species ecology in the conditions of Central Poland. A suggestion to investigate the mycorrhizal biota similarity between *Dentaria enneaphyllos* and ash trees *Fraxinus excelsior* has been put forward. The latter occur in the forest complex of Wola Wydrzyna, however they cannot be found in the projected Kluki nature reserve. It has been assumed that ash trees may stimulate *D. enneaphyllos* population growth.
- The positive results of metaplantation are determined by a correlation of local factors. Transferring species to a location with similar habitat conditions is not enough to guarantee the success of the operation. It is much more important to ensure the largest degree possible of similarity between the species native and secondary biocenosis.

- There is a necessity of introducing programmes that would enable transferring selected populations of rare and endangered species away from areas planned for future widespread investigations. Moreover, the future investors should contribute to such actions. Currently, there is no distinction between species covering large areas in a given region and those occupying single, isolated stands. All the instances are approached in the same manner. There is a need for a legal regulation ensuring the protection of the gene pool of species valuable to a given region. It should be done *via* metaplantation to secondary stands, whereas protection issues should be discussed at the very beginning of planning any future investments in a given area.
- In the nearest future there is a need to transfer part of the population *D. enneaphyllos* before it will be annihilated, to another forest complex in vicinity which is similar to the original one.

## 5. REFERENCES

- DĄBROWSKA, K., FRANSZCZAK-BYĆ, M., SAWICKI, R. 1995. Metaplantacja i restytucja *Echium russicum* J. F. Gmel. i *Iris aphylla* L. In: Z. MIREK, J.J. WÓJCICKI (eds), Szata roślinna Polski w procesie przemian. Materiały konferencji i sympozjów 50 Zjazdu Polskiego Towarzystwa Botanicznego. Kraków 26.06-01.07.1995. Polskie Towarzystwo Botaniczne, Oddział Krakowski, Instytut Botaniki im. W. Szafera PAN, Kraków, pp.77.
- DĄBROWSKA, K., SAWICKI, R., CHERNETSKYY, M., KWIATKOWSKI, M. 2011. Ocena efektów wzbogacenia i metaplantacji wielosiętu błękitnego *Polemonium coeruleum* na Lubelszczyźnie. *Chrońmy Przyr. Ojcz.* 67 (3): 218–223.
- FALIŃSKA, K. 2002. Przewodnik do badań biologii populacji roślin. Wydawnictwo Naukowe PWN, Warszawa.
- JAKUBOWSKA-GABARA, J. 1989. Nowe stanowiska interesujących gatunków roślin naczyniowych w Bełchatowskim Okręgu Przemysłowym oraz ich zagrożenie pod wpływem oddziaływania inwestycji górnictwo-energetycznej. *Fragm. Flor. Geobot.* 34 (1-2): 53–73.

- JAKUBOWSKA-GABARA, J., KUCHARSKI, L. 1999. Ginące i zagrożone gatunki flory naczyniowej zbiorowisk naturalnych i półnaturalnych Polski Środkowej. *Fragm. Flor. Geobot. Polonica* 6: 55–74.
- JERMACZEK, A. 2007. Przesadziliśmy. *Bociek. Biuletyn Klubu Przyrodników* 91 (3): 8–11.
- KAMIŃSKI, R. 1995. Reintrodukcja *Aldrovanda vesiculosa* L. na Pojezierzu Łęczyńsko-Włodawskim. *Acta Univ. Wratislaviensis. Pr. Bot.* 67: 157–166.
- KIEDRZYŃSKI, M. 2000. Nowe stanowiska żywca dziewięciolistnego *Dentaria enneaphyllos* i wrońca widlastego *Huperzia selago* w Spalskim Parku Krajobrazowym. *Chrońmy Przyr. Ojcz.* 56 (6): 133–136.
- KIEDRZYŃSKI, M., KUROWSKI, J.K. 2011. *Dentaria enneaphyllos* L. Żywiec dziewięciolistny. In: R. OLACZEK (ed.), *Czerwona księga roślin województwa łódzkiego. Zagrożone rośliny naczyniowe. Zagrożone zbiorowiska roślinne*. Ogród Botaniczny w Łodzi, Uniwersytet Łódzki. Łódź, pp. 80–81.
- KLASA, A. 1991. Gatunki introdukowane do Ojcowskiego Parku Narodowego w ostatnim dwudziestoleciu. *Chrońmy Przyr. Ojcz.* 47 (1-2): 19–27.
- KRASICKA-KORCZYŃSKA, E., KORCZYŃSKI, M. 2007. Metaplantacje kukułki krwistej *Dactylorhiza incarnata* (L.) Soo. z obszaru zainteresowania. *Ekologia i Technika* 15 (4): 127–130.
- KUROWSKI, J.K. 1984. Sieć stałych powierzchni badawczych w lasach Bełchatowskiego Okręgu Przemysłowego. *Prace Inst. Bad. Leśn.* 631: 3–22.
- KUROWSKI, J.K. 1993. Dynamika fitocenoz leśnych w rejonie kopalni odkrywkowej Bełchatów. Wydawnictwo Uniwersytetu Łódzkiego, Łódź.
- KUROWSKI, J. K. 2004. Metaplantacja zimoziołu północnego *Linnaea borealis* L. w rezerwacie Jaksonek w Polsce Środkowej. *Chrońmy Przyr. Ojcz.* 60 (4): 5–16.
- KUROWSKI, J.K. 2007a. Procesy syndynamiczne w zbiorowiskach leśnych wywołane odwodnieniem siedlisk. *Leśne Prace Badawcze* 2: 27–44.
- KUROWSKI, J.K. 2007b. Xerophytisation of marsh forests in the vicinity of an open pit brown coal mine in Central Poland. *Ekologia (Bratislava)*. 26 (3): 282–294.
- KWIATKOWSKA, A., 2001. *Cochlearia polonica* Fröhlich Warzucha polska. In: R. KAŹMIERCZAKOWA, K. ZARZYCKI (eds) *Polska Czerwona Księga Roślin*.

- Paprotniki i rośliny kwiatowe. PAN, Instytut Botaniki im. W. Szafera, Instytut Ochrony Przyrody, Kraków, pp. 166–167.
- ŁUKASIEWICZ, A. 1984. Metodyka prac nad zachowaniem gatunków rzadkich i ginących, stosowana w Ogrodzie Botanicznym UAM w Poznaniu. *Wiad. Bot.* 28 (2): 165–168.
- MATUSZKIEWICZ, W. 2007. Przewodnik do oznaczania zbiorowisk roślinnych Polski. Wydawnictwo Naukowe PWN, Warszawa.
- OLACZEK, R. 1978. Chronione i rzadkie składniki flory dorzecza Pilicy. In: A. S. KLECZKOWSKI (ed.), *Wartości środowiska przyrodniczego dorzecza Pilicy i zagadnienia jego ochrony*. *Studia Ośr. Dok. Fizjogr. T. VI*. PAN, Kraków, pp. 160–180.
- OLACZEK, R. 1986. Projekt zasad metaplantacji, czyli ochrony zasobów genowych roślin w warunkach naturalnych *ex situ*. 47 Zjazd Polskiego Towarzystwa Botanicznego, Łódź, 3–6 IX 1986 r.
- PAWLACZYK, P., JERMACZEK, A. 2008. Metaplantacja i jej niebezpieczeństwa. In: P. PAWLACZYK, A. JERMACZEK (eds), *Poradnik lokalnej ochrony przyrody*. Wydawnictwo Klubu Przyrodników, Świebodzin, pp. 273–274.
- RUTKOWSKI, L. 2006. Klucz do oznaczania roślin naczyniowych Polski niżowej. Wydawnictwo Naukowe PWN, Warszawa.
- SZAFER, W., KULCZYŃSKI, S., PAWŁOWSKI, B. 1988. *Rośliny polskie. Opisy i klucze do oznaczania wszystkich gatunków roślin naczyniowych rosnących w Polsce bądź dziko, bądź też zdiczałych lub częściej hodowanych*. Część I i II. PWN, Warszawa.
- TESKE, E. 1992. Problemy związane z ochroną gatunków roślin rzadkich i zagrożonych prowadzoną w warunkach *ex situ*. *Chrońmy Przyr. Ojcz.* 48 (5): 18–24.
- WĘGLARSKI, K., JAŃCZYK-WĘGLARSKA, J. 2000. Aktywna ochrona gatunku zagrożonego wymarciem na przykładzie *Dianthus gratianopolitanus* Vill. z rezerwatu „Goździk siny w Grzybnie” (woj. wielkopolskie). *Bad. Fizjogr. Pol. Zach. B.* 49: 157–172.

- WITOSŁAWSKI, P. 2004. Stanowisko zastępcze zimoziołu północnego *Linnaea borealis* w rezerwacie Jawora, Chrońmy Przyr. Ojcz. 60 (2): 105–107.
- ZAJĄC, M. 1996. Mountain vascular plants in the polish lowlands. Polish Bot. Stud. 11: 1–92.
- ZAJĄC, A., ZAJĄC, M. 2001. Atlas rozmieszczenia roślin naczyniowych w Polsce. Nakładem Pracowni Chorologii Komputerowej Instytutu Botaniki Uniwersytetu Jagiellońskiego, Kraków.
- ŻÓŁKOŚ, K., AFRANOWICZ, R., BLOCH-ORŁOWSKA, J., MINASIEWICZ, J. 2010. Problems of metaplantation of protected species – a case study of Sea Holly (*Eryngium maritimum* L.) and Dark Red Helleborine (*Epipactis atrorubens* (Hoffm.) Besser). Baltic Coastal Zone 14:17–23.