Steciana

2018, Vol. 22(4): 211–216
doi:10.12657/steciana.022.025

www.up.poznan.pl/steciana

ISSN 1689-653X

RESOURCES OF DEAD WOOD ON SURFACES FOR LONG-TERM RESEARCH IN THE KAMPINOS NATIONAL PARK

Karol Torzewski, Anna Otręba

K. Torzewski, Department of Ecology, Biogeochemistry and Environmental Protection, University of Wrocław, Kanonia 6/8, 50-328 Wrocław, Poland, e-mail: karol.torzewski@uwr.edu.pl
A. Otręba, Forest farm in Julinek, Kampinos National Park, Polna 37, 05-084 Leszno, Poland, e-mail: aotreba@kampinoski-pn.gov.pl

(Received: November 27, 2018. Accepted: December 28, 2018)

Abstract. The research covered 46 areas (each 400 sq.m) located in nine regions of the Kampinos National Park. This research is the result of field work carried out three times in years: 2007, 2012 and 2018. Dead wood measurements are one of the elements of testing on solid surfaces, which also includes vegetation, soil and stand.
The average dead wood content in the Kampinos National Park over the past 11 years on long-term surfaces increased by 53% (from averages 35.59 m^3/ha in 2007 to 54.37 m^3/ha in 2018). Areas located in strictly protected zones showed greater abundance of dead wood in relation to the surface in active protection, and this difference is significant. On the surfaces covered by both forms of protection, during 11 years of research an increase in dead wood resources was noted, but only in areas covered by active protection it was statistically significant. In terms of the type of stand, oak stands with the average thickness of standing and lying wood in 2018 amounting to 110.70 m^3/ha are the richest in dead wood, and the poorest pine stands with an average of 20.07 m^3/ha. The results obtained on solid surfaces indicate a much greater richness of dead wood in the forests of the Kampinos National Park compared to the lowland state forests. However, due to the relatively small number of areas covered by the study, this work contributes to the knowledge of dead wood resources in this area and does not exhaust the need for a complete inventory.

Key words: dead wood, Kampinos National Park, long-term research, strict and active protection

INTRODUCTION

The temperate deciduous forests are one of the most disturbed and threatened ecosystems in the world (Peterken 1996). Contemporary intensive forest management has dramatically changed the structure of such forests in Europe (Heliövaara & Väisänen 1984, Kirby et al. 1991, Miko & Hošek 2009). As a result, the number of natural or semi-natural temperate zone forests has fallen sharply (Andersson & Löfgren 2000, Nilsson et al. 2001). One of the most important changes is the decrease in the amount of dead wood, both inside and outside the reserves (Fridman & Walheim 2000). Dead wood is essential for biodiversity and ecosystem services (Harmon et al. 1986). Fallen dead wood ensures regeneration of the forest in a cool boreal and mountain climate (Takahashi et al. 2000). It can also act as an important element that accumulates water in the dry season (Maser & Trappe 1984), as well as store nutrients in the long term ensuring continuous supply of organic substances in the process of humification (Harmon et al. 1986). In addition, dead wood is the living environment for many species of fungi (Renvall et al. 1991), mosses (Andersson & Hytteborn 1991) and invertebrates (Palm 1955). In forests, dead wood occurs in the form of standing, broken or felled trees, as well as branches and pieces of bark lying on the ground, as well as roots, carp and stumps (Harmon et al. 1986). In addition, dead wood appears in the forest both as a result of competition between trees and as a result of biotic-induced disorders (Harmon et al. 1986, Stevens 1997). Knowledge of dead wood and its biology is therefore needed as part of ongoing programs to protect and restore temperate forests. Most of the existing literature on dead wood relates to the boreal zone, where productivity is lower and where conifers dominate (Nilsson et al. 2002). The Kampinos Forest due to its location at the confluence of three large rivers and the vicinity of Warsaw, has been transformed by man for centuries. Thanks to the establishment of the first "Granica" and "Sieraków" reserves in the 1930s, and in 1959 the creation of a national park, it was possible to preserve the remains of the former forest. The Kampinos National Park is the second largest national park in Poland. It covers the historical areas of the Kampinos Forest, reaches north on the right bank of the Vistula River, south covers a fragment of the Łowicz-Błońsk Plain. The cultural and natural values of this area were the basis for the creation of the UNESCO MaB "Puszcza Kampinoska" in 2000. Due to the richness of species and the occurrence of valuable natural habitats, the main park complex has been included in the European Ecological Network Natura 2000 (PLC 140001).

Contemporary vegetation of the Kampinos National Park is the effect of geographical location, environmental conditions and anthropopressure. The location of the area decided on a relatively poor species composition of dominant trees in forest communities, limited in this case to Scots pine, pedunculate and sessile oak, black alder, silver birch and mossy birch. The forest lies in the area of spruce dysfunction, out of reach of fir and beech (Matuszkiewicz 2003).

In terms of the area occupied, the Kampinos National Park is dominated by forests (about 73% of the park's area), representing all 21 complexes in the central part of the Polish Lowland. Scots pine *Pinus sylvestris* is currently the most abundant species in the stands of the Kampinos forest. This is due to natural factors – geographical location and geomorphology of the area, but is also the result of past forest management. According to the current inventory, this species prevails on 69% of the forest area, i.e. 18.5 thousand ha (Operat... 2002). Among pine stands, 1/5 has reached over 100 years, and among alder 1/3 it has reached over 60 years. In the Kampinos National Park, mature stands form compact complexes, while younger ones are most often found in mosaics with non-forest communities. Currently, strict protection is implemented in 22 areas, on a total area of 4.6 thousand ha, which is 12% of the park area. Despite the dominance of forests in the vegetation of the Kampinos National Park, relatively little research is devoted to stands.

The aim of the study was to learn about the transformation of dead wood resources over 11 years depending on the type and age of the stands and the method of protection.

MATERIAL AND METHODS

The research covered 46 research areas located in nine regions of the Kampinos National Park. This research is the result of field work on surfaces for long-term testing carried out in 2018. It was the third entry with stand measurements, the previous two cycles took place in 2007 and 2012. Dead wood measurements in one of the elements of research on solid surfaces, which also include vegetation, soil and stand (Ferchmin et al. 2002, Czępińska-Kamińska et al. 2007, Otręba & Torzewski 2012).

Dead wood was measured using the surface method, strictly referring to the limits of the 4-ares (20 m × 20 m) long-term surfaces, which corners are permanently marked in the field. Dead standing trees (whole and broken), which DBH in the bark exceeded 7 cm, were measured, in accordance with generally accepted standards for thicknesses (Czerepko et al. 2008, Jabłoński et al. 2014). Species were determined for standing dead trees, the DBH was measured in two directions using a calipers and height using a Sunnto altimeter. Measuring was lying wood, half of which was at least 5 cm thick and 0.5 m long. Length was measured with tape with an accuracy of 0.1 m, and thickness in one direction with a diameter gauge with an accuracy of 0.1 cm (or 0.5 cm for classes with advanced distribution). The position of standing trees and deadwood was plotted. Calculation of the thickness of dead trees standing according to the Denzin formula, whereas dead lying wood was calculated from the middle section formula (Bruchwald 1999). Obtained thicknesses of dead wood on individual surfaces were converted into 1 ha.

For the purposes of the analysis, distinguished groups of surfaces characterised:

- type of stand (according to the dominant species),
- group of age of the stand (according to data from the forest management survey, as of 2018). Stands representing the generally accepted age management in forest management, due to the insufficient number of areas, were combined into three groups of form of protection (active and strict): 1 group – stands of I, II and III age classes (< 60 years), 2 group – stands of IV, V, VI class age (60–120 years), 3rd group – stands from VII to XI age class (> 120 years).

Among of the long-term surfaces, pine (19 areas) and alder (12 areas) stands dominated, oak and birch stands constituted 33% of the total (Fig. 1). Among the pine stands, a significant part represents pine forests with varying degrees of fertility and humidity (12 plots), moreover in one plot high-forest oak-hornbeam was found, and for other species of undergrowth indicate belonging to the classes of non-forest vegetation: *Koelerio-Corynephoretea* (4 area), *Nardo-Callunetea* (1 area), *Phragmitetea* (1 area) (Solon & Zaniewski 2018). Alder stands represent typical

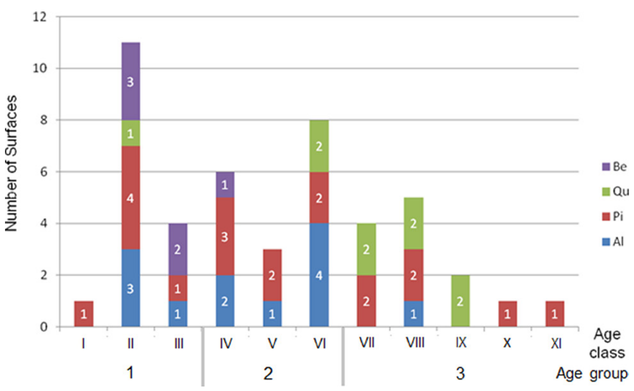

Fig. 1. Share of dominant species in stands on monitoring plots broken down by age classes
Stand of trees: Be – *Betula pendula*, Qu – *Quercus robur*, Pi – *Pinus sylvestris*, Al – *Alnus glutinosa*.
Age group: 1 – < 60 years, 2 – 60–120 years, 3 – > 120 years.

alder *Ribeso nigri-Alnetum* (5 plots), riparian communities from the *Alno-Ulmion* compound (3 plots), low oak-hornbeam *Tilio-Carpinetum stachyetosum sylvaticae* (1 plot) and succession stages classified as *Magnocaricion* (3 plots) area. The oak stands are oak-hornbeam *Tilio-Carpinetum* with varying degrees of fertility, and in one case the *Fraxino-Alnetum* alder-ash forest bed. In the case of birch stands, only one area represents a typical forest community – wet mixed forest *Querco-Pinetum molinietosum*, the others are successive stages in wet habitats – *Magnocaricion* or dry habitat – *Koelerio-Corynephoretea* class or *Nardo-Callunetea* class.

The stands on the research plots varied in age, from the youngest belonging to the 1st century class to over 200 years old from the 11th century. Stands represented by the II age class (26%) and class VI (17%) were the most numerous, other age classes did not exceed 10% of the total (Fig. 1).

The differences in the tested elements were developed using statistical methods, using the Statistica 13.1 program. The normality of the distribution of the analysed elements was also checked by the Shapiro-Wilk test, the homogeneity of variance was checked by the Brown-Forsyth test. The Friedman test was used to investigate the diversity of the above-discussed mean values between test cycles. To assess the significance of differences between the two forms of protection used Mann-Whitney U tests.

RESULTS

Dead wood resources on 46 long-term surfaces of the Kampinos National Park averaged (lying + standing) 35.59 m^3/ha in 2007 and 54.37 m^3/ha in 2018, which is an increase of 53% compared to the beginning of measurements. The amount of dead wood lying increased by 120% and averaged 12.60 m^3/ha in 2007 and 26.69 m^3/ha in 2018. The resources of dead wood standing increased by 20% (22.99 m^3/ha in 2007 and 27.68 m^3/ha in 2018). Areas located in strictly protected zones showed greater abundance of dead wood in relation to the surface in active protection, and this difference is significant ($p = 0.008$ in 2007; $p = 0.002$ in 2018). Volume of dead wood in strictly protected areas, increased of 41%, On average, in 2007, the volume amounted to 61.76 m^3/ha, and 87.18 m^3/ha 2018 on these surfaces. The amount of dead wood in areas under active protection increased by 110% and amounted to 11.59 m^3/ha in 2007 and 24.30 m^3/ha on average (Table 1). As a result of statistical tests, significant differences were found in the amount of dead wood in 2007–2018 on areas under active protection ($p = 0.01$). However, the amount of dead wood in 2007–2018 in strict protection is not significantly differentiated ($p = 0.64$). Analysing dead wood lying in 2007–2018 in relation to the forms of protection used, both the areas covered by active protection ($p = 0.003$) and strict ($p = 0.004$) are significantly differentiated. In the case of dead wood standing in both active ($p = 0.076$) and strict ($p = 0.873$) protection, the data are not significantly differentiated.

In terms of the type of stand, the most abundant in dead wood are stands classified as oak. The average volume in 2007 was 85.09 m^3/ha and increased over the years by 30% compared to the beginning of measurements. The poorest are the pine stands, the average amount of dead wood from all cycles is 17.88 m^3/ha. The largest fluctuations in the abundance of dead wood were recorded in stands with the dominance of birch, over 11 years there was an increase by over 18 times from 4.03 m^3/ha to 72.94 m^3/ha in 2018. As a result of statistical tests, the amount of dead wood in 2007–2018 in relation to the type of stand is significantly differentiated only in stands with the dominance of birch ($p = 0.049$, Table 2). Among all age

Table 1. Summary information on average resources of dead wood (m^3/ha) on the studied surfaces

Form of protection	N	2007		2012		2018	
		lying	standing	lying	standing	lying	standing
Active	24	4.55	7.05	4.42	6.14	7.78	16.52
Strict	22	21.38	40.38	22.39	39.46	47.32	39.86
Sum	46	12.60	22.99	13.01	22.08	26.69	27.68
Dead wood (lying and standing)							
Active	24	11.59		10.57		24.30	
Strict	22	61.76		61.85		87.18	
Sum	46	35.59		35.09		54.37	

Table 2. Summary information on average dead wood (m^3/ha) resources depending on the type of tree stand

Tree stand	N	2007			2012			2018			p
		min.	max.	average	min.	max.	average	min.	max.	average	
Al	12	0.00	184.18	41.58	0.00	164.29	41.81	0.00	137.48	57.17	0.306
Pi	19	0.00	118.15	18.32	0.00	79.01	15.24	0.00	69.49	20.07	0.181
Qu	9	1.69	375.08	85.09	2.45	349.56	81.75	1.04	327.55	110.70	0.235
Be	6	0.00	11.93	4.03	0.00	71.09	14.54	0.00	331.85	72.94	0.049

Stand of trees: Al – *Alnus glutinosa*, Be – *Betula pendula*, Qu – *Quercus robur*, Pi – *Pinus sylvestris*.

Table 3. Summary information on average dead wood (m^3/ha) resources depending on age group of stand

Age group	N	2007			2012			2018			p
		min.	max.	average	min.	max.	average	min.	max.	average	
1	15	0.00	22.95	5.48	0.00	47.59	7.56	0.00	103.67	23.81	0.118
2	18	0.15	77.36	27.04	0.00	86.90	32.52	0.22	331.85	62.91	0.032
3	13	0.16	375.08	82.16	1.28	349.56	70.41	1.04	327.55	77.82	0.053

Age group: 1 – < 60 years old, 2 – 60–120 years old, 3 – > 120 years old.

groups, the most abundant in dead wood are stands above 120 years (3rd group), in which the average resources from the three testing cycles amounted to 76.80 m^3/ha. In contrast to the other two groups, these stands recorded a slight decrease (5%) of dead wood resources during 11 years of research. In the middle ages stands (60–120 years, group 2), within 11 years an increase in the amount of standing and lying wood was found by 133%, and this difference was statistically significant (Table 3).

DISCUSSION

The estimation of dead wood resources in forest ecosystems depends on many factors. The occurrence of dead organic matter in the forest is primarily affected by the potential of the forest, stand characteristics and habitat features including humidity and type of use such as conservation status (Harmon et al. 1986, Wolski 2003, Bujoczek 2012). Dead wood is an element found in huge quantities in natural forests. Nilsson et al. (2002) estimate that before the expansion of man, there was an average of 130–150 m^3/ha in European forests. Others, on the other hand, report values reaching almost 275 m^3/ha (Dudley & Vallauri 2004). In Polish national parks, the amount of dead wood was estimated at 37.4 m^3/ha in 2010–2014 and at 45.0 m^3/ha in 2014–2018 (Wielkoobszarowa inwentaryzacja… 2015, 2019). According to recent research, there are 84.5 m^3/ha of dead wood in the forests of the Białowieża National Park, and in nature reserves in this complex as much as 98.4 m^3/ha, with about half falling on Norway spruce (Kuberski & Paluch 2016). In the State Forests, dead wood resources are at a much lower level, which was 5.5 m^3/ha on average, and after four years increased to 7.5 m^3/ha. Lowland forests located in central Poland are particularly poor in this respect. In the most common pine stands in Poland, there can be about 2–5 m^3/ha (Holeksa & Maciejewski 2006). Slightly higher, because at the level of 14 m^3/ha, dead wood resources were found in the muncipial forests in Warsaw (Skwarek & Bijak 2015). Against this background, the forests of the Kampinos National Park with average standing and lying dead wood resources at level 54 in 2018, 4 m^3/ ha seems to be very rich in this respect. Particularly a lot of dead standing and lying wood was recorded in strict protection areas (on average 87.2 m^3/ha in 2018), which is consistent with the results obtained in five stands in KNP by Tyburski (2019). It is worth noting that during 11 years of research the difference in dead wood resources between strictly protected and active protected areas has decreased. While in 2007 there were 6 times more dead wood in strict protection areas than in active protection areas, in 2018 only 3 times more (Table 1). It seems that the significant increase in dead wood resources recorded in protected areas is an active effect of both leaving a greater dry mass in recent years and the result of local disturbances – flooding or windbreaks. Particularly dynamic growth of dead matter was noted in birch stands. Most of the area with this species is located on swampy belts, where in recent years local flooding has occurred due to increased rainfall or small retention measures. Their consequence was the dying of young, descending from the succession of birchwood.

The largest dead wood resources, with an average exceeding 85 m^3/ha at the beginning of the study, were recorded in stands with oak dominance. Apart from one area, they were over 100 years old oak-hornbeam forests, which have been under strict protection for decades, which guaranteed the systematic growth of dead wood in these stands. Similarly, in the urban forests of Warsaw, the largest amounts of dead wood were recorded in forest habitats (Skwarek & Bijak 2015). Pine stands proved to be relatively the poorest in the resources of dead wood, for the most part pine forests under active protection. This is due to the ecology of the species, but also to the removal of individual dead trees that separated during the development of the stand.

Comparison of the obtained results with other areas is burdened with an error resulting from methodological differences in measurements and calculating the thickness between individual inventories. Therefore, when compiling the results one should take into account the order of magnitude and not the detailed result.

Due to the large diversity of the studied areas in terms of age and species composition, and a relatively small sample for such a vast forest complex (random, unevenly distributed in this area), as for the needs of stand research, the obtained results do not entitle to generalizations regarding the resources of dead wood in the entire Kampinos National Park. The performed research is only a contribution to the knowledge of dead wood resources in the Kampinos National Park, and not to fill the gap in this respect. The strength of these measurements is the fact that they are carried out on solid surfaces and are part of interdisciplinary research. This allows the obtained results to be combined with studies of vegetation and soil, and to track the transformation of dead wood resources over time.

ACKNOWLEDGEMENTS

The research was carried out under the project "Długoterminowe badania ekosystemów leśnych na 52 stałych powierzchniach – czwarte powtórzenie" (contract number EZ.0290.1.11.2018, action No. 7) co-financed by the PGL LP Fundusz Leśny in 2018.

REFERENCES

Andersson L.I., Hytteborn H. (1991): Bryophytes and decaying wood: a comparison between manager and natural forest. Holarctic Ecology 14(2): 121–130.

Andersson L., Löfgren R. (2000): Sydsvenska lövskogar och andra lövbärande marker: kriterier för naturvärdering, skydd och skötsel. Swedish Environmental Protection Agency, Stockholm.

Bruchwald A. (1999): Dendrometria. Wydawnictwo SGGW, Warszawa.

Ciach M. (2011): Martwe i zamierające drzewa w ekosystemie leśnym – ilość, jakość i zróżnicowanie. Studia i Materiały CEPL w Rogowie 27: 186–199.

Czerepko J., Hilszański J., Jabłoński M. (2014): Martwe drewno – żywy problem. Studia i Materiały CEPL w Rogowie, SGGW 41: 36–45.

Czępińska-Kamińska D., Ferchmin M., Kania J., Kondras M., Maciejewska A., Majcher H., Markowski M., Otręba A. (2007): Monitoring zbiorowisk leśnych Kampinoskiego Parku Narodowego. Vol. 1. Raport z prac wykonanych w 2007 roku. Typescript. Kampinoski Park Narodowy, Warszawa–Izabelin.

Dudley N., Vallauri D. (2004): Deadwood – living forests. World Wildlife Fund for Nature, Gland, Switzerland.

Ferchmin M., Markowski M., Solon J. (2002): Monitoring zbiorowisk leśnych Kampinoskiego Parku Narodowego. Raport z prac wykonanych w 2001 r. Typescript. Biuro Urządzania Lasu i Geodezji Leśnej, Warszawa.

Fridman J., Walheim M. (2000): Amount, structure, and dynamics of dead wood on managed forestland in Sweden. Forest Ecology and Management 131(1–3): 23–36.

Harmon M.E., Franklin J.F., Swanson F.J., Sollins P., Gregory S.V., Lattin J.D., Anderson N.H., Cline S.P., Aumen N.G., Sedell J.R., Lienkaemper G.W., Cromack K., Cummins K.W. (1986): Ecology of coarse woody debris in temperate ecosystems. Advances in Ecological Research 15: 133–302.

Heliövaara K., Väisänen R. (1984): Effects of modern forestry on northwestern European forest invertebrates: a synthesis. Acta Forestalia Fennica 189: 1–32.

Holeksa J., Maciejewski Z. (2006): Martwe drzewa i ich rola w ekosystemie leśnym. Roztoczańskie Spotkania 6: 61–74.

Jabłoński M., Budniak P., Lech P., Broda J., Neroj B., Zajączkowski S. (2014): Instrukcja wykonania wielkoobszarowej inwentaryzacji stanu lasu. Instytut Badawczy Leśnictwa, Sękocin Stary.

Kirby K.J., Webster S.D., Antczak A. (1991): Effects of forest management and stand structure and the quantity of fallen dead wood: some British and Polish examples. Forest Ecology and Management 43(1–2): 167–174.

Kuberski Ł., Paluch R. (2016): Martwe drewno w polskiej części Puszczy Białowieskiej. Ilość i struktura zasobów na podstawie pomiarów na naziemnych powierzchniach monitoringowych LIFE+ ForBioSensingPL w roku 2015. I Konferencja Naukowa pt. „Aktualny stan Puszczy Białowieskiej na podstawie wstępnych wyników projektu Life+ ForBioSensing", Białowieża 30.11–2.12.2016 r. Presentation http://www.forbiosensing.pl.

Maser C., Trappe J.M. (1984): Seen and unseen world of the fallen tree. The Bark Beetles, Fuels, and Fire Bibliography. Pacific Northwest Forest and Range Experiment Station U.S. Department of Agriculture Forest Service General Technical Report PNW-164.

Matuszkiewicz W. (2003): Charakterystyka Puszczy Kampinoskiej na tle geobotanicznego podziału Polski. In: R. Andrzejewski (ed.). Kampinoski Park Narodowy. Vol. 1. Przyroda. Centrum Edukacji, Izabelin: 2017–2227.

Miko L., Hošek M. (2009): State of nature and landscape in the Czech Republic – Report Agency for Nature Conservation and Landscape Protection of the Czech Republik, Prague.

Nilsson S.G., Hedin J., Niklasson M. (2001): Biodiversity and its assessment in boreal and nemoral forests. Scandinavian Journal of Forest Research 16(3): 10–26.

Nilsson S.G.M., Niklasson J., Hedin G., Aronsson J.M., Gutowski P., Linder H., Ljungberg G., Mikusinski-Ranius T. (2002): Densities of large living and dead trees in old-growth temperate and boreal forests. Forest Ecology and Management 161: 189–204.

Nilsson S.G., Niklasson M., Hedin J., Aronsson G., Gutowski J.M., Linder P., Håkan L., Mikosiński G., Ranius T. (2003): Erratum to "Densities of large living and dead trees in old-growth temperate and boreal forests". Forest Ecology and Management 178(3): 355–370.

Operat ochrony ekosystemów leśnych KPN na okres 01.01.2002 r.-31.12.2021 r. Typescript. Biuro Urządzania Lasu i Geodezji Leśnej, Warszawa.

Otręba A., Torzewski K. (2012): Trzeci cykl badań ekosystemów leśnych na 52 stałych powierzchniach w Kampinoskim Parku Narodowy. Zestawienie wyników z prac wykonanych w 2012 r. Vol. 3. Drzewostany. Typescript. Kampinoski Park Narodowy, Warszawa–Izabelin.

Palm T. (1955): Die Holz-und Rinden-Käfer der süd- und mittelschwedischen Laubbäume. Opuscula Entomologica. Suppl. Entomologiska Sällskapet 26, pp. 552.

Peterken G.F. (1996): Natural woodland – ecology and conservation in northern temperate regions. Cambridge University Press, Cambridge.

Renvall P., Renvall T., Niemelä T. (1991): Basidiomycetes at the timberline in Lapland, 1. Introduction. Karstenia 31(1): 1–12.

Skwarek K., Bijak S. (2015): Zasoby martwego drewna w lasach miejskich Warszawy. Leśne Prace Badawcze 76(4): 322–330.

Stevens V. (1997): The ecological role of coarse woody debris: an overview of the ecological importance of CWD in BC forests. British Columbia, Ministry of Forests, Research Program. Working Paper 30.

Takahashi M., Sakai Y., Ootomo R., Shiozaki M. (2000): Establishment of tree seedlings and water-soluble nutrients in coarse woody debris in an old-growth Picea-Abies forest in Hokkaido, northern Japan. Canadian Journal of Forest Research 30(7): 1148–1155.

Tyburski Ł. (2019): Martwe drewno w starodrzewach sosnowych Kampinoskiego Parku Narodowego. Przegląd Leśniczy 6–7: 20–21.

Wielkoobszarowa inwentaryzacja stanu lasu. Wyniki 2. Cyklu. (2015). Oficyna Wydawnicza Forest, Sękocin Stary.

Wielkoobszarowa inwentaryzacja lasu – wyniki za okres 2014–2018. Etap 2.5.1.b. (2019). Biuro Urządzania Lasu i Geodezji Leśnej, Sękocin Stary.

Wolski J. (2003): Martwe drewno w lesie: ocena zapasu i propozycje postępowania. Prace Instytutu Badawczego Leśnictwa, Seria A 2(953): 23–45.

For citation: Torzewski K., Otręba A. (2018): Resources of dead wood on surfaces for long-term research in the Kampinos National Park. Steciana 22, 4: 211–216. doi: 10.12657/steciana.022.025