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The impact of agricultural land afforestation on air temperatures near the surface

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Abstract: Many studies showed that afforestation increases carbon storage and it can have effects on physical, chemical and biological properties of soil. Afforestation can affect local and regional climate and these effects differ between tropical, temperate and boreal areas. Forests are also efficient in protecting soils against erosion and their flood mitigation functions or other benefits are described in different publications. In this study, the pattern of air temperatures (20 cm, 40 cm and 60 cm above the surface) was studied 10 years after the afforestation of agricultural land (warm, mild dry region of the Czech Republic) with a mixture of broadleaved tree species (*Quercus robur* L., *Quercus rubra* L. and *Acer platanoides* L.) or monospecific *Pinus sylvestris* L. stand. The aim of our study was to find out the pattern of air temperatures (20 cm, 40 cm and 60 cm above the surface) on two plots (one of the plots – old beech trees, the other plot – clearing) in a beech (*Fagus sylvatica* L.) forest in a mildly warm, mildly wet region of the Czech Republic. The afforestation of agriculturally used land led to air temperature cooling and to a reduction of the amplitude of maximum and minimum temperatures. The average air temperature (from April 2021 to the beginning of November 2021) decreased by 0.7–1.1 °C on the afforested plots compared with the agriculturally used plot. In the beech forest, the average temperature decreased on the plot with clearing compared with the old beech trees (from the middle of September 2021 to the middle of November 2021). Our results confirm the benefits of afforestation to climate change mitigation; buffering of extreme temperatures is important for the human thermal comfort.

Keywords: air temperature variations; climate; conifers; European beech; Scots pine; vegetation cover

In the Czech Republic, afforestation of agricultural land has been supported by providing subsidies from the government and the European Union (Ministry of Agriculture of the Czech Republic 2018). Different reasons for afforestation of agricultural land, criteria (and identified areas in the Czech Republic), suitability of forest tree species or wood quality are described in the publication by Vopravil et al. (2021a) and in the publications by Vopravil et al. (2015, 2017), Cukor et al. (2020), Gallo et al. (2020), Vacek et al. (2021a, b). For example, different studies showed that afforestation increases carbon storage and can affect local and regional climate; forests have lower albedos

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than grasses or cultivated crops (e.g. Kirschbaum et al. 2011). For example, the values of albedo for forests (5–20%) or pine and spruce (10–14%), crops – winter wheat, winter barley, winter rapeseed and rye, spring wheat and barley, oats, peas, sunflower, sugar beet, rice etc. (10–25%) or stubble fields (15–17%), grass or different types of grass-clover ley (16–22%) etc. were reported in different publications (Kuusinen et al. 2012; Bakanoğulları et al. 2022; Sieber et al. 2022a, b); Sieber et al. (2022a, b) concluded that barley had the highest albedo from all studied cereals (22%).

Forests are also efficient in protecting soils against erosion and their flood mitigation function was also described (Gomyo, Kuraji 2016); the effect of afforestation on soil erosion is described in different publications (Chirino et al. 2001; Porto et al. 2009; Romero-Diaz et al. 2010; Xu et al. 2019). Rainfall interception ratios differ according to forest tree species etc. (Poleno et al. 2011); litter cover influences infiltration rates and it was described that vegetation litter mostly prevents overland flow etc. Forest cover types were reported to influence runoff and its components – surface runoff, interflow and groundwater flow (e.g. Ding et al. 2022).

Effects of agricultural land afforestation on soil properties, hydrological cycles (e.g. different effects on rainfall interception, transpiration) are also described in different publications; vegetation litter (or grazing) and harvesting of forests etc. were found to influence soil temperatures and forest tree species litter can protect soils from frosts (e.g. Jackson et al. 2005; Ilsted et al. 2007; Kupka, Podrázský 2010; Holubík et al. 2014; Vopravil et al. 2014, 2021a, b; Yao et al. 2016; Jia et al. 2017; Hrabovský et al. 2020). For the vegetation season, Bedrna (1977) reported higher soil temperatures in the fields and meadows compared with forests. Effects of mulching, soil types etc. on soil temperature are described in different publications (Allmaras et al. 1964; Li et al. 2021). Yang et al. (2021) studied the effect of cover crops on soil temperature at depths of 15 cm, 30 cm, 45 cm and 60 cm. Song et al. (2013) observed a reduction in the vegetation cover at increased soil temperatures of grasslands (due to decreased shading of the ground). Also, Poleno et al. (2011) found out lower average annual temperatures of the soil surface in forests compared with fields. Coutts (1955) studied soil temperature (at depths of 1 inch, 6 inches, 12 inches and 18 inches which corresponded with the boundaries of natural horizons) and air temperature (4 ft above ground) – afforestation with conifers (8 to 10 ft high). For example, the author showed the weekly true mean temperatures. At a depth of 1 inch, the author found values below 0 °C in January–April and November–December. The author gave an example of the rain storm which caused a decreased soil temperature (0.9–2.7 °C) at depths of 1 inch and 6 inches; the author also described the efficiency of spot readings etc. Different effects on the land surface temperature were described in tropical, temperate or boreal forests (Bala et al. 2007); Li et al. (2015) stated that tropical forests have a cooling effect throughout the year and temperate forests (or boreal forests) have a net cooling effect annually (or a net warming effect annually). Lal and Cumming (1979) reported that deforestation of tropical rainforest (in southern Nigeria) increased the value of maximum air temperature by 5–8 °C and the value of maximum soil temperature at a depth of 1 cm by 25 °C. In different publications on soil (and air) temperature, the values are given using different scales including Celsius (°C), Kelvin (K) or Fahrenheit (°F) – see Allmaras et al. (1964), Wang et al. (2018), Jin et al. (2019).

In this study, the effect of agricultural land afforestation (for the period of 10 years) on air temperatures 20–60 cm above the surface (the period from April to the beginning of November 2021) was determined in the conditions of Czech Republic. We also attempted to determine differences in air temperatures (20–60 cm above the surface) between two plots in a beech forest (one of the plots = old beech trees, the other plot = clearing) in the period from the middle of September 2021 to the middle of November 2021. As described by Poleno et al. (2011) or Tang et al. (2018), we hypothesized the occurence of lower average air temperatures (20–60 cm above the surface) in the afforested stands compared with agriculturally used land. We also hypothesized lower maximum temperatures and higher minimum temperatures as well as higher average air temperatures on the plot with old beech trees compared with the clearing (e.g. Kubin, Kemppainen 1991; Barna, Schieber 2011).

MATERIAL AND METHODS

As described by Vopravil et al. (2021a), the experimental plots were established near Hovorčovice (north of Prague) in the Czech Republic

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on Haplic Chernozem (IUSS Working Group WRB 2015). This area (warm, mildly dry region of the Czech Republic) is characterised by the mean annual air temperature of 8–9 °C, mean annual precipitation of 500–600 mm and by the sum of average daily air temperatures above 10 °C between 2 600 and 2 800. The afforestation was performed in 2011. As described by Vopravil et al. (2021a), one of the experimental plots was afforested with Scots pine (*Pinus sylvestris* L.) and the other plot with a mixture of pedunculate oak (*Quercus robur* L.), red oak (*Quercus rubra* L.) and Norway maple (*Acer platanoides* L.). The control plot is used for agriculture. The volumetric water content, soil temperature at depths of 20 cm, 40 cm and 60 cm and air temperature (20 cm, 40 cm and 60 cm above the ground level) were continuously measured on each of the experimental plots using TMS−4 datalogger (TOMST, Czech Republic). A rain gauge [Pronamic Professional Rain Gauge, 200 cm^2, accuracy 0.1 mm, Minikin ERi datalogger (EMS Brno, Czech republic)] was placed on the control plot. The measurement was performed from April to the beginning of November 2021. Only the effect of afforestation on air temperatures (20–60 cm above the surface) is described in this publication. Selected physical and chemical soil properties on the study plots including the seasonal changes of temperature and volumetric water content at depths of 20 cm, 40 cm and 60 cm (and precipitation) in the period from April to the beginning of November 2020 were described by Vopravil et al. (2021a). The experimental plots were also established near Lipnice (a part of Dvůr Králové nad Labem) in the Hradec Králové Region of the Czech Republic. This area (mildly warm, mildly wet region of the Czech Republic) is characterised by the mean annual air temperature of 7–8 °C, by the mean annual precipitation of 550–650 (700) mm and the sum of air temperatures above 10 °C between 2 200 and 2 500. One of the plots in beech (*Fagus sylvatica* L.) forest consisted of old beech trees and the other plot was a clearing. The measurement (20–60 cm above the surface) was performed from the middle of September 2021 to the middle of November 2021.

The differences in the values of air temperature were subjected to testing by one-way ANOVA and Tukey HSD test. All statistical analyses were performed with STATISTICA Cz software (Version 10, 2011).

RESULTS AND DISCUSSION

The average air temperatures (from April to the beginning of November 2021) on the afforested (and control) plots are shown in Table 1. Significant ($P < 0.05$) differences were found on the plot afforested with broadleaves when compared with the control plot or on the plot afforested with Scots pine compared with the control plot (20 cm, 40 cm and 60 cm above the surface). The maximum and minimum values of air temperature on the afforested (and control) plots are shown in Table 2. On the control (agriculturally used) plot, the minimum values were measured on April 27 (20 cm) or April 4 (40 cm and 60 cm above the surface);

Table 1. Average values of air temperature on the afforested plots (and the control plot)

Plot	Above-ground height (cm)	Average air temperature above the surface (°C)
Control plot	20	14.5
	40	14.5
	60	14.3
Pedunculate oak + red oak + Norway maple	20	13.5
	40	13.4
	60	13.6
Scots pine	20	13.4
	40	13.5
	60	13.5

Table 2. Maximum and minimum values of air temperature on the afforested plots and the control plot

Plot	Above-ground height (cm)	Air temperature above the surface (°C)	
		minimum	maximum
Control plot	20	−4.1	39.0
	40	−3.9	37.8
	60	−4.1	36.9
Pedunculate oak + red oak + Norway maple	20	−3.5	33.6
	40	−3.6	31.9
	60	−3.5	31.5
Scots pine	20	−2.5	31.5
	40	−2.5	31.5
	60	−2.6	31.5

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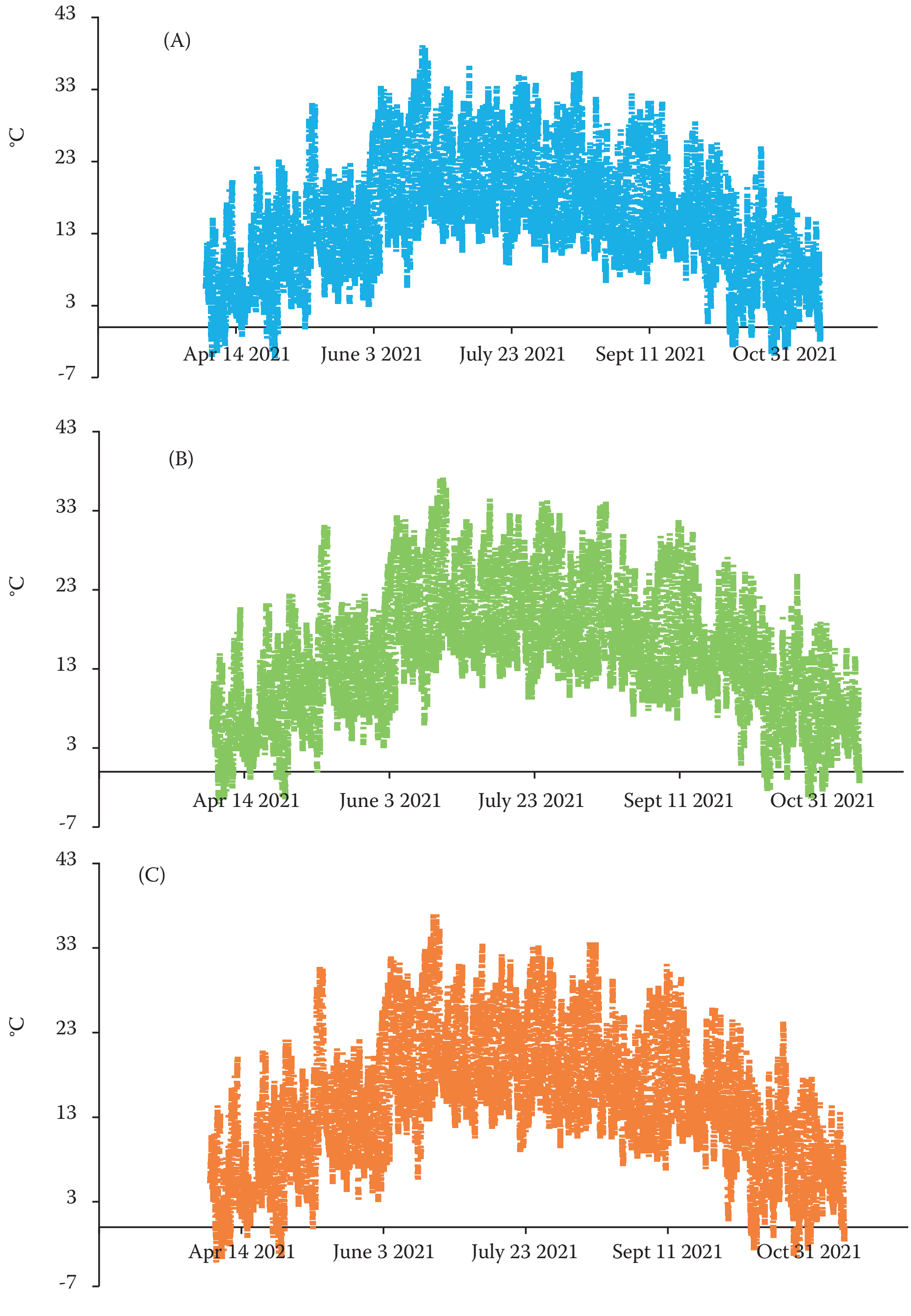

Figure 1. The course of air temperature on the control agriculturally used plot (A) 20 cm above the surface; (B) 40 cm above the surface; (C) 60 cm above the surface

the maximum values were measured on June 19 (20 cm) and June 20 (40 cm and 60 cm) (Figure 1). On the plot with broadleaves, the minimum values were obtained on April 4 (20 cm, 40 cm and 60 cm) and the maximum values on May 11 (20 cm) and May 10 (40 cm and 60 cm) (Figure 2). Concerning the plot with Scots pine, the minimum values were measured on April 6 (20 cm, 40 cm and

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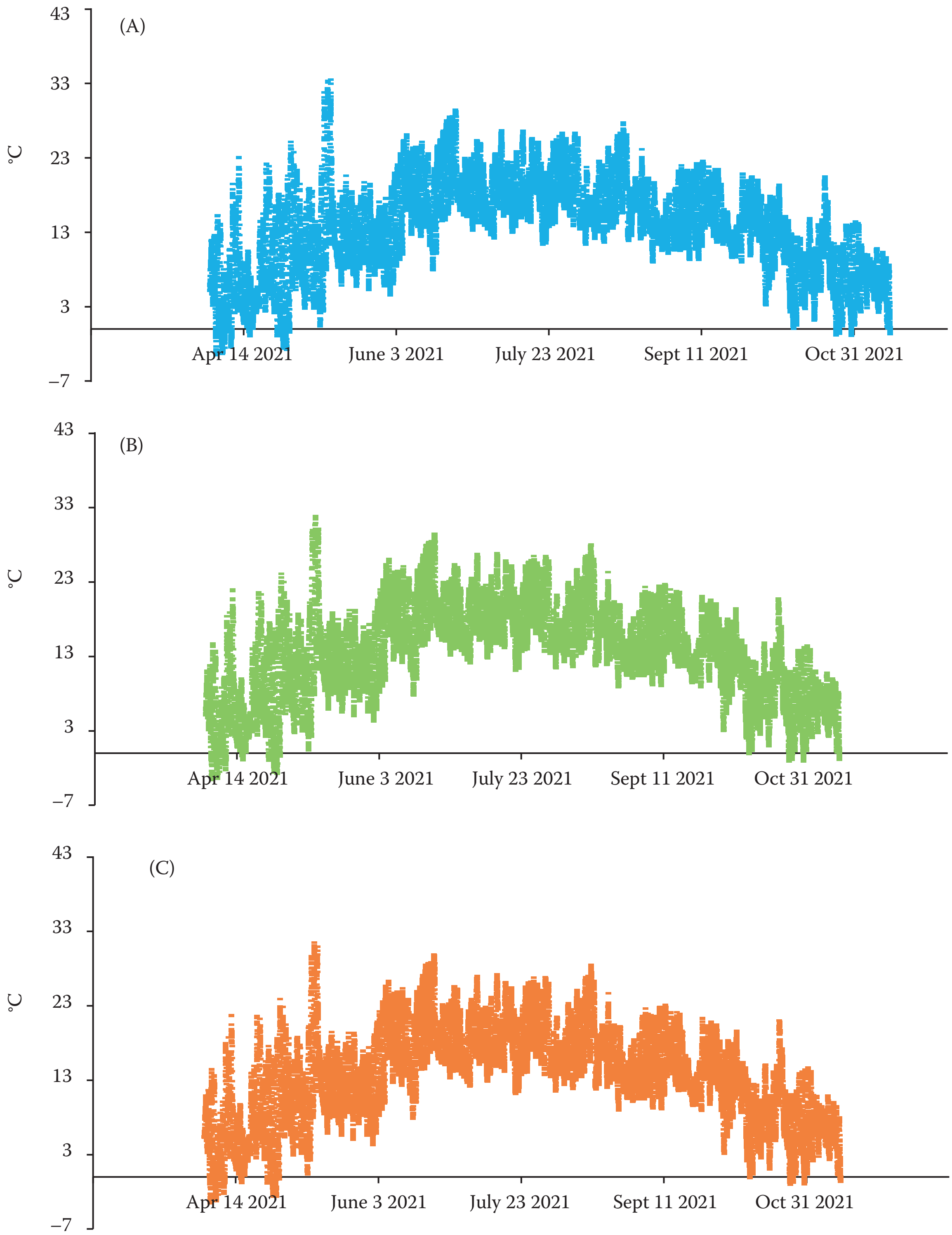

Figure 2. The course of air temperature on the plot with a mixture of pedunculate oak (*Quercus robur* L.), red oak (*Quercus rubra* L.) and Norway maple (*Acer platanoides* L.) (A) 20 cm above the surface; (B) 40 cm above the surface; (C) 60 cm above the surface

60 cm above the surface) and the maximum values on June 21 (20 cm and 40 cm) and June 18 (60 cm) (Figure 3).

The average air temperatures 8.6 °C (20 cm) and 8.7 °C (40 cm and 60 cm above the surface) were measured on the plot with old beech trees. On the

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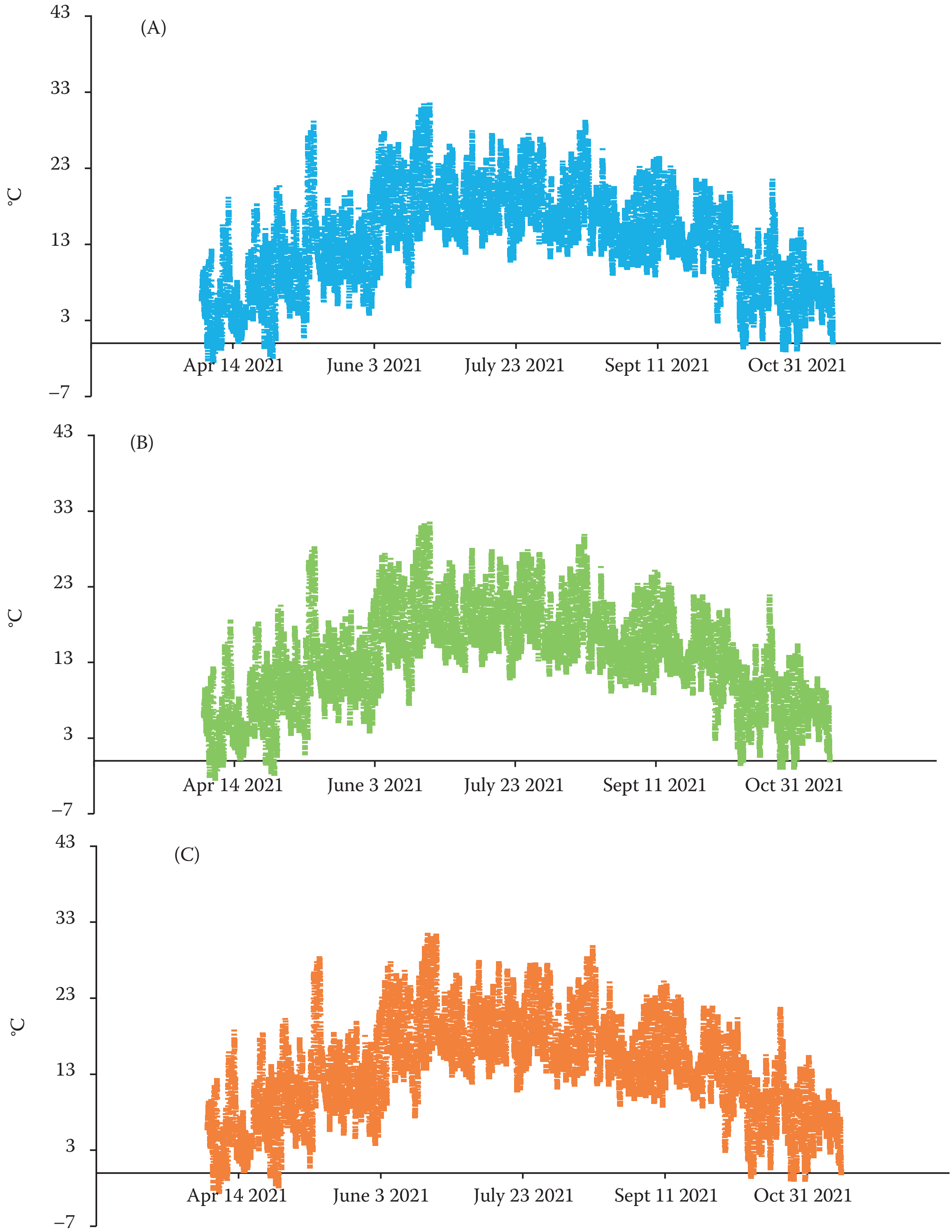

Figure 3. The course of air temperature on the plot with *Pinus sylvestris* L. (A) 20 cm above the surface; (B) 40 cm above the surface; (C) 60 cm above the surface

clearing, the average values 7.6 °C (20 cm), 8.0 °C (40 cm) and 7.7 °C (60 cm) were measured. The maximum and minimum values of air temperature on the studied plots (in a beech forest) are presented in Table 3. On both plots, the minimum temperature values were registered on November 7 (20 cm, 40 cm and 60 cm) (Figures 4 and 5). On the plot with old beech trees, the maximum tempera-

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Table 3. Maximum and minimum values of air temperature on the studied plots in beech forest

Plot	Above-ground height (cm)	Air temperature above the surface (°C)	
		minimum	maximum
Old beech trees	20	–1.1	23.2
	40	–1.1	24.4
	60	–1.3	23.1
Clearing	20	–3.0	27.1
	40	–2.1	26.6
	60	–2.8	27.0

ture values were measured on September 26 (20 cm and 40 cm) and September 27 (60 cm); concerning the clearing, the maximum temperature was found on September 27 (20 cm, 40 cm and 60 cm). Significant ($P < 0.05$) differences between the plots were found at a height of 20 cm, 40 cm and 60 cm above the surface.

Vopravil et al. (2021a) studied the effect of agricultural land afforestation (for the period of 9 years) with a mixture of broadleaves or monospecific *Pinus sylvestris* L. culture on temperature and volumetric soil water content at different depths (20 cm, 40 cm and 60 cm) in the period from April to the beginning of November 2020 – the same experimental plots as in this study. The authors also found lower temperatures in the soil of afforested plots (all studied depths) compared to agriculturally used land; higher temperatures in forested soils in autumn and winter (compared to field soils) were found by Michelsen-Correa and Scull (2005). Poleno et al. (2011) stated that the values of average annual temperatures 25–200 cm above the surface (and soil surface) were lower in a mixed forest (pine, beech and oak) compared with arable land. The authors found the average annual temperature increased from the soil surface (6.5 °C) to 200 cm above the surface (6.7 °C) in the forest; in the field, the authors revealed the surface had the highest temperature (7.7 °C) and the temperature of 7.4 °C was found 200 cm above the surface (see Poleno et al. 2011). Poleno et al. (2011) reported that the average annual air temperature measured 25 cm above the surface was 0.7 °C lower (6.6 °C versus 7.3 °C) in the forest compared with the field – in this study, the average air temperature measured 20 cm (or 40–60 cm) above the surface was 0.9–1.0 °C (or 0.7–1.1 °C) lower on the afforested plots compared with the agriculturally used plot. Jin et al. (2019) studied the effect of afforestation on soil (at depths of 10 cm, 20 cm, 40 cm, 60 cm and 100 cm) and air temperatures (1 m above the ground) on the Chinese Loess Plateau. For example, the authors measured lower daytime and nighttime temperatures at all studied soil depths on the afforested sites compared to grasslands (regardless of topography); the annual average daytime soil temperatures were 0.57–1.40 °C (and the annual average nighttime soil temperatures

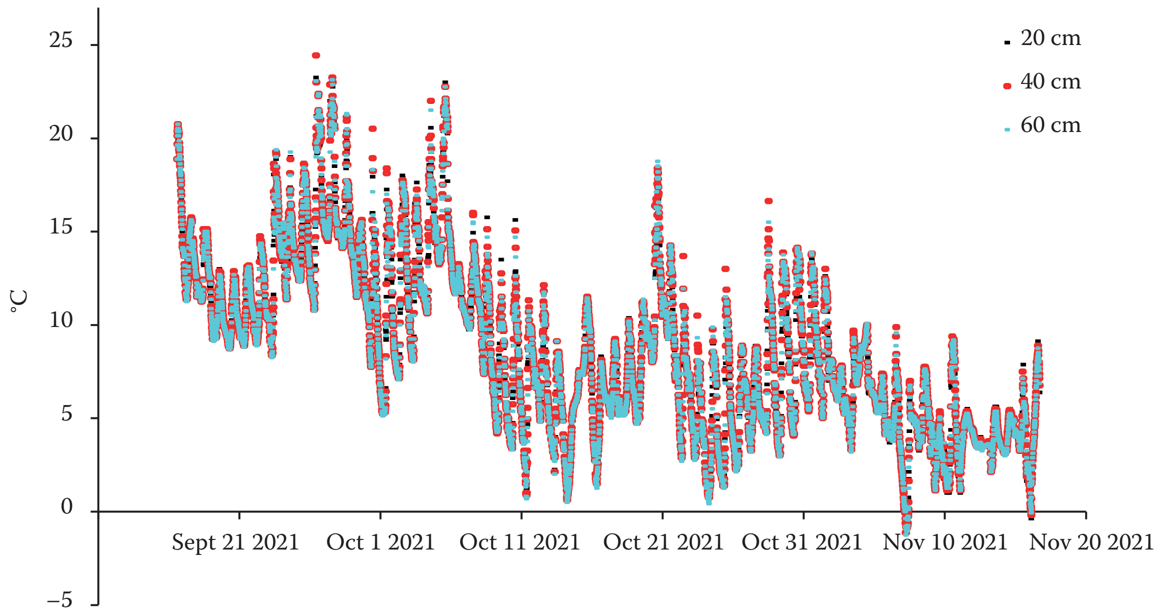

Figure 4. The course of air temperature on the plot with old beech trees (20 cm, 40 cm and 60 cm above the surface)

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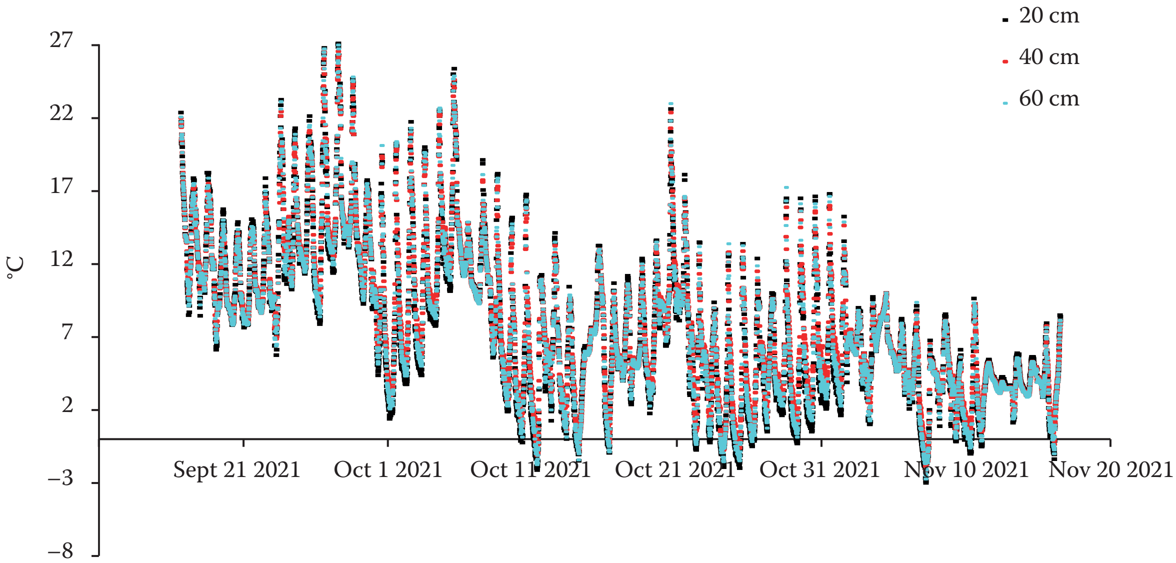

Figure 5. The course of air temperature on the plot with clearing (20 cm, 40 cm and 60 cm above the surface)

0.57–1.53 °C) lower on afforested sites. Concerning the air temperature, the authors found daytime cooling (0.45–1.14 °C) and nighttime warming (0.05–0.99 °C) or cooling (0.24–0.27 °C) on afforested land compared to grassland. Nevertheless, the authors stated that topography (uphill slopes, downhill gullies) had an effect on soil and air temperatures. Peng et al. (2014) studied how afforestation affected land surface temperatures accross China. The autors observed that the values of annual daytime land surface temperatures were 1.2 °C lower on afforested land compared to croplands (and 1.1 °C lower compared to grasslands) – according to the authors, it was given by lower albedo and higher evapotranspiration on afforested land. On the other hand, the average nighttime land surface temperature values were 0.2 °C (or 0.3 °C) higher on afforested land compared with grasslands (or croplands). Nevertheless, the authors showed the afforestation led to daytime and nighttime warming during winter. Concerning the evapotranspiration, it can be influenced by the height of plants (or types of leaves) (e.g. Stan et al. 2014). Wang et al. (2018) studied the effect of afforestation (planting *Populus* spp. to reduce desertification and control dust storms) and found the afforested site (in comparison with the native shrub ecosystem) had lower surface temperatures (in the daytime) in the winter, spring, summer and autumn (according to the authors because of higher albedo – the afforested site had higher albedo compared with the studied shrub ecosystem) and higher surface temperatures in the nighttime in the winter, spring and autumn. Effects of afforestation on the soil surface temperature (cooling or warming) differ according to latitude, daytime or nightime, topography, precipitation etc. (Tang et al. 2018). Tang et al. (2018) realized a study to analyse the effect of forests on land surface temperature and air temperature in Europe and the effect of background climate. For example, they investigated daily net cooling in most areas of Europe. Concerning the effect of forests on air temperatures, forests tend to decrease the values of mean annual maximum temperature and increase the values of mean annual minimum temperature. In this study, we found lower maximum air temperatures and higher minimum air temperatures on the afforested plots compared with the control.

Song et al. (2013) studied the effect of vegetation height and density (the authors used dried reed stalks to simulate different vegetation height and density) on air temperature at 10 cm above the surface and soil temperatures at depths of 5 cm and 20 cm. The authors showed that both soil and air temperatures decreased as the height and density of reed stalks increased probably due to the interception (or reflection) of solar radiation by reed stalks; the authors also reported that differences between maximum and minimum values (both soil and air temperatures) decreased with increasing height and density of reed stalks. Also, lower height and density of reed stalks led to lower differences between the values of air and soil temperature (Song et al. 2013). Tesař et al. (2006) studied

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air (5 cm and 200 cm above the ground) and soil (at depths of 15 cm and 60 cm) temperatures measured during the growing season (and also during the days with low potential evapotranspiration plus rainy or dry conditions as well as the days with high potential evapotranspiration plus dry conditions) at three localities with different plant cover (mature forest – acidophilous mountain spruce-beech forest, dead forest with herb undergrowth – the height of herbs was about 40 cm, clearing with herb cover – the height of herbs was about 30 cm). The author stated that the values of night air temperatures measured 5 cm above the surface (during the above mentioned days selected according to the value of evapotranspiration and rainy or dry conditions) were higher in the mature acidophilous mountain spruce-beech forest compared with the clearing and dead forest. Concerning the maximum values (midday), the highest temperatures were found in the dead forest (under dry conditions – heat from dead trees) or the effect of vegetation was not clear (rainy conditions). For the vegetation season, the mean values of air temperature measured 5 cm above the ground were 13.4 °C (mature forest), 13.7 °C (clearing) and 13.6 °C (dead forest). The mean values of air temperature measured 200 cm above the ground were 13.6 °C (mature forest), 13.7 °C (clearing) or 14.0 °C (dead forest) (see Tesař et al. 2006). In this study, the differences between the average air temperatures were higher (0.7–1.0 °C) when the plot with the old beech forest stand was compared with the clearing.

CONCLUSION

The afforestation of agriculturally used land significantly ($P < 0.05$) decreased air temperatures 20–60 cm above the surface. The average air temperature (from April 2021 to the beginning of November 2021) decreased by 0.7–1.1 °C on the afforested plots compared with the agriculturally used land (with small differences between broadleaves and Scots pine); we proved a reduction of the amplitude of maximum and minimum temperatures on the afforested plots. In the beech forest, the average temperature (from the middle of September 2021 to the middle of November 2021) decreased by 0.7–1.0 °C on the plot with clearing compared with the old beech forest; an increase in the amplitude of maximum and minimum temperatures was also found on the clearing. Our results confirm the benefits of afforestation to climate mitigation. According to knowledge from literature, the cooling effects on afforested plots are given by changes of albedo and evapotranspiration due to the afforestation. Buffering of extreme temperatures is important for the human thermal comfort.

REFERENCES

Allmaras R.R., Burrows W.C., Larson W.E. (1964): Early growth of corn as affected by soil temperature. Soil Science Society of America Journal, 28: 271–275.

Bakanoğulları F., Şaylan L., Yeşilköy S. (2022): Effects of phenological stages, growth and meteorological factor on the albedo of different crop cultivars. Italian Journal of Agrometeorology, 1: 23–40.

Bala G., Caldeira K., Wickett M., Philips T.J., Lobell D.B., Delire C., Mirin A. (2007): Combined climate and carbon-cycle effects of large-scale deforestation. Proceedings of the National Academy of Sciences of the United States of America, 104: 6550–6555.

Barna M., Schieber B. (2011): Climate response to forest management in beech stands. Folia Oecologica, 38: 8–16.

Bedrna Z. (1977): Pôdotvorné procesy a pôdne režimy. Bratislava, Veda: 132. (in Slovak)

Chirino E., Sánchez J.R., Bonet A., Bellot J. (2001): Effects of afforestation and vegetation dynamics on soil erosion in a semi-arid environment (SE Spain). Transactions on Ecology and Environment, 46: 239–248.

Coutts J.R.H. (1955): Soil temperatures in an afforested area in Aberdeenshire. Quarterly Journal of the Royal Meteorological Society, 81: 72–79.

Cukor J., Zeidler A., Vacek Z., Vacek S., Šimůnek V., Gallo, J. (2020): Comparison of growth and wood quality of Norway spruce and European larch: Effect of previous land use. European Journal of Forest Research, 139: 459–472.

Ding B., Zhang Y., Yu X., Jia G., Wang Y., Wang Y., Zheng P., Li Z. (2022): Effects of forest cover type and ratio changes on runoff and its components. International Soil and Water Conservation Research, 10: 445–456.

Gallo J., Baláš M., Linda R., Kuneš I. (2020): The effects of planting stock size and weeding on survival and growth of small-leaved lime under drought-heat stress in the Czech Republic. Austrian Journal of Forest Science, 137: 43–66.

Gomyo M., Kuraji K. (2016): Effect of the litter layer on runoff and evapotranspiration using the paired watershed method. Journal of Forest Research, 21: 306–313.

Holubík O., Podrázský V., Vopravil J., Khel T., Remeš J. (2014): Effect of agricultural lands afforestation and tree species composition on the soil reaction, total organic carbon and

https://doi.org/10.17221/135/2022-JFS

nitrogen content in the uppermost mineral soil profile. Soil and Water Research, 9: 192–200.

Hrabovský A., Dlapa P., Cerdà A., Kollár J. (2020): The impacts of vineyard afforestation on soil properties, water repellency and near–saturated infiltration in the Little Carpathians mountains. Water, 12: 2550.

Ilstedt U., Malmer A., Verbeeten E., Murdiyarso D. (2007): The effect of afforestation on water infiltration in the tropics: A systematic review and meta-analysis. Forest Ecology and Management, 251: 45–51.

IUSS Working Group WRB. (2015): World Reference Base for Soil Resources 2014. International Soil Classification System for Naming Soils and Creating Legends for Soil Maps (Update 2015). Rome, FAO: 192.

Jackson R.B., Jobbágy E.G., Avissar R., Roy S.B., Barrett D.J., Cook C.W., Farley K.A., Le Maitre D.C., McCarl B.A., Murray B.C. (2005): Trading water for carbon with biological carbon sequestration. Science, 310: 1944–1947.

Jia X., Shao M., Zhu Y., Luo Y. (2017): Soil moisture decline due to afforestation across the Loess Plateau, China. Journal of Hydrology, 546: 113–122.

Jin Z., Guo L., Fan B., Lin H., Yu Y., Zheng H., Chu G., Zhang J., Hopkins I. (2019): Effects of afforestation on soil and ambient air temperature in a pair of catchments on the Chinese Loess Plateau. Catena, 175: 356–366.

Kirschbaum M.U.F., Whitehead D., Dean S.M., Beets P.N., Shepherd J.D., Ausseil A.G.E. (2011): Implications of albedo changes following afforestation on the benefits of forests as carbon sinks. Biogeosciences, 8: 3687–3696.

Kubin E., Kemppainen L. (1991): Effect of clearcutting of boreal spruce forest on air and soil temperature conditions. Acta Forestalia Fennica, 225: 3–42.

Kupka I., Podrázský V. (2010): Vliv druhového složení porostů na zalesněné zemědělské půdě na pedofyzikální vlastnosti a poutání uhlíku v povrchových horizontech. In: Knott R., Peňáz J., Vaněk P. (eds.): Pěstování lesů v nižších vegetačních stupních, Křtiny, Sept 6–8, 2010: 71–76. (in Czech)

Kuusinen N., Kolari P., Levula J., Porcar-Castell A., Stenberg P., Berninger F. (2012): Seasonal variation in boreal pine forest albedo and effects of canopy snow on forest reflectance. Agricultural and Forest Meteorology, 164: 53–60.

Lal R., Cummings D.J. (1979): Clearing a tropical forest I. Effects on soil and micro-climate. Field Crops Research, 2: 91–107.

Li Y., Zhao M., Motesharrei S., Mu Q., Kalnay E., Li S. (2015): Local cooling and warming effects of forests based on satellite observations. Nature Communications, 6: 6603.

Li Y., Chai S., Chai Y., Li R., Lan X., Ma J., Cheng H., Chang L. (2021): Effects of mulching on soil temperature and yield of winter wheat in the semiarid rainfed area. Field Crops Research, 271: 108244.

Michelsen-Correa S., Scull P. (2005): The impact of reforestation on soil temperature. Middle States Geographer, 38: 39–44.

Ministry of Agriculture of the Czech Republic (2018): Information on Forests and Forestry in the Czech Republic by 2017. Prague, The Ministry of Agriculture of the Czech Republic: 20.

Peng S.S., Piao S., Zeng Z., Ciais P., Zhou L., Li L.Z.X., Myneni R.B., Yin Y., Zeng H. (2014): Afforestation in China cools local land surface temperature. Proceedings of the National Academy of Sciences, 111: 2915–2919.

Poleno Z., Vacek S., Podrázský V., Remeš J., Mikeska M., Kobliha J., Bílek L., Baláš M. (2011): Pěstování lesů I. Ekologické základy pěstování lesů. Kostelec nad Černými lesy, Lesnická práce: 320. (in Czech)

Porto P., Walling D.E., Callegari G. (2009): Investigating the effects of afforestation on soil erosion and sediment mobilisation in two small catchments in Southern Italy. Catena, 79: 181–188.

Romero-Díaz A., Belmonte-Serrato F., Ruiz-Sinoga J.D. (2010): The geomorphic impact of afforestations on soil erosion in Southeast Spain. Land Degradation and Development, 21: 188–195.

Sieber P., Böhme S., Ericsson N., Hansson P.A. (2022a): Albedo on cropland: Field–scale effects of current agricultural practices in Northern Europe. Agricultural and Forest Meteorology, 321: 108978.

Sieber P., Ericsson N., Hammar T., Hansson P.A. (2022b): Albedo impacts of current agricultural land use: Crop-specific albedo from MODIS data and inclusion in LCA of crop production. Science of the Total Environment, 835: 155455.

Song Y.T., Zhou D.W., Zhang H.X., Li G.D., Jin Y.H., Li Q. (2013): Effects of vegetation height and density on soil temperature variations. Chinese Science Bulletin, 58: 907–912.

Stan F.I., Neculau G., Zaharia L., Ioana-Toroimac G. (2014): Evapotranspiration variability of different plant types at Romanian experimental evapometric measurement stations. Climatologie, 11: 85–90.

Tang B., Zhao X., Zhao W. (2018): Local effects of forests on temperatures across Europe. Remote Sensing, 10: 529.

Tesař M., Šir M., Lichner L., Zelenková E. (2006): Influence of vegetation cover on thermal regime of mountainous catchments. Biologia, 61: S311–S314.

Vacek Z., Cukor J., Vacek S., Linda R., Prokůpková A., Podrázský V., Gallo J., Vacek O., Šimůnek V., Drábek O., Hájek V., Spasić M., Brichta J. (2021a): Production potential, biodiversity and soil properties of forest reclamations: Opportunities or risk of introduced coniferous tree species under climate change? European Journal of Forest Research, 140: 1243–1266.

Vacek Z., Linda R., Cukor J., Vacek S., Šimůnek V., Gallo J., Vančura K. (2021b): Scots pine (*Pinus sylvestris* L.), the

https://doi.org/10.17221/135/2022-JFS

suitable pioneer species for afforestation of reclamation sites? Forest Ecology and Management, 485: 118951.

Vopravil J., Podrázský V., Khel T., Holubík O., Vacek S. (2014): Effect of afforestation of agricultural soils and tree species composition on soil physical chracteristics changes. Ekológia Bratislava, 33: 67–80.

Vopravil J., Podrázský V., Batysta M., Novák P., Havelková L. (2015): Identification of agricultural soils suitable for afforestation in the Czech Republic using a soil database. Journal of Forest Science, 61: 141–147.

Vopravil J., Podrázský V., Holubík O., Vacek S., Beitlerová H., Vacek Z. (2017): Principy zakládání porostů na bývalé zemědělské půdě v rámci ploch vymezených k zalesnění: Metodika pro praxi. Praha, VUMOP: 58. (in Czech)

Vopravil J., Formánek P., Heřmanovská D., Khel T., Jacko K. (2021a): The impact of agricultural land afforestation on soil water content in Central Bohemia. Journal of Forest Science, 67: 512–521.

Vopravil J., Formánek P., Janků J., Holubík O., Khel T. (2021b): Early changes in soil organic carbon following afforestation of former agricultural land. Soil and Water Research, 16: 228–236.

Wang L., Lee X., Schultz N., Chen S., Wei Z., Fu C., Gao Y., Yang Y., Lin G. (2018): Response of surface temperature to afforestation in the Kubuqi Desert, Inner Mongolia. Journal of Geophysical Research: Atmospheres, 123: 948–964.

Xu C., Yang Z., Qian W., Chen S., Liu X., Lin W., Xiong D., Jiang M., Chang C.T., Huang J.C., Yang Y. (2019): Runoff and soil erosion responses to rainfall and vegetation cover under various afforestation management regimes in subtropical montane forest. Land Degradation and Development, 30: 1711–1724.

Yang X.M., Reynolds W.D., Drury C.F., Reeb M.D. (2021): Cover crop effects on soil temperature in a clay loam soil in southwestern Ontario. Canadian Journal of Soil Science, 101: 761–770.

Yao Y., Wang X., Zeng Z., Liu Y., Peng S., Zhu Z., Piao S. (2016): The effect of afforestation on soil moisture content in northeastern China. PLoS One, 11: e0160776.

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