ABSTRACTS OF LECTURES

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LONG-TERM PLANT SPECIES COMPOSITION SHIFTS IN RYBI POTOK VALLEY AND MORSKIE OKO REGION (TATRY WYSOKIE MTS) AS A RESPONSE TO CHANGES IN ENVIRONMENT

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Steep environmental gradients are the main factors determining local plant species composition in high-mountain ranges. Therefore, mountain vegetation is often considered to be good indicator of climate and land-use changes. In this study we present plant species compositional shifts in Rybi Potok Valley and Morskie Oko region (Tatry Wysokie Mountains) over the past 90 years and identify the main drivers causing the changes we observed. The historical vegetation study of the valley that we used is from the year 1927. We used an indirect method to quantify plant species compositional shift, focusing on one species and its co-occurring species and how these co-occurrences shift over time. This was done by calculating relative changes in species optimum values of the co-occurring species for different environmental variables: light, temperature, moisture, nutrients and soil reaction, represented by ecological indicator values. Different factors drove changes in different vegetation types. Increasing temperature and changing precipitation affected snowbeds, hygrophilous tall herbs and calcareous grasslands, while cessation of sheep grazing influenced species composition of granite grasslands. We also revealed that some of these changes were in fact driven by a combined impact of both climate and change in sheep grazing intensity.

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CHANGES IN SILVER FIR (*ABIES ALBA* MILL.) DISTRIBUTION IN POLAND

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A discussion on the natural distribution of silver fir in Poland has recently taken place. The main objective of our study was to compare the growth, productivity, vitality and natural regeneration of silver fir within and beyond its natural range in Poland. The study was conducted in 48 mixed stands with different proportions of silver fir distributed within and beyond this species' natural range. Growth and regeneration of silver fir were assessed on two site types: fresh deciduous and fresh mixed deciduous forest site types. Basal area and volume of silver fir were significantly higher, whereas H/DBH ratio and crown length were significantly lower, beyond the silver fir range. Vitality of silver fir was significantly lower beyond its natural range. Silver fir regenerated naturally in the areas studied. Even though the density of fir seedlings (H≤0.5m) was higher beyond the fir distribution, the number of tall saplings and stand lower-layer trees were significantly higher within silver fir's natural range. Beyond the natural range, silver fir was artificially planted except for in Łuków and Mińsk Mazowiecki forest districts. These places (so-called islands) should be joined to the contiguous range of the species (no genetic differences between these ranges). Silver fir grows very well on lowlands but it is a typical mountaineer tree and should be managed and regenerated in the mountains and highlands. We prepared a new distribution of silver fir in Poland which is being used as a rule in the national Principals of Silviculture.

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WHAT WE CAN EXPECT FROM TREES UNDER CHANGING CLIMATE?

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Species distribution models (SDM) are a useful tool for describing distributions of species within environmental (ecological) and geographical space. At the continental and global scale, species distributions depend mainly on climate conditions. We aimed to (1) develop models for temperate European tree species distributions, (2) apply them to future climate scenarios and (3) recognize potential areas of local extinction risk for the species studied.

We used data on the distribution of *Abies alba*, *Betula pendula*, *Fraxinus excelsior*, *Larix decidua*, *Pinus sylvestris*, *Picea abies*, *Pseudotsuga menziesii*, *Quercus petraea*, *Q. robur*, *Q. rubra*, *Robinia pseudoacacia* and *Tilia cordata* from the Global Biodiversity Information Facility, EUFORGEN and Maps for Forest Tree Species in Europe (ftp://mars.jrc.ec.europa.eu/Afoludata/Public/all_datasets.html). We assumed data about species distribution to be presence-only data, thus we used the MaxEnt model from the dismo package in R software, which is developed for processing this type of input data. As the explanatory variables we used 19 bioclimatic statistics from WorldClim database, available in 2.5' grid and, for comparison, in 0.5' grid.

Models obtained for the majority of tree species studied have shown two main directions of potential distribution range changes based on habitat suitability. The studied species would reach higher latitudes of their potential range limits in the more pessimistic scenarios and species typical of the boreal zone would shift their southern border more rapidly than temperate species. We found areas in which the habitat suitability would probably decrease. For example, reduced habitat suitability may be manifested for *Abies alba* in Carpathians and Central Poland and for *Pseudotsuga menziesii* in Western Poland and Eastern Germany due to lower precipitation. Due to the longevity of trees and relatively fast climate change, it is probable that they would not be able to adapt and self-reproduce. Their resistance to biotic threats outside their ecophysiological optimum will decrease. Thus, growing trees would have to face the increasing mortality connected with outbreaks of herbivorous insects or fungal pathogens, e.g. *Ips typographus* or *Armillaria* spp. Sustainable forestry and conservation management should take into account possible risks connected with particular tree species and consider the impact of climate change on the dynamics of tree stands species composition.

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SPECIES RICHNESS INCREASE IN BIAŁOWIEŻA FOREST: HABITAT CHANGE, CLIMATE CHANGE OR OBSERVER EFFECT?

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The aspect of environmental variation which drives community composition for one group of species may not so strongly affect another, making it challenging to predict the effects of climate change on biodiversity. Comparing several groups in parallel over time can help us tease effects apart and look for common trends. Twenty-five years ago the CRYPTO project documented the plant, fungal and lichen diversity of 144 1-hectare plots in the strictly protected area of the Białowieża National Park, and in the KlimaVeg project those plots have been revisited and resurveyed. It is a particularly special resampling project because of the importance of the Białowieża Forest for biodiversity and the availability of true permanent plots.

The number of species which we observed per plot was considerably higher in 2015 than 1992 for all three groups we were able to resample: vascular plants, bryophytes and lichens – even after taking into account those species of lichens which were could not have been identified in 1992. We will present an exploration of the potential reasons for this increase and for why it is higher for some groups than for others. Could it be climate warming allowing warm-loving species to colonise a greater range of microhabitats, could it be increased levels of disturbance caused by pathogens and pests, or could it simply be that despite all our efforts to replicate the methodology, all our researchers simply had sharper eyes and spotted more species? The results will have implications for other resampling studies, as well as helping us ensure that the Białowieża National Park continues to thrive as a haven for plant biodiversity.

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PLANT DISTRIBUTION SHIFTS IN A WARMER WORLD

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Climate is an important factor for species distributions. The warming we have experienced in recent decades is predicted to cause large shifts in species distributions, and species are expected to shift their ranges northwards in latitude and upwards in elevation. In the high alpine habitats this may even lead to global extinctions as many species may lose all their suitable area as the temperature becomes too warm on the highest peaks. However, so far we have observed much fewer, and much smaller, shifts in species distributions than would be predicted from the warming that has occurred. I will present some of the results we have observed on species range shifts so far, focussing on observations made in Europe, and discuss potential causes for why the observed range shifts are smaller than expected from species distribution models.

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THE EFFECT OF GRAZING AND HIKING ON THE ELEVATIONAL RANGE SHIFT OF VASCULAR PLANT SPECIES IN THE SCANDES DURING RECENT DECADES

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Range shifts towards higher elevations have been observed for alpine vegetation in mountainous areas all over the world during recent decades. A correlation in time between the observed range shift and climatic changes has led to an expectation of climate as the driving factor, while other factors and their interactions with climate have received less attention. Factors which might affect species distribution, both directly and in interaction with climate, are dynamics in the species communities induced by two key factors of disturbance: large herbivores and hikers. The intensity of these factors has changed dramatically over the past century. We investigated the effect of large herbivore grazing and hiking on upward plant species range shift and dynamics in summit flora species composition, through a resurvey study in three areas along the south-north axis of the Scandes. We demonstrate a buffering effect on the upward range shift from grazing by semi-domestic reindeer and sheep. All mountains have had turnover in the species composition in the upper elevation range. Grazing buffered the upwards shift of species in the area, whereas hiking was not found to affect the upward range shift. Grazers have effects on range shifts through a variety of mechanisms which are undistinguishable in this form of resurvey and should be the focus of experimental work in the future.

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TREE-RING WIDTH VARIATIONS IN EUROPEAN BEECH (*FAGUS SYLVATICA*) GROWING WITHIN AND OUTSIDE ITS NATURAL DISTRIBUTION RANGE

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There is currently considerable discussion around the verification of existing ranges. This is the result of observed climate change as well as the occurrence of stands where introduced species are outside of their accepted natural ranges. Stands in north-eastern Poland, Lithuania and Latvia where European beech (*Fagus sylvatica* L.) has been introduced in the nineteenth century by Prussian foresters are an example of this. There, beech trees have been planted in the second storey of stands with Scots pine (*Pinus sylvestris* L.) dominant in the first storey. Those areas are a natural experiment for us. The geographical distribution of beech in the north-east direction is constrained by its low resistance to drought during the summer and vulnerability to late-spring frosts and short growing season, which limit its expansion. The beech occurrence outside of its natural range is limited by severe winter frosts and by high air temperatures during the growing season which are not compensated for by higher precipitation. Although it is a very sensitive species, it shows a remarkable plasticity. In connection with ongoing climate change, beech has possibilities for growth in areas where its presence has been limited so far.

Tree-ring width is linked to productivity, itself likely to depend on both genetic, and environmental factors. However, assuming that in a harsh climate beech develops high-density wood with small-diameter vessels, the aim of study was to compare the tree-ring width and anatomical traits of wood between two groups of the beech trees (*Fagus sylvatica* L.) from natural and outside natural distribution range. Wood samples for surveys were collected at breast height (bh = 1.3 m) from the trunk of 30 beech trees growing outside and within their natural distribution range.

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PHYSICS OF GLOBAL WARMING FOR NATURALISTS

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The Earth is an open thermodynamic system receiving energy in a form of shortwave (high temperature) thermal radiation from the Sun and emitting infrared (low temperature) thermal radiation into deep space. Other energy sources (e.g. geothermal, radiation from other stars and planets) are of many orders of magnitude smaller and can be in this reasoning neglected. In a stationary state the incoming total energy flux is balanced by the outgoing total energy flux. When the balance is positive (Earth gains energy), the planetary temperature increases, which, in turn, results in increased flux of outgoing radiation. The opposite is true for the negative energy balance. All changes of the planetary climate result from such changes of the energy balance.

Mechanisms influencing the Earth's energy balance can be classified as forgings (from outside the climate system) and feedbacks (responses of the climate system to forcings). Obvious forgings are related to changes in incoming shortwave radiation due to solar activity and orbital fluctuations. Less obvious, but equally important forgings are related to the changes of the emissivity of the Earth by variations of the greenhouse effect.

We will present the evidence that the actual climate change results from the lastly mentioned forcing. We will show, how different forcings (and resulting feedbacks) shaped the Earth's climate in the past. The uniqueness of the present anthropogenic forcing will be exhibited. Observed and possible feedbacks will be discussed.

Finally, we will demonstrate the physical backgrounds of the Global Climate Models (tools to quantitatively evaluate the Earth's climate) and discuss the climatic scenarios for a near future.

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"MANAGEMENT OF BIODIVERSITY CHANGE CAUSED BY GLOBAL WARMING AND INVASIVE ALIEN SPECIES" - PLAN AND OBJECTIVES OF THE PROJECT

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It seems that there are just a few threats that will affect the entire Arctic today or in the near future, but climate change certainly will. Even nowadays, we can observe climate-driven changes that include shrub expansion and species composition changes in moist and wet habitats such as snow beds, mires, fens and shallow ponds. It would be, however, very difficult to predict possible changes in the composition of the vascular plant flora and whole plant communities.

Iceland, due to its geographic location, seems to be an excellent place to carry out research on climate change-related topics. In our project we aim to share experience, knowledge, technology and best practices in solving ecological issues connected with climate change. To achieve this, we planned a two-year field study in an Arctic part of NE Iceland (Melrakaslletta peninsula). This is the most northern part of Iceland, covered by shrub tundra communities, which is expected to be severely impacted by the global change in the coming years due to a significant increase in mean temperature.

Our study aim is to identify, classify, and map plant communities occurring within the study area and to establish a net of permanent plots that will serve as a tool for monitoring of the impact of climate change in the future.

The study is carried out in cooperation with the Icelandic Institute of Natural History (IINH). The collaboration with an Icelandic partner gives the Polish partners an opportunity to take advantage of the data owned by IINH such as satellite and aerial images of the area and databases documenting biodiversity and the state of main ecosystems in Iceland.

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CHANGES IN NORWEGIAN WOODLANDS: RELATED TO CLIMATE CHANGE OR LEGACIES OF THE PAST?

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During the past century, changes in forest structure, dynamics and composition have been related to changing climatic conditions. However, most studies of temperate forest communities have not reported a response to recent climatic changes. Most studies which analyze the effect of climate change on temperate forest communities are conducted in areas geographically in the centre of their distribution range and not in their outer limits. Populations that inhabit the latitudinal margins of the distribution range are more likely to be influenced by climate change, as increases in temperature changes their potential species pool and may allow new lower-latitude species to survive. We present a study analyzing the effect of climate change on vegetation communities of temperate forest in the outer limit of the climatic distribution, the most northern broadleaved deciduous woods in Europe. These forest patches, woodlands, are only able to persist in this climatic region due to the microclimatic conditions found in steep and south-facing slopes along the Norwegian fjords. We found changes in species composition and shifting frequencies. These changes are not related to climatic variables such as temperature and precipitation, but related to changes in light and soil nutrients. Our results support the understanding that these woodlands have been affected by humans for a long time and much of the observed changes are likely to be due to the combination of cessation of traditional forest management and an increased storm activity leading to wind throw and break.

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DYNAMICS OF ALIEN PLANT SPECIES IN RESPONSE TO CLIMATE CHANGE

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Attempts to predict and assess the impact of recent climate change on species distributions have made progress in recent years. Correct prediction is particularly important when it can enhance understanding of how to prevent the spread of alien invasive species. Unfortunately, we are still very far from consistent understanding of the ecological processes involved in plant range expansions. However, on the other hand it has been shown that long-distance dispersal is likely to be crucial for range expansions under rapid climate change and that initial population establishment plays a crucial role for climate-driven range expansions.

In this study we make a preliminary exploration of the influence of climate parameters on the local population dynamics and species distribution of the alien invasive plant *Impatiens parviflora*. The spread of this species is destructive to the forest understory. We have been mapping the area covered by the *I. parviflora* population in invaded forest ecosystems. The area occupied by the species significantly increased from 95 (2008) to 246 subplots (2014) of total 408 ($G=140.57$, $p<0.0001$), while the mean non-zero percent cover decreased from 26.26 in 2008 to 8.04 in 2014 (Friedman rank test chi-square=58.37 $p<0.0001$ for paired data, a Kruskal-Wallis test of only colonized plots also gave a significant result). No significant differences in mean monthly temperature, mean minimal or maximal temperatures, nor precipitation among years were observed, thus the general climatic parameters cannot be related to significant changes in occurrence of alien invasive plant. However, other studies and the personal experience of the authors showed that region and weather conditions can have an impact on life history traits in *I. parviflora*, thus research on possible influences of weather and climate should be continued. It remains extremely challenging to relate dispersal processes and pathways with the establishment of pioneer populations ahead of the contiguous species range. Addressing this link requires integrating research perspectives and approaches from various sub-disciplines. Such transdisciplinary efforts will be key for improving our understanding of how plant populations 'move' across changing landscapes. Plant population ecology and in particular dispersal research have much to offer to the current debate on climate-driven range dynamics.

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GLOBAL CLIMATE CHANGE AND SPECIES COMPOSITION OF FOREST STANDS: CHALLENGES FOR THE FORESTRY IN CENTRAL EUROPE

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According to numerous forecasts, global climate change will cause substantial shifts in species distribution ranges. Forest management has already contributed to the establishment of many outposts of tree species outside their former distribution limits. However, until now it has affected the species composition and structure of forest stands to a very limited extent. Forest ecosystems react to climate changes relatively slowly; this is due to the longevity of trees, their slow growth rates and long time needed to reach maturity. Changes in species composition of forests in Poland during the last five decades have not exceeded a few percent. It is quite likely that the most dramatic effects resulting from global climate warming may be the radical increase of tree mortality rates caused by natural disturbances, such as droughts, wildfires, hurricanes and floods. The majority of climate change scenarios suggest a high probability of increase in frequency and severity of disturbances. Spontaneous regeneration of forest communities after disturbance may follow different pathways than those which we are used to. Combining high mortality rates with fast rates of spontaneous regeneration of forest communities may produce stand compositions and structures very different from those which we see in our forests today. That would be a great challenge for the forestry sector. The current rules of forest management, which had been developed upon assumptions of relative stability of environmental factors and of full control by forest managers over of the processes taking place in forest stands, should probably be strongly modified in the future.

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PHENOLOGICAL RESPONSE OF THE BIAŁOWIEŻA FOREST UNDERSTOREY TO CLIMATE CHANGE

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Białowieża Forest has become warmer since the 1950s, with greatest warming in winter and spring (0.6°C per decade in March). A 52-year long phenological data-set from four 50m transects in the *Tilio-Carpinetum* community in Białowieża Forest allows us to track the response of understorey vegetation to this climate change. The phenological state (budding, flowering, fruiting, etc.) of each species was recorded every ten days. Most spring-flowering plant show a strong relationship with climate, flowering earlier in years with warm winters and springs and early snow-melt. Summer-flowering plants have a weaker response to warming. Precipitation changes do not seem to have driven phenological shifts in the understorey.

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ASSESMENT OF HYPERSPECTRAL AND LIDAR DATA FOR IDENTIFICATION OF NON-FOREST NATURA 2000 HABITATS

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The aim of this study is to analyze the influence of phenological changes in plants on their spectral properties, which can be acquired from ground (ASD FieldSpec 4) and airborne level (HySpex) sensors. As the reference source of information, Airborne Lidar Scanning (ALS), photogrammetric images and chlorophyll measurements were used.

The research covers 11 Natura 2000 habitats: inland salt meadows (habitat code: 1340), European dry heaths (4030), xeric sand calcareous grasslands (6120), semi-natural dry grasslands and scrubland facies on calcareous substrates (*Festuco-Brometea*) (6210), alluvial meadows of river valleys of the *Cnidion dubii* (6440), species-rich *Nardus* grasslands, on siliceous substrates in mountain areas (6230), *Molinia* meadows on calcareous, peaty or clayey-silt laden soils (*Molinion caeruleae*) (6410), lowland hay meadows (*Alopecurus pratensis*, *Sanguisorba officinalis*) (6510), mountain hay meadows (6520), transition mires and quaking bogs (7140), alkaline fens (7230).

The results are sets of maps of Natura 2000 habitats and statistical analyses of accuracies.

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POA ANNUA INVASION ON KING GEORGE ISLAND - ONE OF THE CONSEQUENCES OF CLIMATE CHANGE IN THE ANTARCTIC?

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Because of its harsh environmental conditions and remoteness, Antarctica is considered to be at low risk of plant invasion. Global anthropogenic activities, along with local human influence, weakened the barriers that isolate this continent from the rest of the world. This could play a relevant role in the abundance of invasive species. An increasing number of reports have shown the presence and spread of non-native plants in Antarctica. In stressful environments, it has been predicted that alien species are unlikely to colonize and extend their distribution range, unless some process relaxes the environmental constraints. One of the most visible effects of climate change in the Antarctic Peninsula region is the dramatic retreat of glaciers. New habitats created by deglaciation and direct human influence can generate microhabitats more favorable to alien species, such as *Poa annua* L. (annual bluegrass), than to native plants. *P. annua* was introduced accidentally to the vicinity of the Arctowski Polish Antarctic Station over 30 years ago. Since the first record of this species in 1985/86, populations of *P. annua* have increased markedly in density and abundance within the original areas of establishment and it is the only non–native flowering plant species that has successfully established a breeding population in the maritime Antarctic.

If the current level of human activity is maintained in Antarctica, the establishment success and spread of *P. annua* could increase and harm the native flora.

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ABSTRACTS OF POSTERS

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CHANGES IN THE SPATIAL STRUCTURE OF VEGETATION ON AN UNMOWN MEADOW: THE IMPACT OF CLIMATE OR/AND THE EFFECT OF SUCCESSION

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The most important factors that shape the ecosystems of Białowieża National Park are water conditions and ecological processes occurring in plant communities. The ground water level has an essential effect on plant communities found on hydrogenic soils located in the river valleys and other parts of this area. The Reski Range of meadows (about 15 ha) are situated in the north-west part of the Białowieża Glade, in the Narewka river valley. In the period when these meadows were used (until the 1980s), substantial fluctuations in the water level (10-50 cm) were observed. This resulted in the mosaic of different phytocoenoses which occurred in the area at that time. The most common are: 1) floristically rich fragments of thistle meadow (*Cirsietum rivularis*) occurring in the periodically flooded habitats and 2) floristically poor stands of the sedge *Caricetum acutiformis* occupying habitats flooded for long periods.

Many studies indicate that the level of ground water changes in time and space. Habitats with a high water level are the most sensitive to variations in weather conditions. In these habitats, the ground water level reacts quickly to any decrease or increase in precipitation.

After the cessation of meadow use in the Reski Range, the changes in the spatial structure of vegetation and in species dominance have been studied for over 40 years. In recent years, the greatest successional changes occurred in the fragments of thistle meadow. However, as a result of continuous decrease in the ground water level, patches of *Iris pseudacorus* which occurred abundantly in the depressions of *Caricetum acutiformis* sedges have disappeared.

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EUROPEAN ASH (*FRAXINUS EXCELSIOR* L.) DIEBACK IN THE BIAŁOWIEŻA NATIONAL PARK

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Ash dieback has been observed in Europe since the early 1990s. The first information about the mass dieback of ash trees in Europe came from northeastern Poland. The phenomenon spread quite quickly across Europe. Research conducted by phytopathologists demonstrated that it is caused by the fungus *Chalara fraxinea* (Kowalski 2006), which causes partial necrosis and the death of trees. The aim of our study was to describe the progression and assess the scale of European ash dieback in the Białowieża National Park. The study was carried out on four 1 ha plots in the core area of the Białowieża National Park, two in an ash-alder forest and two in a wet deciduous forest. Monitoring of trees in ash-containing stands was conducted over the years 1990-2016. The diameter at breast height of all trees was recorded in each sampling period. The analyses included all standing living trees, divided into two groups: saplings (dbh < 8 cm) and mature trees (dbh > 8 cm). The data show that ash dieback caused a decrease in the percentage of ash on the plots, starting after 1998. Compared with 1990 the number of ash trees fell by more than 80%. The number of ash tree saplings in 2016 depended on the type of habitat. In the wet forests regeneration of ash was missing – all trees were broader than 8 cm at breast height. In the ash-alder forest regeneration was abundant – ash saplings comprised up to 95% of all living ashes on the plot. Based on the results it could be concluded that intensity of the phenomenon of European ash dieback was not dependant on the type of the habitat. The habitat of ash-alder forest favored the natural renewal of the ash population.

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RESPONSE OF THE HIGH-ALPINE SEDGE *CAREX LACHENALII* TO RECENT TOURISM AND CLIMATE CHANGE

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Snowbed vegetation is considered to be particularly sensitive to climate warming (e.g. Björk & Molau 2007). In particular, the rarest and most vulnerable plants of these communities are expected to respond rapidly to any change in environment. *Carex lachenalii* Schkuhr occurs in Poland on only a few isolated sites in the Tatry Mountains. Most of the historical records have not been re-confirmed for a long time and date back to the years 1890-1950. Of 39 historical localities examined in 2016, *C. lachenalii* was confirmed on 20, including the highest one in the Tatry Mountains (2153 m a.s.l.). We also documented this sedge on 57 new localities. To find out whether there was an elevational range shift of *C. lachenalii*, the elevation of each recent plot was recorded and compared with historical records. The maximum height and diameter, number of vegetative and generative stems and the distance from the nearest trail was recorded for each sedge tuft, with the aim of determining whether tourism affects the current population distribution. As expected, *C. lachenalii* mostly occurred in snowbed vegetation, constituting a reasonably important component of the species composition. We recorded a significant upward shift in elevation of close to 100 m in average over the past 50-100 years. The maximum diameter, number of tufts and vegetative stems were negatively correlated with distance from the trails, which suggests that tourism was the most important factor causing the observed change in distribution of *C. lachenalii* in Tatry. The climate warming effect was not easily detectable but we suppose that it could influence an upward shift of the species at least at the highest sites and farthest from the tourist trails.

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CLIMATE CHANGE AND HISTORICAL SHEEP GRAZING DRIVE SHIFTS IN PLANT SPECIES COMPOSITION OF TATRY MOUNTAIN SUMMITS OVER THE PAST 100 YEARS

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Many studies find that recent changes in alpine plant species composition could be explained by an increase in air temperature resulting from climate warming. However, very few detailed studies have been carried out within the highest parts of the Carpathians. The aim of this study was to evaluate whether the alpine flora of summits in the Tatry Mountains has changed over the last 100 years, and if observed changes could be explained by climate change or historical sheep grazing. Historical data on the flora of Tatry Mountains summits dates back to the years 1878-1948. We resurveyed the flora of 14 mountain summits in 2014. We used climatic data from the Meteorological Observatories on Kasprowy Wierch and Łomnica summits, combined with data on historical sheep grazing intensity (the area was closed to grazing when the National Park was established). We used ordination methods to quantify changes in species composition. To check whether there are changes in the mean value of ecological indicators between the two sampling periods we used a paired t-test. Changes were greater on lower-elevation summits, which are more accessible for sheep. Average ecological indicator values for temperature, soil moisture and trophism increased significantly over time. However, on higher-elevation summits the share of warm-demanding species decreased, contrary to expectations. Climate change influenced the species composition change on the higher-elevation and inaccessible summits in a considerable way over the timescale of our resampling.

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EFFECTS OF CLIMATIC VARIABILITY ON AQUATIC VEGETATION IN A HARD WATER LAKE

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The effect of long-term changes in total precipitation on physical and chemical parameters of water and the structure of submerged aquatic vegetation were studied from 2003 to 2013 in the deep, hard water Lake Rogóźno in the West Polesie region of eastern Poland. With respect to total precipitation, two different periods were distinguished: dry (2003-2006) and wet (2007-2013). Between the dry and wet periods the water level in the lake as well as in the catchment area rose (on average 0.45 m). It resulted in an increased concentration of dissolved organic carbon, brown water colour and a decrease in the electrolytic conductivity and concentration of nutrients in water, whereas the underwater light climate was favourable and comparable in both periods. When the precipitation and water level were low in the dry period, charophytes, mostly *Lychnothamnus barbatus*, dominated (18.2-18.3% of the lake area). After the precipitation and water level increased in the wet period, the abundance of charophytes strongly declined (1.2%). Indeed, maximum depth of aquatic macrophytes in the lake decreased between the dry and wet periods from 5 to 2.4 m. Vascular plants (7.9% of the lake area), mainly *Myriophyllum spicatum*, and the bryophyte *Fontinalis antipyretica* (2.7%) became dominant in the wet period. The transformation in the submerged aquatic vegetation was linked with the variation in physicochemical parameters determined by the total precipitation and mean air temperature in March. Hydrologic trends can explain some changes in the vegetation between charophytes and other macrophytes in a few lakes in the West Polesie region.

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THE IMPACT OF GLOBAL WARMING ON THE EFFECT OF VIRULENCE AND SPREAD OF PARASITIC *CUSCUTA EPITHYMUM* IN THE NIDA BASIN (S POLAND)

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Continuous global warming is leading to unavoidable changes in composition of the flora of the Nida Basin. In particular, we should focus on parasitic species like those of the genus dodder (*Cuscuta* L.), which may be a great threat to other species of plants – particularly protected ones. The genus dodder contains around 200 obligatory parasitic plants, widespread in the world, belonging to the family Convolvulaceae. The most widespread species of thermophilic habitats is *Cuscuta epithymum* (L.), which also has the most extensive range of hosts. The impact of global warming on the spread of parasitic plants such as *C. epithymum* can be critical. This species, which used to be considered as harmless in Poland, has become invasive recently due to climate change. Field studies conducted in the years 2014-2015 showed significant spreading of *Cuscuta* in the region of the Nida Basin. The number of identified host plants numbered more than 100, belonging to 28 families. The highest numbers of host plant species belonged to families: Asteraceae, Fabaceae, Poaceae, Apiaceae, Lamiaceae and Rosaceae. In the case of many host species *C. epithymum* becomes invasive. One such species is *Dorycnium germanicum* which is being infected tremendously in the only place that it can be found in Poland. We should also mention species endangered in our flora like *Cerasus fruticosa*, or *Thymus kosteleckyanus*. Studies from warmer parts of the world are indicating that *C. epithymum* and other species of *Cuscuta* may be considered as invasive plants there, while studies from colder territories are showing that usually this group of species poses no threat.

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FLOWERING OF SELECTED XEROTHERMIC PLANT SPECIES IN DROUGHT CONDITIONS IN THE RESERVE "WINNICA"

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Prolonged droughts, occurring increasingly during the vegetation period, are an effect of climate change being experienced in central Poland. Such droughts significantly modify the development phases of plants. We studied the date of initiation of flowering and the duration of flowering for focal species and compared our data with that presented in the botanical key "Polish Plants" (Szafer et al. 1967). The studies were conducted in 2011-2012, in the reserve „Winnica" which is situated in the Landscape Park Warta and Widawka, near Wielka Wieś (Łódź voivodeship, Widawa community, geographical coordinates: 51°26′11″N 18°49′50″E). This nature reserve was created in 1995 to protect the steppe grasslands and xerothermic scrubland, including rare plant species. Nine plant species, mostly from the class *Festuco-Brometea*, were studied: *Melampyrum arvense, Campanula sibirica, Campanula bononiensis, Anthemis tinctoria, Brachypodium pinnatum, Medicago falcata, Centaurea scabiosa, Centaurea stoebe* and *Agrimonia eupatoria*. The two growing seasons in which the studies were carried out were classified as very dry; hydrothermic index of Vinczeffy was 0.111 mm $^{o}C^{-1}$ (as the quotient of total precipitation to the sum of temperature) and 0.112 respectively. These weather conditions (high temperature, shortage of precipitation) changed the course of the flowering phase in different ways. Both an earlier start of the flowering phase (*M. arvense*), and delay in start (*C. bononiensis, A. tinctoria, M. falcata, A. eupatoria, B. pinnatum*) were observed in comparison with the dates published by Szafer et al. (1967). These differences ranged from 1.5 to 2.5 weeks. Only two species (*C. sibirica, C. scabiosa*) began flowering at the time specified by these authors. For most of the focal species the drought caused the shortening of flowering and fruiting phases, and an earlier end of the vegetation season (as much as one month earlier compared with better moisture conditions, as found for *M. arvense*).

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CHARACTERISTICS OF DIASPORES OF SELECTED WILD FLOWERS RIPENING IN CONDITIONS OF EXTREME DROUGHT

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The aim of the study was to determine the impact of weather conditions on the morphology and seed sowing value of eight wild flowers (*Allium angulosum, Cnidium dubium, Galium boreale, Sanguisorba officinalis, Achillea millefolium, Plantago lanceolata, Eryngium planum, Scabiosa ochroleuca*). The diaspores (seeds and fruits) were collected on the meadows of the Lower Pilica River Valley (PLH 140016) area near Mniszew (Kozienice county, Mazovian voivodeship) in the years 2014 (dry) and 2015 (extremely dry). Within our study the following investigations were carried out: (1) morphometric evaluation of the seed material of wild flowers comprising the length, the widths and the coarseness of 30 cleaned seeds for each species, plus the mass of thousand seeds. (2) Evaluation of the vigour (as first count in germination analysis) and germination capacity (last count), for the seeds (50 in each of three replicates) under variable temperature conditions – 20°C for 16 hours (darkness) and 30°C for 8 hours (light). The weather conditions during generative development are of high importance for the seed sowing value. The catastrophic drought in 2015 caused a decreasing in seed mass and germination capacity and an increase in the proportion of dead seeds. Thousand-seed mass was low, especially in the case of late-blooming species (*S. officinalis* and *C. dubium*), which were developing their seeds during the drought period. The vigour of the seeds collected in 2015 was significantly lower than collected in 2014 only in the case of four species, on average 30-40% lower for *A. angulosum, E. planum* and *A. millefolium*, but four times lower in the case of *C. dubium*. It may be assumed that the basic reason was the high temperature during forming and ripening of the seeds. The average germination capacity (last count) for the species was lower, with an average of 24% and greater variability (3-74%). In 2015 on average twice as many dead seeds were observed than in 2014, but in the case of *E. planum* that difference was equal to ten times.

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CONSEQUENCES OF DIEBACK OF BLACK ALDER (*ALNUS GLUTINOSA*) FOR BRYOPHYTE COMMUNITIES IN NATURAL FOREST

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Dieback of black alder *Alnus glutinosa* (L.) Gaertner has occurred recently along streams in Europe. The main reason has been an invasive oomycete pathogen, *Phytophthora alni* species complex, which can spread rapidly along stream networks. In Poland it was first noticed in 2003. *P. alni* is favoured by mild winters and warm summers. That may suggest possible further spreading of the pathogen in response to global climate change. The black alder has a high species richness of epiphytic bryophytes and hosts many epiphytic mosses that have high host specificity. Furthermore, bog forests in general are very important ecosystems for conservation of bryophyte diversity. The aim of this study was to predict consequences of alder dieback for bryophyte communities inhabiting living trees and dead alder wood, investigate changes in bryophyte communities influenced by various types of tree death and identify, using Bayesian Information Criterion (BIC), the factors affecting species richness and bryophytes cover. We studied bryophyte communities on alder, in an alder bog forest of the *Ribeso nigri-Alnetum* community in an area of about 8 hectares in Białowieża National Park. We have made a list of bryophytes occurring on selected living trees, dead standing trees, logs and stumps. We observed 52 species of mosses and 21 species of liverworts associated with black alder and alder deadwood. The community of bryophytes inhabiting trees changed after death of the host tree. Differences were pronounced in species richness, cover of bryophytes and species composition. The highest species richness and bryophyte cover were observed on alder logs. Humidity of the substrate and its vertical position were the main factors affecting the bryophytes species richness and cover. A decreasing share of black alder in forest stands, especially the lack of alder's logs, can thus contribute to a decline in bryophyte diversity in forests.

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LICHENS NEW TO SCIENCE AND NEW TO POLAND DISCOVERED IN BIAŁOWIEŻA NATIONAL PARK

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Białowieża Forest is one of the biggest and the oldest forest complexes in Poland. Knowledge on the lichen diversity in this region is still incomplete and new species are continuously reported from this part of the country. This is mostly due to the new approaches (chemotaxonomic and phylogenetic methods) developed over the last 30 years, which have enabled the identification of species that have been overlooked in the past.

During our lichenological studies conducted in Białowieża National Park, carried out under the project KlimaVeg, we have found two species new to Poland (Kukwa et al. 2017) and also described one taxon as new to science: *Micarea soralifera* (Guzow-Krzemińska et al. 2016). A further five undescribed species are currently under elaboration.

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DOES *FRAXINUS EXCELSIOR* DIEBACK IN *CIRCAEO-ALNETUM* FOREST AFFECT THE LICHEN BIOTA?

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Dieback of *Fraxinus excelsior* L. in natural habitats has been known for over a decade. The main reason for this phenomenon is the fungus *Chalara fraxinea*. Loss of ash trees within communities where the ash has a dominant role causes changes in species composition and structure of forest stands. Therefore, it is important to determine the impact of these changes on the preservation of the lichen biota occurring on the bark of ash and other trees, particularly in forest communities where ash has a dominant role.

For this purpose, we used and compared data of species composition of lichens collected in the past (1990s) and more recently (2014-2016). Data were collected on the same permanent research plots, involving the community *Circaeo-Alnetum* (phytosociological classification), located in the Białowieża National Park.

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IDENTIFICATION OF AN URBAN HEAT ISLAND IN THE CITY OF SANDOMIERZ (SE POLAND) BASED ON THE DISTRIBUTION OF THERMOPHILIC PLANTS - PRELIMINARY RESULTS

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Urban heat islands are a microclimatic phenomenon typical of urban areas and a dominant feature of urban climate. They are characterised by elevated temperature of the atmospheric boundary layer in the city centre as compared with suburban and agricultural areas. The cause of urban heat islands consists mostly of the physical properties of concrete and asphalt, which absorb large amounts of heat during the day and release it at night. It is a phenomenon negatively affecting the health and well-being of humans. We present preliminary results of studies on the identification of an urban heat island in Sandomierz based on the distribution of thermophilic species, alongside a brief overview of floristic studies with regard to this phenomenon in selected Polish cities (Warsaw, Wrocław). The studies were conducted in 2015-2016. They were based on preparing distribution maps of thermophilic species of the vascular plants in Sandomierz. We used an ATPOL-compatible cartogram (1 km x 1 km). Within each square, a list of species was used to identify urban heat islands in Sandomierz and the other Polish cities. These were: *Eragrostis minor*, *Hordeum murinum*, *Bromus sterilis* and *Clematis vitalba*. *Duchesnea indica*, which has not been applied for this purpose so far, was used by us; according to the German botanists, it may be associated with the presence of an urban heat island. The studies have shown a high concentration of the above species in the Sandomierz city centre, which may reflect the range of the urban heat island.

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THE CAUSES OF CHANGES IN THE GEOGRAPHICAL DISTRIBUTION OF *SENECIO ERUCIFOLIUS* IN POLAND, WITH PARTICULAR EMPHASIS ON CHANGES IN THE PHYTOCENOTIC SPECTRUM

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Senecio erucifolius L. (Asteraceae) is a Eurasian rhizomatous perennial plant. It has been recorded from 137 localities in Poland but currently occurs at only 31. These are scattered across different regions in Poland with centres of distribution falling in the Lubelskie and Świętokrzyskie voivodships. My research revealed the progress of disappearing localities for *S. erucifolius* and its local extinction due to the intensification of agriculture and the associated enlargement of the cropped area. The negative impact of invasive species, such as *Solidago gigantea* and expansive *Calamagrostis epigejos*, was also observed in numerous occurrences. Of great importance was a change of use of xerothermic grasslands and meadows, which is one of the main habitats of *S. erucifolius*. The current phytocoenotic spectrum of this species in Poland was also defined. *S. erucifolius* was found in patches of eight communities of the following four classes: *Artemisietea vulgaris*, *Festuco-Brometea*, *Stellarietea mediae* and *Molinio-Arrhenatheretea*. The progress of extinction seems to confirm the analysis of the phytocenotic spectrum. *S. erucifolius* was regarded in Poland as an indicator species for the *Festuco-Brometea*. Currently, *S. erucifolius* was confirmed only few times from this class. The striking fact is that the studied species coexists in the meadow associations with a significant number of xerothermic species.

The patterns described here can be explained as a result of the process of transformation of xerothermic grasslands and adaptation of the species to changing environmental conditions observed nowadays. The existing habitat degenerates under the influence of anthropogenic pressure and *S. erucifolius* moves to neighbouring habitats with lower competition. For most of the currently confirmed localities, phytocoenoses from classes *Artemisietea vulgaris* and *Molinio-Arrhenatheretea* dominate. In the light of this new information relating to the disappearance of many populations of *S. erucifolius*, it should be included in the red list of vascular plant species endangered in Poland.

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THE IMPACT OF CLIMATE CHANGES ON THE SPECIES COMPOSITION OF XEROTHERMIC GRASSLANDS OF THE SANDOMIERZ UPLAND BASED ON THE ORIGINS OF GEOGRAPHICAL ELEMENTS OF FLORA

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The Sandomierz Upland is located in south-eastern Poland, covering an area of about 1140 km^2. According to the physicogeographical division, it is a mesoregion situated in the Małopolska Upland. The study area is suitable for cultivation of fruit and vegetables due to favourable climate and soil conditions. Mechanisation and intensification of agriculture have taken xerothermic grasslands to the brink of extinction. The aim of the study was to present the species diversity of xerothermic grasslands based on the origins of geographical elements of the flora and determine the impact of climate change on the studied habitat. The field work was carried out in 2014-2016. In order to study the distribution of xerothermic grasslands flora of the Sandomierz Upland, a cartogram method was used in accordance with methodological assumptions for ATPOL with a square of 2.5 km as the basic unit. The affiliation of a given species to a certain geographical element was determined on the basis of literature sources. During the study, about 450 vascular plant species were recorded. The flora of xerothermic grasslands of the Sandomierz Upland mainly consists of species with broad ranges of occurrence. A large group belongs to such connective elements (59% of the species) as the Holarctic-Mediterraneo-Irano-Turanian (24%) and Holarctic-Mediterranean (23%) ones. Moreover, a few species represent the Pontic-Pannonian sub-element (3). The study results showed that the climate change may contribute to diversity in species composition of xerothermic grasslands over the years.

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MODELLING THE CLIMATE AND HABITAT DRIVEN DISTRIBUTION OF BRYOPHYTES AT DIFFERENT SPATIAL SCALES

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Species distribution models (SDMs) are mathematical models describing the distribution of species within environmental (ecological) and geographical space. These models are used for biodiversity conservation in two ways: to define threatened species requirements and to predict the spread of invasive species. We aimed to model the distribution of a focal bryophyte species – *Dicranum viride* (Sull. & Lesq.) Lindb. – in Poland and in Europe and compare the ecological niches obtained by these two models. We chose *D. viride* as this easily-recognizable species is subject to Natura 2000 protection, is an ancient forest species, and furthermore may be an 'umbrella' species representing the needs of numerous bryophyte species occurring on decaying wood and in old woodlands. We used data from Global Biodiversity Information Facility, published papers and herbarium collections to collate comprehensive information about *D. viride* localities. As most species distribution data for large areas is presence-only data, we used the MaxEnt model from the dismo package, which is developed to process this type of input data. As explanatory variables we used 19 bioclimatic statistics from WorldClim database (2.5' grid), and, in the model for Poland only, data on the share of old (>100 years old) forests within the grid square. We also analyzed data about phorophyte species and collection data.

The output produced by MaxEnt is a probalistic model, which permits manipulation of the threshold of species occurrence via the Receiver-Operator Curve, and thus the restrictiveness of the model can be managed. Our model has shown the importance of bioclimatic variables and the potential distribution of this species. The results we obtained allow us to reach conclusions about the climatic requirements of *D. viride* and its potential habitats, where the species may be found or may be protected ex situ.

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CLIMATE CHANGES VS. SPECIES RANGES – RESEARCH METHODS

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Nowadays, changing climate is a hot topic. Climatic influence on ecosystems is crucial for biodiversity and also for human safety, in areas such as flood protection and food security. There are many articles addressing the problem of the impact of climate change on plant species ranges and floristic composition of plant communities. Authors often use a variety of methods, including field research, ecological experiments, palynological analyses, special programmes for species habitat modelling and assessing the potential risk of invasions (Maxent, Climex), capabilities of GIS datasets, and even genetic analyses (e.g. experiments conducted at the Buxton Climate Change Impacts Laboratory).

The aim of our study was to conduct an analysis of meta-data of these methods to show which are most popular, which are the most innovative and which are no longer in favour – without judging their effectiveness. It also attempts to compare and contrast approaches to this topic in various parts of the scientific world.

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INFLUENCE OF CHANGES INDUCED BY THE URBAN HEAT ISLAND ON THE MICROCLIMATE CONDITIONS, CONDUCTIVE TO EXISTENCE OF ISLAND COMMUNITIES

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Urban heat islands (UHIs) affect the ecology of organisms growing under their influence. We studied the urban heat island effect on pollinator visits to *Corydalis solida* (L.) Clairv. Communities of spring geophytes were studied in two forests in the city limits of Warsaw (the capital of Poland) and in Puszcza Słupecka Forest, which served as reference site. Data was collected in spring 2016. The analyses incorporated video observations with meteorological data from the period of observations. As well as the expected honey bees, many different groups of wild pollinators took part in the pollination process. We found a positive effect of the heat island (UHI) on the number of pollinator visits to flowers, with the greatest impact of temperature observed for the number of fly visits. This suggests that climatic conditions, especially temperature, are crucial for insect activity and in effect also for the existence of obligatorily cross-pollinated plant communities.

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