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Thriving on the Verges

Man-made linear structures, such as railway embankments, highway verges, and flood barriers, can serve as habitats for pollinating insects.

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Biodiversity plays a pivotal role in the provision of what are known as "ecosystem services." These include the critical function of insects in pollinating a variety of plant species, both wild and cultivated. The presence of pollinators in natural settings is vital for agricultural crop production. Every one of us benefits from the services they provide, and the importance of the pollination process, which is integral to food production, cannot be overstated. With population growth and climate change potentially leading to more frequent food access issues, the contribution of pollinating insects to food production is becoming more crucial than ever.

An estimated 78% of wild plants in temperate regions rely on animal pollination. In the European Union, the economic value of insect pollination is estimated to amount to 14 billion EUR a year. Pollinators are a crucial group of organisms in both heavily modified and natural landscapes across virtually all continents and climate zones. In Poland's geographical area, this group includes species such as bees, butterflies, and flies.

The spatial distribution of pollinators across the landscape is important for the health of the entire ecosystem. The complex relationships that have formed between pollinators and plants through co-evolution play a significant role in shaping this distribution. Important factors include the appearance and behavior of pollinators and their ability to transport pollen between different habitats.

Overlooked Areas

In our rapidly changing world, populations of pollinators face significant environmental challenges. In developed countries, the agricultural landscape is often intensely cultivated. Pollinators are found in natural or semi-natural patches of habitat, such as meadows, which are isolated from one another by fields of crops. Metapopulation theory, an important concept in biology, suggests that habitat loss and fragmentation have a detrimental impact on biodiversity. As a result, the crucial services provided by these living organisms are diminished and insufficient.

Addressing biodiversity loss by adapting landscapes to support a diverse array of species poses quite a few practical problems. Managing landscapes in agricultural settings can be costly. Moreover, the success of such initiatives varies depending on the specific organisms involved, the type of landscape, and its distinctive characteristics. One underexplored yet potentially effective approach is to leverage the overlooked advantages of existing man-made structures that form extensive networks across the landscape. These structures, including road verges, flood barriers, and railway embankments, can significantly affect the distribution of various pollinator species and enhance the ecosystem services they provide, even influencing areas far removed from one another in the surrounding landscape.

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Railway embankments are often home to many flower plants that are a source of food for pollinating insects

Unfortunately, the role of linear man-made structures in supporting pollinating insects and the ecosystem services they offer remains ill-understood. In specific, it is unclear whether we can manage these structures to tap into their potential for sustaining biodiversity, especially within human-altered landscapes. There's a research-supported view that certain linear structures, like highways, do contribute to high rates of animal mortality. Additionally, these structures can act as barriers to animal movement, leading to their often overlooked importance in influencing the distribution and proliferation of both animal and plant species across agricultural landscapes. Nevertheless, areas such as road verges and railway embankments are home to numerous species of butterflies and bees, playing a crucial role in connecting fragmented habitats at a landscape level.

Linear structures have certain characteristics that distinguish them from semi-natural habitat patches, such as their elongated shape and prevalence across landscapes. For example, steep embankments feature a dry, more sunlit area at their peak, while a more humid environment can be found at their base. The stark environmental contrasts within these linear structures can cater to species with diverse habitat needs, thereby enhancing the range of ecosystem services available. Consequently, the impact of linear structures on the distribution and spread of species may differ from what is outlined by metapopulation theory or island biogeography. These theories typically describe the movement of individuals between isolated patches of habitat. However, the unique properties of linear structures may support a very different scenario for species dispersal and settlement.

To properly grasp how linear structures influence the distribution of organisms across landscapes, further research is essential. Such studies must assess the combined effects of managing these structures

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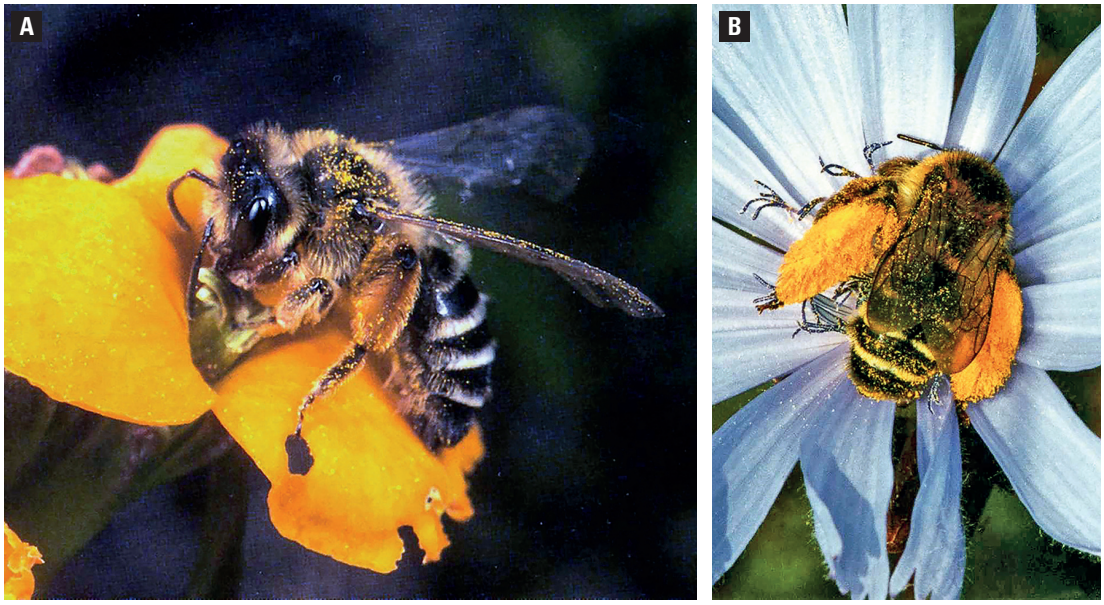

Andrena flavipes (A) and *Dasypoda altercator* (B) bees collecting pollen

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along with broader landscape management practices. This is particularly crucial given that findings from frequently studied semi-natural linear habitats (such as hedges, river valleys, and field margins) may not directly translate to the linear man-made structures under discussion here. The significance of these structures in determining species distribution is underscored by their prevalence across the agricultural regions of North America, Asia, and Europe. For instance, the European Union has over 200,000 km of railway lines, approximately 70,000 km of highways, and more than 150,000 km of flood embankments, making such constructions a ubiquitous aspect of the landscape throughout nearly all of Europe.

In Poland, linear structures – including highway and railway embankments and flood embankments, along with areas adjacent to them that are not used for agriculture – are estimated cover about 0.33% of the country's total land area. By comparison, the combined area of all Polish national parks accounts for around 1%. The elongated nature of these structures means they create extensive habitats that can span many kilometers, even extending continent-wide, which is a stark contrast to the fragmented semi-natural habitats found within agricultural landscapes.

Key considerations

Given these factors, the management of linear structures and the surrounding landscape is of great importance. The way in which the landscape is managed can significantly influence species distribution and the ecosystem services they provide along the length of such structures. For instance, intensive management practices, such as frequent mowing or the application of herbicides, can adversely affect these processes. Conversely, less intensive management of agricultural land, characterized by a low percentage of tillable land and a greater diversity of habitats, might diminish the role of linear structures in species distribution and the provision of ecosystem services. In such scenarios, habitat patches are less isolated, reducing the pressure for insects to seek out alternative areas.

In conclusion, research on linear structures is crucial for understanding their effect on pollinators and the ecosystem services they offer. This complex approach requires multiple biological theories to be taken into consideration, addressing questions such as: How do species characteristics, population dynamics, and landscape appearance affect organism distribution? In what situations do landscape structures significantly influence distribution and population density? How can linear structures enhance biodiversity and ecosystem services over the long term?

The rapid pace and global scope of environmental change presents significant challenges for ecologists, necessitating a continual reevaluation of theoretical foundations and management practices in nature conservation. Such research needs to integrate fundamental ecological concepts related to species distribution with a focus on societal and economic benefits, namely the provision of ecosystem services – an approach that has not yet been widely adopted.

Understanding the role of man-made linear structures in shaping biodiversity will be instrumental in safeguarding numerous pollinator species.

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