

Summary

The railway network with associated train traffic has a number of well described negative effects on biodiversity, for example loss of natural habitat, barrier and mortality effects, noise disturbance, changes in hydrology, and an increasing fragmentation. However, railway areas such as rail yards, embankments and verges may also provide habitat for many plant and animal species, some of which are rare and endangered while others are invasive aliens. The importance of railway habitats for plant and animal conservation has been acknowledged rather recently, and there are yet much to learn about the ecology of these areas, including their history, ecological functions, and the threats to, prospects for, and management of species of particular importance. The aim of this article is to give an overview of the diversity of species and habitats in Swedish railway areas, suggest a conceptual theory of how these species link to the pre-industrial landscape, describe current goals for and management of railway habitats, and point out the need for future research in the field.

Many railway areas in Sweden are characterized by a small-scale habitat mosaic, including micro niches, where species of plants, insects and other invertebrates thrive. Sandy soils and regular vegetation management create dry and sun-exposed "mini steppes" favoring low-growth plants and specialized insects that otherwise have problems surviving in the modern landscape. Frequent disturbances to the ground and soil, caused by a range of human activities, result in ruderal habitats, not least in stations and rail yards where vegetation can be found in various early successional stages. Stands of flowering plants such as blueweed, bluebells, legumes and hawkweeds constitute nectar and pollen resources and host plants for a range of beetles, bees, bugs and butterflies. Patches of bare soil create habitat for nest digging bees and ground-living carabid beetles. Objects such as solitary trees or rose shrubs, stone walls, older wood constructions and wood piles provide substrate for many lichen and insect species and may therefore also be of conservation value.

Seeds and invertebrates dispersing along railway verges and hitch-hiking with vehicles further contribute to the variety of species.

During assessments of species (selected taxa) and habitats in 747 Swedish rail yards and stations in 2008-2018, a total of ca 2,700 species were recorded, of which 123 species are red-listed. Some 40% of the recorded species could be labelled *railway associated*, meaning that they significantly benefit from and contribute to the railway habitats, but are also found in similar habitats elsewhere in the landscape. Some 3% of the species are *railway bound*, meaning that they depend on railway habitats and are largely lacking in other areas. A total of 237 of the rail yards and stations were classified as *species rich*, i.e. with records of species of particular importance or with the right conditions for such species. This classification can serve to point out railway areas for special conservation action.

Species favored by dry and warm conditions (referred to as xerothermophilic) can be assumed to have evolved in natural steppe or ruderal grassland. Such species found new niches and spread to new areas in the historical agricultural landscape. In Sweden before industrialization, the agricultural landscape was dominated by grasslands required to feed large stocks of domestic animals, many forests were sparse and semi-open, soils were emaciated, and frequent human and livestock activities in the landscape such as trampling, digging, cutting etc. mimicked natural disturbance regimes. With the industrialization, in the late 19th and early 20th century, the landscape started undergoing large changes and the conditions diminished for the many species linked to open, dry grasslands. However, in the same period the national railway network was established, and many of the species found recourse in railway areas, which again provided conditions resembling natural habitats and ecological processes. The railway network reached through a landscape of grasslands, villages and farms, and species could easily spread into their new habitats. While sparse and sometimes declining, the xero-



*Rigt blomsterflor ved Norberg i det sydlige Dalarna, 2019
(foto: Tommy Lennartsson).*

thermophilic species and the sandy, ruderal grasslands found in railway areas could be considered a biological heritage from the pre-industrial landscape. Still today the railway verges may serve as ecological corridors that functionally connect remnant habitats. Railway areas provide a combination of ancient and new conditions for biodiversity and may form an ecological bridge in both time and space – thereby being part of the landscape's green infrastructure.

The Swedish Transport Administration, the authority in charge of the management of railway areas, currently acknowledges the significance of species conservation in railway habitats, and state in their regulatory documents that species rich railway habitats should be maintained and if possible created, in order to strengthen the green infrastructure and to avoid habitat loss. Efforts are made to adapt the current railway maintenance, to build knowledge, and enable research and experimental management, to reach this goal.

Possible adaptations of regular vegetation maintenance in railway areas may include i) postponed vegetation cutting, ii) cutting targeted to certain areas, iii) control of alien invasive species, iv) removal of cutting mulch, v) controlled burning and iv) livestock grazing. Other examples of management actions to benefit species conservation in railway areas are i) ground scarification, ii) providing open sand, iii) uprooting of woody shrub, iv) seeding with desired species such as host plants or nectar and pollen plants for insects. Also regional railway managers, as well as nature conservation authorities and NGOs, should take part in this endeavor, to help prioritizing the efforts and set them in relation to conservation efforts in the surrounding landscape.

The toolbox for railway habitat management needs development. Any adapted management measures should be carefully monitored, in order to build knowledge about their conservation potential and their cost-effectiveness. We also need a better general understanding of the ecology of railway habitats and of the threats to their conservation. However, already the current level of knowledge vouch for immediate action, at selected sites in the existing railway network and in all railway (re-)construction projects.