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Mixed forest stands better resist insect pests

As a result of climate change, insect pests are causing ever greater levels of damage to forests in Europe and other temperate regions of the world. To explore how tree diversity affects forest resistance to insect pests, researchers at INRAE and CSIC (*Misión Biológica de Galicia*, Spain) performed a meta-analysis using data from more than 600 case studies published between 1966 and 2019. It is the most comprehensive study of its kind to date. Published September 16 in the Annual Review of Entomology, the study's results show that mixed forest stands, which are composed of multiple tree species, are better at resisting the attacks of most herbivorous insects. On average, such stands experienced 20% less damage than did pure forest stands, which are monocultures. This work lays the foundation for future research on forest management strategies that better limit the impacts of insect pests.

Forests play a crucial role in preserving biodiversity and tempering the effects of climate change. They are also a major source of natural materials, such as wood. Over recent years, the damage done to forests by pests such as defoliating insects or bark beetles, among other groups, has greatly accelerated because of the spread of invasive species and the effects of climate change, notably increased temperatures and drought frequencies. Research in forest ecology over the past 50 years has often found that insect pests have less pronounced impacts in mixed forest stands, composed of several tree species, than in pure forest stands, characterised by monocultures. This phenomenon has been named associational resistance. To test for the broader occurrence of associational resistance and to understand its underlying mechanisms, researchers analysed data from 624 case studies published between 1966 and 2019 documenting the effects of herbivorous insects on pure versus mixed forest stands. They identified the ecological mechanisms underpinning associational resistance and proposed strategies for designing mixed-tree plantations that are less vulnerable to insect pests.

Disorienting insect pests and promoting predator presence

The study's findings confirm that mixed forest stands better resist insect pests and experience approximately 20% less damage than pure forest stands. This result reflects the interactions that take place between trees and insects. Herbivorous insects, and especially specialist species, tend to target specific tree species. These tree species are their hosts, which the insects seek out when feeding and laying their eggs. In mixed forest stands, a variety of olfactory and visual signals are emitted by the diverse tree species present, which can confound insects in their search for their host's signal. Furthermore, mixed forest stands attract a range of predator species, such as birds, bats, and spiders. They naturally prey upon insects, helping to control pest populations.

Choosing effective tree associations

To boost associational resistance to herbivorous insects, tree species identity is more important than tree species number. Indeed, it is critical that mixed forest stands contain tree species with contrasting functional ecologies. For example, it is rare for insect pests to attack both broad-leaf and conifer species. As a result, it is more effective to combine a broad-leaf species with a

conifer species than to combine two conifer species. Finally, the researchers have suggested that the protection provided by associational resistance in mixed forest stands is even more crucial when insect pests are abundant.

These findings have clear applications for forest management. Pure forest stands should thus be avoided because they are more vulnerable to insect pests. It is also important to maximise associational resistance, which can be done by mixing broad-leaf and conifer species, for instance. Indeed, research is currently exploring forest management strategies for evaluating the level of pest protection provided by such species combinations. Other work is examining techniques for managing mixed forest stands composed of species with different growth rates and needs.

Reference:

Hervé Jactel, Xoaquín Moreira, and Bastien Castagnerol. Tree Diversity and Forest Resistance to Insect Pests: Patterns, Mechanisms and Prospects. *Annual Review of Entomology*: 66: 14.1–14.20. Advance online publication: September 8, 2020. Print publication: January 2021.
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