



HAL
open science

Surviving in Changing Forests: Abiotic Disturbance Legacy Effects on Arthropod Communities of Temperate Forests

Jérémy Cours, C. Bouget, N. Barsoum, J. Horák, E. Le Souchu, A. Leverkus, S. Pincebourde, S. Thorn, Aurélien Sallé

► To cite this version:

Jérémy Cours, C. Bouget, N. Barsoum, J. Horák, E. Le Souchu, et al.. Surviving in Changing Forests: Abiotic Disturbance Legacy Effects on Arthropod Communities of Temperate Forests. *Current Forestry Reports*, 2023, 9 (4), pp.189-218. 10.1007/s40725-023-00187-0 . hal-04158713

HAL Id: hal-04158713

<https://hal.science/hal-04158713v1>

Submitted on 7 Jun 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Surviving in Changing Forests: Abiotic Disturbance Legacy Effects on Arthropod Communities of Temperate Forests

J. Cours ^{1,2,3}, C. Bouget ¹, N. Barsoum⁴, J. Horák ^{5,6}, E. Le Souchu ⁷, A. B. Leverkus ⁸, S. Pincebourde ⁹, S. Thorn ¹⁰, and A. Sallé* ⁷

¹INRAE, UR EFNO, Domaine des Barres, 45290, Nogent-Sur-Vernisson, France

²Department of Biological and Environmental Science, University of Jyväskylä, Jyväskylä, Finland

³School of Resource Wisdom, University of Jyväskylä, Jyväskylä, Finland

⁴Forest Research, Alice Holt Lodge, Farnham, GU10 4LH, Surrey, UK

⁵Faculty of Forestry and Wood Sciences, Department of Forest Protection and Entomology, Czech University of Life Sciences Prague, Kamýcká 1176, 165 21, Prague, Czech Republic

⁶Faculty of Science, University of Hradec Králové, Rokitanského 62, 500 03, Hradec Králové, Czech Republic

⁷Laboratoire de Biologie des Ligneux et des Grandes Cultures, INRAE, Université d'Orléans, 45067, Orléans, France

⁸Department of Ecology, University of Granada, Granada, Spain

⁹Institut de Recherche Sur la Biologie de L'Insecte, UMR 7261, CNRS, Université de Tours, 37200, Tours, France

¹⁰Hessian Agency for Nature Conservation, Environment and Geology, Biodiversity Center, Europastrasse 10, 35394, Giessen, Germany

* corresponding author: aurelien.salle@univ-orleans.fr

Published in *Current Forestry Report*, 2023

This article is part of the Topical Collection on *Forest Entomology*

Abstract

Purpose of Review

The increasing impact of droughts, wildfires and windstorms in temperate areas poses a significant challenge to the adaptation capacity of forests and their associated arthropod communities. Organisms, organic material, and environmental conditions occurring after disturbances, i.e. the disturbance legacies, shape arthropod communities during their transition from pre- to post-disturbance conditions. We describe the contribution of disturbance legacies to the organization of forest arthropod communities following droughts, wildfires, or windstorms. We also highlight how forest conditions, arthropod traits and post-disturbance management influence disturbance legacies and their impact on arthropod communities.

Recent Findings

Key disturbance legacies include surviving arthropods, micro-environmental legacies, and tree- and ground-related resources. Most of these are driven by canopy openness and tree condition. For arthropods, dispersal ability and other biological and demographic traits determine their vulnerability to disturbances, but also their capacity to colonize post-disturbance microhabitats, and withstand micro-environmental legacies. Dominant tree species and management strategies influence disturbance regimes and mediate the pattern of their legacies. Droughts, wildfires and windstorms have idiosyncratic effects on disturbance legacies, and arthropod taxa can have specific responses to legacies, making it difficult to predict the likely composition of post-disturbance arthropod communities.

Summary

This review highlights a particular gap in our understanding of the effects of drought on forest arthropod communities and the need for more research in this area. In addition, a better understanding of how forest arthropod communities are altered by changes in disturbance regimes is urgently needed. Our goal is to foster an improved understanding of the role of disturbance legacies for forest arthropod communities in order to improve management decisions and promote the conservation of forest arthropod species.

Keywords: Drought; Wildfire; Windstorm; Forest management; Microclimate; Trophic resources

1 Introduction

Major abiotic disturbances in temperate forests worldwide include droughts [127, 332, 330], windstorms [131, 114, 331], and wildfires [114, 331, 97]. Climate and land-use changes have increased the incidence and the ecological consequences of these three disturbances across large areas over the last three decades [329, 236, 333, 75]. The frequency, magnitude and intensity (which define the disturbance regime) of droughts, windstorms and wildfires are predicted to increase further in temperate regions with global warming [327, 315, 342], thereby challenging the acclimation and adaptation capacities of temperate forests and their associated communities [236, 3, 368].

Droughts, windstorms and wildfires alter the physical characteristics of forest ecosystems in several ways, including the availability of water and nutrients [116, 328, 341], and the forest microclimate [87, 183]. Likewise, they affect key biotic elements such as the distribution and structural architecture of surviving trees and shrubs, the quantity and viability of their propagules, and decomposer and tree symbiont communities [116, 353, 226]. This in turn affects a whole host of forest features such as soil and litter conditions, canopy and understory cover and the availability and distribution of microhabitats [116, 183, 165, 314]. As a consequence, forest biodiversity also undergoes significant changes [359, 388].

Arthropods make up the majority of biodiversity on Earth [298]. This makes them a particularly relevant taxonomic group to consider when seeking to better understand and predict the consequences of droughts, windstorms and wildfires on forest biodiversity and ecosystem functioning. Arthropods are: (i) major

components of forest biodiversity across multiple strata (i.e. canopy, sub-canopy, forest floor and soil; 298, 396), (ii) important food sources for forest-associated species and vital components of complex trophic webs, (iii) key contributors to vital forest ecosystem functions (i.e. pollination, decomposition, biological control of pests and diseases), and (iv) hyper-diverse, displaying significant variation in traits that are reflected in wide-ranging levels of susceptibility to the direct and indirect effects of disturbances (e.g., 103, 89). In addition, they can (v) cause disturbance feedback effects (e.g., outbreaks of opportunistic pests; 329) and (vi) show rapid responses to disturbance-mediated changes.

Understanding the responses of forest arthropod communities to droughts, windstorms and wildfires is necessary in order to anticipate likely arthropod-induced feedback effects on forest ecosystem structures and processes. This knowledge is crucial to identify management options that may curb any negative feedback effects, especially in a context of changing disturbance regime. An improved understanding is also needed to deliver effective arthropod conservation actions and strategies, considering that arthropods are currently in global decline [141]. We lack a comprehensive overview of the responses of arthropod communities to key abiotic disturbances in temperate forests [359, 388••]. We strive, in this review, to fill this gap and seeking to gain improved insights by considering responses of arthropod communities through the lens of disturbance legacies.

Disturbance legacies can be defined as the post-disturbance physical and biological state of an ecosystem [116, 167]. An example of a disturbance legacy is a physical shelter created during a windstorm or a fire which serves to protect organisms and their propagules from the harmful effects of subsequent disturbances [353, 233, 235]. Disturbance legacies are defined by the amount, availability and diversity of resources and microhabitats left behind following a disturbance [314•, 364, 79]. They are key filters that define how arthropod communities are shaped as they transition from pre-disturbance to post-disturbance communities [116, 353, 293•].

Several factors can modulate the nature, amount and spatio-temporal distribution of disturbance legacies, and ultimately the effects they have on the composition and structure of post-disturbance arthropod communities. A prominent factor is the disturbance regime, as it dramatically affects the amount, distribution and diversity of disturbance legacies [293•, 66, 192]. Other factors include pre-disturbance forest characteristics such as forest stage of development and the taxonomic, functional and phylogenetic diversity of resident tree species. These are themselves influenced by forest management strategies and past disturbances (Fig. 1; 167, 192, 374, 212, 218). Intrinsic traits of forest arthropod communities can also modulate their ability to tolerate disturbances and to exploit the resulting legacies (Fig. 1; 377, 25). Finally, post-disturbance management can markedly modify disturbance legacies (Fig. 1; e.g., dead wood clearance), and consequently, post-disturbance arthropod communities [215, 259, 369].

Our primary aim is to highlight the key roles of disturbance legacies originating from droughts, windstorms and wildfires in shaping arthropod communities in temperate forests. We also consider the contribution of various intensities and methods of both pre- and post-disturbance forest management as an additional filter shaping post-disturbance arthropod communities. Our review is organized into four sections. We first introduce key disturbance legacies associated with droughts, windstorms and wildfires that have a role in shaping forest arthropod communities and explore how each of these disturbance regimes might affect these

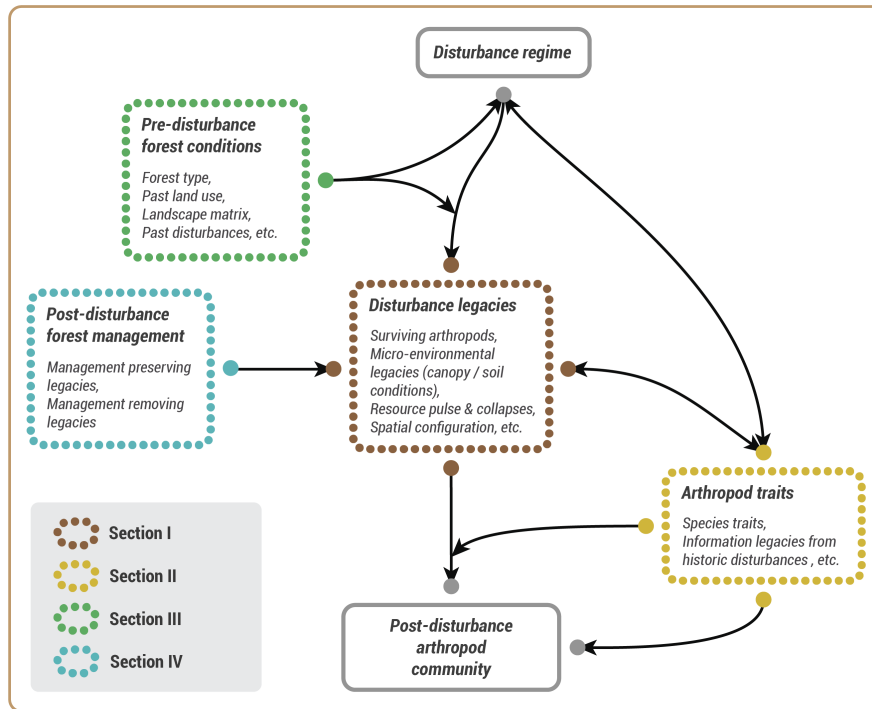


Figure 1: General structure of this review, with factors affecting disturbance legacies and their exploitation by forest arthropod communities

legacies. Secondly, we describe how pre-disturbance conditions at tree, stand and landscape scales can affect the nature, distribution and diversity of disturbance legacies. In a third section, we seek to identify the key arthropod traits that influence how arthropods interact with and respond to disturbance legacies. In a final section, we evaluate how post-disturbance management strategies can exacerbate or alleviate disturbance impacts on arthropod communities. We conclude by identifying key knowledge gaps and propose a number of future research directions.

2 Key Drought, Wildfire and Windstorm Disturbance Legacies Influencing Arthropod Communities

Disturbance legacies are a combination of material and information legacies [167]. Material legacies are the biologically-derived materials left in the wake of disturbances, which include surviving individuals, but also the resources and microhabitats available for arthropods (*sensu* 167). Information legacies are ecological traits filtered by the selective pressures exerted by previous disturbances (*sensu* 167).

Droughts, windstorms and wildfires have many similar but also idiosyncratic effects on forest ecosystems, and each type of disturbance can generate a specific set of both material and information legacies for arthropods. Here we describe key disturbance legacies for arthropods and how they specifically influence arthropod communities. These legacies include surviving organisms (including arthropods), micro-environmental conditions, and spatiotemporal dynamics of key resources at local and landscape scales (Fig. 2). How arthropod communities respond to legacies, and how arthropod traits modulate their responses, is detailed in

"Key Drought, Wildfire and Windstorm Disturbance Legacies Influencing Arthropod Communities" section.

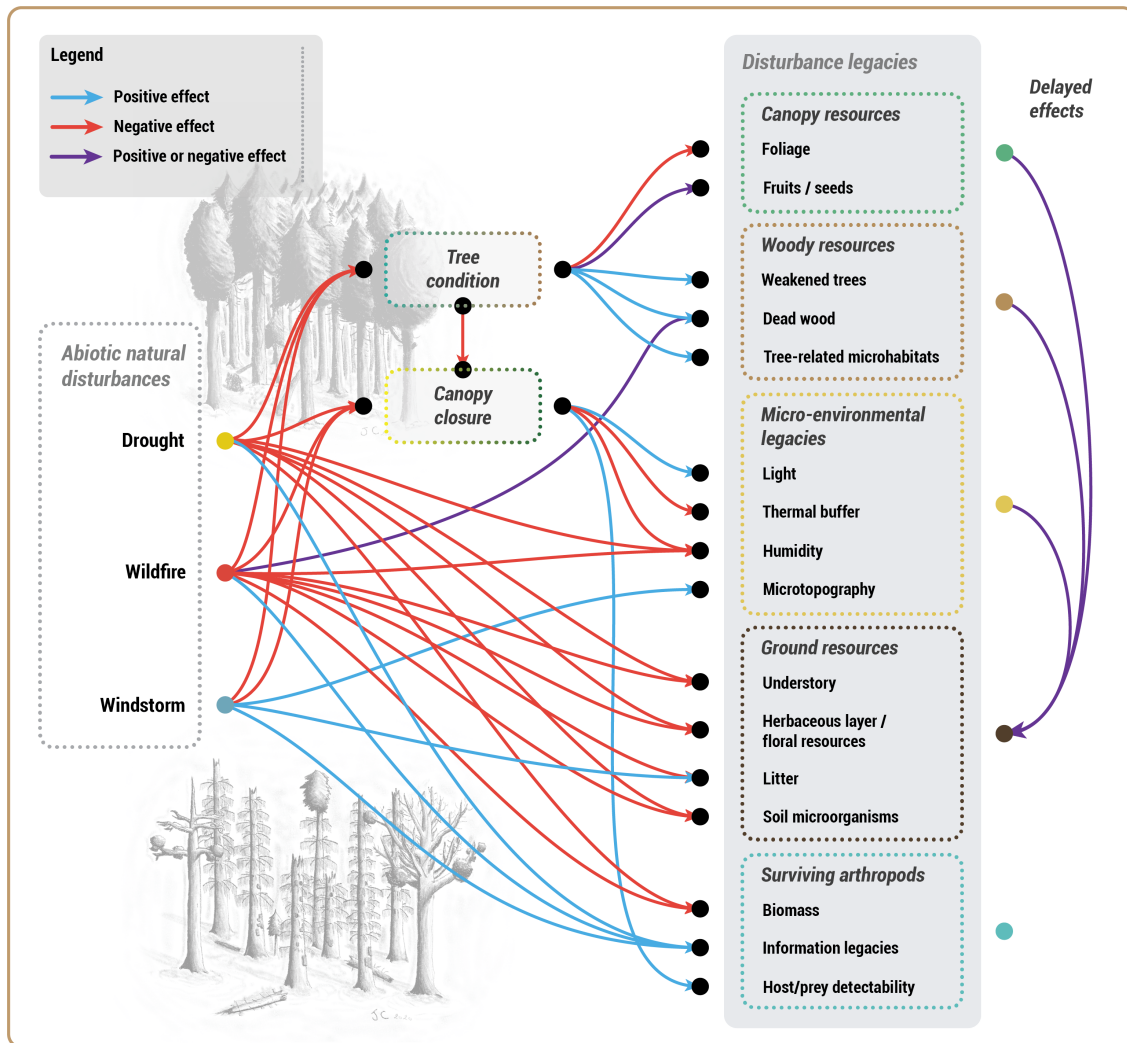


Figure 2: *Effects of droughts, wildfires and windstorms on key disturbance legacies for forest arthropods. Effects can be both direct and indirect through disturbance impacts on tree condition and canopy closure. Some disturbance legacies can also have delayed effects on ground resources. For instance, changes in microclimatic conditions (brighter and warmer conditions) can subsequently enhance the herbaceous layer and floral resources. In general, effects can be positive, negative or both, depending on the context*

2.1 *Surviving Arthropods*

Large forest disturbances negatively affect populations of many organisms (Fig. 2). Wildfires can cause massive arthropod mortality, and even lead to local extinctions [399, 254]. Windstorms and droughts are less lethal but can severely disrupt the structure of above- and belowground arthropod communities and the structure of forest food webs [213, 124, 275, 395, 171]. Eggs, larvae, pupae, and the adults that survive constitute a major disturbance legacy, and their capacity to survive and subsequently reproduce in the disturbed landscape determines the composition of the post-disturbance community, until immigration takes effect (e.g., 40, 291, 129). Some taxa of surviving arthropods may serve as prey for non-arthropod

species, but are also a key resource across various arthropod trophic guilds (i.e. among predatory, parasite and parasitoid species). Disturbances exert strong selective pressures, promoting information legacies in arthropod communities related to survival and colonization processes (see section 2; Fig. 2).

2.2 **Micro-Environmental Legacies**

Due to their small body size, fine microscales are more relevant to most arthropods than meso- or macroscales [283]. Within forest ecosystems, the canopy, ground vegetation and surface soil layers are key compartments that provide a wide array of resources and microhabitats for a significant proportion of forest arthropods [349]. These compartments can be significantly altered by direct impacts of droughts, wildfires and windstorms (Fig. 2; 243, 38, 250). Canopy structure can be further altered by subsequent tree dieback or decline (Fig. 2; 314•, 310, 13, 20). This increases canopy openness, which is a major determinant of disturbance-mediated effects on arthropod communities. A reduction in canopy cover has a considerable effect on microclimates from the ground level to the upper canopy layer. The higher insolation produces warmer microclimates (e.g., warmer soil surfaces, warmer understory), and a reduced environmental buffer thereby exposing the forest understory to temperature extremes (Fig. 2; 183, 1, 401). Among and within deadwood logs and stumps, sun-exposure increases microclimatic heterogeneity (temperature and moisture), promoting saproxylic beetle species richness at the stand scale [323, 205•]. At the same time, higher insolation can also negatively affect leaf litter arthropods that are sensitive to temperature extremes [139].

Droughts, wildfires and windstorms can have contrasting effects on soil conditions (Fig. 2; 81). For instance, wildfires can entirely remove the litter layer and some portions of the upper organic horizon [65]. This can affect soil biochemical properties, alter soil texture and reduce soil permeability [65, 64, 262, 35]. Windstorms, on the other hand, generally increase the litter cover and add woody debris [104, 392]. The pit-and-mound topography and root plates of uprooted trees in windthrown stands can cause small-scale gradients in soil moisture, temperature and litter accumulation [31]. This provides refuge areas where many arthropod species are comparatively safe from desiccation compared with areas of the forest floor under canopy gaps [388••, 365]. Droughts reduce soil water films and increase soil hardness, which could impede the movement of soil fauna [81]. Disturbance-driven changes in micro-environmental conditions can in turn impact the development, survival and behaviour of ground- and canopy-dwelling arthropods, and ultimately the composition and structure of their community [314•, 388••, 385, 278], but see below (section 2).

2.3 **Resource Pulses and Collapses**

Disturbances affect the diversity and the amount of resources available to arthropods. In this regard, the timeframe of disturbance effects is important to consider as both the amplitude and direction of resource fluctuations can vary over time (Fig. 2, Table 1; e.g., 288, 15). Some resources may suddenly collapse or increase at the onset of a disturbance (e.g., deadwood after a windstorm), while the temporal dynamics of other habitats and resources may be subject to a timelag and can vary considerably.

Table 1: *Effects of drought on trophic resource and microhabitat availability considering immediate, short-term (weeks/months) and delayed (years/decades) effects. TreMs: tree-related microhabitats*

Habitat / resource	Drought effects		
	Immediate	Short-term (< 1 year)	Delayed (1 year +)*
TreMs	(0/+): cavitation can generate dry branches	(+): Partial branch mortality triggers an accumulation of dead wood in the canopy. Tree mortality can occur under severe water constraint and the resulting snags can accumulate diverse TreMs. TreMs associated with living trees may decrease	(+): There can be a lag in drought legacy effects over several years causing progressive tree decline and mortality resulting in an accumulation of TreMs in the canopy and on the trunk (dead branches, loose bark and bark cracks, cavities, etc.). TreMs associated with living trees may decrease
Foliage	(-): premature leaf shedding occurs during severe droughts	Canopy layer (-): (i) partial branch death reduces foliage abundance; (ii) decreased C allocation to non-perennial organs reduces the amounts of buds and foliage Herbaceous / shrub layer (\pm): increased canopy openness can favor ground vegetation regeneration and growth but this can also lead to more exposed conditions (e.g., higher temperatures, lower soil moisture)	Canopy layer (0/-): (i) gradual increase in dead branches progressively reduces foliage abundance and leads to increased canopy openness; (ii) decreased C allocation to non-perennial organs reduces the amounts of buds and foliage. Resilient trees may compensate crown degradation by forming epicormic shoots Herbaceous / shrub layer (\pm): increased canopy openness can favor ground vegetation regeneration and growth, but this can also lead to more exposed conditions (e.g., higher temperatures, lower soil moisture)
Fruit and seeds	(0/+): premature abscission or fruit abortion can occur during severe summer droughts	Canopy layer (0/+): large mast events can occur following droughts Herbaceous / shrub layer (+): Increased canopy openness can promote floral resources	Canopy layer (-): (i) fewer branches reduces the number of reproductive structures; (ii) C allocation to perennial organs reduces the size and abundance of reproductive organs Herbaceous / shrub layer (+): Increased canopy openness can promote floral resources in ground vegetation

* variable according to stand resilience. Here it is considered that the expected repeated droughts will compromise tree recovery

Some resources can be markedly reduced or locally depleted as a direct consequence of a disturbance. For example, degraded canopies provide less foliage for herbivorous species [314•]. Similarly, flowers and fruits may abort during a drought [108, 263] and, over longer time scales, weakened trees produce less reproductive organs (Fig. 2, Table 1; 123). Nonetheless, large mast events occasionally occur following disturbances [9, 381, 382, 223], and may provide a pulse of flowers, fruits and seeds that remain hardly predictable. Abiotic disturbances may also alter host plant tissue nutritional content and/or levels of defensive compounds, which in turn can alter host plant resistance to phytophagous insects [124, 300, 152, 158, 69]. In this regard, the immediate and short-term effects of drought have been investigated in several tree species, and the outcomes largely depend on drought severity and duration [124, 152, 158]. Similar modifications probably occur over long-time scales in declining trees, although evidence is lacking [314•]. The pulse in soil nutrient availability following fire may also affect several leaf traits of surviving trees, including leaf mass per area and levels of nitrogen or non-structural carbohydrates [300, 69]. However, Rieske et al. [300] did not observe cascading effects of fire-induced changes in foliage quality on the performance of defoliators. Overall, the quantitative and qualitative fluctuations of these canopy-related resources during decline and dieback processes have been poorly documented [314•, 157].

The reduction of canopy cover stimulates successional dynamics and provides colonization opportunities for early successional and thermophilous plant species [72, 280, 93]. Depending on disturbance type, spatial extent and severity, the change in canopy cover could be important also for late-successional and shade-tolerant species [66, 373, 224]. As a result, windstorms and wildfires may promote plant species richness in the herbaceous layer, but have contrasting effects on plant functional diversity and traits [373, 224, 48, 86, 52], with cascading effects on arthropod communities. For instance, canopy opening can increase ground-related floral resources available for pollinators [48, 305]. This is however a rather short-lived resource pulse, as a few years after disturbance, floral resources tend to decline [288]. In addition, increased canopy openness accelerates decomposition and could provide a pulse of microbial resources and nutrients for soil arthropods [309, 277].

On the ground, wildfires can consume large patches of the litter and superficial organic horizon [64, 88], leaving a charred biomass with altered biochemical properties for long periods [35, 91]. This can profoundly alter the microhabitats and trophic resources for soil-dwelling arthropods, but also for other forest arthropods occupying the forest floor [387]. Wildfires can, however, improve the amount and diversity of ground-nesting sites for some arthropods [48]. The immediate consequences of wildfires on soil microorganisms are a decrease in abundance, biomass and richness, and an alteration of their community structure [15, 290]. Likewise, drought adversely affects microbial communities in forest soils, at least over short time scales [213, 275, 18, 317]. This can be expected to have negative consequences for soil-dwelling arthropods since they rely on soil microorganisms as key food source [275, 285]. However, responses of the soil microbial community can also be complex. Responses may be positive, negative and of varying amplitude, when considering longer time periods following a disturbance [15, 220].

Disturbances may lead to transient increases of resources which are traditionally scarce in managed forest ecosystems, and thus, enhance the structural heterogeneity of the ecosystem [314•, 334, 195, 241]. One of the best examples is the accumulation and diversification of deadwood resources (Fig. 2). Droughts and

windstorms promote the accumulation of fallen twigs, branches, stems, uprooted trees and logs on the ground, perched dead branches in the canopy and snags [353, 79, 366]. Another important factor driving arthropod communities is tree-related microhabitats (TreMs; Fig. 2). Canopy openness and compromised tree health can promote the formation of TreMs such as bark scratches, bark cracks, loose bark, mistletoe, and dead branches [264, 190•, 201•]. Snags also offer more TreMs than living trees [267, 8]. As a result, disturbances can significantly affect the abundance and types of available TreMs, thereby generating legacies that could have positive consequences for arthropod species associated with these microhabitats (see below). Disturbances may also occasionally generate very particular substrates and environmental conditions, promoting atypical arthropod communities. For instance, wildfires can produce large amounts of sun-exposed charred deadwood, yielding to specific communities of "burn-associated" saproxylic beetles (e.g., in boreal forests 28). Following disturbances, fallen and weakened trees also constitute a major pulse of suitable breeding substrates for opportunistic pest species [314•, 268, 184, 176]. Similarly, disturbances may favor particular arthropod communities through the process of landscape complementation by spatially combining several habitats occupied by different life stages, e.g. wood-eating larvae with flower-visiting adults [31]. Together with contrasting survival among species, and micro-environmental legacies, resource pulses and collapses contribute to the structural complexity of forest ecosystems over several spatial and temporal scales [192, 157, 241, 321]. This increases the variability of available niches at different ecological scales, changes inter-specific interactions, creates colonization opportunities for novel species and can be major drivers of post-disturbance community structure for arthropods [293•, 157, 149, 378•].

2.4 Composition, Organization and Spatial Patterns of Disturbance Refugia

Disturbances generally do not affect forests uniformly at the landscape scale. They create a mosaic of affected and unaffected habitats of varying ratio depending on the disturbance regime [321]. Forest patches that are not or only minimally affected by disturbances are called disturbance refugia [192, 53]. Depending on the disturbance regime, disturbance refugia can resemble unaffected islands within a disturbed landscape matrix, but they can also be more diffuse and less clearly delineated [192, 375, 238]. These refugia constitute reservoirs of genetic diversity and propagules from pre-disturbance communities, from which recolonization of disturbed areas can take place [192, 238, 326, 301]. They can also provide resources, suitable microhabitats and micro-environments in an otherwise hostile environment for survivors of the disturbance [192, 238, 301]. In this regard, the spatial pattern of disturbance refugia can be a key driver of forest ecosystem resilience. The spatial distribution of disturbance legacies affects whether post-disturbance arthropod communities stem primarily from recolonization processes, or from survivors. Disturbance refugia also contribute to the spatial heterogeneity at the landscape scale, especially if refugia and the disturbed landscape matrix follow different recovery pathways [238].

2.5 Disturbance Regimes and Disturbance Legacies

Disturbance regimes partly define the type, amount and diversity of legacies that commonly occur in an ecosystem. For instance, the intensity and duration of a disturbance drive its impacts on the number of

surviving arthropods, the amplitude of deadwood resource pulses, the impact on soil conditions, and the size of canopy gaps (e.g., 387, 340, 21). Likewise, the spatial extent of disturbances influences (micro-)environmental conditions, and the spatial distribution of refugia in the landscape [372]. Equally, disturbance frequency will affect information legacies. Recurrent disturbances leave evolutionary imprints on communities. Pyrophilous plants and arthropods in fire-prone ecosystems are examples of disturbance-adapted species that improve the ecosystem resilience and resistance capacity of forest communities [178, 273]. Therefore, disturbances can be the catalysts that stimulate adaptation of forest organisms to environmental changes [93, 361].

Through disturbance legacies, successive disturbances can interact and have antagonistic, synergistic or additive effects (e.g., see section 2.2; 329, 193, 219). In this context, legacies from one disturbance can modify ecosystem resistance and resilience to a second disturbance [268, 336, 45, 56]. For example, the pulse of deadwood and litter resources on the ground following a windstorm can promote the spread of subsequent wildfires [261, 94]. Likewise, windstorms may reduce mature tree density and seed production, and consequently delay the recovery following a subsequent wildfire [46]. Severe wildfires can hinder tree regeneration by reducing seed availability thereby altering microclimate and increasing the risk of drought impacts on seed establishment [84]. Successive disturbance events can also generate unusual legacies. For example, disturbance legacies of forests subjects to repeat burns are composed of lower volumes of deadwood, with altered physical and biochemical characteristics, compared with forests burned only once [95].

Changes in climate and silvicultural practices are currently affecting natural disturbance regimes, which are diverging from historical disturbance regimes [131, 315, 83], sometimes leading to so-called "mega-disturbances" [345]. These more frequent, severe and spatially extended droughts, wildfires and storms produce novel types and amounts of disturbance legacies [114, 167]. For instance, increases in the frequency and severity of wildfires can reduce the amount of dead wood and the density of resprouting plants. These changes in available resource can alter the composition of saproxylic beetle communities, potentially lowering diversity and evenness [95, 102, 357].

Changing drought or wildfire regimes can also lead to major ecosystem reorganization through plant community replacement [19, 166, 168, 133]. An example of this is when there is an increase in fire frequency in fire prone ecosystems. This can reduce resilience since serotinous trees can be burnt before reaching sexual maturity and therefore, regeneration is impeded [177, 47, 138]. Ultimately, these regime shifts can disrupt ecological trajectories [84]. In some cases, this may lead to a shift from forests to grassland [345, 19]. These profound ecological changes can occur from the microscale [87] to the landscape scale [50, 376].

3 Forest Arthropod Responses to Disturbance Legacies

3.1 Key Traits of Arthropod Communities Driving Their Responses to Disturbances

Responses to disturbance can be grouped into general strategies according to life-history traits that facilitate population recovery and persistence despite (or because of) disturbance [307]. These strategies include: (i) *invaders* as opportunistic species, taking advantage of disturbance legacies and colonizing recently disturbed areas; (ii) *evaders* that rely on specialized strategies to "get around" the disturbance, being able to immediately re-establish post-disturbance populations; (iii) *resisters* that survive the disturbance itself, using specialized

mechanisms to withstand direct, disturbance-induced mortality, or to recover after the disturbance event (e.g., survivors, see section 1) and (iv) *avoiders* which include species that are not considered to be disturbance-adapted and are only found in late successional stages. In this section we review the traits and strategies by which these four categories of organisms (i) increase their survival to disturbance, (ii) re-colonize and/or exploit spatial refugia, (iii) exploit novel micro-environmental legacies associated with disturbances, and (iv) make use of the pulse and collapse of resources.

3.1.1 Traits Aiding Survival to the Direct Effects of Abiotic Disturbances

Many "resisters" occupy micro-environments that can act as refugia for at least part of their life cycle; e.g. within plant tissues or plant shelters [377, 40, 351, 304], or in patches that remain unaffected by the disturbance (i.e. disturbance refugia; 192). For instance, arthropods that have the capacity to use deeper portions of the soil profile have better chances of surviving a fire or avoiding the impacts of desiccation [291, 81, 234, 173]. Likewise, burrowing spiders, ground- and deadwood-nesting bees and ants, and larvae of saproxylic beetles can survive heat and direct flames within large-diameter logs [377, 234, 386]. Synchronization between disturbance seasonality and arthropod phenology can also influence the chances of surviving negative effects. For instance, in Mediterranean ecosystems, summer wildfires have less impact on soil arthropods as most of them have migrated into deeper soil layers or entered a cryptozoic stage at this time of the year [143].

Some morphological traits also contribute to resistance to disturbance among the "resisters". Drought-resistant species are equipped with specific protective body traits like hairs and thick cuticles [81, 199, 232]. Thick cuticles can additionally enhance resistance to wildfires [399]. Small arthropods such as mites (Acari) tend to be more sensitive to changes in soil temperature and dryness than larger arthropods (e.g., Collembola) [254, 27, 44].

Several "evaders" are able to detect wildfires well in advance, using olfactory or auditory cues, and may rapidly engage in escape behaviors, actively fleeing to disturbance refugia [89, 254]. In this regard, high mobility is a key asset to avoid deleterious disturbance effects. Winged insect orders consequently have higher survivorship to wildfires than less-mobile taxa [89], and smaller-bodied soil-dwelling arthropods are better able to take shelter from wildfires and move to refugia such as underground burrows, beneath rocks, or within tree trunks or roots [81]. Above-ground arthropods may also escape from wildfires by actively burrowing into the soil, or by moving upwards into the cooler canopy during low-intensity surface wildfires [89, 273].

The vulnerability of arthropods to abiotic disturbances depends on their preferred microhabitat [40], especially across the vertical gradient of forests. For instance, arthropods that live in the upper soil layers are likely to experience stronger disturbance-induced fluctuations in temperature and moisture compared to their deeper soil-dwelling counterparts [81], or compared to canopy-dwelling arthropods that may have better chances of surviving ground-level fires [89]. Ferrenberg et al. [109] suggest that aboveground communities are influenced to a greater extent by deterministic processes, while the relative influence of stochastic processes are greater for belowground communities.

3.1.2 Traits Related to Post-Disturbance Colonization Processes and the Spatial Distribution of Disturbance Refugia

Colonization and re-colonization processes depend on the proportion of arthropods that survive in situ or in distant refugia. Post-disturbance arthropod communities can be dominated at first by disturbance-adapted taxa [291]. "Invaders" can also rapidly colonize disturbed areas. This colonization of new habitat patches or newly-created substrates relies on the ability of these arthropods to detect material legacies. Phytophagous arthropods can detect weakened or recently perished trees through the emission of kairomones such as ethanol [248]. Similarly, saproxylic beetles can locate particular types of dead wood at some distance prior to colonization [130]. Pyrophilous insects, seeking burnt substrates, possess specialized chemoreceptors that sense smoke volatiles, and/or sensilla that respond to radiant heat and infrared [103, 273].

Disturbances also lead to the selection of traits related to mobility [253]. "Invaders" are by definition highly mobile, as they exploit ephemeral resources in post-disturbance environments [311]. Similar traits are also selected for in "evaders" and "avoiders", especially when disturbance refugia are highly scattered throughout the landscape. The composition of post-disturbance communities highlights the importance of dispersal in disturbed areas. For example, windthrown and burnt areas generally host lower numbers of brachypterous (small-winged) and higher numbers of macropterous (large-winged) ground beetle species compared with undisturbed forests [29, 316, 339]. Similarly, in recently burnt sites, there can be an increase in the abundance of spiders with greater ballooning dispersal abilities [199] and of wild bees with higher capacities for dispersal [234]. As a result, the spatial scale describing the effect of storms on arthropod communities increases with their dispersal ability [147]. Body size is another trait that is related to dispersal ability; i.e. post-disturbance soil communities often shift from small-bodied to relatively large-bodied, more effectively dispersing species [27, 44].

The colonization of material legacies also involves demographic parameters. The most successful "invaders" tend to have short generation times, high fecundity and long life spans. For instance, eusocial bees can quickly rebound following a fire during the early growing season since they are active across seasons and have several generations per year [337]. Similarly, ants recover rapidly after wildfires and maintain near-stable population sizes due to their large broods, small body size, diverse foraging niches and relatively broad diets [23]. These autecological and demographic parameters might be particularly relevant for recolonization processes when disturbance refugia are small compared to the surrounding disturbed matrix and consequently shelter a small reservoir of "avoiders" and "evaders".

In addition to the availability of space and new trophic resources, the local extinction of certain taxa may constitute an opportunity for the immigration of exotic invasive species into disturbed patches. Examples in support of this hypothesis include *Cacyreus marshalli*, an invasive butterfly, which tends to appear in Mediterranean shrublands after wildfires [319], and also exotic ant species found to have a high probability of establishing colonies in pine forests where there are frequent wildfires [10]. Likewise, arthropods can take advantage of post-disturbance conditions because of likely reductions in predation [147, 274] or competition pressures [297]. *Tentyria grossa*, a rare soil-dwelling beetle species, became dominant after wildfires in Italy partly because of the decreased abundance of almost all other related species [106]. Conversely, for some taxa critical population sizes must be reached before recolonization processes can take place. Resources

created by large disturbances in Central Europe led to the return of *Peltis grossa*, a primeval forest specialist beetle, but at a slower rate than two more common, related species [51].

3.1.3 Traits Related to Micro-Environmental Legacies

In general, stand-removing forest disturbances benefit taxa that are adapted to more open, micro-environmental conditions (e.g., open-land ground-dwelling carabids, ground-hunting spiders or some saproxylic beetles), while groups typically associated with shady conditions are negatively impacted (e.g., forest-preferring sheet-web weaver spiders and shade-preferring carabid and saproxylophagous species) [323, 302, 63, 30].

Disturbances also disrupt patterns of humidity. Post-fire environments tend to have drier atmospheric and soil conditions, leading to a predominance of drought-resistant arthropod species [81, 199] and a decline in hygrophilous taxa [365, 316, 339, 380]. In this regard, the phenotypic plasticity of some soil arthropods, and more specifically their capacity to adapt some of their physiological, behavioral, and morphological traits to drier conditions (e.g., urine concentration, thermoregulation strategies, cuticular permeability, etc.) is a major advantage to improve tolerance to these shifting environmental conditions [232].

Open conditions also expose arthropods to higher potential levels of predation [63, 188]. Consequently, for some arthropod taxa the frequency of dark cryptic individuals increases in burned areas [273]. The ability for camouflage may be favored in disturbed forests but there is still limited supporting evidence for this.

3.1.4 Traits Related to Resource Pulses and Collapses

Disturbance legacies generate pulses or collapses in critical resources for arthropods. The largest impacts on arthropod communities are expected in the initial stages of the disturbance, but changes in community structure can unfold over more than a decade [126•]. The responses of arthropod communities to changes in resource diversity, amount and accessibility can be largely mediated by their composition, although idiosyncratic responses at the family or species levels also frequently occur [81, 134, 5, 54, 80•].

A higher diversity and abundance of deadwood-associated arthropods are generally observed in disturbed stands. In response to pulses in the abundance and diversity of deadwood substrates and associated TreMs (Table S1, Fig. 3; 388••). This also affects the taxonomic, functional, and phylogenetic composition of species in disturbed forests [190•, 80•, 338]. In general, saproxylic insects, benefit from these pulses [314•, 359, 365, 366] and this includes saproxylophagous arthropods [80•, 111], cavity-nesting species [80•, 335], and xylomycetophagous and mycophagous insects [29, 80•, 398], unless wildfire has altered wood biochemical properties [356]. The pulse of weakened host trees following severe forest disturbances also promotes xylophagous species (Fig. 3) and may trigger outbreaks of opportunistic pests (cf. III.2.). Impacts of tree dieback or decline on crown-related resources have more contrasting effects on leaf-dwelling guilds. Overall, tree decline has a negative impact on specialized leaf-feeders (Table S1), but has no effect on seed- and fruit-consuming species, although responses to variations in food are generally poorly understood among these guilds (Fig. 3; 314•, 313).

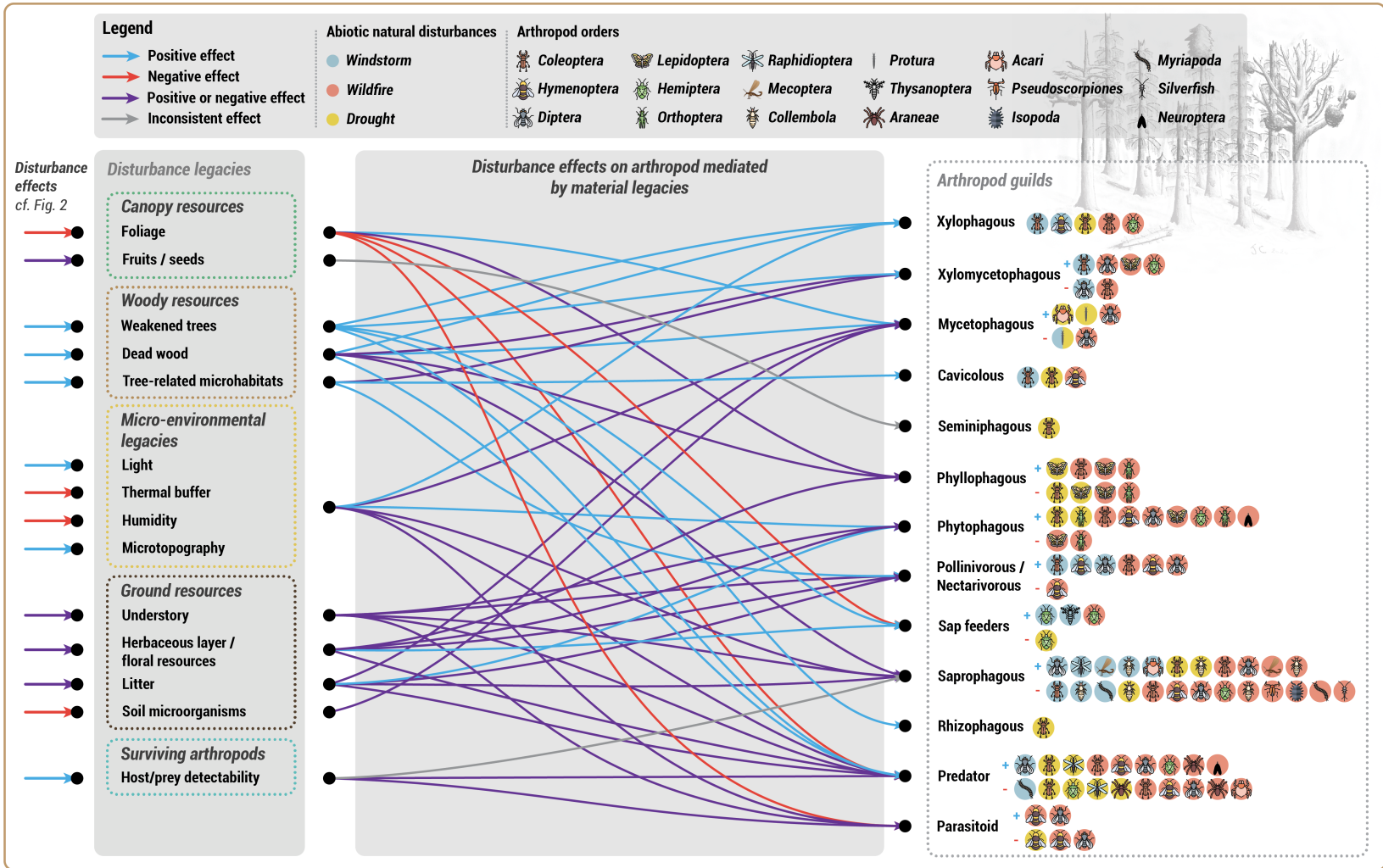


Figure 3: Responses of forest arthropods to disturbance legacies according to their trophic guild. Details on arthropod groups investigated ($N = 28$), and references ($N = 52$), are provided in Table S1. On the right is a list of arthropod guilds with reported specific effects (positive or negative) against the investigated disturbances (windstorm, drought or wildfire)

Increased canopy openness and the resulting pulse in herb layer and floral resources, consistently increase understory-associated herbivores and pollinators (Fig. 3; 388••, 112), and potentially also root-feeding insect larvae (Fig. 3). This pulse may also promote generalist leaf-feeders that seek alternative food sources to compensate for thinning tree crowns [313]. However, while cascading effects of wildfires on the herbaceous layer benefit pollinators in general, they also can have negative effects on this guild, or for some vulnerable taxa, when fire frequency is high (e.g., 112, 57). Post-disturbance regrowth of aboveground vegetation additionally increases habitat heterogeneity and can lead to a greater abundance of herbivores in the mid-term [362].

Belowground, soil arthropods exhibit an overall negative short-term response to wildfires (Table S1). This is a consequence of collapses in microbial food resources [197], and detrimental soil conditions (Fig. 3; 139, 297, 197). Their response to wildfire and similar disturbances is often strongly determined by the depth of remaining litter [387, 155, 110]. The response may be different following windstorms as they may benefit both from the pulse in ground-lying resources (e.g., dead wood, litter, etc.) and from the mosaic of soil microhabitats related to windfalls and windbreaks (Fig. 3; 388••, 31). Some guilds of soil arthropods may also benefit from post-disturbance conditions at later stages of the ecosystem recovery process [139, 380, 82]. They may take advantage of the pulse of easily-decomposable organic matter and from the related pulse in microbial activity, but also from changes in micro-environmental conditions related to canopy opening [277]. This latter point is, however, debated and can depend on the taxonomic groups or functional guilds considered [82, 347].

Populations of predatory arthropods may be driven by disturbance-induced variations in prey availability, i.e. prey density and prey detectability. Surviving predators may benefit from surviving prey and an increase in deadwood- and litter-dwelling prey [379]. Conversely, the general decrease in detritivores (Fig. 3) may have cascading effects on higher trophic levels as suggested by reductions in surface predators, such as spiders, centipedes, and predatory ground beetles (e.g., 81, 31; but see 63, 188). Nonetheless, we compiled inconsistent bottom-up effects on higher trophic levels in saproxylic [79, 389] and soil food webs [90]. In addition, predatory arthropods may themselves be affected by higher predatory pressures from higher trophic levels (e.g., insectivorous birds: 217; or bats: 186, 296). This means that predaceous groups can both increase or decrease in disturbed forest stands compared with undisturbed forests (Table S1, Fig. 3), and the drivers of the direction of effects still requires further research.

3.1.5 Spatiotemporal Changes in Community Structure

Post-disturbance community patterns hinge on spatio-temporal dynamics of microhabitats and resources. The increase in within-patch heterogeneity in disturbed areas may play an important role in community organization by niche partitioning among species [31]. Post-disturbance conditions may result in an increased range of food sources and breeding substrates for some arthropod guilds, expanding their trophic and reproductive niche space and resulting in a potential functional divergence in the disturbed area [80•, 255]. At the same time, micro-environmental legacies could lead to niche filtering and a decrease in trait variations, by reducing abiotic niche space and selecting species with narrow microclimatic requirements, i.e., xerothermic, heliophilous, and diurnal species [255]. The spatial extent of disturbed areas can also affect the response

of arthropod communities to a disturbance. As an example, flower-visiting saproxylic beetles were more abundant in mid-size and large windthrow gaps than in small ones [29].

At the landscape scale, local variations in disturbance regimes increase habitat heterogeneity [238] and should consequently promote local and regional biodiversity, according to the habitat heterogeneity hypothesis [358]. In this regard, landscapes with a high diversity of fire histories (i.e., a high pyrodiversity *sensu* 230) support a greater abundance and diversity of pollinators [378•, 286]. The total amount of habitat over a landscape can also modulate communities at a local scale, according to the habitat amount hypothesis [105]. For instance, in declining silver fir forests, the local abundance and richness of saproxylic beetles responded positively to local forest dieback only if the landscape level of forest dieback was high [80•].

Environmental effects of disturbance on forest arthropod communities can be ephemeral or long-lasting, immediate or delayed, or even cumulative over time. Saproxylic insect assemblages associated with older burned forests were found to consist of a mix of pyrophilous specialists and non-pyrophilous secondary users, i.e. opportunistic generalist saproxylic species which are not restricted to freshly burnt wood but which benefit from fire-induced pulses of deadwood after a delay [311]. In windthrown areas, reinvigorated community dynamics of ground-dwelling arthropods are also a matter of time since wind disturbances: i.e. positive effects are observed in response to short-term pulses of litter after windstorms, and then mid-term with a reduction in the quantities of litter generated from weakened trees [81].

3.2 Disturbance Legacy, Insect Outbreak and Arthropod Community Interactions

The pulse of weakened host trees following severe abiotic disturbances may promote outbreaks of opportunistic bark and wood-boring insects, bark beetles being a prime example. These outbreaks are major biotic disturbances causing forest diebacks sometimes over large spatial scale [26, 22, 306, 258, 312]. These opportunistic insects can also act as aggravating elements in complex multifactorial forest declines, further deteriorating stand conditions in previously disturbed forest areas [312]. Severe droughts and windstorms are major initial drivers of such outbreaks [329, 26, 22, 312, 284]. Wildfires, however, only occasionally contribute to large-scale pest outbreaks as a function of their severity. This is because high-intensity crown fires generally destroy the breeding substrate which hinders any pest outbreaks [112, 194, 289, 164, 61]. Nevertheless, low intensity ground fires are less destructive, and weakened trees can provide ample substrates for breeding outbreaks of opportunistic pests [39, 222, 354].

Compound disturbances can lead to a situation when a disturbance alters ecosystem response to a subsequent disturbance (see 3.1; 268). Large-scale outbreaks of opportunistic pests trigger or contribute to extended forest diebacks and declines [26, 22, 312, 284]. They consequently compound the effects of wildfires, windstorms and drought since pest outbreaks increase the severity and spatial extent of abiotic disturbances [221, 282]. Therefore, pest outbreaks can amplify some of the disturbance legacies left by previous disturbances such as the volume of deadwood, abundance of TreMs, and canopy openness [79, 366]. Cascading effects on arthropod communities are consequently similar to those of abiotic disturbances: flower-visiting insects [79, 203, 24, 360, 187] are stimulated in canopy gaps as a result of micro-environmental legacies and related pulses of plant resources [85]. Conversely, taxonomic groups linked to closed-canopy forests, such as Mycetophilidae, might suffer from canopy opening and the desiccation of decaying litter [203]. Increases in

deadwood volume, in sunnier environments, fosters the diversity of saproxylic beetles [323, 205, 130, 24], although the trend varies with the dynamics of dieback [79]. Several soil-dwelling groups (i.e., ground beetles, harvestmen, springtails) seem, however, to be unaffected in bark beetle infestation areas [24, 400] compared with undisturbed forests. The response of fungus-dwelling arthropods to bark beetle-induced diebacks depends on inconsistent variations in wood-dwelling fungi [79, 80, 24] and in a very significant decline in the biomass of the forest soil fungi community, reflecting both the disappearance of fungi that form symbiosis with tree roots and the changing availability of needle litter [235, 350]. Overall, eruptive pests, like the spruce bark beetle in Europe, may be considered as keystone ecosystem engineers, providing habitat structures that promote the occurrence of other species, including endangered species [51, 258, 17, 146, 245]. Outbreaks of opportunistic pests are triggered by abiotic disturbances, but through their disturbance legacies, they can also, in turn, have additive or synergistic effects on these abiotic disturbances [329]. For instance, fuel accumulation and changes in microclimatic conditions (e.g., temperature, moisture, etc.) following outbreaks may promote subsequent wildfires, but depends on the time that has passed since a pest outbreak, and also the characteristics of available fuels and of the fire (e.g., 61, 145, 140; but see 240). Likewise, increased canopy openness may amplify the impact of subsequent droughts on forest stands [219, 182], and similar effects could be expected following large-scale outbreaks. Pest outbreaks may also compound the effects of wildfires since depending on disturbance severity and forest type, they may alter recovery processes following a subsequent wildfire [58, 181, 320].

4 Pre-Disturbance Forest Conditions: from Forest Characteristics to Long-Term Legacies

4.1 Pre-Disturbance Forest Type

4.1.1 Pre-Disturbance Vegetation

Initial stand characteristics modulate the composition of post-disturbance vegetation [374, 166]. For instance, the maintenance of trees and understory seedlings and saplings after a disturbance significantly contribute to the vegetation composition (Fig. 4; 92, 119, 394, 299). Depending on the degree of reorganization undergone by pre-disturbance vegetation and disturbance type, forest ecosystems could follow different pathways leading to resilience (no change in structure and composition), restructuring (structure changes but not composition), reassembly (composition changes but not structure), or replacement (both structure and composition change; 325). While forest resilience may also promote the resilience of forest arthropod communities, the three other pathways should reshape arthropod communities to varying extents. In this regard, Iida et al. [155] found that, following a volcanic eruption, pre-eruptive vegetation influenced post-disturbance communities of ground-dwelling arthropods. Nonetheless, this effect was strongly mediated by disturbance severity and/or type, and by the depth of remaining litter.

At the tree species and individual tree levels, several characteristics can affect tree resistance to droughts, windstorms or wildfires, and there is significant intra- and interspecific variation among trees in their susceptibility to these disturbances (e.g., 55 for windstorms; 70 for drought; 14 for wildfire). For instance,

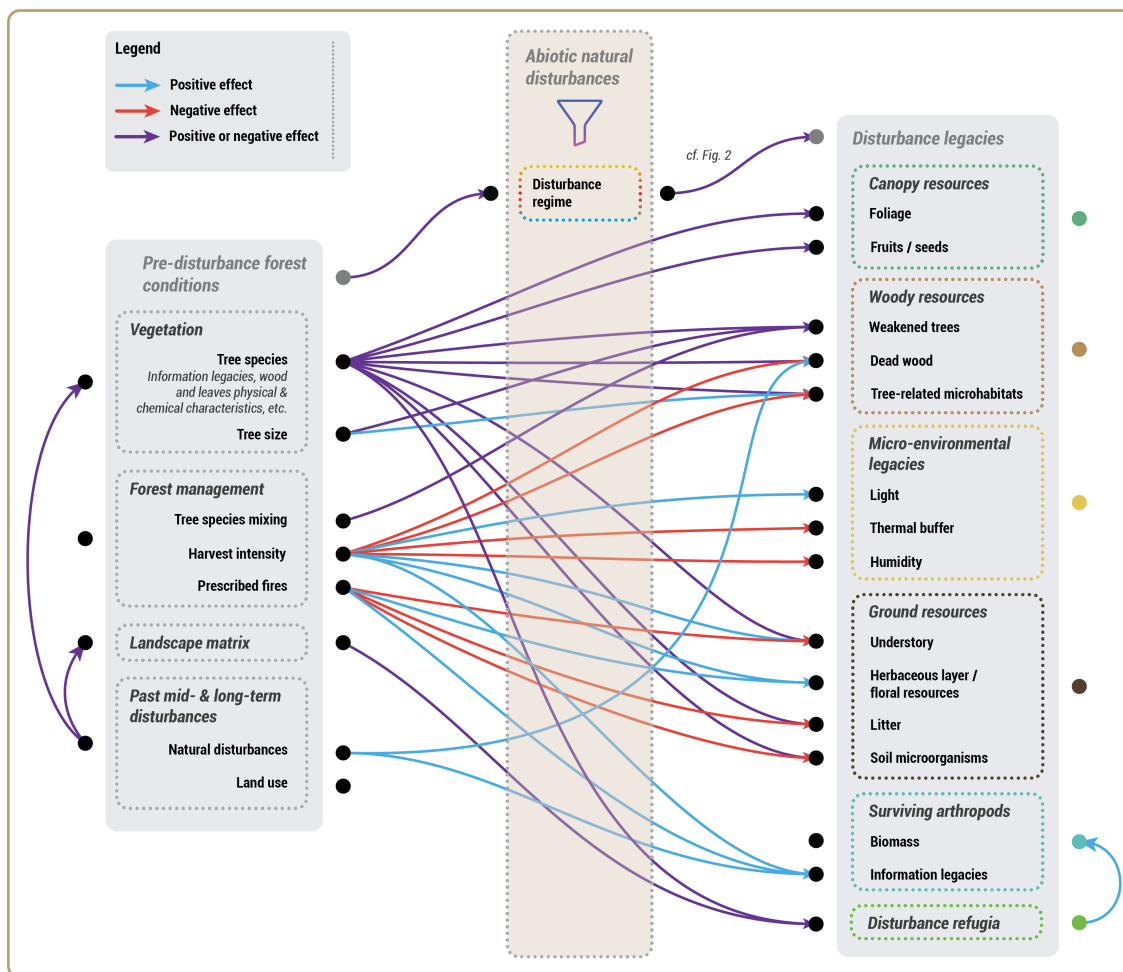


Figure 4: Effects of pre-disturbance forest conditions on key disturbance legacies for forest arthropods. Pre-disturbance forest conditions modulate the impact of disturbances on the amount and diversity legacies, by altering disturbance regimes, modulating initial amounts and diversity of resources and initial micro-environmental conditions, and by imprinting information legacies on forest organisms

large and more mature trees are generally more resistant to fire damage [374, 67], while they are frequently more susceptible to wind damage [161] (Fig. 4). Trees may also have traits that confer resilience to specific disturbances, especially if these disturbances are reoccurring [16]. For example, resistance and resilience to wildfires typically occurs via the emergence and relative success of trees with fire-resilient traits such as serotiny, thick bark, high resprouting capacities, and lignotubers, providing resistance and resilience to wildfires [178, 122, 74]. These information legacies (Fig. 4) can be paramount drivers of ecosystem resilience [36] as they modulate the nature and spatial pattern of disturbance refugia on scales ranging from the tree to the landscape [192, 326]. Resistant trees can serve as disturbance refugia for arthropod communities since they ensure the persistence of suitable micro-environmental conditions and trophic resources for arthropod communities during the disturbance, and in the post-disturbance environment. For instance, fire-resistant grass trees in Australia (*Xanthorrhoea* sp.) have tightly packed leaves around their apical stem, which provide micro-climatic refugia for several arthropod taxa [40].

Conversely, some characteristics of disturbance-adapted tree species may also increase the intensity, severity

or spatial extent of disturbances. For instance, leaf moisture content, leaf area and leaf chemistry affect the flammability of trees and influence the spread of wildfires within stands [287] and at landscape scales (59; Fig. 4). Highly flammable tree species may also provide disturbance refugia for arthropods (e.g., 40), but forests dominated by such tree species should promote disturbance-prone arthropod communities, and communities associated with open habitats.

Tree characteristics also influence key resource pulses (Table 2). For instance, there is a significant inter-specific variability in decomposition rates of deadwood [174, 137]. This affects the amount, diversity and persistence of deadwood resources, and modulates post-disturbance communities of saproxylic arthropods [324]. Tree species, and some morphological features like trunk diameter, also significantly influence the ontogenesis, and ultimately the assemblages of TreMs [201•, 267, 78]. Interestingly, early-successional tree species promoted by stand-replacing disturbances, develop different TreMs than mid- and late-successional tree species promoted by low- and mid-severity disturbances [78, 196]. Therefore, the complex interplay between tree characteristics and disturbance regime may lead to peculiar assemblages of TreMs [229], and significantly contribute to the organization of post-disturbance arthropod communities [190•, 189]. Likewise, species-specific physical and chemical characteristics of leaves differentially affect their flammability, e.g., long curly leaves containing high amounts of terpenes are highly flammable [266, 383]. Consequently, depending on dominant plant species, litter can be more or less severely affected by wildfires, which implies more or less extended impacts on soil arthropod communities [387].

Table 2: *Examples of interactive effects of tree species and drought on two key resources for arthropods, tree-related microhabitats (TreMs) and foliage.* * TreMs profiles vary among species, and depending on tree status (e.g., 201•); ° Depending on drought regime

Tree species	TreMs abund. & diversity [390, 6, 7]*	Susceptibility to drought [101]		Decomposition rate [174]	Post-disturbance accumulation pattern of TreMs	Post-disturbance foliage loss
		Acute stress	Repeated stress			
Beech	Medium	High	High	High	Rapid & ephemeral	Rapid
Oak	High	Low	Low	Low	Slow & persistent	Slow
Pine	Low	Low	High	Low	Slow / rapid° & persistent	Slow
Spruce	Low	High	High	Medium	Rapid & moderately persistent	Rapid

4.1.2 Pre-Disturbance Forest Management

Pre-disturbance forest management can modulate both disturbance regimes and stand susceptibility to disturbances (e.g., for windstorm: [161]; for wildfire: [346, 363, 211]; for drought: [128, 99, 62, 227]; Fig. 4). For example, dense plantations of easily flammable species promote severe wildfires [212, 346, 363, 211]. Conversely, landscape fuel reduction treatments can decrease wildfire severity and promote post-fire seedling regeneration [84, 371]. Following a high intensity fire in south-eastern Australia, Bowd et al. [36] showed that old-growth forests recovered better than younger ones, because old-growth forests displayed a higher abundance of seed-tree species. Likewise, mixing tree species can affect stand susceptibility to windstorms [370], and, depending on tree mixing characteristics, increase stand resistance to drought and wildfire [159, 271]. Mixing tree species also provides associational resistance to herbivores, by increasing predation / parasitism pressures, and may prevent outbreaks of opportunistic pests in response to pulses of weakened

host trees (159, 160; Fig. 4). The inflection of disturbance regimes by forest management could modulate the amount and diversity of disturbance legacies such as stand structure (e.g., complexity of vertical stratum), micro-environments and resources (e.g., soil, burned pieces of deadwood, etc.), with cascading effects on post-disturbance arthropod communities. Pre-disturbance management can also interact with disturbance regime and influence the amount of disturbance legacies. For instance, green tree retention during harvest increased the amount of deadwood following prescribed fires, and promoted red-listed saproxylic insects (e.g., in boreal forests [154]).

Forest management modulates the initial amount of microhabitats and trophic resources and consequently filters ecological traits in pre-disturbance arthropod communities, which may promote or hamper their resilience to disturbances (Fig. 4). At the tree level, pruning and pollarding promote the formation of tree cavities [322]. At the stand level, thinning can reduce the amount of dead and living trees carrying large arrays of TreMs [390, 78, 200, 77]. Thinning may also promote particular TreMs, such as bark injuries occurring during harvesting operations, or dendrotelms [390, 78]. As a result, thinning and logging may alter the initial supply of critical resources like deadwood and TreMs, and initial environmental conditions in the canopy and ground layers through increased canopy openness [68]. More generally, intensive forest management negatively affects the community of saproxylic arthropods [334, 132, 348], and could therefore limit their response to deadwood pulses following a disturbance. On the contrary, by regularly creating canopy gaps, forest management maintains populations of forest pollinators [135], allowing them to rapidly exploit the post-disturbance pulses in floral resources [142] (Fig. 4).

4.1.3 Pre-Disturbance Landscape Matrix

Landscape matrix influences disturbance regimes. For instance, patterns of wildfire spread and severity are an interactive function of topography, vegetation, management and land use [374, 212, 60, 303]. Likewise, large forest gaps increase the likelihood of windstorm damage at the landscape level [370, 136, 270]. Forest edge exposure also results in a disruption of the microclimatic buffer and therefore exacerbates the effects of drought on vegetation and arthropod communities [87, 275, 182, 352]. Consequently, the landscape matrix can be seen as a mosaic of habitats more or less prone to disturbances. This will markedly influence the spatial distribution of disturbance refugia, and the recolonization processes by arthropod communities (Fig. 4).

4.2 Material and Information Legacies from Past Disturbances

Past disturbances can directly influence current arthropod communities in forests through changes in forest structure. Kozák et al. [190•] showed that current saproxylic beetle assemblages are influenced by the historical disturbances that occurred over the last 250 years. Overall, the recency and the severity of the last disturbance increased the current species richness, although maximum disturbance severity had negative effects [190•]. The changes in current insect assemblage were mainly mediated through past changes in deadwood resources and canopy openness [12].

Pre-disturbance conditions are also influenced by changes in land-use that occurred a long time ago (Fig. 4).

For example, Mollier et al. [252] showed that the forest area of 150 years ago is a better predictor of current beetle communities than the current forest area. This is probably mediated by ancient forest legacies related to forest maturity and continuity [162]. Past land-use also significantly determined current forest vegetation, due to the trees historically favored by man [76], colonization credit [252, 144], and nutrient availability (e.g., generally higher in former agricultural lands; 117), which largely affect the dynamics of the post-disturbance vegetation [292].

5 Post-Disturbance Forest Management Influences on Disturbance Legacies and Arthropod Communities

Post-disturbance forest management encompasses an array of strategies, ranging from intensive to passive approaches [96]. Following drought, wildfire, or windstorm disturbances, salvage or sanitation logging are typical management strategies in production forests [216] and can also be implemented in forests with high conservation value [71, 247, 265]. Salvage logging is the practice of extracting trees in disturbed forests and it is frequently conducted to minimize the economic loss of timber [215]. Sanitation logging aims to harvest dead and weakened trees to prevent the build-up of opportunistic pest populations and subsequent outbreaks, but also to reduce the risks of further wildfires [344, 118]. The effectiveness of salvage and sanitation logging in mitigating subsequent disturbances remains unclear [209]. These management strategies can be considered to compound disturbances, as forests are more likely to be harvested after a natural disturbance than if there was no disturbance [207].

Most disturbance legacies are affected by logging (215; Fig. 5). The extent of any negative consequences for forest arthropod communities depends on disturbance severity, as well as on the intensity and extent of logging and the time lag following a disturbance [79, 208, 242]. Logging removes dead and weakened trees, and woody debris. This affects the amount and diversity of material legacies that are essential for saproxylic arthropods. While the amount of deadwood in a stand logged after a disturbance may remain high [79, 126•, 242, 125], the diversity of deadwood resources is generally reduced compared to unlogged stands (392; Fig. 5). For instance, rare types of disturbance-induced deadwood resources, like charred snags and large logs are a key target for salvage logging [28, 153]. Post-disturbance logging also affects the diversity of TreMs as microhabitat-bearing weakened trees and snags are targeted for salvage harvesting despite the many microhabitats they likely provide (79, 392; Fig. 5). Logging can affect species succession by disrupting colonization and recolonization patterns, and by affecting the community of surviving arthropods. For instance, the removal of deadwood disturbance legacies can effectively be ecological traps [32], negatively affecting saproxylic arthropods that have taken shelter from a disturbance within deadwood, but also those arthropods that subsequently colonize the deadwood [126•, 146, 367, 73]. Conversely, increased canopy openness promotes the colonization of logged areas by arthropod species that are associated with open habitats, preferring warmer and sunnier environments, and by species associated with floral resources [338, 142, 125, 33].

Post-disturbance logging also affects micro-environmental legacies. Removal of dead and weakened trees further increases canopy openness (115, 279, 179; Fig. 5). The impact of logging on soil conditions is highly context-dependent, and it is influenced by logging intensity and the construction and distribution of roads

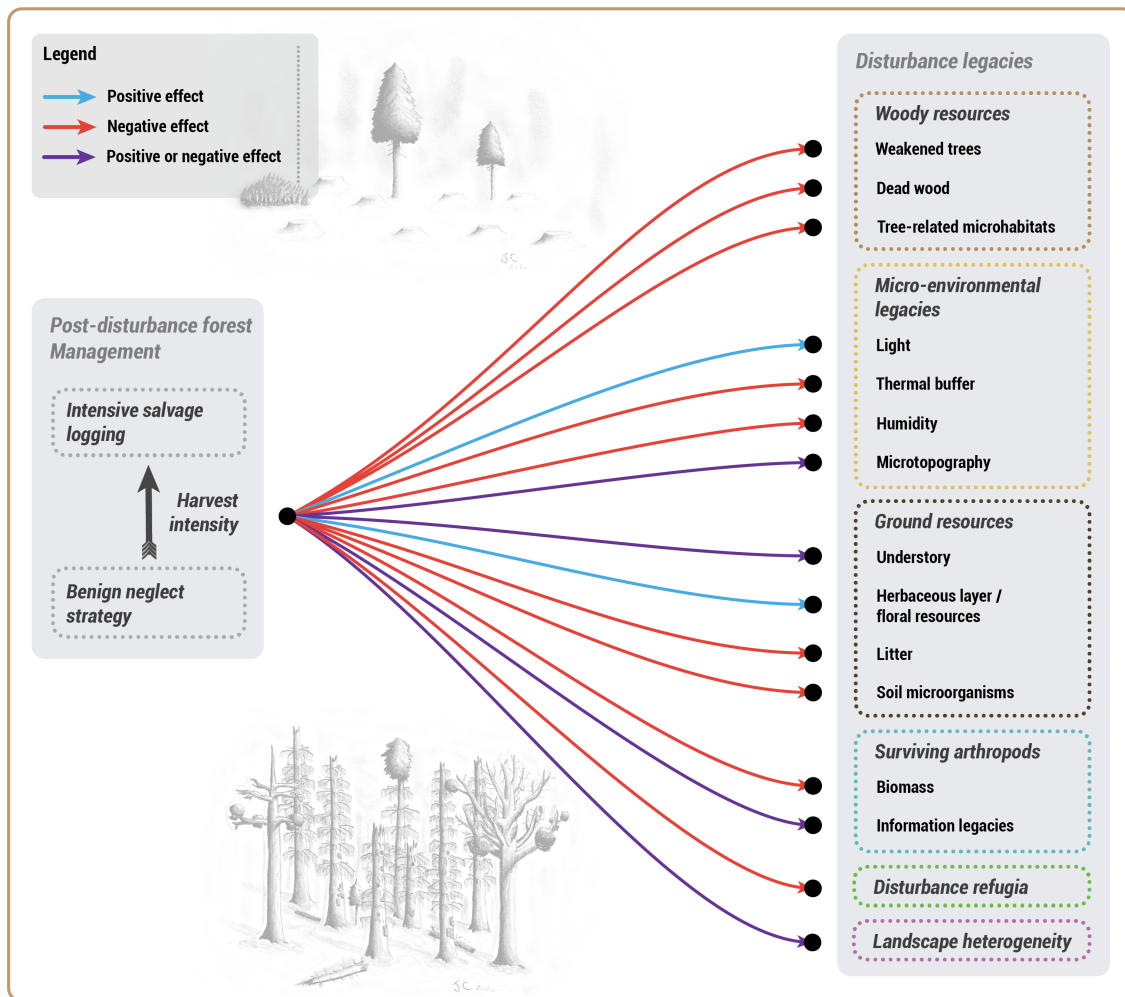


Figure 5: *Effects of post-disturbance forest management on key disturbance legacies for forest arthropods. Increasing harvest intensity from benign neglect strategy to intensive logging largely affects a wide array of disturbance legacies*

(279, 225, 231; Fig. 5). Increased canopy openness and the removal of downed deadwood generally results in increased soil temperature, and decreased soil moisture [237], thereby affecting soil microbial communities (235; Fig. 5). Removal of downed deadwood also reduces the amount of available nutrients compared to stands that retain their legacies [228, 121, 276, 172]. In addition, the use of forestry machinery generally increases soil compaction [225, 121, 295, 391]. Together with the removal of woody debris, it modulates the pattern of soil microsites and microtopography, with a decrease in pits and mounds but an overall increase in microsite richness (392, 279, 393, 355; Fig. 5). These effects on soil properties can persist for a long time (e.g., 10 years in boreal forests; 180). These changes in micro-environmental conditions can negatively affect soil arthropods [251].

At the landscape scale, logging increases habitat diversity if it creates a mosaic of undisturbed, disturbed and logging-disturbed patches [397, 281]. The alteration of local deadwood composition can increase β -diversity of saproxylic organisms across salvaged areas, compared to unsalvaged and undisturbed forests (e.g., 126•, 397). This may in turn promote the γ -diversity of arthropod communities [397, 281]. The configuration

and size of such mosaics certainly are important to define the extent to which these mosaics can help certain insect communities maintain their populations, but we lack knowledge about this issue. Nonetheless, logging may also increase habitat fragmentation, putting disturbance refugia further away from each other [247, 246], which may also affect the dispersal and colonization processes of disturbed areas by arthropod species [311]. It is often conducted extensively, in a way that the landscape ends up dominated by a burnt and clearcut matrix with some patches of deadwood only in inaccessible areas [207].

Following post-disturbance harvest, different reforestation strategies can be implemented, from natural regeneration to full planting of new tree species. While post-disturbance logging does not produce a generalized effect on the density or height of subsequent tree regeneration, there can be a variety of local responses [210] and effects on composition are generalized [355]. Logging often promotes early-successional resprouting species, but disfavors late-successional seeder species [355, 169, 269, 206, 113, 244]. However, these immediate effects generally fade in the longer term (e.g., [210, 308, 318]; but see 256). Reforestation leading to the plantation of novel, and potentially exotic, tree species may increase habitat diversity at the landscape scale, but result in a dramatic shift of tree-related resources and habitats for arthropods at a local scale [294]. Shifting tree species during post-disturbance reforestation may result in a major resource collapse for the community of plant-feeding arthropods [37, 384, 204], but also for saproxylophagous species [324, 260, 175], at least at initial stages of the saproxilation process [324, 170]. This would be particularly true if native tree species are replaced by exotic and phylogenetically- and functionally-distant tree species [175, 34, 249]. At the landscape scale, this may however increase β - and γ -diversity of arthropod communities [42, 4, 148]. Nonetheless, natural regeneration following disturbance is heterogenous and naturally produce landscape diversity [373, 321].

In contrast, the absence of active management, within the frame of a "benign neglect" or passive strategy, allows the retention of disturbance legacies [259]. The latter strategy is mainly implemented in conservation forests [259, 96, 150, 151]. Forest managers can retain some disturbance legacy features that may be of interest [146, 96, 163] to achieve a compromise between fully preserving disturbance legacies and virtually eliminating them through clearfell. They also may implement variable management strategies in different part of the landscape to prioritize different functions and services. Compared to logged stands, saproxylic arthropods greatly benefit from the retention of deadwood following disturbances [79, 24, 125]. Even though logged areas are generally favorable to open-habitat arthropod species, Galbraith et al. [120] observed greater α - and β -diversity of wild bees in unlogged than in logged areas. Furthermore, passive post-disturbance strategy also maintains greater network connections between pollinators and plant species than salvage logging [49]. Only a few studies considered the effects of intermediate forest management strategies after a natural disturbance, such as retention harvesting or close-to-nature forestry [96, 207]. Scattered trees or groves retained during clear-cuts generally support intermediate communities composed of both species from intact forest and clear-cut areas but do not support specialists (e.g., interior forest species; 107, 214). Even when retention levels are high, the community of saproxylic arthropods exhibits substantial changes compared to those of intact forests [187, 202]. According to Müller and Bütler [257], minimum threshold values of 30 to 50m³.ha⁻¹ are needed to ensure a relatively high richness of saproxylic organisms. In addition, Thorn et al. [369] found that 75% of disturbed forest areas must be retained to maintain 90% of the species richness present in those

disturbed areas.

6 Conclusion

One of the main similarities between droughts, windstorms, and wildfires is their direct and indirect impacts on canopy openness. Increased canopy openness, and its cascading effects on forest microclimates at different strata, and on understory and herbaceous layers, sets in motion the transition of forest arthropod communities towards communities adapted to sunnier/warmer and drier conditions, with a reduced thermal buffer, and to the exploitation of resources related to the herbaceous layer, like floral resources. The impacts of disturbances on canopy resources and microhabitats has received little attention to date [314•], but seems to generally have null to negative effects on canopy-dwelling arthropods depending on their ecological guild. The three disturbances considered in our review increase the amount and diversity of weakened trees and deadwood resources, and consequently have positive cascading effects on saproxylic species, including opportunistic pests. However, compared to drought and windstorms, wildfires tend to alter the quality of deadwood resources, which are consequently preferentially exploited by a specialized pyrophilous fauna. Likewise, the impacts of these disturbances on soil conditions are quite variable. While droughts and wildfires have an overall negative impact on soil organisms and their micro-environmental conditions, disturbance legacies of windstorms are generally beneficial for soil arthropods. Through their material legacies, abiotic disturbances may have positive outcomes on forest arthropod communities, at least for certain guilds like saproxylic and flower-visiting arthropods, although responses of arthropod taxa may be frequently idiosyncratic. Considering that with our current knowledge it is still difficult to predict the likely composition of post-disturbance arthropod communities, we call for more comprehensive investigations on disturbance impacts on arthropod diversity. These investigations should include several taxa and guilds and consider the taxonomical, functional and phylogenetic responses to changes in microhabitat amount and diversity, at various spatial scales.

Pre-disturbance forest conditions influence the amount and diversity of several disturbance legacies such as the amount of surviving arthropods and the amount, diversity and temporal dynamics of several of their key resources, like deadwood and TreMs. Fostering silvicultural practices which promote TreMs in stands at risk might prove useful to promote the resilience of forest arthropod communities. Since they can modulate local disturbance regimes and consequently the post-disturbance habitat heterogeneity at landscape scales, they are also of paramount importance for recolonization processes of disturbed areas. They either allow the resilience of pre-disturbance arthropod communities, or lead to a recolonization by communities dominated by large, highly mobile, fecund and long-lived arthropod species. Post-disturbance management, especially logging, considerably alters the amount and diversity of both deadwood resources and TreMs, and soil conditions. Consequently it restricts beneficial disturbance effects on saproxylic taxa and further affects soil arthropods. Conversely, it also exacerbates some disturbance impacts like canopy opening and habitat heterogeneity at the landscape scale and may therefore have beneficial impacts on certain arthropod guilds such as pollinators. For biological conservation purposes, an optimal management of disturbed forest areas should therefore aim at conserving benefits provided by (i) the accumulation and diversification of deadwood resources and TreMs for saproxylic taxa, (ii) by canopy opening for pollinators and some saproxylic and soil-dwelling taxa, and

(iii) habitat diversification at the landscape scale. To achieve this, sanitation logging could be limited to a restricted proportion of disturbed forest areas at the landscape-scale, to prevent bark beetle outbreaks [11], especially when harvesting costs are lower than the selling price [98, 185]. Conversely, since maximizing the retention of disturbance legacies limits the detrimental effects of logging on biodiversity and subsequent successional process, it should become an increasingly common response to disturbances, especially when timber prices are low [148].

A majority of the studies investigating the impact of forest disturbances on material and information legacies, and/or more specifically on arthropod communities, have focused on wildfires, and on windstorms, to a much lower extent (e.g., Fig. 3; Table S1). Comparatively, fewer studies have evaluated the impacts of drought on legacies and on forest arthropod communities, although there is a growing body of literature highlighting the increasing involvement of this disturbance in forest diebacks and declines worldwide [330, 236, 2, 41]. Heatwaves also frequently co-occur with droughts, and are also expected to become more frequent, intense and longer lasting in the second half of the twenty-first century [236, 239]. However, both disturbances can have idiosyncratic impacts on forest ecosystems and their associated communities [150], which may be difficult to disentangle under field conditions. We therefore call for more studies on the impacts of drought and heat waves on forest resources and microhabitats, and their cascading effects on arthropod communities. In our review, we focused on the three main disturbances for temperate forest ecosystems. Nonetheless, additional disturbances with more localized impacts could also be considered, like flooding events which are expected to increase and affect floodplain forests and their arthropod communities in Central and Northern Europe in the future [156, 191, 198].

Several shifts in disturbance regimes occurred in forest ecosystems during the last centuries with sometimes major ecological impacts [372, 357, 343, 100, 43]. For instance, a recent shift in the disturbance regime in Alaska towards more severe wildfires led to a modification of the plant community from coniferous to deciduous species [166, 168]. However, the speed of current changes in disturbance regimes appears to be unprecedented and largely questions the future of world's forests and their associated communities [167, 372, 376, 272]. We therefore need a better mechanistic understanding of disturbances and compounded disturbances impacts on arthropod communities to better forecast how changes in disturbance regimes will affect disturbance legacies and the arthropod communities their shelter.

7 Acknowledgements

ABL acknowledges grant B-FQM-366-UGR20 from Junta de Andalucía/FEDER and Smart Ecomountain Lifewatch ERIC Thematic Center (LifeWatch-2019-10-UGR-01). JH is grateful to Excellence project PñF UHK 2209/2021-2022 for the financial support. We are grateful to the anonymous reviewer and Dr. Bastien Castagneyrol for their valuable comments.

Papers of particular interest, published recently, have been highlighted as: • Of importance •• Of major importance

Bibliography

- [1] Z. Abd Latif and G. A. Blackburn. The effects of gap size on some microclimate variables during late summer and autumn in a temperate broadleaved deciduous forest. *International Journal of Biometeorology*, 54(2):119–129, Mar. 2010. ISSN 1432-1254. doi:10.1007/s00484-009-0260-1. URL <https://doi.org/10.1007/s00484-009-0260-1>.
- [2] C. D. Allen, A. K. Macalady, H. Chenchouni, D. Bachelet, N. McDowell, M. Vennetier, T. Kitzberger, A. Rigling, D. D. Breshears, E. H. T. Hogg, P. Gonzalez, R. Fensham, Z. Zhang, J. Castro, N. Demidova, J.-H. Lim, G. Allard, S. W. Running, A. Semerci, and N. Cobb. A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forests. *Forest Ecology and Management*, 259(4):660–684, Feb. 2010. ISSN 0378-1127. doi:10/c3s4s4. URL <http://www.sciencedirect.com/science/article/pii/S037811270900615X>.
- [3] C. D. Allen, D. D. Breshears, and N. G. McDowell. On underestimation of global vulnerability to tree mortality and forest die-off from hotter drought in the Anthropocene. *Ecosphere*, 6(8):art129, Aug. 2015. ISSN 2150-8925. doi:10.1890/ES15-00203.1. URL <http://doi.wiley.com/10.1890/ES15-00203.1>.
- [4] E. Ampoorter, L. Barbaro, H. Jactel, L. Baeten, J. Boberg, M. Carnol, B. Castagnyrol, Y. Charbonnier, S. M. Dawud, M. Deconchat, P. D. Smedt, H. D. Wandeler, V. Guyot, S. Hättenschwiler, F.-X. Joly, J. Koricheva, H. Milligan, B. Muys, D. Nguyen, S. Ratcliffe, K. Raulund-Rasmussen, M. Scherer-Lorenzen, F. van der Plas, J. V. Keer, K. Verheyen, L. Vesterdal, and E. Allan. Tree diversity is key for promoting the diversity and abundance of forest-associated taxa in Europe. *Oikos*, 129(2):133–146, 2020. ISSN 1600-0706. doi:10.1111/oik.06290. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/oik.06290>.
- [5] K. O. Apigian, D. L. Dahlsten, and S. L. Stephens. Fire and fire surrogate treatment effects on leaf litter arthropods in a western Sierra Nevada mixed-conifer forest. *Forest Ecology and Management*, 221(1):110–122, Jan. 2006. ISSN 0378-1127. doi:10.1016/j.foreco.2005.09.009. URL <https://www.sciencedirect.com/science/article/pii/S0378112705005530>.
- [6] T. Asbeck, P. Pyttel, J. Frey, and J. Bauhus. Predicting abundance and diversity of tree-related microhabitats in Central European montane forests from common forest attributes. *Forest Ecology and Management*, 432:400–408, Jan. 2019. ISSN 0378-1127. doi:10.1016/j.foreco.2018.09.043. URL <https://www.sciencedirect.com/science/article/pii/S037811271831082X>.
- [7] T. Asbeck, M. Basile, J. Stitt, J. Bauhus, I. Storch, and K. T. Vierling. Tree-related microhabitats are similar in mountain forests of Europe and North America and their occurrence may be explained by

- tree functional groups. *Trees*, 34(6):1453–1466, Dec. 2020. ISSN 1432-2285. doi:[10.1007/s00468-020-02017-3](https://doi.org/10.1007/s00468-020-02017-3). URL <https://doi.org/10.1007/s00468-020-02017-3>.
- [8] T. Asbeck, D. Kozák, A. P. Spînu, M. Mikoláš, V. Zemlerová, and M. Svoboda. Tree-Related Microhabitats Follow Similar Patterns but are More Diverse in Primary Compared to Managed Temperate Mountain Forests. *Ecosystems*, 25(3):712–726, Apr. 2022. ISSN 1435-0629. doi:[10.1007/s10021-021-00681-1](https://doi.org/10.1007/s10021-021-00681-1). URL <https://doi.org/10.1007/s10021-021-00681-1>.
- [9] D. Ascoli, G. Vacchiano, J. Maringer, G. Bovio, and M. Conedera. The synchronicity of masting and intermediate severity fire effects favors beech recruitment. *Forest Ecology and Management*, 353:126–135, Oct. 2015. ISSN 03781127. doi:[10/f7s9j4](https://doi.org/10.1016/j.foreco.2015.08.014). URL <https://linkinghub.elsevier.com/retrieve/pii/S037811271500300X>.
- [10] R. A. Atchison, J. Hulcr, and A. Lucky. Managed Fire Frequency Significantly Influences the Litter Arthropod Community in Longleaf Pine Flatwoods. *Environmental Entomology*, 47(3):575–585, June 2018. ISSN 0046-225X. doi:[10.1093/ee/nvy038](https://doi.org/10.1093/ee/nvy038). URL <https://doi.org/10.1093/ee/nvy038>.
- [11] A. L. D. Augustynczyk, L. Dobor, and T. Hlásny. Controlling landscape-scale bark beetle dynamics: Can we hit the right spot? *Landscape and Urban Planning*, 209:104035, May 2021. ISSN 0169-2046. doi:[10.1016/j.landurbplan.2020.104035](https://doi.org/10.1016/j.landurbplan.2020.104035). URL <https://www.sciencedirect.com/science/article/pii/S016920462031519X>.
- [12] R. Bače, J. S. Schurman, M. Brabec, V. Čada, T. Després, P. Janda, J. Lábusová, M. Mikoláš, R. C. Morrissey, H. Mrhalová, T. A. Nagel, M. H. Nováková, M. Seedre, M. Synek, V. Trotsiuk, and M. Svoboda. Long-term responses of canopy–understorey interactions to disturbance severity in primary *Picea abies* forests. *Journal of Vegetation Science*, 28(6):1128–1139, 2017. ISSN 1654-1103. doi:[10.1111/jvs.12581](https://doi.org/10.1111/jvs.12581). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/jvs.12581>.
- [13] A. Bär, S. T. Michaletz, and S. Mayr. Fire effects on tree physiology. *New Phytologist*, 223(4):1728–1741, 2019. ISSN 1469-8137. doi:[10.1111/nph.15871](https://doi.org/10.1111/nph.15871). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/nph.15871>.
- [14] A. Bär, D. M. Schröter, and S. Mayr. When the heat is on: High temperature resistance of buds from European tree species. *Plant, Cell & Environment*, 44(8):2593–2603, 2021. ISSN 1365-3040. doi:[10.1111/pce.14097](https://doi.org/10.1111/pce.14097). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/pce.14097>.
- [15] A. Barreiro and M. Díaz-Raviña. Fire impacts on soil microorganisms: Mass, activity, and diversity. *Current Opinion in Environmental Science & Health*, 22:100264, Aug. 2021. ISSN 2468-5844. doi:[10.1016/j.coesh.2021.100264](https://doi.org/10.1016/j.coesh.2021.100264). URL <https://www.sciencedirect.com/science/article/pii/S2468584421000362>.

- [16] J. Barrere, B. Reineking, T. Cordonnier, N. Kulha, J. Honkaniemi, M. Peltoniemi, K. T. Korhonen, P. Ruiz-Benito, M. A. Zavala, and G. Kunstler. Functional traits and climate drive interspecific differences in disturbance-induced tree mortality. *Global Change Biology*, n/a(n/a), 2023. ISSN 1365-2486. doi:[10.1111/gcb.16630](https://doi.org/10.1111/gcb.16630). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.16630>.
- [17] C. Bässler and J. Müller. Importance of natural disturbance for recovery of the rare polypore *Antrodia citrinella* Niemelä & Ryvarden. *Fungal Biology*, 114(1):129–133, Jan. 2010. ISSN 1878-6146. doi:[10.1016/j.funbio.2009.11.001](https://doi.org/10.1016/j.funbio.2009.11.001). URL <https://www.sciencedirect.com/science/article/pii/S1878614609002359>.
- [18] F. Bastida, I. F. Torres, M. Andrés-Abellán, P. Baldrian, R. López-Mondéjar, T. Větrovský, H. H. Richnow, R. Starke, S. Ondoño, C. García, F. R. López-Serrano, and N. Jehmlich. Differential sensitivity of total and active soil microbial communities to drought and forest management. *Global Change Biology*, 23(10):4185–4203, 2017. ISSN 1365-2486. doi:[10.1111/gcb.13790](https://doi.org/10.1111/gcb.13790). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.13790>.
- [19] E. Batllori, F. Lloret, T. Aakala, W. R. L. Anderegg, E. Aynekulu, D. P. Bendixsen, A. Bentouati, C. Bigler, C. J. Burk, J. J. Camarero, M. Colangelo, J. D. Coop, R. Fensham, M. L. Floyd, L. Galiano, J. L. Ganey, P. Gonzalez, A. L. Jacobsen, J. M. Kane, T. Kitzberger, J. C. Linares, S. B. Marchetti, G. Matusick, M. Michaelian, R. M. Navarro-Cerrillo, R. B. Pratt, M. D. Redmond, A. Rigling, F. Ripullone, G. Sangüesa-Barreda, Y. Sasal, S. Saura-Mas, M. L. Suarez, T. T. Veblen, A. Vilà-Cabrera, C. Vincke, and B. Zeeman. Forest and woodland replacement patterns following drought-related mortality. *Proceedings of the National Academy of Sciences*, 117(47):29720–29729, Nov. 2020. ISSN 0027-8424, 1091-6490. doi:[10.1073/pnas.2002314117](https://doi.org/10.1073/pnas.2002314117). URL <https://www.pnas.org/content/117/47/29720>.
- [20] M. Beloiu, R. Stahlmann, and C. Beierkuhnlein. Drought impacts in forest canopy and deciduous tree saplings in Central European forests. *Forest Ecology and Management*, 509:120075, Apr. 2022. ISSN 0378-1127. doi:[10.1016/j.foreco.2022.120075](https://doi.org/10.1016/j.foreco.2022.120075). URL <https://www.sciencedirect.com/science/article/pii/S037811272200069X>.
- [21] A. Bento-Gonçalves, A. Vieira, X. Úbeda, and D. Martin. Fire and soils: Key concepts and recent advances. *Geoderma*, 191:3–13, Dec. 2012. ISSN 0016-7061. doi:[10.1016/j.geoderma.2012.01.004](https://doi.org/10.1016/j.geoderma.2012.01.004). URL <https://www.sciencedirect.com/science/article/pii/S0016706112000195>.
- [22] B. J. Bentz, J. Régnière, C. J. Fettig, E. M. Hansen, J. L. Hayes, J. A. Hicke, R. G. Kelsey, J. F. Negrón, and S. J. Seybold. Climate Change and Bark Beetles of the Western United States and Canada: Direct and Indirect Effects. *BioScience*, 60(8):602–613, Sept. 2010. ISSN 0006-3568. doi:[10.1525/bio.2010.60.8.6](https://doi.org/10.1525/bio.2010.60.8.6). URL <https://doi.org/10.1525/bio.2010.60.8.6>.
- [23] E. C. Bess, R. R. Parmenter, S. McCoy, and M. C. Molles. Responses of a Riparian Forest-Floor Arthropod Community to Wildfire in the Middle Rio Grande Valley, New Mexico. *Environmental*

- Entomology*, 31(5):774–784, Oct. 2002. ISSN 0046-225X. doi:[10.1603/0046-225X-31.5.774](https://doi.org/10.1603/0046-225X-31.5.774). URL <https://doi.org/10.1603/0046-225X-31.5.774>.
- [24] B. Beudert, C. Bässler, S. Thorn, R. Noss, B. Schröder, H. Dieffenbach-Fries, N. Foullois, and J. Müller. Bark Beetles Increase Biodiversity While Maintaining Drinking Water Quality. *Conservation Letters*, 8(4):272–281, 2015. ISSN 1755-263X. doi:[10.1111/conl.12153](https://doi.org/10.1111/conl.12153). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/conl.12153>.
- [25] P. Biedermann and F. Vega. Ecology and Evolution of Insect–Fungus Mutualisms. *Annual Review of Entomology*, 65:431–455, Jan. 2020. doi:[10.1146/annurev-ento-011019-024910](https://doi.org/10.1146/annurev-ento-011019-024910).
- [26] P. H. W. Biedermann, J. Müller, J.-C. Grégoire, A. Gruppe, J. Hagge, A. Hammerbacher, R. W. Hofstetter, D. Kandasamy, M. Kolarik, M. Kostovcik, P. Krokene, A. Sallé, D. L. Six, T. Turrini, D. Vanderpool, M. J. Wingfield, and C. Bässler. Bark Beetle Population Dynamics in the Anthropocene: Challenges and Solutions. *Trends in Ecology & Evolution*, 34(10):914–924, Oct. 2019. ISSN 0169-5347. doi:[10.1016/j.tree.2019.06.002](https://doi.org/10.1016/j.tree.2019.06.002). URL <https://www.sciencedirect.com/science/article/pii/S0169534719301673>.
- [27] S. Bokhorst, G. K. Phoenix, J. W. Bjerke, T. V. Callaghan, F. Huyer-Brugman, and M. P. Berg. Extreme winter warming events more negatively impact small rather than large soil fauna: Shift in community composition explained by traits not taxa. *Global Change Biology*, 18(3):1152–1162, 2012. ISSN 1365-2486. doi:[10.1111/j.1365-2486.2011.02565.x](https://doi.org/10.1111/j.1365-2486.2011.02565.x). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2486.2011.02565.x>.
- [28] J. Boucher, C. Hébert, J. Ibarzabal, and É. Bauce. High conservation value forests for burn-associated saproxylic beetles: An approach for developing sustainable post-fire salvage logging in boreal forest. *Insect Conservation and Diversity*, 9(5):402–415, 2016. ISSN 1752-4598. doi:[10.1111/icad.12175](https://doi.org/10.1111/icad.12175). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/icad.12175>.
- [29] C. Bouget. Short-term effect of windstorm disturbance on saproxylic beetles in broadleaved temperate forests: Part II. Effects of gap size and gap isolation. *Forest Ecology and Management*, 216(1):15–27, Sept. 2005. ISSN 0378-1127. doi:[10.1016/j.foreco.2005.05.036](https://doi.org/10.1016/j.foreco.2005.05.036). URL <https://www.sciencedirect.com/science/article/pii/S0378112705003701>.
- [30] C. Bouget. Short-term effect of windthrow disturbance on ground beetle communities: Gap and gap size effects. In *European Carabidology 2003: Proceedings of the 11th European Carabidologists Meeting, Aarhus (DK). Danish Institute of Agricultural Sciences Report*, number 114, pages 25–40, 2005.
- [31] C. Bouget and P. Duelli. The effects of windthrow on forest insect communities: A literature review. *Biological Conservation*, 118(3):281–299, July 2004. ISSN 0006-3207. doi:[10.1016/j.biocon.2003.09.009](https://doi.org/10.1016/j.biocon.2003.09.009). URL <https://www.sciencedirect.com/science/article/pii/S0006320703003677>.

- [32] C. Bouget, A. Lassauce, and M. Jonsell. Effects of fuelwood harvesting on biodiversity — a review focused on the situation in Europe. This article is one of a selection of papers from the International Symposium on Dynamics and Ecological Services of Deadwood in Forest Ecosystems. *Canadian Journal of Forest Research*, 42(8):1421–1432, Aug. 2012. ISSN 0045-5067. doi:10.1139/x2012-078. URL <https://cdnsiencepub.com/doi/full/10.1139/x2012-078>.
- [33] C. Bouget, L. Larrieu, and A. Brin. Key features for saproxylic beetle diversity derived from rapid habitat assessment in temperate forests. *Ecological Indicators*, 36:656–664, Jan. 2014. ISSN 1470-160X. doi:10/gfdb7s. URL <http://www.sciencedirect.com/science/article/pii/S1470160X13003634>.
- [34] C. Bouget, A. Brin, and L. Larrieu. The use of sentinel logs to assess host shifts in early beetle colonisers of deadwood under climate- and forestry-induced tree species substitutions. *Insect Conservation and Diversity*, 14(1):117–131, 2021. ISSN 1752-4598. doi:10.1111/icad.12434. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/icad.12434>.
- [35] E. J. Bowd, S. C. Banks, C. L. Strong, and D. B. Lindenmayer. Long-term impacts of wildfire and logging on forest soils. *Nature Geoscience*, 12(2):113–118, Feb. 2019. ISSN 1752-0908. doi:10/gftvw. URL <https://www.nature.com/articles/s41561-018-0294-2>.
- [36] E. J. Bowd, D. P. Blair, and D. B. Lindenmayer. Prior disturbance legacy effects on plant recovery post-high-severity wildfire. *Ecosphere*, 12(5):e03480, 2021. ISSN 2150-8925. doi:10.1002/ecs2.3480. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/ecs2.3480>.
- [37] M. Brändle and R. Brandl. Species richness of insects and mites on trees: Expanding Southwood. *Journal of Animal Ecology*, 70(3):491–504, 2001. ISSN 1365-2656. doi:10.1046/j.1365-2656.2001.00506.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1046/j.1365-2656.2001.00506.x>.
- [38] N. Bréda, R. Huc, A. Granier, and E. Dreyer. Temperate forest trees and stands under severe drought: A review of ecophysiological responses, adaptation processes and long-term consequences. *Annals of Forest Science*, 63(6):625–644, Sept. 2006. ISSN 1286-4560, 1297-966X. doi:10.1051/forest:2006042. URL <http://dx.doi.org/10.1051/forest:2006042>.
- [39] C. R. Breece, T. E. Kolb, B. G. Dickson, J. D. McMillin, and K. M. Clancy. Prescribed fire effects on bark beetle activity and tree mortality in southwestern ponderosa pine forests. *Forest Ecology and Management*, 255(1):119–128, Feb. 2008. ISSN 0378-1127. doi:10.1016/j.foreco.2007.08.026. URL <https://www.sciencedirect.com/science/article/pii/S0378112707006500>.
- [40] K. E. C. Brennan, M. L. Moir, and R. S. Wittkuhn. Fire refugia: The mechanism governing animal survivorship within a highly flammable plant. *Austral Ecology*, 36(2):131–141, 2011. ISSN 1442-9993. doi:10.1111/j.1442-9993.2010.02127.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1442-9993.2010.02127.x>.

- [41] D. D. Breshears, N. S. Cobb, P. M. Rich, K. P. Price, C. D. Allen, R. G. Balice, W. H. Romme, J. H. Kastens, M. L. Floyd, J. Belnap, J. J. Anderson, O. B. Myers, and C. W. Meyer. Regional vegetation die-off in response to global-change-type drought. *Proceedings of the National Academy of Sciences*, 102(42):15144–15148, Oct. 2005. doi:[10.1073/pnas.0505734102](https://doi.org/10.1073/pnas.0505734102). URL <https://www.pnas.org/doi/abs/10.1073/pnas.0505734102>.
- [42] E. G. Brockerhoff, H. Jactel, J. A. Parrotta, C. P. Quine, and J. Sayer. Plantation forests and biodiversity: Oxymoron or opportunity? *Biodiversity and Conservation*, 17(5):925–951, May 2008. ISSN 1572-9710. doi:[10.1007/s10531-008-9380-x](https://doi.org/10.1007/s10531-008-9380-x). URL <https://doi.org/10.1007/s10531-008-9380-x>.
- [43] B. W. Brook, E. C. Ellis, M. P. Perring, A. W. Mackay, and L. Blomqvist. Does the terrestrial biosphere have planetary tipping points? *Trends in Ecology & Evolution*, 28(7):396–401, July 2013. ISSN 0169-5347. doi:[10.1016/j.tree.2013.01.016](https://doi.org/10.1016/j.tree.2013.01.016). URL <https://www.sciencedirect.com/science/article/pii/S0169534713000335>.
- [44] S. Buckingham, N. Murphy, and H. Gibb. Effects of fire severity on the composition and functional traits of litter-dwelling macroinvertebrates in a temperate forest. *Forest Ecology and Management*, 434:279–288, Feb. 2019. ISSN 0378-1127. doi:[10.1016/j.foreco.2018.12.030](https://doi.org/10.1016/j.foreco.2018.12.030). URL <https://www.sciencedirect.com/science/article/pii/S0378112718316712>.
- [45] B. Buma. Disturbance interactions: Characterization, prediction, and the potential for cascading effects. *Ecosphere*, 6(4):art70, 2015. ISSN 2150-8925. doi:[10.1890/ES15-00058.1](https://doi.org/10.1890/ES15-00058.1). URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/ES15-00058.1>.
- [46] B. Buma and C. A. Wessman. Disturbance interactions can impact resilience mechanisms of forests. *Ecosphere*, 2(5):art64, 2011. ISSN 2150-8925. doi:[10.1890/ES11-00038.1](https://doi.org/10.1890/ES11-00038.1). URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/ES11-00038.1>.
- [47] B. Buma, C. D. Brown, D. C. Donato, J. B. Fontaine, and J. F. Johnstone. The Impacts of Changing Disturbance Regimes on Serotinous Plant Populations and Communities. *BioScience*, 63(11):866–876, Nov. 2013. ISSN 0006-3568. doi:[10.1525/bio.2013.63.11.5](https://doi.org/10.1525/bio.2013.63.11.5). URL <https://doi.org/10.1525/bio.2013.63.11.5>.
- [48] L. A. Burkle, M. P. Simanonok, J. S. Durney, J. A. Myers, and R. T. Belote. Wildfires Influence Abundance, Diversity, and Intraspecific and Interspecific Trait Variation of Native Bees and Flowering Plants Across Burned and Unburned Landscapes. *Frontiers in Ecology and Evolution*, 7, 2019. ISSN 2296-701X. doi:[10.3389/fevo.2019.00252](https://doi.org/10.3389/fevo.2019.00252). URL <https://www.frontiersin.org/articles/10.3389/fevo.2019.00252>.
- [49] L. A. Burkle, L. J. Heil, and R. T. Belote. Salvage logging management affects species' roles in connecting plant–pollinator interaction networks across post-wildfire landscapes. *Journal of Applied Ecology*, 58(8):1790–1801, 2021. ISSN 1365-2664. doi:[10/gj5n3z](https://doi.org/10/gj5n3z). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/1365-2664.13928>.

- [50] S. U. Busby, K. B. Moffett, and A. Holz. High-severity and short-interval wildfires limit forest recovery in the Central Cascade Range. *Ecosphere*, 11(9):e03247, 2020. ISSN 2150-8925. doi:10.1002/ecs2.3247. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/ecs2.3247>.
- [51] A. Busse, L. Cizek, P. Čížková, L. Drag, V. Dvorak, J. Foit, M. Heurich, P. Hubený, J. Kašák, F. Kittler, P. Kozel, L. Lettenmaier, L. Nigl, J. Procházka, J. Rothacher, C. Straubinger, S. Thorn, and J. Müller. Forest dieback in a protected area triggers the return of the primeval forest specialist *Peltis grossa* (Coleoptera, Trogossitidae). *Conservation Science and Practice*, 4(2):e612, 2022. ISSN 2578-4854. doi:10.1111/csp2.612. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/csp2.612>.
- [52] C. Cacciatori, G. Bacaro, E. Čečko, J. Zaremba, and J. Szwagrzyk. Windstorm effects on herbaceous vegetation in temperate forest ecosystems: Changes in plant functional diversity and species trait values along a disturbance severity gradient. *Forest Ecology and Management*, 505:119799, Feb. 2022. ISSN 0378-1127. doi:10.1016/j.foreco.2021.119799. URL <https://www.sciencedirect.com/science/article/pii/S0378112721008902>.
- [53] A. Camp, C. Oliver, P. Hessburg, and R. Everett. Predicting late-successional fire refugia pre-dating European settlement in the Wenatchee Mountains. *Forest Ecology and Management*, 95(1):63–77, July 1997. ISSN 0378-1127. doi:10/bhjnfn. URL <https://www.sciencedirect.com/science/article/pii/S0378112797000066>.
- [54] J. W. Campbell, P. A. Vigueira, C. C. Viguiera, and C. H. Greenberg. The Effects of Repeated Prescribed Fire and Thinning on Bees, Wasps, and Other Flower Visitors in the Understory and Midstory of a Temperate Forest in North Carolina. *Forest Science*, 64(3):299–306, May 2018. ISSN 0015-749X. doi:10.1093/forsci/fxx008. URL <https://doi.org/10.1093/forsci/fxx008>.
- [55] C. D. Canham, M. J. Papaik, and E. F. Latty. Interspecific variation in susceptibility to windthrow as a function of tree size and storm severity for northern temperate tree species. *Canadian Journal of Forest Research*, 31(1):1–10, Jan. 2001. ISSN 0045-5067. doi:10.1139/x00-124. URL <https://cdnsiencepub.com/doi/abs/10.1139/x00-124>.
- [56] J. B. Cannon, C. J. Peterson, J. J. O'Brien, and J. S. Brewer. A review and classification of interactions between forest disturbance from wind and fire. *Forest Ecology and Management*, 406:381–390, Dec. 2017. ISSN 0378-1127. doi:10.1016/j.foreco.2017.07.035. URL <https://www.sciencedirect.com/science/article/pii/S0378112717308885>.
- [57] L. M. Carbone, J. Tavella, J. G. Pausas, and R. Aguilar. A global synthesis of fire effects on pollinators. *Global Ecology and Biogeography*, 28(10):1487–1498, 2019. ISSN 1466-8238. doi:10.1111/geb.12939. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/geb.12939>.

- [58] A. R. Carlson, J. S. Sibold, T. J. Assal, and J. F. Negrón. Evidence of compounded disturbance effects on vegetation recovery following high-severity wildfire and spruce beetle outbreak. *PLOS ONE*, 12(8):e0181778, Aug. 2017. ISSN 1932-6203. doi:10.1371/journal.pone.0181778. URL <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0181778>.
- [59] D. J. Carlson, P. B. Reich, and L. E. Frelich. Fine-scale heterogeneity in overstory composition contributes to heterogeneity of wildfire severity in southern boreal forest. *Journal of Forest Research*, 16(3):203–214, June 2011. ISSN 1341-6979. doi:10/bxmb4b. URL <https://doi.org/10.1007/s10310-011-0251-z>.
- [60] M. Carmo, F. Moreira, P. Casimiro, and P. Vaz. Land use and topography influences on wildfire occurrence in northern Portugal. *Landscape and Urban Planning*, 100(1-2):169–176, Mar. 2011. ISSN 01692046. doi:10.1016/j.landurbplan.2010.11.017. URL <https://linkinghub.elsevier.com/retrieve/pii/S0169204611000028>.
- [61] T. A. Carter, K. Hayes, and B. Buma. Putting more fuel on the fire... or maybe not? A synthesis of spruce beetle and fire interactions in North American subalpine forests. *Landscape Ecology*, 37(9):2241–2254, Sept. 2022. ISSN 0921-2973, 1572-9761. doi:10.1007/s10980-022-01481-1. URL <https://link.springer.com/10.1007/s10980-022-01481-1>.
- [62] D. Castagneri, G. Vacchiano, A. Hackett-Pain, R. J. DeRose, T. Klein, and A. Bottero. Meta-analysis Reveals Different Competition Effects on Tree Growth Resistance and Resilience to Drought. *Ecosystems*, 25(1):30–43, Jan. 2022. ISSN 1435-0629. doi:10.1007/s10021-021-00638-4. URL <https://doi.org/10.1007/s10021-021-00638-4>.
- [63] E. Černecká, I. Mihál, P. Gajdoš, and B. Jarčuška. The effect of canopy openness of European beech (*Fagus sylvatica*) forests on ground-dwelling spider communities. *Insect Conservation and Diversity*, 13(3):250–261, 2020. ISSN 1752-4598. doi:10.1111/icad.12380. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/icad.12380>.
- [64] G. Certini. Effects of fire on properties of forest soils: A review. *Oecologia*, 143(1):1–10, Mar. 2005. ISSN 0029-8549, 1432-1939. doi:10.1007/s00442-004-1788-8. URL <https://link.springer.com/article/10.1007/s00442-004-1788-8>.
- [65] D. S. Chanasyk, I. R. Whitson, E. Mapfumo, J. M. Burke, and E. E. Prepas. The impacts of forest harvest and wildfire on soils and hydrology in temperate forests: A baseline to develop hypotheses for the Boreal Plain. *Journal of Environmental Engineering and Science*, 2(S1):S51–S62, June 2003. ISSN 1496-256X. doi:10.1139/s03-034. URL <https://cdnsiencepub.com/doi/abs/10.1139/s03-034>.
- [66] C. C. Chang, C. B. Halpern, J. A. Antos, M. L. Avolio, A. Biswas, J. E. Cook, R. del Moral, D. G. Fischer, A. Holz, R. J. Pabst, M. E. Swanson, and D. B. Zobel. Testing conceptual models of early plant succession across a disturbance gradient. *Journal of Ecology*, 107(2):517–530, 2019. ISSN 1365-2745. doi:10.1111/1365-2745.13120. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/1365-2745.13120>.

- [67] S. Charnley, T. Spies, A. Barros, E. White, and K. Olsen. Diversity in forest management to reduce wildfire losses: Implications for resilience. *Ecology and Society*, 22(1), Feb. 2017. ISSN 1708-3087. doi:10.5751/ES-08753-220122. URL <https://www.ecologyandsociety.org/vol22/iss1/art22/>.
- [68] L. Chevaux, A. Mårell, C. Baltzinger, V. Boulanger, S. Cadet, R. Chevalier, N. Debaive, Y. Dumas, M. Gosselin, F. Gosselin, A. Rocquencourt, and Y. Paillet. Effects of stand structure and ungulates on understory vegetation in managed and unmanaged forests. *Ecological Applications*, 32(3):e2531, 2022. ISSN 1939-5582. doi:10.1002/eap.2531. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/eap.2531>.
- [69] J.-M. Chiang and K. J. Brown. The effects of thinning and burning treatments on within-canopy variation of leaf traits in hardwood forests of southern Ohio. *Forest Ecology and Management*, 260(6):1065–1075, Aug. 2010. ISSN 0378-1127. doi:10.1016/j.foreco.2010.06.033. URL <https://www.sciencedirect.com/science/article/pii/S0378112710003658>.
- [70] B. Choat, T. J. Brodribb, C. R. Brodersen, R. A. Duursma, R. López, and B. E. Medlyn. Triggers of tree mortality under drought. *Nature*, 558(7711):531–539, June 2018. ISSN 1476-4687. doi:10.1038/s41586-018-0240-x. URL <https://www.nature.com/articles/s41586-018-0240-x>.
- [71] P. Chylarecki and N. Selva. Ancient forest: Spare it from clearance. *Nature*, 530(7591):419–419, Feb. 2016. ISSN 1476-4687. doi:10.1038/530419b. URL <https://www.nature.com/articles/530419b>.
- [72] F. E. Clements. *Plant Succession; an Analysis of the Development of Vegetation*. Carnegie Institution of Washington, Washington, 1916. doi:10.5962/bhl.title.56234. URL <https://www.biodiversitylibrary.org/bibliography/56234>.
- [73] T. P. Cobb, J. L. Morissette, J. M. Jacobs, M. J. Koivula, J. R. Spence, and D. W. Langor. Effects of Postfire Salvage Logging on Deadwood-Associated Beetles. *Conservation Biology*, 25(1):94–104, 2011. ISSN 1523-1739. doi:10/dngznh. URL <https://conbio.onlinelibrary.wiley.com/doi/abs/10.1111/j.1523-1739.2010.01566.x>.
- [74] L. Collins, A. F. Bennett, S. W. J. Leonard, and T. D. Penman. Wildfire refugia in forests: Severe fire weather and drought mute the influence of topography and fuel age. *Global Change Biology*, 25(11):3829–3843, 2019. ISSN 1365-2486. doi:10.1111/gcb.14735. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.14735>.
- [75] L. Collins, R. A. Bradstock, H. Clarke, M. F. Clarke, R. H. Nolan, and T. D. Penman. The 2019/2020 mega-fires exposed Australian ecosystems to an unprecedented extent of high-severity fire. *Environmental Research Letters*, 16(4):044029, Mar. 2021. ISSN 1748-9326. doi:10.1088/1748-9326/abeb9e. URL <https://dx.doi.org/10.1088/1748-9326/abeb9e>.

- [76] M. Conedera, D. Colombaroli, W. Tinner, P. Krebs, and C. Whitlock. Insights about past forest dynamics as a tool for present and future forest management in Switzerland. *Forest Ecology and Management*, 388:100–112, Mar. 2017. ISSN 0378-1127. doi:[10.1016/j.foreco.2016.10.027](https://doi.org/10.1016/j.foreco.2016.10.027). URL <https://www.sciencedirect.com/science/article/pii/S0378112716307800>.
- [77] H. Cosyns, B. Joa, R. Mikoleit, F. Krumm, A. Schuck, G. Winkel, and T. Schulz. Resolving the trade-off between production and biodiversity conservation in integrated forest management: Comparing tree selection practices of foresters and conservationists. *Biodiversity and Conservation*, 29(13):3717–3737, Nov. 2020. ISSN 1572-9710. doi:[10.1007/s10531-020-02046-x](https://doi.org/10.1007/s10531-020-02046-x). URL <https://doi.org/10.1007/s10531-020-02046-x>.
- [78] B. Courbaud, L. Larrieu, D. Kozak, D. Kraus, T. Lachat, S. Ladet, J. Müller, Y. Paillet, K. Sagheb-Talebi, A. Schuck, J. Stillhard, M. Svoboda, and S. Zudin. Factors influencing the rate of formation of tree-related microhabitats and implications for biodiversity conservation and forest management. *Journal of Applied Ecology*, 59(2):492–503, 2022. ISSN 1365-2664. doi:[10.1111/1365-2664.14068](https://doi.org/10.1111/1365-2664.14068). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/1365-2664.14068>.
- [79] J. Cours, L. Larrieu, C. Lopez-Vaamonde, J. Müller, G. Parmain, S. Thorn, and C. Bouget. Contrasting responses of habitat conditions and insect biodiversity to pest- or climate-induced dieback in coniferous mountain forests. *Forest Ecology and Management*, 482, Feb. 2021. ISSN 0378-1127. doi:[10/ghpnxz](https://doi.org/10/ghpnxz). URL <http://www.sciencedirect.com/science/article/pii/S0378112720315802>.
- [80] J. Cours, L. Sire, S. Ladet, H. Martin, G. Parmain, L. Larrieu, C. Moliard, C. Lopez-Vaamonde, and C. Bouget. Drought-induced forest dieback increases taxonomic, functional, and phylogenetic diversity of saproxylic beetles at both local and landscape scales. *Landscape Ecology*, June 2022. ISSN 1572-9761. doi:[10.1007/s10980-022-01453-5](https://doi.org/10.1007/s10980-022-01453-5). URL <https://doi.org/10.1007/s10980-022-01453-5>.
- [81] D. R. Coyle, U. J. Nagendra, M. K. Taylor, J. H. Campbell, C. E. Cunard, A. H. Joslin, A. Mundepi, C. A. Phillips, and M. A. Callahan. Soil fauna responses to natural disturbances, invasive species, and global climate change: Current state of the science and a call to action. *Soil Biology and Biochemistry*, 110:116–133, July 2017. ISSN 0038-0717. doi:[10.1016/j.soilbio.2017.03.008](https://doi.org/10.1016/j.soilbio.2017.03.008). URL <https://www.sciencedirect.com/science/article/pii/S0038071717301530>.
- [82] P. Čuchta, D. Miklisová, and E. Kováč. The impact of disturbance and ensuing forestry practices on Collembola in monitored stands of windthrown forest in the Tatra National Park (Slovakia). *Environmental Monitoring and Assessment*, 185(6):5085–5098, June 2013. ISSN 1573-2959. doi:[10.1007/s10661-012-2927-z](https://doi.org/10.1007/s10661-012-2927-z). URL <https://doi.org/10.1007/s10661-012-2927-z>.
- [83] V. H. Dale, L. A. Joyce, S. McNulty, R. P. Neilson, M. P. Ayres, M. D. Flannigan, P. J. Hanson, L. C. Irland, A. E. Lugo, C. J. Peterson, D. Simberloff, F. J. Swanson, B. J. Stocks, and B. M. Wotton. Climate Change and Forest Disturbances. *BioScience*, 51(9):723–734, Sept. 2001. ISSN

- 0006-3568. doi:[10.1641/0006-3568\(2001\)051\[0723:CCAFD\]2.0.CO;2](https://doi.org/10.1641/0006-3568(2001)051[0723:CCAFD]2.0.CO;2). URL <https://academic.oup.com/bioscience/article/51/9/723/288247>.
- [84] K. T. Davis, M. D. Robles, K. B. Kemp, P. E. Higuera, T. Chapman, K. L. Metlen, J. L. Peeler, K. C. Rodman, T. Woolley, R. N. Addington, B. J. Buma, C. A. Cansler, M. J. Case, B. M. Collins, J. D. Coop, S. Z. Dobrowski, N. S. Gill, C. Haffey, L. B. Harris, B. J. Harvey, R. D. Haugo, M. D. Hurteau, D. Kulakowski, C. E. Littlefield, L. A. McCauley, N. Povak, K. L. Shive, E. Smith, J. T. Stevens, C. S. Stevens-Rumann, A. H. Taylor, A. J. Tepley, D. J. N. Young, R. A. Andrus, M. A. Battaglia, J. K. Berkey, S. U. Busby, A. R. Carlson, M. E. Chambers, E. K. Dodson, D. C. Donato, W. M. Downing, P. J. Fornwalt, J. S. Halofsky, A. Hoffman, A. Holz, J. M. Iniguez, M. A. Krawchuk, M. R. Kreider, A. J. Larson, G. W. Meigs, J. P. Roccaforte, M. T. Rother, H. Safford, M. Schaedel, J. S. Sibold, M. P. Singleton, M. G. Turner, A. K. Urza, K. D. Clark-Wolf, L. Yocom, J. B. Fontaine, and J. L. Campbell. Reduced fire severity offers near-term buffer to climate-driven declines in conifer resilience across the western United States. *Proceedings of the National Academy of Sciences*, 120(11):e2208120120, Mar. 2023. doi:[10.1073/pnas.2208120120](https://doi.org/10.1073/pnas.2208120120). URL <https://www.pnas.org/doi/10.1073/pnas.2208120120>.
- [85] T. S. Davis, P. R. Rhoades, A. J. Mann, and T. Griswold. Bark beetle outbreak enhances biodiversity and foraging habitat of native bees in alpine landscapes of the southern Rocky Mountains. *Scientific Reports*, 10(1):16400, Oct. 2020. ISSN 2045-2322. doi:[10.1038/s41598-020-73273-z](https://doi.org/10.1038/s41598-020-73273-z). URL <https://www.nature.com/articles/s41598-020-73273-z>.
- [86] N. J. Day, A. L. White, J. F. Johnstone, G. É. Degré-Timmons, S. G. Cumming, M. C. Mack, M. R. Turetsky, X. J. Walker, and J. L. Baltzer. Fire characteristics and environmental conditions shape plant communities via regeneration strategy. *Ecography*, 43(10):1464–1474, 2020. ISSN 1600-0587. doi:[10.1111/ecog.05211](https://doi.org/10.1111/ecog.05211). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/ecog.05211>.
- [87] P. De Frenne, J. Lenoir, M. Luoto, B. R. Scheffers, F. Zellweger, J. Aalto, M. B. Ashcroft, D. M. Christiansen, G. Decocq, K. De Pauw, S. Govaert, C. Greiser, E. Gril, A. Hampe, T. Jucker, D. H. Klings, I. A. Koelemeijer, J. J. Lembrechts, R. Marrec, C. Meeussen, J. Ogée, V. Tyystjärvi, P. Vangansbeke, and K. Hylander. Forest microclimates and climate change: Importance, drivers and future research agenda. *Global Change Biology*, 27(11):2279–2297, 2021. ISSN 1365-2486. doi:[10.1111/gcb.15569](https://doi.org/10.1111/gcb.15569). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.15569>.
- [88] L. F. DeBano, D. G. Neary, and P. F. Ffolliott. *Fire Effects on Ecosystems*. John Wiley & Sons, Mar. 1998. ISBN 978-0-471-16356-5.
- [89] J. Dell, J. O'Brien, L. Doan, L. Richards, and L. Dyer. An arthropod survival strategy in a frequently burned forest. *Ecology*, 98(11):2972–2974, 2017. doi:[10.1002/ecy.1939](https://doi.org/10.1002/ecy.1939). URL <http://www.fs.usda.gov/treesearch/pubs/55303>.

- [90] R. J. Delph, M. J. Clifford, N. S. Cobb, P. L. Ford, and S. L. Brantley. Pinyon Pine Mortality Alters Communities of Ground-Dwelling Arthropods. *Western North American Naturalist*, 74(2):162–184, Aug. 2014. ISSN 1527-0904, 1944-8341. doi:10.3398/064.074.0203. URL <https://bioone.org/journals/western-north-american-naturalist/volume-74/issue-2/064.074.0203/Pinyon-Pine-Mortality-Alters-Communities-of-Ground-Dwelling-Arthropods/10.3398/064.074.0203.full>.
- [91] T. H. DeLuca and G. H. Aplet. Charcoal and carbon storage in forest soils of the Rocky Mountain West. *Frontiers in Ecology and the Environment*, 6(1):18–24, 2008. ISSN 1540-9309. doi:10.1890/070070. URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/070070>.
- [92] R. J. DeRose and J. N. Long. Regeneration response and seedling bank dynamics on a Dendroctonus rufipennis-killed Picea engelmannii landscape. *Journal of Vegetation Science*, 21(2):377–387, 2010. ISSN 1654-1103. doi:10.1111/j.1654-1103.2009.01150.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1654-1103.2009.01150.x>.
- [93] L. Dietz, C. Collet, J.-L. Dupouey, E. Lacombe, L. Laurent, and J.-C. Gégout. Windstorm-induced canopy openings accelerate temperate forest adaptation to global warming. *Global Ecology and Biogeography*, 29(11):2067–2077, 2020. ISSN 1466-8238. doi:10/gm7dhc. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/geb.13177>.
- [94] D. C. Donato, J. B. Fontaine, J. L. Campbell, W. D. Robinson, J. B. Kauffman, and B. E. Law. Post-Wildfire Logging Hinders Regeneration and Increases Fire Risk. *Science*, 311(5759):352–352, Jan. 2006. ISSN 0036-8075, 1095-9203. doi:10.1126/science.1122855. URL <https://www.science.org/doi/10.1126/science.1122855>.
- [95] D. C. Donato, J. B. Fontaine, and J. L. Campbell. Burning the legacy? Influence of wildfire reburn on dead wood dynamics in a temperate conifer forest. *Ecosphere*, 7(5):e01341, 2016. ISSN 2150-8925. doi:10.1002/ecs2.1341. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/ecs2.1341>.
- [96] P. S. Duncker, S. M. Barreiro, G. M. Hengeveld, T. Lind, W. L. Mason, S. Ambrozy, and H. Spiecker. Classification of Forest Management Approaches: A New Conceptual Framework and Its Applicability to European Forestry. *Ecology and Society*, 17(4), 2012. ISSN 1708-3087. doi:10.5751/ES-05262-170451. URL <https://www.jstor.org/stable/26269224>.
- [97] J.-I. Dupuy, H. Fargeon, N. Martin-StPaul, F. Pimont, J. Ruffault, M. Guijarro, C. Hernando, J. Madrigal, and P. Fernandes. Climate change impact on future wildfire danger and activity in southern Europe: A review. *Annals of Forest Science*, 77(2):1–24, June 2020. ISSN 1297-966X. doi:10.1007/s13595-020-00933-5. URL <https://annforsci.biomedcentral.com/articles/10.1007/s13595-020-00933-5>.

- [98] A. Eklund, M. G. Wing, and J. Sessions. Evaluating Economic and Wildlife Habitat Considerations for Snag Retention Policies in Burned Landscapes. *Western Journal of Applied Forestry*, 24(2):67–75, Apr. 2009. ISSN 0885-6095. doi:10/gnbdm6. URL <https://doi.org/10.1093/wjaf/24.2.67>.
- [99] C. Elkin, A. Giuggiola, A. Rigling, and H. Bugmann. Short- and long-term efficacy of forest thinning to mitigate drought impacts in mountain forests in the European Alps. *Ecological Applications*, 25(4):1083–1098, 2015. ISSN 1939-5582. doi:10.1890/14-0690.1. URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/14-0690.1>.
- [100] E. C. Ellis. Anthropogenic transformation of the terrestrial biosphere. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, 369(1938):1010–1035, Mar. 2011. doi:10.1098/rsta.2010.0331. URL <https://royalsocietypublishing.org/doi/10.1098/rsta.2010.0331>.
- [101] S. Etzold, K. Ziemińska, B. Rohner, A. Bottero, A. K. Bose, N. K. Ruehr, A. Zingg, and A. Rigling. One Century of Forest Monitoring Data in Switzerland Reveals Species- and Site-Specific Trends of Climate-Induced Tree Mortality. *Frontiers in Plant Science*, 10, 2019. ISSN 1664-462X. doi:10.3389/fpls.2019.00307. URL <https://www.frontiersin.org/articles/10.3389/fpls.2019.00307>.
- [102] M. J. Evans, P. Barton, S. Niwa, M. Soga, S. Seibold, K. Tsuchiya, and M. Hisano. Climate-driven divergent long-term trends of forest beetles in Japan. *Ecology Letters*, 25(9):2009–2021, Sept. 2022. ISSN 1461-0248. doi:10.1111/ele.14082. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/ele.14082>.
- [103] W. G. Evans. Infrared Radiation Sensors of *Melanophila acuminata* (Coleoptera: Buprestidae): A Thermopneumatic Model. *Annals of the Entomological Society of America*, 98(5):738–746, Sept. 2005. ISSN 00138746, 00138746. doi:10/b8kxq3. URL <https://academic.oup.com/aesa/article/98/5/738-746/69666>.
- [104] E. M. Everham and N. V. L. Brokaw. Forest damage and recovery from catastrophic wind. *The Botanical Review*, 62(2):113–185, Apr. 1996. ISSN 1874-9372. doi:10.1007/BF02857920. URL <https://doi.org/10.1007/BF02857920>.
- [105] L. Fahrig. Rethinking patch size and isolation effects: The habitat amount hypothesis. *Journal of Biogeography*, 40(9):1649–1663, 2013. ISSN 1365-2699. doi:10.1111/jbi.12130. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/jbi.12130>.
- [106] S. Fattorini. Effects of fire on tenebrionid communities of a *Pinus pinea* plantation: A case study in a Mediterranean site. *Biodiversity and Conservation*, 19(5):1237–1250, May 2010. ISSN 1572-9710. doi:10.1007/s10531-009-9749-5. URL <https://doi.org/10.1007/s10531-009-9749-5>.
- [107] K. Fedrowitz, J. Koricheva, S. C. Baker, D. B. Lindenmayer, B. Palik, R. Rosenvald, W. Beese, J. F. Franklin, J. Kouki, E. Macdonald, C. Messier, A. Sverdrup-Thygeson, and L. Gustafsson.

- REVIEW: Can retention forestry help conserve biodiversity? A meta-analysis. *Journal of Applied Ecology*, 51(6):1669–1679, 2014. ISSN 1365-2664. doi:10.1111/1365-2664.12289. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/1365-2664.12289>.
- [108] M. Fernández-Martínez, J. Belmonte, and J. Maria Espelta. Masting in oaks: Disentangling the effect of flowering phenology, airborne pollen load and drought. *Acta Oecologica*, 43:51–59, Aug. 2012. ISSN 1146-609X. doi:10.1016/j.actao.2012.05.006. URL <https://www.sciencedirect.com/science/article/pii/S1146609X12000586>.
- [109] S. Ferrenberg, A. S. Martinez, and A. M. Faist. Aboveground and belowground arthropods experience different relative influences of stochastic versus deterministic community assembly processes following disturbance. *PeerJ*, 4:e2545, Oct. 2016. ISSN 2167-8359. doi:10.7717/peerj.2545. URL <https://peerj.com/articles/2545>.
- [110] S. Ferrenberg, P. Wickey, and J. D. Coop. Ground-Dwelling Arthropod Community Responses to Recent and Repeated Wildfires in Conifer Forests of Northern New Mexico, USA. *Forests*, 10(8):667, Aug. 2019. ISSN 1999-4907. doi:10.3390/f10080667. URL <https://www.mdpi.com/1999-4907/10/8/667>.
- [111] S. M. Ferrenberg, D. W. Schwilk, E. E. Knapp, E. Groth, and J. E. Keeley. Fire decreases arthropod abundance but increases diversity: Early and late season prescribed fire effects in a Sierra Nevada mixed-conifer forest. *Fire Ecology*, 2(2):79–102, Dec. 2006. ISSN 1933-9747. doi:10.4996/fireecology.0202079. URL <https://doi.org/10.4996/fireecology.0202079>.
- [112] C. J. Fettig, J. B. Runyon, C. S. Homicz, P. M. A. James, and M. D. Ulyshen. Fire and Insect Interactions in North American Forests. *Current Forestry Reports*, Aug. 2022. ISSN 2198-6436. doi:10.1007/s40725-022-00170-1. URL <https://doi.org/10.1007/s40725-022-00170-1>.
- [113] G. Fidej, A. Rozman, T. A. Nagel, I. Daksobler, and J. Diaci. Influence of salvage logging on forest recovery following intermediate severity canopy disturbances in mixed beech dominated forests of Slovenia. *iForest - Biogeosciences and Forestry*, 9(3):430, 2016. ISSN 1971-7458. doi:10/gm97tn. URL <https://iforest.sisef.org/abstract/?id=ifor1616-008>.
- [114] G. Forzieri, M. Girardello, G. Ceccherini, J. Spinoni, L. Feyen, H. Hartmann, P. S. A. Beck, G. Camps-Valls, G. Chirici, A. Mauri, and A. Cescatti. Emergent vulnerability to climate-driven disturbances in European forests. *Nature Communications*, 12(1):1081, Feb. 2021. ISSN 2041-1723. doi:10.1038/s41467-021-21399-7. URL <https://www.nature.com/articles/s41467-021-21399-7>.
- [115] D. R. Foster and D. A. Orwig. Preemptive and Salvage Harvesting of New England Forests: When Doing Nothing Is a Viable Alternative. *Conservation Biology*, 20(4):959–970, 2006. ISSN 0888-8892. doi:10/dzn94t. URL <https://www.jstor.org/stable/3879164>.

- [116] J. F. Franklin, D. Lindenmayer, J. A. MacMahon, A. McKee, J. Magnuson, D. A. Perry, R. Waide, and D. Foster. Threads of Continuity. *Conservation in Practice*, 1(1):8–17, 2000. ISSN 1552-5228. doi:[10.1111/j.1526-4629.2000.tb00155.x](https://doi.org/10.1111/j.1526-4629.2000.tb00155.x). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1526-4629.2000.tb00155.x>.
- [117] J. M. Fraterrigo, M. G. Turner, and S. M. Pearson. Previous land use alters plant allocation and growth in forest herbs. *Journal of Ecology*, 94(3):548–557, 2006. ISSN 1365-2745. doi:[10.1111/j.1365-2745.2006.01081.x](https://doi.org/10.1111/j.1365-2745.2006.01081.x). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2745.2006.01081.x>.
- [118] S. Fraver, T. Jain, J. B. Bradford, A. W. D’Amato, D. Kastendick, B. Palik, D. Shinneman, and J. Stanovick. The efficacy of salvage logging in reducing subsequent fire severity in conifer-dominated forests of Minnesota, USA. *Ecological Applications*, 21(6):1895–1901, 2011. ISSN 1939-5582. doi:[10.1890/11-0380.1](https://doi.org/10.1890/11-0380.1). URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/11-0380.1>.
- [119] L. E. Frelich and P. B. Reich. Neighborhood Effects, Disturbance Severity, and Community Stability in Forests. *Ecosystems*, 2:151–166, 1999. ISSN 1432-9840. doi:[10.1007/s100219900066](https://doi.org/10.1007/s100219900066). URL <https://doi.org/10.1007/s100219900066>.
- [120] S. M. Galbraith, J. H. Cane, A. R. Moldenke, and J. W. Rivers. Salvage logging reduces wild bee diversity, but not abundance, in severely burned mixed-conifer forest. *Forest Ecology and Management*, 453:117622, Dec. 2019. ISSN 0378-1127. doi:[10/gpbzhw](https://doi.org/10.1016/j.foreco.2019.117622). URL <https://www.sciencedirect.com/science/article/pii/S0378112719310163>.
- [121] F. García-Orenes, V. Arcenegui, K. Chrenková, J. Mataix-Solera, J. Moltó, A. B. Jara-Navarro, and M. P. Torres. Effects of salvage logging on soil properties and vegetation recovery in a fire-affected Mediterranean forest: A two year monitoring research. *Science of The Total Environment*, 586: 1057–1065, May 2017. ISSN 0048-9697. doi:[10/f942fj](https://doi.org/10.1016/j.scitotenv.2017.05.075). URL <https://www.sciencedirect.com/science/article/pii/S0048969717303388>.
- [122] S. Gauthier, Y. Bergeron, and J.-P. Simon. Effects of Fire Regime on the Serotiny Level of Jack Pine. *Journal of Ecology*, 84(4):539–548, 1996. ISSN 0022-0477. doi:[10.2307/2261476](https://doi.org/10.2307/2261476). URL <https://www.jstor.org/stable/2261476>.
- [123] J. Gavinet, J.-M. Ourcival, and J.-M. Limousin. Rainfall exclusion and thinning can alter the relationships between forest functioning and drought. *New Phytologist*, 223(3):1267–1279, 2019. ISSN 1469-8137. doi:[10.1111/nph.15860](https://doi.org/10.1111/nph.15860). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/nph.15860>.
- [124] C. Gely, S. G. Laurance, and N. E. Stork. How do herbivorous insects respond to drought stress in trees? *Biological Reviews*, 95(2):434–448, 2020. ISSN 1469-185X. doi:[10.1111/brv.12571](https://doi.org/10.1111/brv.12571). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/brv.12571>.

- [125] K. B. Georgiev, B. Beudert, C. Bässler, H. Feldhaar, C. Heibl, P. Karasch, J. Müller, M. Perlík, I. Weiss, and S. Thorn. Forest disturbance and salvage logging have neutral long-term effects on drinking water quality but alter biodiversity. *Forest Ecology and Management*, 495:119354, Sept. 2021. ISSN 0378-1127. doi:10/gj4953. URL <https://www.sciencedirect.com/science/article/pii/S0378112721004424>.
- [126] K. B. Georgiev, C. Bässler, H. Feldhaar, C. Heibl, P. Karasch, J. Müller, M. Perlik, I. Weiss, and S. Thorn. Windthrow and salvage logging alter β -diversity of multiple species groups in a mountain spruce forest. *Forest Ecology and Management*, 520:120401, Sept. 2022. ISSN 0378-1127. doi:10.1016/j.foreco.2022.120401. URL <https://www.sciencedirect.com/science/article/pii/S0378112722003954>.
- [127] M. P. Girardin, E. H. Hogg, P. Y. Bernier, W. A. Kurz, X. J. Guo, and G. Cyr. Negative impacts of high temperatures on growth of black spruce forests intensify with the anticipated climate warming. *Global Change Biology*, 22(2):627–643, 2016. ISSN 1365-2486. doi:10.1111/gcb.13072. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.13072>.
- [128] R. Gobin. *Contribution relative de la végétation du sous-bois dans la consommation en eau des placettes forestières soumises aux changements de climat et de pratiques*. Sciences de l'environnement, Université d'Orléans, Orléans, 2014.
- [129] K. B. Gongalsky and T. Persson. Recovery of soil macrofauna after wildfires in boreal forests. *Soil Biology and Biochemistry*, 57:182–191, Feb. 2013. ISSN 0038-0717. doi:10.1016/j.soilbio.2012.07.005. URL <https://www.sciencedirect.com/science/article/pii/S0038071712002799>.
- [130] M. Graf, L. Lettenmaier, J. Müller, and J. Hagge. Saproxylic beetles trace deadwood and differentiate between deadwood niches before their arrival on potential hosts. *Insect Conservation and Diversity*, 15(1):48–60, 2022. ISSN 1752-4598. doi:10.1111/icad.12534. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/icad.12534>.
- [131] H. Gregow, A. Laaksonen, and M. E. Alper. Increasing large scale windstorm damage in Western, Central and Northern European forests, 1951–2010. *Scientific Reports*, 7(1):46397, Apr. 2017. ISSN 2045-2322. doi:10.1038/srep46397. URL <https://www.nature.com/articles/srep46397>.
- [132] S. J. Grove. Saproxylic Insect Ecology and the Sustainable Management of Forests. *Annual Review of Ecology and Systematics*, 33(1):1–23, 2002. doi:10.1146/annurev.ecolsys.33.010802.150507. URL <https://doi.org/10.1146/annurev.ecolsys.33.010802.150507>.
- [133] L. Gustafsson, V. Johansson, A. B. Leverkus, J. Strengbom, S. Wikberg, and G. Granath. Disturbance interval modulates the starting point for vegetation succession. *Ecology*, 102(9), Sept. 2021. ISSN 0012-9658, 1939-9170. doi:10/gmkx45. URL <https://onlinelibrary.wiley.com/doi/10.1002/ecy.3439>.

- [134] J. L. Hanula and D. D. Wade. Influence of long-term dormant-season burning and fire exclusion on ground-dwelling arthropod populations in longleaf pine flatwoods ecosystems. *Forest Ecology and Management*, 175(1):163–184, Mar. 2003. ISSN 0378-1127. doi:10.1016/S0378-1127(02)00130-5. URL <https://www.sciencedirect.com/science/article/pii/S0378112702001305>.
- [135] J. L. Hanula, M. D. Ulyshen, and S. Horn. Conserving Pollinators in North American Forests: A Review. *Natural Areas Journal*, 36(4):427–439, Oct. 2016. ISSN 0885-8608, 2162-4399. doi:10.3375/043.036.0409. URL <https://bioone.org/journals/natural-areas-journal/volume-36/issue-4/043.036.0409/Conserving-Pollinators-in-North-American-Forests-A-Review/10.3375/043.036.0409.full>.
- [136] P. A. Harcombe, S. E. Greene, M. G. Kramer, S. A. Acker, T. A. Spies, and T. Valentine. The influence of fire and windthrow dynamics on a coastal spruce–hemlock forest in Oregon, USA, based on aerial photographs spanning 40 years. *Forest Ecology and Management*, 194(1):71–82, June 2004. ISSN 0378-1127. doi:10.1016/j.foreco.2004.02.016. URL <https://www.sciencedirect.com/science/article/pii/S0378112704001379>.
- [137] M. E. Harmon, B. G. Fasth, M. Yatskov, D. Kastendick, J. Rock, and C. W. Woodall. Release of coarse woody detritus-related carbon: A synthesis across forest biomes. *Carbon Balance and Management*, 15(1):1, Jan. 2020. ISSN 1750-0680. doi:10.1186/s13021-019-0136-6. URL <https://doi.org/10.1186/s13021-019-0136-6>.
- [138] S. J. Hart, J. Henkelman, P. D. McLoughlin, S. E. Nielsen, A. Truchon-Savard, and J. F. Johnstone. Examining forest resilience to changing fire frequency in a fire-prone region of boreal forest. *Global Change Biology*, 25(3):869–884, 2019. ISSN 1365-2486. doi:10.1111/gcb.14550. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.14550>.
- [139] J. Hartshorn. A Review of Forest Management Effects on Terrestrial Leaf Litter Inhabiting Arthropods. *Forests*, 12(1):23, Jan. 2021. ISSN 1999-4907. doi:10.3390/f12010023. URL <https://www.mdpi.com/1999-4907/12/1/23>.
- [140] B. J. Harvey, D. C. Donato, and M. G. Turner. Recent mountain pine beetle outbreaks, wildfire severity, and postfire tree regeneration in the US Northern Rockies. *Proceedings of the National Academy of Sciences*, 111(42):15120–15125, Oct. 2014. doi:10.1073/pnas.1411346111. URL <https://www.pnas.org/doi/abs/10.1073/pnas.1411346111>.
- [141] J. A. Harvey, K. Tougeron, R. Gols, R. Heinen, M. Abarca, P. K. Abram, Y. Basset, M. Berg, C. Boggs, J. Brodeur, P. Cardoso, J. G. de Boer, G. R. De Snoo, C. Deacon, J. E. Dell, N. Desneux, M. E. Dillon, G. A. Duffy, L. A. Dyer, J. Ellers, A. Espíndola, J. Fordyce, M. L. Forister, C. Fukushima, M. J. G. Gage, C. García-Robledo, C. Gely, M. Gobbi, C. Hallmann, T. Hance, J. Harte, A. Hochkirch, C. Hof, A. A. Hoffmann, J. G. Kingsolver, G. P. A. Lamarre, W. F. Laurance, B. Lavandero, S. R. Leather, P. Lehmann, C. Le Lann, M. M. López-Uribe, C.-S. Ma, G. Ma, J. Moiroux, L. Monticelli,

- C. Nice, P. J. Ode, S. Pincebourde, W. J. Ripple, M. Rowe, M. J. Samways, A. Sentis, A. A. Shah, N. Stork, J. S. Terblanche, M. P. Thakur, M. B. Thomas, J. M. Tylianakis, J. Van Baaren, M. Van de Pol, W. H. Van der Putten, H. Van Dyck, W. C. E. P. Verberk, D. L. Wagner, W. W. Weisser, W. C. Wetzel, H. A. Woods, K. A. G. Wyckhuys, and S. L. Chown. Scientists' warning on climate change and insects. *Ecological Monographs*, 93(1):e1553, 2023. ISSN 1557-7015. doi:[10.1002/ecm.1553](https://doi.org/10.1002/ecm.1553). URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/ecm.1553>.
- [142] L. J. Heil and L. A. Burkle. Recent post-wildfire salvage logging benefits local and landscape floral and bee communities. *Forest Ecology and Management*, 424:267–275, Sept. 2018. ISSN 0378-1127. doi:[10/gpbzhj](https://doi.org/10/gpbzhj). URL <https://www.sciencedirect.com/science/article/pii/S0378112718303244>.
- [143] N. Henig-Sever, D. Poliakov, and M. Broza. A novel method for estimation of wild fire intensity based on ash pH and soil microarthropod community. *Pedobiologia*, 45(2):98–106, Jan. 2001. ISSN 0031-4056. doi:[10.1078/0031-4056-00072](https://doi.org/10.1078/0031-4056-00072). URL <https://www.sciencedirect.com/science/article/pii/S0031405604700955>.
- [144] M. Hermy and K. Verheyen. Legacies of the past in the present-day forest biodiversity: A review of past land-use effects on forest plant species composition and diversity. *Ecological Research*, 22(3):361–371, 2007. ISSN 1440-1703. doi:[10.1007/s11284-007-0354-3](https://doi.org/10.1007/s11284-007-0354-3). URL <https://onlinelibrary.wiley.com/doi/abs/10.1007/s11284-007-0354-3>.
- [145] J. A. Hicke, M. C. Johnson, J. L. Hayes, and H. K. Preisler. Effects of bark beetle-caused tree mortality on wildfire. *Forest Ecology and Management*, 271:81–90, May 2012. ISSN 0378-1127. doi:[10.1016/j.foreco.2012.02.005](https://doi.org/10.1016/j.foreco.2012.02.005). URL <https://www.sciencedirect.com/science/article/pii/S0378112712000746>.
- [146] J. Hilszczański, T. Jaworski, R. Plewa, and J. Horák. Tree species and position matter: The role of pests for survival of other insects. *Agricultural and Forest Entomology*, 18(4):340–348, 2016. ISSN 1461-9563. doi:[10.1111/afe.12165](https://doi.org/10.1111/afe.12165). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/afe.12165>.
- [147] T. Hirao, M. Murakami, J. Iwamoto, H. Takafumi, and H. Oguma. Scale-dependent effects of windthrow disturbance on forest arthropod communities. *Ecological Research*, 23(1):189–196, Jan. 2008. ISSN 1440-1703. doi:[10.1007/s11284-007-0370-3](https://doi.org/10.1007/s11284-007-0370-3). URL <https://doi.org/10.1007/s11284-007-0370-3>.
- [148] T. Hlásny, L. König, P. Krokene, M. Lindner, C. Montagné-Huck, J. Müller, H. Qin, K. F. Raffa, M.-J. Schelhaas, M. Svoboda, H. Viiri, and R. Seidl. Bark Beetle Outbreaks in Europe: State of Knowledge and Ways Forward for Management. *Current Forestry Reports*, 7(3):138–165, Sept. 2021. ISSN 2198-6436. doi:[10/gm6fkh](https://doi.org/10/gm6fkh). URL <https://doi.org/10.1007/s40725-021-00142-x>.

- [149] J. Horák. Niche partitioning among dead wood-dependent beetles. *Scientific Reports*, 11(1):15178, July 2021. ISSN 2045-2322. doi:10.1038/s41598-021-94396-x. URL <https://www.nature.com/articles/s41598-021-94396-x>.
- [150] J. Horak, S. Vodka, J. Kout, J. P. Halda, P. Bogusch, and P. Pech. Biodiversity of most dead wood-dependent organisms in thermophilic temperate oak woodlands thrives on diversity of open landscape structures. *Forest Ecology and Management*, 315:80–85, Mar. 2014. ISSN 0378-1127. doi:10.1016/j.foreco.2013.12.018. URL <https://www.sciencedirect.com/science/article/pii/S0378112713008207>.
- [151] J. Horák, J. Kout, Š. Vodka, and D. C. Donato. Dead wood dependent organisms in one of the oldest protected forests of Europe: Investigating the contrasting effects of within-stand variation in a highly diversified environment. *Forest Ecology and Management*, 363:229–236, Mar. 2016. ISSN 0378-1127. doi:10.1016/j.foreco.2015.12.041. URL <https://www.sciencedirect.com/science/article/pii/S0378112715007744>.
- [152] A. F. Huberty and R. F. Denno. Plant Water Stress and Its Consequences for Herbivorous Insects: A New Synthesis. *Ecology*, 85(5):1383–1398, 2004. ISSN 1939-9170. doi:10.1890/03-0352. URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/03-0352>.
- [153] R. L. Hutto. Toward Meaningful Snag-Management Guidelines for Postfire Salvage Logging in North American Conifer Forests. *Conservation Biology*, 20(4):984–993, 2006. ISSN 1523-1739. doi:10.1111/j.1523-1739.2006.00494.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1523-1739.2006.00494.x>.
- [154] E. Hyvärinen, J. Kouki, and P. Martikainen. Fire and Green-Tree Retention in Conservation of Red-Listed and Rare Deadwood-Dependent Beetles in Finnish Boreal Forests. *Conservation Biology*, 20(6):1710–1719, 2006. ISSN 1523-1739. doi:10.1111/j.1523-1739.2006.00511.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1523-1739.2006.00511.x>.
- [155] K. Iida, D. Hayasaka, Y. Suzuki, T. Uchida, T. Sawahata, and K. Hashimoto. Legacy of pre-eruption vegetation affects ground-dwelling arthropod communities after different types of volcanic disturbance. *Ecology and Evolution*, 11(13):9110–9122, 2021. ISSN 2045-7758. doi:10.1002/ece3.7755. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/ece3.7755>.
- [156] IPCC. *Climate Change 2007: Synthesis Report*. IPCC Geneva, Switzerland, 2007.
- [157] H. T. Ishii, S.-i. Tanabe, and T. Hiura. Exploring the Relationships Among Canopy Structure, Stand Productivity, and Biodiversity of Temperate Forest Ecosystems. *Forest Science*, 50(3):342–355, June 2004. ISSN 0015-749X. doi:10.1093/forestscience/50.3.342. URL <https://academic.oup.com/forestscience/article/50/3/342/4617567>.
- [158] H. Jactel, J. Petit, M.-L. Desprez-Loustau, S. Delzon, D. Piou, A. Battisti, and J. Koricheva. Drought effects on damage by forest insects and pathogens: A meta-analysis. *Global Change*

- Biology*, 18(1):267–276, 2012. ISSN 1365-2486. doi:10.1111/j.1365-2486.2011.02512.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2486.2011.02512.x>.
- [159] H. Jactel, J. Bauhus, J. Boberg, D. Bonal, B. Castagneyrol, B. Gardiner, J. Olabarria, J. Koricheva, N. Meurisse, and E. Brockerhoff. Tree Diversity Drives Forest Stand Resistance to Natural Disturbances. *Current Forestry Reports*, 3:223–243, Sept. 2017. doi:10.1007/s40725-017-0064-1. URL <https://link.springer.com/article/10.1007/s40725-017-0064-1>.
- [160] H. Jactel, X. Moreira, and B. Castagneyrol. Tree Diversity and Forest Resistance to Insect Pests: Patterns, Mechanisms, and Prospects. *Annual Review of Entomology*, 66(1): 277–296, 2021. doi:10.1146/annurev-ento-041720-075234. URL <https://doi.org/10.1146/annurev-ento-041720-075234>.
- [161] A. Jahani and M. Saffariha. Modeling of trees failure under windstorm in harvested Hyrcanian forests using machine learning techniques. *Scientific Reports*, 11(1):1124, Jan. 2021. ISSN 2045-2322. doi:10.1038/s41598-020-80426-7. URL <https://www.nature.com/articles/s41598-020-80426-7>.
- [162] P. Janssen, M. Fuhr, E. Cateau, B. Nusillard, and C. Bouget. Forest continuity acts congruently with stand maturity in structuring the functional composition of saproxylic beetles. *Biological Conservation*, 205:1–10, Jan. 2017. ISSN 0006-3207. doi:10.1016/j.biocon.2016.11.021. URL <http://www.sciencedirect.com/science/article/pii/S0006320716308540>.
- [163] T. Jaworski, R. Plewa, G. Tarwacki, K. Sućko, J. Hilszczański, and J. Horák. Ecologically similar saproxylic beetles depend on diversified deadwood resources: From habitat requirements to management implications. *Forest Ecology and Management*, 449:117462, Oct. 2019. ISSN 0378-1127. doi:10.1016/j.foreco.2019.117462. URL <https://www.sciencedirect.com/science/article/pii/S0378112719300866>.
- [164] M. J. Jenkins, J. B. Runyon, C. J. Fettig, W. G. Page, and B. J. Bentz. Interactions among the Mountain Pine Beetle, Fires, and Fuels. *Forest Science*, 60(3):489–501, June 2014. ISSN 0015-749X. doi:10.5849/forsci.13-017. URL <https://doi.org/10.5849/forsci.13-017>.
- [165] K. Jögiste, H. Korjus, J. A. Stanturf, L. E. Frelich, E. Baders, J. Donis, A. Jansons, A. Kangur, K. Köster, D. Laarmann, T. Maaten, V. Marozas, M. Metslaid, K. Nigul, O. Polyachenko, T. Randveer, and F. Vodde. Hemiboreal forest: Natural disturbances and the importance of ecosystem legacies to management. *Ecosphere*, 8(2):e01706, 2017. ISSN 2150-8925. doi:10.1002/ecs2.1706. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/ecs2.1706>.
- [166] J. F. Johnstone, E. J. B. McIntire, E. J. Pedersen, G. King, and M. J. F. Pisaric. A sensitive slope: Estimating landscape patterns of forest resilience in a changing climate. *Ecosphere*, 1(6):art14, 2010. ISSN 2150-8925. doi:10.1890/ES10-00102.1. URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/ES10-00102.1>.

- [167] J. F. Johnstone, C. D. Allen, J. F. Franklin, L. E. Frelich, B. J. Harvey, P. E. Higuera, M. C. Mack, R. K. Meentemeyer, M. R. Metz, G. L. Perry, T. Schoennagel, and M. G. Turner. Changing disturbance regimes, ecological memory, and forest resilience. *Frontiers in Ecology and the Environment*, 14(7): 369–378, Sept. 2016. ISSN 1540-9295, 1540-9309. doi:10/f83hfj. URL <https://onlinelibrary.wiley.com/doi/10.1002/fee.1311>.
- [168] J. F. Johnstone, G. Celis, F. S. Chapin III, T. N. Hollingsworth, M. Jean, and M. C. Mack. Factors shaping alternate successional trajectories in burned black spruce forests of Alaska. *Ecosphere*, 11(5): e03129, 2020. ISSN 2150-8925. doi:10.1002/ecs2.3129. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/ecs2.3129>.
- [169] M. Jonášová and K. Prach. Central-European mountain spruce (*Picea abies* (L.) Karst.) forests: Regeneration of tree species after a bark beetle outbreak. *Ecological Engineering*, 23(1):15–27, Aug. 2004. ISSN 0925-8574. doi:10/b47w9p. URL <https://www.sciencedirect.com/science/article/pii/S0925857404000928>.
- [170] M. Jonsell, J. Weslien, and B. Ehnström. Substrate requirements of red-listed saproxylic invertebrates in Sweden. *Biodiversity & Conservation*, 7(6):749–764, June 1998. ISSN 1572-9710. doi:10.1023/A:1008888319031. URL <https://doi.org/10.1023/A:1008888319031>.
- [171] S. Jouveau, C. Poeydebat, B. Castagneyrol, I. van Halder, and H. Jactel. Restoring tree species mixtures mitigates the adverse effects of pine monoculture and drought on forest carabids. *Insect Conservation and Diversity*, n/a(n/a), 2022. ISSN 1752-4598. doi:10.1111/icad.12599. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/icad.12599>.
- [172] R. Juan-Ovejero, C. R. Molinas-González, A. B. Leverkus, F. J. Martín Peinado, and J. Castro. Decadal effect of post-fire management treatments on soil carbon and nutrient concentrations in a burnt Mediterranean forest. *Forest Ecology and Management*, 498:119570, Oct. 2021. ISSN 0378-1127. doi:10.1016/j.foreco.2021.119570. URL <https://www.sciencedirect.com/science/article/pii/S0378112721006605>.
- [173] D. K. Jue, A. C. Merwin, S. S. Jue, D. McElveen, and B. D. Inouye. Effects of frequency and season of fire on a metapopulation of an imperiled butterfly in a longleaf pine forest. *Conservation Science and Practice*, 4(8):e12739, 2022. ISSN 2578-4854. doi:10.1111/csp2.12739. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/csp2.12739>.
- [174] T. Kahl, T. Arnstadt, K. Baber, C. Bässler, J. Bauhus, W. Borken, F. Buscot, A. Floren, C. Heibl, D. Hessenmöller, M. Hofrichter, B. Hoppe, H. Kellner, D. Krüger, K. E. Linsenmair, E. Matzner, P. Otto, W. Purahong, C. Seilwinder, E.-D. Schulze, B. Wende, W. W. Weisser, and M. M. Gossner. Wood decay rates of 13 temperate tree species in relation to wood properties, enzyme activities and organismic diversities. *Forest Ecology and Management*, 391:86–95, May 2017. ISSN 0378-1127. doi:10.1016/j.foreco.2017.02.012. URL <https://www.sciencedirect.com/science/article/pii/S0378112716307137>.

- [175] S. Kärvmemo, M. Schroeder, and T. Ranius. Beetle diversity in dead wood is lower in non-native than native tree species, especially those more distantly related to native species. *Journal of Applied Ecology*, n/a(n/a), 2022. ISSN 1365-2664. doi:10.1111/1365-2664.14318. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/1365-2664.14318>.
- [176] K. L. Kausrud, J.-C. Grégoire, O. Skarpaas, N. Erbilgin, M. Gilbert, B. Økland, and N. C. Stenseth. Trees Wanted—Dead or Alive! Host Selection and Population Dynamics in Tree-Killing Bark Beetles. *PLOS ONE*, 6(5):e18274, May 2011. ISSN 1932-6203. doi:10.1371/journal.pone.0018274. URL <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0018274>.
- [177] J. E. Keeley, M. B. Keeley, and W. J. Bond. Stem demography and post-fire recruitment of a resprouting serotinous conifer. *Journal of Vegetation Science*, 10(1):69–76, 1999. ISSN 1654-1103. doi:10.2307/3237162. URL <https://onlinelibrary.wiley.com/doi/abs/10.2307/3237162>.
- [178] J. E. Keeley, J. G. Pausas, P. W. Rundel, W. J. Bond, and R. A. Bradstock. Fire as an evolutionary pressure shaping plant traits. *Trends in Plant Science*, 16(8):406–411, Aug. 2011. ISSN 13601385. doi:10.1016/j.tplants.2011.04.002. URL <https://linkinghub.elsevier.com/retrieve/pii/S1360138511000835>.
- [179] J. A. Kendrick, R. R. Ribbons, A. T. Classen, and A. M. Ellison. Changes in canopy structure and ant assemblages affect soil ecosystem variables as a foundation species declines. *Ecosphere*, 6(5):art77, 2015. ISSN 2150-8925. doi:10/gm8g4s. URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/ES14-00447.1>.
- [180] B. Kishchuk, E. Thiffault, M. Lorente, S. Quideau, T. Keddy, and D. Sidders. Decadal soil and stand response to fire, harvest, and salvage-logging disturbances in the western boreal mixedwood forest of Alberta, Canada. *Canadian Journal of Forest Research*, 45(2):141–152, 2015. doi:10/f6zks7. URL <https://cdnsiencepub.com/doi/abs/10.1139/cjfr-2014-0148>.
- [181] J. S. Kleinman, J. D. Goode, A. C. Fries, and J. L. Hart. Ecological consequences of compound disturbances in forest ecosystems: A systematic review. *Ecosphere*, 10(11):e02962, 2019. ISSN 2150-8925. doi:10.1002/ecs2.2962. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/ecs2.2962>.
- [182] I. A. Koelemeijer, J. Ehrlén, M. Jönsson, P. De Frenne, P. Berg, J. Andersson, H. Weibull, and K. Hylander. Interactive effects of drought and edge exposure on old-growth forest understory species. *Landscape Ecology*, May 2022. ISSN 1572-9761. doi:10.1007/s10980-022-01441-9. URL <https://doi.org/10.1007/s10980-022-01441-9>.
- [183] J. Kopáček, R. Bače, J. Hejzlar, J. Kaňa, T. Kučera, K. Matějka, P. Porcal, and J. Turek. Changes in microclimate and hydrology in an unmanaged mountain forest catchment after insect-induced tree dieback. *Science of The Total Environment*, 720:137518, June 2020. ISSN 0048-9697. doi:10.1016/j.scitotenv.2020.137518. URL <https://www.sciencedirect.com/science/article/pii/S0048969720310299>.

- [184] N. Korolyova, A. Buechling, R. Ďuračiová, K. Zabihi, M. Turčáni, M. Svoboda, J. Bláha, K. Swarts, M. Poláček, J. Hradecký, J. Červenka, P. Němčák, F. Schlyter, and R. Jakuš. The Last Trees Standing: Climate modulates tree survival factors during a prolonged bark beetle outbreak in Europe. *Agricultural and Forest Meteorology*, 322:109025, July 2022. ISSN 0168-1923. doi:10.1016/j.agrformet.2022.109025. URL <https://www.sciencedirect.com/science/article/pii/S0168192322002143>.
- [185] M. Kortmann. *Biodiversity and Recreation – Optimizing Tourism and Forest Management in Forests Affected by Bark Beetles*. PhD thesis, Universität Würzburg, 2022. URL <https://opus.bibliothek.uni-wuerzburg.de/frontdoor/index/index/docId/24031>.
- [186] M. Kortmann, J. Hurst, R. Brinkmann, M. Heurich, R. Silveyra González, J. Müller, and S. Thorn. Beauty and the beast: How a bat utilizes forests shaped by outbreaks of an insect pest. *Animal Conservation*, 21(1):21–30, 2018. ISSN 1469-1795. doi:10/gcxv48. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/acv.12359>.
- [187] M. Kortmann, N. Roth, J. Buse, J. Hilszczański, T. Jaworski, J. Morinière, R. Seidl, S. Thorn, and J. C. Müller. Arthropod dark taxa provide new insights into diversity responses to bark beetle infestations. *Ecological Applications*, 32(2):e2516, 2022. ISSN 1939-5582. doi:10.1002/eap.2516. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/eap.2516>.
- [188] O. Košulič, R. Michalko, and V. Hula. Impact of Canopy Openness on Spider Communities: Implications for Conservation Management of Formerly Coppiced Oak Forests. *PLOS ONE*, 11(2):e0148585, Feb. 2016. ISSN 1932-6203. doi:10.1371/journal.pone.0148585. URL <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0148585>.
- [189] D. Kozák, M. Mikoláš, M. Svitok, R. Bače, Y. Paillet, L. Larrieu, T. A. Nagel, K. Begovič, V. Čada, A. Diku, M. Frankovič, P. Janda, O. Kameniar, S. Keren, P. Kjučukov, J. Lábusová, T. Langbehn, J. Málek, S. Mikac, R. C. Morrissey, M. H. Nováková, J. S. Schurrman, K. Svobodová, M. Synek, M. Teodosiu, E. Toromani, V. Trotsiuk, L. Vítková, and M. Svoboda. Profile of tree-related microhabitats in European primary beech-dominated forests. *Forest Ecology and Management*, 429:363–374, Dec. 2018. ISSN 0378-1127. doi:10.1016/j.foreco.2018.07.021. URL <https://www.sciencedirect.com/science/article/pii/S0378112718305462>.
- [190] D. Kozák, M. Svitok, M. Wiezik, M. Mikoláš, S. Thorn, A. Buechling, J. Hofmeister, R. Matula, V. Trotsiuk, R. Bače, K. Begovič, V. Čada, M. Dušátko, M. Frankovič, J. Horák, P. Janda, O. Kameniar, T. A. Nagel, J. L. Pettit, J. M. Pettit, M. Synek, A. Wieziková, and M. Svoboda. Historical Disturbances Determine Current Taxonomic, Functional and Phylogenetic Diversity of Saproxylic Beetle Communities in Temperate Primary Forests. *Ecosystems*, 24:37–55, 2021. ISSN 1435-0629. doi:10.1007/s10021-020-00502-x. URL <https://doi.org/10.1007/s10021-020-00502-x>.
- [191] K. Kramer, S. J. Vreugdenhil, and D. C. van der Werf. Effects of flooding on the recruitment, damage and mortality of riparian tree species: A field and simulation study on the Rhine

- floodplain. *Forest Ecology and Management*, 255(11):3893–3903, June 2008. ISSN 0378-1127. doi:10.1016/j.foreco.2008.03.044. URL <https://www.sciencedirect.com/science/article/pii/S0378112708002922>.
- [192] M. A. Krawchuk, G. W. Meigs, J. M. Cartwright, J. D. Coop, R. Davis, A. Holz, C. Kolden, and A. J. Meddens. Disturbance refugia within mosaics of forest fire, drought, and insect outbreaks. *Frontiers in Ecology and the Environment*, 18(5):235–244, 2020. ISSN 1540-9309. doi:10/gg2fd4. URL <https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/fee.2190>.
- [193] D. Kulakowski and T. T. Veblen. Influences of fire history and topography on the pattern of a severe wind blowdown in a Colorado subalpine forest. *Journal of Ecology*, 90(5):806–819, 2002. ISSN 1365-2745. doi:10.1046/j.1365-2745.2002.00722.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1046/j.1365-2745.2002.00722.x>.
- [194] D. Kulakowski, D. Jarvis, T. T. Veblen, and J. Smith. Stand-replacing fires reduce susceptibility of lodgepole pine to mountain pine beetle outbreaks in Colorado. *Journal of Biogeography*, 39(11):2052–2060, 2012. ISSN 1365-2699. doi:10.1111/j.1365-2699.2012.02748.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2699.2012.02748.x>.
- [195] D. Kulakowski, R. Seidl, J. Holeksa, T. Kuuluvainen, T. A. Nagel, M. Panayotov, M. Svoboda, S. Thorn, G. Vacchiano, C. Whitlock, T. Wohlgemuth, and P. Bebi. A walk on the wild side: Disturbance dynamics and the conservation and management of European mountain forest ecosystems. *Forest Ecology and Management*, 388:120–131, Mar. 2017. ISSN 0378-1127. doi:10.1016/j.foreco.2016.07.037. URL <http://www.sciencedirect.com/science/article/pii/S0378112716303930>.
- [196] T. Kuuluvainen. Conceptual models of forest dynamics in environmental education and management: Keep it as simple as possible, but no simpler. *Forest Ecosystems*, 3(1):18, Aug. 2016. ISSN 2197-5620. doi:10.1186/s40663-016-0075-6. URL <https://doi.org/10.1186/s40663-016-0075-6>.
- [197] T.-S. Kwon, Y. K. Park, J.-H. Lim, S. H. Ryou, and C. M. Lee. Change of arthropod abundance in burned forests: Different patterns according to functional guilds. *Journal of Asia-Pacific Entomology*, 16(3):321–328, Sept. 2013. ISSN 1226-8615. doi:10.1016/j.aspen.2013.04.008. URL <https://www.sciencedirect.com/science/article/pii/S1226861513000435>.
- [198] K. Lambeets, M. L. Vandegheuchte, J.-P. Maelfait, and D. Bonte. Understanding the impact of flooding on trait-displacements and shifts in assemblage structure of predatory arthropods on river banks. *Journal of Animal Ecology*, 77(6):1162–1174, 2008. ISSN 1365-2656. doi:10.1111/j.1365-2656.2008.01443.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2656.2008.01443.x>.
- [199] P. R. Langlands, K. E. C. Brennan, V. W. Framenau, and B. Y. Main. Predicting the post-fire responses of animal assemblages: Testing a trait-based approach using spiders. *Journal of Animal Ecology*, 80(3):558–568, 2011. ISSN 1365-2656. doi:10.1111/j.1365-2656.2010.01795.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2656.2010.01795.x>.

- [200] L. Larrieu, A. Cabanettes, and A. Delarue. Impact of silviculture on dead wood and on the distribution and frequency of tree microhabitats in montane beech-fir forests of the Pyrenees. *European Journal of Forest Research*, 131(3):773–786, May 2012. ISSN 1612-4677. doi:[10.1007/s10342-011-0551-z](https://doi.org/10.1007/s10342-011-0551-z). URL <https://doi.org/10.1007/s10342-011-0551-z>.
- [201] L. Larrieu, B. Courbaud, C. Drénou, M. Goulard, R. Bütler, D. Kozák, D. Kraus, F. Krumm, T. Lachat, J. Müller, Y. Paillet, A. Schuck, J. Stillhard, M. Svoboda, and K. Vandekerckhove. Key factors determining the presence of Tree-related Microhabitats: A synthesis of potential factors at site, stand and tree scales, with perspectives for further research. *Forest Ecology and Management*, 515: 120235, July 2022. ISSN 0378-1127. doi:[10.1016/j.foreco.2022.120235](https://doi.org/10.1016/j.foreco.2022.120235). URL <https://www.sciencedirect.com/science/article/pii/S0378112722002298>.
- [202] S.-I. Lee, J. R. Spence, and D. W. Langor. Conservation of Saproxylic Insect Diversity Under Variable Retention Harvesting. In M. D. Ulyshen, editor, *Saproxylic Insects: Diversity, Ecology and Conservation*, Zoological Monographs, pages 639–667. Springer International Publishing, Cham, 2018. ISBN 978-3-319-75937-1. doi:[10.1007/978-3-319-75937-1_19](https://doi.org/10.1007/978-3-319-75937-1_19). URL https://doi.org/10.1007/978-3-319-75937-1_19.
- [203] L. W. Lehnert, C. Bässler, R. Brandl, P. J. Burton, and J. Müller. Conservation value of forests attacked by bark beetles: Highest number of indicator species is found in early successional stages. *Journal for Nature Conservation*, 21(2):97–104, Apr. 2013. ISSN 1617-1381. doi:[10.1016/j.jnc.2012.11.003](https://doi.org/10.1016/j.jnc.2012.11.003). URL <http://www.sciencedirect.com/science/article/pii/S1617138112001124>.
- [204] J. Leidinger, M. Blaschke, M. Ehrhardt, A. Fischer, M. M. Gossner, K. Jung, S. Kienlein, J. Kozák, B. Michler, R. Mosandl, S. Seibold, K. Wehner, and W. W. Weisser. Shifting tree species composition affects biodiversity of multiple taxa in Central European forests. *Forest Ecology and Management*, 498:119552, Oct. 2021. ISSN 0378-1127. doi:[10.1016/j.foreco.2021.119552](https://doi.org/10.1016/j.foreco.2021.119552). URL <https://www.sciencedirect.com/science/article/pii/S0378112721006423>.
- [205] L. Lettenmaier, S. Seibold, C. Bässler, R. Brandl, A. Gruppe, J. Müller, and J. Hagge. Beetle diversity is higher in sunny forests due to higher microclimatic heterogeneity in deadwood. *Oecologia*, 198(3):825–834, Mar. 2022. ISSN 1432-1939. doi:[10.1007/s00442-022-05141-8](https://doi.org/10.1007/s00442-022-05141-8). URL <https://doi.org/10.1007/s00442-022-05141-8>.
- [206] A. B. Leverkus, J. Lorite, F. B. Navarro, E. P. Sánchez-Cañete, and J. Castro. Post-fire salvage logging alters species composition and reduces cover, richness, and diversity in Mediterranean plant communities. *Journal of Environmental Management*, 133:323–331, Jan. 2014. ISSN 0301-4797. doi:[10/f5svq6](https://doi.org/10.1016/j.jenvman.2013.10.066). URL <https://www.sciencedirect.com/science/article/pii/S030147971300755X>.
- [207] A. B. Leverkus, D. B. Lindenmayer, S. Thorn, and L. Gustafsson. Salvage logging in the world’s forests: Interactions between natural disturbance and logging need recognition. *Global Ecology and Biogeography*, 27(10):1140–1154, 2018. ISSN 1466-8238. doi:[10/gfn4bg](https://doi.org/10.1111/geb.12772). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/geb.12772>.

- [208] A. B. Leverkus, L. Gustafsson, D. B. Lindenmayer, J. Castro, J. M. R. Benayas, T. Ranius, and S. Thorn. Salvage logging effects on regulating ecosystem services and fuel loads. *Frontiers in Ecology and the Environment*, 18(7):391–400, 2020. ISSN 1540-9309. doi:10/gjcvrq. URL <https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1002/fee.2219>.
- [209] A. B. Leverkus, B. Buma, J. Wagenbrenner, P. J. Burton, E. Lingua, R. Marzano, and S. Thorn. Tamm review: Does salvage logging mitigate subsequent forest disturbances? *Forest Ecology and Management*, 481:118721, Feb. 2021. ISSN 0378-1127. doi:10/gnbhhf. URL <https://www.sciencedirect.com/science/article/pii/S0378112720314900>.
- [210] A. B. Leverkus, I. Polo, C. Baudoux, S. Thorn, L. Gustafsson, and R. R. de Casas. Resilience impacts of a secondary disturbance: Meta-analysis of salvage logging effects on tree regeneration. *Journal of Ecology*, n/a(n/a), 2021. ISSN 1365-2745. doi:10/gm6mjc. URL <https://besjournals.onlinelibrary.wiley.com/doi/abs/10.1111/1365-2745.13581>.
- [211] A. B. Leverkus, S. Thorn, D. B. Lindenmayer, and J. G. Pausas. Tree planting goals must account for wildfires. *Science*, 376(6593):588–589, May 2022. doi:10.1126/science.abp8259. URL <https://www.science.org/doi/full/10.1126/science.abp8259>.
- [212] J. I. Levine, B. M. Collins, Z. L. Steel, P. de Valpine, and S. L. Stephens. Higher incidence of high-severity fire in and near industrially managed forests. *Frontiers in Ecology and the Environment*, n/a(n/a), 2022. ISSN 1540-9309. doi:10.1002/fee.2499. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/fee.2499>.
- [213] N. Lindberg, J. B. Engtsson, and T. Persson. Effects of Experimental Irrigation and Drought on the Composition and Diversity of Soil Fauna in a Coniferous Stand. *Journal of Applied Ecology*, 39(6):924–936, 2002. ISSN 0021-8901. doi:10.1046/j.1365-2664.2002.00769.x. URL <https://www.jstor.org/stable/827280>.
- [214] D. Lindenmayer, D. Blair, and L. McBurney. Variable retention harvesting in Victoria’s Mountain Ash (*Eucalyptus regnans*) forests (southeastern Australia). *Ecological Processes*, 8(1):2, Jan. 2019. ISSN 2192-1709. doi:10/gm95d4. URL <https://doi.org/10.1186/s13717-018-0156-2>.
- [215] D. B. Lindenmayer and R. F. Noss. Salvage Logging, Ecosystem Processes, and Biodiversity Conservation. *Conservation Biology*, 20(4):949–958, 2006. ISSN 0888-8892. doi:10/dvkfpw. URL <https://www.jstor.org/stable/3879163>.
- [216] D. B. Lindenmayer, P. J. Burton, and J. F. Franklin. *Salvage Logging and Its Ecological Consequences*. Island Press, 2008. ISBN 978-1-59726-402-0. URL <https://agris.fao.org/agris-search/search.do?recordID=US201300128956>.
- [217] D. B. Lindenmayer, W. Blanchard, E. Bowd, B. C. Scheele, C. Foster, T. Lavery, L. McBurney, and D. Blair. Rapid bird species recovery following high-severity wildfire but in the absence of

- early successional specialists. *Diversity and Distributions*, 28(10):110–2123, 2022. ISSN 1472-4642. doi:10.1111/ddi.13611. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/ddi.13611>.
- [218] D. B. Lindenmayer, E. J. Bowd, C. Taylor, and G. E. Likens. The interactions among fire, logging, and climate change have sprung a landscape trap in Victoria’s montane ash forests. *Plant Ecology*, Jan. 2022. ISSN 1573-5052. doi:10/gp3jvh. URL <https://doi.org/10.1007/s11258-021-01217-2>.
- [219] J. S. Littell, D. L. Peterson, K. L. Riley, Y. Liu, and C. H. Luce. A review of the relationships between drought and forest fire in the United States. *Global Change Biology*, 22(7):2353–2369, 2016. ISSN 1365-2486. doi:10.1111/gcb.13275. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.13275>.
- [220] L. Liu, M. Estiarte, P. Bengtson, J. Li, D. Asensio, H. Wallander, and J. Peñuelas. Drought legacies on soil respiration and microbial community in a Mediterranean forest soil under different soil moisture and carbon inputs. *Geoderma*, 405:115425, Jan. 2022. ISSN 0016-7061. doi:10.1016/j.geoderma.2021.115425. URL <https://www.sciencedirect.com/science/article/pii/S001670612100505X>.
- [221] F. Lloret and T. Kitzberger. Historical and event-based bioclimatic suitability predicts regional forest vulnerability to compound effects of severe drought and bark beetle infestation. *Global Change Biology*, 24(5):1952–1964, 2018. ISSN 1365-2486. doi:10.1111/gcb.14039. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.14039>.
- [222] M. J. Lombardero and M. P. Ayres. Factors Influencing Bark Beetle Outbreaks After Forest Fires on the Iberian Peninsula. *Environmental Entomology*, 40(5):1007–1018, Oct. 2011. ISSN 0046-225X. doi:10.1603/EN11022. URL <https://doi.org/10.1603/EN11022>.
- [223] J. Losseau, M. Jonard, and C. Vincke. Pedunculate oak decline in southern Belgium: A long-term process highlighting the complex interplay among drought, winter frost, biotic attacks, and masting. *Canadian Journal of Forest Research*, 50(4):380–389, Apr. 2020. ISSN 0045-5067. doi:10.1139/cjfr-2019-0341. URL <https://cdnsiencepub.com/doi/abs/10.1139/cjfr-2019-0341>.
- [224] D. Lu, G. Zhang, J. Zhu, G. G. Wang, C. Zhu, Q. Yan, and J. Zhang. Early natural regeneration patterns of woody species within gaps in a temperate secondary forest. *European Journal of Forest Research*, 138(6):991–1003, Dec. 2019. ISSN 1612-4677. doi:10.1007/s10342-019-01219-w. URL <https://doi.org/10.1007/s10342-019-01219-w>.
- [225] M. E. Lucas-Borja, R. Ortega, I. Miralles, P. A. Plaza-Álvarez, J. González-Romero, E. Peña-Molina, D. Moya, D. A. Zema, J. W. Wagenbrenner, and J. de las Heras. Effects of wildfire and logging on soil functionality in the short-term in *Pinus halepensis* M. forests. *European Journal of Forest Research*, 139(6):935–945, Dec. 2020. ISSN 1612-4669, 1612-4677. doi:10/gm8g8t. URL <https://link.springer.com/10.1007/s10342-020-01296-2>.

- [226] A. Malmström. Life-history traits predict recovery patterns in Collembola species after fire: A 10 year study. *Applied Soil Ecology*, 56:35–42, May 2012. ISSN 0929-1393. doi:10.1016/j.apsoil.2012.02.007. URL <https://www.sciencedirect.com/science/article/pii/S092913931200039X>.
- [227] À. Manrique-Alba, S. Beguería, and J. J. Camarero. Long-term effects of forest management on post-drought growth resilience: An analytical framework. *Science of The Total Environment*, 810: 152374, Mar. 2022. ISSN 0048-9697. doi:10.1016/j.scitotenv.2021.152374. URL <https://www.sciencedirect.com/science/article/pii/S0048969721074520>.
- [228] S. Marañón-Jiménez, J. Castro, E. Fernández-Ondoño, and R. Zamora. Charred wood remaining after a wildfire as a reservoir of macro- and micronutrients in a Mediterranean pine forest. *International Journal of Wildland Fire*, 22(5):681–695, Mar. 2013. ISSN 1448-5516, 1448-5516. doi:10/f46b6h. URL <https://www.publish.csiro.au/wf/WF12030>.
- [229] M. Martin, N. J. Fenton, and H. Morin. Tree-related microhabitats and deadwood dynamics form a diverse and constantly changing mosaic of habitats in boreal old-growth forests. *Ecological Indicators*, 128:107813, Sept. 2021. ISSN 1470-160X. doi:10.1016/j.ecolind.2021.107813. URL <https://www.sciencedirect.com/science/article/pii/S1470160X21004787>.
- [230] R. E. Martin and D. B. Sapsis. Fires as agents of biodiversity: Pyrodiversity promotes biodiversity. In *Proceedings of the Conference on Biodiversity of Northwest California Ecosystems. Cooperative Extension*, pages 150–157. University of California, Berkeley, 1992.
- [231] C. Martineau, J. Beguin, A. Séguin, and D. Paré. Cumulative Effects of Disturbances on Soil Nutrients: Predominance of Antagonistic Short-Term Responses to the Salvage Logging of Insect-Killed Stands. *Ecosystems*, 23(4):812–827, June 2020. ISSN 1432-9840, 1435-0629. doi:10/gm6mjd. URL <http://link.springer.com/10.1007/s10021-019-00432-3>.
- [232] M. T. Marx, P. Guhmann, and P. Decker. Adaptations and Predispositions of Different Middle European Arthropod Taxa (Collembola, Araneae, Chilopoda, Diplopoda) to Flooding and Drought Conditions. *Animals*, 2(4):564–590, Dec. 2012. ISSN 2076-2615. doi:10.3390/ani2040564. URL <https://www.mdpi.com/2076-2615/2/4/564>.
- [233] R. Marzano, M. Garbarino, E. Marcolin, M. Pividori, and E. Lingua. Deadwood anisotropic facilitation on seedling establishment after a stand-replacing wildfire in Aosta Valley (NW Italy). *Ecological Engineering*, 51:117–122, Feb. 2013. ISSN 0925-8574. doi:10/f4rvd6. URL <https://www.sciencedirect.com/science/article/pii/S0925857412003850>.
- [234] S. C. Mason, V. Shirey, L. C. Ponisio, and J. K. Gelhaus. Responses from bees, butterflies, and ground beetles to different fire and site characteristics: A global meta-analysis. *Biological Conservation*, 261:109265, Sept. 2021. ISSN 0006-3207. doi:10.1016/j.biocon.2021.109265. URL <https://www.sciencedirect.com/science/article/pii/S0006320721003177>.

- [235] M. Mayer, C. Rosinger, M. Gorfer, H. Berger, E. Deltedesco, C. Bässler, J. Müller, L. Seifert, B. Rewald, and D. L. Godbold. Surviving trees and deadwood moderate changes in soil fungal communities and associated functioning after natural forest disturbance and salvage logging. *Soil Biology and Biochemistry*, 166:108558, Mar. 2022. ISSN 0038-0717. doi:[10.1016/j.soilbio.2022.108558](https://doi.org/10.1016/j.soilbio.2022.108558). URL <https://www.sciencedirect.com/science/article/pii/S0038071722000153>.
- [236] N. G. McDowell, C. D. Allen, K. Anderson-Teixeira, B. H. Aukema, B. Bond-Lamberty, L. Chini, J. S. Clark, M. Dietze, C. Grossiord, A. Hanbury-Brown, G. C. Hurtt, R. B. Jackson, D. J. Johnson, L. Kueppers, J. W. Lichstein, K. Ogle, B. Poulter, T. A. M. Pugh, R. Seidl, M. G. Turner, M. Uriarte, A. P. Walker, and C. Xu. Pervasive shifts in forest dynamics in a changing world. *Science*, 368(6494):eaaz9463, May 2020. ISSN 0036-8075, 1095-9203. doi:[10.1126/science.aaz9463](https://doi.org/10.1126/science.aaz9463). URL <https://www.sciencemag.org/lookup/doi/10.1126/science.aaz9463>.
- [237] J. D. McIver and L. Starr. A Literature Review on the Environmental Effects of Postfire Logging. *Western Journal of Applied Forestry*, 16(4):159–168, Oct. 2001. ISSN 0885-6095. doi:[10.1093/wjaf/16.4.159](https://doi.org/10.1093/wjaf/16.4.159). URL <https://doi.org/10.1093/wjaf/16.4.159>.
- [238] A. J. H. Meddens, C. A. Kolden, J. A. Lutz, A. M. S. Smith, C. A. Cansler, J. T. Abatzoglou, G. W. Meigs, W. M. Downing, and M. A. Krawchuk. Fire Refugia: What Are They, and Why Do They Matter for Global Change? *BioScience*, 68(12):944–954, Dec. 2018. ISSN 0006-3568. doi:[10.1093/biosci/biy103](https://doi.org/10.1093/biosci/biy103). URL <https://doi.org/10.1093/biosci/biy103>.
- [239] G. A. Meehl and C. Tebaldi. More Intense, More Frequent, and Longer Lasting Heat Waves in the 21st Century. *Science*, 305(5686):994–997, Aug. 2004. doi:[10.1126/science.1098704](https://doi.org/10.1126/science.1098704). URL <https://www.science.org/doi/abs/10.1126/science.1098704>.
- [240] G. W. Meigs, H. S. J. Zald, J. L. Campbell, W. S. Keeton, and R. E. Kennedy. Do insect outbreaks reduce the severity of subsequent forest fires? *Environmental Research Letters*, 11(4):045008, Apr. 2016. ISSN 1748-9326. doi:[10.1088/1748-9326/11/4/045008](https://doi.org/10.1088/1748-9326/11/4/045008). URL <https://dx.doi.org/10.1088/1748-9326/11/4/045008>.
- [241] G. W. Meigs, R. C. Morrissey, R. Bače, O. Chaskovskyy, V. Čada, T. Després, D. C. Donato, P. Janda, J. Lábusová, M. Seedre, M. Mikoláš, T. A. Nagel, J. S. Schurman, M. Synek, M. Teodosiu, V. Trotsiuk, L. Vítková, and M. Svoboda. More ways than one: Mixed-severity disturbance regimes foster structural complexity via multiple developmental pathways. *Forest Ecology and Management*, 406:410–426, Dec. 2017. ISSN 0378-1127. doi:[10.1016/j.foreco.2017.07.051](https://doi.org/10.1016/j.foreco.2017.07.051). URL <https://www.sciencedirect.com/science/article/pii/S037811271730854X>.
- [242] J. Merganič, K. Merganičová, M. Vlčková, Z. Dudáková, M. Ferenčík, M. Mokroš, V. Juško, M. Allman, and D. Tomčík. Deadwood Amount at Disturbance Plots after Sanitary Felling. *Plants*, 11(7):987, Jan. 2022. ISSN 2223-7747. doi:[10.3390/plants11070987](https://doi.org/10.3390/plants11070987). URL <https://www.mdpi.com/2223-7747/11/7/987>.

- [243] S. T. Michaletz and E. A. Johnson. How forest fires kill trees: A review of the fundamental biophysical processes. *Scandinavian Journal of Forest Research*, 22(6):500–515, Dec. 2007. ISSN 0282-7581. doi:[10.1080/02827580701803544](https://doi.org/10.1080/02827580701803544). URL <https://doi.org/10.1080/02827580701803544>.
- [244] Z. Michalová, R. C. Morrissey, T. Wohlgemuth, R. Bače, P. Fleischer, and M. Svoboda. Salvage-Logging after Windstorm Leads to Structural and Functional Homogenization of Understory Layer and Delayed Spruce Tree Recovery in Tatra Mts., Slovakia. *Forests*, 8(3):88, Mar. 2017. doi:[10/f93qw6](https://doi.org/10/f93qw6). URL <https://www.mdpi.com/1999-4907/8/3/88>.
- [245] M. Mikoláš, M. Svitok, K. Bollmann, J. Reif, R. Bače, P. Janda, V. Trotsiuk, V. Čada, L. Vítková, M. Teodosiu, J. Coppes, J. S. Schurman, R. C. Morrissey, H. Mrhalová, and M. Svoboda. Mixed-severity natural disturbances promote the occurrence of an endangered umbrella species in primary forests. *Forest Ecology and Management*, 405:210–218, Dec. 2017. ISSN 0378-1127. doi:[10.1016/j.foreco.2017.09.006](https://doi.org/10.1016/j.foreco.2017.09.006). URL <https://www.sciencedirect.com/science/article/pii/S0378112717309568>.
- [246] M. Mikoláš, M. Svitok, M. Teodosiu, T. A. Nagel, and M. Svoboda. Land use planning based on the connectivity of tree species does not ensure the conservation of forest biodiversity. *Land Use Policy*, 83:63–65, Apr. 2019. ISSN 0264-8377. doi:[10.1016/j.landusepol.2019.01.036](https://doi.org/10.1016/j.landusepol.2019.01.036). URL <https://www.sciencedirect.com/science/article/pii/S0264837718310718>.
- [247] G. Mikusiński, J. W. Bubnicki, M. Churski, D. Czeszczewik, W. Walankiewicz, and D. P. J. Kuijper. Is the impact of loggings in the last primeval lowland forest in Europe underestimated? The conservation issues of Białowieża Forest. *Biological Conservation*, 227:266–274, Nov. 2018. ISSN 0006-3207. doi:[10.1016/j.biocon.2018.09.001](https://doi.org/10.1016/j.biocon.2018.09.001). URL <https://www.sciencedirect.com/science/article/pii/S0006320717321390>.
- [248] D. R. Miller and R. J. Rabaglia. Ethanol and (-)- α -Pinene: Attractant Kairomones for Bark and Ambrosia Beetles in the Southeastern US. *Journal of Chemical Ecology*, 35(4):435–448, Apr. 2009. ISSN 1573-1561. doi:[10.1007/s10886-009-9613-9](https://doi.org/10.1007/s10886-009-9613-9). URL <https://doi.org/10.1007/s10886-009-9613-9>.
- [249] R. J. Mitchell, R. L. Hewison, R. K. Haghi, A. H. J. Robertson, A. M. Main, and I. J. Owen. Functional and ecosystem service differences between tree species: Implications for tree species replacement. *Trees*, 35(1):307–317, Feb. 2021. ISSN 1432-2285. doi:[10.1007/s00468-020-02035-1](https://doi.org/10.1007/s00468-020-02035-1). URL <https://doi.org/10.1007/s00468-020-02035-1>.
- [250] S. Mitchell. Wind as a natural disturbance agent in forests: A synthesis. *Forestry: An International Journal of Forest Research*, 86(2):147–157, Apr. 2013. ISSN 0015-752X. doi:[10.1093/forestry/cps058](https://doi.org/10.1093/forestry/cps058). URL <https://doi.org/10.1093/forestry/cps058>.
- [251] C. R. Molinas-González, J. Castro, A. González-Megías, and A. B. Leverkus. Effects of Post-Fire Deadwood Management on Soil Macroarthropod Communities. *Forests*, 10(11):1046, Nov. 2019. ISSN 1999-4907. doi:[10/gn5zq4](https://doi.org/10/gn5zq4). URL <https://www.mdpi.com/1999-4907/10/11/1046>.

- [252] S. Mollier, G. Kunstler, J.-L. Dupouey, and L. Bergès. Historical landscape matters for threatened species in French mountain forests. *Biological Conservation*, 269:109544, May 2022. ISSN 0006-3207. doi:10.1016/j.biocon.2022.109544. URL <https://www.sciencedirect.com/science/article/pii/S0006320722000970>.
- [253] M. Moretti and C. Legg. Combining plant and animal traits to assess community functional responses to disturbance. *Ecography*, 32(2):299–309, 2009. ISSN 1600-0587. doi:10.1111/j.1600-0587.2008.05524.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1600-0587.2008.05524.x>.
- [254] M. Moretti, P. Duelli, and M. K. Obrist. Biodiversity and resilience of arthropod communities after fire disturbance in temperate forests. *Oecologia*, 149(2):312–327, Aug. 2006. ISSN 1432-1939. doi:10.1007/s00442-006-0450-z. URL <https://doi.org/10.1007/s00442-006-0450-z>.
- [255] M. Moretti, M. De Cáceres, C. Pradella, M. K. Obrist, B. Wermelinger, P. Legendre, and P. Duelli. Fire-induced taxonomic and functional changes in saproxylic beetle communities in fire sensitive regions. *Ecography*, 33(4):760–771, 2010. ISSN 1600-0587. doi:10.1111/j.1600-0587.2009.06172.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1600-0587.2009.06172.x>.
- [256] J. Morimoto, T. Umebayashi, S. N. Suzuki, T. Owari, N. Nishimura, S. Ishibashi, M. Shibuya, and T. Hara. Long-term effects of salvage logging after a catastrophic wind disturbance on forest structure in northern Japan. *Landscape and Ecological Engineering*, 15(2):133–141, Apr. 2019. ISSN 1860-188X. doi:10/gnmxnq. URL <https://doi.org/10.1007/s11355-019-00375-w>.
- [257] J. Müller and R. Bütler. A review of habitat thresholds for dead wood: A baseline for management recommendations in European forests. *European Journal of Forest Research*, 129(6):981–992, Nov. 2010. ISSN 1612-4677. doi:10.1007/s10342-010-0400-5. URL <https://doi.org/10.1007/s10342-010-0400-5>.
- [258] J. Müller, H. Bußler, M. Goßner, T. Rettelbach, and P. Duelli. The European spruce bark beetle *Ips typographus* in a national park: From pest to keystone species. *Biodiversity and Conservation*, 17(12): 2979, May 2008. ISSN 1572-9710. doi:10.1007/s10531-008-9409-1. URL <https://doi.org/10.1007/s10531-008-9409-1>.
- [259] J. Müller, R. F. Noss, H. Bussler, and R. Brandl. Learning from a “benign neglect strategy” in a national park: Response of saproxylic beetles to dead wood accumulation. *Biological Conservation*, 143(11):2559–2569, Nov. 2010. ISSN 0006-3207. doi:10.1016/j.biocon.2010.06.024. URL <https://www.sciencedirect.com/science/article/pii/S0006320710002909>.
- [260] J. Müller, B. Wende, C. Strobl, M. Eugster, I. Gallenberger, A. Floren, I. Steffan-Dewenter, K. E. Linsenmair, W. W. Weisser, and M. M. Gossner. Forest management and regional tree composition drive the host preference of saproxylic beetle communities. *Journal of Applied Ecology*, 52(3): 753–762, 2015. ISSN 1365-2664. doi:10.1111/1365-2664.12421. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/1365-2664.12421>.

- [261] R. K. Myers and D. H. van Lear. Hurricane-fire interactions in coastal forests of the south: A review and hypothesis. *Forest Ecology and Management*, 103(2):265–276, Apr. 1998. ISSN 0378-1127. doi:10.1016/S0378-1127(97)00223-5. URL <https://www.sciencedirect.com/science/article/pii/S0378112797002235>.
- [262] L. E. Nave, C. M. Gough, K. D. Maurer, G. Bohrer, B. S. Hardiman, J. Le Moine, A. B. Munoz, K. J. Nadelhoffer, J. P. Sparks, B. D. Strahm, C. S. Vogel, and P. S. Curtis. Disturbance and the resilience of coupled carbon and nitrogen cycling in a north temperate forest. *Journal of Geophysical Research: Biogeosciences*, 116(G4), 2011. ISSN 2156-2202. doi:10.1029/2011JG001758. URL <https://onlinelibrary.wiley.com/doi/abs/10.1029/2011JG001758>.
- [263] A. Nussbaumer, K. Meusburger, M. Schmitt, P. Waldner, R. Gehrig, M. Haeni, A. Rigling, I. Brunner, and A. Thimonier. Extreme summer heat and drought lead to early fruit abortion in European beech. *Scientific Reports*, 10(1):5334, Mar. 2020. ISSN 2045-2322. doi:10.1038/s41598-020-62073-0. URL <https://www.nature.com/articles/s41598-020-62073-0>.
- [264] V. S. Ojeda, M. L. Suarez, and T. Kitzberger. Crown dieback events as key processes creating cavity habitat for magellanic woodpeckers. *Austral Ecology*, 32(4):436–445, 2007. ISSN 1442-9993. doi:10.1111/j.1442-9993.2007.01705.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1442-9993.2007.01705.x>.
- [265] A. Orczewska, P. Czortek, and B. Jaroszewicz. The impact of salvage logging on herb layer species composition and plant community recovery in Białowieża Forest. *Biodiversity and Conservation*, 28(13):3407–3428, Nov. 2019. ISSN 1572-9710. doi:10/gm95mh. URL <https://doi.org/10.1007/s10531-019-01795-8>.
- [266] E. Ormeño, B. Céspedes, I. A. Sánchez, A. Velasco-García, J. M. Moreno, C. Fernandez, and V. Baldy. The relationship between terpenes and flammability of leaf litter. *Forest Ecology and Management*, 257(2):471–482, Jan. 2009. ISSN 0378-1127. doi:10.1016/j.foreco.2008.09.019. URL <https://www.sciencedirect.com/science/article/pii/S0378112708007020>.
- [267] Y. Paillet, N. Debaive, F. Archaux, E. Cateau, O. Gilg, and E. Guilbert. Nothing else matters? Tree diameter and living status have more effects than biogeoclimatic context on microhabitat number and occurrence: An analysis in French forest reserves. *PLOS ONE*, 14(5):e0216500, May 2019. ISSN 1932-6203. doi:10.1371/journal.pone.0216500. URL <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0216500>.
- [268] R. T. Paine, M. J. Tegner, and E. A. Johnson. Compounded Perturbations Yield Ecological Surprises. *Ecosystems*, 1(6):535–545, Nov. 1998. ISSN 1432-9840. doi:10.1007/s100219900049. URL <https://doi.org/10.1007/s100219900049>.
- [269] B. Palik and D. Kastendick. Woody plant regeneration after blowdown, salvage logging, and prescribed fire in a northern Minnesota forest. *Forest Ecology and Management*, 258(7):1323–1330, Sept. 2009.

- ISSN 0378-1127. doi:10/c9pv9b. URL <https://www.sciencedirect.com/science/article/pii/S0378112709004526>.
- [270] O. Panferov and A. Sogachev. Influence of gap size on wind damage variables in a forest. *Agricultural and Forest Meteorology*, 148(11):1869–1881, Oct. 2008. ISSN 0168-1923. doi:10.1016/j.agrformet.2008.06.012. URL <https://www.sciencedirect.com/science/article/pii/S0168192308001937>.
- [271] M. Pardos, M. del Río, H. Pretzsch, H. Jactel, K. Bielak, F. Bravo, G. Brazaitis, E. Defossez, M. Engel, K. Godvod, K. Jacobs, L. Jansone, A. Jansons, X. Morin, A. Nothdurft, L. Oreti, Q. Ponette, M. Pach, J. Riofrío, R. Ruíz-Peinado, A. Tomao, E. Uhl, and R. Calama. The greater resilience of mixed forests to drought mainly depends on their composition: Analysis along a climate gradient across Europe. *Forest Ecology and Management*, 481:118687, Feb. 2021. ISSN 0378-1127. doi:10.1016/j.foreco.2020.118687. URL <https://www.sciencedirect.com/science/article/pii/S0378112720314560>.
- [272] C. Parmesan, M. D. Morecroft, Y. Trisurat, R. Adrian, G. Z. Anshari, A. Arneth, Q. Gao, P. Gonzalez, R. Harris, J. Price, N. Stevens, and G. H. Talukdar. Terrestrial and freshwater ecosystems and their services. In H.-O. Pörtner, D. C. Roberts, M. M. B. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, and B. Rama, editors, *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, 2022.
- [273] J. G. Pausas and C. L. Parr. Towards an understanding of the evolutionary role of fire in animals. *Evolutionary Ecology*, 32(2):113–125, June 2018. ISSN 1573-8477. doi:10.1007/s10682-018-9927-6. URL <https://doi.org/10.1007/s10682-018-9927-6>.
- [274] J. G. Pausas, J. Belliure, E. Mínguez, and S. Montagud. Fire benefits flower beetles in a Mediterranean ecosystem. *PLOS ONE*, 13(6):e0198951, June 2018. ISSN 1932-6203. doi:10.1371/journal.pone.0198951. URL <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0198951>.
- [275] G. Peguero, E. Folch, L. Liu, R. Ogaya, and J. Peñuelas. Divergent effects of drought and nitrogen deposition on microbial and arthropod soil communities in a Mediterranean forest. *European Journal of Soil Biology*, 103:103275, Mar. 2021. ISSN 1164-5563. doi:10.1016/j.ejsobi.2020.103275. URL <https://www.sciencedirect.com/science/article/pii/S1164556320303459>.
- [276] L. Pereg, J. Mataix-Solera, M. McMillan, and F. García-Orenes. The impact of post-fire salvage logging on microbial nitrogen cyclers in Mediterranean forest soil. *Science of The Total Environment*, 619–620: 1079–1087, Apr. 2018. ISSN 0048-9697. doi:10/gm8gc9. URL <https://www.sciencedirect.com/science/article/pii/S0048969717332059>.

- [277] K. I. Perry, K. F. Wallin, J. W. Wenzel, and D. A. Herms. Forest disturbance and arthropods: Small-scale canopy gaps drive invertebrate community structure and composition. *Ecosphere*, 9(10):e02463, 2018. ISSN 2150-8925. doi:10.1002/ecs2.2463. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/ecs2.2463>.
- [278] K. I. Perry, F. S. Sivakoff, K. F. Wallin, J. W. Wenzel, and D. A. Herms. Forest disturbance and arthropods: Small-scale canopy and understory disturbances alter movement of mobile arthropods. *Ecosphere*, 12(11):e03771, 2021. ISSN 2150-8925. doi:10.1002/ecs2.3771. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/ecs2.3771>.
- [279] C. J. Peterson and A. D. Leach. Salvage logging after windthrow alters microsite diversity, abundance and environment, but not vegetation. *Forestry: An International Journal of Forest Research*, 81(3): 361–376, July 2008. ISSN 0015-752X. doi:10.1093/forestry/cpn007. URL <https://doi.org/10.1093/forestry/cpn007>.
- [280] C. J. Peterson and S. T. A. Pickett. Forest Reorganization: A Case Study in an Old-Growth Forest Catastrophic Blowdown. *Ecology*, 76(3):763–774, 1995. ISSN 1939-9170. doi:10.2307/1939342. URL <https://onlinelibrary.wiley.com/doi/abs/10.2307/1939342>.
- [281] I. D. Phillips, T. P. Cobb, J. R. Spence, and R. M. Brigham. Salvage Logging, Edge Effects, and Carabid Beetles: Connections to Conservation and Sustainable Forest Management. *Environmental Entomology*, 35(4):950–957, Aug. 2006. ISSN 0046-225X. doi:10.1603/0046-225X-35.4.950. URL <https://doi.org/10.1603/0046-225X-35.4.950>.
- [282] L. S. Pile, M. D. Meyer, R. Rojas, O. Roe, and M. T. Smith. Drought Impacts and Compounding Mortality on Forest Trees in the Southern Sierra Nevada. *Forests*, 10(3):237, Mar. 2019. ISSN 1999-4907. doi:10.3390/f10030237. URL <https://www.mdpi.com/1999-4907/10/3/237>.
- [283] S. Pincebourde and H. A. Woods. There is plenty of room at the bottom: Microclimates drive insect vulnerability to climate change. *Current Opinion in Insect Science*, 41:63–70, Oct. 2020. ISSN 2214-5745. doi:10.1016/j.cois.2020.07.001. URL <https://www.sciencedirect.com/science/article/pii/S2214574520300870>.
- [284] X. Pineau, M. Bourguignon, H. Jactel, F. Lieutier, and A. Sallé. Pyrrhic victory for bark beetles: Successful standing tree colonization triggers strong intraspecific competition for offspring of *Ips sexdentatus*. *Forest Ecology and Management*, 399:188–196, Sept. 2017. ISSN 0378-1127. doi:10.1016/j.foreco.2017.05.044. URL <https://www.sciencedirect.com/science/article/pii/S0378112717304206>.
- [285] M. M. Pollierer, J. Dyckmans, S. Scheu, and D. Haubert. Carbon flux through fungi and bacteria into the forest soil animal food web as indicated by compound-specific ¹³C fatty acid analysis. *Functional Ecology*, 26(4):978–990, 2012. ISSN 1365-2435. doi:10.1111/j.1365-2435.2012.02005.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2435.2012.02005.x>.

- [286] L. C. Ponisio, K. Wilkin, L. K. M’Gonigle, K. Kulhanek, L. Cook, R. Thorp, T. Griswold, and C. Kremen. Pyrodiversity begets plant–pollinator community diversity. *Global Change Biology*, 22(5):1794–1808, 2016. ISSN 1365-2486. doi:[10.1111/gcb.13236](https://doi.org/10.1111/gcb.13236). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.13236>.
- [287] Z. Popović, S. Bojović, M. Marković, and A. Cerdà. Tree species flammability based on plant traits: A synthesis. *Science of The Total Environment*, 800:149625, Dec. 2021. ISSN 0048-9697. doi:[10.1016/j.scitotenv.2021.149625](https://doi.org/10.1016/j.scitotenv.2021.149625). URL <https://www.sciencedirect.com/science/article/pii/S0048969721047008>.
- [288] S. G. Potts, B. Vulliamy, A. Dafni, G. Ne’eman, C. O’Toole, S. Roberts, and P. Willmer. Response of plant-pollinator communities to fire: Changes in diversity, abundance and floral reward structure. *Oikos*, 101(1):103–112, 2003. ISSN 1600-0706. doi:[10.1034/j.1600-0706.2003.12186.x](https://doi.org/10.1034/j.1600-0706.2003.12186.x). URL <https://onlinelibrary.wiley.com/doi/abs/10.1034/j.1600-0706.2003.12186.x>.
- [289] E. N. Powell, P. A. Townsend, and K. F. Raffa. Wildfire provides refuge from local extinction but is an unlikely driver of outbreaks by mountain pine beetle. *Ecological Monographs*, 82(1):69–84, 2012. ISSN 1557-7015. doi:[10.1890/11-0607.1](https://doi.org/10.1890/11-0607.1). URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/11-0607.1>.
- [290] Y. Pressler, J. C. Moore, and M. F. Cotrufo. Belowground community responses to fire: Meta-analysis reveals contrasting responses of soil microorganisms and mesofauna. *Oikos*, 128(3):309–327, 2019. ISSN 1600-0706. doi:[10.1111/oik.05738](https://doi.org/10.1111/oik.05738). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/oik.05738>.
- [291] J. Pryke and M. Samways. Importance of using many taxa and having adequate controls for monitoring impacts of fire for arthropod conservation. *J. Insect Conserv.*, 16:177–185, Apr. 2012. doi:[10.1007/s10841-011-9404-9](https://doi.org/10.1007/s10841-011-9404-9).
- [292] C. Puerta-Piñero, J. M. Espelta, B. Sánchez-Humanes, A. Rodrigo, L. Coll, and L. Brotons. History matters: Previous land use changes determine post-fire vegetation recovery in forested Mediterranean landscapes. *Forest Ecology and Management*, 279:121–127, Sept. 2012. ISSN 0378-1127. doi:[10.1016/j.foreco.2012.05.020](https://doi.org/10.1016/j.foreco.2012.05.020). URL <https://www.sciencedirect.com/science/article/pii/S0378112712002897>.
- [293] S. A. Pulsford, D. B. Lindenmayer, and D. A. Driscoll. A succession of theories: Purging redundancy from disturbance theory. *Biological Reviews*, 91(1):148–167, 2016. ISSN 1469-185X. doi:[10/f762wh](https://doi.org/10/f762wh). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/brv.12163>.
- [294] C. P. Quine and J. W. Humphrey. Plantations of exotic tree species in Britain: Irrelevant for biodiversity or novel habitat for native species? *Biodiversity and Conservation*, 19(5):1503–1512, May 2010. ISSN 1572-9710. doi:[10.1007/s10531-009-9771-7](https://doi.org/10.1007/s10531-009-9771-7). URL <https://doi.org/10.1007/s10531-009-9771-7>.

- [295] M. A. Rab. Recovery of soil physical properties from compaction and soil profile disturbance caused by logging of native forest in Victorian Central Highlands, Australia. *Forest Ecology and Management*, 191(1):329–340, Apr. 2004. ISSN 0378-1127. doi:10/fhcxkm. URL <https://www.sciencedirect.com/science/article/pii/S0378112704000039>.
- [296] A. Rachwald, M. Ciesielski, M. Szurlej, and M. Żmihorski. Following the damage: Increasing western barbastelle bat activity in bark beetle infested stands in Białowieża Primeval forest. *Forest Ecology and Management*, 503:119803, Jan. 2022. ISSN 0378-1127. doi:10.1016/j.foreco.2021.119803. URL <https://www.sciencedirect.com/science/article/pii/S037811272100894X>.
- [297] C. Radea and M. Arianoutsou. Soil Arthropod Communities and Population Dynamics Following Wildfires in Pine Forests of the Mediterranean Basin: A Review. *Israel Journal of Ecology and Evolution*, 58(2-3):137–149, May 2012. ISSN 2224-4662, 1565-9801. doi:10.1560/IJEE.58.2-3.137. URL https://brill.com/view/journals/ijee/58/2-3/article-p137_4.xml.
- [298] M. L. Reaka-Kudla, D. E. Wilson, and E. O. Wilson. *Biodiversity II: Understanding and Protecting Our Biological Resources*. Washington, DC, a Joseph Henry Press book edition, 1997. ISBN 978-0-309-05584-0. doi:10.17226/4901. URL <https://nap.nationalacademies.org/catalog/4901/biodiversity-ii-understanding-and-protecting-our-biological-resources>.
- [299] G. P. Reyes and D. Kneeshaw. Moderate-severity disturbance dynamics in *Abies balsamea*-*Betula* spp. forests: The relative importance of disturbance type and local stand and site characteristics on woody vegetation response. *Écoscience*, 15(2):241–249, June 2008. ISSN 1195-6860. doi:10/cs2h7r. URL <https://doi.org/10.2980/15-2-3082>.
- [300] L. K. Rieske, H. H. Housman, and M. A. Arthur. Effects of prescribed fire on canopy foliar chemistry and suitability for an insect herbivore. *Forest Ecology and Management*, 160(1):177–187, May 2002. ISSN 0378-1127. doi:10.1016/S0378-1127(01)00444-3. URL <https://www.sciencedirect.com/science/article/pii/S0378112701004443>.
- [301] N. M. Robinson, S. W. Leonard, E. G. Ritchie, M. Bassett, E. K. Chia, S. Buckingham, H. Gibb, A. F. Bennett, and M. F. Clarke. REVIEW: Refuges for fauna in fire-prone landscapes: Their ecological function and importance. *Journal of Applied Ecology*, 50(6):1321–1329, 2013. ISSN 1365-2664. doi:10.1111/1365-2664.12153. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/1365-2664.12153>.
- [302] A. Rodrigo, F. Sardà-Palomera, J. Bosch, and J. Retana. Changes of dominant ground beetles in black pine forests with fire severity and successional age. *Écoscience*, 15(4):442–452, Dec. 2008. ISSN 1195-6860. doi:10.2980/15-4-3117. URL <https://doi.org/10.2980/15-4-3117>.
- [303] M.-P. Rogeau, Q. E. Barber, and M.-A. Parisien. Effect of Topography on Persistent Fire Refugia of the Canadian Rocky Mountains. *Forests*, 9(6):285, June 2018. ISSN 1999-4907. doi:10.3390/f9060285. URL <https://www.mdpi.com/1999-4907/9/6/285>.

- [304] G. Q. Romero, T. Gonçalves-Souza, T. Roslin, R. J. Marquis, N. A. Marino, V. Novotny, T. Cornelissen, J. Orivel, S. Sui, G. Aires, R. Antoniazzi, W. Dáttilo, C. P. B. Breviglieri, A. Busse, H. Gibb, T. J. Izzo, T. Kadlec, V. Kemp, M. Kersch-Becker, M. Knapp, P. Kratina, R. Luke, S. Majnarić, R. Maritz, P. Mateus Martins, E. Mendesil, J. Michalko, A. Mrazova, S. Novais, C. C. Pereira, M. S. Perić, J. S. Petermann, S. P. Ribeiro, K. Sam, M. K. Trzcinski, C. Vieira, N. Westwood, M. L. Bernaschini, V. Carvajal, E. González, M. Jausoro, S. Kaensin, F. Ospina, E. J. Cristóbal-Pérez, M. Quesada, P. Rogy, D. S. Srivastava, S. Szpryngiel, A. J. Tack, T. Teder, M. Videla, M.-L. Viljur, and J. Koricheva. Climate variability and aridity modulate the role of leaf shelters for arthropods: A global experiment. *Global Change Biology*, 28(11):3694–3710, 2022. ISSN 1365-2486. doi:10.1111/gcb.16150. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.16150>.
- [305] W. L. Romey, J. S. Ascher, D. A. Powell, and M. Yanek. Impacts of Logging on Midsummer Diversity of Native Bees (Apoidea) in a Northern Hardwood Forest. *Journal of the Kansas Entomological Society*, 80(4):327–338, Oct. 2007. ISSN 0022-8567, 1937-2353. doi:10.2317/0022-8567(2007)80[327:IOLOMD]2.0.CO;2. URL [https://bioone.org/journals/journal-of-the-kansas-entomological-society/volume-80/issue-4/0022-8567_2007_80_327_IOLOMD_2.0.CO_2/Impacts-of-Logging-on-Midsummer-Diversity-of-Native-Bees-Apoidea/10.2317/0022-8567\(2007\)80\[327:IOLOMD\]2.0.CO;2.full](https://bioone.org/journals/journal-of-the-kansas-entomological-society/volume-80/issue-4/0022-8567_2007_80_327_IOLOMD_2.0.CO_2/Impacts-of-Logging-on-Midsummer-Diversity-of-Native-Bees-Apoidea/10.2317/0022-8567(2007)80[327:IOLOMD]2.0.CO;2.full).
- [306] G. Rouault, J.-N. Candau, F. Lieutier, L.-M. Nageleisen, J.-C. Martin, and N. Warzée. Effects of drought and heat on forest insect populations in relation to the 2003 drought in Western Europe. *Annals of Forest Science*, 63(6):613–624, Sept. 2006. ISSN 1286-4560, 1297-966X. doi:10.1051/forest:2006044. URL <http://dx.doi.org/10.1051/forest:2006044>.
- [307] J. S. Rowe. Concepts of Fire Effects on Plant Individuals and Species. In *The Role of Fire in Northern Circumpolar Ecosystems*, SCOPE, pages 135–154. John Wiley & Sons Ltd. edition, 1983.
- [308] A. A. Royo, C. J. Peterson, J. S. Stanovick, and W. P. Carson. Evaluating the ecological impacts of salvage logging: Can natural and anthropogenic disturbances promote coexistence? *Ecology*, 97(6):1566–1582, 2016. ISSN 1939-9170. doi:10.1890/15-1093.1. URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/15-1093.1>.
- [309] J. R. Runkle. Disturbance regimes in temperate forests. *The ecology of natural disturbance and patch dynamics*, pages 17–33, 1985. URL <https://www.cabdirect.org/cabdirect/abstract/19880621360>.
- [310] K. X. Ruthrof, J. B. Fontaine, G. Matusick, D. D. Breshears, D. J. Law, S. Powell, G. Hardy, K. X. Ruthrof, J. B. Fontaine, G. Matusick, D. D. Breshears, D. J. Law, S. Powell, and G. Hardy. How drought-induced forest die-off alters microclimate and increases fuel loadings and fire potentials. *International Journal of Wildland Fire*, 25(8):819–830, Feb. 2016. ISSN 1448-5516, 1448-5516. doi:10.1071/WF15028. URL <https://www.publish.csiro.au/wf/WF15028>.

- [311] M. Saint-Germain, P. Drapeau, and A. Hibbert. Saproxylic beetle tolerance to habitat fragmentation induced by salvage logging in a boreal mixed-cover burn. *Insect Conservation and Diversity*, 6(3):381–392, 2013. ISSN 1752-4598. doi:10.1111/j.1752-4598.2012.00216.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1752-4598.2012.00216.x>.
- [312] A. Sallé, L. M. Nageleisen, and F. Lieutier. Bark and wood boring insects involved in oak declines in Europe: Current knowledge and future prospects in a context of climate change. *Forest Ecology and Management*, 328:79–93, Sept. 2014. ISSN 0378-1127. doi:10/gnqqb4. URL <https://www.sciencedirect.com/science/article/pii/S037811271400317X>.
- [313] A. Sallé, G. Parmain, B. Nusillard, X. Pineau, R. Brousse, T. Fontaine-Guenel, R. Ledet, C. Vincent-Barbaroux, and C. Bouget. Forest decline differentially affects trophic guilds of canopy-dwelling beetles. *Annals of Forest Science*, 77(3):86, Sept. 2020. ISSN 1297-966X. doi:10.1007/s13595-020-00990-w. URL <https://doi.org/10.1007/s13595-020-00990-w>.
- [314] A. Sallé, J. Cours, E. Le Souchu, C. Lopez-Vaamonde, S. Pincebourde, and C. Bouget. Climate Change Alters Temperate Forest Canopies and Indirectly Reshapes Arthropod Communities. *Frontiers in Forests and Global Change*, 4:120, 2021. ISSN 2624-893X. doi:10.3389/ffgc.2021.710854. URL <https://www.frontiersin.org/article/10.3389/ffgc.2021.710854>.
- [315] L. Samaniego, S. Thober, R. Kumar, N. Wanders, O. Rakovec, M. Pan, M. Zink, J. Sheffield, E. F. Wood, and A. Marx. Anthropogenic warming exacerbates European soil moisture droughts. *Nature Climate Change*, 8(5):421, May 2018. ISSN 1758-6798. doi:10.1038/s41558-018-0138-5. URL <https://www.nature.com/articles/s41558-018-0138-5>.
- [316] F. Samu, F. Kádár, G. Ónodi, M. Kertész, A. Szirányi, É. Szita, K. Fetykó, D. Neidert, E. Botos, and V. Altbäcker. Differential ecological responses of two generalist arthropod groups, spiders and carabid beetles (Araneae, Carabidae), to the effects of wildfire. *Community Ecology*, 11(2):129–139, Oct. 2010. ISSN 1588-2756, 1585-8553. doi:10.1556/comec.11.2010.2.1. URL <https://akjournals.com/view/journals/168/11/2/article-p129.xml>.
- [317] M. Santonja, C. Fernandez, M. Proffit, C. Gers, T. Gauquelin, I. M. Reiter, W. Cramer, and V. Baldy. Plant litter mixture partly mitigates the negative effects of extended drought on soil biota and litter decomposition in a Mediterranean oak forest. *Journal of Ecology*, 105(3):801–815, 2017. ISSN 1365-2745. doi:10.1111/1365-2745.12711. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/1365-2745.12711>.
- [318] E. M. Sass, A. W. D’Amato, and D. R. Foster. Lasting legacies of historical clearcutting, wind, and salvage logging on old-growth *Tsuga canadensis*-*Pinus strobus* forests. *Forest Ecology and Management*, 419–420:31–41, July 2018. ISSN 0378-1127. doi:10.1016/j.foreco.2018.03.012. URL <https://www.sciencedirect.com/science/article/pii/S0378112717321357>.
- [319] A. Scandurra, L. Magliozzi, M. Aria, and B. D’Aniello. Short-term effects of fire on Papilionoidea (Lepidoptera) communities: A pilot study in Mediterranean maquis shrubland. *Italian Journal of*

- Zoology*, 81(4):599–609, Oct. 2014. ISSN 1125-0003. doi:[10.1080/11250003.2014.953218](https://doi.org/10.1080/11250003.2014.953218). URL <https://doi.org/10.1080/11250003.2014.953218>.
- [320] Z. Schapira, C. Stevens-Rumann, D. Shorrocks, C. Hoffman, and A. Chambers. Beetlemania: Is the bark worse than the bite? Rocky Mountain subalpine forests recover differently after spruce beetle outbreaks and wildfires. *Forest Ecology and Management*, 482:118879, Feb. 2021. ISSN 0378-1127. doi:[10.1016/j.foreco.2020.118879](https://doi.org/10.1016/j.foreco.2020.118879). URL <https://www.sciencedirect.com/science/article/pii/S0378112720316480>.
- [321] T. Schoennagel, E. A. H. Smithwick, and M. G. Turner. Landscape heterogeneity following large fires: Insights from Yellowstone National Park, USA. *International Journal of Wildland Fire*, 17(6): 742–753, Dec. 2008. ISSN 1448-5516, 1448-5516. doi:[10.1071/WF07146](https://doi.org/10.1071/WF07146). URL <https://www.publish.csiro.au/wf/WF07146>.
- [322] P. Sebek, J. Altman, M. Platek, and L. Cizek. Is Active Management the Key to the Conservation of Saproxylic Biodiversity? Pollarding Promotes the Formation of Tree Hollows. *PLOS ONE*, 8(3): e60456, Mar. 2013. ISSN 1932-6203. doi:[10.1371/journal.pone.0060456](https://doi.org/10.1371/journal.pone.0060456). URL <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0060456>.
- [323] S. Seibold, C. Bässler, R. Brandl, B. Büche, A. Szallies, S. Thorn, M. D. Ulyshen, and J. Müller. Microclimate and habitat heterogeneity as the major drivers of beetle diversity in dead wood. *Journal of Applied Ecology*, 53(3):934–943, 2016. doi:[10/f8xb6d](https://doi.org/10/f8xb6d).
- [324] S. Seibold, W. W. Weisser, D. Ambarlı, M. M. Gossner, A. S. Mori, M. W. Cadotte, J. Hagge, C. Bässler, and S. Thorn. Drivers of community assembly change during succession in wood-decomposing beetle communities. *Journal of Animal Ecology*, n/a(n/a), 2022. ISSN 1365-2656. doi:[10.1111/1365-2656.13843](https://doi.org/10.1111/1365-2656.13843). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/1365-2656.13843>.
- [325] R. Seidl and M. G. Turner. Post-disturbance reorganization of forest ecosystems in a changing world. *Proceedings of the National Academy of Sciences*, 119(28):e2202190119, July 2022. doi:[10.1073/pnas.2202190119](https://doi.org/10.1073/pnas.2202190119). URL <https://www.pnas.org/doi/full/10.1073/pnas.2202190119>.
- [326] R. Seidl, W. Rammer, and T. A. Spies. Disturbance legacies increase the resilience of forest ecosystem structure, composition, and functioning. *Ecological Applications*, 24(8):2063–2077, 2014. ISSN 1939-5582. doi:[10/f3s52d](https://doi.org/10/f3s52d). URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/14-0255.1>.
- [327] R. Seidl, M.-J. Schelhaas, W. Rammer, and P. J. Verkerk. Increasing forest disturbances in Europe and their impact on carbon storage. *Nature Climate Change*, 4(9):806–810, Sept. 2014. ISSN 1758-6798. doi:[10.1038/nclimate2318](https://doi.org/10.1038/nclimate2318). URL <https://www.nature.com/articles/nclimate2318>.

- [328] R. Seidl, T. A. Spies, D. L. Peterson, S. L. Stephens, and J. A. Hicke. REVIEW: Searching for resilience: Addressing the impacts of changing disturbance regimes on forest ecosystem services. *Journal of Applied Ecology*, 53(1):120–129, 2016. ISSN 1365-2664. doi:10.1111/1365-2664.12511. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/1365-2664.12511>.
- [329] R. Seidl, D. Thom, M. Kautz, D. Martin-Benito, M. Peltoniemi, G. Vacchiano, J. Wild, D. Ascoli, M. Petr, J. Honkaniemi, M. J. Lexer, V. Trotsiuk, P. Mairota, M. Svoboda, M. Fabrika, T. A. Nagel, and C. P. O. Reyer. Forest disturbances under climate change. *Nature Climate Change*, 7(6):395–402, June 2017. ISSN 1758-6798. doi:10.1038/nclimate3303. URL <https://www.nature.com/articles/nclimate3303>.
- [330] C. Senf and R. Seidl. Persistent impacts of the 2018 drought on forest disturbance regimes in Europe. *Biogeosciences*, 18:5223–5230, Sept. 2021. ISSN 1726-4170. doi:10/gnkxwg. URL <https://bg.copernicus.org/articles/18/5223/2021/>.
- [331] C. Senf and R. Seidl. Storm and fire disturbances in Europe: Distribution and trends. *Global Change Biology*, 27(15):3605–3619, 2021. ISSN 1365-2486. doi:10.1111/gcb.15679. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.15679>.
- [332] C. Senf, D. Pflugmacher, Y. Zhiqiang, J. Sebal, J. Knorn, M. Neumann, P. Hostert, and R. Seidl. Canopy mortality has doubled in Europe’s temperate forests over the last three decades. *Nature Communications*, 9(1):4978, Nov. 2018. ISSN 2041-1723. doi:10.1038/s41467-018-07539-6. URL <https://www.nature.com/articles/s41467-018-07539-6>.
- [333] C. Senf, A. Buras, C. S. Zang, A. Rammig, and R. Seidl. Excess forest mortality is consistently linked to drought across Europe. *Nature Communications*, 11(1):6200, Dec. 2020. ISSN 2041-1723. doi:10.1038/s41467-020-19924-1. URL <https://www.nature.com/articles/s41467-020-19924-1>.
- [334] J. Siitonen. Forest Management, Coarse Woody Debris and Saproxylic Organisms: Fennoscandian Boreal Forests as an Example. *Ecological Bulletins*, (49):11–41, 2001. ISSN 0346-6868. URL <https://www.jstor.org/stable/20113262>.
- [335] M. P. Simanonok and L. A. Burkle. Nesting success of wood-cavity-nesting bees declines with increasing time since wildfire. *Ecology and Evolution*, 9(22):12436–12445, 2019. ISSN 2045-7758. doi:10.1002/ece3.5657. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/ece3.5657>.
- [336] M. Simard, W. H. Romme, J. M. Griffin, and M. G. Turner. Do mountain pine beetle outbreaks change the probability of active crown fire in lodgepole pine forests? *Ecological Monographs*, 81(1):3–24, 2011. ISSN 1557-7015. doi:10.1890/10-1176.1. URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/10-1176.1>.

- [337] S. A. Simmons and J. L. Bossart. Apparent Resilience to Fire of Native Bee (Hymenoptera: Apoidea) Communities from Upland Longleaf Pine Forests in Louisiana and Mississippi. *Southeastern Naturalist*, 19(3):567–581, Sept. 2020. ISSN 1528-7092, 1938-5412. doi:10.1656/058.019.0316. URL <https://bioone.org/journals/southeastern-naturalist/volume-19/issue-3/058.019.0316/Apparent-Resilience-to-Fire-of-Native-Bee-Hymenoptera--Apoidea/10.1656/058.019.0316.full>.
- [338] L. Sire, P. S. Yáñez, C. Wang, A. Bézier, B. Courtial, J. Cours, D. Fontaneto, L. Larrieu, C. Bouget, S. Thorn, J. Müller, D. W. Yu, M. T. Monaghan, E. A. Herniou, and C. Lopez-Vaamonde. Climate-induced forest dieback drives compositional changes in insect communities that are more pronounced for rare species. *Communications Biology*, 5(1):1–17, Jan. 2022. ISSN 2399-3642. doi:10.1038/s42003-021-02968-4. URL <https://www.nature.com/articles/s42003-021-02968-4>.
- [339] J. Sklodowski and P. Garbalinska. Ground beetle (Coleoptera, Carabidae) assemblages inhabiting Scots pine stands of Puszcza Piska Forest: Six-year responses to a tornado impact. *ZooKeys*, 100: 371–392, May 2011. ISSN 1313-2970. doi:10.3897/zookeys.100.1360. URL <https://zookeys.pensoft.net/article/2391/>.
- [340] E. Smirnova, Y. Bergeron, and S. Brais. Influence of fire intensity on structure and composition of jack pine stands in the boreal forest of Quebec: Live trees, understory vegetation and dead wood dynamics. *Forest Ecology and Management*, 255(7):2916–2927, Apr. 2008. ISSN 0378-1127. doi:10.1016/j.foreco.2008.01.071. URL <https://www.sciencedirect.com/science/article/pii/S0378112708001497>.
- [341] A. Sommerfeld, C. Senf, B. Buma, A. W. D’Amato, T. Després, I. Díaz-Hormazábal, S. Fraver, L. E. Frelich, Á. G. Gutiérrez, S. J. Hart, B. J. Harvey, H. S. He, T. Hlásny, A. Holz, T. Kitzberger, D. Kulakowski, D. Lindenmayer, A. S. Mori, J. Müller, J. Paritsis, G. L. W. Perry, S. L. Stephens, M. Svoboda, M. G. Turner, T. T. Veblen, and R. Seidl. Patterns and drivers of recent disturbances across the temperate forest biome. *Nature Communications*, 9(1):4355, Dec. 2018. ISSN 2041-1723. doi:10/gfddzv. URL <http://www.nature.com/articles/s41467-018-06788-9>.
- [342] J. Spinoni, J. V. Vogt, G. Naumann, P. Barbosa, and A. Dosio. Will drought events become more frequent and severe in Europe? *International Journal of Climatology*, 38(4):1718–1736, 2018. ISSN 1097-0088. doi:10.1002/joc.5291. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/joc.5291>.
- [343] D. G. Sprugel. Disturbance, equilibrium, and environmental variability: What is ‘Natural’ vegetation in a changing environment? *Biological Conservation*, 58(1):1–18, Jan. 1991. ISSN 0006-3207. doi:10.1016/0006-3207(91)90041-7. URL <https://www.sciencedirect.com/science/article/pii/0006320791900417>.

- [344] G. Stadelmann, H. Bugmann, F. Meier, B. Wermelinger, and C. Bigler. Effects of salvage logging and sanitation felling on bark beetle (*Ips typographus* L.) infestations. *Forest Ecology and Management*, 305:273–281, Oct. 2013. ISSN 0378-1127. doi:10/f4947s. URL <http://www.sciencedirect.com/science/article/pii/S037811271300371X>.
- [345] Z. L. Steel, G. M. Jones, B. M. Collins, R. Green, A. Koltunov, K. L. Purcell, S. C. Sawyer, M. R. Slaton, S. L. Stephens, P. Stine, and C. Thompson. Mega-disturbances cause rapid decline of mature conifer forest habitat in California. *Ecological Applications*, n/a(n/a):e2763, 2022. ISSN 1939-5582. doi:10.1002/eap.2763. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/eap.2763>.
- [346] S. L. Stephens and J. J. Moghaddas. Silvicultural and reserve impacts on potential fire behavior and forest conservation: Twenty-five years of experience from Sierra Nevada mixed conifer forests. *Biological Conservation*, 125(3):369–379, Oct. 2005. ISSN 0006-3207. doi:10.1016/j.biocon.2005.04.007. URL <https://www.sciencedirect.com/science/article/pii/S0006320705001801>.
- [347] M. Sterzyńska, J. Shrubovych, K. Tajovský, P. Čuchta, J. Starý, J. Kaňa, and J. Smykla. Responses of soil microarthropod taxon (Hexapoda: Protura) to natural disturbances and management practices in forest-dominated subalpine lake catchment areas. *Scientific Reports*, 10(1):5572, Mar. 2020. ISSN 2045-2322. doi:10.1038/s41598-020-62522-w. URL <https://www.nature.com/articles/s41598-020-62522-w>.
- [348] J. N. Stokland, J. Siitonen, and B. G. Jonsson. *Biodiversity in Dead Wood*. Ecology, Biodiversity and Conservation. Cambridge University Press, Cambridge, 2012. ISBN 978-0-521-88873-8. doi:10.1017/CBO9781139025843. URL <https://www.cambridge.org/core/books/biodiversity-in-dead-wood/32EA8DA79A503B95795384FFA5BC993D>.
- [349] N. E. Stork and P. S. Grimbacher. Beetle assemblages from an Australian tropical rainforest show that the canopy and the ground strata contribute equally to biodiversity. *Proceedings of the Royal Society B: Biological Sciences*, 273(1596):1969–1975, Aug. 2006. doi:10.1098/rspb.2006.3521. URL <https://royalsocietypublishing.org/doi/full/10.1098/rspb.2006.3521>.
- [350] M. Štursová, J. Šnajdr, T. Cajthaml, J. Bárta, H. Šantrůčková, and P. Baldrian. When the forest dies: The response of forest soil fungi to a bark beetle-induced tree dieback. *The ISME Journal*, 8(9): 1920–1931, Sept. 2014. ISSN 1751-7370. doi:10.1038/ismej.2014.37. URL <https://www.nature.com/articles/ismej201437>.
- [351] A. J. Suggitt, R. J. Wilson, N. J. B. Isaac, C. M. Beale, A. G. Auffret, T. August, J. J. Bennie, H. Q. P. Crick, S. Duffield, R. Fox, J. J. Hopkins, N. A. Macgregor, M. D. Morecroft, K. J. Walker, and I. M. D. Maclean. Extinction risk from climate change is reduced by microclimatic buffering. *Nature Climate Change*, 8(8):713–717, Aug. 2018. ISSN 1758-6798. doi:10.1038/s41558-018-0231-9. URL <https://www.nature.com/articles/s41558-018-0231-9>.

- [352] Z. Šustek, J. Vido, J. Škvareninová, J. Škvarenina, and P. Šurda. Drought impact on ground beetle assemblages (Coleoptera, Carabidae) in Norway spruce forests with different management after wind-storm damage – a case study from Tatra Mts. (Slovakia). *Journal of Hydrology and Hydromechanics*, 65(4):333–342, Dec. 2017. doi:[10.1515/johh-2017-0048](https://doi.org/10.1515/johh-2017-0048). URL <https://www.sciendo.com/article/10.1515/johh-2017-0048>.
- [353] M. E. Swanson, J. F. Franklin, R. L. Beschta, C. M. Crisafulli, D. A. DellaSala, R. L. Hutto, D. B. Lindenmayer, and F. J. Swanson. The forgotten stage of forest succession: Early-successional ecosystems on forest sites. *Frontiers in Ecology and the Environment*, 9(2):117–125, 2011. ISSN 1540-9309. doi:[10.1890/090157](https://doi.org/10.1890/090157). URL <https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/090157>.
- [354] C. A. Tabacaru, J. Park, and N. Erbilgin. Prescribed fire does not promote outbreaks of a primary bark beetle at low-density populations. *Journal of Applied Ecology*, 53(1):222–232, 2016. ISSN 1365-2664. doi:[10.1111/1365-2664.12546](https://doi.org/10.1111/1365-2664.12546). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/1365-2664.12546>.
- [355] A. Taeroe, J. H. C. de Koning, M. Löf, A. Tolvanen, L. Heiðarsson, and K. Raulund-Rasmussen. Recovery of temperate and boreal forests after windthrow and the impacts of salvage logging. A quantitative review. *Forest Ecology and Management*, 446:304–316, Aug. 2019. ISSN 0378-1127. doi:[10/gjcsfm](https://doi.org/10/gjcsfm). URL <https://www.sciencedirect.com/science/article/pii/S0378112718321546>.
- [356] F. Tello, M. E. González, N. Valdivia, F. Torres, A. Lara, and A. García-López. Diversity loss and changes in saproxylic beetle assemblages following a high-severity fire in Araucaria–Nothofagus forests. *Journal of Insect Conservation*, 24(3):585–601, June 2020. ISSN 1572-9753. doi:[10.1007/s10841-020-00223-5](https://doi.org/10.1007/s10841-020-00223-5). URL <https://doi.org/10.1007/s10841-020-00223-5>.
- [357] F. Tello, M. E. González, E. Micó, N. Valdivia, F. Torres, A. Lara, and A. García-López. Short-Interval, Severe Wildfires Alter Saproxylic Beetle Diversity in Andean Araucaria Forests in Northwest Chilean Patagonia. *Forests*, 13(3):441, Mar. 2022. ISSN 1999-4907. doi:[10.3390/f13030441](https://doi.org/10.3390/f13030441). URL <https://www.mdpi.com/1999-4907/13/3/441>.
- [358] J. Tews, U. Brose, V. Grimm, K. Tielbörger, M. C. Wichmann, M. Schwager, and F. Jeltsch. Animal species diversity driven by habitat heterogeneity/diversity: The importance of keystone structures. *Journal of Biogeography*, 31(1):79–92, 2004. ISSN 1365-2699. doi:[10.1046/j.0305-0270.2003.00994.x](https://doi.org/10.1046/j.0305-0270.2003.00994.x). URL <https://onlinelibrary.wiley.com/doi/abs/10.1046/j.0305-0270.2003.00994.x>.
- [359] D. Thom and R. Seidl. Natural disturbance impacts on ecosystem services and biodiversity in temperate and boreal forests. *Biological Reviews*, 91(3):760–781, 2016. ISSN 1469-185X. doi:[10.1111/brv.12193](https://doi.org/10.1111/brv.12193). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/brv.12193>.
- [360] D. Thom, W. Rammer, T. Dirnböck, J. Müller, J. Kobler, K. Katzensteiner, N. Helm, and R. Seidl. The impacts of climate change and disturbance on spatio-temporal trajectories of biodiversity in

- a temperate forest landscape. *Journal of Applied Ecology*, 54(1):28–38, 2017. ISSN 1365-2664. doi:10.1111/1365-2664.12644. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/1365-2664.12644>.
- [361] D. Thom, W. Rammer, and R. Seidl. Disturbances catalyze the adaptation of forest ecosystems to changing climate conditions. *Global Change Biology*, 23(1):269–282, 2017. ISSN 1365-2486. doi:10.1111/gcb.13506. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.13506>.
- [362] H. M. Thompson, M. R. Lesser, L. Myers, and T. B. Mihuc. Insect Community Response Following Wildfire in an Eastern North American Pine Barrens. *Forests*, 13(1):66, Jan. 2022. ISSN 1999-4907. doi:10.3390/f13010066. URL <https://www.mdpi.com/1999-4907/13/1/66>.
- [363] J. R. Thompson, T. A. Spies, and L. M. Ganio. Reburn severity in managed and unmanaged vegetation in a large wildfire. *Proceedings of the National Academy of Sciences*, 104(25):10743–10748, June 2007. ISSN 0027-8424, 1091-6490. doi:10/dbgzvr. URL <http://www.pnas.org/cgi/doi/10.1073/pnas.0700229104>.
- [364] S. Thorn, C. Bässler, T. Gottschalk, T. Hothorn, H. Bussler, K. Raffa, and J. Müller. New Insights into the Consequences of Post-Windthrow Salvage Logging Revealed by Functional Structure of Saproxylic Beetles Assemblages. *PLOS ONE*, 9(7):e101757, 2014. ISSN 1932-6203. doi:10/f6whv7. URL <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0101757>.
- [365] S. Thorn, H. Bußler, M.-A. Fritze, P. Goeder, J. Müller, I. Weiß, and S. Seibold. Canopy closure determines arthropod assemblages in microhabitats created by windstorms and salvage logging. *Forest Ecology and Management*, 381:188–195, Dec. 2016. ISSN 0378-1127. doi:10.1016/j.foreco.2016.09.029. URL <https://www.sciencedirect.com/science/article/pii/S0378112716306119>.
- [366] S. Thorn, C. Bässler, M. Svoboda, and J. Müller. Effects of natural disturbances and salvage logging on biodiversity – Lessons from the Bohemian Forest. *Forest Ecology and Management*, 388:113–119, Mar. 2017. ISSN 0378-1127. doi:10.1016/j.foreco.2016.06.006. URL <http://www.sciencedirect.com/science/article/pii/S0378112716303036>.
- [367] S. Thorn, C. Bässler, R. Brandl, P. J. Burton, R. Cahall, J. L. Campbell, J. Castro, C.-Y. Choi, T. Cobb, D. C. Donato, E. Durska, J. B. Fontaine, S. Gauthier, C. Hebert, T. Hothorn, R. L. Hutto, E.-J. Lee, A. B. Leverkus, D. B. Lindenmayer, M. K. Obrist, J. Rost, S. Seibold, R. Seidl, D. Thom, K. Waldron, B. Wermelinger, M.-B. Winter, M. Zmihorski, and J. Müller. Impacts of salvage logging on biodiversity: A meta-analysis. *Journal of Applied Ecology*, 55(1):279–289, 2018. ISSN 1365-2664. doi:10/gcq7rg. URL <https://besjournals.onlinelibrary.wiley.com/doi/abs/10.1111/1365-2664.12945>.
- [368] S. Thorn, J. Müller, and A. B. Leverkus. Preventing European forest diebacks. *Science*, 365(6460):1388–1388, Sept. 2019. ISSN 0036-8075, 1095-9203. doi:10.1126/science.aaz3476. URL <https://science.sciencemag.org/content/365/6460/1388.2>.

- [369] S. Thorn, A. Chao, K. B. Georgiev, J. Müller, C. Bäessler, J. L. Campbell, J. Castro, Y.-H. Chen, C.-Y. Choi, T. P. Cobb, D. C. Donato, E. Durska, E. Macdonald, H. Feldhaar, J. B. Fontaine, P. J. Fornwalt, R. M. H. Hernández, R. L. Hutto, M. Koivula, E.-J. Lee, D. Lindenmayer, G. Mikusiński, M. K. Obrist, M. Perlík, J. Rost, K. Waldron, B. Wermelinger, I. Weiß, M. Żmihorski, and A. B. Leverkus. Estimating retention benchmarks for salvage logging to protect biodiversity. *Nature Communications*, 11(1): 4762, Sept. 2020. ISSN 2041-1723. doi:[10/gjcxg8](https://doi.org/10/gjcxg8). URL <https://www.nature.com/articles/s41467-020-18612-4>.
- [370] P. Torun and A. O. Altunel. Effects of environmental factors and forest management on landscape-scale forest storm damage in Turkey. *Annals of Forest Science*, 77(2):39, Apr. 2020. ISSN 1297-966X. doi:[10.1007/s13595-020-00945-1](https://doi.org/10.1007/s13595-020-00945-1). URL <https://doi.org/10.1007/s13595-020-00945-1>.
- [371] C. L. Tubbesing, D. L. Fry, G. B. Roller, B. M. Collins, V. A. Fedorova, S. L. Stephens, and J. J. Battles. Strategically placed landscape fuel treatments decrease fire severity and promote recovery in the northern Sierra Nevada. *Forest Ecology and Management*, 436:45–55, Mar. 2019. ISSN 0378-1127. doi:[10.1016/j.foreco.2019.01.010](https://doi.org/10.1016/j.foreco.2019.01.010). URL <https://www.sciencedirect.com/science/article/pii/S0378112718320462>.
- [372] M. G. Turner. Disturbance and landscape dynamics in a changing world. *Ecology*, 91(10):2833–2849, 2010. ISSN 1939-9170. doi:[10/b59qjz](https://doi.org/10.1890/10-0097.1). URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/10-0097.1>.
- [373] M. G. Turner, W. H. Romme, R. H. Gardner, and W. W. Hargrove. Effects of Fire Size and Pattern on Early Succession in Yellowstone National Park. *Ecological Monographs*, 67(4):411–433, 1997. ISSN 1557-7015. doi:[10/fn72wk](https://doi.org/10.1890/0012-9615%281997%29067%5B0411%3AEOFSAP%5D2.0.CO%3B2). URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/0012-9615%281997%29067%5B0411%3AEOFSAP%5D2.0.CO%3B2>.
- [374] M. G. Turner, W. H. Romme, and R. H. Gardner. Prefire heterogeneity, fire severity, and early postfire plant reestablishment in subalpine forests of Yellowstone National Park, Wyoming. *International Journal of Wildland Fire*, 9(1):21–36, 1999. ISSN 1448-5516. doi:[10.1071/wf99003](https://doi.org/10.1071/wf99003). URL <https://www.publish.csiro.au/wf/wf99003>.
- [375] M. G. Turner, D. C. Donato, and W. H. Romme. Consequences of spatial heterogeneity for ecosystem services in changing forest landscapes: Priorities for future research. *Landscape Ecology*, 28(6): 1081–1097, July 2013. ISSN 1572-9761. doi:[10.1007/s10980-012-9741-4](https://doi.org/10.1007/s10980-012-9741-4). URL <https://doi.org/10.1007/s10980-012-9741-4>.
- [376] M. G. Turner, K. H. Braziunas, W. D. Hansen, T. J. Hoecker, W. Rammer, Z. Ratajczak, A. L. Westerling, and R. Seidl. The magnitude, direction, and tempo of forest change in Greater Yellowstone in a warmer world with more fire. *Ecological Monographs*, 92(1), Nov. 2021. ISSN 0012-9615, 1557-7015. doi:[10/gm47rp](https://doi.org/10/gm47rp). URL <https://onlinelibrary.wiley.com/doi/10.1002/ecm.1485>.

- [377] M. D. Ulyshen, S. Horn, B. Barnes, and K. J. K. Gandhi. Impacts of prescribed fire on saproxylic beetles in loblolly pine logs. *Insect Conservation and Diversity*, 3(4):247–251, 2010. ISSN 1752-4598. doi:10.1111/j.1752-4598.2010.00095.x. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1752-4598.2010.00095.x>.
- [378] M. D. Ulyshen, J. K. Hiers, S. M. Pokswinski, and C. Fair. Pyrodiversity promotes pollinator diversity in a fire-adapted landscape. *Frontiers in Ecology and the Environment*, 20(2):78–83, 2022. ISSN 1540-9309. doi:10.1002/fee.2436. URL <https://onlinelibrary.wiley.com/doi/abs/10.1002/fee.2436>.
- [379] E. C. Underwood and J. F. Quinn. Response of ants and spiders to prescribed fire in oak woodlands of California. *Journal of Insect Conservation*, 14(4):359–366, Aug. 2010. ISSN 1572-9753. doi:10.1007/s10841-010-9265-7. URL <https://doi.org/10.1007/s10841-010-9265-7>.
- [380] V. Urbanovičová, D. Miklisová, and L. Kováč. Forest disturbance enhanced the activity of epedaphic collembola in windthrown stands of the High Tatra mountains. *Journal of Mountain Science*, 11(2):449–463, Mar. 2014. ISSN 1993-0321. doi:10.1007/s11629-013-2736-z. URL <https://doi.org/10.1007/s11629-013-2736-z>.
- [381] G. Vacchiano, M. Garbarino, E. Lingua, and R. Motta. Forest dynamics and disturbance regimes in the Italian Apennines. *Forest Ecology and Management*, 388:57–66, Mar. 2017. ISSN 0378-1127. doi:10.1016/j.foreco.2016.10.033. URL <https://www.sciencedirect.com/science/article/pii/S0378112716308003>.
- [382] G. Vacchiano, M. B. Pesendorfer, M. Conedera, G. Gratzler, L. Rossi, and D. Ascoli. Natural disturbances and masting: From mechanisms to fitness consequences. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 376(1839):20200384, Dec. 2021. doi:10/gm6mgr. URL <https://royalsocietypublishing.org/doi/full/10.1098/rstb.2020.0384>.
- [383] J. M. Varner, J. M. Kane, J. K. Kreye, and E. Engber. The Flammability of Forest and Woodland Litter: A Synthesis. *Current Forestry Reports*, 1(2):91–99, June 2015. ISSN 2198-6436. doi:10.1007/s40725-015-0012-x. URL <https://doi.org/10.1007/s40725-015-0012-x>.
- [384] H. Vehviläinen, J. Koricheva, and K. Ruohomäki. Tree species diversity influences herbivore abundance and damage: Meta-analysis of long-term forest experiments. *Oecologia*, 152(2):287–298, May 2007. ISSN 1432-1939. doi:10.1007/s00442-007-0673-7. URL <https://doi.org/10.1007/s00442-007-0673-7>.
- [385] A. Véle, J. Holuša, and J. Horák. Ant abundance increases with clearing size. *Journal of Forest Research*, 21(2):110–114, Apr. 2016. ISSN 1341-6979. doi:10.1007/s10310-016-0520-y. URL <https://doi.org/10.1007/s10310-016-0520-y>.
- [386] R. M. Verble and S. P. Yanoviak. Short-Term Effects of Prescribed Burning on Ant (Hymenoptera: Formicidae) Assemblages in Ozark Forests. *Annals of the Entomological Society of America*, 106(2):

- 198–203, Mar. 2013. ISSN 0013-8746. doi:[10.1603/AN12108](https://doi.org/10.1603/AN12108). URL <https://doi.org/10.1603/AN12108>.
- [387] R. M. Verble-Pearson. Effects of Fire Intensity on Litter Arthropod Communities in Ozark Oak Forests, Arkansas, U.S.A. *The American Midland Naturalist*, 172(1):14–24, July 2014. ISSN 0003-0031, 1938-4238. doi:[10.1674/0003-0031-172.1.14](https://doi.org/10.1674/0003-0031-172.1.14). URL <https://bioone.org/journals/the-american-midland-naturalist/volume-172/issue-1/0003-0031-172.1.14/Effects-of-Fire-Intensity-on-Litter-Arthropod-Communities-in-Ozark/10.1674/0003-0031-172.1.14.full>.
- [388] M.-L. Viljur, S. R. Abella, M. Adámek, J. B. R. Alencar, N. A. Barber, B. Beudert, L. A. Burkle, L. Cagnolo, B. R. Campos, A. Chao, B. Chergui, C.-Y. Choi, D. F. R. Cleary, T. S. Davis, Y. A. Dechnik-Vázquez, W. M. Downing, A. Fuentes-Ramirez, K. J. K. Gandhi, C. Gehring, K. B. Georgiev, M. Gimbutas, K. B. Gongalsky, A. Y. Gorbunova, C. H. Greenberg, K. Hylander, E. S. Jules, D. I. Korobushkin, K. Köster, V. Kurth, J. D. Lanham, M. Lazarina, A. B. Leverkus, D. Lindenmayer, D. M. Marra, P. Martín-Pinto, J. A. Meave, M. Moretti, H.-Y. Nam, M. K. Obrist, T. Petanidou, P. Pons, S. G. Potts, I. B. Rapoport, P. R. Rhoades, C. Richter, R. A. Saifutdinov, N. J. Sanders, X. Santos, Z. Steel, J. Tavella, C. Wendenburg, B. Wermelinger, A. S. Zaitsev, and S. Thorn. The effect of natural disturbances on forest biodiversity: An ecological synthesis. *Biological Reviews*, 97(5):1930–1947, 2022. ISSN 1469-185X. doi:[10.1111/brv.12876](https://doi.org/10.1111/brv.12876). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/brv.12876>.
- [389] A. Vincent, P. Tillier, C. Vincent-Barbaroux, C. Bouget, and A. Salle. Influence of forest decline on the abundance and diversity of Raphidioptera and Mecoptera species dwelling in oak canopies. *European Journal of Entomology*, 117:372–379, Oct. 2020. ISSN 12105759, 18028829. doi:[10/gnh9f4](https://doi.org/10/gnh9f4). URL <http://www.eje.cz/doi/10.14411/eje.2020.041.html>.
- [390] A. Vuidot, Y. Paillet, F. Archaux, and F. Gosselin. Influence of tree characteristics and forest management on tree microhabitats. *Biological Conservation*, 144(1):441–450, Jan. 2011. ISSN 0006-3207. doi:[10.1016/j.biocon.2010.09.030](https://doi.org/10.1016/j.biocon.2010.09.030). URL <https://www.sciencedirect.com/science/article/pii/S0006320710004295>.
- [391] J. W. Wagenbrenner, L. H. MacDonald, R. N. Coats, P. R. Robichaud, and R. E. Brown. Effects of post-fire salvage logging and a skid trail treatment on ground cover, soils, and sediment production in the interior western United States. *Forest Ecology and Management*, 335:176–193, Jan. 2015. ISSN 0378-1127. doi:[10/gm6mjh](https://doi.org/10/gm6mjh). URL <https://www.sciencedirect.com/science/article/pii/S037811271400557X>.
- [392] K. Waldron, J.-C. Ruel, and S. Gauthier. Forest structural attributes after windthrow and consequences of salvage logging. *Forest Ecology and Management*, 289:28–37, Feb. 2013. ISSN 0378-1127. doi:[10/f4qs4w](https://doi.org/10/f4qs4w). URL <http://www.sciencedirect.com/science/article/pii/S0378112712006032>.

- [393] K. Waldron, J.-C. Ruel, S. Gauthier, L. De Grandpré, and C. J. Peterson. Effects of post-windthrow salvage logging on microsites, plant composition and regeneration. *Applied Vegetation Science*, 17(2):323–337, 2014. ISSN 1654-109X. doi:[10.1111/avsc.12061](https://doi.org/10.1111/avsc.12061). URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/avsc.12061>.
- [394] S. L. Webb and S. E. Scanga. Windstorm Disturbance Without Patch Dynamics: Twelve Years of Change in a Minnesota Forest. *Ecology*, 82(3):893–897, 2001. ISSN 1939-9170. doi:[10.1890/0012-9658\(2001\)082\[0893:WDWPD\]2.0.CO;2](https://doi.org/10.1890/0012-9658(2001)082[0893:WDWPD]2.0.CO;2). URL <https://onlinelibrary.wiley.com/doi/abs/10.1890/0012-9658%282001%29082%5B0893%3AWDWPD%5D2.0.CO%3B2>.
- [395] K. Wehner, N. K. Simons, N. Blüthgen, and M. Heathoff. Drought, windthrow and forest operations strongly affect oribatid mite communities in different microhabitats. *Global Ecology and Conservation*, 30:e01757, Oct. 2021. ISSN 2351-9894. doi:[10.1016/j.gecco.2021.e01757](https://doi.org/10.1016/j.gecco.2021.e01757). URL <https://www.sciencedirect.com/science/article/pii/S2351989421003073>.
- [396] B. Wermelinger. *Forest Insects in Europe: Diversity, Functions and Importance*. CRC Press, Boca Raton, Aug. 2021. ISBN 978-1-00-318646-5. doi:[10.1201/9781003186465](https://doi.org/10.1201/9781003186465).
- [397] B. Wermelinger, M. Moretti, P. Duelli, T. Lachat, G. B. Pezzatti, and M. K. Obrist. Impact of windthrow and salvage-logging on taxonomic and functional diversity of forest arthropods. *Forest Ecology and Management*, 391:9–18, May 2017. ISSN 0378-1127. doi:[10/f95vxx](https://doi.org/10/f95vxx). URL <https://www.sciencedirect.com/science/article/pii/S0378112717301536>.
- [398] L.-O. Wikars. Dependence on Fire in Wood-living Insects: An Experiment with Burned and Unburned Spruce and Birch Logs. *Journal of Insect Conservation*, 6(1):1–12, Mar. 2002. ISSN 1572-9753. doi:[10.1023/A:1015734630309](https://doi.org/10.1023/A:1015734630309). URL <https://doi.org/10.1023/A:1015734630309>.
- [399] L.-O. Wikars and J. Schimmel. Immediate effects of fire-severity on soil invertebrates in cut and uncut pine forests. *Forest Ecology and Management*, 141(3):189–200, Feb. 2001. ISSN 0378-1127. doi:[10.1016/S0378-1127\(00\)00328-5](https://doi.org/10.1016/S0378-1127(00)00328-5). URL <https://www.sciencedirect.com/science/article/pii/S0378112700003285>.
- [400] M.-B. Winter, C. Ammer, R. Baier, D. C. Donato, S. Seibold, and J. Müller. Multi-taxon alpha diversity following bark beetle disturbance: Evaluating multi-decade persistence of a diverse early-seral phase. *Forest Ecology and Management*, 338:32–45, Feb. 2015. ISSN 0378-1127. doi:[10.1016/j.foreco.2014.11.019](https://doi.org/10.1016/j.foreco.2014.11.019). URL <http://www.sciencedirect.com/science/article/pii/S0378112714006859>.
- [401] F. Zellweger, P. De Frenne, J. Lenoir, P. Vangansbeke, K. Verheyen, M. Bernhardt-Römermann, L. Baeten, R. Hédli, I. Berki, J. Brunet, H. Van Calster, M. Chudomelová, G. Decocq, T. Dirnböck, T. Durak, T. Heinken, B. Jaroszewicz, M. Kopecký, F. Máliš, M. Macek, M. Malicki, T. Naaf, T. A. Nagel, A. Ortmann-Ajkai, P. Petřík, R. Pielech, K. Reczyńska, W. Schmidt, T. Standovár, K. Świerkosz, B. Teleki, O. Vild, M. Wulf, and D. Coomes. Forest microclimate dynamics drive plant

BIBLIOGRAPHY

responses to warming. *Science*, 368(6492):772–775, May 2020. doi:[10.1126/science.aba6880](https://doi.org/10.1126/science.aba6880). URL <https://www.science.org/doi/abs/10.1126/science.aba6880>.